Quest for bulk in a fine paper machine

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ABSTRACT

Paper bulk/smoothness combinations are considered as the most important sheet properties for uncoated woodfree papers. From paper machine technology point of view bulk conservation usually requires gentle processing of the web which often is contradictory for high-speed runnability requirements.

High-speed runnability typically requires extreme paper machine processing conditions. Good example of this is the press outcoming dryness as an always increasing processing parameter at increasing speeds which usually ask for high dry content to manage web handling in different sections of the paper machine. Unfortunately increasing press dryness typically means that higher press loads are needed and this again is not favorable for bulk conservation.

Another disturbance for good web runnability is the quest for low tensile ratio on uncoated woodfree grades. Most of printing and writing papers can improve its web runnability by setting more fibers in machine direction i.e. running with high tensile ratio. Usually this is not acceptable for sheeted uncoated products.

Through studies during the over past 5 years focus on this dilemma, a number of technical solutions has become available and can be applied in the entire paper machine line. These technologies will help paper machines to reach higher production rates bearing in mind this bulk preservation. This article discusses the technology and philosophy of the solutions developed and their contribution in the eternal quest for bulk.

PHILOSOPHY OF REMOVING OPEN DRAWS

Since long time ago it has been acknowledged that the position of the first open draw in a paper machine will determine the first bottleneck for web runnability. For a long period of time this draw used to be between former and press, at web dryness of 20…24%. Later pick-up roll was introduced to overcome this problem.

Today it's common that the first open draw is located after press center roll, at web dryness of 42…50%. Ever increasing need for higher speeds and savings in raw materials put pressure to move this draw further towards a greater dryness and sheet strength. Closed draw technology has moved this first open draw all the way down to right in front of the size press, where the web has typical dryness of no less than 96…98% for uncoated fine papers. This offers a totally new philosophy and possibility for high bulk sheet production.

WET PRESSING IS NOT NECESSARILY THE BULK DESTROYER

Wet pressing influence on paper density and not calendered smoothness is a clear and familiar concept to every body on all uncoated fine paper. Wet pressing influence on paper machine runnability is, I believe, even clearer to all, as high press outcoming dryness is beneficial for both paper machine capacity and runnability.

Pressing paper with higher nip loads provides dryness, but simultaneously has a negative effect on bulk. Shoe presses have proven to help in this equation to some extent, but the correlation between press load and bulk still remains.

The question will soon arise. Is it still possible to dream about higher production rates without fear of bulk loss?

During past five years a number of studies have been carried out on pilot paper machines to learn how a fine paper web could be pressed in an optimal way. This includes a number of pilot comparison studies as well.

The common denominator for all

Authors' references:
1 - Metso Paper - Jyvaskyla, Finland
2 - Metso Paper - Sorocaba, Brazil

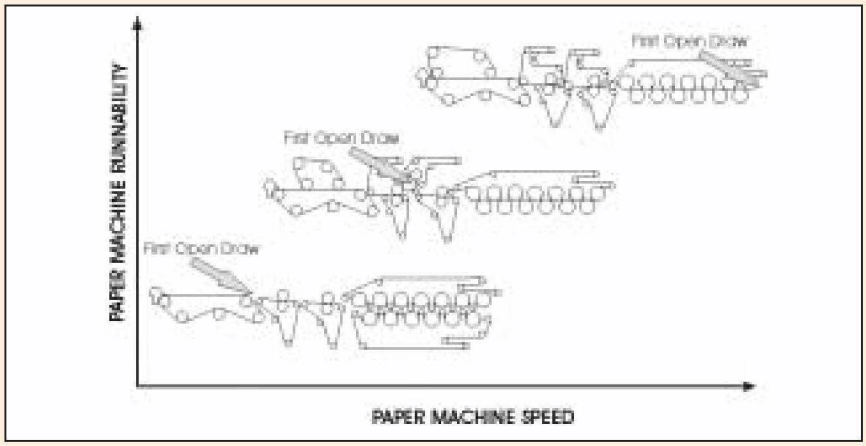

Figure 1 - Development steps of first open draw

press trials was the importance of the first nip, for bulk. Let us start with the most famous press concept, the three-nip press configuration, and the bulk smoothness curve created with this concept.

