Influence of press felt design on energy consumption

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The energy consumption of the paper machine is composed predominantly of :

(1) The power consumption for the drive and vacuum system.

(2) The steam consumption for the drying process.

As regards drive power, no case is known where different constructions of press felt had any influence on the energy consumption. However, the process of the felt closing up either by blinding, mechanical compression or both, will create a braking action at the suction boxes which would marginally increase the drive energy requirement.

The power consumption for the vacuum system is rather different. The proportion of this which is used for conditioning the press felts could in some cases be reduced. We frequently find that unnecessarily high water volumes are often applied for cleaning and conditioning press felts. Such excessive water volumes must be removed from the felt by the conditioning boxes. It is here that savings can be made in the shower water applied which additionally leads to savings in the power consumption of the vaccum system. The correct selection of nozzle diameter, water pressure and application time is important and should be established for each position. Generally, it is our impression that too much water rather than too little is applied.

The greatest influence which press felt design can have on the overall energy consumption is without doubt on the steam consumption in the dryers. This is substantially dependent on the dry content of the sheet after the press section. The dry content achieved is determined by a number of factors including the type of stock, the types of presses and the linear loads applied. However, in addition to these factors the press felt construction can play a significant part.

The main determining factors for the felt in obtaining optimum efficiencies and thereby minimising energy consumption in the dryers are :

a) Specific design suitability and

b) Condition of the felt

Much can be said about the basic suitability of a design. Here I would mention just a few aspects :

In theory, the most even application of pressure is necessary to achieve a good dry content. This would be best obtained by the use of finely structured and relatively dense felts. However, the production of a fine and dense felt involves necessary loss of other characteristics such as permeability and water carrying capacity. Additionally, the hydraulic pressures developed in such a felt would be so high that either crushing of the sheet or even destruction of the felt itself could result.

It is therefore necessary to seek a compromise between permeability, the inevitable loss of permeability through compression on the one hand and a regular application of pressure and freedom of marking on the other.

If we assume that the optimal compromise for the position in question has been obtained, the condition of that felt then becomes the most significant factor in determining the dry content. Felt condition can be divided into 3 phases :

1. Start-up phase
2. Optimal phase
3. Critical phase

START-UP PHASE :

At start-up the caliper and the permeability of a new felt are at their peak. This can be seen in the low vacuum figures recorded in the start-up phase. The compression which takes place in this phase contributes towards the more even application of pressure. During this phase, which can last from a few hours to a few days, the dry content of the sheet is inevitably lower. If only one felt has been changed, it is possible that the other presses can compensate for any loss in dry content. However, if several felts or particularly if the last press felt is changed the start-up phase will be associated with either a

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higher steam consumption or a loss in production.

Following the start-up, the felt reaches a condition which brings its optimum performance. A reduction in the length of the start-up phase can be achieved by the felt manufacturer's use of special chemical and thermal treatments. Considerable development in this field has taken place and it is believed that the start-up phase can be almost eliminated.

OPTIMAL PHASE :

During the optimal phase the best dry content of the sheet is obtained and trouble-free production results. Further compression of the felt takes place only very gradually However, a continuous blinding of the felt is the taking place which even with best conditioning arrangements can only be partly offset. The combination of further compression and increasing blinding lead to the critical phase. Unfortunately this change is so gradual that it is difficult to detetmine a precise moment of transition. For the purposes of energy saving it would be desirable to establish the point of transition more accurately so that the felt could be changed. However, in most cases runnability problems show that the felt has already reached its critical phase.

CRITICAL PHASE :

Reduced sheet dry contents, crushing and increased vacuum figures show clearly that the felt has reached the end of its life. Intensive felt washing can generally produce only a brief improvement.

Lower dry contents and increased steam consumption underline the importance of changing the felt. It is clearly more economical in energy terms to change the felt at the end of its optimal phase or right at the beginning of its critical phase at the very latest. Close observation of vacuum developments indicating felt permeability together with steam consumption and machine speed are a good guide to this. Repeated experience with the same felt type will provide values which help in determining the ideal time for felt change without the necessity of running into problems. It is rather more difficult when different types of felts are being run, but even here the above values give clear indications.

The felts produced for high-speed tissue machines provide a good example of the phases mentioned. The machine runs with only one felt and its condition is a determining factor in machine runnability. On nearly all of these machines very precise observations and records of vacuum figures, felt caliper and energy consumption are made. The start-up phase of tissue felts is usually at significantly lower speeds and pretreatment of these felts has become very sophisticated in order to speed up this phase as much as possible.

A graph shows the felt caliper and vacuum level of a tissue felt during its life. The optimal running characteristics of the machine are achieved when caliper does not drop too low and vacuum does not rise too high. The ideal would be in the area between the dotted lines. Newer felt constructions come closer to this ideal, whereas earlier developments showed too much loss of caliper and too great an increase in vacuum. New designs start with the felt already at a lower caliper and at a higher suction press roll vacuum level, but this condition is much more stable resulting in curves much closer to the optimal level.

By means of the design and precompression treatments applied the runnability of the machine and particularly its energy consumption can be significantly influenced.

Rewetting :

The geometry of a two-roll press produces a situation in which the pressure increases steeply from the entry to about the middle of the nip and then on exiting reduces equally steeply. The graph shows the pressure curves of two presses. In both cases the same line pressure is applied and only the rubber hardness of the bottom roll is altered. The press impulse or the quotient from the line pressure P and the machine speed V otherwise expressed as the integral of the pressure pattern over the time is the same in both cases.

