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Evaluation of Flexographic Printing Packaging Film to Shrinkage and Coefficient of Friction as Quality Control for Add Value and Competition Products

Saber Ibrahim [1,2] **Hager Fahmy***[3]

1- packaging materials department, national research center, 12622 Dokki, Giza, Egypt
2-Nanomaterials investigation lab., central laboratory network, national research center, 12622 Dokki, Giza, Egypt
3-Faculty of applied arts, Benha University, 13518, Qalubia, Egypt.

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ABSTRACT:

Friction and shrinkage factors are considered among the promising challenges in the as quality control packaging system. The research aims to evaluate the thermal range of materials used in machines to avoid the shrinkage problem by using polymers with a high degree of thermal stability. Research hypotheses that, using polymers with a friction rate achieves a problem-free operating range to meet the requirements of the products, in printing, cutting, welding, and packaging processes. Shrinkage of packaging films with high temperature during machine operation has back drain effect than standard machine operating temperature. The research utilized an experimental approach to investigate, evaluation of the fraction coefficient and shrinkage temperature has a great impact to decide the availability of the printing packaging film to applied on packaging machine unit without manufacture problem shooting. Difference in coefficient of friction from the standard rate equivalent to the normal rate required on machines during operation play a vital role in processing. Two tested printing films were evaluated with ST 52 and 63 ^{o}C for bad and good processing, respectively. Studying the problems of shrinkage and slippage on machine cylinders due to the weakness of the temperature range and the low or high coefficient of friction is extreme importance for packaging films during operation, which costs the industry large sums of money and affect the environment. Five sample was examined with COF from 0.57 to 0.9 N as film/metal and from 0.2 to 0.4 N as film/film. Desired COF for film/metal in range (0.8-0.9 N) and film/film (0.2-0.3 N).

1- Introduction

Flexographic printing is renowned for its versatility, efficiency, and ability to produce high-quality prints across a wide array of substrates, including paper, plastic, metal, and film. Central to achieving consistent and high-quality results in this process are the properties of the printing films used, specifically their tolerance to shrinkage and their coefficient of friction (COF) These properties significantly influence the performance and quality of the final printed product, making their accurate measurement and management crucial in the flexographic printing industry.

2-Theoretical background

2.1-Technical solutions to improve the economics of packaging bags

Appropriate labeling and flexible packaging play an important role on the today`s demands. There are diverse possibilities especially related to polymeric materials. Flexible packaging means to consider options such as OPP (Oriented Polypropylene), PVC (Polyvinyl Chloride), OPS (Oriented Polystyrene), PET (Polyethylene Terephthalate) or all kind of self-adhesive paper and foil types. Special highlight are the "Shrink Sleeve" labels that meet the most demanding market challenges. Its capabilities are beneficial. Laminated packaging materials are functional. Both constitute protection and packaging capacity. Coefficient of friction is the value that serves to meet the standard of how the flexible packaging material will glide and move on the packaging machine. This research is focused on the optimum quality of the packaging production process to meet all the preconditions for implementation of the semi-finished product packaging and to avoid difficulties and possible stoppages on the packaging machine itself.

To choose the proper type of material for packaging products, many factors must be considered, the performance characteristics of the packaging material and those that may affect the safe delivery of products to the recipient.

2.2Shrinkage tolerance

Shrinkage tolerance refers to a printing film's ability to maintain its dimensions under varying environmental conditions, such as temperature changes, humidity, and mechanical stress. In the context of flexographic printing, films are subjected to various stages of processing that can affect their stability. Heat is commonly applied during the drying of inks and the curing of coatings, which can cause films to contract. Similarly, fluctuations in humidity can lead to expansion or contraction, affecting the film’s size and shape as shown in Fig. 1. Mechanical stresses during handling and processing can also contribute to dimensional changes.

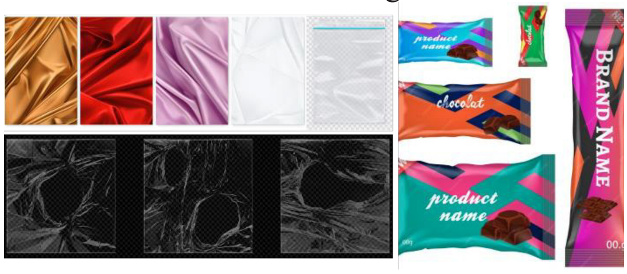

Fig. 1 the shrinkage character of packaging films and products
https://www.freepik.com/

The ability of a film to resist these dimensional changes, or its shrinkage tolerance, is critical for maintaining the integrity of the printed image and ensuring accurate registration. Films that exhibit significant shrinkage can lead to distortions in the printed design, misalignment of images, and overall degradation of print quality. For instance, if a film shrinks unevenly, it can result in off-register prints, where different colors or images do not align correctly. This not only affects the aesthetic appeal but can also impact the functionality of printed materials, such as packaging, where precise alignment is essential for product information and branding as presented in Fig. 2.

