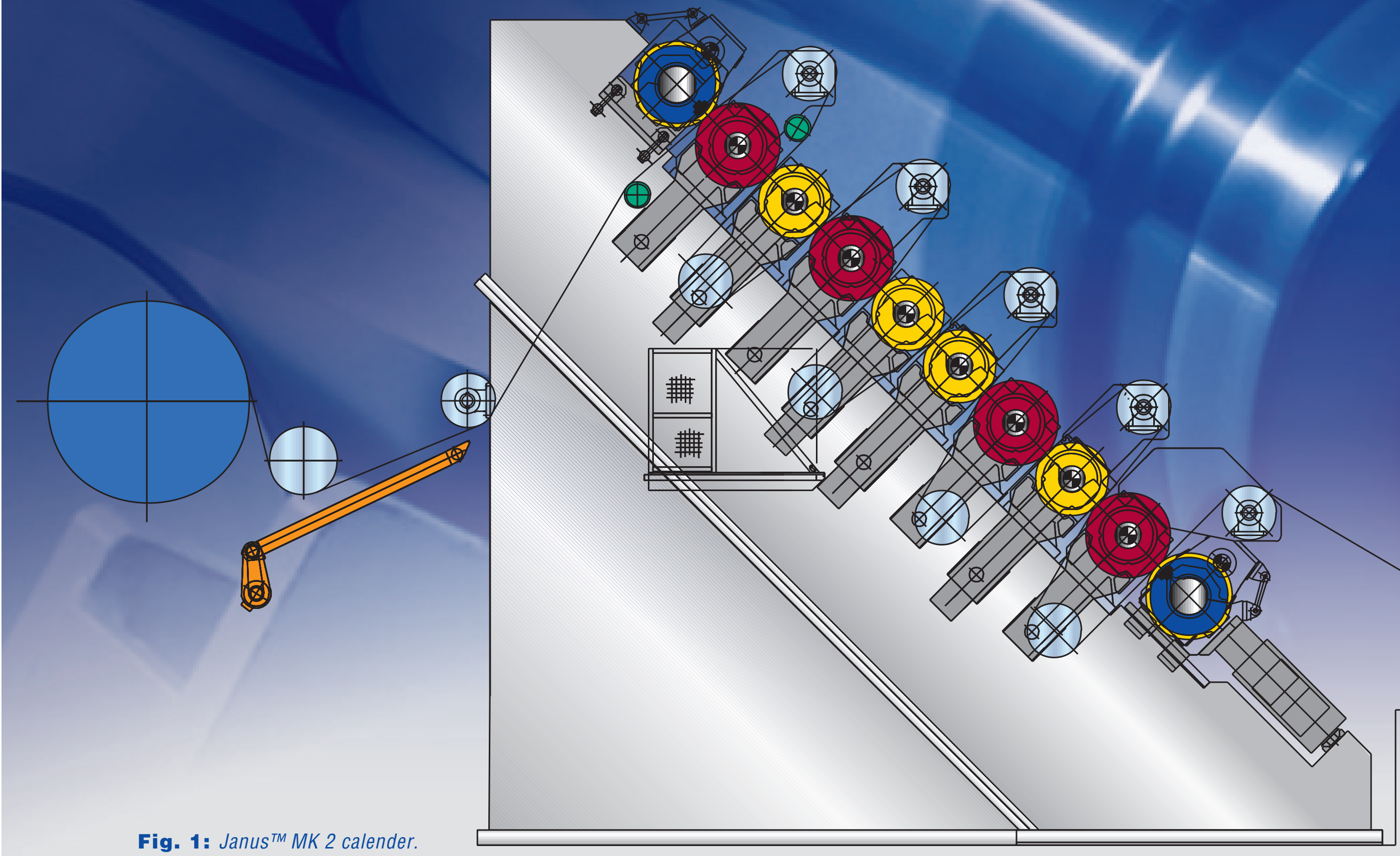

Fig. 1: *Janus™ MK 2 calender.*

Roll cover and coating effects on calendering quality

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To optimize printability, paper has to be calendered, for example, on the Janus™ MK 2 (Fig. 1) after leaving the paper machine. Calenders are basically equipped with hard rolls and soft rolls. The paper is calendered on the side contacting the heated hard rolls, against which it is pressed with controlled force by the soft rolls. To calender the paper on both sides, a reversing nip is required with two soft rolls in contact. The smoothness of the roll surfaces is critical for upholding a high surface gloss on the paper. For this reason, development work has concentrated for years on maintaining, above all, the heated roll surfaces within a certain smoothness limit, even after long periods of operation.

