

Beloit "Converflo" Headbox Concept & Development

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SUMMARY

With the increasing demand for higher production, speed and quality, headbox design has been changed regularly to meet the challenge. The dilemma of headbox design has been finally simplified by compromising on eddy structure and fibre distribution to regard the spectrum comprising of large and small scales of turbulence. The large scales are mainly responsible for the mixing and energy transfer processes and the small scales for the dissipation of energy. In fibre distribution, the large scale is associated with basis weight profile and the small scale with the sheet formation. Converflo headbox is the solution for meeting today's requirement of the paper machine. It is backed by extensive researches conducted by Beloit's and also by the performance obtained in many mills. Sree Rayalaseema Paper Mills at Kurnool, are having the first headbox of this type in India.

CONCEPT

With increased demand for paper and higher standards of quality old style machines had to be discarded and therefore, new designs had to be introduced in order to meet the higher standards of paper required.

One of the most important factor which influences the final paper is the formation. Some of the factors to be considered in the formation are the degree of dispersion or "wildness" and the degree of directionalism of fibres in the paper.

The chances of a well formed sheet increase if the pulp fibres separate but remain uniformly dispersed throughout the liquid. On the contrary if fibres tend to flocculate and form lumps, the sheet will be wild. To produce a well formed sheet fibres are oriented at random, and though it is not difficult to separate fibres it is difficult to maintain them in uniform dispersion.

The headbox is an integral and important part of the paper machine, that delivers to the forming zone a slurry of fibres and water in suspension having suitable conditions for forming a sheet of acceptable quality. It is true that the quality of sheet depends on many other factors, yet the headbox is the main and most important item of the complex paper machine in forming the quality sheet.

It is of great importance that the discharge from the headbox should contain a uniform dispersion of the fibres at an even velocity across the full width of the machine, without large intense flow disturbance in the form of currents, vortices and flocculations.

When the consistency is low the fibres are isolated from each other with the exception of those that collide. High consistency increases flocculation by increasing the number of fibre collisions. Among the factors worth mentioning which increase flocculation are: size, gelatinous bundles, increased hydration, presence of air, increased fibres length and more beaten stock.

Since the required paper making consistencies are high enough to cause flocculations, the headbox has to impart turbulence in the flow without affecting the sheet quality.

Flocculation is the mechanical entanglement of fibres, which are primarily due to turbulent shear. The size of the flock is related to the scale of the eddy size of the turbulence. In other words the fibre flocculation in a turbulent field is apparently closely related to the scale of the eddy structure of the turbulence.

If turbulence in suspension was produced in small scales without large scale eddies, the primary mechanism for large reflocculation or large turbu-

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lance would be absent and the small scale turbulence would decay without a corresponding increase in flock size.

DEVELOPMENT

With the above points in mind the designing and redesigning of headboxes have been constantly undertaken to meet the requirements of today's machines for various grades of paper over a broad range of speeds. This has resulted into making the headboxes a sophisticated machine. The technology of headbox design has been to compromise with devices which produce a level of disturbance high enough to get fibre suspension, but low enough to avoid flow disturbance in discharge jet.

Rectifier rolls till date have been the only tool in the hand of headbox designers for generating mild disturbances in the fibre suspension without fouling the fibre network. They do compromise to the extent which neither maximises the fibre dispersion nor minimises the flow disturbances.

On high speed machines, stable streaks generated sometimes can be attributed due to the holes in the rectifier roll. The problem lies in the geometry of holes, pattern of holes and distance