A three-nip press produces a sheet where bottom side is pressed against the smooth roll twice but topside not. This fact makes the sheet coming out of the press to be somewhat asymmetric, topside being rougher than bottom. This difference can be corrected in calendering.

The study continues with closed draw press configurations, this time with double nip press with different first press configurations. These studies suggest that from the bulk point of view 1st press should be operated as gently as possible. While 2nd press takes care of the final dryness. Of course 2nd press also has an effect on bulk, but according to studies, it has only half of the effect of what the 1st press does.

A double nip press offers only a slightly asymmetric sheet coming out from press. This is an important benefit, since it will help at paper calendering. Smooth and symmetric paper can be reached at gentle calendering parameters, which helps for bulk preserving.

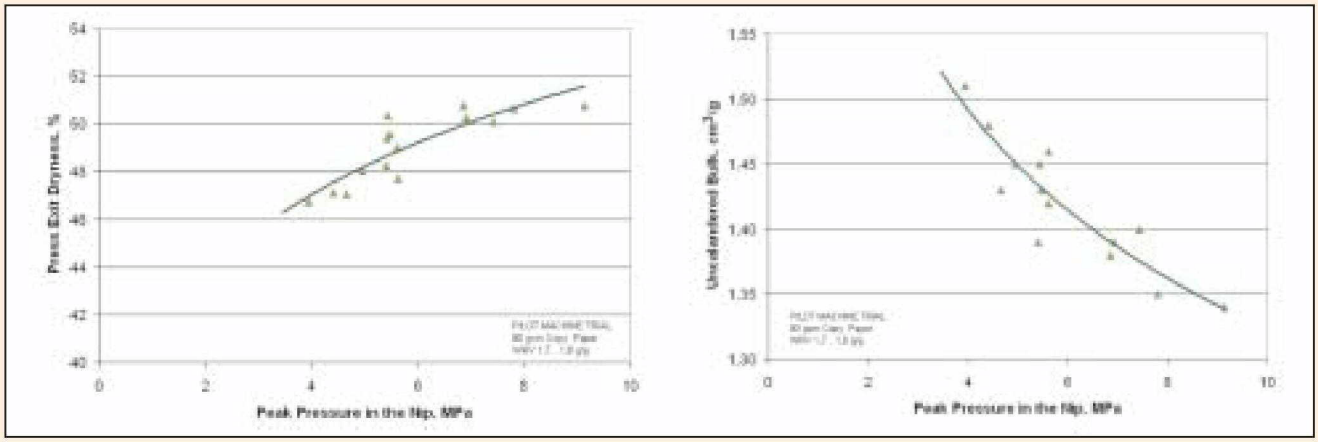

Figure 2 - Nip peak pressure effect on dryness and bulk using fresh Scandinavian fine paper furnish

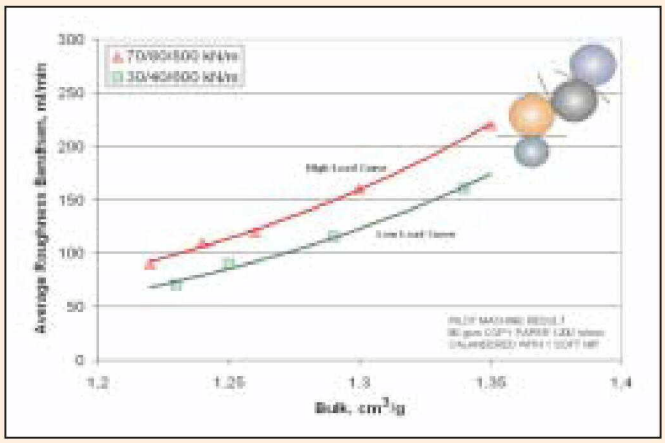

Figure 3 - Bulk/roughness window of three nip press with South-European fine paper furnish

