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BlackBelt for demanding shoe press positions

SUMMARY

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 we compare the properties of three different polyurethane elastomers used as raw materials for shoe press belts.

The elastomers were first studied in the laboratory by measuring hardness, abrasion resistance and dynamic properties. The changes in wear properties were examined by exposing the elastomers to heat, hydrolysis and some chemicals commonly used in pulp manufacturing. In the shoe press, the belt goes through dynamic load up to 100 million cycles. Material with excellent dynamic properties is needed to survive under this high cyclic load.

In the next stage, shoe press belts made of these three elastomers were run consecutively on a fast newsprint machine. A machine with very demanding conditions, high speed, high load and severe process chemicals causing excessive wear, was chosen. The machine conditions were considered to be the same during the running time of all the belts tested. The wear of the belts was monitored with a new method, the belt scanner. This device measures the

surface topography of a grooved belt, and based on this data, profiles of groove dimensions and void volume can be drawn.

One of the elastomers studied was found to be extremely promising in all the laboratory tests. Especially the wear resistance and heat resistance were outstanding compared to other elastomers in this study. The experiences in a shoe press with very high demands confirmed these results.

INTRODUCTION

Polyurethanes are an important class of elastomers with excellent properties and wide applications, one of these is shoe press belts. Polyurethane elastomers are composed of short, alternating polydisperse blocks of soft and hard segments. The two-phase micro-domain structure of polyurethane depends on the molecular structure its components: isocyanate, polyol, and chain extender. Processing conditions, such as temperature, can also change the domain structure significantly. Therefore, physical properties of polyurethane elastomers can be tailored by selecting isocyanate, polyol and chain extender, or by simply varying the processing temperature.

Two most common isocyanates used in industry for castable materials are toluene diisocyanate (TDI), and 4,4'-diphenylmethane diisocyanate (MDI). Also other high performance diisocyanates are available.

Castable polyurethane elastomers are normally manufactured by mixing of two to five ingredients (prepolymer, chain extender, polyol, catalyst etc.) and introducing the mixture into a mold. The material is cured at a proper temperature depending on the chemistry of the components.

Several different elastomers can be used in shoe press belts. Different manufacturers usually have their own choices.

METHODOLOGY

In this study, three different polyurethane elastomers A, B and C were investigated. Elastomer A is a MDI-based polyurethane, elastomer B is a TDI-based polyurethane and elastomer C is BlackBelt polyurethane, based on a new high performance di-isocyanate. Hardness of the elastomers was measured with Wallace H17A Sore A Hardness Tester. The abrasion resistance measurement was based on DIN 53516 method and the compression set measurement was based on SFS 3564 (ISO 815-1972). The dynamic mechanical properties – elastic modulus E' and loss factor tanD - of the elastomers were measured using Dynamic Mechanical Thermal Analysis (DMTA). Dynamic Mechanical Analysis was performed on a Perkin Elmer Pyris Diamond, using bending mode, at 10 Hz frequency and 3 ^{o}C / min temperature increment. Exposing of the elastomers to the heat was tested at two different temperatures using 130 ^{o}C and 160 ^{o}C for one day or four days. Hydrolysis tests were performed in a autoclave keeping the elastomers at 125 ^{o}C temperature (2,3 bar) for 2,5 hours. Exposing of the elastomers to some commonly used chemicals in pulp manufacturing – acetone, hydrogenperoxide (H_2O_2), washing agents (alkalic, acidic), foaming agents – was tested by keeping the speciments in different chemicals at the room temperature (21 ^{o}C) for 20 hours. Many of the physical properties of the speciments were measured after the exposion tests.

To monitor the wear of a belt on a shoe press, a new device called belt scanner was developed. The belt scanner is a portable device, used to monitor the belt surface during shut down. It is equipped with an accurate sensor measuring the belt surface topography and a pulse encoder measuring traversed distance, together with an integrated tablet PC for data logging and result visualization. The measurement is done by traversing the device by hand across the belt surface. The time required to scan a 10 m wide belt is only 1.5 minutes and the report with five different profiles can be done in 15 minutes.

Based on the data measured with the scanner, profiles of the groove dimensions (groove width, groove depth, land width) and void volume can be drawn.

Changes in groove depth and land shape are consequences of wear, and they lead to reduced void volume. Too low void volume leads to decrease in dryness and poor moisture profiles. The scanner can be utilized to evaluate the life potential of the belt. It is also very useful in trouble shooting, for example a moisture peak in the paper may be caused by uneven wear that can be found with the scanner.

RESULTS AND DISCUSSION

Resistance to wear and specific chemicals may determine the service life of shoe press belts. Table 1 reports a list of some general physical properties of the three elastomers studied.