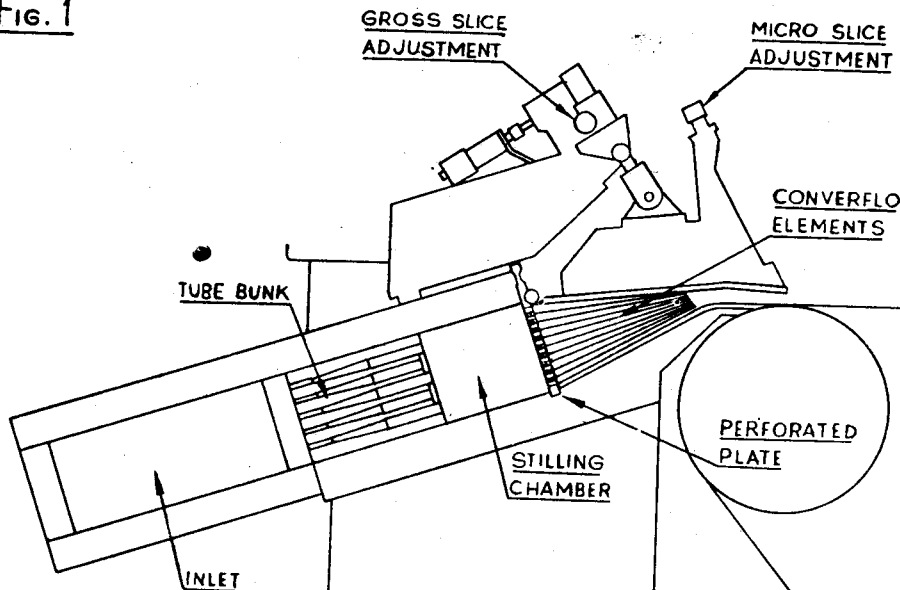
of the roll from slice. The velocity of flow and hole size are responsible for severity. Therefore the headbox designers have to find a solution for an improved headbox that develops more uniform dispersion of the fibres by using smaller scale and less intense turbulence.

Beloit has a solution to this problem in their new concept of headbox design known as "Converflo". It has been after years of trials, flow studies and modifications which ultimately proved the worth of this type of headbox with successful results.

CONVERFLOW HEADBOX

When first introduced the Beloit hydraulic converflo headbox represented a complete new approach to fibre distribution control and was surely the fore-runner of future headbox designs for the industry. Constant improvements in mechanical details have been made but the superior results in the field on over 200 installations have shown no reason to change the basic concept. Fig. 1 gives an idea of the cross-section of this box. The stock is handled in such a way as to have converging flow of this layer of the stock to arrive at a high degree of small turbulence result-

Fig. 1



ing in good fibre orientation as it emerges from the nozzle slice.

There is a growing need for something better than table rolls to support the wire at high speeds. Wet boxes and foils could be used for this purpose but the limitation on this device is that the sheet is set very close to the forming board, and any streaks or other disturbance on non-uniform orientation of fibres coming from the headbox are frozen into the sheet and show upon the reel of the paper. Thus with a finely dispersed stock from headbox, application of wet boxes will be more practical and better. In short, with a converflo type headbox it has been possible to have a table without any rolls.

The Converflo headbox produces better formation of sheet having fibres more uniformly distributed through the sheet thickness. It also gave excellent cross machine profile and permits better utilisation of the fourdrinier forming table. A modern version of "Converflo" headbox is indicated as per Fig. (1). They have been successfully used on all grades of paper and Liner boards also for application on both single wire fourdrinier and twin wire Bel Bone Former. In India, Sree Rayalaseema Paper Mills would have first such headbox for quality writing and printing papers.

The Converflo headbox is a compact, high performance hydraulic headbox which does not need any air pressure thus no need for auxiliary services such as air compressor, pipe work and stock level controls. Rectifier rolls and rotating showers are also eliminated. Fig. 2 gives its geometry in comparison with a normal pressure headbox of the same capacity.

As indicated in Fig. 1, basically it is rectangular channel sloped upwards to avoid any accumulation of Air bubbles, and entrainment of air. Should some air remain it will travel with the stock and discharge on the wire. The sheet is formed without any ill effects whatsoever.

The shipment, installation and erection of this headbox is simple being a compact unit. All it needs is an accurate setting with the Breast Roll.

Stock flows from the fan pump and into the tapered rectangular header which is an integral part of the headbox. The header gives constant static pressure at the entrance of the distributor tube to ensure equal velocity and distribution. Stock from the header passes a large number of closely spaced specially designed distributor tubes which agitate the stock due to increased velocity in the tubes to eliminate flocculation and also allow jets to combine more readily in the stilling chamber, since the tubes are flared out to slow the velocity before discharging into the

stilling chamber. Creation of large scale eddies are thus avoided.