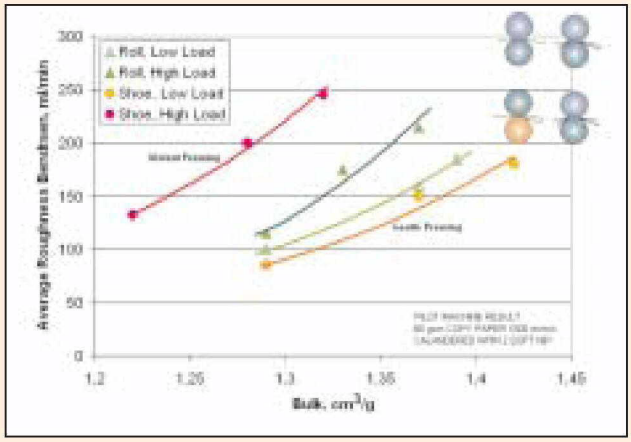

Figure 4 - Bulk/roughness window of a double nip presses with different 1st press configurations and with South-European fine paper furnish

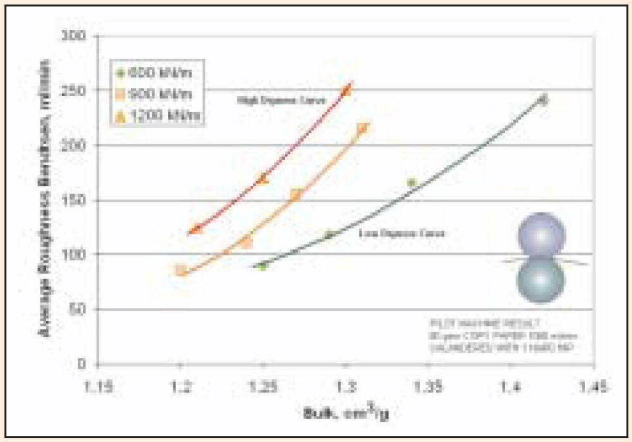

Figure 5 - Bulk/ roughness window of a single nip press, with South-European fine paper furnishes

Modern shoe press is proven to be a very a powerful de-watering tool. Actually, it's powerful enough to operate even alone, without the assistance of other presses. A single nip press, equipped with two felts (or felt-a-likes) is an interesting option for compact, cost-efficient water removal for fine papers.

The first press rule is valid for this press configuration, too. In this case, the first press is the last press at the same time. Pressing heavily in the nip makes the calendering curve to move itself to less bulk direction.

A single nip press produces close to symmetric sheet after press, depending on the felt selection. The absolute roughness and topography of the sheet depends basically on the felt design.

When analyzing these results, an optimal press configuration for uncoated fine paper pressing can be chosen. The idea of the press is to use as low loading in first press as possible. For this purpose, the direct transfer presses are the most favorable. Direct transfer allows first press to operate at the lowest loading conditions, still offering safe sheet transfer after nip. The 2nd press is equipped with transferbelt (smooth, impermeable sheet conveyor) which automatically grabs the sheet on top of it creating so another direct transfer position.

When press section is built according to these rules, it has no felt sandwiches and it results on an even moisture profile after the press. This is beneficial because no extra profiling equipment (press steambox or rewet sprays) are needed, which is a clear benefit in bulk & operation cost point of view.

DRYER SECTION ROLE GROWS STRONGER

Operating press on 'high bulk mode' plus having closed draw (where high draw is no more needed to transfer the sheet to dryers) sets pressure on dryer section operations. First thing to worry about is the dryer capacity. How can the paper machine reach its production targets if press is not allowed to operate at high pressures?

Answer to this question is simply to add dryer capacity. Nowadays this is possible also without extending paper machine length.

Rebuilt impingement technology is an applicable method to increase drying capacity of existing dryer sections. In this technology, a free-standing air dryer unit (or units) can be added in paper machine basement without disturbing the cylinder arrangement of paper machine itself. With these units the lost capacity originated from press "high-bulk mode" operation can be compensated and capacity targets of the rebuild can be still met.

Another dryer related question, as a result of press "high bulk operation mode" is simply the dryer runnability. Conserving dryness for the sake of bulk is usually a bad news for the early dryers. Increasing speed increases the need for web tension to avoid sheet disturbance, such as wrinkles and fluttering. This threat is typically most severe in the first two dryer groups.

The dryer runnability components become even more critical as moister and weaker sheet run through dryers. Both dryness and filler content have significant effect on sheet stretching properties. If web is not capable to maintain its tension it has to be helped with runnability components.

