WASTE PAPER RECYCLING AND ITS FEASIBILITY IN KANO

A thesis submitted to the Postgraduate School of Ahmadu Bello University in partial fulfillment of the requirements for the degree of Master of Science in Production Engineering.

BY

MUNAWAR AHMAD SAQIB

Department of Mechanical Engineering,
Ahmadu Bello University,
Zaria, Nigeria.

AUGUST, 1986

DECLARATION

I hereby declare that this thesis has been composed by myself and that it is a record of my own research work. It has not been accepted in any previous application for higher degree. All quotations are distinguished by quotation marks and the sources of information specifically aknowledged by means of references.

August 1986.

M. A. SAQIB.

CERTIFICATION

This thesis entitled "WASTE PAPER RECYCLING AND ITS FEASIBILITY IN KANO", by M. A. SAQIB, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. P. Mathew,
Chairman, Supervisory Committee.

6/9/1986
Date

Mrs. D. I. Grigorova,
Member, Supervisory Committee.

6/9/1986
Date

The Head, DR. C. B. FOLAYAN
Mechanical Engineering Department.

3/12/86
Date

ACKNOWLEDGEMENT

Any form of recycling takes a great deal of cooperation. So did this work about waste paper recycling.

It is with pleasure that I express my gratitude to all the people and organisations, too numerous for all to be mentioned, that helped me make this project a reality. My special thanks to my supervisors, Dr. P. Mathew and Mrs. D.I. Grigorova, for their expert guidance throughout the course of this project. I am also indebted to all the other staff of Mechanical Engineering Department but especially to Professor S.Y. Aku and Dr. C.O. Folayan for their keen interest, and to Mr. M.A. Sarki and Mr. L.T. Tuleun for thier useful suggestions.

I would like to thank the following employees of Nigerian Paper Mill Ltd., Jebba for their help and cooperation in various aspects of this study: S.O. Ajayi of Chipper house; Alu of Purchased Fibre Processing; Kehinde of the Running Mill; R.K. Maheshwari and Mishra of Paper Production; A. Chopra of Finishing; U.S. Aggarwal and Dokania of Engineering; P.S. Tanwar of Instrumentation; S.N. Khosla, Ajiboye and B. Balogun of the Training School; Dujari and M.L. Bakare of Central Lab.; Kunle of Design Office and Mr. S.M. Ganediwal, the Production Manager.

I would also like to thank the following persons for their help:
Mr. Rabus, Production Manager, Star Modern Paper Mill, Kano;
Mr. M.M. Ugavahakar, General Manager, Triumph Packaging Co., Kano;
Mr. Sunday, Administrative Manager, Nigerian Stationary Factory, Kano;

Mr. Z.Y. Ibrahim, Press Manager, Triumph Publishing Co., Kano; Mr. Varghees, General Manager, Rigidpack Containers, Zaria; Mr. Y.M. Berhanu, Day Production Manager, Nasco Pack, Jos; Alh. J.A. Sani, Manager, Khuddam Scientific Supplies, Kano; Dr. M.A. Mansoor, Technical Director, Agriman Ind. Services, Pakistan; Mr.Khan, Manager, Al-Hilal Group of Companies, Kano and Mr. Srivamadevan, Principal Surveyor, Land and Survey Division, Kano.

I can not afford to miss this oportunity to express my gratitude to my parents, Mr. & Mrs. R.A. Saqib, and my brothers, Anwar & Nasir, for their guidance and help respectively. To all of them I offer my thanks but above all I offer humble thanks to ".... the most Generous - Who taught man by the pen, taught man what he knew not".

Munawar A. Saqib.

ABSTRACT

A study has been conducted to determine the feasibility and benefits of waste paper recycling. It is found that a 7500 tons per year waste paper recycling plant in Kano is technically, commercially and financially feasible.

Trends in manufacture and consumption of paper were studied along with the types of raw materials favoured in both developing and advanced countries. Technology and problems associated with waste paper recycling were investigated and a case study of paper recycling was conducted at Nigerian Paper Mill (NPM) Ltd., Jebba.

Laboratory tests on hand sheets were carried out in order to compare the strength and other physical peoperties of sheets from different pulps. The results of such experiments, in respect of recycled fibre, were quite encouraging. Repeated and long-term recycling in a given area is found not have any significant adverse effect on the quality of recycled paper.

A survey of major paper consumers was conducted in Kano and some near-by towns. It was estimated that Kano State consumes over 20 000 tons of paper annually; and 5 000 to 10 000 tons of recyclable waste paper is generated in Kano and its adjacent areas every year. Other industrial towns near Kano also generate large quantities of recyclable waste paper.

Raw materials, utilities and other plant needs have been determined and it is found that apart from rosin all input requirements can be met locally. The imported rosin consumption will be about 60 t/year; that is, less than $0{,}6\%$ of total inputs.

The plant is recommended to be sited at Chalawa Industrial Estate in Kano because of its proximity to major consumers of paper and numerous waste paper generators. Also, this location can meet the other plant needs such as water, electricity, accommodation, transport and vital road links.

The waste paper will be repulped, deflaked and screened for contaminants. Additives will be mixed and the stock refined before passing through a two-stage centrifugal cleaning system. Sheet formation will take place on a shaking-type fourdrinier machine. On reaching the end of fourdrinier, paper-web will pass through two presses and a set of steam-heated driers to reduce its moisture content to about 5%. Finishing operation will be off-machine and will involve calendering, rewinding and cutting to suitable sizes.

The list of equipment is divided into two parts, the machinery and installations to be imported and those to be procured locally. Specifications for machines are also given.

Manpower requirements for technical and non-technical functions have been determined and it is found that the company will provide employment for about 140 persons. A comprehensive training programme at the Training Centre of NPM Jebba is recommended.

The project will require 24 months for completion between signing of contract with the selected technical partner and start-up of the plant. Time requirements for pre-production activities are shown on Master Time Schedule chart.

Total financial requirement for the project is ₦13 000 000. This includes the costs of company formation, land acquisition, procurement of equipment, plant construction, start-up and working capital. The production cost is ₦ 515/ton and sales revenue is project at ₦900/ton.

A pro-forma balance sheet, cash flow tables and other relevant financial statements have been prepared. Return on equity is 37% and break-even will be reached at 45% of annual capacity. Pay-back period is expected to be less than four years.

The establishment of the proposed project is strongly recommended because it is viable and profitable.

CONTENTS

Chapter	Title	Page
	Declaration	I
	Certification	II
	Acknowledgements	III
	Abstract	V
	Table of Contents	VIII
	List of Tables	XV
	List of Figures	XVII
	List of Appendices	XVIII
	Glossary	XIX
1.	INTRODUCTION	1
1.1.	Recycling	1
1.2.	Paper	2
1.3.	Paper Recycling	2
1.4.	Terms of Reference	4
1.5.	Review of Literature	4
2.	PAPER	6
2.1.	Introduction	6
2.2.	Raw Materials for Paper Making	6
2.2.1.	Fibrous Materials	6
2.2.2.	Non-Fibrous Materials	7
2.3.	Industrial Manufacture of Paper	8
2.3.1.	Stock Preparation	8
2.3.2.	Sheet Forming	8
2.4.	Trends in Manufacture and Consumption ...	9
2.5	Industry in Nigeria	11

2.5.1.	Nigerian Paper Mill, Jebba	13
2.5.2.	Nig. Newsprint Manufacturing Co., Oko-Iboku	14
2.5.3.	Nigerian National Paper Company, Iwopin ...	15
2.6.	Market Situation	15
3.	SECONDARY FIBRE	19
3.1.	Introduction	19
3.2.	Generation of Paper Residuals	20
3.2.1.	Mill Broke	20
3.2.2.	Converting Residuals	20
3.2.3.	Distribution Residuals	22
3.2.4.	Consumption Residuals	22
3.3.	Factors Affecting Recyclability ...	22
3.3.1.	Mass	23
3.3.2.	Contamination	23
3.3.3.	Homogeneity	23
3.3.4.	Location	24
3.4.	Evaluation of Waste Paper Sources ...	24
3.5.	Recycling Statistics	27
3.6.	Need for Legislation	28
4.	WASTE PAPER RECYCLING - PROCESS AND EQUIPMENT	30
4.1.	The Recycling Process	30
4.2.	Some Recycling Systems	32
4.2.1.	Voith-Morden System	32
4.2.2.	Bergstrom System	35
4.2.3.	Recycling Process at NPM Jebba ...	36
4.3.	The Recycling Equipment	37
4.3.1.	Hydrapulper	37

4.3.2.	Junk Remover	39
4.3.3.	The Ragger	39
4.3.4.	Deflaker	40
4.3.5.	Conical Refiner	41
4.3.6.	Centrifugal Cleaners	43
4.3.7.	Jonsson Screen	44
4.3.8.	Pumps	45
5.	CASE STUDY - NPM EXPANSION PROJECT ...	46
5.1.	Introduction	46
5.2.	Historical Background	47
5.3.	Purchased Fibre Processing	48
5.3.1.	Imported Pulp System	48
5.3.2.	Waste Paper System	48
5.3.3.	Final Stock Preparation	50
5.4.	Sheet Forming Machines	50
5.4.1.	Paper Machine No. 1	50
5.4.2.	Paper Machine No. 2	52
5.4.3.	Paper Machine No. 3	52
6.	EFFECT OF RECYCLING ON PAPER	54
6.1.	Introduction	54
6.2.	Pulp Evaluation	54
6.2.1.	Freeness Test	55
6.2.2.	Test Procedure and Results	55
6.3.	Tests for Paper	58
6.4.	Hand-Sheet Making	62
6.4.1.	Hand-Sheet Making at ABU Zaria ...	62
6.4.2.	Hand-Sheet Making at NPM Jebba ...	65
6.5.	Effect of Successive Recycling ...	69

7.	MARKET AND PLANT CAPACITY	73
7.1.	Introduction	73
7.2.	Demand Analysis	73
7.3.	Availability of Waste Paper	77
7.4.	Technical Limitations	80
7.5.	Plant Capacity	82
8.	RAW MATERIALS AND INPUTS	83
8.1.	Introduction	83
8.2.	Raw Materials	83
8.2.1.	Waste Paper	83
8.2.2.	Pulp	84
8.2.3.	Additives	84
8.3.	Utilities	87
8.3.1.	Electricity	87
8.3.2.	Fuel	88
8.3.3.	Water	88
8.3.4.	Steam	89
8.4.	Total Requirements	89
9.	PLANT LOCATION AND TECHNOLOGY	91
9.1.	Location and Site Description	91
9.1.1.	Site and Terrain	91
9.1.2.	Climate	93
9.1.3.	Transport	93
9.1.4.	Utilities	94
9.2.	Criteria for Selection of Technology ...	94

10.	PROJECT ENGINEERING	96
10.1.	Production Process	96
10.1.1.	Fibre Storage and Preparation	96
10.1.2.	Repulping and Deflaking	96
10.1.3.	Screening	97
10.1.4.	Blending and Refining	97
10.1.5.	Certrifugal Cleaning	97
10.1.6.	Sheet Forming	98
10.1.7.	Drying	98
10.1.8.	Finishing	98
10.2.	Machinery and Equipment	99
10.2.1.	List of Imported Machinery	99
10.2.2.	Facilities and Equipment Provided Locally ..	102
10.2.3.	Specifications of Selected Equipment ...	102
10.3.	Plant Engineering	105
10.3.1.	Mechanical	105
10.3.2.	Electrical	106
10.4.	Layout and Civil Works	106
10.4.1.	Plant Layout	106
10.4.2.	Buildings and Civil Structures ...	108
11.	PLANT ORGANISATION AND MANAGEMENT ...	111
11.1.	Introduction	111
11.2.	Organisational Structure	111
11.3.	Wages and Salaries	112
11.4.	Staff Training	112

12.	PROJECT IMPLEMENTATION	116
13.	COST ESTIMATES AND FINANCES	119
13.1.	Introduction	119
13.2.	Cost of the Project	120
13.2.1.	Land and Land Development	121
13.2.2.	Buildings and Civil Works	121
13.2.3.	Plant, Machinery and Equipment	122
13.2.4.	Motor Vehicles	123
13.2.5.	Pre-Production Capital Expenses ...	124
13.2.6.	Operating Capital	124
13.3.	Production Costs	125
13.3.1.	Staff Salaries and Wages	125
13.3.2.	Material and Energy Costs	125
13.3.3.	Administrative Overhead Expenses ...	126
13.3.4.	Other Production Costs	127
13.4.	Financial Plan	127
13.4.1.	Long-Term Loan	128
13.4.2.	Short-Term Loan	128
13.4.3.	Taxation	129
13.5.	Sales Revenue	129
14.	ECONOMICS OF THE PROJECT	131
14.1.	Financial Statements	131
14.1.1.	Summary of Cash Flows	131
14.1.2.	Net Income Statement	131
14.1.3.	Balance Sheet	132
14.2.	Financial Evaluation	132
14.2.1.	Net Present Value	132

14.2.2.	Internal Rate of Return	133
14.2.3.	Pay-Back Period	133
14.2.4.	Break-Even Analysis	134
14.3.	Profits and Returns on Investment ...	136
15.	CONCLUSION	138
15.1.	Concluding Comments	138
15.2.	Suggestions for Further Work	139
	Bibliography	140
	Appendices	144

LIST OF TABLES

Table	Title	Page
2.1	Annual per capita consumption of paper in 1977 ...	11
2.2	Paper mills: capacities and investment ...	13
2.3	Paper production at NPM	14
2.4	Import license approvals for paper as at 11/4/85 ...	16
2.5	Paper and board: production, import and demand ...	17
3.1	Paper recycling potential and its utilisation by stages of generation	26
3.2	Relative quality of paper residuals by their sources of generation	26
3.3	Recycling statistics	27
6.1	Freeness of waste paper pulps ...	57
6.2	Freeness of unrefined wood and non-wood pulps ...	58
6.3	Effect of number of paper-making cycles on sheet properties	70
6.4	Constitution of recycled paper with respect to re-use cycles of fibre	72
7.1	Annual paper consumption of some paper converters ..	76
7.2	Amounts of waste paper discarded by some paper converters	78
7.3	Waste paper generation in ABU in 1985	79
7.4	Seasonal variation in the amount of waste paper collected by some agents in Tokyo in 1960 ...	80
8.1	Raw material requirements	90
8.2	Utility requirements	90
10.1	List of imported machinery	100
10.2	Area requirements for factory and auxiliary buildings	107

List of tables(Contd.)

Table	Title	Page
11.1	Wages and salaries: Staff on regular duty ...	114
11.2	Wages and salaries: Staff on shift	115
13.1	Initial investment cost	120
13.2	Land and land development cost	121
13.3	Buildings and civil works cost	122
13.4	Plant, machinery and equipment cost	123
13.5	Motor vehicle cost	123
13.6	Capital expenses before production	124
13.7	Provision for working capital	125
13.8	Production materials and energy costs	126
13.9	Initial sources of finance	127
13.10	Projected income from sales	130
14.1	Determination of pay-back period	134
14.2	Profits, returns and ratios	137

LIST OF FIGURES

Figure	Title	Page
2.1	Nigeria: Location of paper mills	12
3.1	Stages of waste paper generation	21
4.1	Voith Morden secondary fibre pulping system ...	33
4.2	Black-Clawson secondary fibre pulping system ...	33
4.3	Beloit-Jones secondary fibre pulping system ...	34
4.4	Escher Wyss secondary fibre pulping system ...	34
4.5	Hydrapulper	38
4.6	Junk remover	38
4.7	Deflaker	40
4.8	Conical Refiner	42
4.9	Centrifugal Cleaner	42
4.10	Jonsson screen	44
5.1	Waste paper stock preparation at NPM	49
5.2	Simplified paper-making process at NPM	51
6.1	Scopper-Reigler freeness tester	56
6.2	Strecker sheet former	63
6.3	Tear strength vs. Basis weight	67
6.4	Tear factor vs. Basis weight	67
6.5	Breaking weight vs. Basis weight	68
6.6	Breaking length vs. Basis weight	68
9.1	Chalawa Industrial Estate, Kano	92
10.1	Plant layout	110
11.1	Organisational set-up	113
12.1	Master Time Schedule	118
14.1	Determination of break-even point	135

LIST OF APPENDICES

Appendix	Title	Page
A	Definitions of paper and board	144
B	Consumer survey questionaire	147
C	Some large paper consumers	149
D	Paper imports and production, Nigeria, 1981 ...	151
E	Schedule of operating capital	152
F	Schedule of production costs	153
G	Schedule of administrative overhead expenses ...	154
H	Schedule of debt repayment and service charges ..	155
I	Schedule of depreciation	156
J	Schedule of initial investment	157
K	Schedule of total sources of funds	158
L	Schedule of total assets	159
M	Cash flow table for financial planning ...	160
N	Net income statement	161
O	Projected balance sheet	162
P	Cash flow table for NPV of the project ...	163
Q	Computer Programs	164

GLOSSARY

ADDITIVES. Chemicals added to the paper stock during its preparation. They include fillers, rosin, alum and colouring agents.

BASIS WEIGHT. Weight of one square metre of paper in grams.

BEATING. The mechanical treatment of fibres in water to produce fibrillation or cutting, according to the properties required in finished paper.

BROKE. Paper thrown out in sorting, reeling and other finishing operations, which is usually returned to the stock preparation plant for re-processing.

CALENDERING. Process of smoothing paper by pressing and passing through (calender) rolls.

CONSISTENCY. Percentage of bone-dry pulp in paper stock.

CONTRARIES. Anything in the raw materials which is injurious or unwanted for the purpose of paper-making, such as sand, pins, etc.

CSF Canadian Standard Freeness; unit of freeness measurement.

FLAKE CONTENT. Ratio of unfiberized fibre in total fibre in paper stock.

FURNISH. The fibrous and non-fibrous constituents comprising paper.

SAVEALL. A tray placed under the paper machine wire to collect

water draining from the sheet. This term also refers to a device for reclaiming solids in the form of fibrous and non-fibrous materials from white-water.

SECONDARY FIBRE. Waste paper and paper board.

SIZING. Paste-like material and the process for giving stiffness and a hard shiny surface to paper.

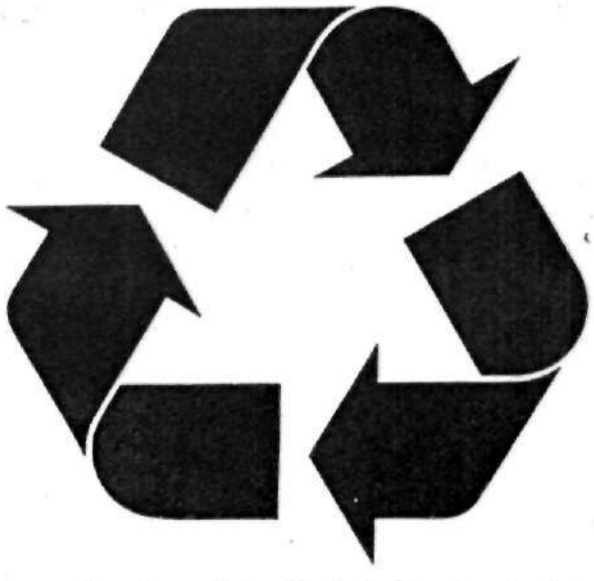
STOCK. A term loosely applied to paper-making fibrous material in all stages before formation on the machine wire.

STUFF. Same as stock.

SUBSTANCE. Same as basis weight

WHITE WATER. Water returned from the paper machine wire-pit and saveall trays for re-use.

WOOD-FREE PAPERS. Papers containing less than 10% of mechanical wood-pulp.



Recycling symbol used by the American Paper Institute.



CHAPTER ONE

INTRODUCTION

1.1 RECYCLING

"One day it will begin to dawn on our masters that to plunder in a single generation resources that have taken 350 million years to accumulate is a crime for which our descendants will never forgive us".

Lord Avebury,

New Scientist, 22nd February, 1973.

In the natural world there is no waste. The products of any process in nature are inputs to other natural processes. Fallen tree leaves and animal dung contain nutrients for plant growth. Carbon dioxide produced during animal respiration is used by plants to produce Oxygen; and this in-turn is used by animals.

The activities of man (harvesting, manufacturing, packaging, etc.) result, in part, in outputs not considered useful by man. These are normally termed as waste.

Now, this waste has created a host of new problems. Garbage disposal requires energy in removal process. Garbage dumps are unsightly and unsanitary, nor are there endless areas for dumping. Burning garbage causes huge air-pollution problems. Using the garbage as landfill is also costly in land area, in transportation and in sanitary landfill methods. Industry is also a large polluter in the form of waste disposal and dumping of effluent materials into lakes, rivers and other areas. Solution to some of these problems, RECYCLING, is the subject of this dissertation.

Recycling is defined as the process of reclaiming a product after it has served its initial purpose and putting it back into use in another form.

1.2 PAPER

The word 'paper', like the word 'metal', is a general term, designating a sheet material made of many small discrete fibres bonded together. Most commonly the fibres are cellulosic in nature and are formed into a sheet on a wire-mesh from a dilute watery suspension containing fibres and non-fibrous additives.

By suitable choice of the types of fibres and additives, and of their treatment in the process, a wide range of products is made, all coming under the general heading of "Paper and Board". Slight modification of additives or the manufacturing process will usually produce papers of widely varying descriptions. Some examples are: tissue paper, kraft liner, fluting medium, magazine, paper board, newsprint and writing paper. A detailed list containing all the major classes of paper and board, along with their descriptions, is given in appendix A.

1.3 PAPER RECYCLING

Formation of paper from pulp is not an irreversible process and, therefore, used paper can be re-pulped and formed into a sheet again. As new sources of pulp become scarce, more emphasis is being put on research into use of waste paper for paper manufacture. Waste paper is being used in increasingly high quality paper and more of it is being reclaimed from "mixed urban waste" (a polite term for garbage).

Recent research has shown that reclaiming of used wood fibre requires less energy to reduce them to their fibrous state than that needed to process them in the first place (Saltman, 1978). Also, the capital investment required for making paper from round wood is much greater than the capital investment required for making the same quantity of paper from paper residuals (Quimby, 1975). Even more encouraging results are obtained when other factors such as equipment, their complexity, effluent disposal, land and manpower requirements for recycling are compared with wood-based manufacture of paper.

A study by the Federal Ministry of Works and Housing has found that in Nigeria by the year 2000 refuse collection and disposal would require no less than 500 million Naira annually (Anonymous, 1985 e). Since quite a large proportion of refuse consists of paper and its products, their recycling will certainly reduce the total disposal costs and the burden on environment along with substantial economic benefits.

Apart from cheaper paper and reduced garbage disposal problems, paper recycling will reduce unemployment and contribute towards saving of national forests. According to available statistics only 10% of Nigeria's 92.4 million hectare land area is covered by productive natural forests and only 1.95 million hectares (or 2%) is actually reserved (Anonymous 1985 a) compared to the internationally recommended 25% (Anonymous, 1985f).

1.4 TERMS OF REFERENCE (Scope of study)

- To determine the recycling potential of waste paper in Kano and recommend methods for its increased utilisation.
- To recommend an optimum plant size based on surveys for raw material availability and product demand.
- To study the different technical options for paper recycling and recommend the most suitable process.
- To survey the available machinery and recommend the type and number suitable for suggested plant size.
- To select a suitable plant location, draw the plant layout and determine manpower requirements.
- To carry out financial analysis and profitability of the project.

1.5 REVIEW OF LITERATURE

The number of articles written on paper making and paper recycling must amount to many thousands. The following section will consider only a few of those that relate to small and medium sized mills, paper recycling and local raw materials.

Norton (1976) has summarized recent trends in stock preparation and considered future developments in recycled fibre-use for different grades. Another work, covering the state of the art in process equipment and equipment design, has been published by Forsythe (1972). Technology of waste paper stock-preparation systems and flow diagrams, along with operating cost have been discussed by Felton (1975).

Smythe (1978) examines the trends in paper making process and describes some break-throughs achieved with new paper machines. Technical developments in pulp and paper industry have been reviewed by Mahanta and Chaliha (1978). Problems of waste paper recycling, and their solutions are also discussed.

Bayliss and Reid (1983) have described the operation of some waste-paper-based paper mills. Particular emphasis is given to the methods of collecting and sorting waste paper before treatment. Problems of stickies and ink removal are also mentioned.

Abubakar (1976) and Bugaje (1980) have both investigate the use of local raw materials for paper manufacture. The effect of variation of pH, rosin and alum have been studied by Bolaji (1975).

A brochure from Voith (undated) paper company contains descriptions and flow diagrams of about a dozen waste paper stock preparation systems for different qualities of raw materials and different end products.

McDonald and Franklin (1983) have given an excellent description of the paper mill equipment. Particular emphasis is given to manufacture of paper board from secondary fibre.

Operation manuals of Birla Brothers (undated) at NPM Jebba give a detailed description of every single item used in the mill. Also given are the maintenance procedures and design calculations for some important machines. FAO has collected and published a number of papers related to pulp and paper industries of developing countries (FAO, 1979).



CHAPTER TWO

PAPER

2.1 INTRODUCTION

Paper is considered a prerequisite of modern existence. Since there is a correlation between its consumption and the standard of living, per capita consumption of paper is regarded as one of the indeces of the stage of development of a country. Higher levels of education, particularly technical education, are necessary to raise the earning capacity of the general population. Availability of paper is an essential factor in achieving this objective.

2.2 RAW MATERIALS FOR PAPER MAKING

2.2.1 Fibrous Materials

Without trees in the forest, paper as we know it today, would not exist. Wood continues to be the preferred source of fibres for the paper industry even though historically paper has been made from non-woody fibres such as rags, canes and straws. Among the reasons for using wood have been its relative availability, low cost, convenience in handling and storage, high quality pulp content, high yield and a very large variety of fibre types (Egol, 1982).

The emphasis in the paper industry of most developing countries is now shifting from wood to non-wood sources since most tropical countries do not have dependable reserves of wood. Research in non-wood fibrous raw materials for paper-making has produced very good results. Notable advances have been achieved with grass species in Indonesia, with bagasse (sugar cane waste) in India, with reeds (water grass) in Iraq and with Manila-stripping process in Phillipines (UNIDO, 1979).

Major paper exporters, like Canada, Finland, Sweden and United States, still rely on their enormous reserves of wood for paper manufacture.

2.2.2 Non-Fibrous Materials

Although cellulose fibres are the main component of the sheet in most conventional papers, many non-fibrous materials are also added during and after the stock preparation stage of paper making. These materials, known as additives, assist in the paper making process or improve some property of the resulting paper. Some of the commonest additives are mentioned below.

Fillers. Fillers improve smoothness, whiteness, opacity and printability.

Rosin size. This reduces absorbency. Synthetic rosins may be used to make paper which remains strong when wet (e.g. for making bottle lables).

Alum. It is used for various purposes, including the precipitation of Rosin Size, to 'fix' colours and to reduce foam.

Starch. It is used to add strength, firmness and stiffness to the sheet.

Dyes and pigment. These are used to impart different colours to the paper.

These are only some of the large number of additives used in paper industry. There are several other types of additives that are used to control such other properties as the rate of burning (for cigarette paper), folding endurance (for currency notes), heat resistance (for gaskets) electrical properties (for paper capacitors) and gloss (for magazine papers).

2.3 INDUSTRIAL MANUFACTURE OF PAPER.

Paper making is a continuous process but which, for clearer description, has been divided into two parts: stock preparation and sheet forming.

2.3.1 Stock Preparation

Stock preparation is a broad term denoting several operations which must be undertaken in order to prepare the "furnish" from which paper is made. Preparation at the initial stage consists of pulping by chemical means (cooking) or mechanical means (grinding) or combinations of the two. Aim of pulping is to reduce the wood to individual fibres. Also it is at this stage that deleterious materials (e.g. lignin) are removed and pulp is washed and bleached.

The next stage is to modify the fibres under controlled conditions to produce "stuff" which has the characteristic necessary to make paper with the required properties. This modification is performed by beaters or refiners or both. In these machines fibres are passed between sets of moving and stationary bars. This action deforms the fibres in different ways and makes them more suitable for paper making.

Having prepared the fibres, additives are mixed into the pulp according to predetermined proportions to bring the slury or furnish to its desired state. Finally, it is cleaned, screened and pumped to the head-box on paper machine. The stock preparation is now complete.

2.3.2 Sheet Forming

The stock in head-box, over 99% water, is released through slice (an opening in the headbox) onto a rapidly moving wire-mesh called fourdrinier.

As the paper flows onto the 'wire', fourdrinier moves rapidly forward and, to improve formation and drainage, it vibrates from side to side. Drainage of water is further assisted by suction boxes placed along the underside of the wire. When paper reaches end of the wire it is transferred to a felt blanket which conveys it through a set of presses and several steam-heated drums. While passing over these drums excess water is evaporated, leaving about 5% moisture.

Depending on the type of paper to be produced, this may form the final operation in the entire process or it may simply provide a base which is then the subject of finishing, coating or other operations.

Although fourdrinier is the machine used most often for sheet forming (Lavigne, 1979), there are other less common machines available. Most important of these is the cylinder machine in which a mat or web of fibres is formed on a perforated rotating cylinder. The mat, as it is formed, is treated in the same way as the one produced on the fourdrinier machine or it is joined with other mats from cylinder or fourdrinier to form a multi-ply board.

This is the basic paper-making process used by most mills with moderate variations and it is by no means complete. For a better and more detailed description, the reader should refer to PULP AND PAPER, volumes 1 and 2 by J. P. CASEY.

2.4 TRENDS IN MANUFACTURE AND CONSUMPTION

World demand for paper is increasing at about three percent; the figure is higher for developing countries (10.6% for Africa) than for developed countries (FAO, 1980). Forecasts by Food and Agriculture Organisation of the United Nations (FAO, 1977) indicate that the planned growth of manufacturing capacity for paper and board in African countries for the period 1981 to 1986 amounts to an increase of some 419 000 tons

(of which slightly less than half is in Nigeria) to give a total of 1.2 million tons by the end of 1986. According to the same source, at the end of 1986, the total pulp manufacturing capacity in Africa would reach only 914 000 tons, leaving unsatisfied demand for 286 000 ton of pulp per year. In order to overcome this problem, without resorting to import, the Industrial Development Organisation of UN has recommended (UNIDO, 1979) increased use of secondary fibre (waste paper).

To attain a level of self sufficiency by 1990, Africa would need to establish pulp and paper manufacturing capacity amounting to between 2.8 and 3.1 million tons. (FAO, 1982)

Many African Governments (notably Kenya, Egypt and Nigeria) have invested heavily in paper industries of their respective countries. Unfortunately, both Kenya and Nigeria have relied on sophisticated technology requiring highly skilled manpower not available locally. In Egypt and several other developing countries the emphasis is rightly placed on small and medium sized mills (up to 100 t/d) spread around the country. Most such mills are based on non-wood plant fibres or agricultural residues such as bagasse, rice-straw and cotton linters. Some mills suppliment part of their fibre input with either waste paper or imported pulp to manufacture special grades of paper.

Looking at the paper consumption habits of people in different countries, it is observed that there is a wide gap in the annual per capita consumption of paper between developed and developing countries. Data for selected countries is given in table 2.1.

Table 2.1 Annual per capita consumption of paper in 1977

(Adhikiri, 1979; Ebiary, 1979; Western, 1979; Rait, 1983)

Country	Consumption (kg/person/year)	Remarks
United States	273	
Sweden	195	
Japan	151	(1979)
United Kingdom	124	
Malayasia	20	
China	10	
Egypt	7	
India	2.1	
Nigeria	2.5	(1981)

UNIDO has estimated that a level of 30 kg/a is a minimum to achieve full literacy and adequate communication, while 40 kg/a would be a desirable objective to allow for some element of packaging for industrial purposes (UNIDO, 1979).

