Influence of roll covers in film transfer size presses and coaters

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ABSTRACT

Film transfer size presses have increased demand for elastomeric roll covers with greater wear resistance and improved film splitting characteristics. This paper examines the various roll cover types used in blade metering and rod metering size presses for starch sizing and coating applications. It reviews many important cover properties including cover hardness and the resultant nip width relationships, wear resistance, thermal expansion, swelling, vibration dampening, and surface characteristics. Rubber elastomeric covers and considerations for use of polyurethane, resin composite, and ceramic covers in selected applications are included.

Application:

New rubber, polyurethane, and resin composite covers operate with long regrind intervals in film transfer size presses and coaters running at speeds more than 3000 fpm.

RAPID GROWTH IN FILM TRANSFER press designs has created a wider range of uses in surface sizing and coating applications. Besides extending conventional sizing beyond the speed limits of puddle presses, film transfer size presses find use in pigmented sizing and higher solids coating applications. This has also resulted in a potential for broader paper grade development.

Although roll covers contribute significantly to the performance of film transfer size presses, their operational effects have only recently become more fully understood. As an example, cover wear rates were higher than expected soon after introduction of the various designs. Later, other factors such as wettability of the cover surfaces, nip pressure relationships, thermal effects, film splitting, sheet transfer, roll drive relationships, and the influence of alternate cover materials with different properties were explored. While pilot studies originally defined some relationships, others became more evident from many mill trials or changes made in reaction to problems such as excessive cover wear or sheet sizing and coating deficiencies. **Table I** summarizes some key parameters involved in roll covers used for size press applications. These are in arbitrary divisions according to those previously defined and others that have become more fully understood from additional field experience and pilot work. The following sections will explore some parameters.

COVER HARDNESS AND THICKNESS

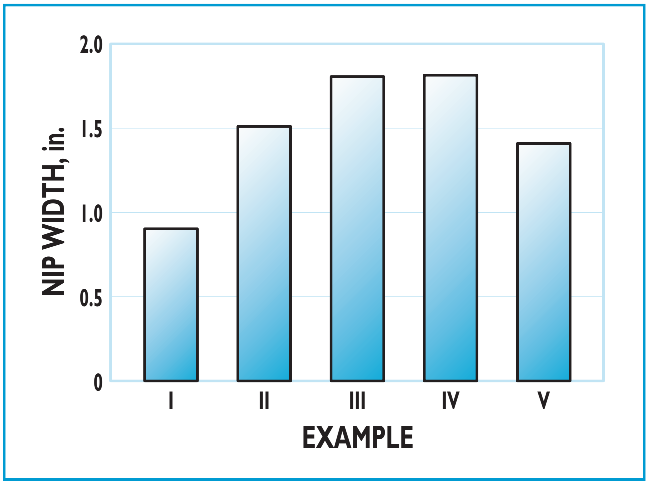
From the results of pilot film transfer size press studies and field evaluations, the conditions of **Table II** represent applications "typically" observed now. Obviously, actual conditions will vary from mill to mill. The table does not show, as an example, one type of commercially available transfer coater. This unit uses 16–28 in. wire wound rolls generally mated with 1.00 in. thick rubber covers in the 90–100 P&J hardness range for applying high solids coating.

NIP WIDTH AND PRESSURE

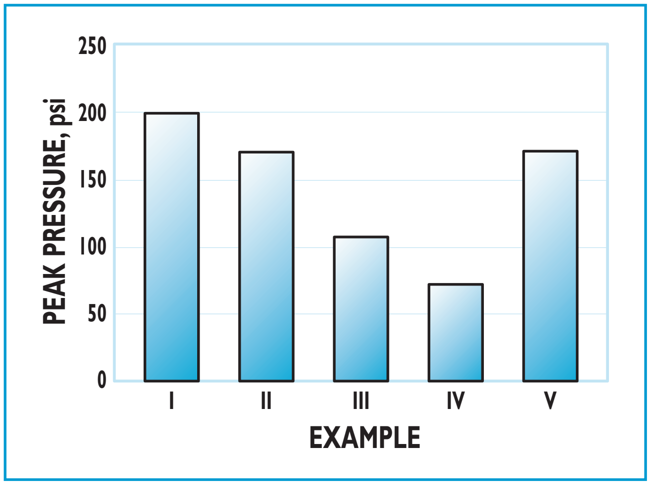
Using the above example application conditions, **Figs. 1 and 2** show the nip width and pressure relationships using 1.00 in cover thickness for the properties of premium rubber covers. Note that pigmented sizing and coating applications usually have wider nip width and lower pressure. This trend has continued with newer installations. It is due to lower nip pressure, improved runnability, higher coat weights, surface location of coating, and moderate dewatering.