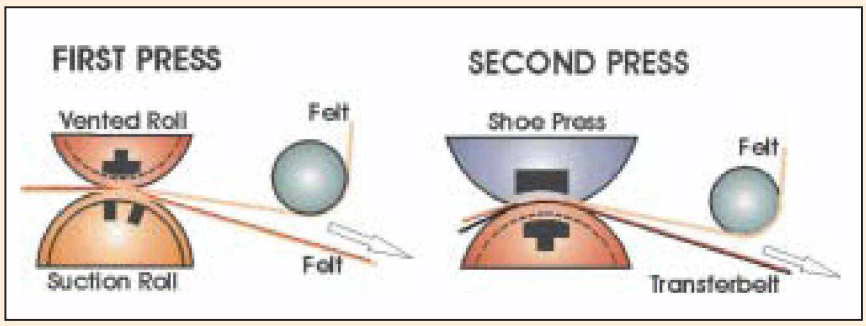

Figure 6 - Direct transfer principle

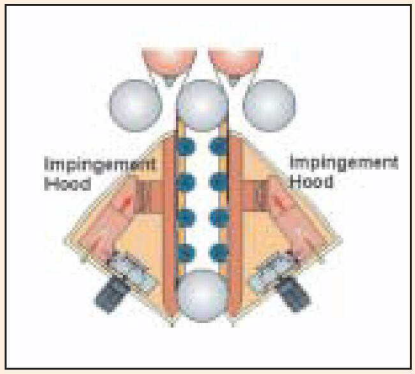

Figure 7 - Impingement dryer blows hot air against the web

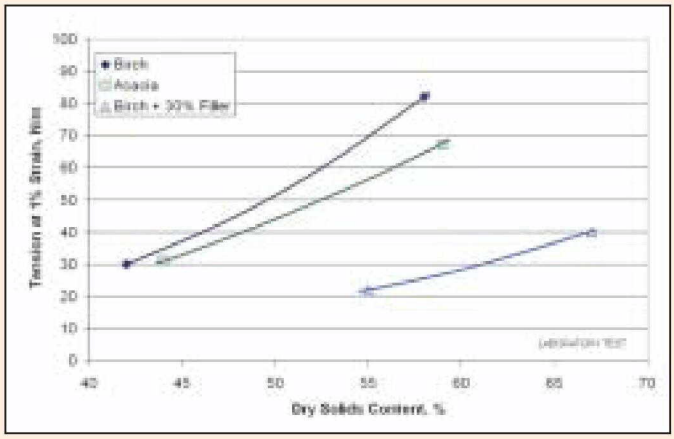

Figure 8 - Dryness effect on sheet tension at 1% strain with fine paper furnish

The beginning of fine paper machine dryer should be designed in such a manner that they offer the best grip of the web when coming out from the previous cylinder surface in the group. Grip is especially needed mainly at the point were cylinder and sheet separate. Low tensile ratio requirement together with ever-increasing use of short fibers put additional pressure on how to handle this area of paper machine.

SIZING PARAMETERS OFFER OPTIMIZATION POSSIBILITIES

Applying surface sizing starch decreases bulk of WFU paper. Starch also roughens the sheet, which makes surface sizing more unfavorable in terms of bulk. Surface sizing variables can, however, have an effect to bulk development. Generally, minimizing the starch amount can be favorable in terms of bulk optimization. Starch solids content - despite of its strong effect to starch distribution across the z-direction of the sheet - does not seem to have a strong effect on bulk.

But indirectly it can effect to bulk certain properties, e.g. surface strength level of the sheet is targeted.

Increasing the starch solids content will have a positive effect on surface strength (e.g. i, ii). Then, targeting a constant surface strength can allow reducing the starch amount applied. This will result in increased (or actually less decreased due to surface sizing) bulk in surface sized final WF sheet.

Increasing the starch solids content and - at the same time - decreasing the starch amount to the sheet will result in a demand for thinner film applied on the surface of the roll in an MSP unit. Here, very finely grooved rods (or even smooth rods) are needed.

