STUDY OF THE ADHESION ON OVERMOULDED PARTS WITH THERMOPLASTIC/LSR COMBINATION

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Abstract. Multi-material parts with PBT/LSR combination were produced in two separate steps, one for the injection of PBT parts, and a second for the LSR overmoulding. The aim of this work is to study the influence of process-parameters such as mold temperature, curing time, temperature of the PBT insert before performing the overmoulding with LSR, on the adhesion with LSR's. The effect on the adhesion of the amount of glass fiber content on the PBT was also studied. The adhesion between the materials was measured using a peel-test 90º.

The results of the peel-test indicated that the adhesion is influenced by the parameters described. The adhesion between the two materials increase significantly with the increase of the process-parameters.

Introduction

The use of liquid silicone rubbers, LSR, in engineering applications had a significant growth over the last few years, particularly in the automotive and medical industry. This is due to the advantages it provides the material with, specially for its high service temperature, good features for sterilization and dielectric properties [1, 2].

Liquid silicone rubbers have a lot of advantages for the manufacturer, for example, the easy, fast and automated processing possibility. The materials are delivered ready for processing and cured thermally. The polyaddition-reaction happens without the emission of volatile contents, preventing blistering and mold fouling. The raw of materials are delivery uncured and ready for processing in two standardized drums, separated as component A and B, stored at room temperature. The material is taken from the drums by a fully automated dosing system, then mixed in a ratio of 1:1 and fed into the screw aggregate.

The LSR standard materials for injection molding are characterized by good thermomechanical properties. They rarely show any modification of their mechanical properties over a wide range of temperature. They show good creep resistance, good attenuation properties and high elastical transfer to reserve. Rigid-flexible parts made of LSR are applicable for constant load at temperatures up to 180ºC [4, 5].

With the emergence of non-conventional processing techniques such as overmoulding, the use of LSR's multi-material applications increases the range of possible applications with reduced costs [3].

However the challenges resulting from the processing of LSR, which implies high mold temperatures (around 190ºC), and issues related with the adhesion between LSR's and thermoplastics, amplifies the importance of studies on these aspects and is relevant to a desideratum to be achieved [4, 5].

All thermoplastics used in Thermoplastic/LSR combinations have to be temperature resistant. This is important because of the process specifications which are different than the ones used for

conventional injection molding of thermoplastic material. The more relevant difference is that thermoplastics are cooled down in the mould and LSR's are heated up [4].
Good adhesion strength is the condition for non-positive joint combinations; it is to be found in the adhesion of modified LSR types to different thermoplastics, the so called self-adhesive LSR´s. An antiadhesive coating of the mould walls is not necessary; the production works with conventional moulds [6].

Experimental

Specimen. The multi-material specimen produced for this work is shown in Fig. 1.

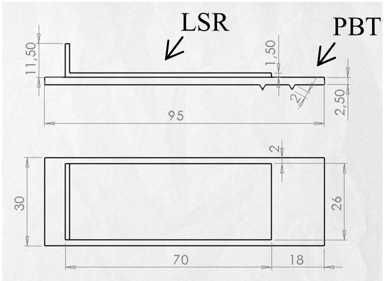

Fig. 1 - Multi-material Specimen.

Materials. The thermoplastics chosen for this were are two polybutilene-therephthalates (PBT) with 15% and 30% of glass fiber content (Dupont CRASTIN SK 602 and CRASTIN SK 605), in order to evaluate the effect of the glass fiber in the adhesion.
The LSR selected is a self-adhesive liquid silicone rubber, Wacker ELASTOSIL LR3070, with 40 Shore A hardness.
Injection molding. The specimens were manufactured in a two step process. First the PBT strips were processed. Then the stripes were inserted into the mold and overmolded with LSR. The injection machine used to produce the PBT stripes was an ARBURG 320C. The Table 1 shows the processing conditions of the PBT stripes.

Table 1 - Processing conditions of PBT stripes.

Barrel Temperature [ºC]	245 250 260 270 270
Mold Temperature [ºC]	70
Srew rotation speed [rpm]	250
Injection Pressure [bar]	60
Injection speed [mm/s]	80
Holding Pressure [bar]	40
Cooling time [s]	16

The injection machine used to perform the overmolding of the LSR was an ARBURG 420C. A dryer was used to preheat the thermoplastic stripes, and rise the superficial temperature to approximately 60ºC before performing the overmolding of the LSR.
The studied process-parameters are shown in the Table 2.

Table 2 - Values of process-parameters changed.

	Min.	**Max.**
Mold Temperature [ºC]	170	190
Insert Temperature [ºC]	24	60
Cure time [s]	13	18
Amount GF [%]	15	30

The overmolding of the self adhesive LSR was difficult to perform due to the adhesion of the LSR to the mold. Trials show that the cure time affects the adhesion to the mold. Lower values of cure time were used to process the specimens with no adhesion to the mold.

Peel test. The equipment used to perform the peel test 90º was an INSTRON 4505 universal tensile machine, with a homemade peel test device, shown in Fig. 2.

Fig. 2 - Tensile machine and peel test feature.

The device to perform the peel test was design and made at University of Minho, in accordance with the ASTM D6862 standard requests.

Five specimens were tested per process condition at room temperature and a 25 mm/min testing speed. All specimens were conditioned at temperature (23 ± 1) ºC and relative humidity of (50 ± 2) % for at least 24 h before testing.

Results and discussion

The Table 2 shows the results of the peel test. The Fig. 3 and 4 shows the influence of the process-parameters under study for the Crastin SK 602.

Table 2 - Results of peel test.

