Increasing Young's Modulus in BlackBelt Base Structure

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ABSTRACT

Shoe presses are generally used in pulp, cardboard and paper machines to improve the press section efficiency and to improve paper bulk properties. A shoe press belt is like a changeable roll cover. The belt consists of textile reinforcing structure buried in polyurethane elastomer.

In this paper the properties of different base structures and materials used in sleeves are compared. 2- and 3- layer structures are compared as are different base yarn materials.

As polyurethane being incompressible material it has to stretch under nip load, Poisson's ratio is close to 0,5. Without base yarns sleeve would eventually stretch too much to fit in the machine. Pressure in shoe press is gradually increasing on machine direction, causing acceleration to sleeve in the nip.

Studies are made in Metso Fabrics textile laboratory and dynamic sleeve tests are made in Metso's pilot paper machine. Two case studies are included as well. According to these real life experiences it was proven that there is a clear correlation between sleeve dynamic stretching, wear and base structure and material used.

Introduction

Main focus on developing shoe press sleeves has been polyurethane optimization. Polyurethane elastomers are composed of short, alternating polydisperse blocks of soft and hard segments. There are numerous different polyurethane elastomers which can be tailored by selecting isocyanate, polyol and chain extender, or by simply varying the processing temperature. Less attention has been paid to re-inforcing structure of the sleeve. However press sleeve is a composite made of base fabric and polyurethane elastomer.

Traditionally sleeves are made by coating woven base fabric as shown in figure 1. Stretching behaviour of woven fabric has been quite challenging and on early times there was typically a need to trim sleeves on CMD due to widening in the machine.

On modern sleeve manufacturing process more advanced method is used. Centrifugal casting inside a steel mold with non-woven straight yarns is state of the art technology, shown in figure 2.

With new advanced technology there is no need to use woven base fabric, straight re-inforcing yarns on two or three layers can be used instead. Different base structures are shown in figure 3. This kind of new technology enables usage of the very best possible yarns.

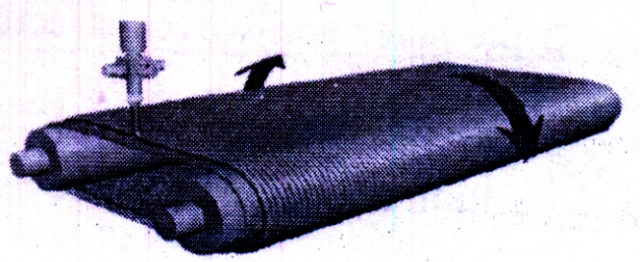

Figure 1. Traditional sleeve manufacturing method.

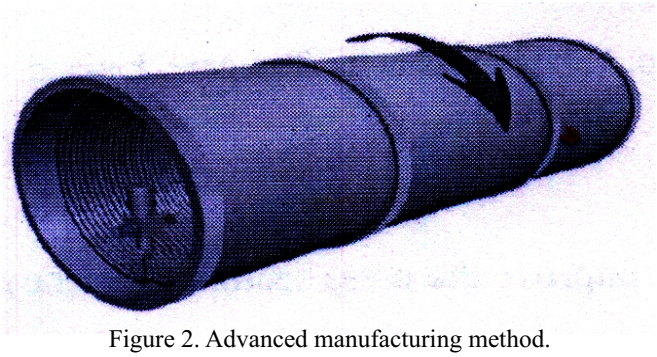

Figure 2. Advanced manufacturing method.

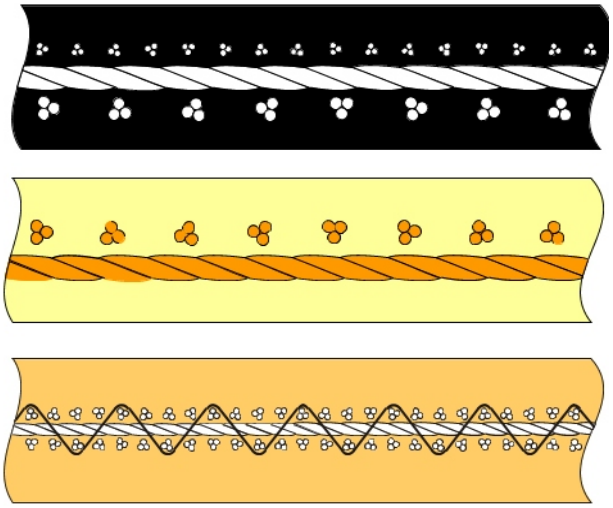

Figure 3. Different base structures in sleeves.

