Paper Making Raw Material Research Using Modern Equipment

By

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In 1975 a joint United Nations Development Programme (UNDP)—Government of India (GOI) Project "Exploration and Identification of Alternative Raw Materials for Paper and Newsprint Manufacture" was commenced. The funds for the international component are provided by UNDP, while the executing agency is the Food and Agriculture Organization of the United Nations (FAO). On the Government of India side, the Ministry of Industries through Hindustan Paper Corporation Ltd. (HPC) is the cooperating agency. The project is essentially a research project. The paper presented gives the particulars of the laboratory and pilot plant equipment provided by the project and discusses the methods used in investigation of papermaking raw materials iu the project's laboratorys and pilot plant.

Introduction

Bamboo, the traditional papermaking raw material in India is fast depleting and the further expansion of the India pulp and paper industry is to be based on hardwoods and on agricultural residues, mainly bagasse. The Manufacture of writing and printing papers from bagasse is a well-established technology. Two bagasse paper mills were built in India using the Pandia continuous digester Bagasse pulping was discontinued in one of the mills due to difficulties in bagasse procurement, but the other one. Mandya National paper Mill is manufacturing writing and printing papers utilizing upto 90% bagasse pulp in the furnish. It is evidents that writing and printing papermaking from bagasse is virtually a problem of bagasse supplies.

Different is the situation with regard to utilization of tropical hardwoods in papermaking. In the past 30 years, papermaking from hardwoods was developed in Australia (1) and Japan. High grace printing papers containing 70-80% bleadhed kraft hardwood pulp and 20-30% softwood pulp as well as medium grade writing papers containing bleached kraft hardwood pulp only are manufactured successfully. However, it is not possible to use this technology in Indian conditions without future research and development. In contrast to bagasse, which is fairly uniform in regard to papermaking properties in various countries, hardwoods differ extremely from region to region. Generally, temperature zone hardwoods are more suitable for papermaking than tropical species. A tropical forest is extremely complex, includes many species which are different in various regions even within a country. Moreover, in India bamboo pulp has to be used as substitute for long fibre softwood pulp in the furnish due to the scarcity of softwoods in accessible areas.

The change from bamboo to hardwoods is unavoidable and some Indian paper mills use already 20-30% hardwoods in writing-printing furnish. But, these mills are facing some difficulties which are in the present situation restrictive to increased utilization of hardwoods as its shown in the following brief survey. Some species of high density hardwoods (e.g. Terminalia tormentosa) are causings serious difficulties in chipping. Knives are to be changed very frequently. Some of the chips are oversized. A good cooperation between the paper industry/manufacturers of chippers and research is required to develop a suitable chipper.

Tropical hardwoods require higher chemical charge in pulping, in contrary to bamboo and a separate pulping is widely adopted. Some tropical hardwoods yield a High Kappa number and are difficult to bleach.

Major difficulties seems to be

encountered in evaporation of black liquor from hardwood pulping as the black liquor from some hardwood species, containing a high percentage of polyphenols, has a high viscosity due to condensation of lignin with polyphenols (2).

Due to these problems in chipping, pulping and recovery, some tropical hardwoods are rejected for pulping. This causes difficulties in forest operations and increases the pulpwood costs.

Another limitation for increased hardwood utilization in India is difficulty with hardwoods pulps on the paper machine. While increasing the proportion of hardwoods in furnish to more than 30%, a poor runnability is observed. Passing of the paper through the paper machine, especially at open draws is becomirg difficult. This may be attributed to shorter fibre length of the hardwoods and consequent low wet web strength. The runnability could be considerably increased by modifying existing paper machines and especially by using modern paper machines with compact presses and pick-up arrangements. However, even paper machine improvements cannot solve the problem entirely. The stock preparation has to be improved, as this may be the key to increased hardwood utilization. It should be mentioned that the utilization of Eucalyptus species for papermaking in Australia was actually solved by introducing disc refiners, as hollander beaters and conical refiners could not refine the pulp properly (1). Similar was the situation in Japan.

It is evicent that intensive research will be necessary to solve the problems related to increased hardwood utilization for papermaking in India. Some important results were already achieved. The Cellulose and Paper Branch of the Fores. Research institute (FRD), Dehra Dun, has tested a number of hardwoods by standard pulping techniques and this excellent work is a good basis for further research (3, 4). Some mill research laboratories investigated pulp and papermaking from hardwoods in mill conditions and based on this research, hardwood content could be increased to 30% in the furnish. However, not all aspects of pulping and papermaking could be investigated due to the lack of modern equipment and insufficient experience with modern research methods. The cosiderable improvement in research methods in the past two decades both on the pulping and papermaking side should be pointed out.

To improve the situation in pulp and papermaking research and to assist the Indian pulp and paper industry in increasing paper production, the above mentioned UNDP/FAO-GOI Project was commenced in 1975. The objectives of the Project are installation of new laboratories with modern equipment, upgrading the existing pilot plant in the Forest Research Institute (FRI), Dehra Dun, training a research team in modern research techniques to investigate alternative raw materials for writing and printing papers as well as newsprint manufacture. Last but not the least, a training pilot plant is to be installed in the Institute of Paper Technology (IPT), Saharanpur.

