Shoe Press-Design And Applications

Halsall Steve

Walmsleys Limited,Withnell Mill,Railway Road,Withnell,Chorley,Lancashire,PR6 8UA,England

ABSTRACT

Shoe press technology improves dewatering of paper sheet in wet pressing section and works better than Roll press technology. Due to higher dewatering it reduces the consumption of steam at dryer section. The major argument to incorporate shoe press was to increase the machine capacity of existing machine and to reduce the capital intensity of new machine. Shoe press technology is also an energy-efficient technology.

The dewatering capacity of a press is a function of both the time spent in nip zone and the load applied. The long nip of the shoe press allows for much greater time in the nip zone. It allows for a much higher linear load to be applied without creating too high peak pressure. The addition of a Shoe press to an existing press arrangement has improved paper dryness after press by 4% - 5% "This facilitates higher machine speeds and improved efficiency because of better internal bonding of the sheet".

Agro residue fiber has weak strength properties which constraints the load at press section. Agro residue fiber can withstand a maximum linear load of 500 KN/m. Therefore, SIL has opted for Mini Shoe Press which is an ideal option for furnish of 95% agro based residue and 5% soft wood pulp.

Introduction

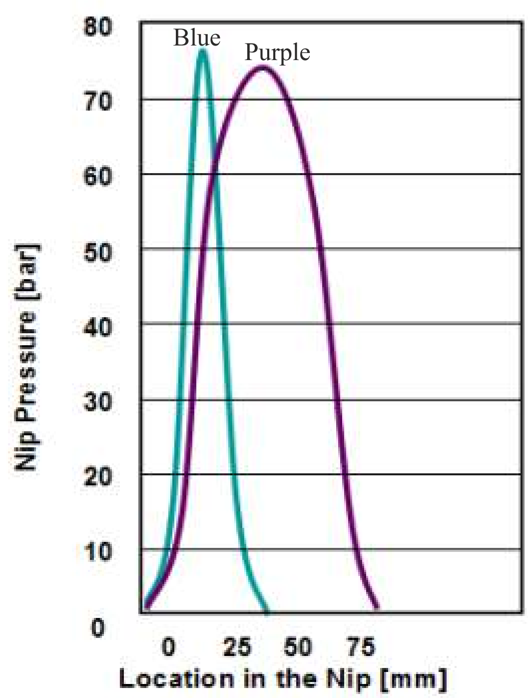
The Pulp and Paper Industry is a capital-intensive industry. Demand for paper will be increasing slowly and steadily. The industry is focused on proven technology that can increase paper machine's production capacity.

SIL has always stepped its foot forward for such technology. SIL decided to enhance its capacity, by installing shoe press in place of conventional bi-nip press. Shoe press is now state of the art product for paper making sector. There are several considerable benefits that support a press section realized with shoe press, the advantages it brings in terms of improved paper quality and enormous increase in productivity, flat pressure gradients which ensure: high dry content; uniform web compaction and a constant CD moisture profile, minimized paper breaks and reduction in energy consumption. For equal dryness values, Shoe pressing will yield a higher bulk index than traditional roll pressing.

The success of the shoe pressing concept in all grades of paper has given the paper industry a tool to increase the off press dryness by at least 4% -5% compared to conventional press section. Since every 1% increase in off-press dryness reduces the drying capacity requirement in dryer Section by 4-5%, the size of dryer section and steam energy consumption can be readily reduced with Shoe Press concept.

Roll Press Limitations

In any press, the linear load creates a nip zone of a certain width. Within this zone the pressure applied to the sheet increases to a maximum, then tails off towards the nip exit. Some typical pressure profiles are shown in the graph The dewatering capability of a press is a function of both the time spent in the nip zone and the load applied in effect, the area under the nip pressure curve. In graphical terms, therefore, the greatest dewatering would be associated with the wider curve (purple), as would be expected.