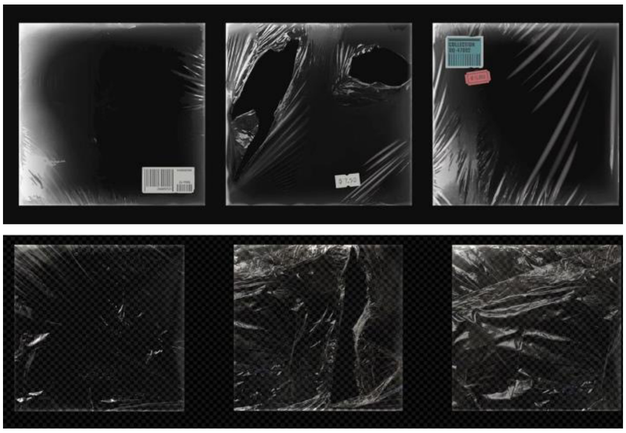

Fig. 2 the shrinkage character of packaging films with hole defects
https://www.freepik.com/

2.3 The coefficient of friction (COF)

The coefficient of friction (COF) is the value measured to determine how flexible the polymeric packaging material will glide on the packaging machine, move or slide with difficulty or cause possible shortages. COF is measured on the inside and outside of the foil because both sides slide over the metal parts of the packaging machine depending on the pressure it might change its property.

Fig. 3 the COF of high-tension films on packaging machine
https://packtest.com/coefficient-of-friction-cof-test/

The coefficient of friction (COF) is another vital property influencing flexographic printing film performance[9]. It quantifies the resistance encountered when the film slides against other surfaces, such as rollers, plates, and guides within the printing press. This resistance affects several aspects of the printing process, including film handling, ink transfer, and overall press operation as sown in Fig. 3.

In flexographic printing, films with a high COF can cause excessive drag and increased wear on the press components[12]. This resistance can lead to difficulties in film handling and inconsistent ink application, which can negatively impact print quality[13]. On the other hand, films with a low COF may slide or shift during printing, causing registration issues and uneven ink distribution[14]. This can result in problems such as smudging, ghosting, or poor adhesion of the ink to the substrate[13].

2.4 Friction and shrinkage coefficients of packaging films as competitive value

Effective management of COF is essential for optimizing the performance of the printing process[15]. By ensuring that the film's COF is appropriately matched to the requirements of the press and the type of ink used, printers can achieve smoother operation, more accurate prints, and reduced wear on equipment[16]. Additionally, the COF impacts the handling and processing of the film during production and storage, influencing factors such as ease of feeding into the press and the likelihood of film-related defects[17].

Evaluation of the effectiveness of friction coefficient and shrinkage coefficient in improving the properties of packaging films to increase competitive value.
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Developing innovative methods to increase the competitive value of packaging products by evaluating the most important criteria for controlling the quality of packaging materials, which are friction and shrinkage, the economic goal of reducing the waste of materials in the packaging machine is achieved, as determining the correct criteria for packaging materials before they enter the packaging machine has a positive economic return.

Both shrinkage tolerance and COF play integral roles in ensuring the efficiency and quality of flexographic printing. A comprehensive understanding and measurement of these properties allow for better selection of films suited to specific printing conditions and requirements. By addressing these factors, printers can enhance the reliability of their processes, maintain high standards of print quality, and minimize operational challenges.

3.Experimental

3.1. Materials and methods

Two types of commercial printing metallized oriented polypropylene (MOPP) from universal converter to test as shrinking samples. In addition, five paper printed sheets were collected from dairy milk company to apply as COF measurements.

3.2. Characterization

3.2.1. Differential scanning calorimetry

Differential scanning calorimetry DSC131 evo (SETARAM Inc., France) was used to perform the differential scanning calorimeter analysis, Nanomaterial Investigation laboratory, Central Laboratories Network, National Research Centre (NRC), Egypt[21]. The instrument was calibrated using the standards (Mercury, Indium, Tin, Lead, Zinc and Aluminum). Nitrogen and Helium were used as the purging gases. The test was programed including the heating zone from 30 °C to 300 °C with a heating rate 10 °C / min. The samples were weighted in Aluminum crucible 30 ul and introduced to the DSC. The thermogram results were processed using (CALISTO Data processing software v.149).