ABRASION RESISTANCE

In some applications, mills could not initially achieve satisfactory regrind intervals using the premium rubber cover types normally used in puddle size presses. This related to softer nips, higher speeds, thermal effects, crown problems, roll drive and remove problems, wear from blade and rod wipe exposure, and wear from pigmented size and coating fillers used. This has led to increased attention to establishing correct dynamic cover crowning and the evaluation of alternative cover materials for wear resistance. Those mills that achieved very uniform nip conditions have usually reached about 4–6 week regrind intervals on the softer premium rubber covers in starch sizing applications. Other mills requiring longer intervals due to maintenance schedules or needing more cover wear resistance due to the softer nip relationships used in coating applications have evaluated high performance rubber covers and polyurethane covers. These covers may provide 6–12 week regrind interval possibilities. Examples of high performance rubber covers include those using chlorosulfonated polyethylene (CSM) and hydrogenated nitrile rubber (HNBR). Recent years have seen a strong



1. Nip width comparison



2. Nip pressure maximum comparison

Previously defined

Abrasion resistance
Cover hardness and thickness
Nip width and pressure
Heat accumulation effects
Marking resistance
Rebound and resiliency

Better understood

Dynamic cover behavior
- Thermal changes
- Swelling effects
- Chemical effects

Vibration
- Transmissibility
- Temperature effects
- Frequency effects

Surface characteristics
- Smoothness
- Wettability
- Film splitting
- Coating transfer
- Material effects

I. Key roll cover parameters for size press covers

Example I
Blade metering, starch sizing
Mating 58-in. finished diameter rolls, 170–190 pli
Harder cover: 01– P&J Hardness, 0.5-in. thickness
Softer cover: 10–15 P&J Hardness, 0.75–100-in. thickness

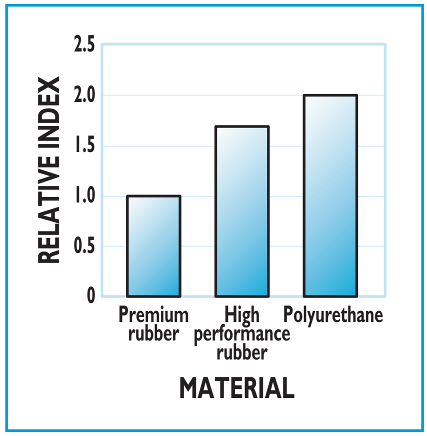
Example II
Grooved rod metering, starch sizing
Mating 58 in.- finished diameter rolls, 200 pli
Harder cover: 10–15 P&J Hardness, 0.75–100-in. thickness
Softer cover: 20–25 P&J Hardness, 0.75–100-in. thickness

Example III
Grooved rod metering
Pigmented sizing, <50% solids
Mating 58 in. finished diameter rolls, 150 pli
Harder cover: 25–35 P&J Hardness, 0.75–100-in. thickness
Softer cover: 35–45 P&J Hardness, 0.75–1.00-in. thickness

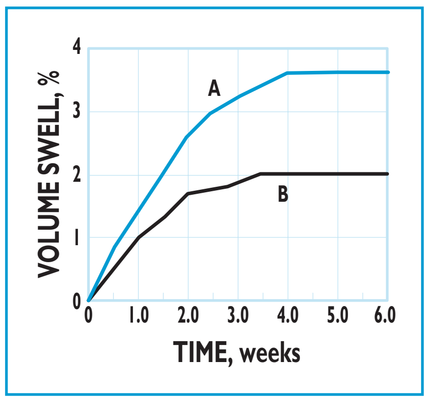
Example IV
Smooth rod metering
Coating, >50% solids
Mating 58 in. finished diameter rolls, 100 pli
Both covers: 50–55 P&J Hardness, 0.75–1.00-in. thickness

Example V
Gate roll, starch sizing
Mating 50 in. finished diameter applicator rolls
1.00 in. thickness covers, 200 pli
Both covers: 15–25 P&J Hardness range