Research Laboratories

The laboratories of the project, located in the Cellulose and Paper Branch of the FRI are already in operation. A number of modern equipments has been imported by FAO from UNDP funds and indigenous equipment provided by the HPC from the GOI funds. The pulping laboratory is equipped with a *group digester* developed by the Swedish Research Institute consisting of six 2.5 litre autoclaves mounted on a frame and rotated in an electrically heated polyglycol bath. This gives a possibility of simultaneous six cooks under identical conditions. The autoclaves have relief cocks. Besides this, the 10 litres tumbling digester of FRI is used in pulping experiments. For semi and chemimechanical pulping, a *12" Sprout-Waldron refiner* equipped with 40 KW motor has been provided. A new bleaching laboratory was installed.

In view of the variability of chemical composition of hardwoods, a well equipped analytical and physico-chemical laboratory was installed. The physical laboratory is dust-proof, airconditioned and dehumidified to counteract the unfavourable climatic condtions. One of the most important instruments is the *Perkin-Elmer Model 3920 Gas Chromatograph.* Chromatography in general is essentially a physical method of separation of chemical compounds. Chromatographic methods are especially useful in qualitative and quantitative analysis of complex mixtures consisting of chemically similar compounds. The chromatographic process occurs as a result of repeated sorption-desorption acts during the movement of the sample components along the stationary bed and the separation is due to differences in the distribution coefficients of the individual components. In gas liquid chromatography, the moving phase is a gas and the stationary phase is a liquid distribution in the form of a thin film over a support material of high surface area. The sample is votalized and then carried by the moving phase, the carrier gas into the column where the separation process takes place. At the end of the column the individual components emerge more or less separated in time and are detected by a suitable detector. Gas Liquid Chromatography (GLC) is a very useful instrument in pulping research and environmental control. It is a quick method for separation and determination of evaporator condensates/sulphur containing odorous relief gases of sulphate pulping. It is a very precise method for determination of carbohydrate composition of wood and pulp waste liquors. However, it is first necessary to hydrolize the polysaccharides and to convert the monosaccharides to the volatile compound. An analysis of colouring wood extractives is also possible.

Spectrophotometry is very important in pulping research. The Project provided an Infrared and Ultraviolet and Visible Spectrophotometers. *The Perkin—Elmer Model 402 UV and Visible Spectrophotometer* is an automatic and recording instrument for measurement of absorption of light in the ultraviolet and visible region (190-850 mm). Many substances of the pulping and papermaking technology and coloured (lignin, extractives) or could be converted to coloured substances by chemical reactions (sugar, starches). Some substances have a more characteristic absorption in the UV region. All these substances could be determined by UV and VIS absorption spectrophotometry and thus this instrument is useful in mill and environmental control and in raw materials analysis. This instrument is very important in studies related to colour of wood and mechanical type of pulp used in newsprint manufacture. Tropical woods contain coloured materials, which reduce the brightness of mechanical pulp and thus of the newsprint. The colour is caused by conjugated chromophores. The elimination of this colour is one of the main problems in the manufacture of newsprint from tropical hardwoods.

The Perkin-Elmer IR Model 735 Spectrophotometer (Range 4000^{-1} to 400^{-1} cm) is useful not only in basic research, but also in analytical application in pulping and papermaking technology. The infra red spectrum of a compound is essentially the superosition of absorption bands of specific functional groups. The absorption or lack of absorption could be used for quantitative analysis. Thus, by interpretation of the spectrum, it is possible to state that certain functional groups are present in the material and that certain others are absent. This method is very useful to identify, e.g., changes in the cellulose during pulp bleaching, changes in lignin due to cooking condition (important for bleaching) in chemotaxonomic studies, etc. Important application is the qualitative and quantitative analysis of papermaking additives. Besides the absorption techniques (in KBr pellets), the reflection techniques (ATR, FMIR) are of utmost importance, especially in coated and surface-sized paper analysis, in analysis of pitch problems, etc.

In addition to the spectrophotometers, a *LANGE Flame Photometer* has been provided. Flame photometry is a very useful and quick method of quantitative analysis of alkaline metals. The samples to be analysed are prepared in solution and sprayed under controlled conditions into a flame. A fraction of the metal atoms will become activated and subsequently will drop back to the ground state with the emission of photon radiation which can be identified and measured with a suitable flame photometer. From a calibration curve, the amount of the metal could be calculated. The method is extremely useful in a mill using sodium or magnesium salts (kraft, cold soda, NSSC, magnesiumbisulphite) or determination of sodium (or magnesium) losses, circulation of sodium salts, sodium content of pulp, analysis of scalings in evaporators, etc.

For the measurement of black liquor viscosity, *a Brookfield Model RVT Viscometer* was provided. The viscomete measures the viscosity of various liquids and solutions in a wide range of viscosities and shear factors.