2.5 INDUSTRY IN NIGERIA

There are only three factories in the country designed to manufacture educational and industrial grades of paper.

These are:

I. Nigerian Paper Mill (NPM) Ltd., Jebba, Kwara State.

II. Nigerian Newsprint Manufacturing Co. (NNMC) Ltd., Oku-Iboku, Cross River State.

III. Nigerian National Paper Manufacturing Co. (NNPMC) Ltd., Iwopin, Ogun State.

Taking a close look at these mills, the following features appear to be common to all.

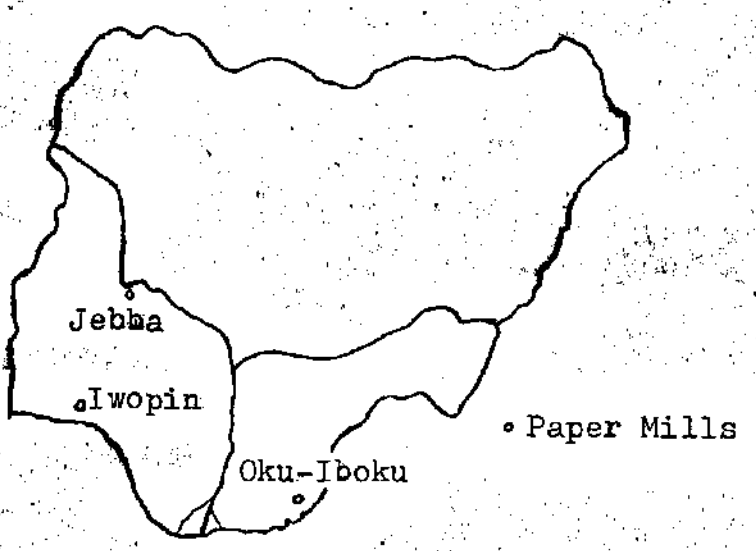
I. All the three mills are located below rivers Niger and Benue. Hence not even one paper manufacturer in 500 000 km^2 area North of these rivers (fig. 2.1).

II. All are fully government controlled, hence they are not profit or efficiency oriented.

III. The design capacity of each mill is above 60 000 t/y, hence extensive use of automatic control systems. This in-turn requires highly skilled manpower.

IV. All the mills are behind schedule with respect to installed capacity.

Fig. 2.1 Nigeria. Location of paper mills.



The combined design capacity of the three mills is over 225 thousand tons per year. Apparently, this is sufficient to meet the present local requirement but it will be at-least three to four years before this production level can be attained. And by then local demand for paper and board would also have increased due to both increased population as well as improved standard of living.

Although the use of local raw materials is increasing, the industry is still partially dependant on imported pulp. The mill at Iwopin is based on locally produced pulp and a percentage of imported long fibre (FMED, 1975). The expanded mill at Jebba will require about 50 tons of imported pulp per day when working at full capacity (NPM, 1981), while the Calabar Mill is going to use about 20% imported long-fibre pulp (FAO, 1985).

The breakdown of manufacturing capacities and the amount of money spent on each of three mills in the 3rd and 4th National Development Plans is as follows.

Table 2.2: Paper Mills: Capacities and investment.
(FMED, 1975; FMNP, 1981; Anonymous, 1985b)

Mill Site	Design Capacity 1 000 t/y	Amount allocated (₦1 000) 1975-80	1981-85	Total Spent ₦1000
Jebba	65	60 000	N.A.	225 000
Calabar	100	76 000	50 000	N.A.
Iwopin	60-100	64 000	92 000	N.A.*

*Iwopin mill has been allocated ₦37 million in 1986 budget (Anonymous, 1986).

.5.1. Nigerian Paper Mill, Jebba.

NPM in Kwara State comprises of two separate units, namely the old Running Mill and the new Expansion Unit. Production at the Running Mill includes both unbleached kraft as well as some bleached grades of writing and printing papers from the purchased fibre. The Expansion Unit is designed to manufacture only industrial-grade papers of 50-250 gsm. Although its rated capacity is 160 t/d, the daily production is often below 100 tons. The Running Mill is also producing far below

capacity (about 50%) due to spare-part problems. Total paper production at NPM for 1984 and the monthly production for the first ten months of 1985 is given in table 2.3.

Table 2.3: Paper Production at NPM

Time Period	Paper Production in metric tons			TOTAL metric tons
	PMC I	PMC II	PMC III	
1984 Total	8792.74	4161.63	3030.72	15985.09
Jan. '85	763.300	484.500	117.400	1365.200
Feb. '85	702.750	1314.900	1088.320	3105.970
Mar. '85	704.670	1516.800	1232.100	3453.570
Apr. '85	575.030	1355.100	1463.900	3394.030
May '85	688.200	2018.100	1350.200	4056.500
Jun. '85	482.612	1103.700	1031.200	2617.512
Jul. '85	731.960	2621.800	1670.500	5024.260
Aug. '85	415.250	1813.500	1273.900	3502.650
Sept. '85	621.700	1830.900	471.300	2923.900
Oct. '85	621.900	1969.400	1264.600	3855.900
Total (Jan.-Oct.'85)	6307.372	16028.700	10963.420	33299.492

PMC II & PMC III are in Expansion Unit while PMC I (Paper Machine I) is in Running Mill.

2.5.2 Nigerian Newsprint Manufacturing Company, Oku-Iboku

NNMC in Cross River State is designed to produce newsprint from locally grown Gmelina arborea and imported long-fibre pulp. The potential production rate is 100 000 t/yr. All the major equipment has been installed and final interconnections of instrumentation and electrical

components is also nearly completed. Production runs have been made on trial basis and the mill is expected to be commissioned by the middle of 1986 (Anonymous, 1986b).

Forestry operations for the mill have been going on for some time. Adequate wood supplies, though within economic haulage distance now, are not expected to last beyond 1986 (Rait, 1983). This is because the reafforestation determined originally has never been achieved and thus longer hauls will be necessary to bring in mature timber from the outlaying plantation areas.

2.5.3 Nigerian National Paper Company, Iwopin

This mill in Ogun State is designed to produce woodfree writing and printing papers. The mill now stands with almost all the civil work and a major portion of Mechanical installation completed. A tentativ start-up date can not be given because this is totally dependant on regular availability of the very scarce funds. The company has been allocated ₦37 million in 1986 budget. With the allocation of this grant, the project might be completed before the end of 1986 (Anonymous, 1986c).

2.6 MARKET SITUATION

From the latest authentic statistics available (FOS, 1982b) it is found that Nigeria imported 202 000 tons of paper in 1981. In 1982 the paper imports increased (Rait, 1983) by only 3 000 tons. During the two years in question, local production remained constant at about 14 000 tons per year. This increase in market supply (less than 1.5%) was far below the estimated increase in demand of about 10% (FAO, 1980). This shortfall created an enormous gap betwee the demand and supply and led to a serious scarcity of paper and its products.

The situation worsened and became more critical in 1983. Artificial inflation in products of paper reached over 300%. Many printers and publishers were forced to close down or reduce their businesses. New Nigerian had to reduce the number of pages in its newspaper from upto 32 to only 8. In order to control the situation, import restrictions on paper and board were decreased in the following year and local production raised. Prices did not drop as sharply as was expected because hoarders were at work.

With the improved management of foreign reserves, the Federal Government became less stingy in matters concerning foreign exchange and import restrictions for essential goods have decreased. Table 2.4 lists the foreign exchange approvals to import paper and its products as on 11 April, 1985.

Table 2.4: Import licence approvals for paper as at 11/4/85 (Anonymous, 1985 b).

Item	Approval (₦)
Pulp and paper	17 445 000
Newsprint	20 000 000
Packaging	27 000 000
Printers/Publishers	89 149 000
Papers (Nig./Brazilian Trade agreement)	17 900 000
Total	171 494 000

As a whole, the market situation for past few years has been very unpredictable and mostly chaotic. It is difficult to pin-point

exactly the factors responsible for this but economy and its mismanagement certainly top the list.

A very commendable step taken by the Federal Government was the increase of customs and excise tariff on imported Kraft paper (Anonymous, 1984). The increase, from 10% to 40%, was announced soon after the trials to produce kraft paper at the Expansion Unit of NNM proved successful. It is hoped that this protectionist policy of the government will continue, atleast until the industry is fully established.

To achieve a per capita consumption of even 10 kg/yr(UNIDO has recommended 30 to 40; UNIDO, 1979) Nigeria, with an estimated population of 95.6 million (Anonymous,1985d) would require nearly one million tons of paper annually. Presently less than a quarter of this is made available in the market. Even after the planned expansion of paper mills in Nigeria, the installed capacity will still be short by over half a million tons. Table 2.5 shows the local production, imports and total paper requirement at 5 kg/person/year for Nigeria for years 1978, 1981 and 1984. It shows that the market can absorb a lot more paper than is presently supplied to it.

Table 2.5: Paper and Board production, import and demand. (All figures in thousand metric tons).

NIGERIA	1978	1981	1984
Production	13 (1)	14 (4)	16
Imports	230 (2)	203 (5)	N.A.
Total in Market	243	217	N.A.
Estimated Demand*	418 (3)	450	478 (6)
Difference	174	233	> 225

* at 5 kg per person per year.

(1) FAO, 1982, (2) Anonymous, 1981, (3) FOS, 1982a,
(4) Rait, 1983, (5) FOS, 1982b, (6) Anonymous, 1985d.



CHAPTER THREE

SECONDARY FIBER

3.1 INTRODUCTION

Ever since the development of digesters (huge pressure cookers) paper industry has relied heavily on wood to supply its fibrous raw material. In more recent times, countries with forest resources have been keen to sell their products with the highest possible value. This policy has contributed to the rise of price for pulp and paper in the international market. This, coupled with increasing pressure by ecologists to reduce the amount of waste disposed to the environment, has led to an increased scope for paper mills based, partly or wholly, on "Secondary Fibre".

The term, "secondary fibre", in this dissertation, refers to those vegetative fibres that have been used, at least once, in the manufacture of paper and paper board. Recent research, followed by pilot plant testing, has confirmed that there are no major technical problems in the pulping of secondary fibre and that this can be used to manufacture satisfactory grades of paper (FAO, 1977). Already waste paper is being used to manufacture all kinds of papers but particularly cardboard, carton board and, increasingly, the newsprint. Another grade where secondary fibre is becoming more popular is tissue (Attwood, 1979).

Economic availability of the raw material is often the deciding factor for whether and where a project will be executed. To study properly, the possibility of waste paper recycling it is, therefore, necessary to first understand how and where the reusable fibre is disposed and what factors can make it a less or more preferred source of fibre and how these factors can be influenced by good management

techniques. This chapter attempts to answer these and other questions regarding generation, disposal, collection and recycling of re-usable secondary fibre.

3.2 GENERATION OF PAPER RESIDUALS

The term "paper residual" is synonymous with the term "waste paper" and refers to all paper-waste in the solid form generated during its production-consumption sequence. The four major stages during which large quantities of paper residuals are generated are production, conversion, distribution and consumption. These are shown in figure 3.1.

3.2.1 Mill Broke

The paper residuals from the paper mill operation, termed mill broke, are re-used directly by the mill itself and are not available to other paper mills. Mill broke varies between 15 and 20 percent of the paper machine input (Quimby, 1975).

3.2.2 Converting Residuals

The paper residuals generated in converting operation range from about 4% to as high as 30% of input, depending on the product and other factors. The average figure quoted by paper converters in Nigeria is 20 percent. From newspaper printing it is often less than 5 percent.

For writing papers, converting operation includes the cutting of huge reels into sheets of small, standard sizes, printing of lines and then binding, to be later used as notebooks, graph books, pads and pocket books. Similarly, duplicating and typing papers may be cut and packed without printing. Industrial paper may be converted into corrugated boxes or other types of packaging containers. News and other printing papers are usually converted by the printers themselves.

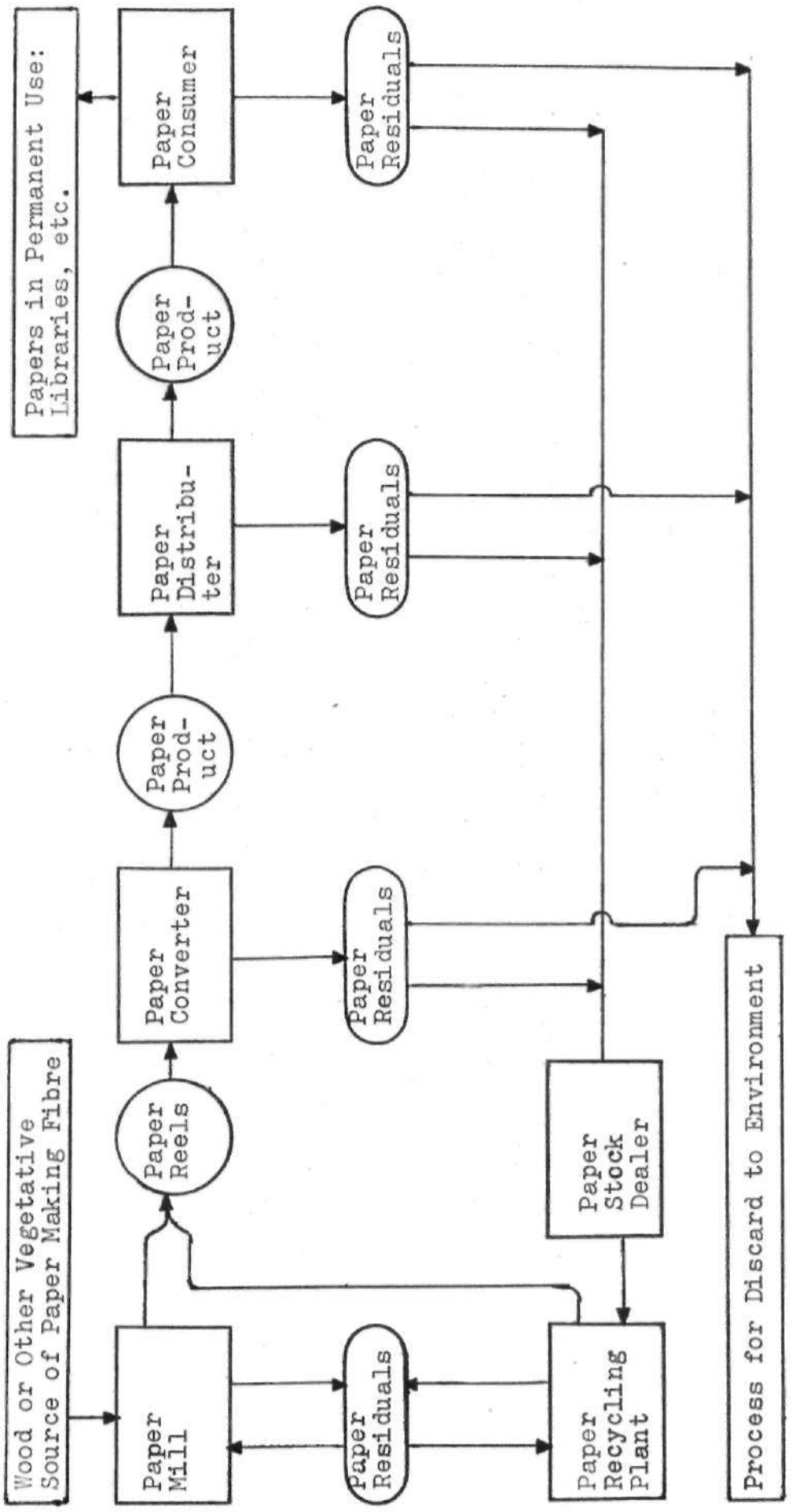


Fig. 3.1 Stages of Waste Paper Generation and Reuse.

3.2.3 Distribution Residuals

Majority of waste generated at this stage of production-consumption sequence consists of obsolete and unsold inventories of paper and paper products. It may include both newsprint and high quality magazine stock. Overissue newspapers may be as much as 5% of production.

3.2.4 Consumption Residuals

These are paper products themselves which, having fulfilled the function for which they were manufactured, are discarded. It is estimated by Quimby (1975) that more than 60% of the paper residuals are generated at the consumption stage. These are generated by both commercial as well as domestic activities.

3.3 FACTORS AFFECTING RECYCLABILITY

If paper is to be recycled then the extent to which it is recycled depends on its cost as raw material and the cost of processing compared with the cost of other sources of fibre and the cost of their processing.

The quantity of commercial long-fibred soft-wood available in Nigeria is practically insignificant. Also, other sources of fibre for paper making are inadequate for local requirement. Hence factors affecting the suitability (in terms of cost) of fibrous raw materials other than waste paper are not considered here. Primarily, there are four factors that determine the recyclability of waste paper. These are as follow.

3.3.1 Mass.

This refers to the quality of waste paper generated.

Ten thousand copies of newspapers, each weighing 100 g and each in a different household, have no value. But all of these tied together in one bale have a value of ₦60.00 to ₦80.00. A certain level of aggregation or accumulation may be necessary before waste paper from households could be used economically. This may not be necessary if the waste paper is obtained from only those organisations that dispose paper in large quantities such as paper converters, printers, government offices, supermarkets, computer installations and banks.

3.3.2 Contamination

This refers to the extent to which contaminants occur in combination with waste paper and the difficulty of separating them.

Contaminants in household waste are varied but in commercial waste they include carbon papers, typewriter ribbons, pins and staples. Hence for effective utilisation of office waste some work has to be done manually at the site of generation before relatively clean waste paper is taken to the recycling plant. Contaminants that can not be separated at the site of generation include ink, glue and wax. But technology exists to economically separate them at the recycling plant.

3.3.3 Homogeneity.

This is another factor bearing on the recyclability of residuals. For example, mixing the waste from the manufacture of folding boxes with the waste generated in the manufacture of high quality note books will down-grade the latter; whereas both types of wastes can be processed separately to produce different types of papers.

3.3.4 Location

There are two aspects of location that may increase or diminish the recycling potential for any type of waste. The first refers to the degree of effort required to collect them in a recyclable quantity (this has earlier been referred to as mass (Sec.3.3.1)). And the second is the distance (and cost of transport) between the generating site and the recycling plant.

3.4 EVALUATION OF WASTE PAPER SOURCES

As mentioned earlier, economic obtainability of raw material can make the difference on an otherwise viable project. This section examines different sources of waste paper and attempts to list the merits and demerits of their residuals in the light of recyclability factors listed in the previous section.

Mill broke, though an ideal source of waste paper, has not been considered here since it is rarely available for sale. In Nigeria all the existing paper mills are designed to use their broke almost automatically.

Residuals of converting mills possess to a very high degree, the quality of favourable location. They also possess the quality of homogeneity and are usually available in sufficient quantity. The scrap produced in a converting operation may also be said to be specifically contaminated. Hence it is highly suitable for recycling.

In distribution residuals, overissue newspaper is the most significant component. Like converting residuals, overissue newspaper has highly desirable characteristics as a raw material and is generally in demand by recycling plants. Another important source of waste paper is printers. Although, the waste is contaminated by printing, it can

be deinked or it may be used to produce coloured paper.

Consumer waste, if proper method for its collection is employed, can become the largest source of waste paper. Commercial activities usually discard relatively homogenous types of paper and since they are inherently on a larger scale, they generate residuals in some quantity at a single location. Also a little care can reduce the contaminants to a tolerable level. It should be noted here that high quality stationary waste from government establishments usually contains some very undesirable contaminants such as carbon papers and typewriter ribbons; hence this type of residuals need to be sorted manually before baling. Many industries and supermarkets dispose of large quantities of packaging material. This material contains few contaminants apart from staples and requires very little sorting. Usually it has little or no economic value to anyone except the recycling plant.

Paper residuals from household waste can only be used if they are separated from rest of the waste BEFORE disposal. Technology has not yet advanced to the stage where paper could be separated from trash economically on a small scale. A number of system have been patented in the U.S. that separate different constituents of solid waste like paper, plastic, ferrous and non-ferrous metals; but these are expensive to install and maintain. The reader should refer to Organic and Polymer Waste Reclaiming Encyclopedia (Sitting, 1981) for brief descriptions of some of these systems.

Table 3.1 shows estimated quantities of paper residuals generated at different stages of production-consumption sequence in Nigeria. It is assumed that the pattern of consumption here is the same as in America . Hence the percentage figures are based on a similar table about the United States (Quimby, 1975).

Table 3.1 Paper recycling potential and its utilisation by stages of generation, Nigeria, 1983. (thousands of tons).

Stage of generation.	Residuals generated		Recycling potantial		Residuals recycled	Residuals not recycle
	% of total consumption	Quantity	% of generation	Quantity		
Convertion	9	17	82	14	≤3	≥14
Distribution	3	6	33	2	0	6
Consumption (domestic)	38	71	7	5	0	71
Consumption (commercial)	36	67	25	17	≥0	≤67
TOTAL	86*	161*	23.6	38	3	158

*Approximately 14% (26 thousand tons) went into permanent use.

Relative quality of the residuals generated by different categories of consumers is given in table 3.2. The figures quoted in this table were arrived at after a survey of relevant establishments.

Table 3.2 Relative quality of paper residuals by their sources of generation.

Source	Mass	Homogeneity	Cleanliness*
Converters	5	4, 5	5
Distributors	5	5	4
Offices	5, 4	3	3, 4
Super Markets	5	4	4
Residential	1, 2, 3	1, 2, 3	1, 2, 3, 4
Banks	3	5	4, 5

*Cleanliness is the opposite of contamination

(Turn-over for the meaning of 1 - 5 of this table.)

1 .. Not suitable for recycling

2 .. poor

3 .. good

4 .. Very good

5 .. Excellent, ideal for recycling.

3.5 RECYCLING STATISTICS

Availability of waste paper is considered as a function of annual paper consumption. No data is available for Nigeria but from reports about other countries, it is found that at least 20% of the paper consumed can be easily obtained for recycling (UNIDO, 1979). Hence Nigeria, with annual paper consumption of over 200 thousand tons, has a potential raw material source of at least 40 000 tons. At the moment, the country is utilising only about 5 500 tons annually.

Technologically advanced countries, as well as many developing countries, recycle waste paper in much greater proportions than Nigeria. Recent figures for some selected countries are given below.

Table 3.3 Recycling Statistics (in thousand metric tons).
(Saltman, 1978; Pait, 1983: Escolano and Tamolang, 1979).

Countries	Consumption	Recycled	% recycled
United States	65 700	14 200	22 (1974)
EEC*	24 250	10 480	43 (1980)
Philippines	260	91	35 (1975)
Nigeria	217	3	1.4 (1981)

*European Economic Community Countries.

3.6 NEED FOR LEGISLATION

Apart from the economic benefit of recycling, dumping and burning of wastes must be viewed as a major cause of pollution. When wastes are dumped on land, the soil suffers and ground-water supplies are threatened. Dumped into rivers, pure water is rendered unfit for use without treatment. All this continues because few notice or complain about the spreading dumps and the fish do not write nasty letters to the complaints commission.

Recycling has been advocated by many as the solution to this problem. How far we go with this, will undoubtedly take public enlightenment and then some firm legal steps and incentives. Infact countries that have developed their recycling potential have done so with a strong support by their respective governments backed by relevant decrees. Examples of such countries are: Iraq, Sri Lanka, Indonesia, Philippines and Kenya. In Iraq, paper dumping has been banned by a decree. In Kenya, 20% of paper supplied to packers must be returned. Sweden is considering legislation making it compulsory for households, offices and the like, to collect and grade waste paper. In India, there is a duty rebate for use of waste paper as raw material and small paper mills are exempted from certain other restrictions (UNIDO, 1979).

In Nigeria, the policy makers have not yet realised the necessity of recycling - paper, glass, metals, rubber and a host of other things found on rubbish dumps. Maybe, this is why no legal steps have been taken in this direction. There is need for the government to restrict indiscriminate disposal of wastes, but before imposing any restrictions it must provide facilities for "Recycling - the alternative to disposal". Industrialists could be given low interest loans, limited tax relief and other incentives to set up small recycling plants. Research should be conducted into new recycling processes and information made available to anyone interested.

Transfer of technology does not just happen. It is something nations have to strive for. Private sector has a major role to play in this, but government assistance is essential. In Kenya, paper mills are granted exemption from duties on imported raw materials, can veto competing imports and obtain government assistance for housing and medical care (Moorthy, 1979). In Nigeria, it is suggested that a national policy for government protection or incentives should be formulated, such as, assistance with infrastructural costs, duty exemptions, tax relief, and for small mills, relaxation of pollution requirements.



CHAPTER FOUR

WASTE PAPER RECYCLING - PROCESS AND EQUIPMENT

4.1 THE RECYCLING PROCESS

Waste paper recycling process, like the paper making process (Sec 2.3), can be divided into two stages for convenience; namely stock preparation and sheet forming. A number of different sheet forming methods are employed by the recycling industry but the basic process remains the same. It is only at the stock preparation stage where widely differing methods and machinery are used by the waste paper based and pulp wood based paper manufacturers. Several wet-processing methods have been designed for commercial use. Following is a brief general description of the usual process along with its variations (Ortner, 1966).

The first step in the recycling of secondary fibre is fiberising, i.e. breaking the inter-fibre bonds and separating individual fibres. Almost all fiberising systems make use of a hydrapulper to break-up the bundles or bales of waste paper. Most hydrapulpers are equipped with machines to remove contraries and screens to retain oversized flakes.

Prolonged stay in a hydrapulper may itself complete the fiberising process but single-stage pulping is rarely employed since a considerable saving in energy can be achieved by the use of a so-called secondary pulper. The secondary pulpers (see 4.3.4) maintain a relatively high efficiency of defibering to a point where the stock is completely defibered. If the recycling plant practices deinking then the hydra-pulper may be covered, insulated and steam heated to aid both deinking and fiberisation.

To remove impurities several types of special machines are available for specific class of contaminants. A junker is used to remove heavy

junk, a ragger to remove floating strings and rags; vibrating screen to remove oversized particles and centrifugal cleaners to remove minute particles of dirt. Plants using mixed waste paper containing high percentage of objectionable material use centrifugal trash separators such as turbo-separator. This machine is designed on the principle of centrifuge to extract materials lighter and heavier than paper. Turbo-separator is actually a trade-mark and different machines exist based on the same principle.

After fiberisation and the rough cleaning stage the stock passes through a refiner or a beater to improve certain fibre characteristics (e.g. freeness). If no deinking is practiced then the stock may be passed through a disperger plant (also a trade-mark) to treat the fibre at very high consistency (consistency (c) = 25 - 30%) and disperse dirt and ink particles to below visibility level.

Screening may be done at low consistency (c = 0.8 - 1.0%) or high consistency (c = 4.0 - 4.5%) or it may be done by a method known as floatation or by some combination of these. Both low and high consistency screening satisfy the normal quality requirements although lower consistency yields slightly better results but with correspondingly higher power requirements. Floatation screening is widely used by plants practicing deinking; the process is then called floatation deinking.

Finally, fillers and other chemicals are added to the clean stock in a blending chest. The stock is then sent to the paper machine either directly or through a set of refiners. This completes the basic stock preparation process. The sheet forming process, as mentioned earlier, is essentially the same as the one mentioned in section 2.3.

4.2 SOME RECYCLING SYSTEMS

4.2.1 Voith-Morden System

Several paper machinery manufacturers have done a considerable amount of research to improve the secondary fibre pulping and screening machinery. Four of the most well-known manufacturers, Voith-Morden, Black-Clawson, Beloit-Jones and Escher Wyss, have each designed and patented a system for thorough deflaking and screening of waste paper (Casey, 1980a). Since all these systems operate basically on very similar principles it is deemed unnecessary to describe each in detail. Hence only one, that of voith-morden, is described. For others, figures 4.2, 4.3 and 4.4 are self explanatory.

The system, shown in fig 4.1, consists of a continuous pulper, turbo separator, cyclone cleaners, vibrating screens and deflakers. It is designed to remove both heavy and light contaminants with minimal loss of usable fibres. Operating consistency is about 3 - 4% and power requirement is in the range of 36 kWh/ton.

The pulper receives the baled waste paper from the conveyor. Light contaminants, rags and wires are removed by the ragger and the heavy contaminants collect in the junk box. Partially defibered secondary fibre plus the floating contaminants not removed by ragger are discharged through a screen. These are pumped into the turboseparator which acts as a secondary pulper as well as a cleaner. Light weight and heavy contraries are discharged continuously and separately. Light rejects go to the pulper after passing through a Jonsson type vibrating screen (the rejects of which are not used) and heavy rejects pass through a cyclone cleaner and then back into the pulper. Accepts from turbo separator are screened and deflaked. This completes the system (Casey, 1980a).

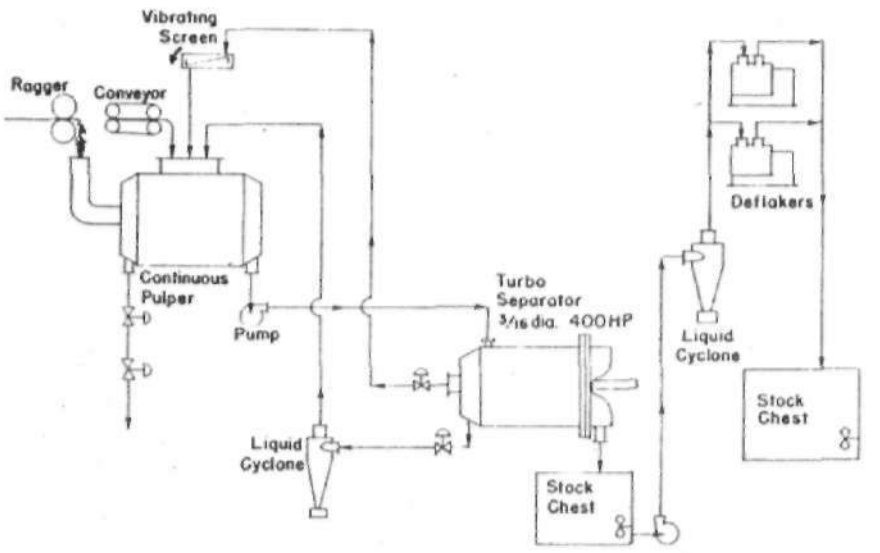


Fig. 4.1 Voith Morden secondary fibre pulping system.

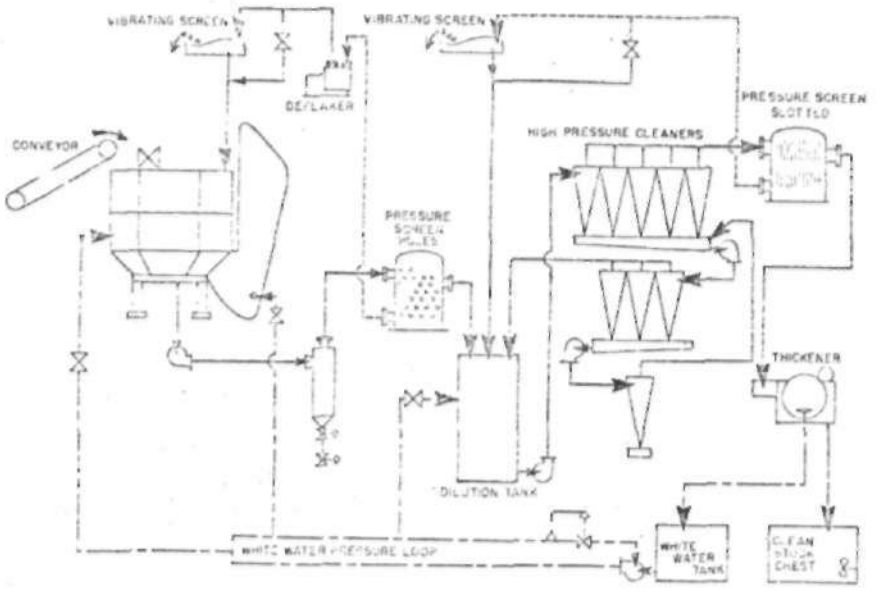


Fig. 4.2 Black-Clawson secondary fibre pulping system.