Ordinary roll presses apply their linear load over a narrow nip zone. This means that the peak pressure within the nip can be quite high, even at relatively low line loads. For these two curves, the total applied linear load (in kN/m) is much greater for the wider curve (purple) than for the blue curve. The peak pressure is similar because the linear load is spread over a wider area. Peak pressure is the key parameter affecting the bulk of the sheet, as it represents the maximum applied mechanical load on the sheet fibres.

In a typical roll press, the pressure profile is symmetrical around the nip line, and the pressure through the nip increases at a very steep rate. Water flow is always from high pressure to low pressure, and a steep pressure gradient will cause a high rate of flow. On the ingoing side of the nip this flow will be upstream through the sheet, and if the rate is too high crushing can occur.

So the three key characteristics of the curve area enclosed, peak pressure, and ingoing gradient each represent an aspect of the pressing process. It is common to desire high dewatering (area), while minimising the peak pressure (bulk loss) and the gradient (crushing effect). However, in a given roll press the first of these can only be increased with a corresponding increase to the other two not always a desirable situation.

The solutions to these problems are to reduce the applied linear load, which has a negative effect on the dryness of the sheet, or to widen the nip, which can be achieved by increasing the size of the rolls and softening the covers. This is limited in scope, however it is difficult to achieve meaningful nip widths greater than 75mm.

Shoe Press Initial Development

The development by Beloit Corporation in the 1980s of the Shoe Press allowed the designers to engineer the characteristics of the nip in much closer detail than before. The principle is very simple. Instead of two rolls being pressed together along a narrow line, one roll was replaced with an extended “shoe”, up to 250mm in length. Of course, this shoe had to remain stationary, and so a method was required of allowing the opposing roll, press felts and sheet to move through the nip without excessive friction. The answer was to run a rubber blanket through the nip also, and to lubricate the underside of this blanket where it passed over the shoe. Oil is applied via a shower on the ingoing side of the nip, and collected on the outgoing side by a doctor and a tray. The blanket was run around four rolls, and as such was open at the front and back sides.

The blanket kept the lubrication oil away from the felts and sheet, but at high speeds the oil became difficult to contain. A simple modification to the design led to the Closed Shoe Press that is the norm today. Here the blanket is clamped at the front and back side by two circular heads. This makes the entire space inside the blanket loop a closed area, and so the lubrication oil can be kept inside at all machine speeds. Conceptually, however, the shoe press remains the same thing a structural beam to press against, a shoe loaded against the opposing roll, and a blanket to allow lubrication of the shoe surface.

Press Comparison

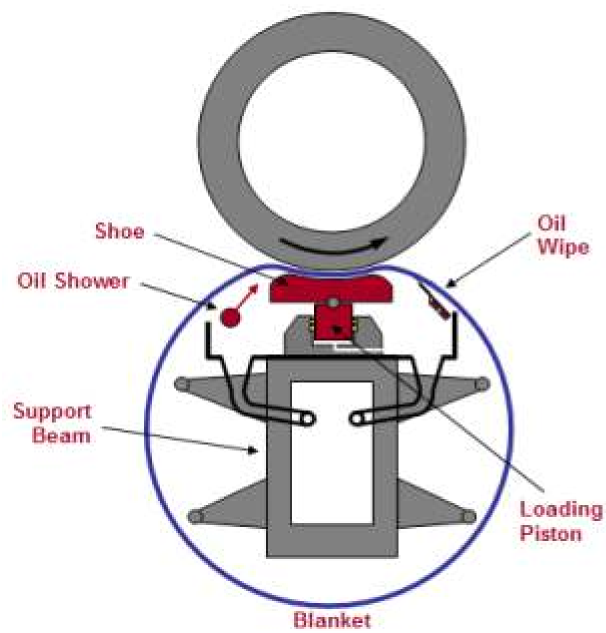
The long nip of the shoe press allows for much greater time in the nip zone. It also allows for a much higher linear load to be applied without creating too high a peak pressure.