It is of worth mentioning also that increasing the solids content of the starch will demand adequate stability of the starch itself with sufficient binding ability.

FINAL APPEARANCE OF THE SHEET IS DETERMINED BY CALENDER

Calender determines the final sheet quality. Target is to produce paper, which is at the same time, bulky, smooth and symmetric in smoothness. As press will produce a sheet, which is only slightly two-sided, with soft calender it is relatively easy to adjust the final roughness without pressing the web too hard.

Thinking of the final bulk and smoothness combination, the double nip press with transferbelt delivers slightly twosided sheet. The top side of the sheet will appear rougher than the bottom side but the difference, however, will remain low, about 10…30%. This means that the sheet will be twosided enough to remain sustainable through felt ageing, still easily controlled by calender without too heavy calendering parameters.

At calender this rougher top side will

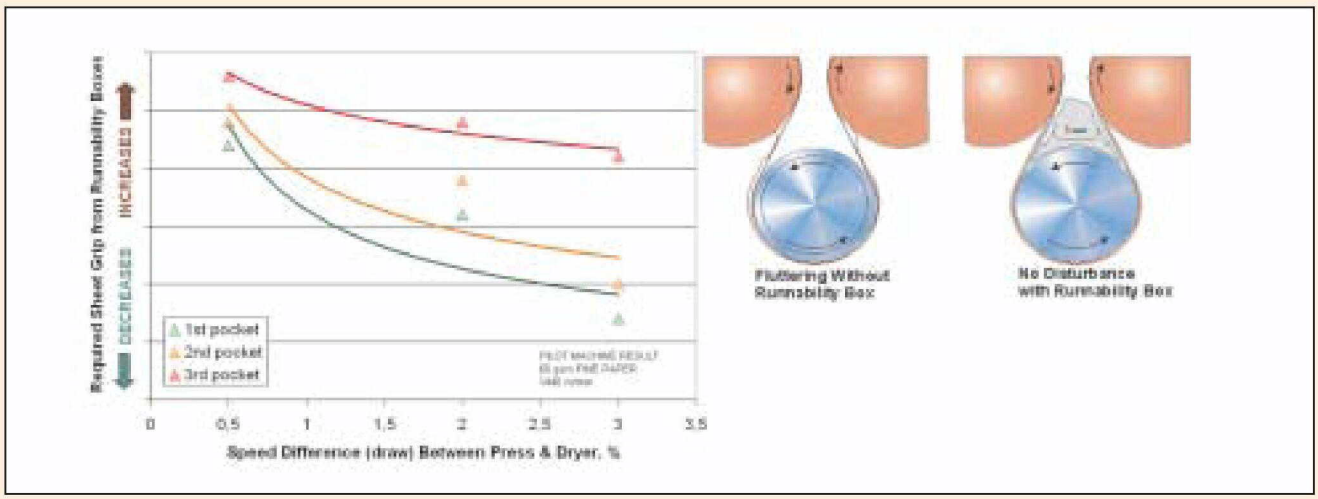

Figure 9 - Runnability equipment become more and more essential as wetter and weaker web must run through early dryers