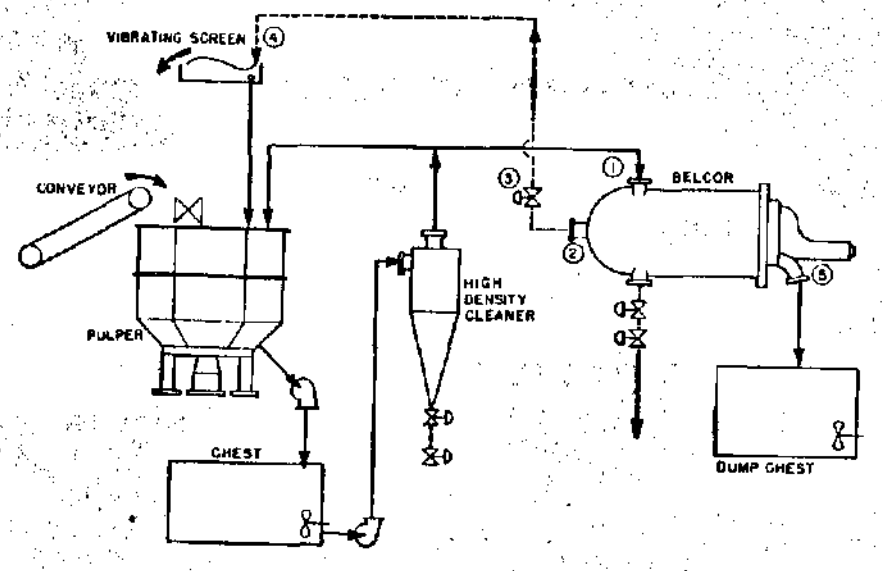


Fig. 4.3 Beloit-Jones secondary fibre pulping system.

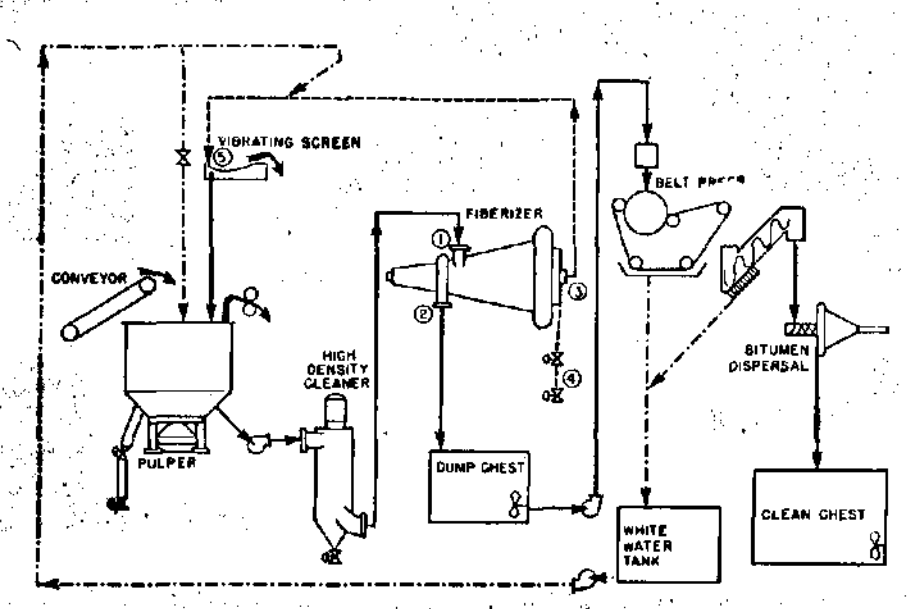


Fig. 4.4 Escher Wyss secondary fibre pulping system.

4.2.2 Bergstrom System

Bergstrom Paper Company of United States is one of the most notable fine paper mills using recycled paper to manufacture quality paper. Following is a brief description of the stock preparation process employed by this company (Bergstrom, undated).

Raw Materials. The mill uses three main categories of stock: Book papers, ledger and kraft. Typically, these include magazines, tabulating cards, computer print-out stock, office ledgers, high-grade cartons, business forms and cuttings from a variety of printers including book manufacturers. The papers are inspected and unacceptable material eliminated.

Pulping. A conveyor system delivers the waste paper to a hydrapulper in which a solution of hot water, caustic soda, ink dispersants and detergents is also added. Steam diffuses through the mix and temperatures run from 81° to 93°C. The stock is reduced to a slurried pulp and pumped to blending chests where it is diluted further with hot water and chemicals.

Washing and Filtering. Stock from the blending chests is pumped to a large drum filter, where it is washed and filtered and chemicals from the previous process are removed.

Cleaning and Screening. Next, the stock is routed to large centrifiers, which spin it to create centrifugal forces that remove staples, pins, paper clips and similar heavier-than-fibre objects. Then the stock passes over a series of vibratory screens which remove wet-strength papers, bundles, plastic particles and other rejectable materials.

Vacuum Filtering. Some of the heat and chemicals introduced thus far are recovered by vacuum filtres. The liquid is recirculated to the hydrapulping phase for further use.

Bleaching. Three-phase bleaching is practiced. Washed pulp is pumped to the chlorination tower, where chlorine gas is introduced. The gas reacts with the woody fibres' brownish constituents. After chlorination the pulp is washed and vacuum screened to remove chlorinated compounds. In the second phase of bleaching the pulp is treated with caustic soda and sodium hypochlorite, drained, and washed again before going to the third phase where hypochlorite is added a second time. At the end of bleaching process the pulp is again washed and diluted to a thin slury.

Screening and Cleaning. From the bleachery the stock is diluted to pulp slury and passed through two stages of fine screens. Then come four stages of centricleaners, all cross-linked, whereby each stage sends its accepts to the stage ahead, and its rejects to the previous stage.

Reverse Centrifugal Cleaning. While previous centrifugal cleaners removed heavier-than-fibre materials, the second battery of these cleaners reject lighter-than-fibre impurities. [This process is patented by Bergstrom].

Final Washing and Storage. Acceptable stock goes next to a washer for final washing and thickening and finally it is stored in one of the two storage towers. The stock at this point represents 70 - 75% yield from the raw material that went into the hydrapulper initially.

4.2.3 Recycling Process at NPM, Jebba.

Nigerian Paper Mill Limited, with factory in Jebba, Kwara State, recycles over 3 000 tons of waste paper annually.

Most of the raw material consists of cuttings from paper converters and used corrugated cartons. The mill uses both selected waste (multiply and corrugated container board) and mixed waste. A brief description of the recycling process designed and used at this mill is given in Section 5.3.

4.3 THE RECYCLING EQUIPMENT

Although most machines designed for waste paper recycling do not differ much from those designed for making paper from conventional sources of fibre, there are some machines which are only used in recycling. Following is a brief description of the recycling machines that will be installed at the proposed recycling plant. It is felt that a basic understanding of the principles and modes of operation of these machines will help in a better understanding of the recycling process.

4.3.1 Hydrapulper.

The first step in waste paper pulping process is to agitate water and paper until the mixture is pumpable. This is done in a hydrapulper.

Hydrapulper (fig. 4.5) consists of a tub or vat with a rotor to provide agitation. Various piping arrangements are used to provide a continuous or intermittent supply of water and chemicals. Hydrapulpers may be designed for continuous or batch operation. Hydrapulpers are always provided with pulper dump chests into which the slurry is dumped from hydrapulper. Chests designed for hydrapulpers operating on batch system are several times the capacity of the hydrapulper-vat so that the slurry from several batches can be mixed together in the chest and be of uniform quality.

The tub of the pulper can be made of concrete but the inside surface must be very smooth. If the stock requires deinking, which involves the use of chemicals and steam in the pulper, the tub is usually made of either Cast-Iron (for alkaline process) or stainless steel (for acidic treatment of wet-strength papers). A rotor, which consists of a large metallic plate with propeller-shaped protrusions a few centimetres high, is installed at the bottom of the pulper. It is driven by a motor

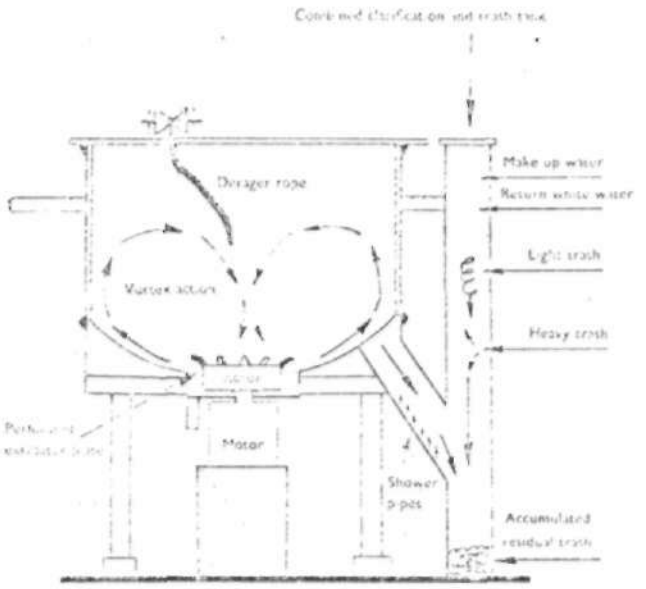


Fig. 4.5 Hydrapulper.

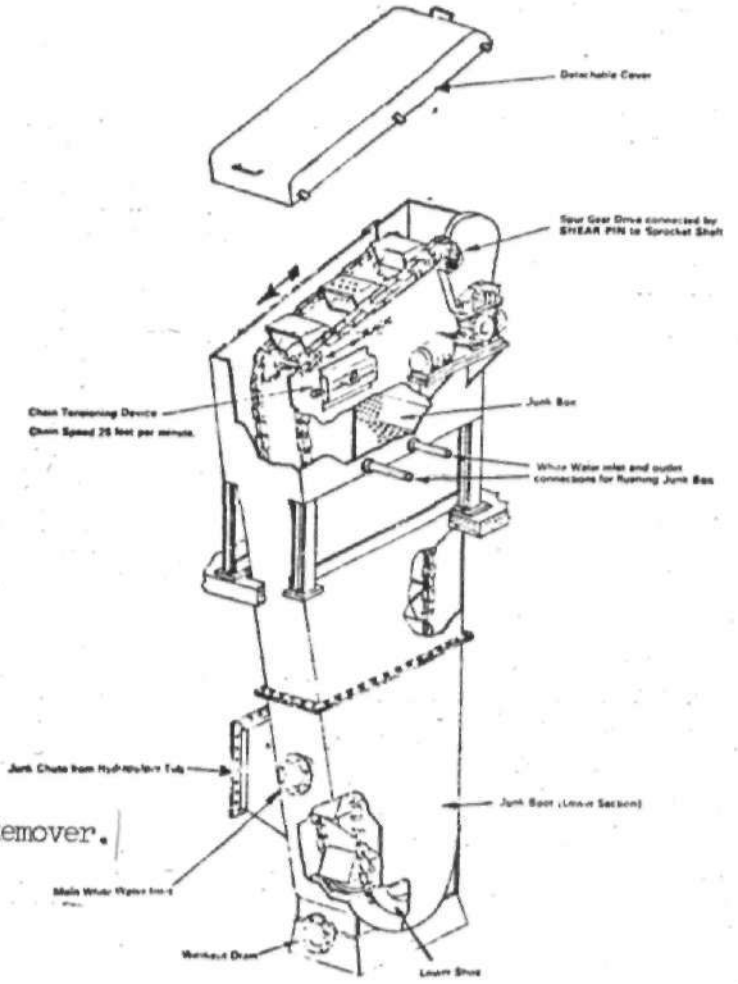


Fig. 4.6. Junk Remover.

through a bevel-gear type speed reduction unit. Sometimes, it is driven by a direct-coupled steam turbine. If steam is used for heating, then the vat is covered and provided with a hood and exhaust fan. Hydrapulpers used for slushing of mixed dirty waste papers require the addition of two accessories, namely: Junk remover and ragger.

4.3.2 Junk Remover

This equipment is erected adjacent to the Hydrapulper and is connected in such a manner as to dispose of the junk automatically and continuously as fast as it accumulates at the bottom and sides of the Hydrapulper.

Junk remover (fig. 4.6) consists of an enclosed bucket conveyer comprising of a chain and sprocket arrangement which lifts the accumulating junk from the bottom of the boot to a junk box situated above the hydrapulper operating level. In order to salvage good fibres adhering to this waste material a perforated plate is installed in the bottom of the junk box and white water flows through this plate washing such fibres back into the Hydrapulper tub.

4.3 3 The Ragger.

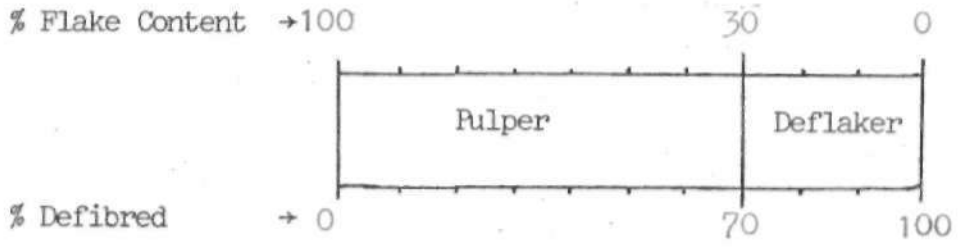
Unsorted mixed waste paper contains among other things, rags, strings and wet-strength papers. Function of the ragger is to remove these from the Hydrapulper. If a ragger is installed then baling wires need not be removed before throwing bales into the hydrapulper, though, the wires must be cut.

In principle, a ragger consists of a fluted drum and roll. Several strands of barbed wire are cut to a length of about 3m and are attached to one end of a short piece of approximately 7 cm diameter rope. This rope is inserted between the fluted drum and the pinch roll of the ragger and the free end of the wire is dropped into the tub when the hydrapulper is running. The wire will be pulled towards the centre of

the tub by swirling action of the water, causing the stingy materials to twist round the wire tail of the rope which will begin to increase in diameter as the rejects accumulate. As the diameter of the rope increases, controlled rotation of the drum pulls it out of the hydrapulper so that wire diameter does not exceed about 15 cm.

4.3.4 Deflaker

In modern stock preparation plants using dry raw materials (like waste paper) it is uneconomical to reduce the flake content to below 30% in a pulper. The range of 0% to 70% defibred is called the slushing range where the raw material sheet is wetted and the weakest intrafibre bonds broken. In this range pulpers are found to be quite efficient. On the other hand, deflakers maintain a relatively high efficiency of defibring up to a point where the stock is nearly 100% defibred.



Working elements of all deflakers, shown in fig. 4.7, are designed to be non-contacting and the work done on fibre is through hydraulic shear. Most deflakers consist of parallel plates called rotor and stator. The suspension, which enters the deflaker centrally, is split into streams

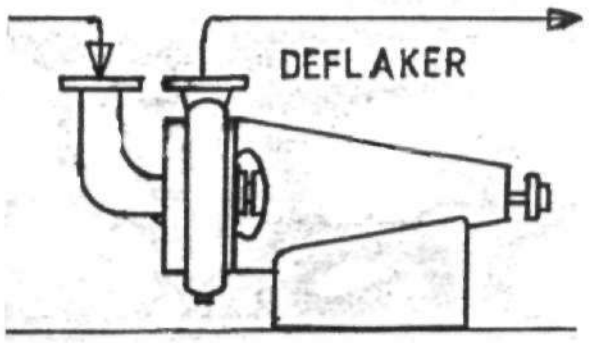


Fig. 4.7. Deflaker.

by slits in both the rotor and stator. The stock is therefore accelerated and decelerated repeatedly as it passes through the machine. The resulting mechanical impact loosens and releases the bonds between individual fibres. Additionally, the narrow gap between rotor and stator produces hydrodynamic shear forces leading to high velocity gradients which also play an essential part in the deflaking process.

There are several possible positions where a deflaking unit can be located in a secondary fibre processing system but it is never placed ahead of the rough cleaning stage. Reason for this is that deflakers are extremely fragile and if tramp metal enters, the unit becomes self destructive.

4.3.5 Conical Refiner

The quality of end product, paper or board, is increased decisively by refining of the stock. Refining can be defined as the mechanical treatment of pulp carried out in the presence of water by passing the suspension of pulp fibres through a narrow gap between a revolving rotor and stationary stator. This operation also reduces ink particles (from waste paper) to below visibility level.

Refining and Deflaking appear to be very similar but they are completely separate and distinct operations designed to achieve different results. Refining affects hydration and freeness of stock whereas a deflaker reduces the flake content and acts as a secondary pulper.

Conical refiner, shown in fig. 4.8, consists of a tapered shell and a similarly tapered rotating plug. The shaft on which the rotor is fixed protrudes from both ends of the refiner. At the smaller end the shaft is connected (through a coupling) to the driving motor and on the larger end it is connected to a mechanism which controls the axial movement of the rotor. This movement changes the distance between the rotor and stator (shell), thereby changing the refining action on the stock.

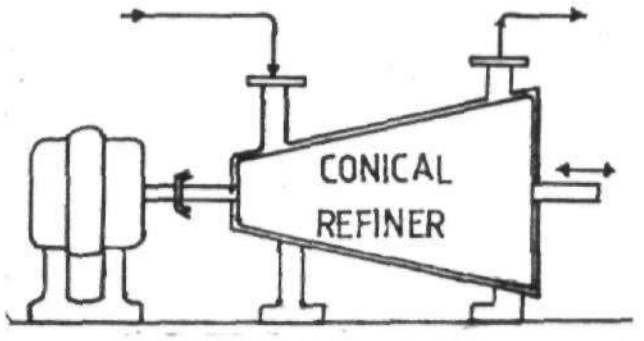


Fig. 4.8. Conical Refiner.

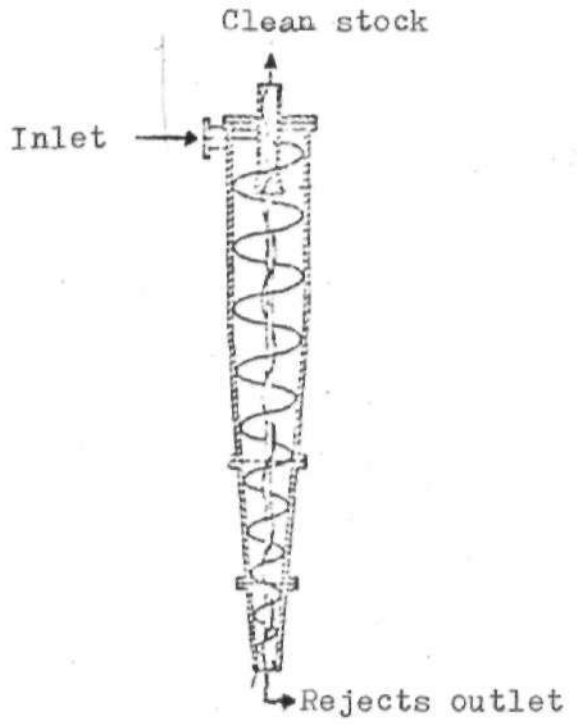


Fig. 4.9. Centrifugal Cleaner.

4.3.6 Centrifugal Cleaners

Centrifugal cleaners serve the purpose of continuously separating heavy contraries (e.g. dust particles) at stock consistencies below 2%. They consist of a hollow cone section joined at the top by a cylinderical head with inlet and outlet connections. Reject outlet is situated at the bottom of the cone. Some cleaners have another (light) rejects outlet at the top of the cylinderical head.

Pulp suspension enters tangentially (near the top) under pressure which keeps it moving downward along the wall of the upper cylinder (fig. 4.9). As long as it has a free path, the axial region remains relatively undisturbed. This results in the formation of two distinct concentric regions within the cylinder; one adjacent to the wall in which the suspension moves downward and the other as a central core in which the fibre suspension moves helically upward discharging at the top.

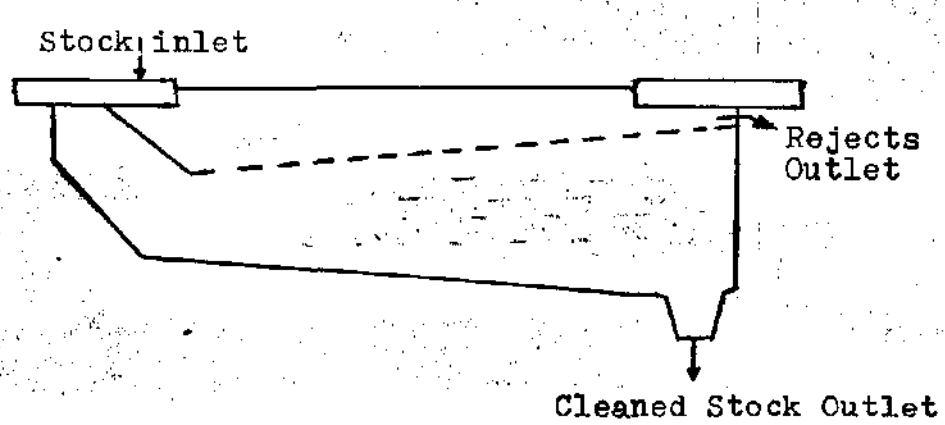
Increasing velocities and centrifugal forces occur as the suspension moves downward to smaller and smaller radii. Heavy dirt such as sand may be thrown immediately to the wall of the cleaner and together with some fibre is discharged continuously at the bottom of the cone. Only cleaned stock travels upward along the axis of the cleaner. Since a little good fibre is always rejected with the dirt several stages of cleaning are necessary.

Most installations have primary and secondary stage cleaning system. To further reduce the fibre-loss, a tertiary stage may be added; reducing the fibre-loss to between 0.5 and 0.75% of production. Accepts from primary stage are accepted as "clean" whereas accepts from secondary and tertiary stages are recycled to primary stage.

4.3.7 Jonsson Screen

This is a high consistency screen capable of handling large volumes of stock. It consists of an open trough in which perforated screen plates form the base (fig. 4.10). The frame is resiliently suspended on channel mounts and is given highly effective vibratory action by an off-balance shaft. This shaft is driven through a v-belt so that a minimum of vibration is transmitted to the foundation.

Fig. 4.10 Jonsson Vibrating Screen



Stock flows into one end of the screen and is subjected to intense but precisely controlled vibration while travelling over the contoured screening area. During operation, about 80% of the screening surface is submerged. The good, clear fibres pass through the screen plate openings while the rejects are rapidly transported to the discharge end of the screen which is not submerged.

The screen is highly efficient and can handle up to 60 tons/day of pulp at 0.95% consistency with only one square meter plate of 6 mm perforations. Normal variation in volume or consistency of the feed have no appreciable effect on its efficiency, and power consumption is extraordinarily low.

4.3.8 Pumps

Heavy reliance of paper industry on centrifugal pumps has led to their tremendous development for consistencies of up to 6% (McDonald, 1983)

Centrifugal pumps deliver a constant capacity only when the total head (from stock level to the discharge point) is kept constant. Arrangements, therefore, have to be made to control chest levels within close limits. Maximum head developed by most pumps is in the range of 45 to 80 m depending upon the size of the pump and pump speed.

One of the greatest problems in pumping paper stock is air in the stock (McGill, 1980). Paper stock, especially when it is free, has a tendency to pick up air very readily. When this stock impinges against any surface or when it changes in velocity, the air has a tendency to escape and form bubbles, which collect at low pressure points in a pump and cause air binding. Manufacturers have designed machines to correct this condition and for deaerating pulp and paper stock.



CHAPTER FIVE

CASE STUDY - NPM EXPANSION PROJECT

5.1 INTRODUCTION

In order to fully understand the process of paper making and recycling, it was necessary that I spend some time at a paper mill since reading alone cannot give a thorough understanding of the complex nature of the whole process. Nigerian Paper Mill at Jebba was selected for this purpose. Some of the reasons for its selection were:

1. It is the oldest paper mill in Nigeria.
2. It is capable of using both secondary fiber and wood for making paper.
3. The mill was undergoing expansion, and
4. Mr. S. O. Ajayi of chipper house, Expansion project NPM, had promised to help in all aspects of my stay at the mill.

I spent close to three weeks in Jebba and a total of about 120 hours in the mill itself. Most of this time was spent in the following sections:

1. Paper Machine 1 (Running Mill).
2. Purchased Fiber Processing (Area 40).
3. Paper Machines 2 and 3 (Expansion Project).
4. Laboratory and
5. Library.

In the remaining pages of this chapter, a report is given of the waste paper recycling at NPM Jebba. The information on which this report is based was obtained from a variety of sources including hand-books, manuals, other related material and private interviews with Senior NPM Personnel.

The report starts with a historical note and goes on to describe the installed fibre processing systems and ends with a brief description of the sheet forming machines. All other processes, such as those related to wood yard, digesters, recovery boiler, etc., are not mentioned as the project is concerned with recycling alone.

5.2 HISTORICAL BACKGROUND

The mill was established in 1963. Construction was completed by 1965 but due to the disturbed conditions then prevailing in the Country production started only in 1969. Soon afterwards the production increased to full capacity of 40 tpd and within three years the company had recorded net profit.

In late seventies the mill was producing only about 10% of the country's requirements of industrial grade paper and it was decided to increase the production capacity to 200 tpd of pulp and paper. Work on Expansion Project started in 1979 but financial constraints caused cutbacks in the release of funds and allotment of import licenses. This in-turn slowed down the execution schedule of the project slated for 1984 (Anonymous, 1985 b).

The Expansion Unit was commissioned in April 1985 after a total of ₦225 million had been spent. Inspite of the fact that the unit has been commissioned, full scale production has not commenced. Problems such as lack of spare parts and unsteady supply of fresh water contribute to down-time. Machine utilisation was below 65% by the end of 1985.

5.3 PURCHASED FIBRE PROCESSING

Purchased fibre processing section, otherwise known as "Area 40", is part of the Expansion Unit at NPM Jebba. This area is designed to process purchased soft-wood pulp and waste paper and deliver the pulp in a suspension form to the blend chest in stock preparation areas of paper machines.

Area 40 contains three hydra-pulpers, two of which are designed to handle waste paper. Each of these is equipped with a ragger and a junker. Apart from the pulpers, the area contains a turbo-separator, a centrifugal cleaner system, pressure screens, vibrating screens, a thickener, deflakers, refiners and storage tanks. A complete dispersion system has also been installed to disperse dirt and ink particles in waste paper pulp.

5.3.1 Imported Pulp System

Purchased pulp in bales is reclaimed from the storage area by fork-lift trucks and delivered to conveyor No. 1. This conveyor feeds pulper No. 1, the one that is not equipped with a ragger and junker.

The pulp is made down in the pulper and pumped to the pulper dump tank. From this tank it is pumped to the disc refiners and finally to the blend chests in the stock preparation areas of paper machines. Here it is mixed with chemicals and other types of pulps and pumped to paper machines.

5.3.2 Waste Paper System

Baled and unbaled waste paper is delivered to the factory by trailer trucks from as far away as Lagos and Ibadan. It is unloaded and stored in waste paper shed adjacent to Area 40. Before storage, it is divided into two categories: Selected waste and mixed waste. Selected waste is

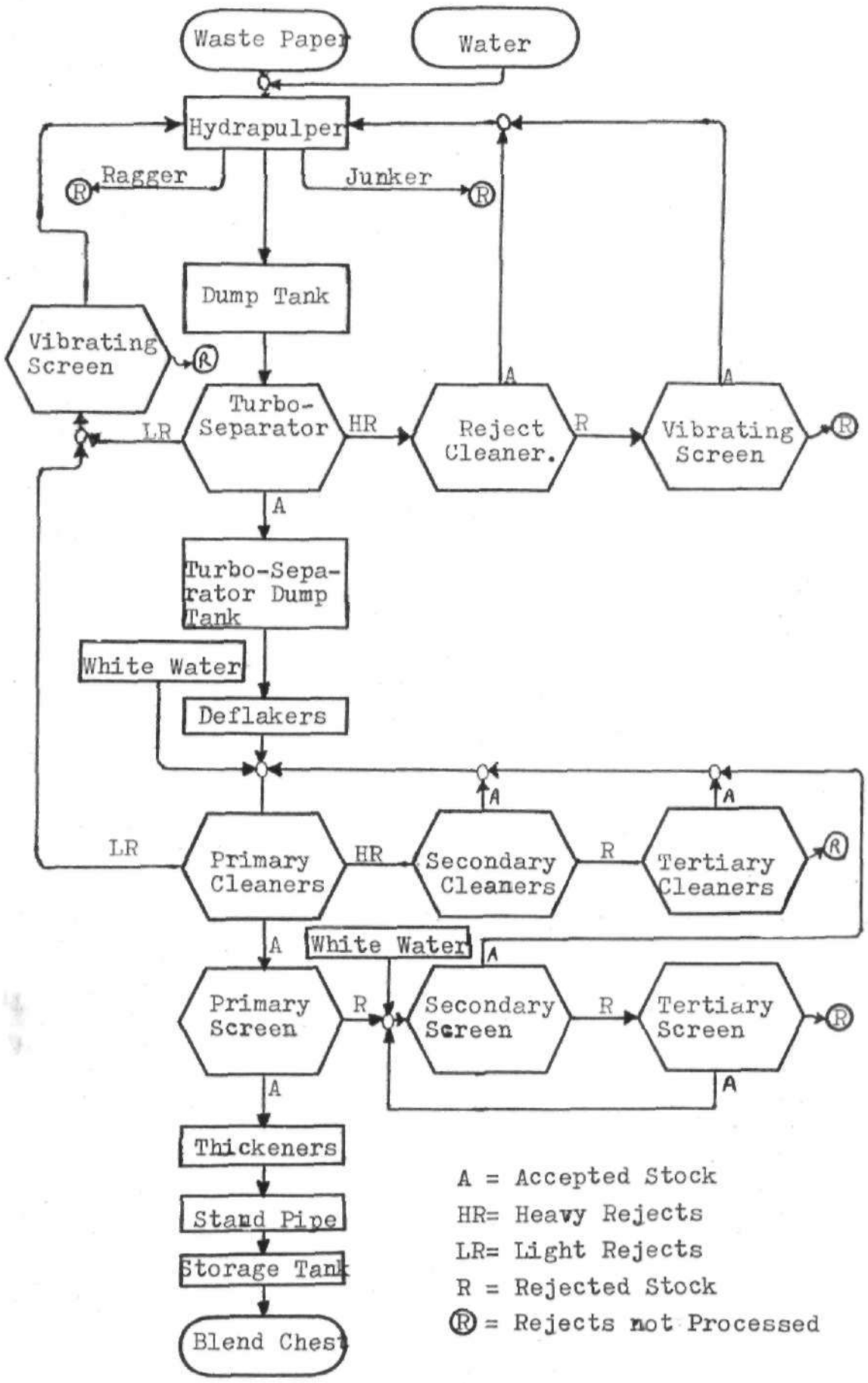


Fig. 5.1 Waste Paper Stock Preparation at NPM Jebba.

a term used at NPM to refer to sorted multi-ply and corrugated container board. When required, the waste paper is reclaimed from the storage and placed on one of the two conveyor belts feeding the two waste paper pulpers. From the conveyor, it falls directly into the pulper which is designed to handle waste paper continuously.