Fig. 2: *Hard cast roll surface.*

Fig. 3: *Doctored chromium roll surface.*

Fig. 4: *Spray coating microstructure, scale 1,000 : 1.*

Fig. 5: *HVOF coating: particle boundary corrosion.*

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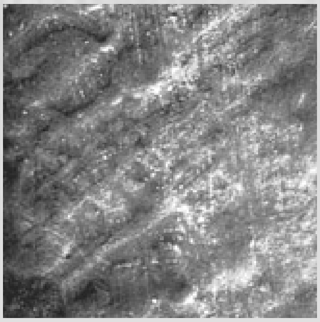

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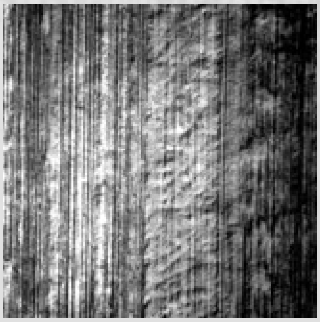

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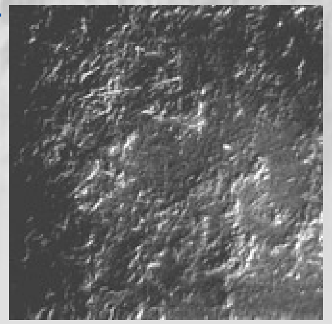

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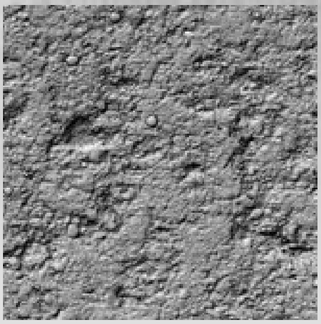

The steel or grey cast iron rolls used in the first supercalenders wore out so rapidly that they soon had to be replaced by chilled cast iron rolls. The impression of such a roll surface in **Fig. 2** clearly shows the roughness due to the relatively coarse iron carbide microstructure.

Surface quality was greatly improved with chromium plated rolls, but their extreme vulnerability to scratching precluded doctoring. Nevertheless, attempts were still made to doctor this type of roll.

Fig. 3 shows a chromium roll surface after about 38 days of operation. The grooves in peripheral direction can still be seen. The overall surface roughness is 0.15 Ra at that time and, therefore, still assures good operating conditions.

The development of HVOF (High Velocity Oxygen Fuel) technology enabled extremely hard surface coatings (>1,100 HV) which could be ground to a smoothness of Ra < 0.08 µm. They were then used instead of chromium surfacing wherever doctoring was important as well as resistance to abrasion. The more this coating was used, the more it became obvious that even this new coating technology was not suitable for every application.

For example, a customer producing wood-free coated paper, was not satisfied with the gloss attained using this kind of roll coating. And in another mill, producing SC grades, despite the long-term abrasion difference between HVOF coated rolls and chilled cast iron rolls **(Figs. 2 and 4)**, there was no difference in paper surface quality. In a third mill, also producing SC papers, HVOF coating resulted in a significantly longer service life, which, however, was still far too short. It turned out here that the surface had been damaged by particle boundary corrosion **(Fig. 5)**.

The problem is that the spray coating particles impinging on the roll are mechanically flattened on to the previous spray material without forming an integral bond. Under certain conditions this can lead to boundary corrosion.

Further attempts were then made to develop an optimal kind of roll coating. In the meantime, technical advances in galvanic chromium plating had increased the attainable surface hardness from 850 HV to 950 HV. This new kind of chromium surfacing is currently in service, with doctoring, at a mill producing SC-A+ grades. The customer is very satisfied so far with product quality, but his heated rolls already show abrasion grooves due to doctoring. Although no roll coating with an optimally homogeneous surface, also compatible with doctoring, exists as yet, some very promising developments in spray coating technology are underway at Voith Paper.

Soft roll cover and surface characteristics

Due to the heavy loading on the intermediate rolls of high-speed, high performance Janus™ calenders, subsequent development work concentrated on increasing the service life and reliability of their soft covers.

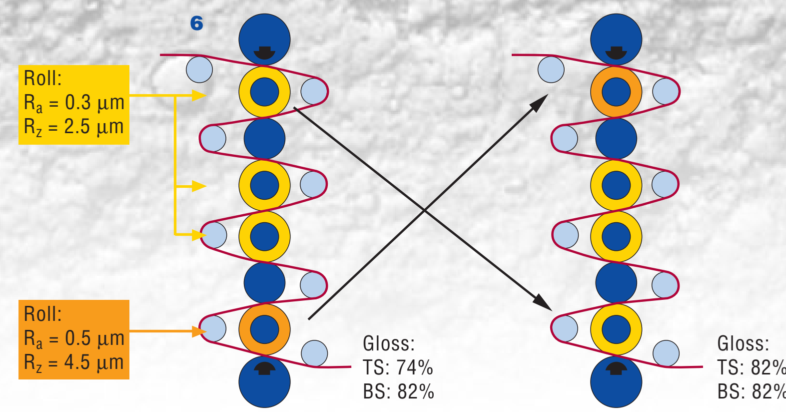

Fig. 6: *Effect of soft roll surface roughness on calendering results.*
v= 1,000 m/min, Q = 450 N/mm, T = 130°C coated wood-free paper, calendered on both sides, 100 g/m²

With the new cover materials now developed, damage caused by internal flexural overheating can be practically excluded. As the next stage of development, attention is now being focused on the cover properties required for optimal calendering results.