Methodology

In this study, three different base-structures A, B and C were investigated. Base A is a polyester-polyester double layer non-woven structure. Base B is a polyamide-polyester-polyester triple layer non-woven structure and Base C is a polyester-polyester-special polyester triple layer non-woven structure. Tensile properties of the yarns were measured according ISO 13934-1:1999 Textiles -- Tensile properties of fabrics -- Part 1: Determination of maximum force and elongation at maximum force using the strip method. Device used was Alwetron TCT 20

All three different sleeve types were run in Metso's pilot paper machine and dynamic stretching behavior in relation to press load was measured from running machine. Measuring principle is to measure rotating speed of the sleeve. When speed and diameter of the counter roll is known as well is clothing and sheet thickness, sleeve run diameter can be calculated. Figure 3.

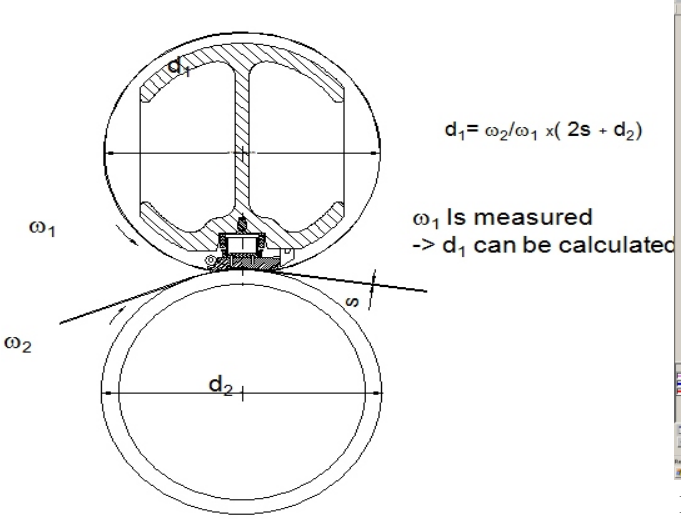

Figure 3. Sleeve diameter measuring set-up

Results And Discussion

As polyurethane being rubber like material poisson's ratio is close to 0,5. This means that sleeves are virtually incompressible. When this kind of a material is compressed in one direction, it expands in the other two directions perpendicular to the direction of compression. This expansion tends to stretch the sleeve in the nip. From practice it is known that modern sleeves stretch in the machine less than 2 %, therefore force needed to stretch 2 % was measured.

Force needed to stretch 5 mm polyurethane film without yarns by 2 % is 0,6 kN/m when measurement from different sleeves were in range of 23 kN/m to 48 kN/m. As a result it can be said that yarns are giving at least 96 % of the tensile properties to the sleeve.

Table 1 shows forces needed to stretch the sleeve by 2 %.

Sleeves made with different base structures were run in Metso

Table 1. General tensile on MD properties of the different base structures and

Properties	Base A	Base B	Base C
Force to break kN/m	160	210	210
Force to stretch 2 % kN/m	23	28	48

Pilot machine. On trial runs speed was kept the same and linear load was changed from 150 kN/m to 1200 kN/m. As seen from figure 4 sleeve diameter follows linear load linearly.