Modern and adequate instruments are provided for pulp and paper testing. For beating of pulps, the *PFI Mill* was selected. This laboratory beating equipment was developed by the Norwegian Paper Industry Research Institute. The PFI Mill consists of a roll beater housing and a loading device to provide the beating pressure. The roll and housing rotate independently in the same direction on vertical shafts. The roll has 33 bars each 50 mm wide. The reproducibility of beating in the PFI Mill is very good. The clearance between the beating elements, the relative speed between the housing and roll, the beating load and the consistency could be varied in vide limits and therefore, it is possible to simulate beating condition of mill equipment and to investigate the influence of beating variables on papermaking properties of the tested pulp. Very important features of the PFI Mill are reproducibility of beating and a small charge of pulp (30g. in contrary to 450g in Valley beater) and thus small samples from the 2.5 litre digesters could be tested.

British sheetmaking equipment equipped with a semi-automatic press is used in the pulp testing laboratory. It should be mentioned that one of the sheetmoulds is equipped with whitewater recycling to simulate mill conditions especially in vessel-picking and wet web strength tests. This is important in hardwood pulp testing, as without recycling of white water, a considerable portion of fines and vessel elements is lost and the sheet properties are changed accordingly.

For fibre distribution measurement, a *Bauer-McNett Classifier* and for fibre dimensions measurements a *VISOPAN (Reichert) Projection Microscope* is available.

For measurement of wet web strength properties, the *Lorentzen-Wettre Recording Wet Web Tester* was provided. This instrument records the load-stretch relationship, the initial wet web tensile strength as well as the initial wet web stretch a tensile energy absorption could be calculated. Several authors (5,6) related the runnability of open draw machines as well as modern pick up machines to wet web strength. By this test, it is possible to investigate improvement of runnability by better refining or changes of runnability by alterations of the furnish.

The FRI paper testing laboratory was rebuilt and equipped with new standard equipment (*burst tester, APPTA Tear Tester, Double Fold Tester Kohler-Molin, Concora Medium Flutter, etc.*) and with sophisticated research equipment. *The Alwetron Electronic Strength Tester* (5 kN) is suitable for tensile and compression tests. The tester has digital strength indication or the load elongation relationship could be recorded and the tensile absorption energy calculated. The instrument is suitable for relaxation measurements as well.

A number of instruments were provided for testing of printing papers. *The IGT AIC2 Printability Tester* is useful for the purpose of testing small samples of paper under controlled conditions. Thus the behaviour of the paper during production printing can be predicted. Besides, it is possible to examine how a certain factor, such as printing speed or printing pressure influences the result. This method of testing offers advantages over mere determining of physical properties of papers. The printability tester is based on the principle of a sector that performs the function of impression cylinder and against which one or two printing discs can be placed. Printing can be carried out at constant speed (between 20 and 500 cm/s) or at an increasing speed (final velocity between 50 and 800 cm/s). The printability tester has a separate inking arrangement.

With IGT printability tester, an assessment of quality of paper for letterpress, offset, rotary letterpress (newspaper print) and gravure printing is possible. The density of the print, the ink-transfer, the strike-in and the strike-through (print-through) could be determined in combination with the *Macbeth Densitometer*.

One of the important tests which could be carried out on the IGT Printability Tester is the picking test. In an offset, especially high speed rotary offset press poorly bounded fibres are picked up from the surface of the paper and contaminate the printing forms. The picking tendency increases with increasing percentage of short fibred pulp in the furnish, but could be decreased by improved beating, wet end additives and surface sizing.

The Parker Print Surf Tester is used for surface roughness measurements under conditions similar to those experienced on the printing press. The *ELREPHO Electric Reflectence Photometer* was selected for measurement of optical properties of pulp and paper. This instrument measures the diffuse reflectence as sample and standards are diffusely illuminated from the inside of the photometer sphere. Due to this condition, the scattering and absorption coefficient could be calculated from the Kubelka-Munk equation. This is important especially in investigating chemi-mechanical pulp for newsprint and magazine paper manufacture, as brightness as well as opacity are related to both scattering and absorption coefficients. It was found in previous investigations (7,8) that changes of absorption coefficient of lignin are of utmost importance in chemi-mechanical pulp production.

In addition to standard instruments, special equipment is built for simulating mill conditions in laboratory, e.g. a small press for simulating PREX impregnation as impregnation of especially dense hardwoods is considered as the most important problem of chemi-mechanical pulping (9).

Pilot Plants

Laboratory research has to be verified by pilot plant experiments especially when using lesser known raw materials. Consequently, it was considered as most important to upgrade the pilot plant facilities in FRI, Dehra Dun. The most important equipment provided by UNDP/FAO is the *chemi-thermomechanical pulping (CTMP) system.* Production of newsprint in India has to be increased and quality is to be improved in order to replace expensive imports. Wood containing writing-printing papers are actually absent in the product mix of Indian mill due to non-availability of conventional softwood mechanical pulp. It is obvious that research of mechanical type pulp production from tropical hardwoods is of primary importance.

The existing pilot plant kraft mill consists of a 11M³ mild steel digester with cooking liquor circulation and indirect heating, a blow tank, a flat screen, sand table and a Leith Walk screen and a 4′ x 4′ Kamyr washer-filter.

The kraft pulp mill is complemented by a *Johnson Knotter Screen, a Cowan KX-35 centrifugal pulp screen* (capacity 0.45 BDT pulp per hour), a *battery of centricleaners* (Paper Engineering Services Pvt. Ltd., India).