It can be assumed that in the moment of highest pressure application or immediately after it the highest dry content is reached. When the pressure drops on leaving the nip, the caliper of the felt increases significantly and that of the sheet to a lesser extent. However, both are firmly pressed together at this stage. Water which has already been pressed out of the sheet now tries to find equilibrium in the combination of felt and paper. In the case of the softer press roll this equilibrium is possible over a longer period.

Additionally, capillary forces are in operation, the effectiveness of which increase with the smallness of the capillaries. Fibres used in wet felt manufacture and the whole structure of the felt have substantially greater capillaries and therefore lower capillary forces than the paper sheet. As a result a certain amount of water flows back from the felt into the sheet. It is estimated that this results in a reduction of sheet dry content from 2 to 4%.

In order to minimise this rewetting attempts are made to increase the capillary forces of the felt by the use of finer fibres, particularly on the side of the felt in contact with the sheet. The use of finer fibres, however, leads automatically to an increase in the density of the felt and makes it more likely to compact. For this reason such modifications must be made with care. The most usual compromise is to produce a multi-layer construction composed of coarser fibres on the base weave and finer fibres on the paper contacting surface.

Felt and sheet geometry after the press section are also significant. They should be separated as soon as possible after the nip, since an extended contact can lead to much reduced dry content. The design of older machines was particulary critical in this respect where the sheet sometimes followed the felt for up to 2—3 m after the press nip.

Similar conditions are met on cylinder mould board machines where the mould felt and sheet travel together after the suction return through a substantial part of the press section. Felt and sheet are sometimes in contact for 15—20 m with the result that a moisture equilibrium between felt and sheet takes place with losses of up to 6% dry content.

The use of finer fibres on the top surface of the felt also increase the felt surface smoothness with the possible disadvantage of sheet sticking after the nip. In extreme cases this might result in the sheet following the felt after the nip rather than the top roll.

In this context the exit angle of the felt from the press nip is important. In pick-up positions the felt roll after the nip should be adjustable so that the best compromise between sheet stealing and rewetting can be obtained. In most cases it is necessary to couch the felt marginally onto the granite roll to eliminate sheet stealing at the loss of some dry content.

Even today in some cases very fine wool fibres are used to increase the capillarity of the surface and to avoid rewetting. However, the use of wool is limited by mechanical wear and by the use of caustic soda for cleaning. Although the use of very fine synthetic fibres leads to a denser felt, this can be partly offset by the use of a more open base weave.

In every case the rewetting that takes place leads to a reduction in the dry content and thereby an increase in the necessary drying energy. The felt construction can only limit rewetting to a limited extent. Further improvements could reasonably expected from the most modern press developments such as the Extended Nip and the Flexo-Nip presses, since in these cases the reduction of pressure after the nip is more abrupt.

FELT MOISTURE :

The felt moisture is also a factor in the dewatering efficiency in a press. It is possible with the Scanpro or similar equipment to measure the water content in the felt at different points in its run. In this way the water take-up (and in individual cases the water removal) in the press nip together with water removal after the conditioning boxes can be measured. Similarly we believe that the correct level of water content depending on felt weight is in the range of 500—850 g/m². Water volumes above this level could lead to reduced dewatering efficiency, particularly in plain presses. An extremely dry felt would also appear not to be ideal for dewatering. Additionally, there is increased mechanical and thermal attack. Most important, however, is that the water content of the felt before the nip is less than that after the nip. Exceptions to this rule include felts in high loaded nips, which are frequently run without shower water.

The water content of the felt is influenced on the one hand by its weight and on the other more particularly by its construction. Certain felt constructions such as top felts have the job of taking up as much water as possible in the nip and transporting it away for removal at the conditioning boxes. If such a felt were to be installed in a position where very little water was removed, its high water acceptance characteristics would be disadvantageous and a lower sheet dry content would result.

On the other hand, if felts with low water carrying capacities are installed in positions when high water volumes are present, the results on the sheet and its dry content are also negative, if there is not sufficient alternative free space for the water in the nip such as suction roll holes, grooves or blind-drilled holes.

The absolute water content of a felt is therefore not the sole factor of importance but must be seen in the context of the felt construction, the press type and its position in the machine.

The componet parts of the felt construction, namely the type of base weave and type of batt surface, can also be adjusted to control the water content in the press nip. Generally, the aim is to reduce flow resistance in the machine-direction and to avoid the build-up of excessive hydraulic pressures. To some extent waterflow in the machine-direction is hindered by the use of cross-machine yarns. For this reason, base weaves are often produced with cross-machine yarns which are as fine as possible or as widely spaced as possible. Here the limitation in design is that water storage capacity in the base weave can only be achieved by an appropriate number of cross-machine yarns. Furthermore, the demands for a base weave which does not easily compact require a balanced proportion of machine-direction to cross-direction yarns.

A further method of reducing flow resistance in the machine-direction can be achieved by the machine-direction layering of the batt surface. The traditional methods of producing the batt surface result in a cross machine-direction orientation of the fibres. The MERIDIAN development, which effectively turns the batt layering process through 90°, reduces machine-direction flow resistance and can in certain cases thereby improve dewatering efficiency.

CONCLUSION :

The construction of the press felt can clearly contribute to or detract from the energy efficiency of the paper machine. The suitability of its design, therefore, for the press position and type in question, the grade of paper and the water volumes to be handled is critical. However, the influence of the press felt has its limits as compared with the considerably greater influences of the press construction and its geometry.