Paper machine rebuild : Technology and Economy

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ABSTRACT

Paper machine rebuild provides the significant advantages of improving production capacity and paper quality reducing operating costs and energy consumption by incorporating state-of-the art technology. The artical highlights mainly developments in forming, press and dryer technology relevant to rebuilding.

There are about 9000 paper machines presently in the World producing 230 million tons of paper. A large number of machines are old and ineffecient because of obsolate technology. With expected annual growth of future demand for paper rising by 2.2 percent, the paper industry will require 50-60 new machines and 200 rebuilds every year. Therefore there is great emphasis on rebuilding paper machines as it has clear advantages of improving production capacity and product quality, reducing operating costs and energy consumption. In sharp contrast to new machines rebuild offers a chance to introduce new technology with limited investment. As a matter of fact the number of rebuilds has risen steadily in keeping with present global trend from 50 in 1970 to 225 in 1989[2]

The total installed capacity of 290 Paper mills in India stands at 2.9 million tons level. The actual demand of paper is about 1.8 million tons at present and it is expected to cross over 4.0 million ton mark by the turn of the century on account of growing urbanisation, the Government thrust on education, higher off-take by the packing sector and rising export market. This means that if the expected demand of over 4.0 million tonnes by 2000 A.D. is to be met through indegeneous production, the country will have to install additional capacity of 1.1 million tons. Therefore the prospect for the paper mills to increase capacity through new machines or re-built of existing machines is highly promising in the coming years. As paper industry is highly capital intensive, mills cannot immediately respond to the improvements. Rebuilding a paper machine is therefore more economical than installing a new machine. It offers an opportunity to incorporate state-of the-art techno logy in a single stage or in phases to boost production capacity and quality It also improves mills, chances of survival in an inflationary economy through cost effective production operation i.e. productivity.

Most of the paper machines in India are very old and slow speed, about 300 meter per minute maximum. The article mainly highlight developments in forming, press and dryer technology relevent to rebuild. Since there are no universal solutions, a mill can choose appropriate technology to solve its rebuild problem.

WIRE-SECTION (Wet end technology)

Development in forming technology which include modern head-boxes, better drainage elements and fabrics, can be retrofitted to existing units saving several meters of machine length and permitting several dryer cylinders to be added They thus not only boost quality but considerably extend capacity.

The headbox must not only spread out the stock evenly across the width of the machine at the correct speed and angle but should also level out cross currents

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machine direction velocity gradients and consistency variations Flocculation of fibres must be controlled by the creation of turbulence. The design of headbox has advanced from the open wooden tubs with crude inlet channels of century ago to today's modern stain-less steel flow devices. Old type head-boxes cannot meet today's more demanding paper properties at higher machine speed. Open flow boxes are designed upto a maximum speed of 300 meters minute.

The ordinary, air pressuried, rectifier roll equipped head-box is especially suitable for many paper grades. Modern trend is to use these head-boxes above 200-250 meter per minute machine speed.

Head-box turbulence is a major consideration in the case of fast machines (over 1000 meter per minute speed) with short forming lengths as twin wires. Intense microturbulence creates better formation. while hydraulic headboxes can be optimised for one particular speed and consistency, the head box with perforated rolls is preferable for machines which manufacture different grades with turn-down approaching 3 : 1.

Uniformity of flow, absence of streaks and large eddies, headbox stability, and ease of operation are features which are requirements for all paper grades. The approach flow system just upstream of the head-box must be designed with pulsations minimised. All modern headboxes have tapered cross-machine inlet distributor header to creat uniform flow across the width of machine. Inside wet surfaces should be highly polished for cleanliness and provisions for inspection and clean-out are incorporated. On the run adjustability of jet impingment and slica opening is standard. Anti-deflection arrangements have been incorporated into the head-box structure to control deflection caused by dead weight, pressure in flow-chamber and differences in temperatures. Some of the famous manufactures offer the following types of head-boxes for manufacturing different grades of paper.

BELOIT

Offers headboxes to achieve higher quality and tonnage of a paper grade at lower cost. The converflow headbox and Bel-Bai twin wire formers represent standard of industry. The latest is concept III head-box for quality and speed upgradarion on existing machines. The manufacturer also offers head-boxes with layering technology.