In the case of selected waste the slurry is then pumped through a deflaker to selected waste storage tank and then to the paper machine blend chest. The process for mixed waste is quite complex, hence it is described in the form of a flow sheet, fig. 5.1. A simplified diagram of the overall process is shown in fig. 5.2.

5.3.3 Final Stock Preparation

Final stock preparation is done in the paper machine room. Pipes from Area 40 and pulp mill convey different types of pulps for the blend chest. The blend chest receives refined hard-wood kraft, soft-wood kraft, semi-chemical, waste paper pulps and broke in different quantities as required for various grades to be produced. These furnish components are blended and pumped through a tickler refiner to the machine chest and then through the regulating box and the fan pump to the double dilution cleaning and screening system. Accepts from cleaning system go direct to the head boxes on paper machines.

5.4 SHEET FORMING MACHINES

The mill has three paper machines. First machine was installed when the mill started in 1963 while the other two were installed recently during the expansion of the "running mill".

5.4.1 Paper Machine No. 1

This is a multi-ply paper machine capable of producing paper and board in up to 4 plies. The machine consists of 3 mould formers, a shaking

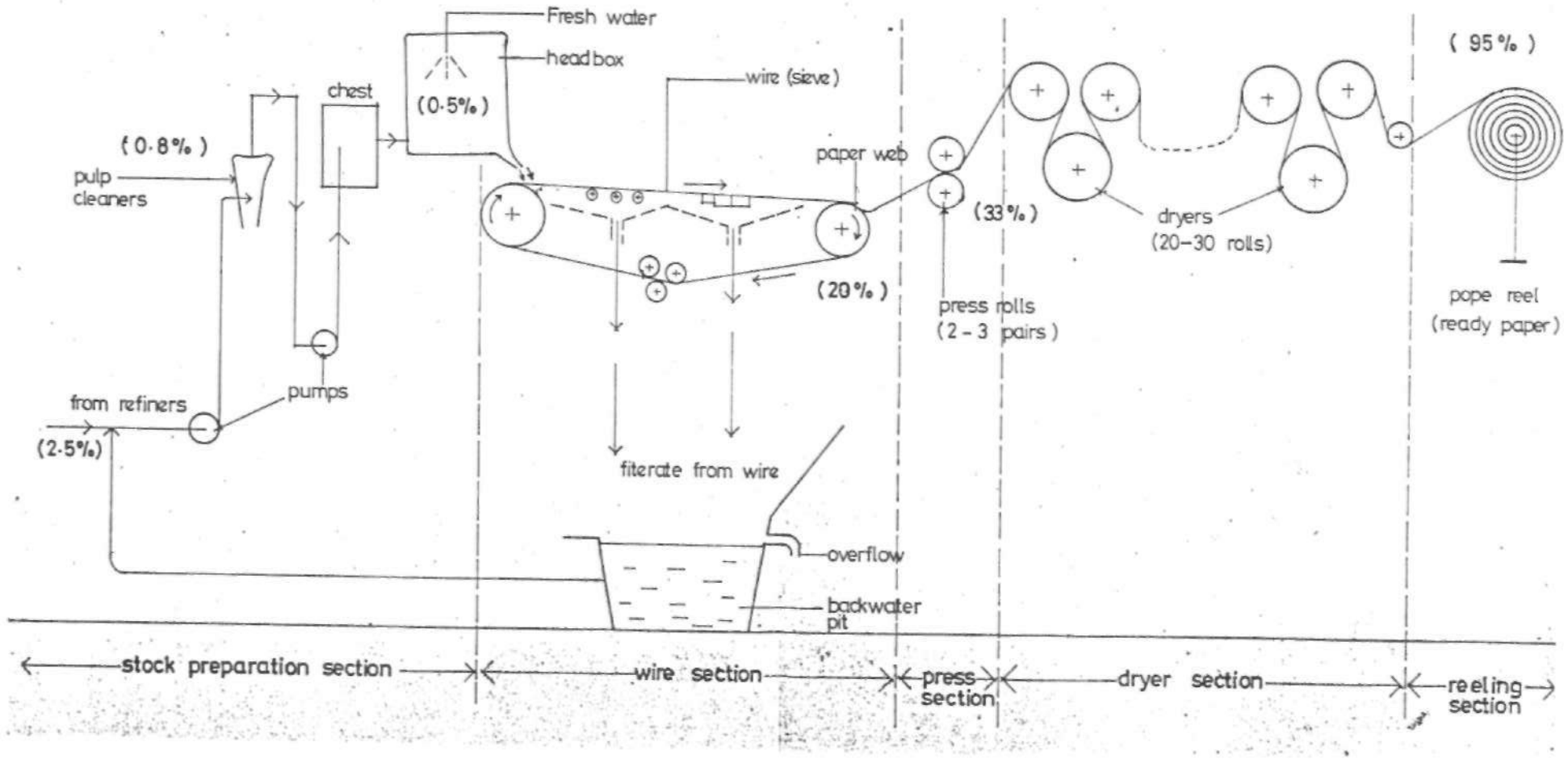


Fig. 5.2 Simplified paper making process at NPM

type fourdrinier, a press section and two sets of driers. It is designed for production of writing and industrial grade papers in the range of 40 to 440 gsm.

5.4.2 Paper Machine No. 2

This is a two-ply paper machine designed primarily for producing unbleached liner-board and corrugating medium according to following specifications.

	liner-board	corrugating medium
grammage	125-250 gsm	110-140 gsm
capacity	105 t/d	94 t/d
speed	106 m/min	120 m/min
Nig. Hard-wood pulp	60%	80%
Imported kraft pulp	30%	10%
Waste paper pulp	10%	10%

Major machine components include a primary headbox, a shaking type fourdrinier, a secondary headbox, a press section, 3 drier sections, a size press, calender, reel and winder.

5.4.3 Paper Machine No. 3

This machine is designed for unbleached kraft paper and sack kraft. A blanket type extensible unit (Clupak extension unit) is provided between the two drier sections to improve the physical properties of sack kraft. Production specification is as follows:

	Kraft	Sack kraft
grammage	50-120 gsm	50-110 gsm
capacity	96 t/d	94 t/d
speed	222 m/min	217 m/min
Nig. Hard-wood pulp	50%	50%
Imported kraft pulp	40%	40%
Waste paper pulp	10%	10%

Major machine components include a pressure headbox, a shaking type fourdrinier, a press section, two drier sections, clupak unit, calender reel and winder.

Auxiliary equipment for each machine includes vacuum pumps, oil lubrication systems, cascade type drier drainage systems, and cranes.



CHAPTER SIX

EFFECT OF RECYCLING ON PAPER

6.1 INTRODUCTION

It is necessary that before a potential source of paper-making fibres is recommended for use, we must be absolutely certain that its product will be suitable for use and acceptable, if not attractive, in appearance.

A series of tests were carried out to determine the effect of recycling on the quality of paper. Pulp samples, hand sheets and machine-made papers were tested for certain important properties. Results of these tests and their procedures are given in this chapter.

Since this is a Production Engineering Project, no attempt is made to determine the chemical properties or to explain the results using theories of paper chemistry. [More inquisitive reader should refer to Clark (1978) for an excellent treatise on chemical and microscopic analysis of pulp and paper]. With the exception of drainage test, all tests conducted were done so to find only the physical properties of the sheet.

6.2 PULP EVALUATION

All potential sources of paper-making fibre must have satisfactory water retention capacity to be considered for paper making.

One of the most common tests, the Freeness Test, indicates the ease with which water drains away from the papermaking fibres while they are being made into a wet mat on the wire-mesh of the

tester. Apart from other effects, freeness of a pulp has direct bearing on several important sheet properties.

6.2.1 Freeness Test

Schopper-Riegler (SR) Wetness Tester, the equipment used for freeness test, consists of a container of one litre capacity from which the drainage takes place. The sheet is formed on a wire-mesh at the bottom of the container (fig. 6.1). The water draining from the sheet, as it is formed, is collected in a funnel shaped receiver. This receiver has a standard orrifice at the bottom and an overflow in the side which creates a standard head over the standard orrifice. Some of the water draining from the sheet, the "slow-running water", passes through the orrifice at a fixed rate of flow. Water draining at a higher rate flows out of the side outlet and is collected in a cylinder graduated in deciliters with zero at the top. The reading obtained is known as the °SR wetness. A High °SR value indicates slow drainage and values of 70°SR to 80°SR are obtained from well beaten pulps (Casey, 1980a).

6.2.2 Test Procedure and Results

Twenty gram of waste paper was placed with two litres of water in the disintegrator and disintegrated for 10 minutes. After this the suspension was poured into a distributor and diluted to 10 litres with water (giving a concentration of 2g/l). After a few minutes, 1 litre of suspension was drawn off and wetness ("freeness") of stock measured. Three readings for wetness were taken to get accurate results. The test was repeated for different qualities of waste paper and for beating times of 5, 10, 15 and 20 minutes. The results obtained are listed in table 6.1. For the sake of comparison the 5 minute values are listed again in table 6.2

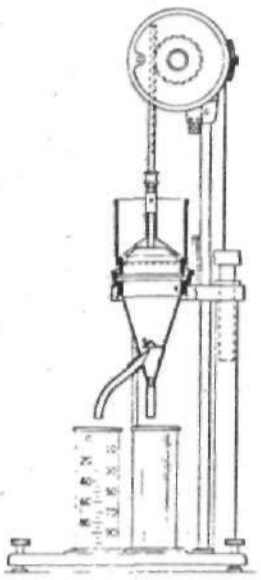


Fig. 6.1. Schopper-Reigler freeness tester.

along with data about other types of pulps from volume I of "PULP AND PAPER" by James Casey.

It is clear from table 6.2 that freeness values of unrefined wastepaper pulp compare very favourably with other pulps of wood and non-wood origins. In table 6.1 it is seen that initially the wetness of wastepaper pulps increases as disintegration progresses but disintegration of more than 15 minutes hardly makes any change in freeness. Infact samples of woodfree writing papers were disintegrated for 85 minutes after which their freeness was found to be between 26° and 28°SR. The reason for this becomes clear when one considers the fact that it is practically impossible to duplicate the real beating and refining conditions in a laboratory, least of all in a disintegrator.

Table 6.1 Freeness of wastepaper pulps.

Type of wastepaper	Time of treatment min	Wetness °SR
Woodfree writing	5	20
	10	23
	15	25
	20	26
Newsprint	5	18
	10	21
	15	25
	20	29
Tabulating cards	5	22
	10	27
	15	33
	20	35

Table 6.2. Freeness of unrefined wood and non-wood pulps.

PULP TYPE	°SR	PULP TYPE	°SR
Bagasse	20	Woodfree writing paper	20
Bamboo	15	Newsprint	18
Esparto	16	Tabulating cards	22
Reeds	18		
Rice straw	41	Hard-woods	15
Wheat straw	30	Soft-woods	12

6.3 TESTS FOR PAPER

In addition to the tests on pulp samples, tests are always made on hand sheets and samples of paper taken from the paper making machine at the reel end. Types of tests and their frequency varies from mill to mill. Standard procedures have been established and these are gaining world-wide acceptance rapidly. Some of the common physical tests and their standard procedures are described below.

1. BASIS WEIGHT (GSM)

   Unit: gramme per square meter (g/m^2). It is the weight of one sheet of paper of one square meter area.

   A sheet of paper is FOLDED ONCE and cut around a template size of (say) 20 cmx25cm to give a sheet of total area

   $$2x0.20x0.25 = 0.1\ m^2$$

   This is weighed and the reading multiplied by ten to obtain the GSM value. Sometimes a special balance is used in which

the scale is adjusted to indicate the actual GSM for different template sizes.

2. TENSILE STRENGTH

a. BREAKING WEIGHT (B.WT)

Unit: kilogram (kgf)

It is the weight required to break a strip of paper 15 mm wide.

A strip of paper 15 mm wide is clamped in the two jaws of a special tensile test machine. The machine is switched to automatic loading and the lower jaw starts moving down-wards. The machine stops as soon as the paper breaks and breaking weight is recorded from the dial of the machine. Another dial gives the percentage stretch.

b. STRETCH (e)

Unit: dimensionless

It is the percentage elongation of a strip of paper up to the point of breaking under tension.

Its value is recorded directly from the tensile test machine after test no. 2a.

c. BREAKING LENGTH (B.L.)

Unit: metre

It is the length of a paper of uniform width which will break the same quality of paper by its own weight.

It is calculated using the following formula

$$B.L. = \frac{B.WT. \times 10^6}{15 \times GSM}$$

3. BURST

a. BURST STRENGTH (B.ST.)

Unit: kilogram per square centimetre (kg/cm^2)

This is a measure of the force required to burst a hole through a single sheet of paper.

Paper is inserted into the B.ST. testing machine and hydraulic pressure applied to the paper through a circular rubber diaphragm until the paper bursts. B.ST. is recorded directly from the pressure gauge on the machine.

b. BURST FACTOR (B.F.)

Unit: Dimensionless

Burst strength is corrected for variation in basis weight and given as burst factor.

$$\text{Burst Factor} = \frac{\text{B.St.}}{\text{GSM}} \times 1000$$

The 1000 factor converts the ratio to a convenient figure, usually between 1 and 100.

4. TEAR

a. TEAR STRENGTH (T.St)

Unit: gram (g)

It is the average force required to tear a piece of paper after the tear has been started.

Scale reading of the dial fitted in the instrument are made 1/16th of the actual values; tear is calculated by multiplying the reading by 16 and dividing by the no. of sheets torn at one time

$$\text{Tear Strength} = \frac{\text{Dial Reading x 16.}}{\text{No. of sheets torn}}$$

b. TEAR FACTOR (TF)

Unit: square decimeter (dm^2)

It is the area of a sheet of paper, the weight of which, if applied to a single sheet of the same quality would cause a tear to progress.

$$\text{Tear Factor} = \frac{\text{T.St.}}{\text{GSM}} \times 100$$

5. FOLDING ENDURANCE

Unit: No. of double folds.

It is the repeated folding of a paper until it breaks. The requisite no of double folds (backward and forward) gives an indication of the folding capacity. No of double folds is directly recorded from the counter fitted on the machine.

6. CALIPER

Unit: micrometer (μm)

This is the thickness of a single sheet of paper when placed under a steady pressure of 55 ± 7 kNm^{-2} between 2 circular and parallel plane surfaces.

7. BULK

Unit: Cubic centimetre per gram (cm^3/g)

Bulk is a measure of the density of paper. It is also known as the specific volume. The formula used for its determination is as follows.

$$\text{Bulk} = \frac{\text{Caliper}}{\text{GSM}}$$

8. SIZING

Unit: gram per 100 square centimeter ($g/100cm^2$)

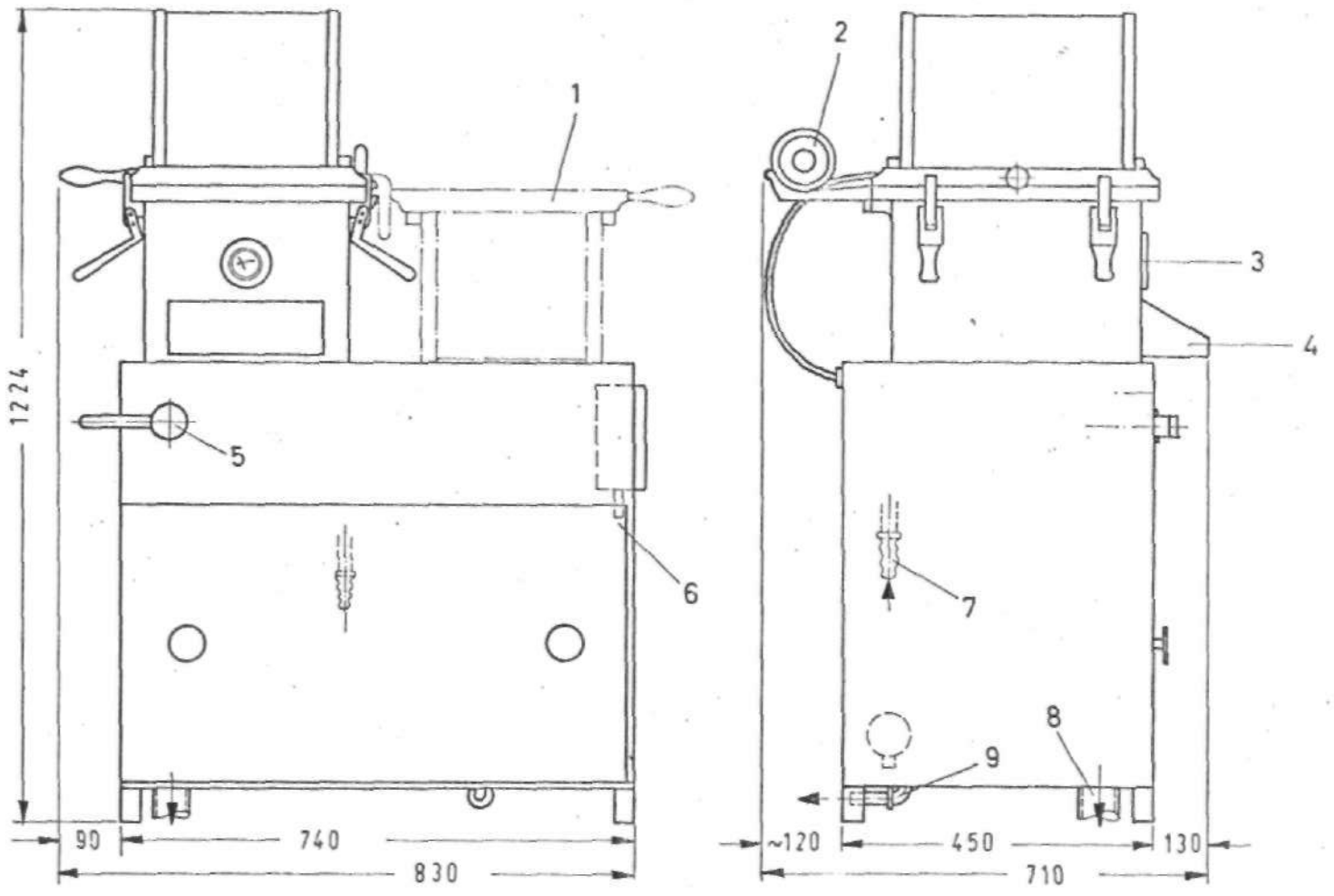
Sizing is a measure of the rate of water absorption of paper giving an indication of clearity and absorption of printing inks. In this test a circular metal ring (about 7.5 cm high) is placed on a weighed sample of paper and then a measured volume of water is added. After a definite period the water is poured off. The superficial water is removed by blotting the surface and sample is immediately weighed. The difference in weight is reported as the amount of water in grams absorbed by 100 sq.cm. of paper surface.

6.4 HAND-SHEET MAKING

6.4.1 Hand-Sheet Making at ABU Zaria

Strecker Sheet Former, shown in fig. 6.2, consists of a wire-mesh at the bottom of a transparent filling chamber. Pulp suspension is poured into this chamber and diluted with water entering from the sides of the filling chamber. It is then mixed and water allowed to drain rapidly. Electrical control is provided for all operations.

Pulp was prepared as described in section 6.2. Two liters of pulp was drawn from the distributor and poured into the filling chamber. Water was allowed to enter by switching the control to position 1 until the total volume was 10 liters. Switch was then turned to position 2 (Mix) and air bubbles were forced in to mix the suspension. After 30 seconds the switch was turned to



1 Upper part folded down
2 Couch roll
3 Vacuum indicator
4 Centre control
5 Ball valve for fast sucking
6 Electrical connection
7 Water connection
8 Outlet fast sucking
9 Backwater outlet

Fig. 6.2 Strecker sheet former

Position 3 (suck) until all the water was drained out. Sucking was continued for another 15 seconds after which the control switch was turned to position 4 (off).

Clamps were released and transparent filling chamber removed to make the wet paper sheet accessible for removal. A plastic sheet was placed over it and pressed with a rubber roller (pressure at the edges allows the wet paper sheet to stick to the plastic) so that it can be removed without damage. The paper and plastic were removed and the paper dried on a felt sheet. Drying was continued in an oven at 70°C until constant weight was obtained.

Results: Hand sheets made were of area 20 x 20 cm^2 and weighed about 4 g after drying (ie about 100 gsm). At this juncture it was decided not to carry out any of the proposed tests since the handsheets obtained were of very uneven thickness. Variation in caliper also affected other properties such as tear strength, burst strength, stiffness and opacity. Following factors are believed to have contributed to the poor quality of hand sheets.

1. Sheet Former did not perform up to expectation due to old age and lack of adequate maintenance.
   a. Wire screen had deformed and replacement was not available.
   b. Mixing was very slow because the air pump had developed a leak. This problem was overcome when an external source of compressed air was used.
   c. Water drainage (suction) was almost nil due to leakage in vacuum pump. A lot of time was wasted in trying to rectify this fault but lack of spares hindered progress.

2. Stock preparation included only disintegration and distribution. No. refining or beating was carried out.

3. No chemicals were added. Sheet formation improves considerably by the use of fillers and other additives.

6.4.2 Hand-Sheet Making at NPM Jebba

Since the sheets made at ABU Zaria were not formed properly due, mainly, to equipment limitation, it was decided to use the facilities available at Nigerian Paper Mill Ltd., Jebba.

Sheet forming and fibre treatment equipment in the laboratory at NPM was old but well maintained. Fibre preparation procedure was similar to the one of ABU except that instead of disintegrator a beater was used. Paper sheets were made on a circular sheet former of manual design and dried in an oven; all according to standard procedures.

About 120 hand sheets of various basis weights were made from recycled fibre, NPM kraft and imported kraft pulps. After conditioning the sheets in the laboratory following tests were performed:

- Basis weight
- Caliper
- Tensile strength
- Tear strength

It will be recalled here that the paper made on sheet former is anisotropic, that is, free from directional effects, whereas the one made on paper machine has distinct properties in machine and cross-directions. Hand-sheets, therefore, do not give the same results as those given by the same pulp on paper machine. Also, sheets made from same pulp would show very different properties if formed under different conditions even if the same paper machine is employed. Hence, the results of hand sheet tests, shown in figures 6.3 to 6.6, should only be used for comparison of properties between different pulp samples. They do not have any direct relationship with the properties expected from machine-made papers of the same pulp samples.

Results: Figure 6.3 shows that the tear strength of recycled fibre approaches the imported pulp very closely and values for these two pulp types are higher than the NPM kraft pulp. Tear factor, which is a function of tear strength and the basis weight, also gives similar results (fig. 6.4). The breaking weight values for the three pulp types are shown against respective basis weights in fig. 6.5. The scattergram shows that the points representing waste paper pulp lie almost half-way between the corresponding points of the imported and the NPM kraft pulps. Similar results are observed in the case of breaking length against the basis weights. This also shows that the strength properties of recycled fibre are much better than the locally produced harwood (NPM) kraft. Paper technologists at the Nigerian Paper Mill, Jebba agree that improved pulping process can considerably improve the strength and other properties of recycled fibre

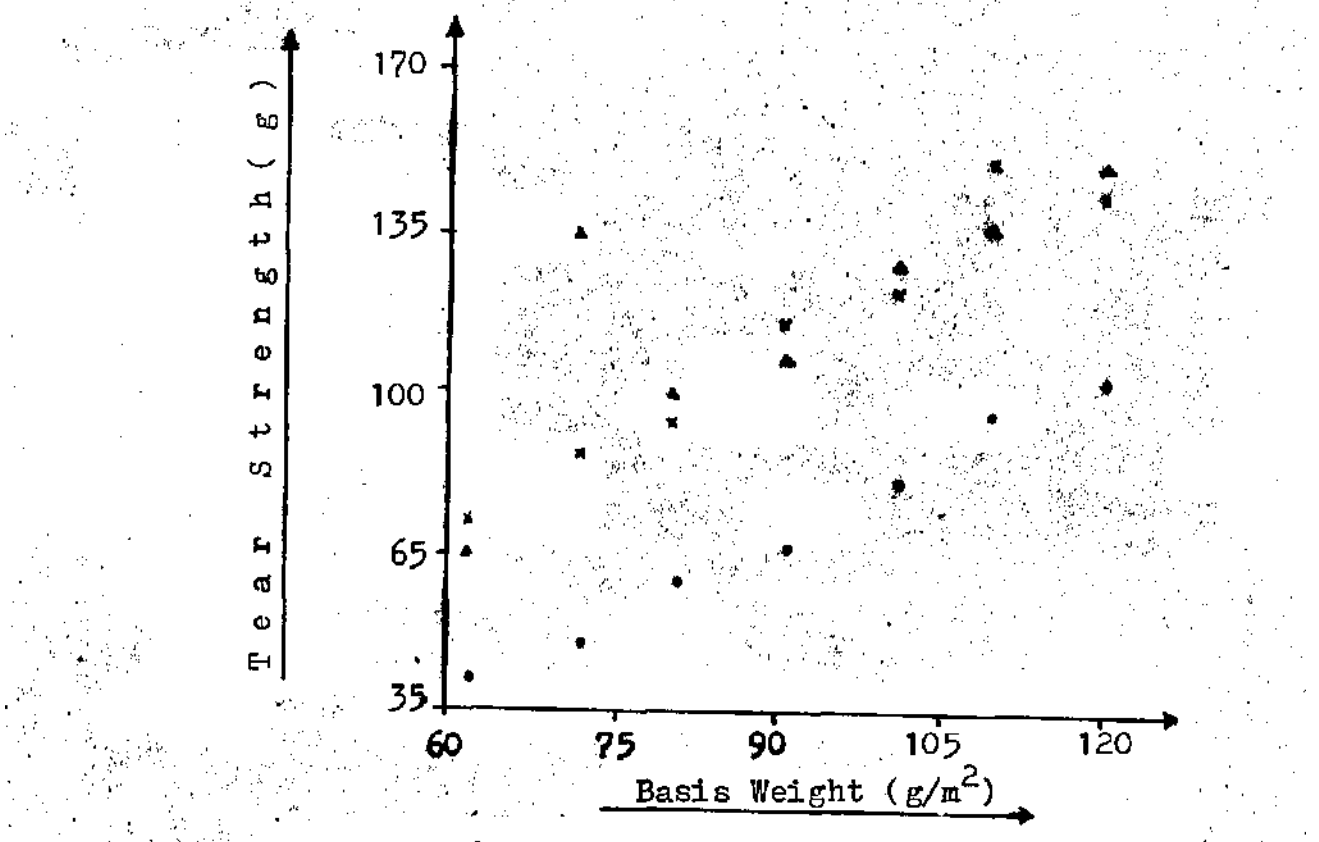


Fig. 6.3 Tear Strength vs. Basis Weight.

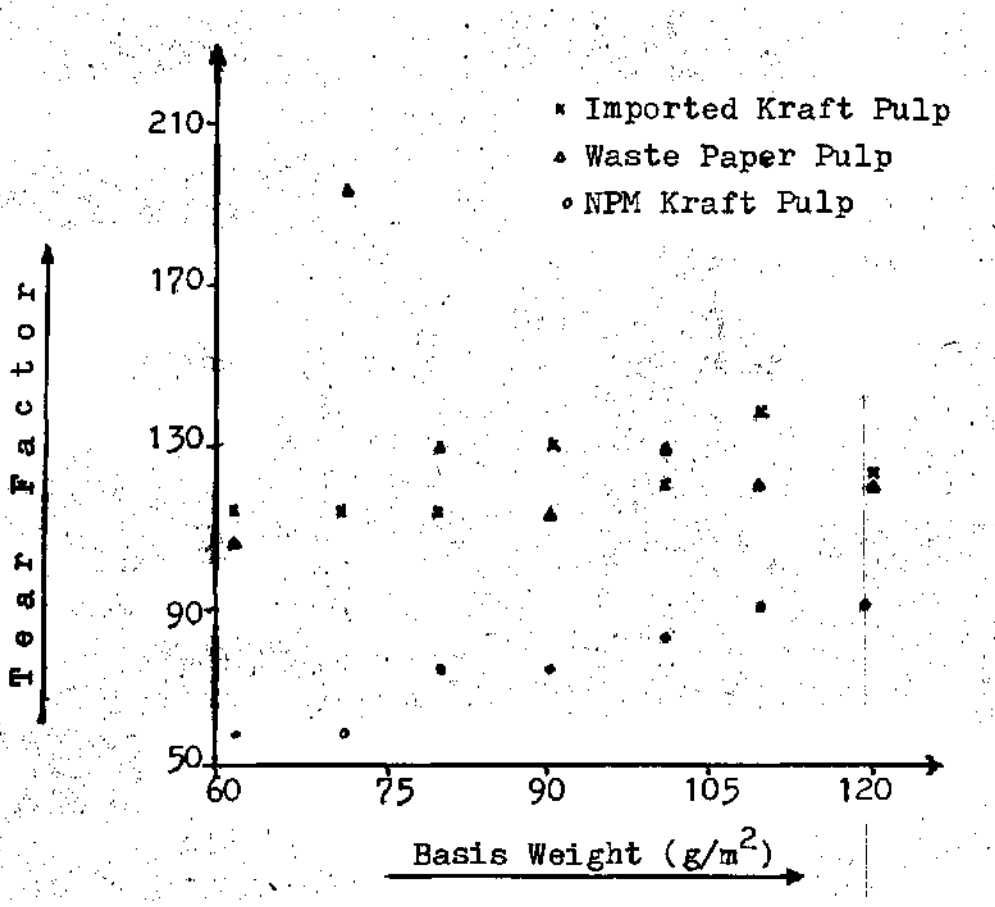


Fig. 6.4 Tear Factor vs. Basis Weight.

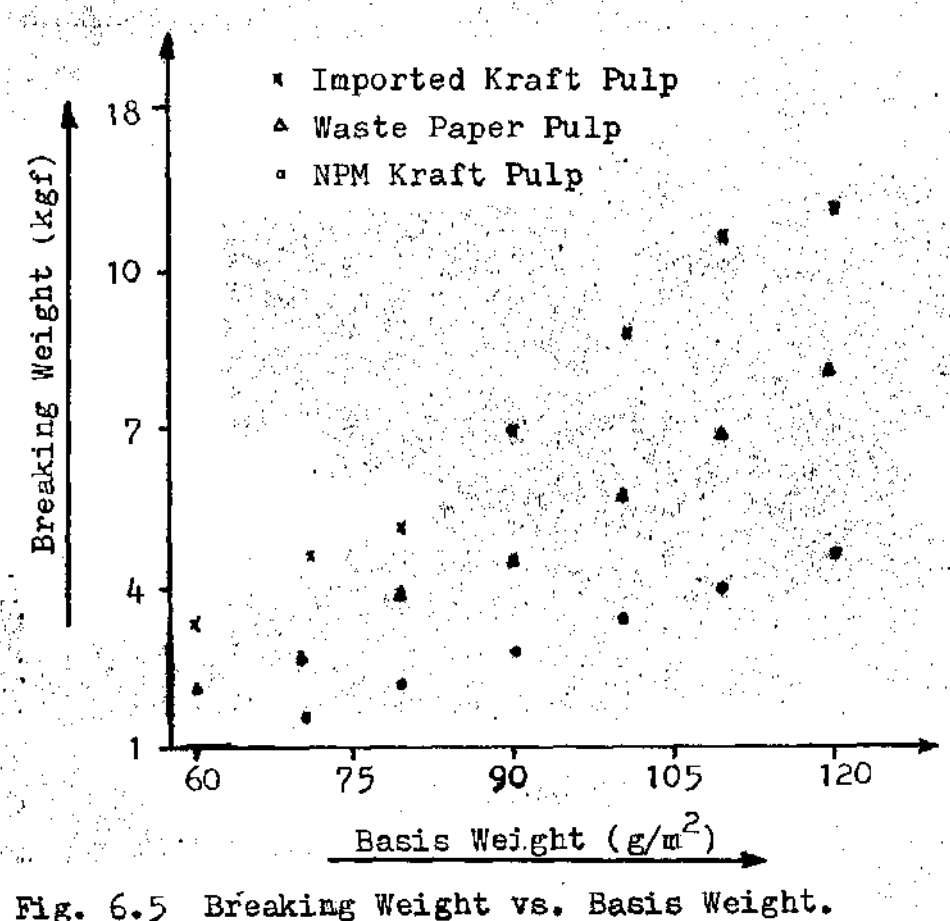


Fig. 6.5 Breaking Weight vs. Basis Weight.