II. Typical applications



3. Cover wear resistance



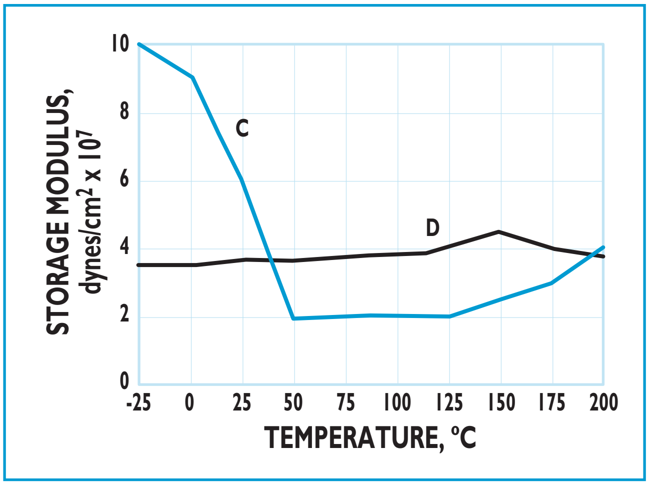
growth in use of high performance rubber covers.

In Europe, ceramic covers also are used now in puddle size press applications. **Figure 3** shows the general relationship between abrasion resistance of various cover types used in cover positions 10 P&J hardness and above.

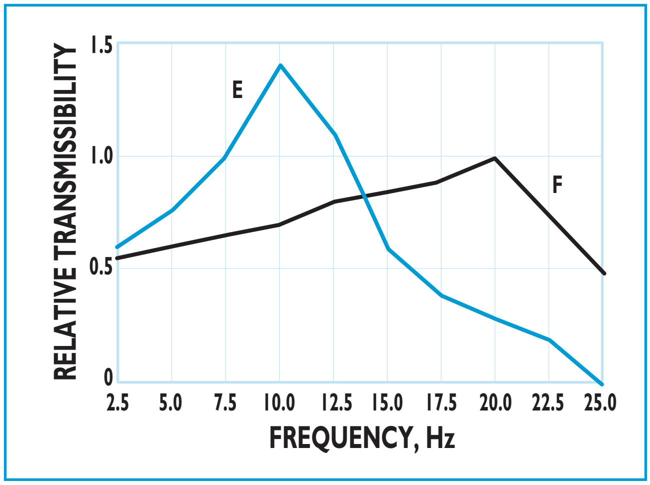
HEAT ACCUMULATION

Excessive heat accumulation will eventually cause an elastomer to fail due to loss of physical properties or degradation. The failure depends on the deformation under load, the rotational frequency, and the properties of the material used *(1)*. The roll diameter and cover thickness also influence heat accumulation.

Various methods of dynamic testing have been used to evaluate different roll covers. These include dynamic mechanical analysis, measuring compressive fatigue hysteresis, and other methods such as dynamic wheel testers or press stands. Due to the low nip pressure and larger roll diameter used in film



5. Storage modulus vs. temperature



6. Vibration transmissibility vs. frequency

transfer size presses, internal heat accumulation effects are usually low at <0.01 kcal/kg.s. With starch sizing, the surface temperature of 150°F or higher is significant and requires consideration when predicting cover performance under dynamic conditions.

DYNAMIC COVER BEHAVIOR

Predicting dynamic cover behavior is a complex issue even when maximum stress and strain levels are known and temperature levels are quantified. The rate of loading changes in the application will influence cover properties. These may not correlate sufficiently with American Society of Testing and Materials (ASTM) or International Standards Organization (ISO) testing procedure results *(2)*. The mechanical properties of a specific material may also change significantly over a limited temperature range *(3)*. Examining cover materials by testing as close as possible to their actual operating conditions is therefore important as is developing tests that correlate with the cover's use more closely than "standard" tests. After definition of operating conditions, the materials also require examination under the anticipated upper and lower control limits of dynamic operation. Accurate definition of the "short-term" properties considered relevant in the cover's operation and considering other long-term factors such as flex fatigue and chemical attack are also important. Fatigue and chemical effects may also be significant for cover bond retention over the expected life cycle.

Figures 4 and 5 illustrate the importance of relevant test data for prediction of operating performance in film transfer size presses. They show time and temperature responses. Figure 4 contains the results of immersion testing of two different size press cover materials. Material A exhibits greater softening and swelling than material B under 150°F immersion conditions.