BLACK-CLAWSON :

Bunch Tube Headbox-application for secondary plies for mottle liner.

Sandy Hill : Hydraulic headbox (better control of MD/CD Tensile ratio)

Eacher Wyss—Step Diffusor head box for all grade of paper and has the potentional to work well at higher consistency.

TEMPLELLA—

Control-Flo-Former Head box for production of webs consisting of several different layers. It allows better control of fibre orientation and MD/CD tensile ratio in the individual plies.

VALMET/KMW/AHLSTROM—

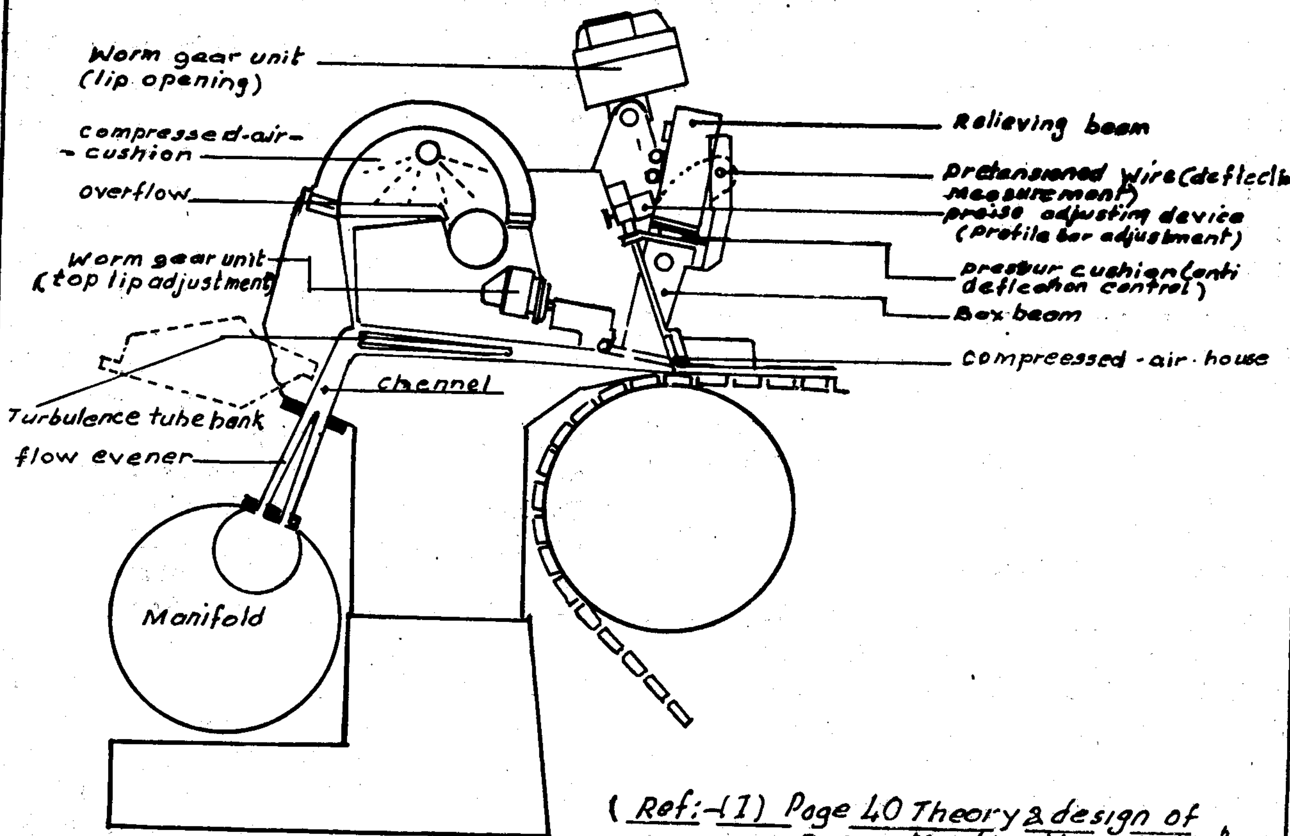
Sym-Flow Headbox controls fibre orientation and MD/CD tensile ratio.