A new *bleach plant* supplied by Hindustan Dorr-Oliver Ltd. is provided. It is a continuous bleach plant, comprising of an upflow chlorination tower (20 M³) with a chlorine mixer, an AISI 316L stainless steel 6′ x 4′ (180 x 120 cm) Dorr-Oliver bleach washer decker (capacity 880 kg/hr of bamboo pulp), a heater mixer and two high density towers (10% consistency) (useful volume 10M³) and a pulp distribution screw conveyor. The operation of the bleach plant will be semi-continuous. The kraft pulp will be continuously chlorinated and washed on the bleach washer. The washed pulp will be mixed with NaOH solution and heated with steam in the heater-mixer and transported to one of the high density towers by the distribution screw conveyor. At the end of the desired retention period, the pulp in the high density tower will be lifted by water and diluted by dilution nozzles and pumped to the same bleach washer. To maintain a uniform retention time, the flow of the pulp is controlled by a consistency controller—magnetic flow meter system. The washed pulp is mixed with hypochlorite solution and heated with steam in the heater mixer and transported to the second high density tower by the distribution screw conveyor. The sequence can be repeated as required. Peroxide bleaching is possible using the high density towers and hydrosulphite bleaching using the chlorination tower.

The main part of the *CIMP system* is the *Preheater-Defibrator unit*, which is widely used for thermomechanical pulping of softwood. Steam pressurized disc refining at high temperatures (160°—185°C) is used for fibreboard production. Fibres at this temperatures are separated easily due to thermal softening of lignin. However, the fibres are coated with lignin. On cooling, lignin reverts to the glossy state and is an obstacle in fibrilation of separated fibres, which is of utmost importance for papermaking. If, on the other hand, the chips are refined at a lower temperature in the range of 120—130°C, most of the lignin, though softened, is still in the glossy state. The fractures occur predominantly in the outer layers of the secondary wall, and the wall fractures render the fibres accessible to filbrilation. This temperature range is used in thermomechanical pulping of softwoods. In fact, strength properties of softwood thermomechanical pulps are surprisingly high due to excessive fibrilation. Hardwoods, are unfortunately unsuitable for thermomechanical pulping due to different morphological properties. Hardwood fibres are not fibrilated in thermomechanical pulping and thus their strength properties are low (10). However, if impregnated with certain chemicals prior to thermal treatment or refining, hardwoods also form fibrils and manufacture of suitable pulps is possible. To fulfil these requirements, facilities for chemithermomechanical pulping are provided by the project.

The chips are washed in a *Sprout-Waldron Chip Washer Conditioner* and transported by a bucket elevator to a 11M³ stainless steel 316 *tumbling digester* (11 atm) with direct steam heating. Chips could be impregnated by vacuum impregnation, hot liquor or hydraulic pressure impregnation. Chips could be cooked in liquor or vapour medium. The cooked or impregnated chips are dumped into the live bottom bin.

Impregnated chips are transported by the bucket elevator into the double screw variable speed drive metering bin. The chips are fed by a *6" Bauer Rotary Valve* to the *Vertical Preheater (Defibrator)* of a diameter 400/500 mm, height 1500 mm (effective volume 0.15M³). This is actually a small continuous digester with direct steam heating. The maximum working pressure is 12 atm. and max. temperature 191°C and variable retention time is upto 25 min. (in batch operation unlimited). The chip level is controlled by a radioactive level controller and the retention time by the level of the chips and the revolutions of the bottom screw. The thermally treated chips are transported by the bottom screw conveyor to the grinding discs of the steam pressurized *Asplund Raffinator ROP 20* with 20" diameter discs powered by a 200 KW motor. The refined pulp is blown through the blow value to a cyclone and transported by a screw conveyor to the second-stage disc refiner type Raffinator RO-20 with 20" discs, powered by a 200 KW motor.

Chips cooked in the digester or impregnated by caustic soda (cold soda pulping) will be transported from the metering bin directly to the atmospheric disc refiner Raffinator RO-20. The refined pulp is discharged into an intermediate bin, diluted to 5% consistency and pumped to a *Watford Screw Press* where it is dewatered to 20-35% consistency and refined in subsequent stages on the same refiner. The fibres from the screw press filtrate are recovered on a *Bauer Hydrasieve*.

The above mentioned CTMP system is really versatile. The rotary valve feeder enables feeding of nearly all fibrous raw materials from dense hardwoods upto bagasse and similar materials. All combinations of mechanical type of pulping of importance for the Indian paper industry could be tested as mentioned below.

Thermomechanical pulping, although suitable for only softwoods, is important for the Indian paper industry. In the Himalaya regions there are considerable amounts of softwoods. Transportation of wood is expensive and local manufacture of chemical pulp is questionable due to small accessible amount in an area and due to polution problems. Thermomechanical pulping produces an extremely low amount of polluting substances and is suitable for small scale production of cultural papers, as shown by a recent FAO study (11).

Suitable processes for hardwoods are the chemi-thermomechanical (CTMP), the chemimechanical (CMP), the semichemical (NSSC) and cold soda (CSSC). The CTMP, CMP and NSSC processes use sodium bisulphite neutral sodium sulphite and alkaline sodium sulphite for impregnation and cooking.