Table 1. General physical properties of the polyurethane elastomers studied

Properties	**Elastomer A**	**Elastomer B**	**Elastomer C**
Hardness, Shore A	93,5	92	93
Weight loss in wear test, mg	30	24	20
Compression set, %	42	31	28

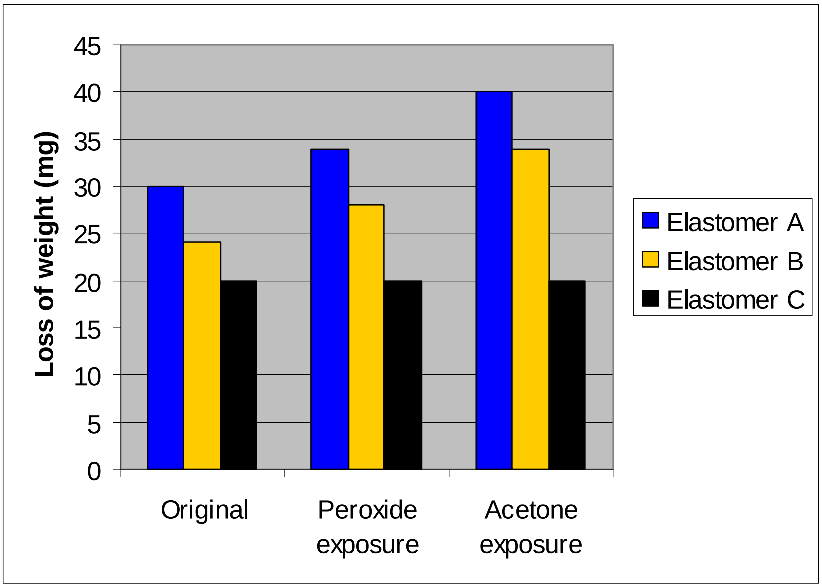
Table 2 reports the abrasive wear values (presented as weight loss in mg) of the elastomers after exposing to peroxide and acetone at room temperature for 20 hours.

Table 2. Abrasive wear values (= weight loss) after exposing to the chemicals

	Elastomer A	**Elastomer B**	**Elastomer C**
Peroxide exposure	34 mg	28 mg	20 mg
Acetone exposure	40 mg	34 mg	20 mg

The elastomer C had clearly the best performance under these conditions, showing lowest weight loss and lowest wear. Elastomer A presented the highest wear values, both originally and after chemical exposure.

Figure 1. Changes of abrasive wear values after chemical exposure

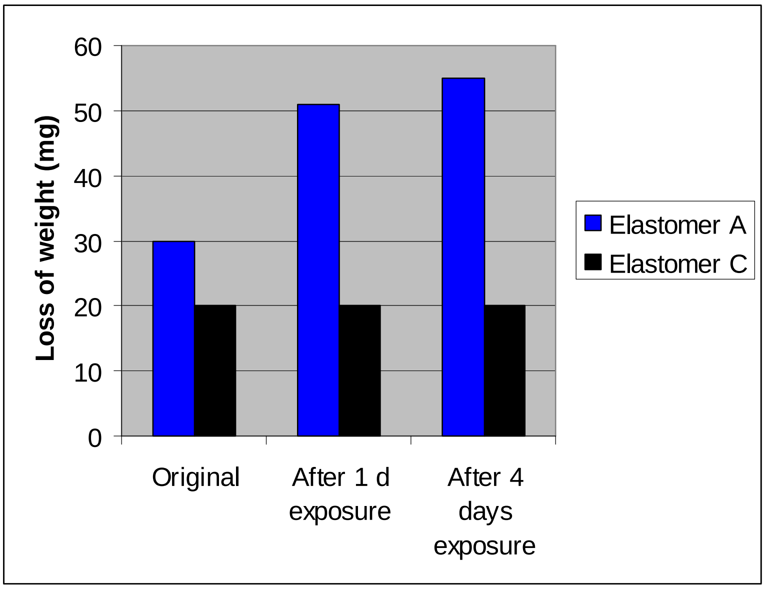


It is also important that the polyurethane elastomers have resistance to thermal degradation. The results in tables 3 and 4 and in figures 2 and 3 show how the abrasive wear values change when the elastomers A and C are exposed to heat for one day and for four days.

Table 3. Abrasive wear values of the elastomers aged at 130 ^{o}C.

	Elastomer A	**Elastomer C**
1 day exposure	51 mg	20 mg
4 days exposure	55 mg	20 mg