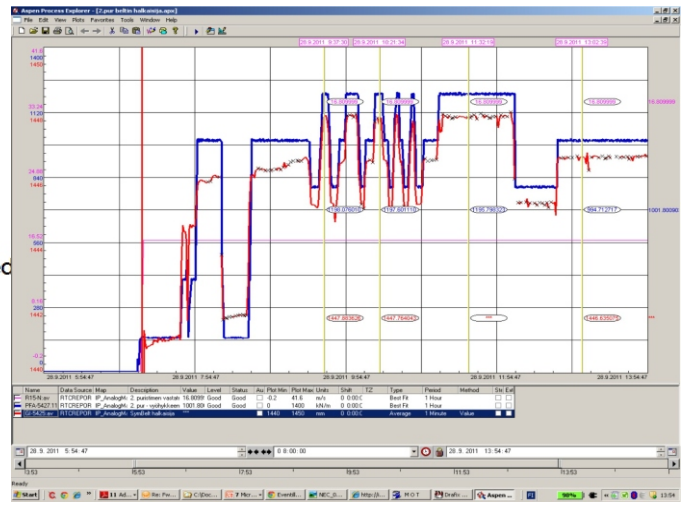

Figure 4. Load vs. diameter. Load is blue graph and diameter is red.

On table 2 diameter measurement results with 400 kN/m and 1200 kN/m can be seen. There is a clear correlation with modulus of the yarn used in the base and sleeve running diameter. Since sleeve is elastic stretching does appear in the nip and recovers outside the nip.

Table 2. Elastic stretch under 400 kN/m and 1200 kN/m load

Properties	Base A	Base B	Base C
Stretch % 400 kN/m	0,42 %	0,34 %	0,20 %
Stretch % 1200 kN/m	0,67 %	0,54 %	0,32 %

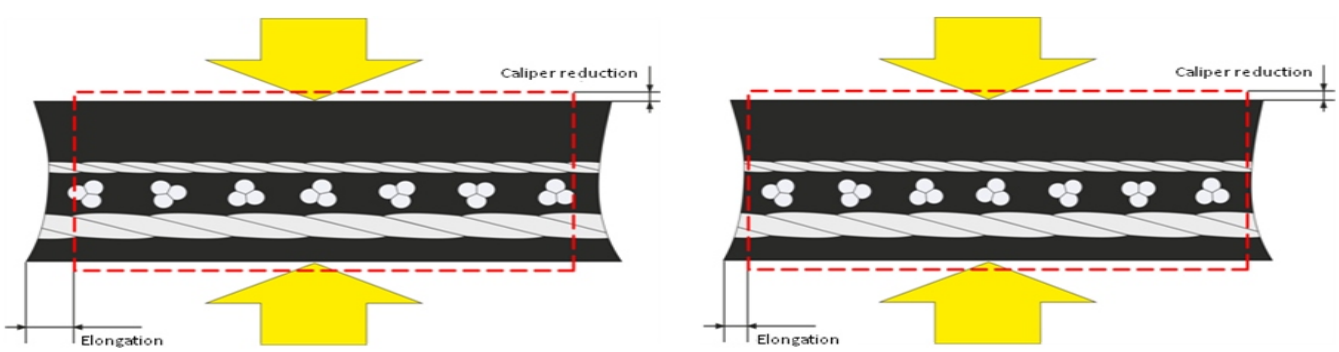

Figure 5. Caliper loss and MD expansion.

Typically shoe press nip in 250 mm long and pressure is gradually increasing on MD. As sleeve is being compressed it will lose it's caliper and expands on MD. Figure 5.

This expansion will result slower rotation speed of the sleeve -> diameter seems to increase. Actually this increase happens only in the nip due to material elasticity. As sleeve is loosing it's caliper and expands 'in nip' speed increases causing rubbing effect between press felt and sleeve surface. This phenomenon will increase sleeve surface wear. By selecting high modulus yarns to sleeve base this 'in nip' speed difference behaviour can be minimized. Figure 6.