The CTMP process consists of impregnation with cooking liquor followed by a short cooking in vapour phase between 120°-170°C, followed by steam pressurized refining at the same temperature. The yields are usually above 85-90% and the pulp has a comparatively high opacity. The low temperature CTMP adopts temperature below 100°C for cooking as well as for refining.

The CMP consists of a cook at elevated temperatures. The cooked chips are refined at atmospheric pressure. The yeilds and properties are similar to CTMP.

The NSSC process is similar to CMP process, but cooking times and yields are lower, consequently the strength properties are higher and the opacity is lower. These pulps are used mainly for corrugating medium and for liner board manufacture. Some coloured hardwoods containing a high percentage of polyphenols cannot be pulped by processes using sulphite chemicals. Some of these species could be pulped by the cold caustic soda process as generally alkaline processes are less sensitive to wood properties.

All these processes could be adopted by suitable combination of the above mentioned pilot plant equipment. The chemimechnical pulp produced could be bleached by hypochlorite, peroxide or hydrosulphite in the pilot bleach plant.

An important part of papermaking raw material research is the pilot plant papermaking. FRI Dehra Dun has a Sandy-Hill pilot plant paper machine. It consists of open flow box, a Fourdrinier wire part, cylinder moulds, 3 presses, a drier section, a Yankee drier and a machine calander. The wire width is 112 cm, trim width is 76 cm.

The maximum operating speed is about 120 m/min. The stock preparation consists of two Banning and one Wolf beater (bronze, stainless steel and lava stone).

The stock preparation is complemented by a double disc *13" Beloit Jones Refiner*, with a double speed 1000-1500 RPM, 100/150 HP motor. It is hydraulic-pressurized refiner. Consistencies upto 5% could be used. The refiner is equipped with an electromechanical positive-action disc positioning system and a power input control system. The flow is controlled by a magnetic flowmeter. The refiner can be operated in Monoflo system with two jobs operation and thus higher power input per ton of pulp or in Duoflo alternative with single pass but higher capacity. The refiner is equipped with a variety of refining discs giving the possibility of refining at a wide range of specific edge load.

Training Pilot Plant

A proper training of technical personnel and of operators is considered very important for the further expansion of the Indian Pulp and Paper Industry. The project provides a pulp pilot plant for training in the Institute (School) of Paper Technology in Saharanpur. The pilot plant comprises of 11M³ tumbling digester for kraft and chemimechanical pulping with a blow tank for kraft pulp and a Raffinator RO-20 with 20" discs for refining of chemimechanical pulps.

The screening and washing epuipment includes a Johnson Knotter Screen, a 6'×4' Dorr-Oliver washer decker, a Cowan KX-35 centrifugal screen and centricleaners. The bleach plant consists of a chlorination tower, a 6'×4' Dorr-Oliver bleach washer, a heater mixer and a 10M³ high density tower.

Conclusions

A new applied research and training complex is set up for the Indian Pulp and Paper Industry.

The laboratories are already in operation and research staff of 15 graduates was trained in India and abroad (Finland, Sweden, Norway, USA, UK, Czechoslovakia, Netherlands, Japan, Portugal, Australia) under FAO fellowships. Research is carried out by Indian researchers. The FAO Project Manager and FAO Consultants are assisting the research staff in planning and evaluation of experiments.

The Dehra Dun research pilot plant is likely to be commissioned by end of 1978 and the training pilot plant in Saharanpur in the first quarter of 1980.

The research activities include investigation of writing and printing paper from Indian hardwoods with the aims to use more wood species and to increase the percentage of hardwood pulp in the furnish, identification of the alternative raw materials for newsprint and wood containing writing and printing papers manufacture and testing of plantation pulpwoods.

