Single nip shoe press impact to paper quality

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Abstract: A single-nip shoe press is able to reach very high dryness with high press nip load with modern felt design, but concern has been raised with the current felt design’s ability to achieve good bulk roughness ratio on calendered sheets. Based on results, single-nip shoe press reaches similar bulk roughness ratio as three-nip press.

PRESS SECTION DEWATERING has evolved over the years and has migrated towards shoe pressing as today’s most economical press design for a growing number of grades and speeds. In many cases, a shoe press can more efficiently remove water from the sheet while maintaining or improving critical sheet properties beyond those produced by using a roll press.

To date there have been several single-nip shoe presses installed in commercial applications, and one common area of challenge has been the press felts copying the felt surface topography to the paper. Felts originally developed for standard roll or multi-nip shoe presses do not give the sheet surface characteristics, felt life or rewet performance required for high quality printing and writing papers when used in a single-nip shoe press. As a result, felt suppliers have recently developed more suitable felt designs for single-nip applications. In this paper, the bulk roughness quality is analysed with recent felt design on various single-nip shoe loads and calendering loads. The difference of sheet surface development between two common press designs, single-nip shoe and three-nip press, are also discussed.

PILOT SINGLE-NIP SHOE TRIAL

During 2004, trials were run in the Metso R&D facility pilot machine in Jyväskylä Technology Center where the nip pressure impact to surface roughness and bulk were measured after calendering. There was concern in earlier studies that the felt batt roughness impact may disappear or change after calendering, and thus it was decided to calendar the sheet. It was also felt that this method would more accurately simulate the full-scale machine operation.

PILOT MACHINE PROCEDURE

Furnish for these trials was copy paper pulp with SR 27 with TAPPI Water Retention Value of 1.4. For each trial day, a fresh furnish was used to minimize the impact of furnish re-circulation in the pilot paper machine. The basis weight was 80 g/ m² copy with 22% filler. The forming section was a modern roll-and-blade type gap former. The press felts were selected to give good surface roughness according to previous trials, Fig. 2. (The result was published in PAPTAC seminar in January 2004.) The average felt surface batt dTex was 5.5 (CP 5 felt set).

The paper machine speed was 1,050 m/ min (3,445 ft/ m). The paper web was reel-up at press solids and dried in a separate KCL facility nearby, and then calendered at Metso Paper Pilot Calender in Järvenpää with an 80C hard roll using nip loads of 25, 50, 75, and 100 kN/ m. In order to find out the single-nip shoe impact to sheet roughness three different press nip loads were run (600, 900 and 1,200 kN/ m). Each press nip load was run with every calender load. As fine paper grades are produced to particular bulk and roughness measurements, sheet bulk and Bendtsen roughness were measured by Metso Technology Center paper laboratory equipment.

TRIAL RESULTS

Paper roughness changes compared to calender linear load at three different single-nip press nip loads are shown in Fig 3. The higher the press nip load is the higher the calender nip load has to be to achieve the same roughness. This result indicates stronger felt surface batt copying to paper surface as grooves. Uncalendered sheet roughness does not show such an impact of batt grooves in paper surface as the grooves are not dominant leak of air when using Bendtsen measuring method. This is an important finding because it verifies the need to use calendered paper when studying press impact to paper surface. By changing the calender load, a similar sheet roughness can be achieved in typical running conditions, but with significant loss in bulk, Fig 4. This result is logical considering both press and calender are in an elevated nip load.

The results in Figs 3 and 4 can be used to optimize existing single-nip shoe press or help in the selection of press design during a rebuild. For example, if mill has a target bulk 1.3 cm³/ g it can be reached with press nip load of 600 kN/ m and calender linear load of 70kN/ m, or with press nip load of 900 kN/ m with calendar nip load of 55 kN/ m. The sheet roughness is, respectively, 125 mL/ min and 220 mL/ min, but more importantly loading of 600 kN/ m produced press solids of 43.4%, and 900 kN/ m resulted in press solids of 49.8%. Such an impact to press dryness often affects paper machine production rate, runnability and moisture profile.
Another element to be studied more in detail is surface topography. Earlier studies have shown a strong correlation between surface topography and printability. In cases where felt batt grooves are too deep, they will show in printed result even though standard roughness or smoothness methods are indicating good surface characteristics. Figure 5 shows an example a digital picture of sheet surface in side light, which clearly shows that the felt batt and surface are being copied to the paper surface. The batt is shown as valleys in the surface and easily may be misinterpreted as missing fibres.

**SINGLE-NIP VERSUS THREE-NIP DESIGN**

Both single-nip and three-nip shoe presses transfer the web from the former to the press with a suction pick-up roll, which brings the bottom felt in contact with the paper web before entering the first nip in the form of a sandwich: felt, paper web, felt. A single-nip shoe press is illustrated in Fig. 1, which has only one nip created with a grooved bottom roll and grooved belt roll.