3.2.2.COF properties

The friction coefficient (μ) is the force that occurs on the touching surface of the two objects.
The COF properties should be taken into consideration to meet the desired processing and applications demands[22]. COF properties of coated films were evaluated; as the applied force on the specific load on the flexographic printed film were measured by Zwick/RoellZ020 instruments, (Ulm, Germany) according to the ASTM-1894-878.

4.Results of Research

4.1. Flexographic printed metallized packaging films

Table 1: thermal factors of OPP metallized films

	Test	Sample 1	Sample 2
1	**Shrinking temperature, °C**	**52.1**	**63.6**
2	**Type of Polymer**	**PP***	**PP**

*Polypropylene

Fig. 4 the shrinkage character of tested packaging films samples
(photography be researcher, NRC)

The working temperature of packing machine was 60 °C. For that, the film applied on machine have to be stable over working temperature[23]. As shown in Table 1 the shrinking temperature of two selected tested films sample 1 and sample 2 were presented 52.1 °C and 63.6 °C, respectively, with working temperature at 60 °C. For that, the sample 2 is suitable for applied machine processing where sample 1 was shrinkage as shown in Fig. 4. (photography be researcher, NRC)
on the cylinder. This can be assumed to difference in molecular weight of PP in each sample.

Fig. 5 illustrated the heating sequence of the two Samples until shrinkage (photography be researcher , NRC)

In Figure 5 (sample1) shows heating rate degree from 44, 50, and 53 which presented the loaded temperature until shrinkage of the film. on the other hand, sample 2 illustrated the action of heating rate from 45, 54, and 60 over infrared thermometer to detect the actual surface temperature to confirm shrinkage process of the applied film.

4.2. Coefficient of friction

Coefficient of friction, ratio of the frictional force resisting the motion of two surfaces in contact to the normal force pressing the two surfaces together[24]. It is usually symbolized by the Greek letter mu (μ). Mathematically, $\mu = F/N$, where F is the frictional force and N is the normal force according to ASTM 1894-878. As shown in Fig. 6, COF measurements on mechanical testing machine were applied for five packaging films.

Figure 6. shows the COF measurements on mechanical testing machine (photography be researcher, NRC)

4.2.1. Metal to film

Table 2. presented the COF of paperboard films with metal surface

Samples	COF, N	ASTM
Sample 1M	0.931622375	1894-878
Sample 2M	0.574325618	1894-878
Sample 3M	0.763897435	1894-878
Sample 4M	0.792543589	1894-878
Sample 5M	0.856201709	1894-878

Table 2 shows COF of paper board printed dairy milk samples. The standard value of COF for film/metal is 0.7-0.8N. Sample (1M) show 0.9N for that high fraction was presented through processing on working machine. That will be caused sticking of the film on machine cylinder. On the other hand, samples 2M show COF 0.5N for that, the film will be slipped on machine. samples 3M, 4M and 5M are shown COF values in the suitable range for working machine.

4.2.2. Film to film

Table 3. presented the COF of paperboard films with other film surface

Samples	COF, N	ASTM
Sample 1F	0.411203631	1894-878
Sample 2F	0.363258412	1894-878
Sample 3F	0.364894130	1894-878
Sample 4F	0.382041577	1894-878
Sample 5F	0.416340502	1894-878

Table 3 shows COF of paper board printed dairy milk samples. The standard value of COF for film/metal is 0.3-0.4N. Sample (1F), (2F), (3F), (4F) and (5F) show COF (0.4N, 0.3N, 0.3N, 0.3N and 0.4N) respectively show COF in the suitable range for working machine.

5. Conclusion

In conclusion, the tolerance of flexographic printing films to shrinkage and their coefficient of friction are pivotal in determining the overall effectiveness and quality of the printing process. Accurate measurement and management of these properties are essential for achieving consistent, high-quality print results, and for ensuring smooth and efficient operation of the flexographic printing system. This study gives high indication to pretesting the printing films with shrinking and COF measurements to evaluate the suitable value to machine processing. That will be saved raw materials scraps and enhance economic add value with product competition by decreasing the trouble shooting during machine processing.

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