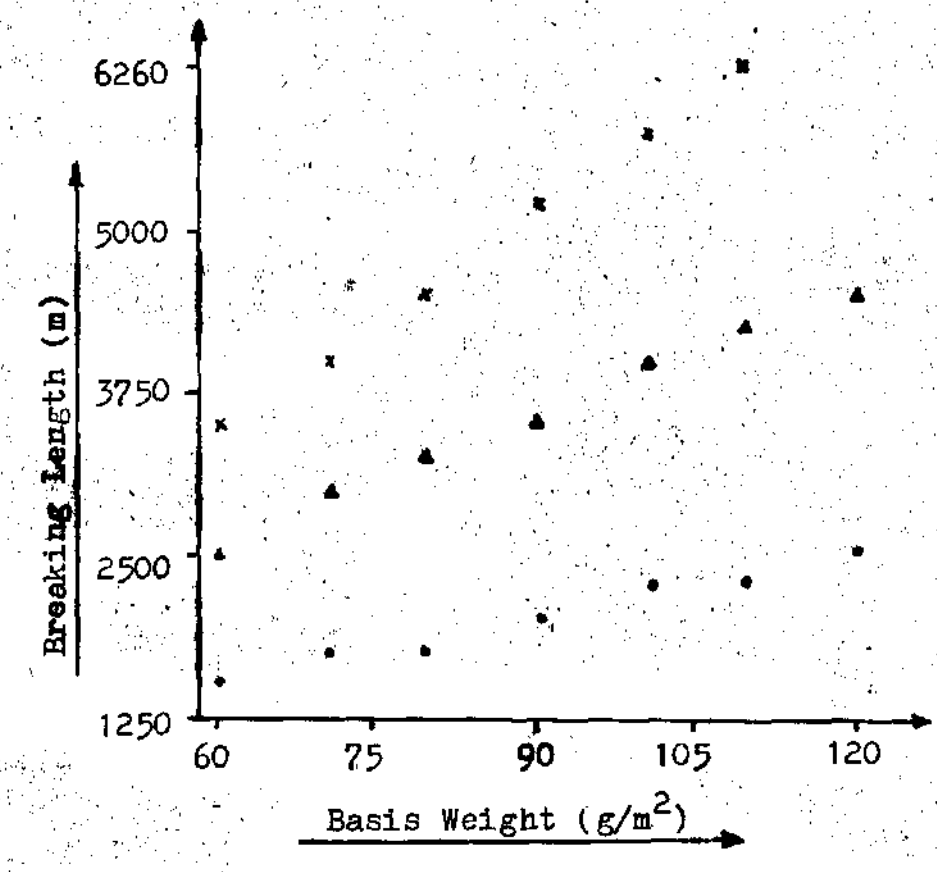


Fig. 6.6 Breaking Length vs. Basis Weight.

It should not be forgotten here that the waste paper fibres and imported pulp fibres had both been dried and repulped once, therefore, similar strengths. Local hard-wood fibres are very short compared to the imported soft-wood fibres, leading to low strength values for NPM kraft.

It is found that as long as the waste paper for recycling does not contain too much hardwood fibres, good quality paper can he produced by recycling.

6.5 EFFECT OF SUCCESSIVE RECYCLING

When pondering over the problems associated with longterm recycling, two questions readily come to mind. First: how long will it take for all the fibres in a sheet of paper to undergo recycling more than once? The second: what will be the effect of repeated recycling of some fibres?

Dealing with the latter question first, we refer to data (given in table 6.3) obtained at the Institute of Paper Chemistry (McKee, 1971). To get these results, virgin, unbleached, dried, kraft pulp was beaten in a valley beater until its freeness was 600 ml CSF. After making standard TAPPI (Technical Association of Pulp and Paper Industry) test sheets the remaining pulp was made into sheets on a mould, dried on a steam heated drier, repulped for the next batch and again made into sheets. This was done for six successive cycles. According to this data the bulk and tear factor went up significantly, tensile stretch and porosity went down and fibre-length did not change.

Property	Original Test	No. of Repulpings						Difference (last-first)	% Difference
		1	2	3	4	5	6		
Bulk (cm^3/g)	1.71	1.80	1.81	1.90	1.95	1.88	1.97	+0.26	+13
Breaking Length (km)	7.3	6.9	5.7	5.7	5.6	5.3	5.2	-2.1	-38
Stretch (%)	3.2	3.0	2.9	2.6	2.4	2.5	2.6	-0.6	-19
Tear Factor (dm^2)	130	140	150	155	150	160	160	+30	+23

Table 6.3 Effect of number of paper-making cycles on sheet properties

Another researcher, Horn (1975), conducting similar tests obtained similar results but found that strength properties improved after the pulp, recycled for the fourth time, was soaked in cold 0.5% caustic soda for one hour. This shows that some undesirable effects of recycling are reversible while others are not altogether discouraging.

Now coming to the first question (of time), the answer is: Over 70% of the fibre in a paper will never undergo recycling more than once. The reason for this is that even if the market for recycling plant is the same as the source of its raw material it is not easy to obtain more than 20 to 30% of the paper consumed for recycling. If this amount of paper is supplied to the market after recycling, the remaining demand of 70 to 80% must be met through the use of paper made from virgin fibre. The recycled paper, after completing several cycles will contain, on the average, the following percentages which would have gone through the corresponding number of cycles.

P.T.O.

Table 6.4 Constitution of recycled paper with respect to re-use cycles of fibre.

Fibre recovery	No. of times used	Percent of total fibre	
20%	once	80	
"	twice	16	
"	thrice	3.2	4
"	four times	0.64	
"	five times	0.128	
"	six times	0.320	
30%	once	70	
"	twice	21	
"	thrice	6.3	9
"	four times	1.89	
"	five times	0.567	
"	six times	0.243	

From table 6.4 above it is seen that only 4 to 9 percent fibre would have been recycled more than twice. This small proportion will not have any significant effect on sheet properties. Hence long-term recycling is as feasible as short-term.



CHAPTER SEVEN

MARKET AND PLANT CAPACITY

7.1 INTRODUCTION

The size of an industrial plant can have very far reaching effects on the economy and standard of living in an area. It also has a direct bearing on the per-unit cost of production. Generally the larger the capacity the lower the unit cost; but this rule can not be applied if other constraints are not considered. Before deciding on the size of an industrial plant the following factors should be looked at:

- availability of raw materials,
- capacity of the market to absorb all the production,
- availability of technology and
- availability of manpower.

This chapter examines the limits imposed on the size of a paper recycling plant in Kano by the first three constraints. In these times of high unemployment, along with the personnel trained by the existing paper mills, recruitment of qualified technical and non-technical manpower will not be a problem.

7.2 DEMAND ANALYSIS

In order to arrive at a reliable estimate of the size and characteristic of the demand for recycled paper, a survey of paper-users was carried out in Kano, Zaria, Kaduna and Jos. Since wholly recycled grades of paper are non-existent in the market, I had to rely on information about papers containing some percentage of recycled paper.

Paper converters, manufacturers of packaging materials and retail stationary shop owners were contacted with specially prepared questionaires. Apart from the data obtained in response to these questionaires, a number of persons directly involved in the manufacture, conversion and sale of paper were interviewed.

Briefly the research method can be summarised as a combination of:

- questionaires,
- personal interviews,
- on-site observation and assessment,
- government publications and
- the drawing of inference from all these sources.

In all, a total of 11 paper converters, 18 other commercial users and 26 retail book sellers were contacted. Posting of questionaires by mail was found to be almost useless for lack of response but the personal interviews were highly beneficial (with few exceptions). Major users of paper, like the paper converters, were generally reluctant to divulge information on operational aspects. And retailers who could have provided very useful information on consumer tastes and habits were, at times, almost hostile. Most retailers demanded financial compensation before giving out any information about sales. I also found that many small-scale retailers do not keep record of any transaction, whether sale or purchase.

During the survey it was observed that most retailers obtain their supply of paper directly from paper converters from all over the country. Retailers' choice of converter was not based entirely on economic considerations and often had some tribal inclination. In spite of this, all the

converters had excess demand from customers of their own locality. Their biggest problem was insufficient supply of raw material (paper reels). One paper converter in Kano claimed that his plant was running at less than 45% of installed capacity because of lack of paper.

Since the paper consumed by Kano and other towns is purchased from converters located in different parts of the country it was not possible to determine the requirements of any of the towns with precision. Seven of the more than fifteen paper converters who responded to my questionaires use about 24 000 tons of paper annually. Most converters rely on imports for a large percentage of their raw material while others use locally produced Kraft and fluting in large quantities. Table 7.1 lists the types and amounts of paper consumed by some of the paper converters. This table is by no means complete and it is estimated that Kano State alone consumes about 20 000 tons of paper and board annually. This figure indicates only the magnitude of consumption without giving any indication of the demand. Estimates about demand are much higher but they depend on size and structure of packaging industry, reading and sanitation habits, and the price and quality of paper and its products.

P.T.O.

Table 7.1: Annual paper consumption of some paper converters in and near Kano.

S/No.	Paper consumption (tons/year)	Types of papers consumed	Products
1	5 000	White wood-free ≃ 90% Printing papers ≃ 5% Brown papers	Stationary and envelopes
2	4 200	Kraft ≃ 65% Fluting ≃ 35%	Corrugated cartons
3	1 400	White wood free	Stationary
4	7 800	Kraft liner, fluting Chip board, etc.	Corrugated carton Wrapping Material
5	700	White woodfree	Printing Material
6	2 500	125-440 gsm kraft	Packaging Containers
7	2 500	Printing and Packaging Papers	Folding Boxes and Cartons

Estimated annual consumption of industrial-grade paper in Kano is over 10 000 t/y; one particular Kano firm consumes about 4 200 tons of this category of papers annually. From the available data, published and otherwise, it is difficult to arrive at accurate figures on consumption in other towns but total consumption in Northern parts of the country can not be less than four times the figure quoted for Kano; and it is rising rapidly. Following industrial sectors were identified as major consumers of industrial grade papers:

- Foods, Beverages and Confectionaries,
- Pharmaceuticals,
- Soap and Detergent,
- Foot wear,
- Stationary,
- Perfumes and Cosmetics
- Building and Construction.

A large number of other industries also use Kraft, Fluting and other grades of papers as corrugated and box-board cartons and for wrapping of a number of manufactured goods such as sports equipment, suitcases and fragile wares.

The survey showed that there exists a substantially large market for most types of papers in the four towns surveyed. Also, it was concluded that a waste-paper-based mill producing up to 20 000 t/y of different grades of paper will not have any difficulty in selling its products provided the quality and price are right.

Sample of questionaire used in the field survey is reproduced in Appendix B. Appendix C contains the names of all major paper consumers contacted; an asterisk indicates lack of response up to the time of compiling this report. Appendix D lists the amounts of different types of papers imported in 1981 as well as the amounts manufactured locally.

7.3 AVAILABILITY OF WASTE PAPER

An extensive survey of establishments generating waste paper in economic quantities was carried out in Kano. Some data was also collected from Zaria, Kaduna and Jos. Majority of the data was obtained from the paper converters while in case of consumer waste from the University the estimate is based on the data collected by Adedayo (1980).

Apart from the paper converters hardly any organisation kept a record of the rate at which waste paper is generated. Secretariats and other government establishments had absolutely no data while some commercial organisations indicated the amounts in approximate number of truck loads of waste paper disposed daily. The figures given in table 7.2 are, therefore, from an incomplete list of paper converters in Kano and nearby towns. It should be noted that residuals generated during converting operation are estimated to be only about 10 per cent of the total amount of paper discarded (QUIMBY, 1975).

Table 7.2: Amounts of waste paper discarded by some paper converters (annual)*.

No.	Quantity Discarded annually (tons)	Type	Method of disposal
1	1 000	White wood-free	Sold at ₦60/ton or incinerated
2	500	Kraft & Fluting	Baled and sold at ₦50.00/ton.
3	250	White wood-free	Sold at ₦50.00/ton or incinerated.
4	65	Newsprint	Sold at ₦60.00/ton
5	110	White wood-free	Sold without weighing.
6	400	Kraft	Sold or incinerated.
7	2 325	Various types	Sold or dumped.

*All figures are for 1984. Names of converters are available but they wished not to be identified.

From personal interviews, government statistics, UN documents, on-site observation and other published and unpublished sources it is estimated that about 20 000 tons of paper is discarded in Kano and its adjacent

industrial areas annually. Of this amount, 5 000 to 10 000 tons can be obtained for recycling depending on the resolve and sophistication of collection procedure. Initially it will not be easy to make use of waste paper from house-holds. Consumer waste from Universities is of high quality and from student hostels it may contain up to 55% paper (Table 7.3). If suitable methods for its collection and segregation are devised, along with organised transport from other sources of waste paper, a paper recycling plant of up to 10 000 t/y will have little difficulty in obtaining its raw materials from Kano and nearby towns.

Table 7.3: Waste paper generation in ABU in 1985.

Category of consumer	Amount of paper discarded		No. of persons	Total paper discarded
	/person/day	/person/year*		
Students	0.20 kg	60 kg	~ 12 400	744 ton
Snr. staff	0.10 kg	30 kg	3 300	99 ton
I & J staff	0.05 kg	15 kg	10 000	150 ton
T O T A L			25 700	993 ton

*300 days.

As seasonal changes and social customs influence the amount of waste paper to be disposed of, it will be difficult to maintain its constant and steady flow. Fortunately these factors do not have much influence on one of the major sources of waste paper, namely the paper converters. End of financial year in March, end of academic year in June/July and end of calender year in December probably lead to higher generation of waste paper during the respective (or next) months. It is estimated that any variation in the supply will be absorbed by the plant with a safety stock of about two months.

To get an idea of this variation during a year, table 7.4 lists the amounts of waste paper collected in different months in Tokyo in 1960. Although this table does not reflect the situation in Nigeria, it shows the magnitude of variation for some classes of waste paper generators.

Table 7.4: Seasonal variation in the amount of waste paper collected by some agents in Tokyo in 1960. (JWPA, undated)

Month	Amount in tons
March	91.8
August	80.6
October	88.9
December	127.7
Total for 12 months	1 089.6
Monthly average	90.8

7.4 TECHNICAL LIMITATIONS

With the present state of technology it is possible to obtain paper recycling machinery for capacity of 5 to 500 ton per day. Availability of lesser or greater capacity equipment is not ruled out though it is extremely rare. The maximum capacity of paper making plant is usually the same as the capacity of sheet forming machines. All other machines such as pumps, deflakers, refiners and cleaners are available in widely varying capacities and two or more can be installed in parallel so as to match the capacity. Usual capacity ranges for some of the machines used in paper recycling are as follows:

Hydrapulper	5 - 100	t/d (bone dry)
Turboseparator	45 - 135	t/d (bone dry)
Fiberiser	50 - 400	t/d (bone dry)
Deflaker	20 - 100	t/d (bone dry)
Conical Refiner	9 - 100	t/d (bone dry)
Double Disk Refiner	15 - 45	t/d (bone dry)
Centrifugal Cleaners	up to 850	gal. perminute
Jonsson Screen	up to 100	t/d (bone dry)
High Density Pumps	1.5 to 6.0	m/s
Fourdrinier: width	up to 9.0	m
speed	up to 1 500	m/minute
capacity	up to 500	t/d (bone dry)

A study by Western (1979) on operation and production efficiencies of Fourdrinier-type paper machines showed that for papers of between 60 and 200 gsm the machine capacity should range from about 20 to 60 t/d for overall economy. Machines with larger capacities can be used at the expense of semi-skilled labour, with increased investment and more sophisticated controls. Capacities of up to 100 t/d are not undesirable although anything above this figure is certainly not recommended for developing countries.

A report by UNIDO (1979), of the working group on Pulp and Paper, states that non-integrated small scale mills (of up to 30 t/d) can be established and operated economically in developing countries. Such mills are less harmful to the environment and more useful to the immediate needs of these countries. The report goes on to state that the mills should be designed to produce packaging materials since they do not require high technical qualities. A number of technical options were also presented concerning mainly the small and medium sized mills of between 20 and 80 ton per day.

7.5 PLANT CAPACITY

Summarising the two surveys reported in section 7.2 and 7.3, the following observations are made.

1. Consumption of paper and board in Kano State is over 20 000 t/y.
2. A large percentage of this is consumed within Kano and its adjacent areas.
3. Consumption of industrial grades of paper in Kano is about 10 000 t/y.
4. Between 5 and 10 thousand tons of recyclable waste paper is discarded annually in Kano.
5. Total amount of recyclable waste paper available in Kano and nearby towns is more than 10 000 t/y.

Based on these assumptions it would seem that a 25 ton per day (7 500 t/y) plant will have little difficulty in procuring its raw material and disposing of its products. Also considered is the fact that none of the existing producers is located within 500 km of Kano.

The 25 t/d assessment is further buttressed by the fact that this volume represents a very small fraction of the total market for paper in Nigeria. More important, this capacity falls within the range recommended for developing countries by UNIDO; i.e neither too small to be uneconomical nor too large to require sophisticated controls.

All further analysis of the project is based on this production capacity.



CHAPTER EIGHT

RAW MATERIALS AND INPUTS.

8.1 INTRODUCTION:

This chapter is concerned with all the raw materials needed for the manufacture of paper from paper-waste. Quantities that will be required to meet the proposed production schedule are given along with brief notes on quality and importance of the related chemicals. Also considered in this chapter are the requirements for electricity, water, fuel and steam.

8.2 RAW MATERIALS

8.2.1 Waste Paper

Paper residuals obtained from several different sources must always be separated into following categories for better quality control.

Direct Entry (or Pulp Substitute). White wood-free papers having little or no printing and of reasonable uniform brightness.

Corrugated Waste. Containing double-lined kraft outer surfaces and a fluted medium centre. Also included are corrugated cuttings, used corrugated containers and boxes.

Newsprint. Sorted, fresh, dry newspapers - not sun-burned.

Unsuitable. Those types of papers that can not be processed with the installed equipment, i.e. carbon papers, plastic-coated papers, wet-strength papers and laminated papers.

Mixed. Containing various qualities of paper not limited as to the type and fibre-content.

It is recommended that initially the emphasis should be placed on high quality waste from converters and commercial establishments including banks and government offices. Later, citizens should be enlightened on the advantages and necessity of recycling. Local mosque, church, school or charity institutions could be used as collection centres.

This paper could then be sold to the recycling plant, thus, generating revenue for these institutions. Similarly, the super-markets may also be encouraged to deposit their packaging waste at the plant and be paid for it instead of incinerating. Another source of wastepaper is the firms specialising in refuse collection and disposal; at present there are four such firms in Kano.

REQUIREMENT: Normal waste-paper requirement depends on the percentage of impurities. Total requirement is expected to be less than 125% of production (by weight).

8.2.2 Pulp.

For the first year after commencement of operation, an average of 20% imported long-fibre pulp will be required to complement the locally obtained secondary fibre. During the first few weeks virgin pulp may contribute as much as 50% of the total fibre consumption so as to enable a successful plant take-off.

Long-fibre unbleached pulp will be imported in sheets from either Scandinavia or Canada. The moisture content of the baled pulp, under no circumstances, should exceed **10%** as this may lead to undesirable effects during storage.

REQUIREMENT: 20% for the first year; none in subsequent years.

8.2.3 Additives.

Except in very few cases several different types of chemicals are added to pulp furnish in order to improve some of the properties of resulting paper.

Fillers. The most important group of additives used in paper industry is fillers. Fillers are fine white powders prepared from minerals either by simple grinding or by chemical means.

Fillers are used to improve the following properties:-

- Opacity. This is an important property for writing and printing papers and is improved by the addition of fillers.
- Colour. Most fillers are whiter than commercial cellulose pulp. Addition of these fillers improves whiteness.
- Printability. Quality and speed of printing is greatly improved by addition of fillers. Mineral materials fill inter-fibre spaces and smoothen surface irregularities; thus giving more even contact with printing plates.
- Softness and Pliability. Fillers are useful in improving the softness and pliability of papers; they also reduce its curling.
- Weight. Fillers, being more dense, increase the weight of paper. This is rarely the reason for addition of fillers.

China clay and Calcium Sulphate account for a large proportion of the materials used today as fillers. Others include $CaCO_3$, TiO_2, MgSiO (talc.), $BaSO_4$ and $ZnSO_4$. The exact quantity of fillers added to the furnish depends on the type of paper being manufactured but rarely does it exceed 15% by weight of dry paper (Casey, 1980; Clark, 1978).

China Clay. The molecular formula of China clay, also known as kaolin, is $Al_2O_3.2SiO_2.2H_2O$. It is white in colour and is commonly found in large deposits in association with impurities. Mica especially is likely to be present and this can be particularly troublesome in paper making and must be eliminated.

In Nigeria, a large deposit of good quality kaolin has been discovered near Kankara in Kaduna State. Already the Metallurgical Engineering Department of ABU is carrying out research to purify this clay and use it in making high temperature refractories. Chemical Engineering Department should also conduct research on this clay and determine

method of its purification so that it can be used by paper manufacturers.

Calcium Sulphate. The usage of $CaSO_4$ in different papers is fairly wide but there is a tendency to use it more for writing than for printing papers. Several varieties of $CaSO_4$ are used in paper-making, most of them natural (e.g gypsum and anhydrite) but one chemically precipitated.

Presently most of the calcium sulphate used in the country is imported with little effort to look for it locally. Recently large deposits of gypsum have been found in Northern parts of Sokoto State (Anonymous, 1985g). The quantity discovered can meet most of the local demand provided it can be extracted and purified economically. Further research is needed.

REQUIREMENT: Total requirement of fillers will be about 15% by weight of production. (Retention = 7%)

Binders. The addition of any filler to the paper pulp decreases the strength of the paper by interfering with cohesion among fibres. This decrease may be compensated adequately by the addition of a bonding substance to the stock. Bonding agents are also good fibre dispersants and thus improve the formation of paper.

Some of the most common binders used in paper industry are starches and gums. Gums are mostly used in conjunction with starches and starches are those from corn, potatoe and tapioca (Clark, 1978). Research conducted at ABU, Zaria (Bugaje, 1980) has shown that locally prepared cassava starch is quite suitable for paper making. Infact its quality was found to be superior in some respects to the imported industrial starch used by paper manufacturers.

REQUIREMENT: Binders (starch + Gum) about 1%.

Alum. Alum is a hydrated salt of Aluminium with the molecular formula $Al_2(SO_4)_3 \cdot 14H_2O$. It is often used to precipitate resin size on pulp and for a number of other reasons, "some of which are highly questionable" (Clark, 1978). However, most experts agree that it helps to reduce pitch troubles and sticking of the wet web to press rolls. Other effects of alum on paper-stock are complicated and presently not very well understood.

REQUIREMENT: about 3% by wt. of dry product.

Rosin Size. Rosin size is a substance added to the pulp furnish in order to improve printability and water absorption capacity of the finished product. Rosins are prepared from resin acids obtained from wood during alkaline pulping (Casey, 1980).

REQUIREMENT: about 0.8% by wt. of dry product.

8.3 UTILITIES

8.3.1 Electricity.

Electricity requirement for paper manufacture varies considerably from mill to mill. At NPM Jebba it is 225 kWh per ton of paper, whereas at Nekoosa Papers Inc. USA it is less than 125 kWh (Saltman, 1978). The large difference can be attributed to both wastage and the type of raw material used.

At the proposed recycling plant it is expected that electric power requirement will be less than 125 kWh per ton. Experts agree that it can be reduced to below 100 kWh in waste paper recycling plants if special care is taken to avoid wastage.

8.3.2 Fuel

Fuel requirement will not be high since it will only be used for steam generation and stand-by generators. It is expected to be less than 50 litre per ton of paper.

Two on-the-ground storage tanks will be installed, each capable of storing up to two weeks' normal requirement of diesel. Fuel will be brought to the factory by local petroleum dealers in their own trailer-tankers.

8.3.3 Water

Paper plants usually require very large quantities of water. Mills situated close to large rivers used to consume up to 400 m^3 of water per ton of paper manufactured. Most of the water (up to 98%) was finally returned to the river as effluent. With pressure from ecologists and governments, more and more mills are now installing effluent treatment plants in order to improve the quality of waste water before discharging to the environment. In ideal treatment plants the water is treated to such an extent that it can be substituted for fresh water. With such a system, the fresh water consumption of a non-integrated paper mill can be brought down to 2 m^3/t (Casey, 1980b).

Since Kano receives only about 850 mm of rain per year, water supply is not unlimited. A save-all water treatment plant will be installed and apart from some solid contaminants no effluent will be discharged to the environment. This system, along with strict water conservation, will reduce the water consumption to less than 5 m^3/t.

8.3.4 Steam

Integrated paper mills use up to 4 tons of steam for each ton of paper manufactured. Part of this is used in cooking and the remainder for heating the dryers. In case of non-integrated mills steam is used mainly for heating the dryers but sometimes also for heating the stock for deinking.

At the proposed recycling plant the steam requirement for dryers is expected to be less than 3.0 ton for each ton of paper produced (the theoretical requirement is about two ton (Casey, 1980)). The plant will not be equipped for de-inking hence no steam is required for this purpose.

Steam will be generated in a diesel-fired boiler located close to the dryers. The charge will consist of condensed steam and make-up water. Already the steam requirement has been taken into account while considering water and fuel requirements. Hence separate provision for water and fuel is not needed.

8.4 TOTAL REQUIREMENTS

The maximum requirement of raw materials and utilities, listed in tables 8.1 and 8.2, is considered on daily as well as annual basis. Estimates for the figures were arrived at after a thorough survey of available information and after consultations with experts on paper. Different mills have different practices and it is not necessary that the quantities quoted are exact. These are only estimates based on the experience of several existing plants.

Table 8.1: Raw Material Requirements.

Raw Material	Requirement (ton)		
	Per ton of Paper	Daily	Annual
Waste Paper	1.25	31.25	9 375
Additives:			
Fillers	0.07	1.75	525
Binders	0.01	0.25	75
Alum	0.03	0.75	225
Rosin	0.008	0.20	60

Table 8.2: Utility Requirements.

Utilities	Unit	Requirement		
		/ton of paper	Daily	Annual
Electricity	kWh	125	3 125	937 500
Fuel	m^3	0.05	1.25	375
Water	m^3	5	1.25	37 500
Steam	ton	3	75	22 500

The requirements shown in tables 8.1 and 8.2 are based on uninterrupted 24 hour production for 300 days per year. Plant construction and commissioning will take two years. Start-up will take another two and during these years the plant will be running at 50 - 80% of the design capacity. Raw material requirements will be lower correspondingly while utility requirements, difficult to estimate, will not exceed the total quantities quoted in table 8.2. Utility requirements for non-production uses will be comparitively very low and their cost is included in administrative over-heads.



CHAPTER NINE

PLANT LOCATION AND TECHNOLOGY

9.1 LOCATION AND SITE DESCRIPTION

Challawa Industrial Estate in Kano State is suggested for the location of the proposed paper recycling plant. This place was chosen for, among others, following reasons.

- Government efforts towards dispersal of industries in semi-urban and rural areas. Also the proposed area comes within the planned expansion areas of industries in Kano State.
- It is less than 15 km from Kano Metropolis and several paper converters are situated in Challawa or the nearby Sharada Industrial Estate.
- All essential requirements for the plant, for example Power, water & transport can be easily met in this area.

The followings are the geographical and other local conditions and the facilities available in the area. See fig. 9.1.

9.1.1 Site and Terrain

Location:	Challawa Industrial Estate, km 9 BUK-Challawa Road, Dawakin Kudu Local Government Area, Kano State, Nigeria.
Nearest Villages:	Panshekara (1 km), Kumbotso (5 km).
Nearest Town:	Kano (13 km).
Height above sea level:	470 m.
Surface:	Plane.

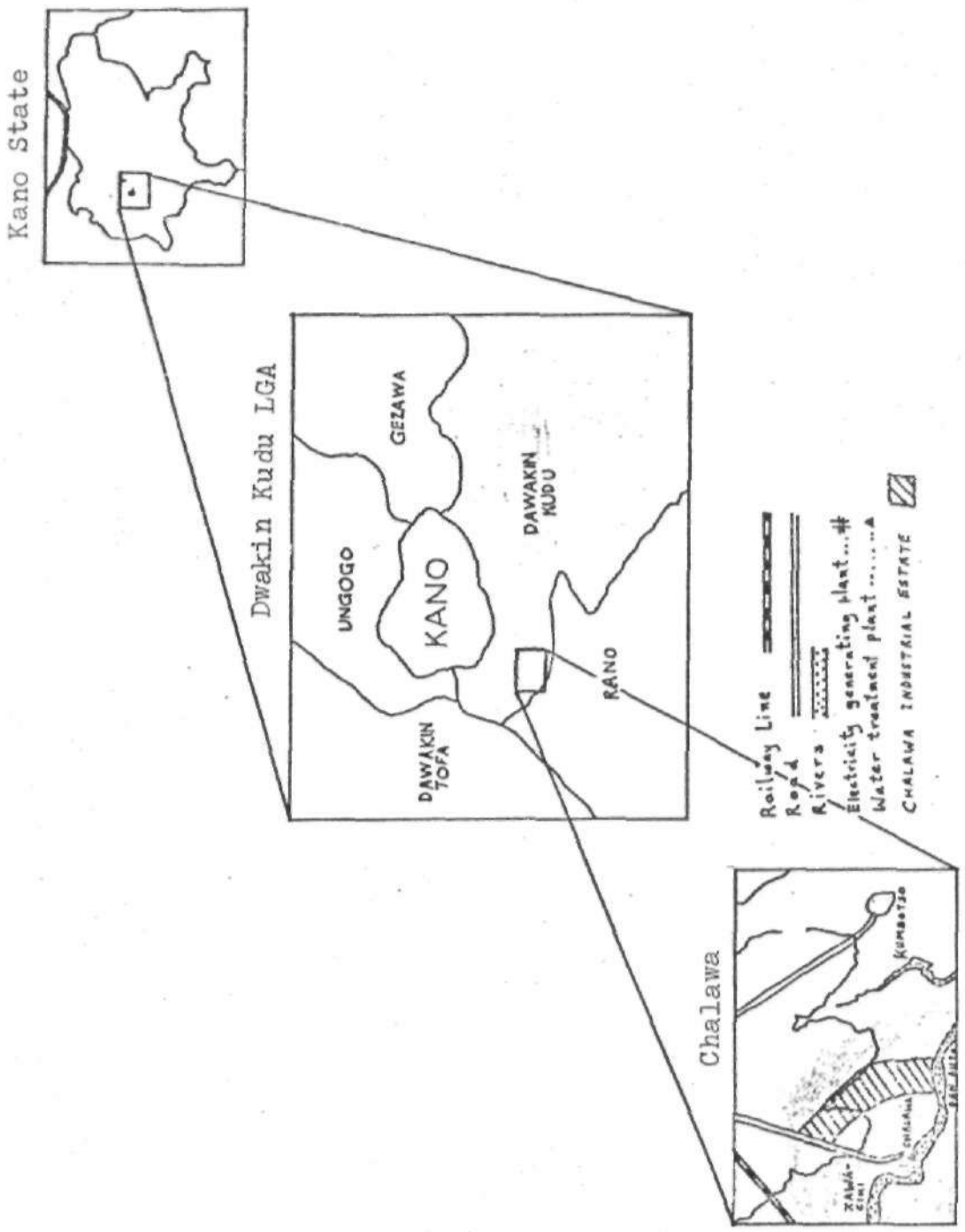


Fig. 9.1 Chalawa Industrial Estate, Kano.