VOITH :

W—type A high turbulence headbox for high speed and wide machines. (Fig. No. 5)[1,4,8]

Sheet formation on Fourdirinier can be enhanced through the use of table rolls, hydrofoils (Fig 1) and top wire formers. Hydrofoils remove water from the web very smoothly than table rolls and hence large amount of loadings and fibres are retained in the web. Vacuum created by hydrofoil is dependent on machine speed and divergence angle between wire and top of foil surface. At a machine speed of 250 meters per minute, vacuum created by hydrofoils is the same as by the table rolls, and afterwards increases very slowly and at 750 meter per minute speed it is about 25% vacuum generated by table rolls. Optimum sheet formation requires controlled drainage and turbulence throughout sheet forming table By varying divergent angle of four inch wide foil blade, drainage can be controlled.[7] (Fig 4).

Angle	**Drainage** (% of its maximum attainable value)
0.5	43
1.0	70
1.5	90



(Ref:-(1) Page 40 Theory & design of Paper Machine Vol. I By RSD Pandey
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Fig No. 5. Voith W_ Head Box

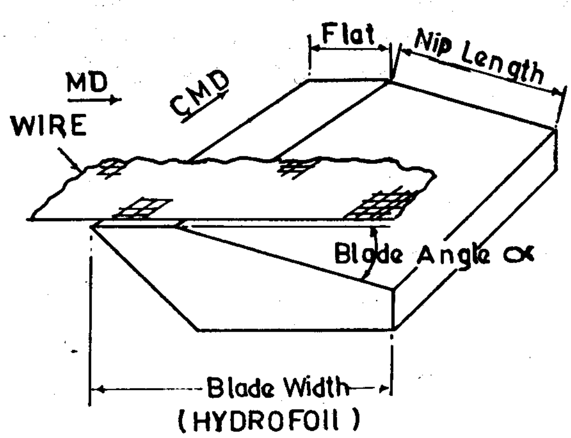

FIG. 1.

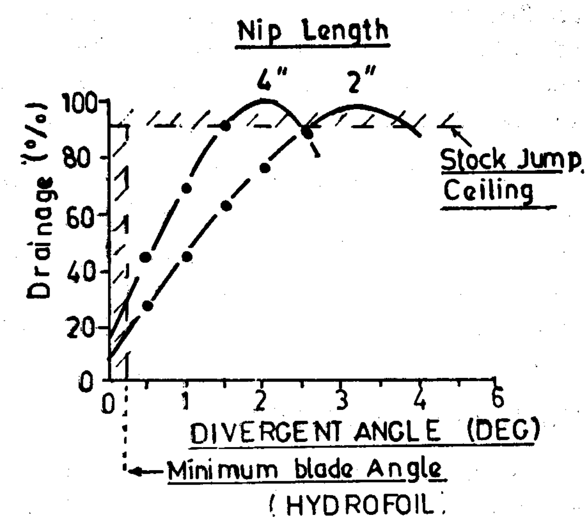

FIG. 4.

Ref: Page 4 Pulp & Paper Magazine of CANADA 71 No. 8, T. 183-T. 187 April 17, 1990

The narrow hydrofoil with two inches nip yields five blade designs, giving drainage rates as follow :

Angle	% Drainage
0.5	27
1.0	49
1.5	65
2 0	78
2.5	91

Wider blades create higher drag load than narrow blades Hydrofoil units working with vacuum have large dewatering capacity. Its proper use can cut wire length drastically. For example a New sprint machine at speed of 400-600 meters/minute will have wire length (distance between couch and breast roll) about 14.0 meters with table rolls whereas the same distance will be 8.0 meters with hydrofoils [1]

Suction developed by hydrofoils is speed dependent. At slow speeds with heavier weight the drainage capacity will be in-adequate. Major benefits of using foils at higher speeds are improved drainage, better formation, more uniform transvers distribution, lesser wire marking and improved retention. Foil tops are made out of plastic, ceremic and tungston carbide to reduce drag on wire.

FABRICS :

The introduction of plastic fabrics instead of bronze wires led to simpler installation and longer running time. Advantages of fabric over metal wire are 3-10 times longer life, less weight, better drainage of stock, more resistant to chemical, easy mounting and repairs, less load on suction boxes and more dryness of web after couch 1-2%.