Figure 2. Changes on abrasive wear values of elastomers aged at 130 ^{o}C

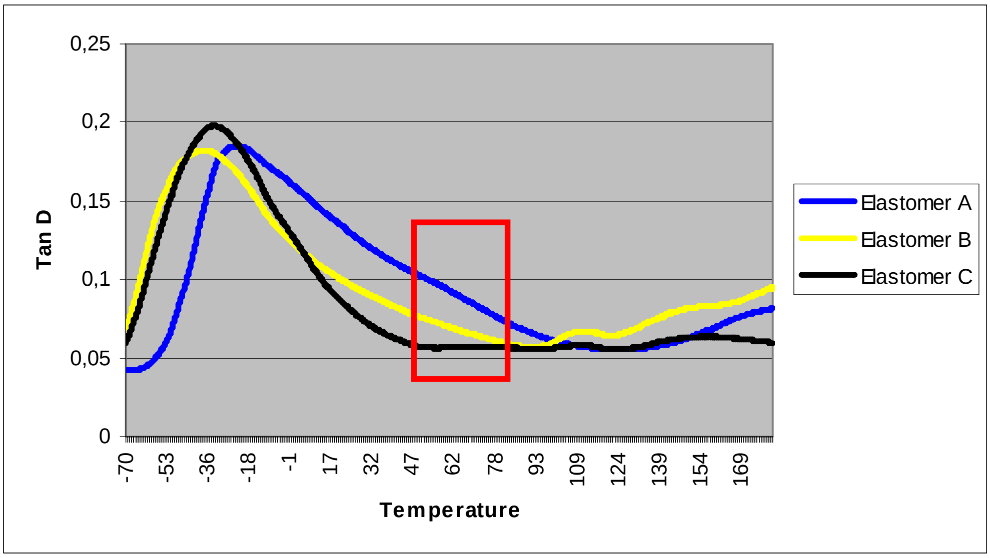


Dynamic properties of polyurethane elastomers can be analyzed using a Dynamic Mechanical Analyzer. A good compound for dynamic applications is generally represented by low tan delta values and constant modulus values over the working temperature range where the products will be utilized.

The dynamic testing was done at a wide temperature range -70 - + 180 C even though the normal process temperature in a shoe press is 40 – 80 C. Special attention was paid to this range: the elastomer material in a shoe press needs to remain its properties stable in this temperature range. The loss factor, tan delta, describes how big share of the energy of the deformation caused by the cyclic load is transferred into heat. A material with a low tan delta has low “internal friction”, it recovers quickly from the deformation and the internal heat build up is low. This means that the material is suitable for applications where it goes through continuous cyclic load, like in the shoe press.

The temperature range in a shoe press is marked with red square on the graph presented in figure 3. The elastomer C has the lowest and most stable tan delta value. It is thus considered to be most suitable for dynamic applications.

Figure 3. Tan delta values of the three elastomers tested



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In the next stage, belts made of these elastomers were run on a shoe press of a fast newsprint machine (1750 m/min, shoe press load 950 kN/m). This machine suffered from severe wear of belts, average life of belts was only 6 weeks. The belts were grooved to certain void volume.

The belts in the study were measured with the belt scanner after 3-4 weeks running time. The dimensions of the grooves were measured and the void volume and open area were calculated based on this data.

The groove profiles drawn based on belt scanner data show significant differences in the wear properties of the elastomers.

Fig. 4. Belt made of elastomer A after 4 weeks running

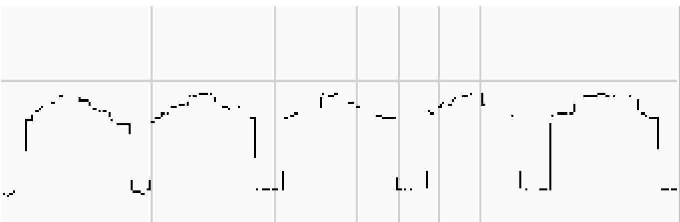


Fig. 5. Belt made of elastomer B after 3 weeks running

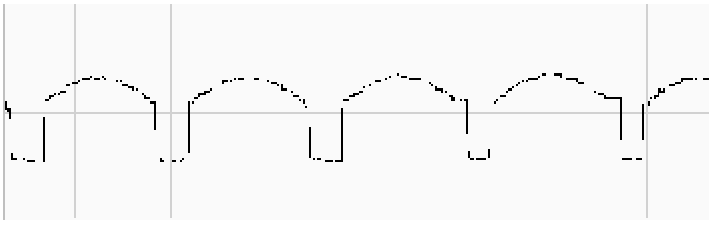
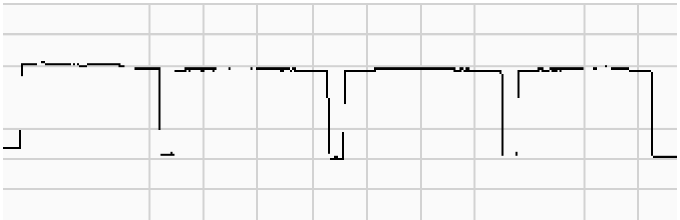


Fig. 6. BlackBelt made of elastomer C after 3 weeks running



CONCLUSION

Elastomers A and B are the most commonly used elastomers in shoe press belt manufacturing. Elastomer C which is used in the manufacturing of BlackBelt combines superior dynamics and excellent abrasion and chemical resistance properties over a wide temperature range. This was confirmed on a shoe press of a fast newsprint machine with very demanding conditions. Of the three belts monitored with belt scanner, after 3-4 weeks running, BlackBelt was the only one showing no wear at all.

BIBLIOGRAPHY

1. Xie, R., Mueller, G. and Upshaw, T.A. 2003. Properties of elastomers based on caprolactone prepolymers. Utech 2003, the Hague, the Netherlands, March 25-27, 2003.
2. Clemitson, I. R. 2008. Castable polyurethane elastomers. Boca Raton., CRS Press. 250 p.
3. Plyhm, Tiia, 2009. Manufacturing of sustainable elastomer. Tampere University of Technology. Master of Science Thesis. 80 p.