Flooding and earthquakes: Nil

Other industries in the area: Soft drink, Ceramic, Paper converting, Plastics, gas, abbatoir.

9.1.2 Climate

The year can be divided into rainy and dry seasons. The rainy season starts in April and ends in October with most of the rainfall concentrated between the months of June and September.

Harmattan, the dry, dusty, North-East winds arrive between the months of November and March with peak in December and January. During this season, lowest values of humidity and temperature are recorded along with the lowest rainfall..

Mean Air Temperature: January (Low) 23°C
July (High): 27°C

Mean Relative Humidity: January (Low): 14 - 17%
July (High): 66 - 79%

Wind Direction: November to April N. E. → S. W.
May to October S. W. → N. E.

Atmospheric Pressure (mean): 1014 millibar
variation: insignificant.

Precipitation (Rain): Annual Average: 850 mm
Highest of 300 mm in August and 200 mm in July.

9.1.3 Transport

Road: All weather roads link with Kano, Kumbotso and Panshekara. Direct road linking with Sharada is planned, however, a dirt track already exists.

Railway: Kano - Zaria part of the national railway network passes through Challawa railway station, where most trains make a scheduled stop.

Air Transport: The nearest airport, Mallam Aminu Kano International Airport, is less than twenty minutes drive from Challawa.

Passenger Transport System: 15 and 19 seater "Danfo" buses operate between Panshekara and Kano. These buses start plying the route (Panshekara-Challawa-Kano) at about 7.00 a.m and continue till night-fall. There are no fixed stops; passengers can request for a stop along the route. Taxi service is not available on this route except by prior arrangement.

9.1.4 Utilities

Electricity: A NEPA Sub-station, situated less than 2 km from Challawa, can supply electric power at up to 11 kV. The 11 kV and 440 V lines already supply power to the industrial area.

Water: A large capacity water treatment plant is situated on Challawa river in Panshekara. Plans are underway to increase the treatment capacity from 240 to 270 million litres per day (Anonymous, 1986a).

9.2 CRITERIA FOR SELECTION OF TECHNOLOGY.

A UNIDO published report (UNIDO, 1979) has indicated that "the objective of any strategy for development of paper production in the developing Countries is in the first place, to create domestic availability of the varieties of paper". The report goes on to suggest that "the technology selected for the production of paper should be accessible in terms of the capital cost involved, cost of the resultant product, available material resources, skill and expertise, and domestic engineering capabilities".

Taking these points into consideration, the following guidelines were agreed upon in consultation with experts from paper industry. These guidelines refer to a 25 ton per day paper recycling plant in Kano.

- The plant should manufacture industrial grades of paper in the range of 60 to about 200 gsm.
- There should be no bleaching; deinking may be practiced at a later stage (it is not economical at this stage).
- Possible end uses of the product may be for file and notebook covers, envelops, grocery and paper bags, light paper boxes and packaging material for pharmaceutical, footwear and other industries.
- The paper machine should be of fourdrinier type. It should be about 2.5 m wide and be capable of speeds of up to 150 - 200 m/min. Allowance should be left for a cylinder-type mould former to be installed at a later stage.
- The power supply should be from a public source but a stand-by generator must be installed.
- The waste paper pulper should be designed for continuous operation and equipped with a ragger and a junker.
- Provision should be made for the installation of a turbo separator at a later stage. Turbo separator will be necessary when it is decided to use the low-quality high-contaminant waste from residential buildings.



CHAPTER TEN

PROJECT ENGINEERING

10.1 PRODUCTION PROCESS

10.1.1 Fibre Storage and Preparation

Waste paper will be brought to the recycling plant in a fleet of pick-up trucks and taken to the receiving area adjacent to waste paper store. Here it will be unloaded and sorted before being stored on wooden crates in the waste paper shed.

The stored fibre will be reclaimed by manually transporting these crates on mobile hydraulic jacks to the conveyor belt. Contents of the crates will be weighed and dumped onto the belt which will convey the waste paper from its store on the ground floor to the first floor of the pulp mill. The conveyor belt will dump the waste paper directly into the pulper. See Process Flow Diagrams after page 98.

10.1.2 Repulping and Deflaking

The pulper will be equipped with a ragger and a junk remover. It will be of verticle type and designed to operate continuously to slush the waste paper for delivery to pulper dump chest. The slushing in pulper will take place at a consistency of 5 to 5.5% and flake content will be reduced to below 40%. The stock will then be passed through a screen plate of holes 18 - 20 mm diameter at the bottom of the pulper and pumped to pulper dump chest (PDC). The stock in PDC will be soaked for about 2 hours before its further treatment. Controlled quantity of water will be added to bring down and maintain the consistency at about 4.5%.

From PDC, the stock will be pumped to a deflaker to complete the defibering of preslushed and presoaked stock.

10.1.3 Screening

The homogenous suspension will be passed through a high density cleaner. The accepted stock will be passed through a Jonsson type vibrating screen before reaching the high consistency holding tank. Rejects from the Jonsson screen, along with rejects from the high density cleaner, will be dumped on the reject conveyor belt. Further processing of this material is not advisable as it is uneconomical.

10.1.4 Blending and Refining

The high consistency holding tank will also serve as the blending chest, where all the additives will be thoroughly mixed with the stock. The resulting slurry will be passed through a conical refiner and dumped into the machine chest. The refiner plug position will be automatically controlled by a reversing motor so as to obtain stock with uniform freeness.

Final checks and adjustments to the stock will be made in machine chest. The stock will then be pumped to stuff-box so that further pumping is done under constant suction head.

10.1.5 Centrifugal Cleaning

From the stuff-box the stock will be pumped to the battery of primary cleaners. The inlet pipe to the cleaners will be supplied with controlled quantity of white water so as to dilute the stock to the required head-box consistency (of 0.7 to 1.2%).

The accepted stock from primary cleaners will be sent directly to the head-box on paper machine while rejected stock will be sent to the secondary cleaners. Accepts from secondary cleaners will go to the feed of primary, while its rejects will be dumped without further treatment.

10.1.6 Sheet Forming

The head-box will be open, gravity type. It will distribute the slurry across the width of the machine and deliver it to "sluice" at a velocity consistent with the running speed of the machine. The sluice, a long, narrow, adjustable slot, will deliver the flow of slurry onto the wire. This endless wire, part of a shaking type fourdrinier machine, will transport the fibre mat to the dry end of the machine. While the mat is on wire, its water content will be reduced from over 99% to about 55% with the help of three vacuum boxes.

10.1.7 Drying

When the paper reaches the end of wire, it will be transferred to a felt blanket which will convey it through two presses and then to the steam heated driers. Moisture content of the paper will be about 5% at the end of drying cycle.

10.1.8 Finishing

On coming out of the driers the paper will pass through a stack of four calender rolls and finally end-up on the winder. Completed rolls on the winder will be lifted by the machine-room crane and transferred to the finishing area for slitting, re-winding and sheeting, as may be required.

10.2 MACHINERY AND EQUIPMENT

The plant will require both imported and locally procured equipment. Most of the machines will be imported while piping, steel works and other fabricated equipment will be obtained from local manufacturers. The list of equipment is, therefore, divided into two parts: The machinery and installations to be imported and those to be procured locally.

All machines will be equipped with safety devices as required by international regulations on accident prevention. Also they will be adjusted to be suitable for tropical conditions.

Major items of equipment to be imported include the paper machine with drive and all other attachments, a set of driers, 2 generators, a boiler, electric motors and various pulping and screening equipment. It is suggested that spare parts for these and other equipment should be ordered together with the machinery.

10.2.1 List of imported machinery

The list of the equipment to be imported, including quantity and installed power, is shown in table 10.1.

P.T.O

Table 10.1: List of imported machinery

Sr.No.	Item Description	Quantity	Installed kW
1	Baling Machine (Manual)	1	
2	Mobile Hydraulic Jacks	6	
3	Weighing Machines (0-2000 kg)	2	
4	Inclined belt conveyor (5t/hr; 12m long)	1	6
5	Pulper (capacity = 15 m^3)	1	60
6	Ragger	1	½
7	Junk remover	1	2
8	Deflaker	1	44
9	High density cleaner	3	3
10	Jonsson vibrating screen	1	2
11	Reject belt conveyor (≃ 10 m long)	1	½
12	Conical Refiner	1	60
13	Centrifugal Cleaners (Primary)	5	
14	Centrifugal Cleaners (Secondary)	2	
15	Agitators/stirrers	3	10
16	Centrifugal Pumps (33 m^3/hr. each)	6	15
17	Centrifugal Pumps (150 m^3/hr. each)	2	20
18	Centrifugal pumps (330 m^3/hr. each)	1	18
19	Fourdrinier Paper Machine (including Head box, suction boxes, dandy roll, vacuum pumps, Presses, etc.)	1	about
20	Complete set of driers	1	200
21	Winder/Rewinder/slitter	1	
22	Air compressor units	2	18
23	Effluent treatment equipment set	1	5

Table 10.1(Continued)

Sr.No.	Item Description	Quantity	Installed kW
24	Generator (500 kVA)	2	
25	Steam Boiler [3.5 t/hr]	1	
26	Set of equipment for workshops [Mech . Elect.]	1	
27	Electric Power distribution equipment set	1	
28	Instrument and control equipment set	1	

303007

10.2.2 Facilities and equipment provided locally

The facilities and equipment that will be obtained locally are:

- Supporting frames and steel work for belt conveyors, gangways, ladders, pit covers and guard rails.
- Pipelines [with mounting supports and valves] for compressed air, steam and water supply.
- Water tanks and drainage system.
- Storage tanks for chemicals.
- Compressed air accumulator units.
- Storage tanks for LPFO and diesel.
- Sheet-metal hood for the drier.
- Hand tools for workshop.
- Complete installations for offices.
- Fire protection system.
- Various shelves, cabinets, tables, chairs, stools, etc.
- Telephone and intercom installation.
- Complete electrical wiring and fittings [including lighting and climatisation].
- Various cleaning and gardening tools.
- Over-head crane [3000 kg, 3.5 kW].

10.2.3 Specifications of selected Equipment.

The specifications of selected equipment are given as follows:-

Deflaker

Make:	Escher Wyss
Type:	ED
Fillings:	K12K
Production capacity:	14.4 tpd at 4% consistency
Consistency range:	3 - 6%
Flow rate:	50 - 250 l/min

Motor Power:	22 kW
Drive:	v-Belt
Speed:	3900 RPM
Max. Outlet Pressure	245 kPa
Pipe connections [in and out]	ϕ65mm with flanges
No. required	2

High Density Cleaner

Make:	Baner Bros Co. OR Escher Wyss
Production capacity:	10 tpd.
Flow rate:	200 l/min
Consistency:	3 - 6 %
Drive:	v-Belt
Motor Power:	1 kW
No. Required	3

Jonsson Vibrating Screen

Make:	Bird
Type:	Model 24
Production capacity:	60 tpd.
Flow rate:	up to 2 500 l/min
Consistency [Max.]:	10% bone dry [b.d.]
Motor Power:	2 kW
Drive:	v-Belt
No. required	1

Conical Refiner

Make:	Escher Wyss
Type:	R2
Production capacity:	55 tpd [at c = 4.5%]
Flow rate:	850 l/min
Consistency [Max.]:	6% bone dry [b.d.]

Motor Power	60 kW
Speed:	1000 rpm
Drive:	Flexible gear coupling
Inlet Pressure:	0.3-0.8 bar
Max. Outlet Pressure	3.5 bar
No. required	1

Primary Centrifugal Cleaners

Make:	Bird
Type:	Cyclean 7"
Production capacity	7 tpd
Flow rate	1000 l/min
Consistency range	0.25-1.00 % b.d.
No. required:	5

Seconday Centrifugal Cleaners

Make	Bird
Type	Cyclean 4"
Production capacity	1.2 tpd
Flow rate	170 l/min
Consistency range	0.25-1.00% b.d.
No. required	2

Paper Machine

Machine type:	Fourdrinier
Wire length:	21 m
Trim width	2.5 m
Headbox	gravity type
Max. speed	200 m/min
No. of saction boxes	3
Felt type	100 % Synthetic needled

10.3 PLANT ENGINEERING

The following principles should dominate equipment selection for those machines that have not been specified in section 10.2.

10.3.1 Mechanical

- Simplicity, sturdiness and easy maintenance
- Direct drives with gearbox and flexible couplings should be preferred as they work even with slight errors of alighment.
- Drive elements, wherever possible, should be of the type that can be taken out without disturbing the main parts (motor or pump), for example, universal joints or Hardy Spicer couplings. The advantage is that they can take more angular and axial misalighments, which are bound to happen with limited skills in manpower.
- Metallurgy should be given a high emphasis. Although it would mean higher capital cost it would also mean lower maintenance cost.
- The lubrication system should, wherever possible, be of the "centralized oil" type.
- Standardized pumps and couplings of limited types and limited sizes should be selected.

Workshop facilities should be soundly based on the following guidelines.

- All major equipment should be able to be maintained locally.
- A lathe machine capable of coping with the longest and largest part of the appliances in the mill should be on hand.
- A shaper and planer machine of similar size, as well as a milling machine, should be available.

10.3.2 Electrical

In the design and selection of electrical equipment, the following points should be noted.

- All electric motors should be protected against direct water spray and water vapour in the atmosphere.
- Cable insulations should be of higher temperature rating and insulation value than for conventional requirements.
- Basically all equipment should be simple and sturdy.

10.4 LAYOUT AND CIVIL WORKS

10.4.1 Plant Layout

In arranging the plant layout, the following points were taken into consideration.

- The need to have both the waste paper store and finished goods store close to the office area. This is to facilitate quick stock taking.
- To leave enough room for future expansion. In particular, the possibility of widening the machine room for the installation of another paper machine.
- To keep the distances between inter-dependant sections minimum.
- In case of fire, the affected areas are to be quickly isolated.
- Administration building, car park, waste paper store and finished goods store are to have easy access from the main entrance.

The area requirements for different buildings in the plant are given in table 10.2, and the layout for the plant is given in fig. 10.1.

Table 10.2: Area requirements for factory and auxiliary buildings

DESCRIPTION/STRUCTURE	AREA (m^2)
Waste paper shed	1350
Pulp mill	135
Paper machine room	920
Finished goods gallery	25
Finished goods store	525
Loading bay	50
Administration building	300
Passages	116
Laboratory	40
Factory offices	40
Power distribution room	24
Generator room	36
Boiler room	24
Compressor room	24
Workshop	120
Spare-parts store	48
Chemicals store	48
First aid centre	18
Canteen and kitchen	48
Toilets/baths	42
Locker/changing room	36
Security/timing post	5
Total roofed area	3974

10.4.2 Buildings and Civil Structures

Because of mild tropical climate, building designs should be kept simple with maximum utilisation of locally available material. Reinforced concrete buildings with structural steel columns and corrugated sheets for roof would be ideal. This choice would reduce the cost of construction and, to a certain extent, ventilation problems.

Waste Paper Store: This will consist of concrete floor with roofing sheets on steel structure. The store will be enclosed by wire-net so as to prevent lose pieces of paper from scattering.

Pulp Mill: This will be a two storey structure. Most of the pulping, refining and screening equipment (except w.p. pulper) will be located on the first floor. The ground floor will be occupied mostly by storage chests and pumps.

Main Factory Building: This building will also be two storied. First floor will house a laboratory, offices, stuff preparation equipment, cleaners, paper machine, driers and some finishing equipment. The ground floor will contain storage chests, pumps, water collection equipment and utility pipes.

Finished Goods Store: This store will be fully enclosed and linked directly to the finishing section of the main factory building with a passage. Apart from the weighing machine, no other machine will be installed here.

Administrative Block: This will be a two storey building with offices on both floors. It will also have a reception lobbey, a conference room and toilets.

Auxiliary Buildings: These buildings will consist of groups of single storey rooms of various sizes containing staff welfare and factory related facilties. They include workshops, stores, boiler house, power house, canteen and conveniences.

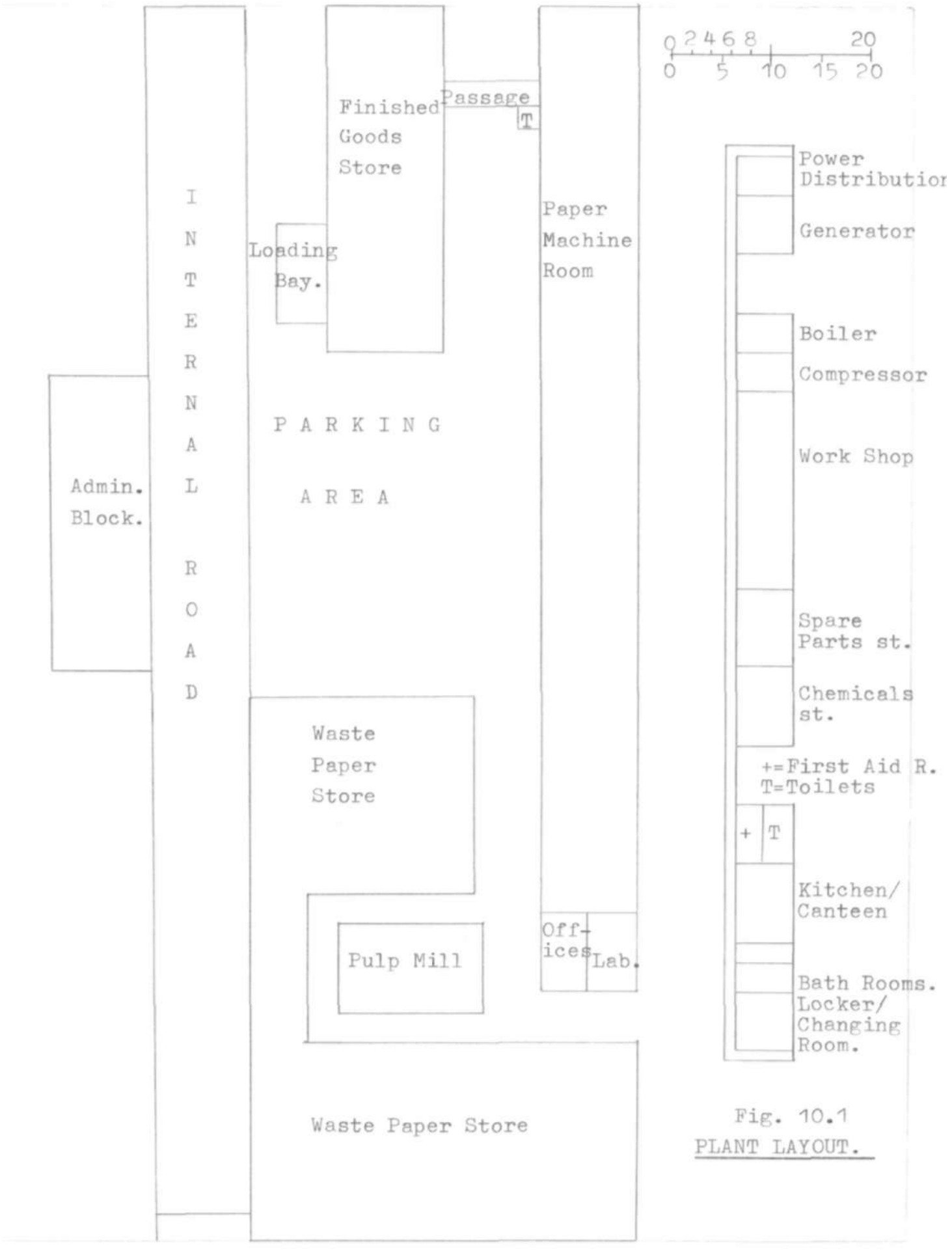


Fig. 10.1
PLANT LAYOUT.

CHAPTER ELEVEN

PLANT ORGANISATION AND MANAGEMENT

11.1 INTRODUCTION

This chapter deals with manpower requirement for the project and outlines the organisational set-up envisaged. It also gives the salaries recommended for various posts and suggests the name of an institution where personnel can be trained to the required standard. For the efficient implementation of the project it is essential that qualified and experienced personnel, covering both technical and non-technical functions, are employed to form a coherent and dedicated team under a centralized management. Manpower planning, therefore, needs to be carefully done so that there is a well defined authority, delegation of responsibility and smooth inter- and intra-departmental communications. Suitable and competitive salaries should be paid so that the plant can attract qualified and experienced personnel. Equally competitive fringe benefits and a sense of belonging will go a long way in retaining the best workers.

11.2 ORGANISATIONAL STRUCTURE

To establish the total manpower that will be required for the project careful thought has been given to every operational function and proper evaluation of each function has been made to complete the work-load of every individual.

It is suggested that four departmental heads - Production Manager, Administrative Manager (who will also act as Company Secretary), Financial Manager and Commercial Manager - will receive directives from, and be answerable to, the General Manager (G.M.). The GM will have direct responsibility to the board of directors. The

suggested organizational set-up is shown in fig. 11.1

All employees will be answerable to their departmental heads through the line of responsibility shown for each department. Production policy decisions will be handed from top to the bottom of the organizational tree for execution.

11.3 WAGES AND SALARIES

Tables 11.1 and 11.2 give the recommended salaries for each post. The figures were selected after a survey of equivalent posts in similar establishments in Nigeria.

11.4 STAFF TRAINING

Prior to project implementation, a training programme should be worked out in consultation with the Training Centre at Nigerian Paper Mill Limited, Jebba. The institution is well equipped to train technical personnel in various fields of paper making. It also organises seminars and workshops for supervisory staff and plant managers. Presently the institution is training maintenance and production staff for NPM Jebba, NNMC Calabar and NNPMC Iwopin. It is the only institution of its kind in Nigeria serving the special needs of paper industry.

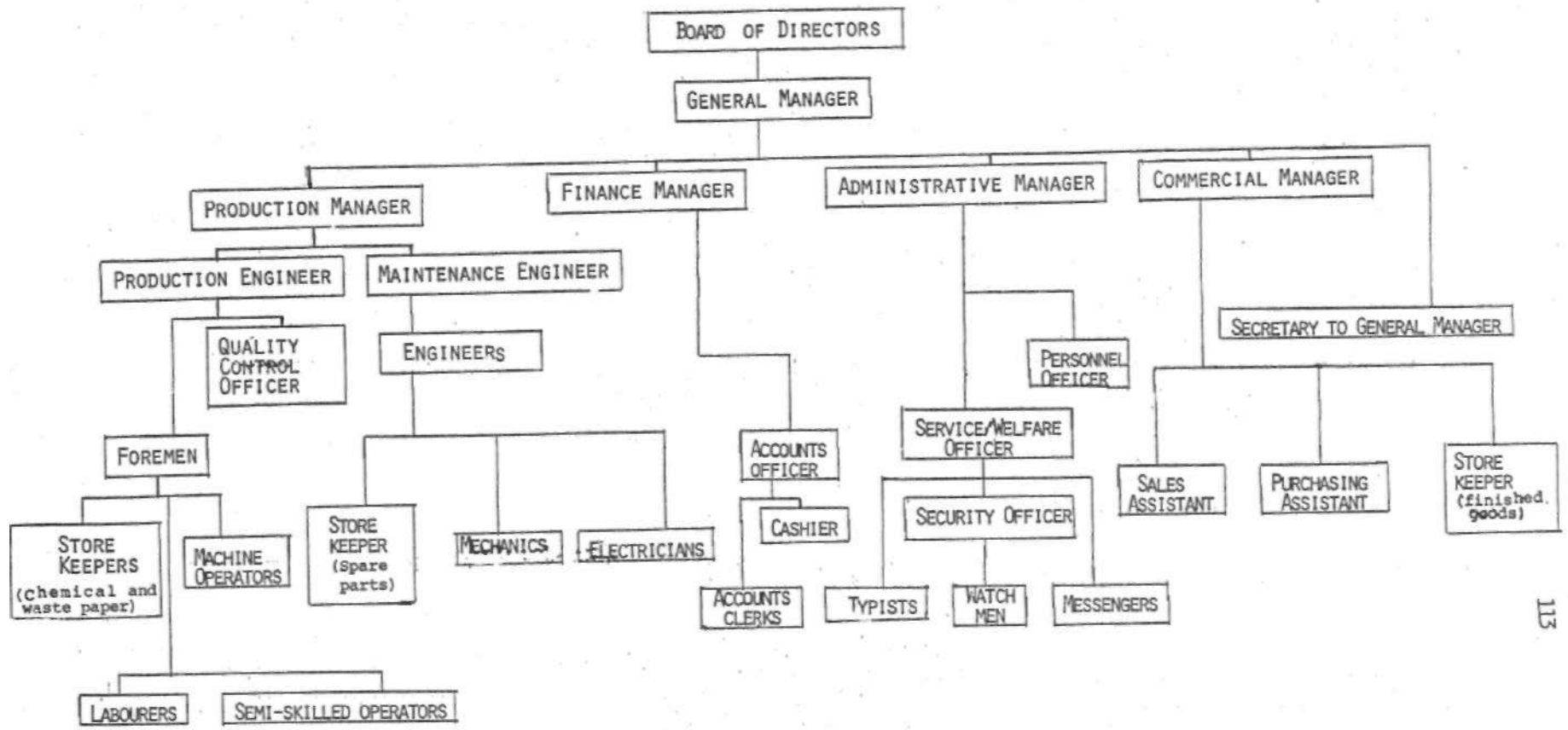


FIGURE: 11.1: ORGANISATIONAL SET-UP

Table 11.1 Wages and salaries: Staff on regular duty (non-shift).

Sr.No.	Post	No.	Unit salary (₦/year)	Total salary (₦/year)
1	General Manager(G.M.)	1	30000	30000
2	Production Manager	1	21600	21600
3	Admin. Mngr/Coy.Sec.	1	21600	21600
4	Finance Manager	1	18000	18000
5	Commercial Manager	1	18000	18000
6	Production Engineer	1	15600	15600
7	Maintenance Engineer	1	15600	15600
8	Quality Control Officer	1	9600	9600
9	Secretary to G.M.	1	7200	7200
10	Accounts Officer	1	7200	7200
11	Personnel Officer	1	7200	7200
12	Service/Welfare Officer	1	7200	7200
13	Purchasing Assistant	1	4800	4800
14	Sales Assistant	1	4800	4800
15	Store Keepers	4	4800	19200
16	Cashier	1	4200	4200
17	Security Officer	1	4200	4200
18	Accounts Clerks	2	3600	7200
19	Typists	2	3000	6000
20	Drivers	7	2400	16800
21	Messengers/Cleaners	4	1800	7200
22	Labourers	3	1800	5400
	TOTAL	38	-	258600

Table 11.2 Wages and salaries: Staff on shift.

Sr.No.	Post	No.	Unit salary (₦/year)	Total salary (₦/year)
1	Engineers	3	13200	39600
2	Foremen	6	7200	43200
3	Mechanics	6	4800	28800
4	Electricians	3	4800	14400
5	Machine Operators	30	4200	126000
6	Plumbers	3	2400	7200
7	Welders	3	3000	9000
8	Semi-skilled workers	30	2160	64800
9	Labourers	12	1800	21600
10	Watchmen	6	1800	10800
	TOTAL	102	-	365400



CHAPTER TWELVE

PROJECT IMPLEMENTATION

Implementation scheduling is one of the most important planning activities affecting the timely start-up of production. If not planned properly, the construction phase may extend over enough time to endanger the potential profitability of the project.

A number of appropriate persons were consulted in order to ascertain the time duration required for different pre-production activities for this project. These activities were then arranged on a master time schedule (fig. 12.1) in such a way that their implementation was realistic and correctly timed; i.e. neither earlier nor later than appropriate.

Company formation, negotiation with financial institutions and government will take about 4 months from signing of contract.

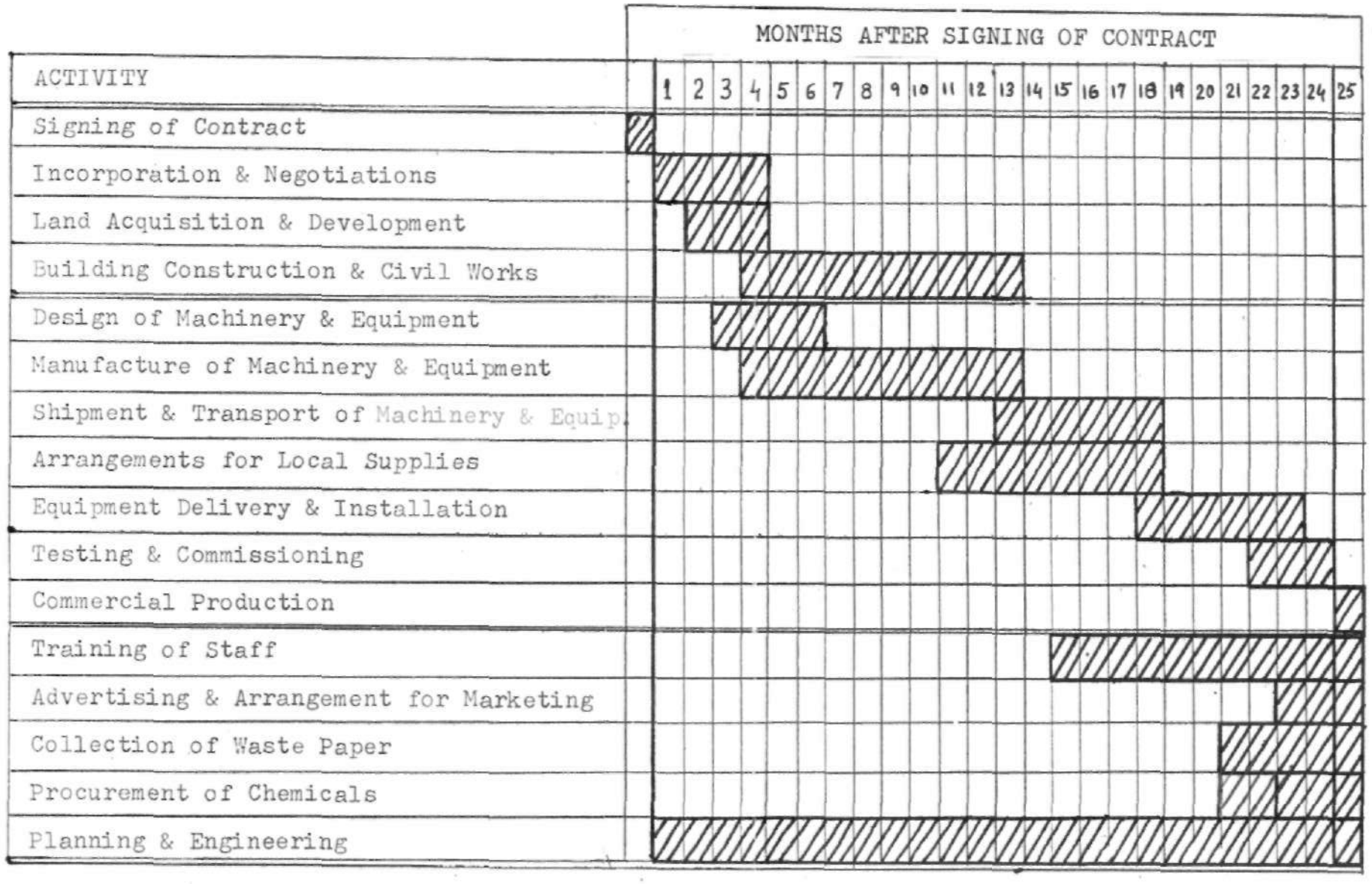
Land aquisition, its levelling and fencing will take less than three months. Construction of buildings will start immediately and will last for about 10 months.