Modern multi-layer fabrics are new-a-days used for their flatness and higher retention. Fabrics cut clothing costs and increase out-put. Incorporation of auto-tension and guide system will reduce manual labour or drudgery of keeping constant watch on wire - run.

TWIN WIRE-CLOTHING :

A fourdrinier paper machine can quickly and economically be re-built into twin-wire former. The benefits are increased capacity, better formation, less linting and two sidedness. The lowest speed for Blade or Roll formers is 300 meters/minute.

PRESS—TECHNOLOGY

As a result of development in press section, the old fashioned straight through presses gave way to multi-nips, allowing several new drying cylindere to be added in the same space. Now a new ganeration of advanced press designs are making an impact, particularly in heavier grade of packaging paper. The wide nip press is the best example of changing technology. Based on the simple principle that if the web is subjected to the same pressure for longer period i.e. lengthening nip, it will emerge several points dryer (i.e. with improved dryness, upto 47% or even more). The press nip can be elongated either by using large diameter rolls with soft converse or by using a shoe as a press element. The latter offers maximum in nip elongation when examining the feasibiity of a press rebuild, the influence on production, operating cost and quality must be considered. A normal press-Section rebuild will allow 5% gain in dryness which means about 30-40% increase in drying capacity depending on range of moisture content entering press. Another benefit is that for the same raw material, better strength properties are attainable or for the same strength values, less expensive raw material or less expensive stock preparation can be used.

The approach is entirely general because paper machines in India differ individually in respect of capacity, speed and grade.

DOUBLE FELTED PRESS :

When compression time becomes limiting factor double felt (Fig. 3) pressing is a radical way of reducing flow resistence by letting water escape from web

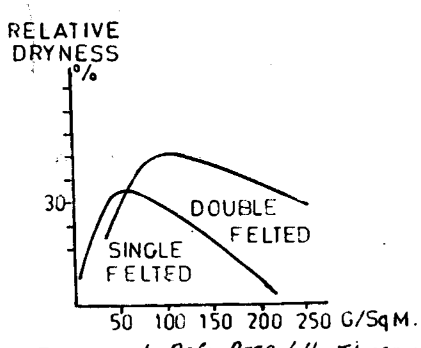

Fig. No 3 (Ref: Page 411. Theory & Design of Paper Machine Vol. I. by R.S.D Pandey)

RELATIVE DRYNESS FROM FIRST PRESS

through both the surfaces of felts. Double felting not only improves water removal at higher nip pressure but also increases nip width by 33% as compared to single felted press provided felt structure and other conditions remain same. It also eliminates web crushing problem with the right type of felt. Its applicability increases with basis weight, the wetness of furnish and speed of the machine. The press is suitable for grease proof paper above 25 gsm, for liner above 90 gsm. and for fine paper above 150 gsm. Nip pressure upto 290 KN/m is possible but below a nip pressure of 100 KN/m, a double felted press is less attractive.

FABRIC PRESS :

Presses with fabric and felt create additional space in the nip region of rolls where extracted water from paper and felt can be accommodated the press may work in top or bottom felt. Its life is 4—12 months depending on condition of working. Application in II & III press following a suction press is common. With the same entering moisture the fabric press removes more than the suction press and has had significant success on paper grades where shadow marking is a problem. It is today running on fastest machines at nip pressure upto 200 kg/cm.

VENTA NIP PRESS :

The development of this press was sought to overcome the speed limitting problem of suction press by providing a means of more rapid water removal from presing zone. It vents the nip to atmosphere by cutting a series of grooves in spiral fashion into roll surface. So that not much back pressure is developed in the felt and the crushing of web generally is reduced. Nip pressure can be raised 100 percent. The venta nip press has one obvious advantage over fabric press of using only felt rather than felt and fabric Nip pressure range is 200 kg/cm² and its application is on second and third press.

CROWN COMPENSATED PRESS :

Maintaining correct crown of press rolls became a growing problem with wide and high nip presses. As non-uniform wear destroyed the crown curves, caused poor moisture profile and necessiated frequent roll grinding. The use of crown compensated rolls to very nip pressure and profile gives versatility of control for different grades of paper. It is now possible to grdind the rolls straight and get the hydraulic pressure of these rolls for required nip pressure profile to correct the effect of non uniformity of the basis weight. Very high nip pressures upto 357 kg/cm (2000 pli) are possible with this design. M/s. Kuster Beloit ahd Escher Wyss (Nipcorroll) manufacture different types of these rolls.