With soft rolls in particular, it is very important to differentiate between the various paper grades. Some calendered papers may require a high volume, for example, while in other cases gloss, smoothness and production speed take priority.

The main calendering requirements for uncoated rotogravure printing papers are high gloss and above all smoothness, with minimal blackening effects.

This demands high stress, high temperatures, and possibly a good deal of steam-moisturizing. Therefore the soft covers must not only stand up to high stress levels, but also have the smoothest possible surface and greatest possible abrasion resistance.

For coated papers, the most critical aspect is the surface smoothness of the soft rolls. Any hard filler particles projecting from the roll covers easily penetrate the extremely fine-grained coating surface, with negative effects on gloss. To prevent this, very smooth-surfaced cover materials are used – at the expense of abrasion resistance.
Special requirements apply to roll covers for technical grades such as silicon base paper. To make this kind of paper transparent, the fibres have to be collapsed by extreme compression. Furthermore, the surface has to be extremely dense in order to prevent penetration of e.g. silicon oil during subsequent processing. The primary demand on roll cover materials is, therefore, high compressive strength, together with surface smoothness and extreme microhardness to compress the fibres and make the paper transparent.

Liner and board must retain a high volume after calendering. This requires very soft and smooth covers for only low compression stress. Such covers tend to heat up due to considerable internal flexing, because they form a wide nip with relatively low compression.

Interaction between covers and coatings in the nip

As explained above, one side of the paper is calendered in the upper section of a Janus™ calender, and the other side after the reversing nip.

Since the paper is calendered on the side contacting the heated roll, the soft roll surfaces after the reversing nip have to meet demanding requirements. This is impressively illustrated by a typical application for wood-free coated high-gloss grades **(Fig. 6)**.

Increasing roughness through wear of the heated roll surfaces has to be counteracted by increasing the line load. For a specified paper surface quality, the line load of e.g. 320 N/mm, required with freshly ground rolls, has to be increased during the service life to around 370 N/mm.

In this way, the required gloss and smoothness values can still be attained despite increased roughness of the heated roll surfaces (Ra >0.8). This is attributable to the more intensive contact between web and heated rolls under higher pressure, with better heat transfer as a result.

Nevertheless, by maintaining heated roll surface roughness below approx. Ra 0.8, paper quality requirements can be met with lower line forces and less flexible deformation of the soft covers.

This not only increases roll cover service life, but also reduces drive power requirements and saves energy accordingly. The overall benefit is even greater if soft roll surface quality can be improved to match that of the heated rolls as far as possible.

Furthermore, with particularly smooth rolls the production parameters can be adjusted accordingly, for example by reducing steam moistening and thus reducing heated roll temperatures.

With these findings, the development goals for roll covers and coatings are clear. Abrasion-resistant heated roll coatings with a typical surface roughness of Ra < 0.1 µm are required, in combination with soft roll surface roughness below Ra = 0.15 µm.

Roll cover and coating recommendations

What are the best surfacing materials today for optimal calendering of each paper grade?

Hard roll coatings:

- For wood-free coated grades demanding high gloss and smoothness, chromium plating plays an important role. Also recommended is CeraCal™ spray coating. Initial trials with CeraCal™ show excellent results without any particle boundary corrosion, also with steam moistening. Over an operating period of 70 days so far, CeraCal™ coating surface roughness has remained within Ra = 0.1 µm.
- CeraCal™ spray coating is also recommended for calendering SC-A, SC-B and LWC grades.
- For SC-C and newsprint, uncoated rolls are adequate unless profile wear is a problem.

Soft roll covers:

- For coated papers with high gloss requirements, Rubin™ S covers are recommended.
- Recommended for less demanding coated papers and LWC grades are Rubin™ covers. Due to the type and quantity of fillers used, these are classified as medium quality covers.
- Wherever high line loads and high production outputs are required, for example with SC-A and SC-B grades, only Safir™ S covers can be recommended. These are particularly tough and abrasion-resistant.

After addressing in this article roll cover and coating effects on calendering quality, the following articles in this issue report on the respective technical advances and design developments.

Paper grade	Special characteristics	Roll cover	Roll coating
Wood-free coated	Very high gloss	Rubin™ S	CeraCal (chromium)
Wood-free coated		Rubin™	CeraCal (chromium)
LWC		Safir™ S (Rubin)	CeraCal
SC-A+		Safir™ S (Rubin)	CeraCal
SC-A		Safir™ S	CeraCal
SC-B		Safir™ S	CeraCal (uncoated)
SC-C		Safir™ S (TopTec HC)	Uncoated
Decor (resin-impregnated) papers		Safir™ S	CeraCal
Technical papers	Very high transparency	Safir™ S	CeraCal (uncoated)
Newsprint		TopTec HC	Uncoated