Within 2 months of signing of contract equipment suppliers will be contacted and work on design of machinery will start. Construction of machinery will begin during the fourth month and will end in about 10 months. Local supplies would be ordered and received from 11th to 18th months. Shipment of imported machinery will start in the 13th month and end in less than 6 months. Installation of equipment will take about 5 months and commissioning of the plant will take place in the 24th month.

Waste paper would be collected during the last 4 months of construction phase and chemicals would be purchased in the 23rd and 24th months. The commercial production will start 24 months after signing of contract.

Recruitment and training of staff will start from the 14th month to 24th month. Training will continue later in the factory to improve the professional quality of the staff. The first group of trainees will participate in the installation of the machines.

Planning and engineering will continue through the 24 months.


MONTHS AFTER SIGNING OF CONTRACT
ACTIVITY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Signing of Contract
Incorporation & Negotiations
Land Acquisition & Development
Building Construction & Civil Works
Design of Machinery & Equipment
Manufacture of Machinery & Equipment
Shipment & Transport of Machinery & Equip.
Arrangements for Local Supplies
Equipment Delivery & Installation
Testing & Commissioning
Commercial Production
Training of Staff
Advertising & Arrangement for Marketing
Collection of Waste Paper
Procurement of Chemicals
Planning & Engineering



CHAPTER THIRTEEN

COST ESTIMATES AND FINANCES

13.1 INTRODUCTION

This chapter, unlike others, is presented predominantly in the form of tables. The tables are meant to be self explanatory as they are preceded by the underlying assumptions. The method of presentation and the basic format of tables is the one recommended by the United Nations Industrial Development Organisation (UNIDO, 1978).

Initial cost of land, recurring land charges and the rates of construction were obtained from the Military Governor's Office, Land and Survey Division, Kano. The price estimates for plant and machinery are based on figures given in a paper presented to FAO (Keswani, 1983). These prices, valid for 1983, were projected for 1986 on the basis of UK inflation rates obtained from two British banks: Lloyds (1984) and Midland (1985). Estimates for auxiliary equipment were supplied by a consultancy firm, Agriman Industrial Services; while the prices of chemicals were obtained from Khuddam Scientific Supplies, Kano. Finally, the price of waste paper and estimates of sale price are based on a market survey conducted by the author in several towns in Northern Nigeria.

For the purpose of this analysis the sale price is assumed to be ₦ 900/ton. This is 25 to 40% below the usual price of 1200 to 1500 Naira for most industrial grades of paper. Similarly, the price of waste paper is assumed to be ₦ 100/ton instead of ₦50 to ₦80 at which it is easily available. This is done in view of the fact that as demand for waste paper increases its price will also rise.

All output sales and input costs are based on the following assumptions.

Plant capacity	7500 ton per year	
Production programme:	year 3:	60%
	year 4:	80%
	year 5-12:	100%

Working days per year: 300

Product: Industrial grade papers in the range 60-150 gsm.

Initial Equity to Debt ratio: 3:2

Interest on loan 13% per year

Exchange rate: ₦1.00=US$1.00

13.2 COST OF THE PROJECT

The project is estimated to cost a total of thirteen million Naira. The break-down of this figure is given in table 13.1

Table 13.1 Initial Investment Cost

ITEM	COST (₦1000)	REF. TABLE
Land and land development	242	13.2
Building and civil works	1 932	13.3
Plant, machinery and equipment	9 438	13.4
Motor vehicles	242	13.5
Pre-production capital expenditure	480	13.6
Operating capital	666	13.7
TOTAL	13 000	13.1

13.2.1 Land and Land Development

The total land requirement is about eight hectares. Of these, the factory and other buildings will require less than two hectares while the rest of the land will contain water storage and treatment facilities. The cost of land acquisition, levelling and fencing will be ₦242 000 as shown below.

Table 13.2 Land and Land Development cost

ITEM	RATE	COST (₦)
Development fee (4 plots of 2 ha each)	₦25 000/plot	100 000
Land leasehold (8 ha for two years)	₦ 5 000/yr/ha	80 000
Clearing and levelling (8 ha)	₦ 1 250/ha	10 000
Walling and fencing (1 200 m)	₦ 25/m	30 000
Sub-total		220 000
Add:Contingencies		22 000
TOTAL		242 000

13.2.2 Buildings and Civil Works

A total of ₦ 1 932 000 will be invested in buildings and civil works with about 4000 m² of covered area. This cost is inclusive of the furniture and fittings needed in the buildings.

Details of the structures and buildings are given in section 10.4 (chapter 10) while break-down of the cost is as follows.

Table 13.3 Buildings and Civil Works Cost

ITEM	Area (m²)	Rate (₦/m²)	Cost (₦)
Factory building	2 270	300	681 000
Administration building	600	400	240 000
Waste paper and other sheds	1 600	100	160 000
Auxiliary buildings	1 100	250	275 000
Residential buildings	5 units	80 000/unit	400 000
Sub-total			1 756 000
Add: Contingencies			176 000
TOTAL			1 932 000

13.2.3 Plant, Machinery and Equipment

Major items of equipment are listed in table 10.1 (Chapter 10). The paper machine, driers and pulping equipment is estimated to cost about 2.5 million U.S. dollars. Total cost, including auxiliary equipment, transport, insurance, customs and excise duties, cost of local supplies and installation is estimated to be ₦ 9 438 000. A break-down of this figure is given in table 13.4 and the basis of calculation is as follows:

Cost of equipment: f.o.b. supplier's port (Europe)

Freight, Insurance & duties: 20%

Foundation and assembly: 10%

Table 13.4 Plant, Machinery and Equipment Cost

ITEM	COST (₦)
Plant and Machinery	5 200 000
Insurance, freight, duties	1 040 000
Foundation and assembly	520 000
Local supplies	800 000
Diesel Generators (2x500 kVA)	500 000
Furniture and fittings	100 000
Work-shop tools and spares	300 000
Industrial boreholes	120 000
Sub-total	8 580 000
Add: Contingencies	858 000
TOTAL	9 438 000

13.2.4 Motor Vehicles

A provision of ₦242 000 is made for 10 motor vehicles; that is, four cars and six Mitsubishi-type light-duty trucks. The break-down of this figure is as follows.

Table 13.5 Motor Vehicle cost

ITEM	COST (₦)
Saloon cars (4)	70 000
Goods transport vehicles (6)	150 000
Sub-total	220 000
Add:Contingencies	22 000
TOTAL	242 000

13.2.5 Pre-Production Capital Expenses

This item includes all expenditure which is incurred before the start-up of the actual operations. The amount budgeted is ₦ 480 000.

Table 13.6 Capital expenses before production

Sr.No.	Expenses
1.	Pre-investment and feasibility studies
2.	Detailed planning and Engineering(PERT/CPM)
3.	Supervision and co-ordination of construction
4.	Testing and commissioning of machinery
5.	Build-up of administration and recruitment of staff
6.	Training of technical and non-technical personnel
7.	Arrangement for supplies
8.	Arrangement for marketing
9.	Printing and stationery
10.	Incorporation and legal fees
11.	Travelling and accommodation
12.	Import license approvals
	TOTAL = ₦ 480 000

13.2.6 Operating Capital (or working capital).

₦ 666 000 is provided for the day-to-day running of the plant. Break-down of this figure is given in table 13.7 and the basis for calculations is given in the schedule of operating capital, appendix E.

Table 13.7 Provision for working capital

ITEM	PROVISION (₦)
Accounts receivable	168 800
Inventory: - Waste paper	112 500
- Chemicals	85 400
- Spares/consumables	32 500
- Finished product	77 100
Cash-in-hand	163 800
Sub-total	640 100
Add: Contingencies	25 900
TOTAL Operating Capaital	666 000

13.3 PRODUCTION COSTS

13.3.1 Staff Salaries and Wages

Total salaries and wages of the staff amount to ₦ 624 000 per year. A break-down of this figure is given in tables 11.1 and 11.2 (Chapter 11) for regular and on-shift staff respectively. When fringe benefits and allowances are included the total remuneration at full capacity production will be ₦ 748 800 per year.

13.3.2 Material and Energy Costs

Material and energy costs for full capacity production are estimated to be ₦ 1 541 000. This comes to ₦ 205.45 per ton of paper produced. Not included in these figures are the overheads for administration, wages and slaries, recurring land charges, interest on loan and

depreciation. The rates of chemicals and utilities, amounts required per year, as well as their total cost are given in table 13.8. Total cost for first five years of production are given in appendix F.

Table 13.8 Production materials and energy costs

ITEM	Unit	Annual Consumption	Unit Price ₦	Total Cost ₦/year
Waste Paper	ton	9 375	100	937 500
Chemicals:-Filler	ton	525	500	262 500
-Binder	ton	75	300	22 500
-Alum	ton	225	600	135 000
-Rosin	ton	20	350	7 000
Utilities:-Electricity	kWh	937 500	0.05	46 900
-Water	m^3	37 500	0.20	7 500
-Fuel	m^3	380	150	57 000
Other consumables	-	-	-	65 000
TOTAL INPUT COSTS				1 540 900

13.3.3 Administrative Over-Head Expenses

This item includes such expenses as are incurred in the day-to-day running of the company. They include stationery, postage, telephone, advertising and medical expenses. During the first year of production (year 3) these expenses come to about ₦ 50 000. A break-down of this figure and figures for succeeding years are given in appendix G.

13.3.4 Other Production Costs

These costs include recurring land charges, interest on long-term loan, interest on short term loan and depreciation.

Recurring land charges amount to ₦ 40 000 per year; this being the land rent for 8 hectares at ₦ 5 000/ha/year.

Interest charges and their payments are listed in appendix H. Highest interest payment is during the third year and decreases progressively in succeeding years until year 9 when it drops to nil, as all debt is repaid.

Depreciation schedule for the assets of the proposed project is based on the straight line method and amounts to ₦ 835 000 per year. The said schedule in appendix I speaks for itself.

13.4 FINANCIAL PLAN

It is proposed that 60% of the project cost will be financed from equity contribution and the remainder from various loans. The overall financial structure will be as follows:

Table 13.9 Initial Sources of Finance

Sources	Contribution (₦)	% of Total
Promotors Equity	7 800 000	60
Long-term loan	3 900 000	30
Short-term loan	1 300 000	10
TOTAL FUNDS	13 000 000	100

Total investment during the first year of operation will be less than 1.5 million Naira. This will rise to 11.5 million at the end of second year and finally to 13 million Naira during the third year. After an initial investment of ₦13 million all external financing will cease and any requirements for more capital will be met from internal resources. Schedule of initial investment in appendix J shows in detail how the investment will rise with time.

The schedule of total funds in appendix K shows the amounts of funds from different sources and when they will become available. Finally the schedule of total assets in appendix L shows the total assets of the company as they are acquired.

13.4.1 Long-Term Loan

The long-term loan of ₦ 3 900 000 will be paid back with six yearly instalments of ₦ 650 000 each. Interest is calculated at 13% on the loan at the start of the year. It is assumed that the loan will have a two year moratorium period with the interest for the first two years to be paid in one instalment at the end of the second year.

13.4.2 Short-Term Loan

In order to strengthen the financial resources and ability to have an adequate working capital, a short-term loan of ₦ 1 300 000 at an interest rate of 13% is envisaged in the third year.

The loan will be paid back in four equal instalments of ₦ 260 000 annually. For details of both long-term and short-term loans refer to the schedule of debt repayment and service charges in appendix H.

13.4.3 Taxation

A five-year tax holiday is assumed and annual income-tax deduction is calculated as 45% of the taxable profit from sixth year of production.

The tax exemption until sixth year of production is assumed in view of the fact that Kano State gives a tax holiday during first five years of production to all pioneer industries. Presently there is no paper manufacturer in Kano State.

Details of the tax are included in the net income statement in appendix N.

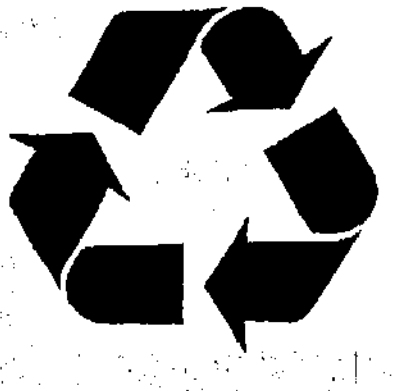
13.5 SALES REVENUE

As stated earlier, the average sale price of paper is expected to be ₦ 900/t. Actually the price will vary from about ₦800 for low-quality high-gsm papers to ₦ 1100 or ₦1200 for high-quality low-gsm papers. These prices compare very favourably with the prices currently obtained in the market.

Revenue expected from the sales at an average rate of ₦ 900/t during first five years of production is as follows:

Table 13.10 Projected income from sales.

YEAR	CAPACITY UTILISATION	PRODUCTION (ton)	SALES REVENUE (₦)
3	60%	4 500	4 050 000
4	80%	6 000	5 400 000
5	100%	7 500	6 750 000
6	100%	7 500	6 750 000
7	100%	7 500	6 750 000



CHAPTER FOURTEEN

ECONOMICS OF THE PROJECT

14.1 FINANCIAL STATEMENTS

14.1.1 Summary of Cash Flows

Financial planning in the form of cash flow tables is done in order to synchronise cash in-flows and out-flows. The table ensures that cash available from sales revenue and other resources will be adequate to cover production costs and all financial commitments.

Estimates of cash flows for the proposed project are given in appendix M. These estimates, covering first 12 years of operation, show that in year 2 cash out-flows exceed the total cash in-flow by ₦432 000. In spite of this, the cumulative cash balance for all the years (including year 2) is positive; and at the end of year 12 it is ₦22.5 m. A negative cash balance (not cash flow) indicates that the company is indebted and has no capital to operate with.

14.1.2 Net Income Statement

The net income statement is used to compute the net income (or deficit) of the project by periods for the duration of the project. As shown in appendix N, during year 3 (the first year of production) the company makes only ₦117 100 profit. This rises to a maximum of about 3 million Naira in year 7 (the last tax-free year) and drops to ₦1.73 m in year 8.

It rises to ₦1.84 m in year 10, which the company maintains till the last year shown (year 12). The accumulated net profit figures show that by the end of year 12 the company would have made a profit of 19.80 million Naira.

14.1.3 Balance Sheet

A twelve year pro-forma balance sheet, set out in appendix O, gives the total financial picture at annual intervals. Current assets of the company rise from ₦0.54 m in the first year to ₦23.42 m in year 12. During the same period the total assets of the company increase from ₦2.0 million to ₦27.90 million.

The balance sheet also shows that the accumulated reserves in bank rise from zero to over 10.75 million Naira within five years of production, and by the end of year 12 the company is expected to have a cash balance of ₦22 451 700.

14.2 FINANCIAL EVALUATION

14.2.1 Net Present Value

Net present value (NPV) of a project is defined as the value obtained by discounting, separately for each year, the difference of all cash out-flows and in-flows accruing throughout the life of a project at a fixed pre-determined interest rate. If the NPV is found to be positive then the profitability of the investment is above the cut-off discount rate and thus the project can be considered acceptable. Otherwise, the project should be dropped.

A discount rate of 13% has been used in appendix P to prepare the cash-flow table for NPV of the project. It is assumed that the project will have a lifespan of only 12 years and salvage value of the machinery will be 25% of the cost price. Overall salvage value of fixed investment and working capital will be ₦4 414 000.

Appendix P shows that the NPV of the project is ₦4 012 900 and the present value of the investment (PVI) is ₦6 312 200. These figures give a very favourable net present value ratio (NPVR) of 64.3%.

14.2.2 Internal Rate of Return

The internal rate of return (IRR) is the discount rate at which the present value of cash inflows is equal to cash out-flows; in other words, it is the discount rate at which the NPV of total cash flows is equal to zero.

A computer program, given in appendix Q, was used to try different values of discount rate and print the value for which Net Present Value of all the cash flows (over the entire assumed life of the project) is equal to zero. IRR was thus found to be 23.69%.

14.2.3 Pay-Back Period

The pay-back period is defined as the period after start-up required to recuperate the original investment outlay through the profits earned by the project; "profit" is defined as profit after tax (PAT) and adding financial cost and depreciation.

The payback period, as shown in table 14.1, is 3.77 years.

Table 14.1: Determination of pay-back period

Year of Production	Profit (Thousand ₦)	Balance at the end of year (thousand ₦)
-	-	13 000.0
1	2 200.8	10 799.2
2	3 310.9	7 488.3
3	4 280.5	3 207.8
4	4 188.8	-

14.2.4 Break-even Analysis

Break even analysis determines the break-even point (BEP). This is the point at which sales revenues equal production costs. For our analysis, the following assumptions are made:

- Year 5 is a typical year.
- Only raw materials and utility requirements vary in proportion to production volume.
- Wages, salaries, maintenance costs, overheads, depreciation and interest costs remain fixed for all production volumes.
- Production volume equals sales volume.

Employing these assumptions fixed cost is found to be ₦2 386 100 and the variable cost is ₦196.79/ton of paper. Writing X for production (or sales) volume at BEP, F for fixed cost, P for unit sale price and V for unit variable cost, the following expression is derived (UNIDO, 1978):

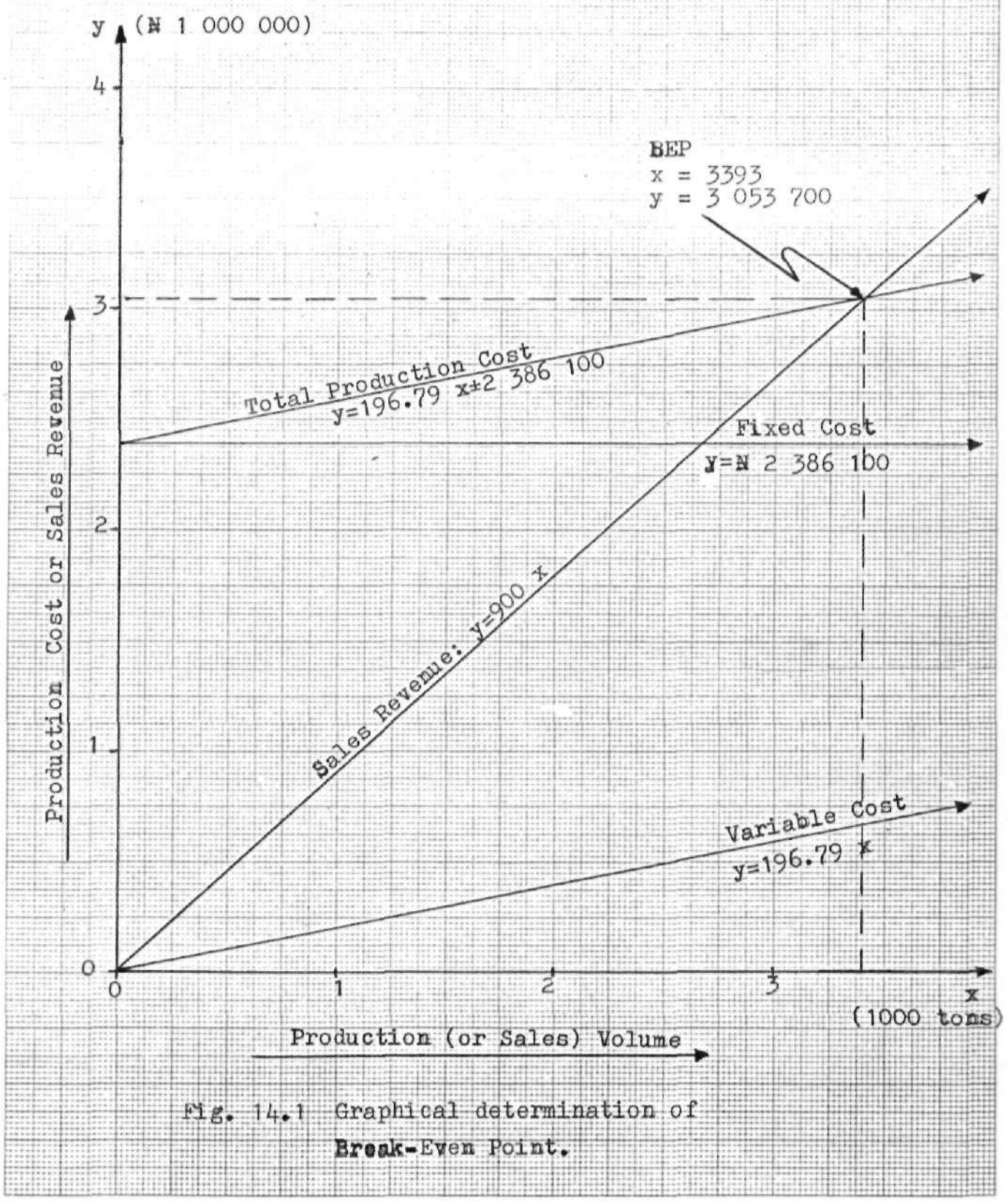


Fig. 14.1 Graphical determination of Break-Even Point.

METRIC

$$X = \frac{F}{P-V}$$

where: F = ₦ 2 386 100.00

P = ₦ 900.00

and V = ₦ 196.79

The BEP obtained from this expression, and confirmed graphically, is 3 393 tons. This means that the total production cost for 3 393 tons of paper would be the same as its sales value. This figure represents 45.2% of installed capacity. Graphical determination of BEP is shown in fig. 14.1.

14.3 PROFITS AND RETURNS ON INVESTMENT

Table 14.2 gives a summary of the project finances and important financial ratios. The figures for sales revenue, operating cost and profits refer to year 5, the first year of full capacity production.

Table 14.2: Profits, Returns and Ratios

No.	ITEM	UNIT	VALUE
1	Total Investment	Thousand ₦	13 000.0
2	Equity Contribution	" "	7 800.0
3	Loans Contribution	" "	5 200.0
4	Leverage Factor	%	40.0
5	Sales Income	Thousand ₦	6 750.0
6	Operating Cost	" "	2 469.5
7	Profit before interest and depreciation	" "	4 280.5
8	Return on Investment	%	32.9
9	Depreciation and Interest	Thousand ₦	1 392.5
10	Profit after interest and depreciation	" "	2 888.0
11	Return on Equity	%	37.0
12	Net Present Value	Thousand ₦	4 012.9
13	Present Value of Investment	" "	6 312.0
14	Net Present Value Ratio	%	63.6
15	Internal Rate of Return	%	23.69
16	Pay-Back Period	Years	3.77
17	Break Even Point	ton	3 393
		%	45.2



CHAPTER FIFTEEN

CONCLUSION

15.1 CONCLUDING COMMENTS

In this exploration of the feasibility of waste paper recycling in Kano an important aspect of raw material availability has not been treated in detail. This is the collection and handling of waste paper at the site of generation and then the organization for its transport to the plant.

According to Quimby (1975) paper residuals can be successfully recycled back to the products from which they were generated if these are kept separate from other residuals. Some residuals (e.g. tin and iron) can be recycled following mixed collection and separation by mechanical means. Paper residuals, on the other hand, lose high-grade qualities on being mixed with other residuals and are not mechanically separable by current techniques. This means that a system for separate storage at the site of generation and separate collection needs to be designed and implemented for better recycling.

The proposed waste paper recycling plant may be sited at any location where raw materials, utilities, transport, market, accommodation and facilities for effluent disposal are available. Industrial areas on the outskirts of large towns (eg: Kaduna and Jos) usually meet the above-mentioned requirements and will be quite appropriate for suitably sized paper recycling plants.

Advantages of such recycling plants will be:

- Reduced environmental pollution
- Reduced garbage disposal costs
- Increased employment
- Training of manpower
- Savings in foreign exchange
- Saving of national forest reserves
- Financial gain from trash.

All these will lead to improved health and a raised standard of living.

15.2 SUGGESTIONS FOR FURTHER WORK

It is recommended that this report should be carefully studied and, if necessary, modified so as to make it more presentable commercially.

Individual financiers and governments should be approached and advised to undertake this project for every one's benefit.

Legislations should be enacted that will discourage large scale dumping of waste-paper and encourage households to dispose paper at selected special places.

More research should be conducted to locally obtain and purify the required chemical additives such as alum, rosin, binders and fillers. Alternative sources of fibres for paper making should be investigated.

BIBLIOGRAPHY

ABUBAKAR, S. 1976. A study of the possibilities of using hardwoods in paper manufacture. Unpublished B.Sc. Industrial Chemistry Thesis. Ahmadu Bello University, Zaria, Nigeria.

ADEDAYO, S. 1981. Feasibility of refuse incineration in ABU Zaria. Unpublished B.Eng. Mechanical Engineering Thesis, ABU, Zaria.

ADHIKIRI, A.D. 1979. Strategies for developing pulp and paper industries in developing countries. In: UNIDO, 1979. pp. 53-65.

ANONYMOUS. 1984. Industrialists frown at new customs duty rates. Business Times. 24 Dec. 1984.

ANONYMOUS. 1985 a. Concern over future of paper industry. Guardian, 25 Jan. 1985.

ANONYMOUS. 1985 b. Advertisement. New Nigerian, 11 Apr. 1985

ANONYMOUS. 1985 c. 1985 import license approvals. New Nigerian, 25 Apr. 1985, p.3.

ANONYMOUS. 1985 d. Population estimate. New Nigerian. 24 May 1985.

ANONYMOUS. 1985 e. Waste disposal could cost ₦1.6 b a year by 2,000. New Nigerian, 22 July, 1985, pp. 1,3.

ANONYMOUS. 1985 f. Mechanical bush clearing is harmful. New Nigerian, 29 July 1985, p. 9.

ANONYMOUS. 1985 g. Duba wants gypsum deposit explored. New Nigerian, 9 Aug. 1985, p. 16.

ANONYMOUS. 1986 a. WRECA increases water supply. Triumph, 10 Jan. 1986.

ANONYMOUS. 1986 b. Newsprint firm starts business soon. National Concord, 8 March 1986, p.1.

ANONYMOUS. 1986 c. Iwopin Mill: Neglect we can't afford. Sunday Times, 18 May 1986, p.18.

ATTWOOD, D. 1979. The search for an appropriate technology for the paper and board industry of the United Kingdom. In: UNIDO, 1979, pp. 78-80.

BAYLISS, M. and REID, S. 1981. Annual review. In: Pulp and Paper, Oct. 1981, pp. 57-60.

BERGSTROM. Undated. Bergstrom primer on recycling. In: Saltman, 1978, pp. 207-214.

BIRLA. Undated. Unpublished instruction manuals for Orient Paper Mills Ltd. Volumes 1, 2 & 3.

BOLAJI, S.B. 1975. Research in sizing aspects of the paper making Process. Unpublished M.Sc. Chemistry Thesis, ABU ZARIA.

BUGAJE, I.M. 1980. An investigation on the effect of oxidised cassava starch addition and the degree of milling (beating) on the optical and surface properties of paper. Unpublished B.Eng. Chemical Engineering Thesis, ABU Zaria.

CASEY, J.P. 1980 a. Pulp and paper, vol. 1. J. Wiley & Sons, New York

CASEY, J.P. 1980 b. Pulp and paper, vol. 2. J. Wiley & Sons, New York.

CLARK, J.A. 1978. Pulp technology and treatment for paper. Miller Freeman Publications, San Francisco.

COMMONWEALTH. 1978. Paper production: Prospects for Commonwealth developing countries. Commonwealth Secretariat, London. pp. 20-21, 26.

EGOL, L. 1982. Pulp for paper: A growth industry. In: National Development, June-July 1982, pp. 105-114.

ESCOLANO, J.O. and TAMOLANG, F.N. 1979. Appropriate industrial technology: Application in pulp and paper industry in the Philippines. In: UNIDO, 1979, pp. 30-35

FAO: 1977. World pulp and paper: demand, supply and trade - 1 FAO Forestry paper 4/1, Food and Agriculture Organisation, Rome.

FAO. 1980 Pulp and paper capacities: survey 1979-1984. Food and Agriculture Organisation, Rome.

FAO. 1982 Pulp and paper capacities: survey 1981 - 1986. Food and Agriculture Organisation, Rome.

FAO. 1983 Establishing pulp and paper mills: A guide for developing countries. FAO Forestry paper 45. Food and Agriculture Organisation, Rome.

FAO. 1985 World pulp and paper industry. Food and Agriculture Organisation, Rome.

FELTON, A.J. 1978. Secondary fibre technology: 1974. Tappi, vol. 58, No. 4, April 1975, pp. 78-83. In: Commonwealth, 1978.

FMED. 1975. Third National Development Plan 1975-1980. Federal Ministry of Economic Development, Lagos.

FMNP. 1981. Fourth National Development Plan 1981-1986. Federal Ministry of National Planning, Lagos.

FORSYTHE, J.J. 1972. Recycling of paper. Tappi, vol. 55. No. 5, May 1972, pp. 679-690. In: Commonwealth, 1978.

FOS. 1982 a. Annual abstrat of statistics 1981. Federal Office of Statistics, Lagos.

FOS. 1982 b. Nigeria trade summary 1981, pp. 93-97 Federal Office of Statistics, Lagos.

GOLDSTEIN, J. 1979. Recycling. Shocken Books, New York.

HORN, R.A. 1975. Paper Trade Journal, 159(7): 78, 17 Feb. 1975. In: Clark, 1978.

IPPTA. 1978. Indian Pulp and Paper Technical Association; Fourteenth annual general meeting and seminar in trends in engineering and technical development in pulp and paper industry at New Delhi on 27th and 28th March, 1978.

JWPA. Undated. Collection and reuse of waste paper. In: Japan waste paper association report. Tokyo.

KESWANI, S.L. 1983. Use of second-hand paper machines in developing countries. In: FAO, 1983. pp. 30-37.

LAVIGNE, J.R. 1979. Instrumentation application for pulp and paper industry, Miller Freeman Publications, San Francisco.

LLOYDS, 1984. Britain: The economy in figures, Lloyds Bank,London

MAHANTA, D. and CHALIHA, B.P. 1978. Trends in technological developments in pulp and paper industry. In: IPPTA, 1978. pp. 55-61.

McDONALD, R.G. and FRANKLIN, J.N. 1983. Pulp and paper manufacture. vol. II: Control, secondary fibre, structural board, coating. McGraw Hill, New York, pp. 107-122, 394-443.

McGILL, R.J. 1980. Measurement and control in paper making. Adam Hilger, Bristol, UK

McKEE, R.C. 1971. Paper Trade Journal, 155(21): 35, 24 May 1971. In: Clark, 1978.

MIDLAND. 1985. Forecasts for the UK economy. In: Midland Bank Review, Winter, 1985, p.4. Midland Bank, London.

MOORTHY, V.L. 1979. The experience of a developing country of Africa. In: UNIDO, 1979. pp. 43-52

NORTON, A. 1976. A waste paper study. Paper, vol. 185, No. 9, 10 May 1976, pp. 524, 526-527. In: Commonwealth, 1978.