LONG NIP PRESS (LNP)

The press is based on the approach that to obtain optimal mechanical dewatering results, a press should not only exert high nip pressure but also the pressing time should be maximised. This became possible with the recent development in press felts and rubber roll coverings. A LNP is a roll press with larger diameter rolls than required from machine design point of view, softer roll covers than on a corresponding conventional roll press and higher linear load. Roll diameters from 1315 mm to 1870 mm are commonly used. The first press (LNP) has a closed frame. Therefore neither the foundation nor the rest of press section frame is subject to press nip loading forces. The loading mechanism can be pneumatic or Hydraulic. The nip is double felted and LNP presses use butt-on mesh, double or Triple layer, laminated base felt. The press is designed to produce 350—430 KN/m linear load and achieves press dryness of 47—49%. Paper properties like brust, Mullen and smoothness also improve considerably (5—7%) and a re-build with LNP has resulted in higher production. With LNP it is possible to build a press section for a container board machine without a suction press rolls. This results in less energy, less cost as there is no expensive suction roll and less noise, Tampella recommends plain covers for most LNP and double felting.

EXTENDED NIP PRESS (ENP) :

For a given pulp the dryness out of a press is the function of press impulse. It means that the way to increase dryness is to increase the pressure and nip residence time (Fig 6 and Fig 2) In 1980 Beloit has introduced Extended Nip Press which replaces one of a pair of press rolls with a concave load shoe, which extendes the nip to about 250 mm by applying the above principle. This extends the wet press loading to over 1000 KN/m and dryness over 47%. It is the best design for Board grade. It is generally installed in

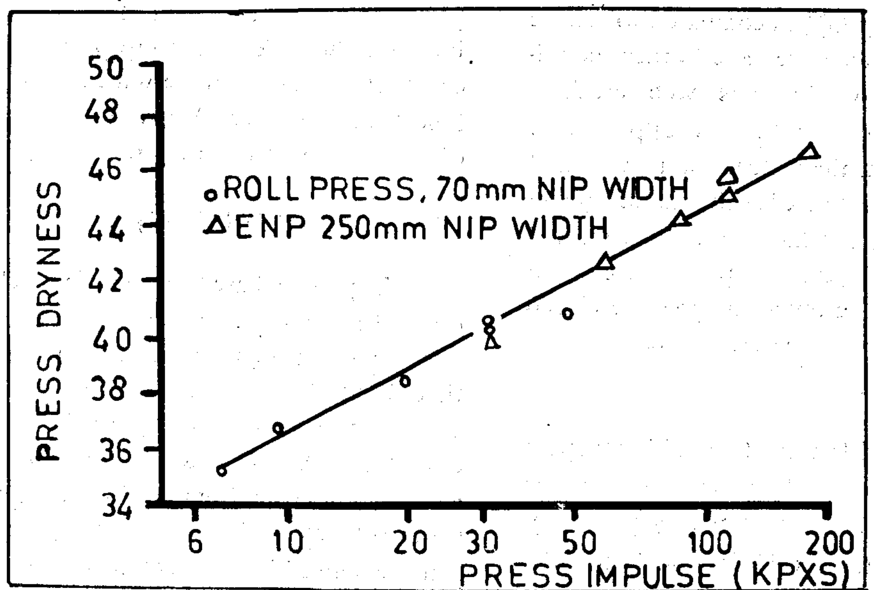

Fig. No-6. (KPaXs.) Ref-Page 167 World pulp & paper Technology 1989)