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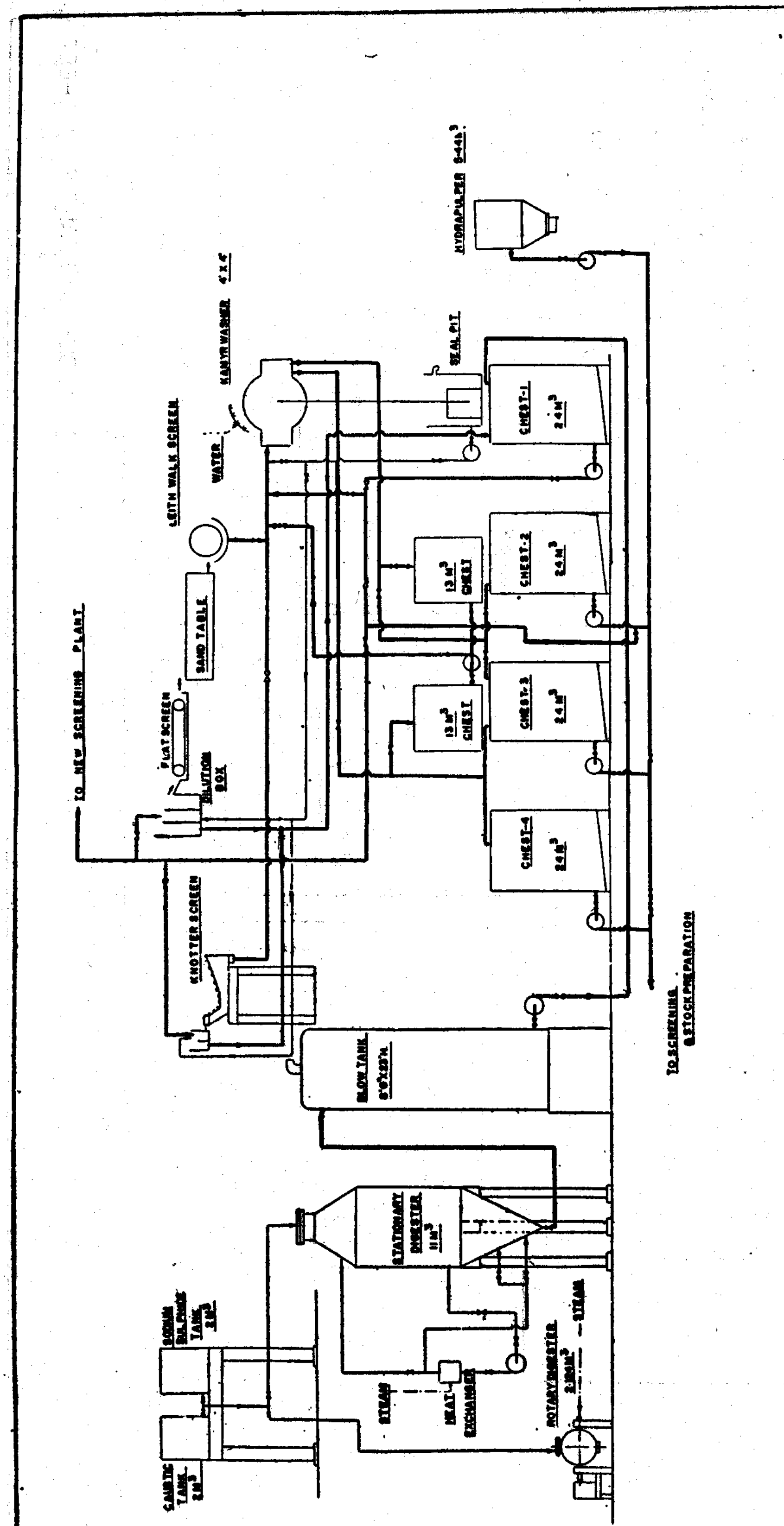