NPM, 1981. Aspiring to greater heights. Nigerian Paper Mill Ltd., Jebba, Kwara State, Nigeria.

ORTNER, H.O. 1966. Present technical state of secondary fibre regeneration. Voith Paper Co. USA.

QUIMBY, T.H.E. 1975. Recycling: The alternative to disposal. Johns Hopkins University Press, Baltimore, USA.

RAIT, M. 1983. PPI Annual Review - July 1983. In: Pulp and paper international, 25 July 1983, pp. 134, 135

SALTMAN, D. 1978. Paper Basics. Van Nostrand, New York

SITTIG, M. 1981. Organic and polymer waste reclaiming encyclopedia. Noyes Data Corp. New Jersey.

SMYTHE, W.H. 1978. Future trends in paper making process. In: Ippta, 1978. pp. 124-125.

UN, 1981. 1980 year book of international trade statistics, p. 718. United Nations, New York.

UNIDO, 1978. Manual for the preparation of feasibility studies, ID/206 pp. 184-186 United Nations Industrial Development Organisation, New York.

UNIDO, 1979. Appropriate industrial technology for paper products and small pulp mills. Appropriate industrial technology No. 3. United Nations Industrial Development Organisation, New York.

VOITH. Undated. VOITH Secondary Fibre Regeneration. Voith Morden paper Co. USA.

WESTERN, A. 1979. Paper, paper products and pulp mills. In: UNIDO, 1979. pp. 108-122

EBIARY, M.A.El- The pulp and paper industry in Egypt. In: UNIDO, 1979. pp. 36-42.

APPENDIX A

DEFINITIONS OF PAPER AND PAPERBOARD

No.	Grade	Definition
1	Newsprint	Uncoated paper, unsized (or only slightly sized), containing at least 65% mechanical or thermo mechanical wood pulp, of the type used mainly for the printing of newspapers, usually weighing not less than 40 g/m2 and generally not more than 57 g/m2.
2	Other printing and writing paper	Paper, except newsprint, suitable for printing, writing or other graphic purposes, made from a variety of pulp blends and with various finishes.
2.1	Coated	Printing and writing papers, except newsprint, which have been coated on one or both sides with coating materials such as clay, barium sulphate, gypsum or zinc oxide, often supplemented with supercalendering, etc.
2.2	Uncoated	Printing and writing papers, except newsprint, which have been subjected to sizing, calendering, super-calendering, glazing, water marking or similar simple finishing processes, but not to coating.
3	Household and sanitary paper	Absorbent paper, creped or uncreped, sometimes embossed, made from bleached or unbleached pulps, waste paper or combination of these. This type of paper should be sufficiently strong to avoid disintegration or tearing in use. Other important characteristics are high absorptive capacity, retention of absorbed fluids, softness, freedom from lint and unpleasant odours. It is made in white and a variety of colours and in single, double or more plies.
4	Wrapping and packaging paper and paperboard	Paper and paperboard designed for wrapping and packaging purposes made from pulps, waste paper and any combination of these.

No.	Grade	Definition
4.1	Linerboard	Paperboard made either from sulphate pulp (unbleached or bleached) or principally from waste paper used as facing material on corrugated or solid paper or paperboard boxes and containers such as Kraft liner. Linerboard made wholly or principally of bleached or unbleached sulphate pulp Other linerboard. Linerboard other than Kraft liner
4.2	Fluting medium	Paper or paperboard used mainly as a corrugating medium in the production of corrugated board. It may be produced wholly or principally from semi-chemical wood pulp or from other materials.
4.3	Kraft wrapping and packaging paper	All other papers made wholly or principally from bleached and unbleached sulphate pulp used in the manufacture of single or multi-wall sacks or for other wrapping and packaging purposes.
4.4	Folding boxboard	Paperboard with good stiffness, scoring and folding characteristics. These paperboards are made from pulp, waste paper or any combination of these. They may be plain or coloured throughout the mass, solid, single or multi-ply, coated or uncoated. They include folding, milk carton and food service boxboard.
4.5	Other wrapping and packaging paper and paperboard	Paper and paperboard designed for wrapping and packaging purposes, not included elsewhere.
5.0	Other paper and paper-board, not elsewhere specified	Paper and paperboard not used for packaging purposes manufactured principally from furnishes other than sulphate pulp and not included elsewhere

No.	Grade	Definition
5.1	Paper	Papers such as: Special thin paper carbonising tissue condenser and capacitor paper electrical paper and tissue cigarette paper lens tissue stencil tissue pattern tissue tea bag paper Kraft paper used for waxing, asphalting, water-proofing, laminating, impregnating, spinning or twisting, gumming, etc. All other grades of paper not included under earlier headings
5.2	Paperboard	Paperboards not included elsewhere, such as: Construction paper and paperboard All other grades of paperboard not included under earlier headings.

APPENDIX B

AHMADU BELLO UNIVERSITY ZARIA

DEPARTMENT OF MECHANICAL ENGINEERING

Market Survey Questionaire

Study of Paper Consumption and Waste Paper Generation

Please answer the following questions on the attached sheets. You may keep the covering letter and these questions for record purposes.

A. 1. Respondent's name and position
   2. Name of business and address
   3. Business activity
   4. Approximate annual turnover

B. 1. What types of papers and paper-boards do you use?
   2. What is your average annual consumption of various types of paper and board (P & B)?
   3. What do you use your P & B for?
   4. Kindly name your sources of supply in the order of importance to you
   5. Please state the approximate cost per ton of P & B you use
   6. What is the design capacity of your plant?
   7. Do your suppliers always meet your demand for P & B? If "no" then indicate the time of the year when your demand exceeds your supply and the approximate shortfall.
   8. Do you face any problems concerning P & B apart from insufficient supply? Please describe briefly.
   9. Does your supply of P & B contain any recycled fibre? If "yes" then to what extent?

C. 1. How much waste paper (w.p) do you generate annually?

2. What is the method of its disposal? If it is sold then how and at what rate?

3. Who buys this w.p from you?

4. Please name the contaminants in your w.p. and the extent to which they contaminate it.

5. Do you have a baling machine for w.p? If "yes" then what is its capacity.

D. 1. Any useful suggestions that may be passed-on to a paper manufacturer?

2. Please feel free to write any other comments.

THANK YOU

APPENDIX C

SOME LARGE PAPER CONSUMERS

PAPER CONVERTERS

NAME	LOCATION
Apex Mill*	Kaduna
Dan Zaki Paper Mill*	Kano
Easy Pack (Nig.) Ltd.*	Kano
JOAH-CO Nigeria Ltd*	Kano
New Nigerian Packaging Co.	Kaduna
Nigerian Stationery Factory	Kano
Nasco Pack	Jos
Rigidpack Containers	Zaria
Star Modern Paper Mill	Kano
Tofa General Enterprises	Kano
Triumph Packaging Co.	Kano

* No reply up to August 1986

PAPER USERS

NAME	LOCATION
Al-Hilal Group of Companies	Kano
Akwa Minerals	Kano
Bagauda Biscuit	Kano
Bata Shoe Co.	Kano
Chettalas Brothers	Kano
Crescent Shoe Nig.	Kano
Fan Ice	Kano
Iya Abubakar Computer Centre	Zaria
Kajawai Com. & Construction Co.	Kano
Kano Suit and Packaging Cases Factory	Kano
Kaura Biscuits and Macaroni Factory	Kano
Leventis Technical	Kano
Nicco Sweets	Kano
Nigerian Brewery Ltd	Kano
Nigerian Engineering Works	Kano
Rabiu Bottling Co.	Kano
Riviera Biscuits	Kano
Triumph Publishing	Kano

APPENDIX D

PAPER IMPORTS AND PRODUCTION

Imports and production of paper and paper board in Nigeria during the year 1981.

Types of Papers	Imports (ton)	Production (ton)
Newsprint	14 637.088	0
Other printing writing papers	84 298.161	1167
Kraft(Paper & Board)	42 705.578	8166
Cigarette Papers	265.677	0
Other m/c made papers	26 637.498	3500
Pulp based building boards	4 229.523	1167
Hand made papers	2 439.075	0
Other Papers and Board	26 821.715	0
TOTAL	202 034.315	14 000

APPENDIX E

SCHEDULE OF OPERATING CAPITAL

Determination of Operating Capital
(Thousand ₦)

	X	Y	Cash Requirement (₦ Thousand)				
			Start-up years		Full capacity years		
	Days of Coverage	Coefficient	3	4	5	6	7
			60%	80%	100%	100%	100%
CURRENT ASSETS							
- Accounts receivable	15	24	168.8	225.0	281.3	281.3	281.3
- Inventory-Waste Paper	90	4	112.5	187.5	234.4	234.4	234.4
-Chemicals	120	3	85.4	113.9	143.3	143.3	243.3
-Spares/consumables	180	2	32.5	32.5	32.5	32.5	32.5
-Finished Product	15	24	77.1	87.0	102.9	106.7	106.9
- Required cash-in-hand(line No. 5)	30	12	163.8	132.0	129.3	127.1	117.6
- Contingency cash-in-hand	-	-	25.9	38.9	46.3	44.7	54.0
1. TOTAL Operating Capital	-	-	666.0	816.8	970.0	970.0	970.0
Less: Current Liabilities (accounts payable)	-	-	-	150.8	304.0	304.0	304.0
2. NET OPERATING CAPITAL	-	-	666.0	666.0	666.0	666.0	666.0
3. Increase in Operating Capital	-	-	666.0	-	-	-	-
4. Increase in current assets	-	-	666.0	150.8	153.2	-	-
Calculation of required cash balance							
TOTAL Production costs	-	-	3932.9	3599.9	3862.0	3835.4	3721.0
Less: Raw materials	-	-	1066.2	1091.6	1364.2	1364.2	1364.2
Utilities	-	-	66.9	89.1	111.4	111.4	111.4
Depreciation	-	-	834.8	834.8	834.8	834.8	834.8
TOTAL	-	-	1965.0	1584.4	1551.6	1525.0	1410.6
5. Required Cash Balance	30	12	163.8	132.0	129.3	127.1	117.6

APPENDIX F

SCHEDULE OF PRODUCTION COSTS

Annual Production Cost Estimates
(Thousand ₦)

PERIOD	START-UP		FULL CAPACITY PRODUCTION		
PRODUCTION PROGRAM	60%	80%	100%		
YEAR	3	4	5	6	7
1. RAW MATERIALS - Pulp	360.0	-	-	-	-
- Waste paper	450.0	750.0	937.5	937.5	937.5
- Filler	157.5	210.0	262.5	262.5	262.5
- Binder	13.5	18.0	22.5	22.5	22.5
- Alum	81.0	108.0	135.0	135.0	135.0
- Rosih	4.2	5.6	7.0	7.0	7.0
TOTAL Raw Materials	1066.2	1091.6	1364.5	1.364.5	1.364.5
2. UTILITIES - Electricity	28.2	37.5	46.9	46.9	46.9
- Water	4.5	6.0	7.5	7.5	7.5
- Fuel	34.2	45.6	57.0	57.0	57.0
TOTAL Utilities	66.9	89.1	111.4	111.4	111.4
3. TOOLS AND MAINTENANCE MATERIALS	65.0	65.0	65.0	65.0	65.0
4. WAGES AND OVERHEADS					
- Wages and salaries	561.6	746.9	825.6	866.8	910.2
- Administrative Overheads	49.5	56.5	63.0	68.5	74.0
- Land Leasehold	40.0	40.0	40.0	40.0	40.0
TOTAL Wages and overheads	651.1	843.4	928.6	975.3	1024.2
TOTAL OPERATING COST	1849.2	2089.1	2469.5	2561.2	2565.1
5. DEPRECIATION AND INTEREST					
- Depreciation	834.8	834.8	834.8	834.8	834.8
- Interest	1248.9	676.0	557.7	439.4	321.1
TOTAL Depreciation and Interest	2083.7	1510.8	1392.5	1274.2	1155.9
TOTAL PRODUCTION COSTS	3932.9	3599.9	3862.0	3835.4	3721.0

APPENDIX G

SCHEDULE OF ADMINISTRATIVE OVERHEADS

ADMINISTRATIVE OVERHEAD EXPENSES

	YEAR OF BUSINESS				
	1	2	3	4	5
	₦	₦	₦	₦	₦
1. Stationery and office equipment	4 000	4 500	5 000	5 500	7 000
2. Postage, Telephone and Telex	3 000	3 500	4 000	4 500	5 000
3. Electricity & Water	2 000	3 000	3 500	4 000	4 500
4. Travelling	5 000	6 000	6 500	7 000	7 500
5. Welfare & Medical	7 500	8 500	10 000	10 500	11 000
6. Advertisement	8 000	9 000	10 000	10 500	11 000
7. Other Expenses	20 000	22 000	24 000	26 000	28 000
TOTAL	49 500	56 500	63 000	68 000	74 000

APPENDIX H

PROJECTED DEBT REPAYMENT AND SERVICE CHARGES SCHEDULE

(At 13% Interest charge per year)
(Thousand ₦)

Period	Construction		Start-up		Full Capacity Production					
Year	1	2	3	4	5	6	7	8	9	10
LONG TERM LOAN										
Loan at the start of year	-	3900.0	3900.0	3900.0	3250.0	2600.0	1950.0	1300.0	650.0	-
Principal repayment during the year	-	-	-	650.0	650.0	650.0	650.0	650.0	650.0	-
Loan at the end of the year	-	3900.0	3900.0	3250.0	2600.0	1950.0	1300.0	650.0	-	-
Interest during the year	-	507.0	572.9	507.0	422.5	338.0	253.5	169.0	84.5	-
TOTAL Disbursement (in respect of long term loan)	-	-	1079.9	1157.0	1072.5	988.0	903.5	819.0	734.5	-
SHORT-TERM LOAN										
Loan at the start of year	-	-	1300.0	1300.0	1040.0	780.0	520.0	260.0	-	-
Principal repayment during the year	-	-	-	260.0	260.0	260.0	260.0	260.0	-	-
Loan at the end of year	-	-	1300.0	1040.0	780.0	520.0	260.0	-	-	-
Interest during the year	-	-	169.0	169.0	135.2	101.4	67.6	33.8	-	-
TOTAL Disbursement (in respect of short-term loan)	-	-	169.00	429.0	395.2	361.4	327.6	293.8	-	-
TOTAL Debt repayment during the year	-	-	-	910.0	910.0	910.0	910.0	910.0	650.0	
TOTAL Interest payment during the year	-	-	1248.9	676.0	557.7	439.4	321.1	202.8	84.5	-
TOTAL Disbursement during the year	-	-	1248.9	1586.0	1467.7	1349.4	1231.1	1112.8	734.5	-

TOTAL DEBT REPAID = 5200.0

TOTAL INTEREST PAID = 3530.4

TOTAL = 8730.4

APPENDIX I

SCHEDULE OF DEPRECIATION

ANNUAL DEPRECIATION

ITEM	Investment Cost (₦)	Estimate Lifespan	Salvage value (₦)	Annual Depreciation (₦)
Civil Works	2 174 000	10 years	1 388 000	78 600
Machinery & Prod. Equipment	9 438 000	10 years	2 360 000	707 800
Vehicles	242 000	5 years	-	48 400
TOTAL				834 800

APPENDIX J

SCHEDULE OF INVESTMENT

TOTAL INITIAL INVESTMENT

(Thousand ₦)

ITEM \ YEAR	1	2	3	4	TOTAL
Land and Land Development	202	40		-	242
Building and Civil Works	1 000	732	200	-	1 932
Machinery and Equipment	100	9 000	338	-	9 438
Motor Vehicles	42	-	200	-	242
Pre-Prod. Capital Expenses	120	360	-	-	480
Operating Capital	-	-	666	-	666
TOTAL	1 464	10 132	1 404	-	13 000

APPENDIX K

SCHEDULE OF TOTAL FUNDS

SOURCES OF FUNDS

(Thousand ₦)

ITEM / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Equity Capital	2 000	5 800	-	-	-	-	-	-	-	-	-	-	7 800
Long-Term Loan	-	3 900	-	-	-	-	-	-	-	-	-	-	3 900
Short-Term Loan	-	-	1 300	-	-	-	-	-	-	-	-	-	1 300
Current Liabilities(Increase)	-	-	-	150.8	153.2	-	-	-	-	-	-	-	304
Reserves	-	-	-	-	-	-	-	500	-	-	-	-	500
TOTAL FUNDS	2 000	9 700	1 300	150.8	153.2	-	-	500	-	-	-	-	13 804

APPENDIX L

SCHEDULE OF TOTAL ASSETS

TOTAL ASSETS

(Thousand ₦)

ITEM / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Fixed Investment													
- Initial Fixed Investment	1 344	9 772	738	-	-	-	-	-	-	-	-	-	11 854
- Replacement	-	-	-	-	-	-	-	500	-	-	-	-	500
Pre-Prod. Expenses	120	360	-	-	-	-	-	-	-	-	-	-	480
Current Assets(increase)	-	-	666	150.8	153.2	-	-	-	-	-	-	-	970
TOTAL ASSETS	1 464	10 132	1 404	150.8	153.2	-	-	500	-	-	-	-	13 804

APPENDIX M

CASH FLOW TABLE FOR FINANCIAL PLANNING
(₦ Thousand)

Period	Construction		Start-up		Full Capacity Production								SALVAGE VALUE	TOTAL
Year	1	2	3	4	5	6	7	8	9	10	11	12		
CASH IN-FLOW														
- Financial Resources	2000.00	9700.0	1300.0	150.8	153.2	-	-	-	-	-	-	-	-	13304.0
- Sales Revenue	-	-	4050.0	5400.0	6750.0	6750	6750	6750	6750	6750	6750	6750	-	63450.0
Total Cash in-flow	2000.0	9700.0	5350.0	5550.8	6903.2	6750	6750	6750	6750	6750	6750	6750	-	76754.0
CASH OUT-FLOW														
-Assets	1464	10132.0	1404.0	150.8	153.2	-	-	500.0	-	-	-	-	4414.0	9390.0
- Operating Cost	-	-	1849.2	2089.1	2469.5	2561.2	2565.1	2565.1	2565.1	2565.1	2565.1	2565.1	-	24359.6
- Debt Service	-	-	1248.9	1586.0	1467.7	1349.4	1231.1	1.112.8	734.5	-	-	-	-	8730.4
-Corporate tax	-	-	-	-	-	-	-	1416.3	1469.5	1507.5	1507.5	1507.5	-	7408.3
Total Cash out-flow	1464	10132.0	4502.1	3825.9	4090.4	3910.6	3796.2	5594.2	4769.1	4072.6	4072.6	4072.6	4414.0	49888.3
NET CASH FLOW	536.0	-432.0	847.9	1724.9	2812.8	2839.4	2953.8	1155.8	1980.9	2677.4	2677.4	2677.4	4414.0	26865.7
CUMULATIVE CASH BALANCE	536.0	104.0	951.9	2676.8	5489.6	8329.0	11282.8	12438.6	14419.5	17096.9	19774.3	22451.7	26865.7	

APPENDIX N

NET INCOME STATEMENT
(Thousand ₦)

Period			Full Capacity Production							
Year	3	4	5	6	7	8	9	10	11	12
Production Program (%)	60	80	100	100	100	100	100	100	100	100
1. Sales Revenue	4050.0	5400.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0
2. Production cost	3932.9	3599.9	3862.0	3835.4	3721.0	3602.7	3484.4	3399.9	3399.9	3399.9
3. Gross taxable profit	117.1	1800.1	2888.0	2914.6	3029.0	3147.3	3265.6	3350.1	3350.1	3350.1
4. Corporate tax	-	-	-	-	-	1416.3	1469.5	1507.5	1507.5	1507.5
5. P.A.T.(Net operating Profit)	117.1	1800.1	2888.0	2914.6	3029.0	1731.0	1796.1	1842.6	1842.6	1842.6
6. Accumulated Net Profit (Reserve)	117.1	1917.2	4805.2	7719.8	10748.8	12479.8	14275.9	16118.5	17961.1	19803.7

APPENDIX O

PROJECTED BALANCE SHEET
(Thousand ₦)

Period	Construction		Start-up		Full Capacity Production							
Year	1	2	3	4	5	6	7	8	9	10	11	12
ASSETS												
1. Current Assets												
a. Cash balance	536.0	104.0	951.9	2676.8	5489.6	8329.0	11282.8	12438.6	14419.5	17096.9	19774.3	22451.7
b. Working capital	-	-	666.0	816.8	970.0	970.0	970.0	970.0	970.0	970.0	970.0	970.0
2. Fixed Assets	1464.0	11596.0	11499.2	10664.4	9829.6	8994.8	8160.0	7825.2	6990.4	6155.6	5320.8	4486.0
TOTAL ASSETS	2000.0	11700.0	13117.1	14158.0	16289.2	18293.8	20412.8	21233.8	22379.9	24222.5	26065.1	27907.7
LIABILITIES												
1. Current Liability	-	-	-	150.8	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0
2. Long-term loan	-	3900.0	3900.0	3250.0	2600.0	1950.0	1300.0	650.0	-	-	-	-
3. Short-term loan	-	-	1300.0	1040.0	780.0	520.0	260.0	-	-	-	-	-
4. Equity capital	2000.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0	7800.0
5. Reserves	-	-	117.1	1917.2	4805.2	7719.8	10748.8	12479.8	14275.9	16118.5	17961.1	19803.7
TOTAL LIABILITIES	2000.0	11700.0	13117.1	14158.0	16289.2	18293.8	20412.8	21233.8	22379.9	24222.5	26065.1	27907.7

APPENDIX P

CASH FLOW TABLE FOR NPV OF PROJECT
(Thousand M)

Period	CONSTRUCTION		START-UP		FULL CAPACITY PRODUCTION								Salvage value in year 12	TOTAL
Year	1	2	3	4	5	6	7	8	9	10	11	12		
A. CASH IN-FLOWS														
1. Sales Revenue	-	-	4050.0	5400.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0	6750.0	-	63450.0
B. CASH OUT-FLOWS													-4414.0	-4414.0
1. Total Investment	2000.0	5800.0	-	-	-	-	-	-	-	-	-	-	-	7800.0
a. Equity Capital	-	-	-	-	-	-	-	500.0	-	-	-	-	-	500.0
b. Replacements	-	-	1248.9	1586.0	1467.7	1349.4	1231.1	1112.8	734.5	-	-	-	-	8664.5
c. Debt service	-	-	1849.2	2089.1	2469.5	2561.2	2565.1	2565.1	2565.1	2565.1	2565.1	2565.1	-	24359.6
2. Operating Cost	-	-	-	-	-	-	-	1253.1	1306.3	1344.3	1344.3	1344.3	-	6592.3
3. Tax	-	-	-	-	-	-	-	-	-	-	-	-	-4414.0	43502.5
TOTAL CASH OUT-FLOW	2000.0	5800.0	3098.1	3675.1	3937.2	3910.6	3796.2	5431.0	4605.9	3909.4	3909.4	3909.4	4414.0	19947.6
C. NET CASH FLOW(A-B)	-2000.0	-5800.0	951.9	1724.9	2812.8	2839.4	2953.8	1319.0	2144.1	2840.6	2840.6	2840.6	1018.3	4012.9
D. PRESENT VALUE AT 13%	-1770.0	-4542.0	659.8	1057.9	1526.8	1363.8	1255.7	496.2	713.8	836.8	740.5	655.3	-	7800.0
E. INVESTMENT	2000.0	5800.0	-	-	-	-	-	-	-	-	-	-	-	6312.2
F. PVI at 13%	1770.0	4542.2	-	-	-	-	-	-	-	-	-	-	-	

APPENDIX Q

The computer programmes listed on following pages are written in the Minnesota version of FORTRAN IV. They were compiled and run on the Control Data CYBER 72-13 computer of Iya Abubakar Computer Centre, Ahmadu Bello University Zaria.

The programme listed on pages 165 and 166 was used to analyse the data on hand-sheets made from different pulps. The results obtained are given on page 166.

The second programme, listed on pages 167 and 168, is made up of two parts. First part of the programme calculates the Net Present Values of the cash flows (by years) for the first 12 years of the project life. The dicount rate is assumed to be 13.00%. Second part of the programme calculates the Internal Rate of Return (IRR) for the project. It determines the discount rate at which the Net Present Value of the project is Zero.

```
C.....THIS PROGRAM READS GSM, BR. WT.,AND TR.ST. FOR PAPERS
C     MADE FROM DIFFERENT PULPS IN DIFFERENT BASIS WEIGHTS. IT
C     THEN CALCULATES AND PRINTS THE GSM AND CORRESPONDING
C     BREAKING WEIGHT, TEAR STRENGTH, BREAKING LENGTH AND
C.....TEAR FACTOR.
      PROGRAM NASIR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
     +  DATA,TAPE7=DATA)
      INTEGER TEAR(7,3),TITLE(2,3),BRLN(7,3),TRFTR(7,3)
      DIMENSION GSM(7,3),BRWT(7,3)
      DATA TITLE/10HPURCHASED ,10HLONG-FIBRE,10HWASTE PAPE,
     +  10HR PULP     ,10HREFINED NP,10HM KRAFT   /
      DO 300 K=1,3
        READ(7,5)
        DO 100 J=1,7
          READ(7,10)GSM(J,K),BRWT(J,K),TEAR(J,K)
100     CONTINUE
        CONST=2.0*1.E5/3.0
        DO 200 J=1,7
          BRLN(J,K)=CONST*BRWT(J,K)/GSM(J,K)
          TRFTR(J,K)=TEAR(J,K)*100.0/GSM(J,K)
200     CONTINUE
300   CONTINUE
C.............PRINT RESULTS.............
      DO 500 K=1,3
        WRITE(6,20)
        WRITE(6,30)(TITLE(J,K),J=1,2)
        WRITE(6,40)
        WRITE(6,50)
        WRITE(6,60)
        DO 400 J=1,7
          WRITE(6,40)
          WRITE(6,80)GSM(J,K),BRWT(J,K),TEAR(J,K),BRLN(J,K),
     +    TRFTR(J,K)
400     CONTINUE
        WRITE(6,40)
500   CONTINUE
C.........FORMAT STATEMENTS.......
  5   FORMAT(6A6)
 10   FORMAT(1X,F5.1,1X,F5.2,1X, I3)
```

```
   20   FORMAT(1H1,//////)
   30   FORMAT(23X,*RESULTS FOR HAND-SHEETS OF *,2A10,/)
   40   FORMAT(20X,56(*-*))
   50   FORMAT(20X,*  GRAMAGE  *,2(*  BREAKING    TEAR    *))
   60   F RMAT(31X,*  WEIGHT     STRENGTH    LENGTH  *,
     +  *  TEAR    *)
   80   FORMAT(23X,F5.1,6X,F5.2,7X,I3,8X,I4,7X,I3,4X)
C.....................THE END.................
        STOP
        END
```

RESULTS FOR HAND-SHEETS OF PURCHASED LONG-FIBRE

GRAMAGE	BREAKING WEIGHT	TEAR STRENGTH	BREAKING LENGTH	TEAR FACTOR
59.1	3.13	69	3530	116
72.3	4.42	84	4075	116
78.6	5.41	92	4588	117
89.2	6.92	117	5171	131
100.8	8.60	123	5687	122
111.2	10.40	150	6235	134
122.3	11.19	145	6099	118

RESULTS FOR HAND-SHEETS OF WASTE PAPER PULP

GRAMAGE	BREAKING WEIGHT	TEAR STRENGTH	BREAKING LENGTH	TEAR FACTOR
60.2	2.27	66	2513	109
69.1	2.99	136	2884	196
78.6	3.81	100	3231	127
89.8	4.86	105	3608	116
100.9	5.96	130	3937	128
108.1	6.93	133	4273	123
120.6	7.99	151	4416	125

RESULTS FOR HAND-SHEETS OF REFINED NPM KRAFT

GRAMAGE	BREAKING WEIGHT	TEAR STRENGTH	BREAKING LENGTH	TEAR FACTOR
58.9	1.28	34	1448	57
72.1	1.81	43	1673	59
79.6	2.19	56	1834	70
91.1	2.75	68	2012	74
99.2	3.23	82	2170	82
108.7	3.86	94	2367	86
117.9	4.49	102	2538	86

```
C.....THIS PROGRAM CALCULATES THE FOLLOWING:
C       -NET PRESENT VALUE OF CASH-FLOWS BY YEARS,
C       -NPV OF PROJECT (12 YEAR LIFE-SPAN), AND
C       -THE INTERNAL RATE OF RETURN.
C.........................
      PROGRAM ANWAR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL INT,INTA,INTB
      DIMENSION CASH(12),STEP(5),PVCF(11),PVIF(12)
      DATA STEP/0.1,0.01,0.001,0.0001,0.00001/
      DATA CASH/-2000.0,-5800.0,951.9,1724.9,2812.8,2839.4,
     + 2953.8,1319.0,2144.1,2840.6,2840.6,7254.6/
C.............
C         .............NET PRESENT VALUE.............
C.............
C     WRITE(6,5)
      INT=0.13
      FACTOR=1.0/(1.0+INT)
      PVIF(1)=FACTOR
      DO 930 N=2,12
        PVIF(N)=PVIF(N-1)*FACTOR
  930 CONTINUE
      PVCF(1)=0.0
      DO 940 N=1,12
        PVAL=PVIF(N)*CASH(N)
        PVCF(1)=PVCF(1)+PVAL
        WRITE(6,20)N,PVAL
  940 CONTINUE
      WRITE(6,30)PVCF(1)
C.............
C         ........INTERNAL RATE OF RETURN.........
C.............
      INT=0.0
      DO 900 K=1,5
        DO 800 M=1,10
          INT=INT+STEP(K)
          FACTOR=1.0/(1.0+INT)
          PVIF(1)=FACTOR
          DO 200 N=2,12
  200     PVIF(N)=PVIF(N-1)*FACTOR
```

```
      PVCF(M+1)=0.0
      DO 300 N=1,12
        PVCF(M+1)=PVCF(M+1)+PVIF(N)*CASH(N)
300   CONTINUE
      V1=PVCF(M)
      V2=PVCF(M+1)
          IF(V1.GT.0..AND.V2.LT-0.)THEN
            INTA=INT-2.0*STEP(K)
            INTB=INT-STEP(K)
            GOTO 900
          ENDIF
800   CONTINUE
  900 CONTINUE
      INTA=INTA*100.0
      INTB=INTB*100.0
      WRITE(6,10)INTB,V2
      WRITE(6,10)INTA,V1
C.....
   20 FORMAT(5X,*P.V. OF CASH-FLOWS FOR YEAR*,I3,* IS*,F8.1)
   30 FORMAT(//5X,*NET PRESENT VALUE OF PROJECT IS*,F8.1//)
   10 FORMAT(5X,*DISCOUNTING AT *,F6.3,* NPV OF CASH FLOWS IS*,
     +  F5.3)
      STOP
      END
```

```
 P.V. OF CASH-FLOWS FOR YEAR  1 IS -1769.9
  "          "          "      2  " -4542.3
  "          "          "      3  "   659.7
  "          "          "      4  "  1057.9
  "          "          "      5  "  1526.7
  "          "          "      6  "  1363.8
  "          "          "      7  "  1255.5
  "          "          "      8  "   496.2
  "          "          "      9  "   713.7
  "          "          "     10  "   836.8
  "          "          "     11  "   740.5
  "          "          "     12  "  1673.7
NET PRESENT VALUE OF THE PROJECT IS  4012.4
DISCOUNTING AT 23.685 NPV OF CASH FLOWS IS  -.083
DISCOUNTING AT 23.684 NPV OF CASH FLOWS IS   .139
```