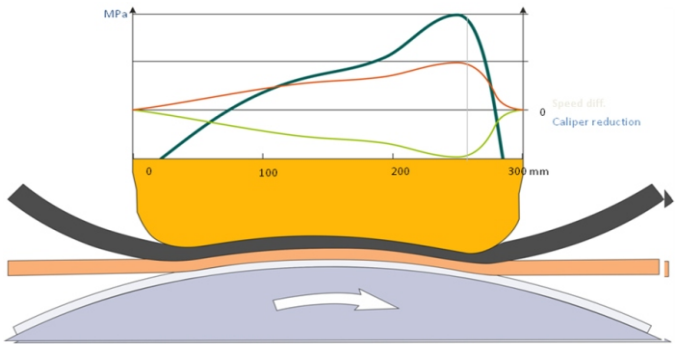

Figure 6. 'in nip' speed difference.

Sleeves in the market

Improved 3-layer base is superior compared to any sleeve in the market. It's heat resistance and tensile properties are by far the best. Nonwoven structure itself is superior to wovens due to the fact that there is no weave pattern in the sleeve. 3-layer base furthermore improves this superiority. It is very likely that future in the shoe press sleeves is 3-layer and nonwoven.

Case studies

Case 1.

A sleeve with high modulus base yarns was run in fast running newsprint machine. Concept has two shoe presses width over 9 meters, typical speed of this machine is 1975 m/min and linear load 1100 kN/m. On figure 7 life times and wear of the previous sleeves can be seen. Y-axis is void volume in ml/m2 X-axis is million nip cycles.
As a result life time doubled and sleeve had highest void volume out of all belts removed.

Case 2

In case 2 there was a severe surface wear and degradation problem in liner board machine. Machine width 7,25 meters, speed 1000 m/min and load 1300 kN/m. Three previously run sleeves were all removed as an average life of 60 days because of the wear. Sleeve with high modulus base ran for 247 days and was removed in good condition due to shoe press maintenance. Figure 8 shows the surface outlook of standard sleeve and figure 9 shows surface of high modulus base sleeve.

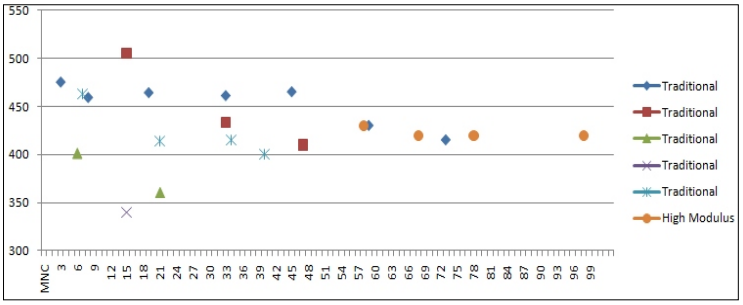

Figure 7.

Figure 8. Surface degradation with standard sleeve

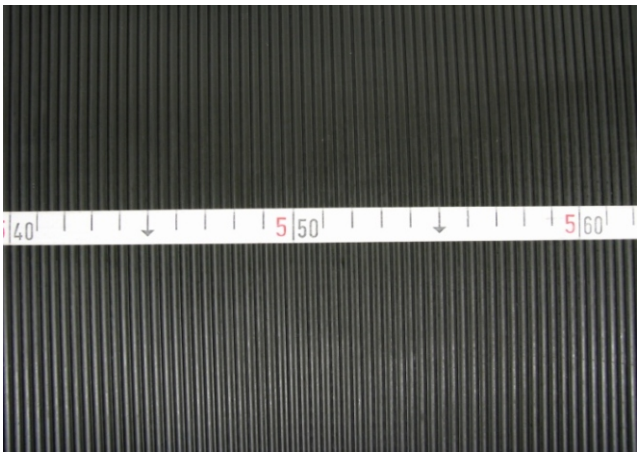

Figure 9. Surface after record life in the position with improved base.

Conclusion

As a result of these studies and real life cases it can easily be said that in past few years there has been major improvement what comes to runnability and life expectancy of the sleeves. Material development together with better understanding on sleeve nip behavior has resulted BlackBelt sleeve that will significally reduce paper machine clothing costs.

References

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2. ISO 13934-1:1999 Textiles -- Tensile properties of fabrics -- Part 1: Determination of maximum force and elongation at maximum force using the strip method
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