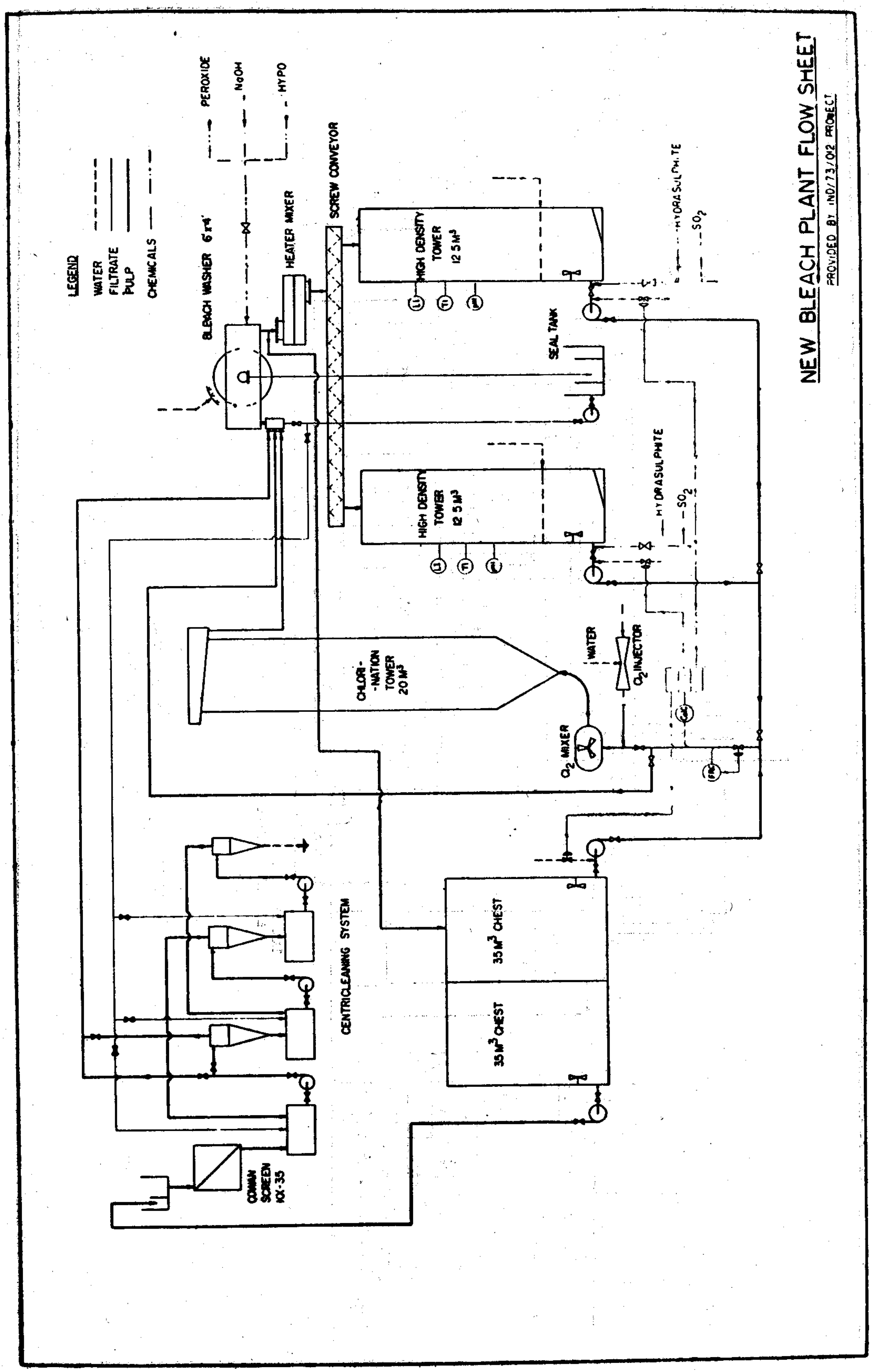
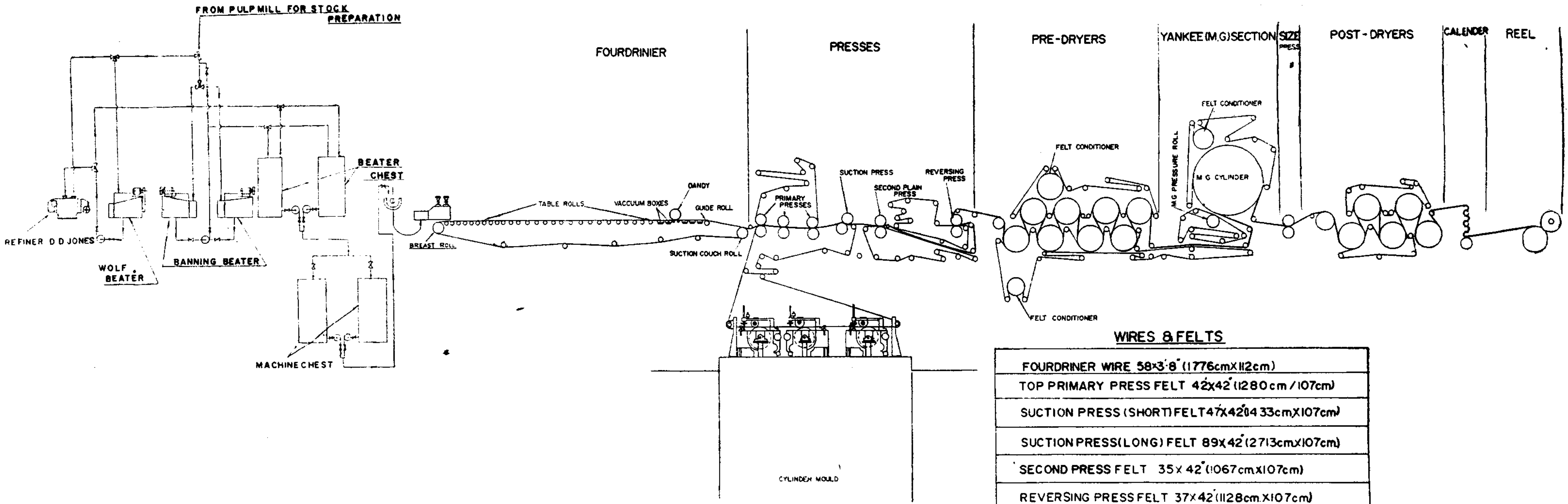