Comparing the three key characteristics of this curve with the standard roll press curves, we see that the shoe press offers immediate advantages. The area under the curve is vastly greater than for the roll press, representing a large increase in the dewatering ability of the shoe press. Despite this, the peak pressure is reduced also, so bulk preservation can be achieved. And the gradient of pressure increase is shallower than for a roll press, so the detrimental effects of the water flow can be eliminated.

Typically, a shoe press can be designed for equivalent linear loads as high as 1300kN/m, compared to a roll press, in which the maximum load is nearer 150kN/m.

Shoe Press Design

The simple concept of the enclosed shoe press is translated easily into a workable machine design. A very strong stationary support beam provides a reaction surface for the shoe loading. The shoe itself is loaded through a piston mounted to the beam. An oil supply shower on the ingoing side, and an oil collection system on the outgoing side, apply and control the shoe lubrication oil. And the whole assembly is enclosed inside a thick polyurethane blanket whose shape is maintained by solid



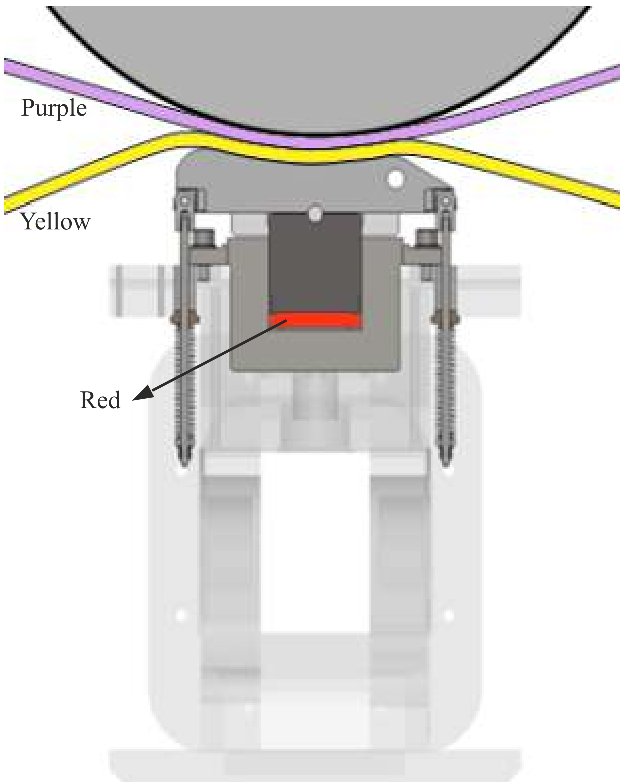
circular heads at each end. These heads, and the blanket attached, are the only rotating part of the assembly, and are mounted on large bearings on the support beam journals.

Thus the finished assembly looks very much like an ordinary roll, albeit with a concave depression at the nip zone. The enclosure formed by the blanket and the two heads is complete no oil can get out of the shoe module except by way of the oil drain piping. In operation therefore, the shoe press appears just as a regular press would, and from the operators point of view can be largely treated as such.

Each “roll” in the press configuration has a bearing housing, and these housings are firmly fastened together. Because the pressing load is created internally, by oil pressure pushing the shoe up from the support beam, the reaction to this load is taken entirely in the connection between the two housings. In other words, despite the very high loads that a shoe press can apply, no pressing load is transferred to the general machine frames. This makes the application of shoe presses, particularly as a rebuild, quite straightforward.

Shoe and Shoe Loading

The shoe itself is a concave single-piece construction, shaped to match the diameter of the opposing roll and the chosen nip length. It is mounted to a full-width piston, which in turn is mounted to the main support beam. Oil pressure under the piston (shown in red) forces the shoe up against the opposing roll, creating the nip. No "external" load is applied; the entire press nip load comes from the hydraulic loading of the piston, pushing the shoe away from the stiff support beam.



In this diagram, the blanket is shown in yellow. The purple represents the combination of one or two press felts, together with the sheet. In the case of a single felted press, the sheet would be between the felt and the opposing roll. The sheet is never run in direct contact with the blanket.