Another example using polyurethane covers shows the change in storage modulus of two covers compared at the same strain amplitude. Storage modulus is a measure of the energy stored and recovered in each cycle. It indicates the stiffness of the material. Figure 5 indicates a significant change in stiffness of material C at 0°C–50°C compared with the relatively uniform stiffness of material D.

The role of cover materials in vibration dampening in film transfer size presses is a subject of frequent discussion. Besides temperature considerations, examination of the frequency dependence of critical properties such as the cover properties is necessary. They may change with excitation frequency *(4)*. Measured response to frequency is also inversely dependent to that of temperature. For vibration dampening, the cover's vibration transmissibility should be low in the operational frequency range. Freakley and Payne (4) have defined transmissibility as the ratio of the highest value of transmitted force (motion) to the highest value of exiting force (motion). Good dampening tries to minimize this.

Figure 6 shows the relative transmissibility of two cover materials with the same hardness. In this graphical comparison, material E may be a better choice for dampening in an application that reaches higher frequencies quickly and continues in a high frequency range. Note that the mass influence of cover materials is very low compared with the metal cores when considering relative contributions to vibration in size presses. Mill experience has shown that paying attention to mating roll finished diameters; cover thickness, hardness, and type; and temperature influences can minimize cover barring effects. Some corrective measures used include:

- Avoiding multiples of roll diameters (5)
- Monitoring of wear on covers (6)
- Identifying the system natural frequency
- Avoiding excessively large differences in mating cover hardness

- Controlling the cover thickness temperature gradient.

Polyurethane covers are popular for their vibration dampening characteristics.

COVER SURFACE CONSIDERATIONS

Blade metering trials conducted using a range of starch type, viscosity, and molecular weight did not indicate poor wettability of rubber covers even at low film thicknesses *(7)*. Field results also continue to support this in rod metering and with various rubber and polyurethane cover types. Cover surface smoothness becomes an important factor as solids increase. In the coating solids range, a cover material's wettability becomes an important influence. While a cover surface smoothness of 1.5 µm Ra may be acceptable with lower solids starch sizing, field results have shown a smoothness of 0.8 µm Ra may be necessary with higher solids coatings to achieve the coating uniformity required on higher quality coated paper grades. The use of high performance nonextruded rubber elastomers may also be necessary. For coating applications, the covers must be free of surface imperfections such as grinding scratches, lead lines, or voids. Due to the requirement of very uniform film thickness control, the grinding tolerance of these cover types falls into a coater classification.

The roll cover has an effect on misting and "orange peel" formation. These are important quality issues in high speed film transfer coating. The uniformity of the cover surface, resistance to nonuniform swelling, and hydrophillic surface properties are important factors. Other parameters also impact very significantly on these problems including coating solids level, coating formulation and viscosity, dewatering rate, thickness of free layer, and air entrapment in the coating.

POLYURETHANE COVERS

Polyurethane covers have excellent properties for film transfer size press applications such as wear resistance and vibration dampening. To obtain satisfactory cover performance in the temperature range of starch sizing, one must appreciate the water permeation effect in the size press cover hardness range. The temperature gradient effect that occurs when an excessively large differential exists between the cover surface temperature and the internal cooling water accelerates problems related to permeation. Previous studies referred to the concept of water vapor diffusion and the possibility of exceeding the saturation content of polyurethane at the bonding interface *(8)*. These and other studies confirm that the internal water cooling temperature should be as high as practical to minimize the effect. This requires use of low heat accumulation polyurethanes and control of the inlet water temperature.

Polyurethane covers have current use in film transfer size presses with inlet cooling temperatures of 120°F and grinding intervals of about eight weeks. Future polyurethane cover developments may eliminate the need for water cooling in film transfer size presses. In film transfer applications with higher solids coatings, rotational cast polyurethane covers have successful use in the 50–55 P&J hardness range.

SUMMARY

The introduction of film transfer size presses and coaters operating at speeds over 3000 fpm has required development of new rubber, polyurethane, and resin composite covers that will operate with regrind intervals longer than many puddle size press covers. Pilot studies and machine trials are providing a better understanding of the influence of roll covers in these applications. Development of new cover types must meet future demands. Additional studies are necessary especially for cover surface characteristics, film splitting, and cover material influence in coating applications.

Experience over the last two years has shown growth in high performance rubber cover use and growth of rotational cast polyurethane in coating applications. **TJ**

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