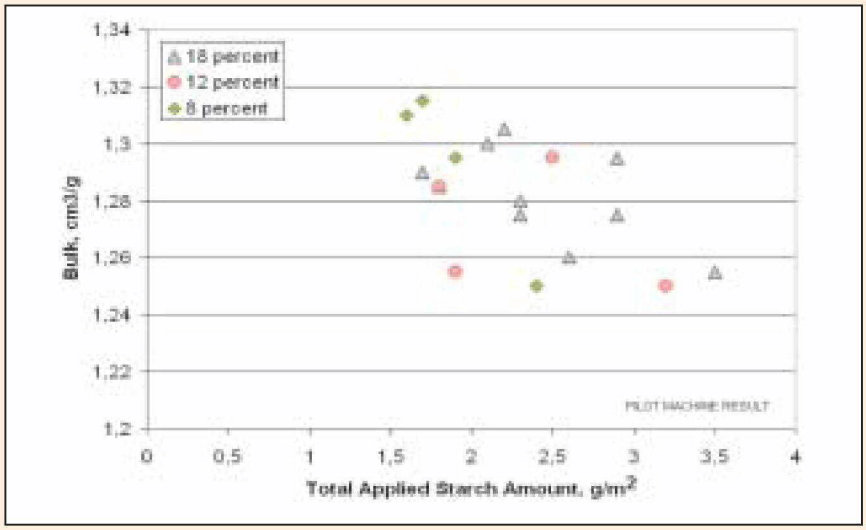

Figure 10 - Effect of surface sizing starch on bulk with uncoated fine paper

be treated against hot and smooth roll surface. Bottom side will be treated with softer polymer roll which is more flexible surface and does not smoothen the belt - pressed surface too much, thus making it easier to achieve symmetric paper.

Pressing the topside (rougher side) of the web against a hot roll smoothens the paper surface. Enclosed is one pilot machine result which illustrate how soft calender can be used when targeting symmetric sheet.

Controlling paper twosidedness is the major advantage of soft calender. As paper caliper is related to smoothness, gaining both bulk and smoothness is difficult. However, a soft calender offers additional tools to win in bulk when applied with optimal press configuration.

CONCLUSIONS

High bulk paper production at high speeds and good efficiency is typically tough combination. During recent years a lot of effort has been put in studying bulk-related issues. As a result Metso Paper has introduced new innovative technologies for various paper machine sections which will enable paper mills to reach higher production without sacrificing sheet bulkiness.

Selecting a press section, which offers good runnability and optimal twosidedness, from the calendering point of view, is good starting point. As press section is not allowed to operate at maximum possible dryness a special attention must be paid on both dryer capacity and runnability. Modern soft calenders allow base paper to be asymmetric since symmetry can be corrected through calendering.

Putting these ideas together offers interesting possibilities for existing fine paper machines to upgrade their production rates without sacrificing paper bulk.

LITERATURE

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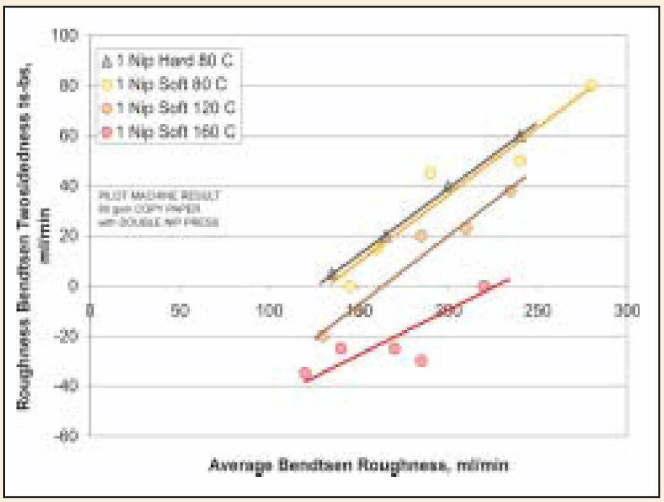

Figure 11 - Roughness twosidedness can be controlled with soft calender temperature and loading. This trial was carried out with fine paper furnish originated from Central-Europe

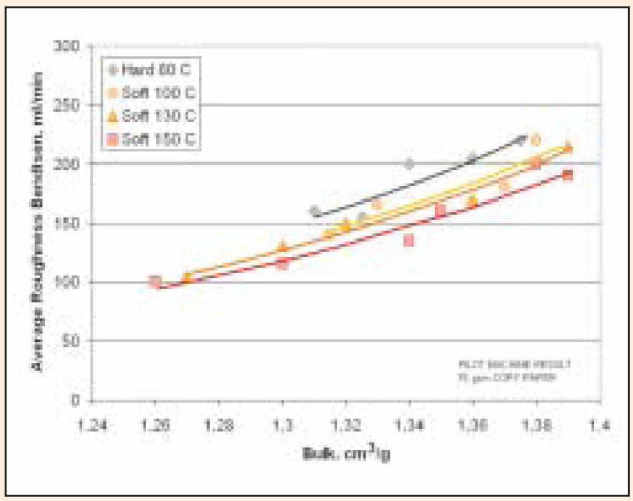

Figure 12 - Bulk and smoothness comparison of different 1 nip calenders with South-European fine paper furnish