The applied lubrication oil runs between the moving blanket (yellow) and the stationary shoe. Applied via a shower on the ingoing side, it is doctored off the blanket at the exit from the nip, and recycled through the external lubrication system.

Also shown on this diagram are the shoe retract springs, connected to the lead-in and lead-out sides of the shoe. In the configuration shown, with the shoe in the bottom position, the shoe will naturally fall away from the opposing roll under gravity when no hydraulic pressure is applied. The springs allow this retraction to occur against gravity if the shoe is in the top roll position. This gives flexibility in the application and use of shoe presses, in that they can be used in any orientation.

Shoe Press Size

Each application is different. On board grades (and typically for heavier weights) the greatest advantage comes from maximum press load. In these cases the largest size of shoe module is commonly used. On lighter grades, especially for printing and writing applications, the full load capability of the shoe press is not always required. In these cases, the designer has several options to consider.

Reducing the maximum load capacity of the shoe press means that several of the components can be reduced in size, making the unit overall lower cost. Primarily, the lower load means that the main support beam can be reduced in size. This beam is what sets the diameter of the shoe module, and therefore the more lightly loaded versions are smaller in diameter. These diameters range from 750mm up to 1500mm for wide, heavily loaded applications.

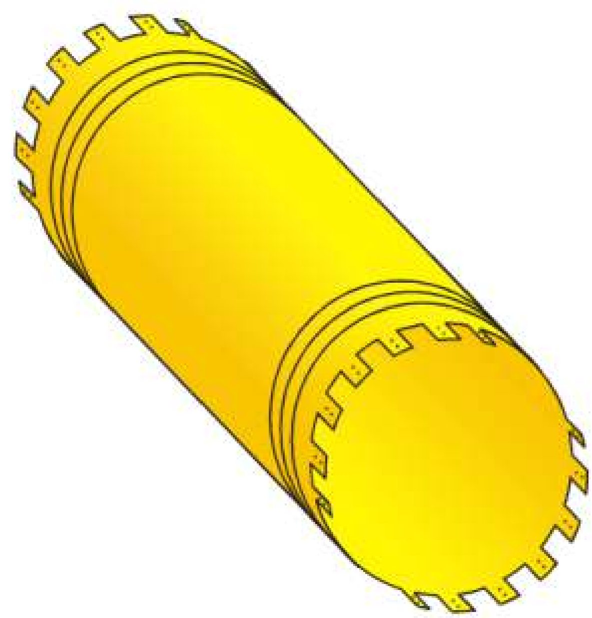
The length of the shoe can also be adjusted to suit a given application. A standard shoe has a length of roughly 250mm, but again for lighter weight grades, all of this length might not necessarily be required. Shoes of 150mm can be used in these applications, which again provide most of the functionality of the shoe press, without requiring the cost of a full-size unit.

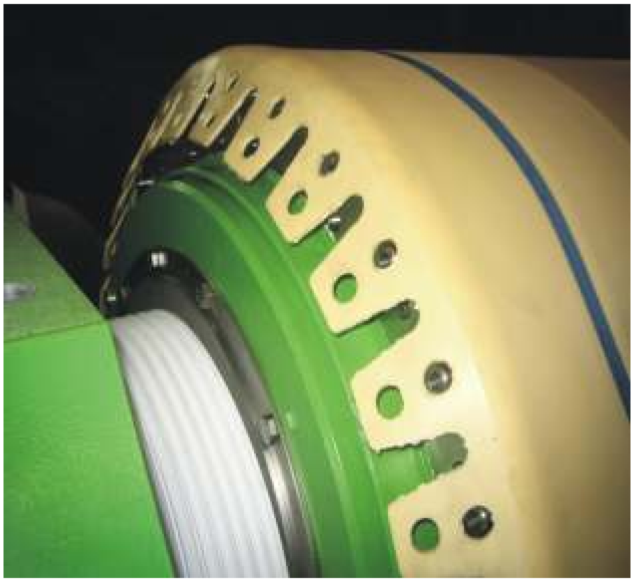
It is important when considering the design of each shoe press to fully consider all of the machine's operating and quality requirements. However, with proper consideration it is often possible to use a smaller shoe press at much lower cost, while still obtaining the benefits outlined above.