In the inside, the grooved belt roll has a stationary shoe, Fig 6, which has a radius matching the nip shape created by the grooved roll. The nip length is determined by shoe length. The nip pressure curve is determined by shoe shape and MD location of the hydraulic loading cylinder. The nip pressure curve can be modified by moving the MD location of the hydraulic loading cylinder if a single-loading cylinder row design is in use, or, alternatively, by adjusting the loading pressure ratio between lead-in and lead-out cylinders if multiple rows of MD cylinders are used for the loading scenario of Fig 6. After the nip, the paper web is sandwiched between two felts until it is transferred to the bottom felt and then the dryer fabric takes the web. Dewatering in the nip follows the principle illustrated in Fig. 7.

In the three-nip configuration shown in Fig. 8, we will have the web similarly entering the first nip sandwiched between felts, but now the nip is created by a suction roll on top and grooved hard roll on the bottom. The nip length is just a fraction of the length of a single-nip shoe press nip length, but has a nip high peak pressure. Due to short nip dwell time, the first roll nip is not able to dewater at the same level as the first shoe nip. After first nip, the suction roll vacuum will hold the web against the pick-up felt as the bottom felt follows downstairs to reconditioning.

The second nip is formed between the suction roll and the press centre roll. The pick-up felt is still on the top-side of the sheet, and the smooth centre roll directly against the bottom side of the paper web. The centre roll smooth surface will smoothen the web bottom surface roughness created by the bottom felt and wire section. The second nip is even shorter nip than first as there is only one felt in the nip. After the second nip, the web will follow the smooth centre roll surface and the pick-up felt goes to reconditioning.

The third press felt is brought into contact with the web top surface just before the third nip. The third nip is a shoe press nip (SymBelt) with a grooved belt on the top and smooth centre roll on the bottom. In principle, the nip is similar to a single-nip shoe nip, except that the sheet bottom-side is against smooth roll instead of a felt. Afterward, the nip web is peeled of from the centre roll and transferred to dryer section.

Dewatering in the first nip is up and down and both follow nips only up. The key difference concerning paper surface characteristic between a single-nip shoe press and a three-nip configuration (SymPress B) is that after a single-nip shoe press both surfaces of paper have copied the felt surface pattern, whereas in a three-nip configuration the bottom surface has been smoothened against the centre roll in the second and third nips and the top surface is smoothened by having a third press felt running over the pick-up felt patterns on the paper surface. The impact of two felts patterns covering each other can be illustrated by thinking...
of a single car tire thread pattern on fresh snow and smoothening impact of running another tire over the same track. Just by judging on smoothening alone, the three-nip press has an advantage on paper surface. On the other hand, two-roll presses before shoe press in the three-nip configuration results in lower bulk before calendering due to high peak pressure in roll nips. In the case of the single-nip shoe press, the additional bulk before calendering helps to reach similar Bendtsen smoothness values as the three-nip press, Fig. 9.

In Fig 9, the results are with the pilot OptiPress I, the single-nip shoe press, and pilot SymPress B. With both presses the furnish was the same (different than in Figs 2-5). Paper reels pro-
duced with OptiPress I were calendered with a two-nip soft calender (140 C in both nips), and reels produced with SymPress B with one-nip soft calender (140 C in top roll). The difference in calendering prevents making a fully accurate comparison, but one can see clear indications of similar roughness/bulk ratio with high press using either press method.

When comparing trial results with different press concepts, press dryness should also be taken into consideration. The OptiPress I type single-nip shoe press generates similar press dryness as the SymPress B-type three-nip configuration at the same press nip load.

The advantage of the OptiPress I is that the nip load can be increased without increasing the peak pressure in the nip as high as the SymPress B, due to a wider shoe in the single nip. With Optipress I, single-nip shoe press extremely high press dryness has been measured at elevated nip loads, Fig 10. This potential will make single-nip shoe press a very interesting versatile alternative for manufacturing paper and board grades where bulk is not as important as in copy type grades.

CONCLUSION
Single-nip shoe press increased nip load, causing a roughness increase at given bulk quite similar to a three-nip press configuration with a shoe press in the third press position. Roughness increase will limit the operating window of single-nip shoe press, by not being able to maximize sheet dryness due to limited nip load. By increased calendering, sheet target roughness can be achieved even with high press nip load, but with loss of bulk. There is still need to further develop the felt designs for bulky fine paper grades to be able to utilize very high dryness potential of single one-nip presses. It should be noted that achieved bulk/roughness ratios are similar as in trials with SymPress B, the three-nip configuration.


Keywords: SHOE PRESSES, NIP, LINEAR LOAD, MACHINE DESIGN, PERFORMANCE EVALUATION.