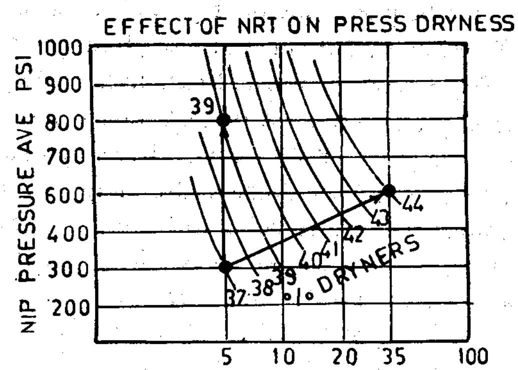

Fig. No.2 NIP RESIDENCE TIME MS

(Ref: Fig - 5-27f Page 461 Theory & Design of Paper Machine Vol. I. by R.S.D Pandey)

last press section. Already 60 ENP Units are running over 100 gsm range. Since there are no known in ENP roll and shoe, there are no moisture profile problem associated with crown and press load mis-matching. ENP presses reduce dryer steam for every ton of board bv allowing production increase on drying limited machines, increasing sheet strength properties and allowing the reduction of furnish cost. The ENP can be designed to control the rate of compression without sacrificing press impulse (i.e. product of average pressure in nip and the nip residence time), something which is not possible with a roll press. ENP eliminates crushing and optimises sheet strength.

SUCTION PICK-UP :

To achieve optimum paper quality, machine runnability and efficiency, it is essential to improve press configuration for transferring the web from the foudrinier wire to dryer section with minimum number of breaks and maximum dryness. As machine speed increased it became apparent that web strength at the first open draw between the wire and press felt was a limiting factor in raising the operating speed. After sucessful advent of suction pick-up a dramatic increase in web strength was realised which could be attained with increased web-dryness after pressing, therefore main objective of machine rebuild should be to get the maximum possible paper dryness consistent with sheet quality requirement before the first open draw.

DRYERS :

The dryer section is often a major constraint to the production capacity of mills—a majority of mills being dryer limited. It is difficult and expansive to expand the dryer section due to physical constraints for example machine house building, problems of moving calender and reel sections quite apart from the actual cost of dryers and associated equipments. Optimum dryer performance depends on a highly complex interrelationship among every aspect of paper making process. Steam heated rotating dryer provide evaporative energy. Passing over the dryer the sheet is reduced from its original state of approx 60% moisture leaving the press-section, to approximately 5% moisture leaving dryer section. The amount of energy required in this evaporative process is governed by entering and existing moisture. For 1% increase in entering moisture, the drying requirements are increased 5% in terms of pounds of water to be evaporated per pound of paper[4]. Since the cost of evaporative energy far exceeds the cost of mechanical methods (like hydro-foils table rolls, vacuum boxes, suction rolls and presses) for removing water, optimum operation of the forming and press section is the first step to optimise dryer operation. For drying by evaporation heat and air are necessary. As the water evaporates from the sheet a correct amount of air at suitable temperature and humidity must be supplied to the dryer section to carry the water vapour away. This is mass transfer. Both conductive heat transfer and mass transfer occur simultaneously in the drying process but evaporation depends upon sufficient mass transfer. Air can hold only limited water at a given temperature. Once it becomes saturated the evaporation process stops. For this reason an optimum air system is a critical factor in drying process. A modern hood and pocket ventilation system in conjunction with permeable fabric can be very effective and has been known to achieve 10% production increase on machines previously without an air system.[4] It also offer the following advantages—increased production, reduction in energy cost, improved cross machine profile and improved machine house condition.

In the dryers the first step towards optimisation is the selection and installation of syphons whose performance is carefully matched to the full range of drying loads required. These loads vary according to grade of paper, production rates, moisture content and other factors. Retained condesnate within a dryer adversely affects the drying rate. The cascanding condensate may create fluctuation in horse power (Fig. 7) required and speed variations which can break the sheet.[8] It also contributes to cxcessive wear and maintenance of dryer bearings, gears and rotary pressure joints. Therefore the best drying rate will be achieved by utilising syphons which allow a minimum level of condensate within the dryer. Equally important