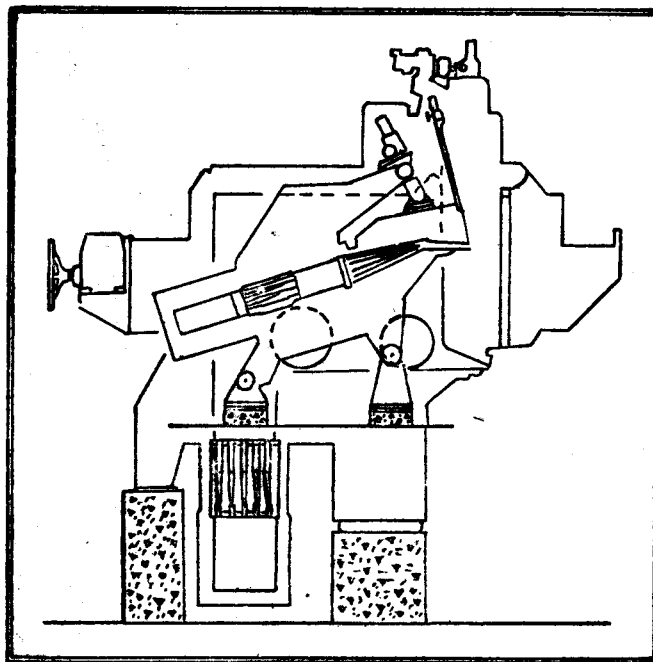
The stilling chamber provides time and space for the jets from the distributor tubes to merge and reduce velocity. From this chamber it passes through specially designed perforated plates which once again agitates the stock which now has a tendency to flocculate once again at the end of the stilling chamber.

Trailing members are attached to the perforated plate which distributes the flow among the channels. These trailing members are of special thin, tough, wear, acid and temperature resistant material.

Fibre dispersion is obtained and eddy currents eliminated by passing stock through multiple thin channels, that converge prior to slice discharge.

Velocity past the plate after entering converging flow area is slow, and as the stock travels towards slice, velocity increases rapidly preventing flocculation and at the same time giving good fibre dispersion.

The principle of operation is based on the creation of high intensity turbulence at a controlled small scale in the jet.



SIZE COMPARISON OF CONVERFLO AND AIR-LOADED HEADBOX. CONVERFLO- 55 gpm/in AIR-LOADED-60 gpm/in

FIG. 2

The narrowness of the flow passages create the turbulence due to boundary friction, the small dimensions at the outlet of the convergent section restrict the scale of the turbulence produced.

The controls on a converflo headbox are simple and only a few Slice bleed maintains uniform flow like in other pressure headboxes.

Having established the micro-formation capacity of the Converflo headbox at relatively higher consistencies, Bel Baie formers with shorter forming lengths and high speeds found it an ideal partner in producing a sheet with better qualities. Fig. 3 gives a typical installation of Bel Baie with Converflo/Strataflo headbox. Today there are more than forty Bel Baie running with converflo headbox, on various grades ranging from fine papers to coated raw stock, liner-board, roto and newsprint.

Strongly influenced with the successes of Bel Baie and the Converflo headbox, Beloit group pioneered a programme of Research with Australian Paper Manufacturers, a company with much Inverform experience. The result was a curved inverted vacuum box Fig. 5 the "heart" of what

we know as Bel-Bond. This name is derived from BELOIT and ply-BOND, the latter being the sheet property so important to the multiply board and folding carton field.

Success at this production installations resulted in orders for board machines from many mills since the superior ply bond characteristics are just about guaranteed with BELBOND because of the wet-on-wet principle being used.

Today BELBOND can be employed as a very effective drainage device on machines where fourdrinier length is the limitation. Fig. 6 gives a typical Bel Bond installation on a fourdrinier.