Blankets

The blanket for a shoe press is typically a 5mm thick composite construction, with a laid or woven substrate layer and a polyurethane outer layer. The surface can be plain or grooved, depending on the requirement. It is a replaceable item with a typical operating life of more than 200 days at 800mpm. The blanket has a series of tabs on each end. These tabs are folded around the heads and clamped in place with segment pieces bolted to the head. This creates the complete seal at each end.

The usual cause of replacement is the hardening of the blanket due to the flexing as it passes through the nip zone. At the ends,



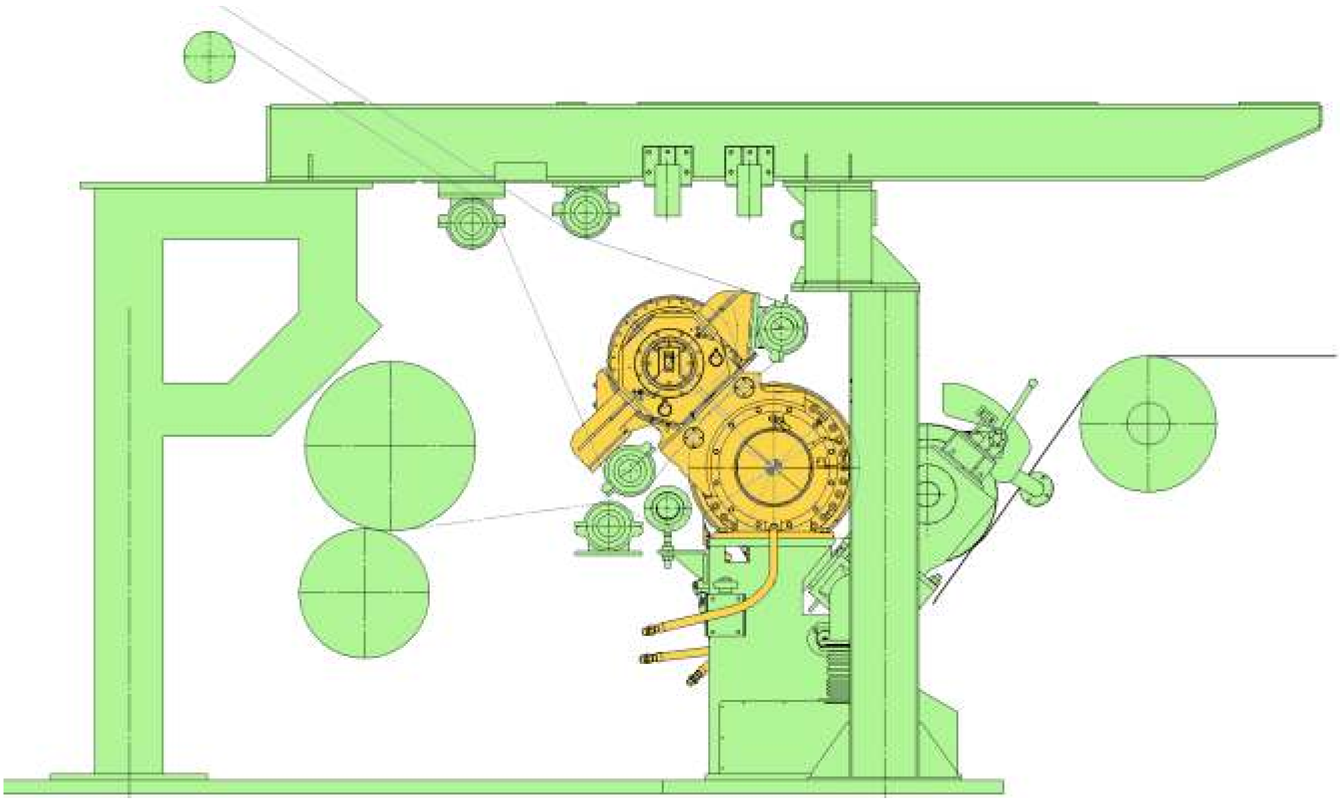


and a new blanket is slid on from the frontside end. Support systems for the shoe module during this period are built into the unit, and a frame for holding the blanket to the right shape and supporting the front of the roll is provided. Belt change time is of the order of 3 hours.

Case Study Mini-Shoe Press for Shreyans Industries

At Shreyans Ahmedgarh Unit, the existing press was a Combi-BiNip type, followed by a separate third press. The remit was to increase ex-press dryness while maintaining the bulk of the sheet, a very important property.

Because the application was for a relatively lightweight product, the shoe press selected was a mini-shoe type. The flexibility of size that this offered enabled the design to match the existing configuration, a Bi-Nip arrangement. The shoe module directly replaced the second press.



the circular heads make the blanket follow a completely circular path. Over the shoe width the path is not fully circular, having of course the concave depression due to the nip. In the transition zone between these areas (outboard of the shoe width at front and back) the blanket undergoes a degree of flexure that is the source of eventual hardening.

The shoe press module has a feature that enables the blanket to be periodically offset in the cross-direction, by adjusting the positions of the heads relative to the shoe. This helps to maximise belt life by avoiding having the flexure described happen to the same part of the blanket at all times.

When a new blanket is required the old one is simply cut away,