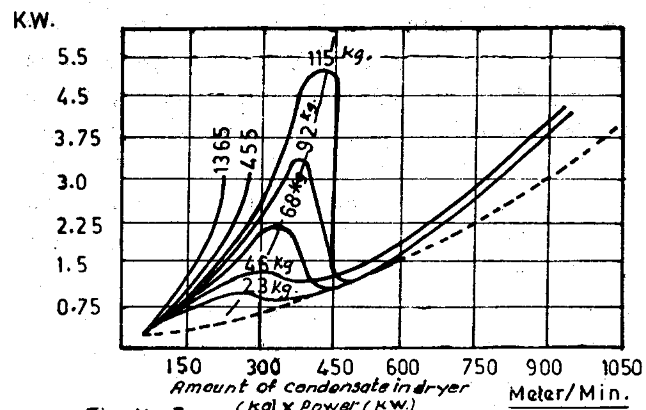

Fig No 7

Ref Page 183 World pulp & paper Technology 1989)

is the installation, operation and maintenance of steam-supply system such rotary joints and condensate removal system consisting of steam traps, non-return valves, sight glasses and air vents. At lower speed, the condensate oscillates inside the dryer and creates turbulence in a thin film of condensate giving excellent heat transfer rate. At high speed above 1800 feet per minute the condensate film is subject to high centrifugal forces and the condensate film becomes sluggish and turbulence disappears. Dryer bars (which are multiple axial bars at the rim of the inner circumference or dryer) become viable as they promote turbulence at higher speeds thereby enhancing heat transfer rate and thus maximising dryer efficiency. In a conventional paper machine there is a long unsupported draw between the press and dryer section. The weak paper sheet is thus influenced by many unstable air flows causing runnability problems. The blow-box concept solves the sheet transfer problem by minimising free draw, keeping the sheet in contact with dryer fabric and eliminates air pumping caused by the dryer fabric and press felt. Thus main advantage of blow-box are no sheet flutter fewer breaks, more effective tail threading, ventilation and possibility to increase machine speed.

CALENDERS :

Most of the old machines have solid chilled cast iron calender rolls in one or two stacks—Main darwback of these rolls is that they deflect under high nip pressure. Therefore bottom calender roll is provided with crown to counter the deflction so that good calendering is achieved with uniform calipar for a particular crown. Hence for any other operating condition, it will not give the same kind of performance. Development work in calendering has produced swimming roll, the nip pressuse profile of these rolls can be controlled by internal oil pressure. By heating the intermediate calender rolls internally, the web of the paper gets plasticised and compressed by an ironing effect, while the middle layer of paper remains cool, resilient and bulky. The paper becomes smoother, glosser and requires less ink while having higher strength. The present day paper reels require the following properties—Uniforms thickness, higher dimensional stability and strength to print at high speed, good smoothness, uniform porosity, lower ink consumption, good ink penetration and uniform density of paper.[4]

The above properties are achieved by introducing swimming rolls at top and bottom and steam heated intermediate calender rolls.

MACHINE DRIVE :

As paper making is a continueous process, it is essential that machine drive is highly reliable. The main types of drive systems are line-shaft for speeds upto 350 meters/minute, sectional electric drive controlled by thyristor for speeds above 400 meters/minute. usually combination types exist.[4] The line shaft system in old machines consists of cone pulleys, friction clutches, canvas belts for power transmission and gear-boxes. The frequent machine stoppage are required to tightness belts and replacing worn-out friction plates in clutches. By introducing nylon sandwitch belts and aero-flex clutches, the machine down-time can be considerably reduced. Draw between machine sections on account of different furnishes and shrinkages can be precisely controlled by installing thyristor control. It also results in energy saving.

GENERAL :

Some of the general features of old machine which require consideration during rebuild are machine frames, roll bearings, pipe lines and instrumentation.

Machine frame design should be simple safe, and modular for quick felt changing, easy maintenance and roll removal. It should be rigid enough to withstand vibrations at high speed. Either stainless steel cladding or fibre-re-inforced plastic coating should be done to prevent corrosion of frames in wet end. By replacing journal bearings of all the rolls by anti-friction bearing, the starting and running friction can be minimised and it results in energy saving. Another benefit is less requirement of lubrication. Dead pockets, sharp bends and haphazard routing of pipe lines should be eliminated so that friction to flow is minimised.

Incorporation of consistency regulators, basis weight (grammage) meter, moisture profile meter and caliper meter will not only enhance the quality and process controll but also make the production cost effective.

CONCLUSIONS :

Prospects for paper machine re-builds are bright throughout the world as paper industry is striving for high capacity and better quality papers to meet present and future demand.

OPITIMUM :

Productivity is achieved through introduction of state-of-the art technology. Paper machine rebuild can be carried in stages to suit one's limited investment. Lastly it improves chance of mill to survice in a competetive and inflationary economy.

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