STRATAFLOW HEADBOX

A still newer concept of the "Converflo" headbox is the application of "Stratflow" headbox on the machines manufacturing multi-strata linerboard. With the Strataflo headbox on a Bel Baie it is now possible to make a three ply sheet with almost the same equipment as for a single ply sheet. All that is needed are three fan pumps and three stock admission valves to the headbox, but the white water system will be common to all the

FIG - 3

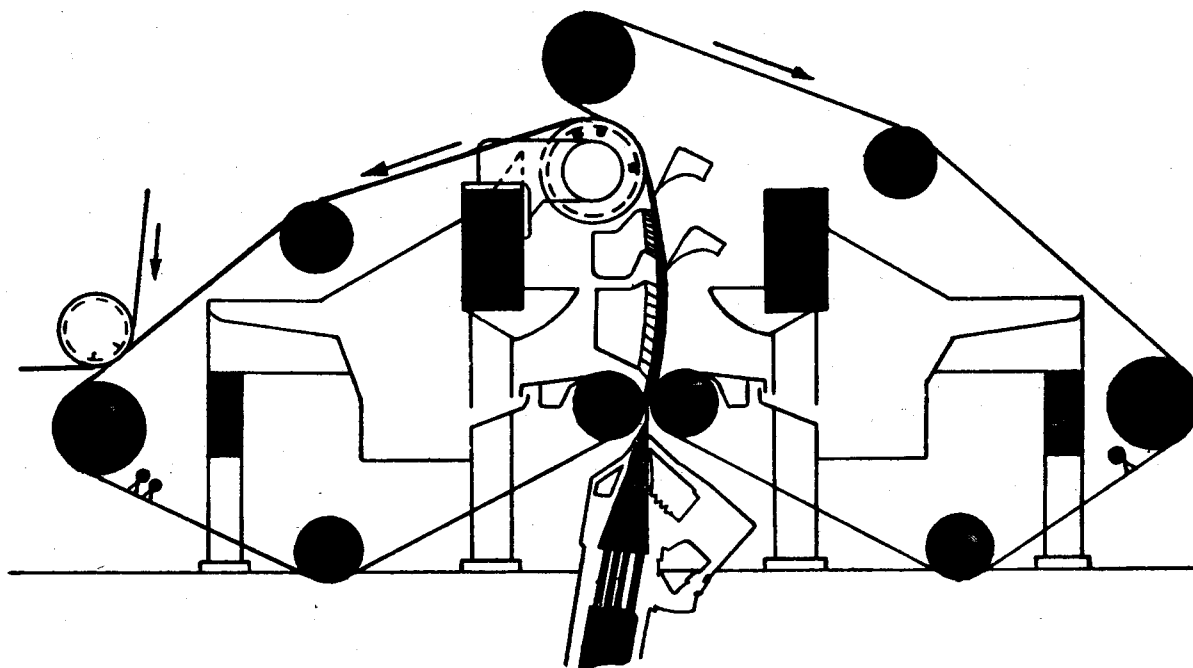


FIG. 4

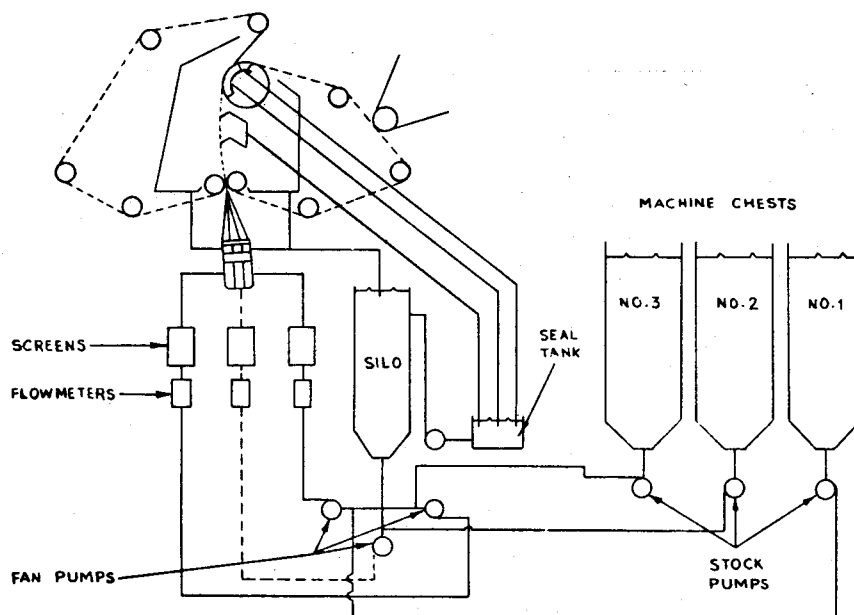
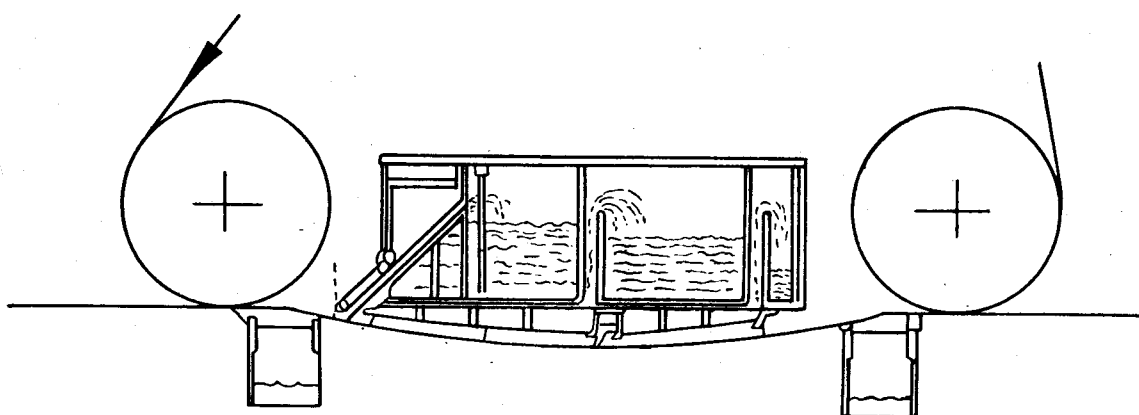
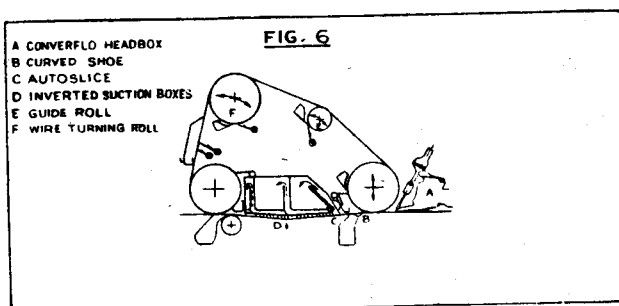


FIG. 5



three The typical instalation of a Strataflo headbox on a Bel Baie using virgin stock in top and bottom layer and recycled fibre in the centre is shown in Fig. 3. The stock system is as per Fig. 4. This has been used most successfully on the Bel-Baie former of Obbola Linerboard AB in Sweden.



It is now producing linerboard grades using a substantial quantity of waste of secondary fibre. This machine was designed to produce a liner board in a basis weight range of 110 gsm to 200 gsm. Sheet produced is a three layer sheet, composed of vergin unbleached kraft in top and bottom layers with the waste fibre added to the centre layer. Up till now 28% reject fibre has been used in the middle layer. The sheet thus produced has been having properties equal to the one produced from virgin pulp.

CONCLUSION

We can now conclude that Beloit's Converflo headbox has the following advantages over the conventional headboxes.

1. Elimination of all rotating parts.

2. Elimination of rectifier rolls which have a low flow resistance due to difficulties in controlling boundary clearance.
3. Due to difficultt manufacturing design of rectifier rolls on account of proper control of spacing, diameter and adius of holes, disturbances are created by them in the jet due to flow differences through the holes.
4. Conventional headboxes require the bridging of the width of the machine with the slice to contain the internal pressure forces. This bridging causes differential cross machine deflection which affects flow uniformity across the machine.
5. Make up and structure of conventional headboxes are massive & expensive for meeting the requirements of increasing width & speed of the present machines.
6. The Bel-Baie formers which have proved themselves highly successful are ideally suited for Converflo headbox.
7. The Strataflo headbox (basically converflo) greatly helps in conserving the virgin stock by using recycled fibre in the middle layer of the sheet.
8. It is an ideal headbox for rebuilds due to its comparatively low weight, ease of erection and since it can be used on fourdrinier machines running at fairly low speeds.