EXISTING PILOT PLANT KRAFT MILL
F.R.I. DEHRADUN


NEW BLEACH PLANT FLOW SHEET
PROVIDED BY IND/73/012 PROJECT
LEGEND
WATER
FILTRATE
PULP
CHEMICALS
PEROXIDE
NaOH
HYPO
BLEACH WASHER 6'x4'
HEATER MIXER
SCREW CONVEYOR
HIGH DENSITY TOWER 12.5 M³
SEAL TANK
HYDRASULPHITE
SO2
CHLORINATION TOWER 20 M³
WATER
O2 INJECTOR
O2 MIXER
CENTRICLEANING SYSTEM
35 M³ CHEST
35 M³ CHEST
COWAN SCREEN KX-35

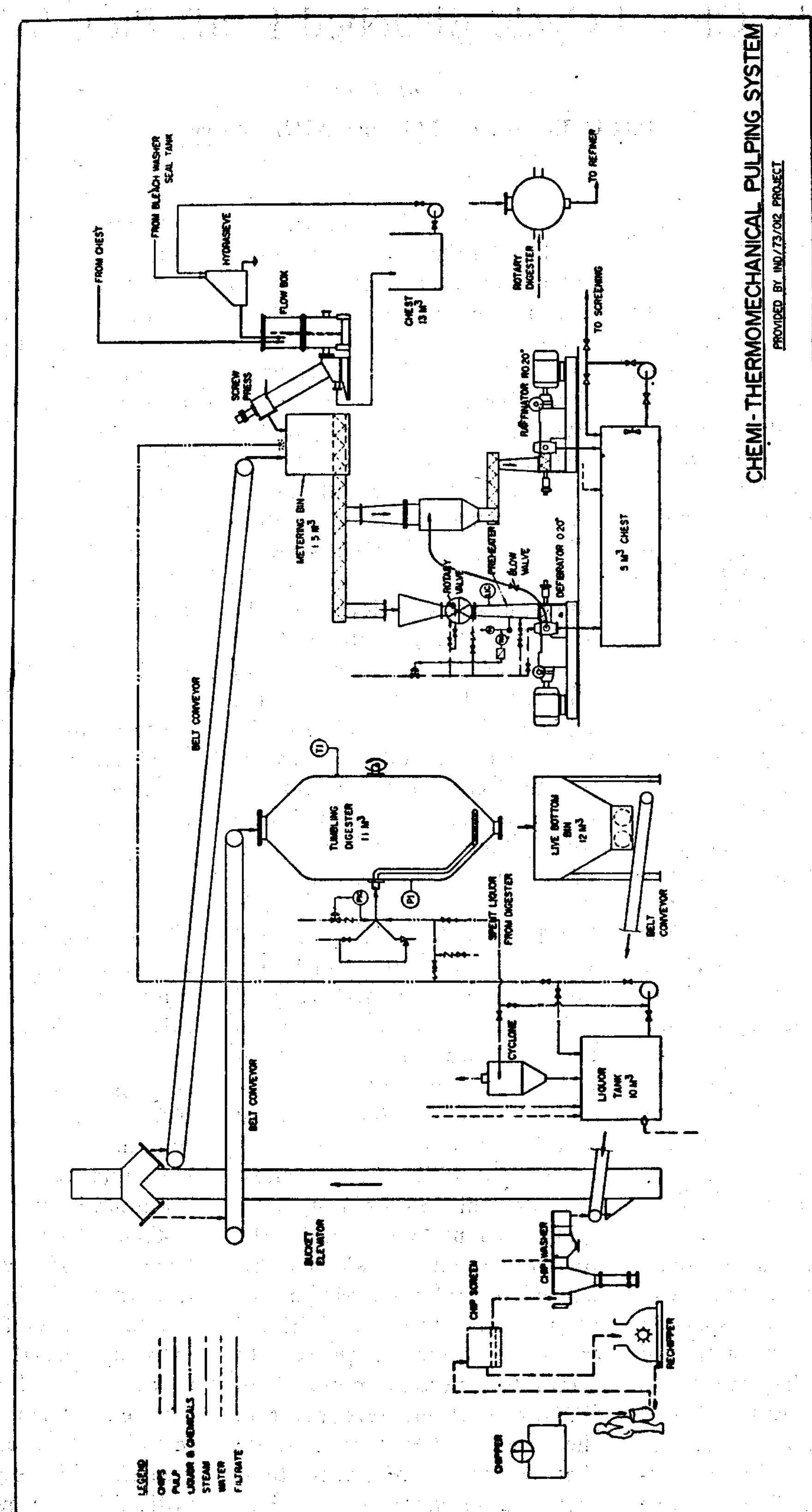
THE EXISTING SANDY-HILL PAPER MACHINE

With the Beloit-Jones D-D 13" Refiner provided by IND 73/012 project



WIRES & FELTS

FOURDRINIER WIRE 58'x3'8" (1776cm x 112cm)
TOP PRIMARY PRESS FELT 42'x42" (1280cm / 107cm)
SUCTION PRESS (SHORT) FELT 47'x42" (1433cm x 107cm)
SUCTION PRESS (LONG) FELT 89'x42" (2713cm x 107cm)
SECOND PRESS FELT 35'x42" (1067cm x 107cm)
REVERSING PRESS FELT 37'x42" (1128cm x 107cm)
TOP PRE DRYER FELT 61'x36" (1859cm x 91cm)
BOTTOM PRE DRYER FELT 100'x36" (3048cm x 91cm)
M.G. TOP FELT 55'x44" (1676cm x 112cm)
M G GLAZING FELT 31-5'x44" (958cm x 112cm)
TOP POST DRYER FELT 32'x36" (975cm x 91cm)
BOTTOM POST DRYER FELT 21'x36" (640cm x 91cm)


CHEMI-THERMOMECHANICAL PULPING SYSTEM
PROVIDED BY IND/73/012 PROJECT
FROM CHEST
FROM BLEACH WASHER SEAL TANK
HYDRASIEVE
FLOW BOX
SCREW PRESS
CHEST 13 M3
ROTARY DIGESTER
TO REFINER
TO SCREENING
METERING BIN 1.5 M3
PREHEATER
ROTARY VALVE
BLOW VALVE
DEFIBRATOR
5 M3 CHEST
BELT CONVEYOR
TUMBLING DIGESTER 11 M3
LIVE BOTTOM BIN 12 M3
SPENT LIQUOR FROM DIGESTER
CYCLONE
LIQUOR TANK 10 M3
BUCKET ELEVATOR
CHIP SCREEN
CHIP WASHER
RECHIPPER
CHIPPER
LEGEND
CHIPS
PULP
LIQUOR & CHEMICALS
STEAM
WATER
FILTRATE