The shoe press module is in the upper left position in this arrangement. A new centre roll for the BiNip was required, due to the much higher loading of the shoe compared to the roll press. The third press was left untouched. As can be seen, the shoe press module is mounted directly to the centre roll bearing housing. All of the press load is taken by this joint none is transferred to the frames. This meant that the general framework of the press could be maintained.For this application the chosen shoe design was:

Shoe Roll Diameter	760mm
Shoe Length	150mm
Maximum Nip	500kN/m

As can be seen, these values are at the smaller end of the general shoe press design range, and yet the results obtained were

Shreyans Shoe Press Summary of Results

	With Roll Press	With Shoe Press	
Maximum Machine Speed	510mpm	570mpm	
Post-press dryness	38 – 40%	43 – 44%	Improved by 4 – 5%
Avg. machine Production	115tpd	134tpd	Increased by 17%
Steam consumption per tonne of paper (on machine)	2.339 Tonnes	1.984 Tonnes	Reduced by 15%
Bulk	Remained the Same		
Runability	Improved considerably, due to higher dryness		
Smoothness	Better than before rebuild		
Ash Content	Increased by 2% with no adverse effect on printing (fluff)		

nonetheless excellent. Start up of the rebuilt press was in January 2012. Shreyans recorded immediate and extremely positive results from the rebuild. The press gave a dryness improvement of around four percentage points, which allowed both a production increase and a steam saving, while maintaining the previous levels of bulk.

Conclusion

Dewatering capability of a press is a function of Dwell time and load applied. Therefore, the greatest dewatering would be associated with the wider nip. Roll press creates a narrow nip zone thereby peak pressure within the nip can be quite high, where as, in a shoe press similar pressure is spread over a wider area and thus reduces the reduction in bulk of the sheet while maintaining higher dewatering.

For higher weight papers, larger size of Shoe Module is used, where as, in lighter weights the full load capability of Shoe Press is not required and hence a Mini Shoe Press is designed matching the existing configuration of Bi-nip arrangement at Shreyans Industries Ltd and replacing second press.Shreyans is getting positive results, such as, 4-5% increase in post press dryness and about 15% reduction in steam consumption. Even with increased dewatering, it is maintaining its bulk similar to that achieved with Bi-nip press.