	Process-parameters			P [N]	
	Mold Temp. [ºC]	Insert Temp. [ºC]	Cure Time [s]	SK 602 (15% GF)	SK 605 (30% GF)
C1	190	24	13	3,326	3,518
C2	190	60	13	3,776	3,491
C3	190	24	18	3,711	2,515
C4	190	60	18	3,797	3,823
C5	170	24	13	3,225	3,271
C6	170	60	13	3,611	NA
C7	170	24	18	3,554	3,745
C8	170	60	18	3,702	3,844

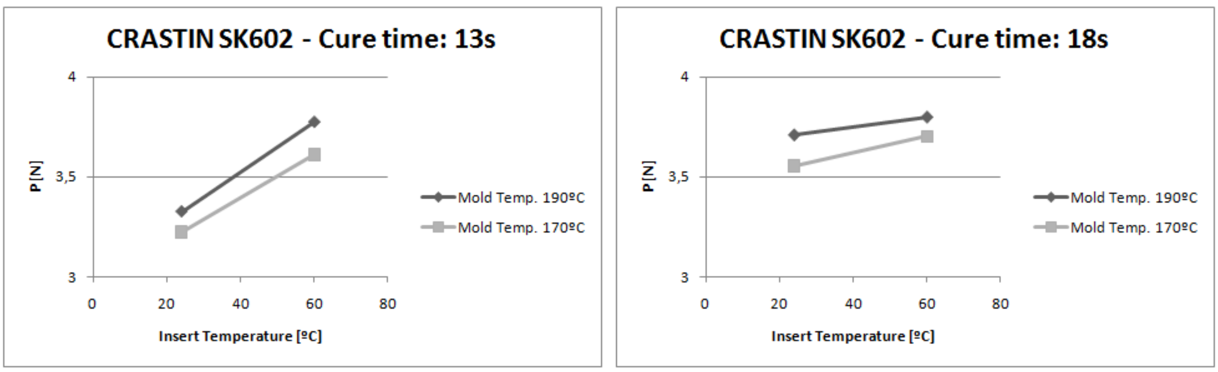

Fig. 3 - Effect of the insert temperature.

Both graphs shown in Fig 3, demonstrate the effect of the thermoplastic insert temperature. It is possible to conclude that increasing the insert temperature leads to higher values of the adhesion strength between the two materials.

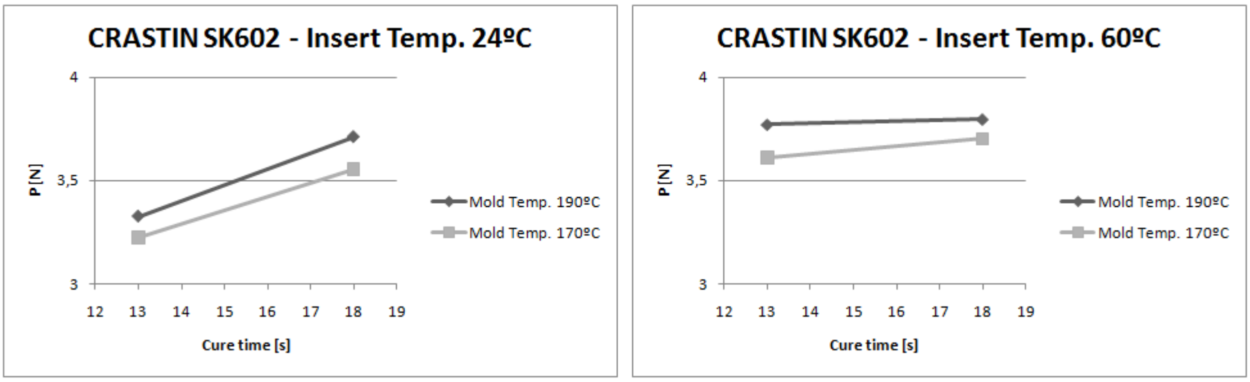

Fig. 4 - Effect of the cure time.

Trough the graphs in Fig. 4, it's possible to conclude that increasing the cure time results in higher values of adhesion between the two materials. In Fig. 3 and 4, it is also possible to evaluate the influence of the mold temperature. Increasing the mold temperature, results in better values of adhesion between the materials.

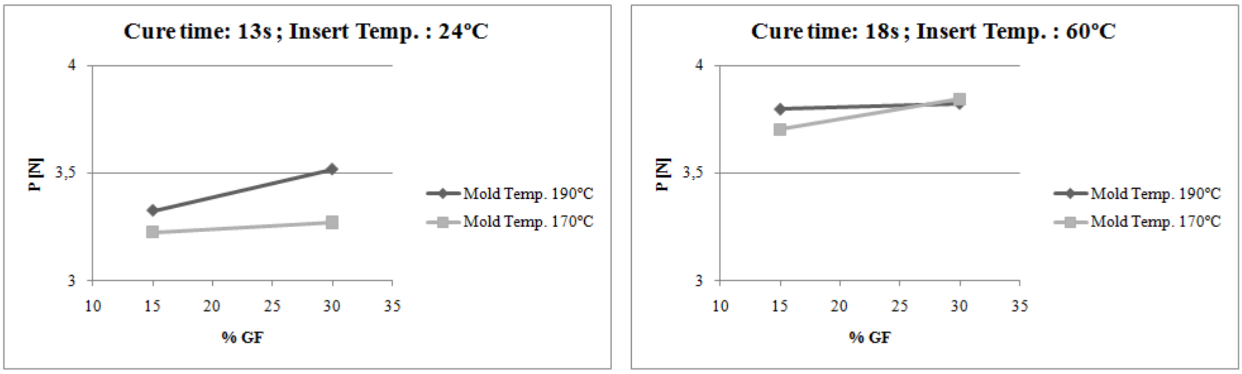

Fig 5 - Effect of the glass-fiber.

The graphs shown in Fig. 5 evaluate the influence of the amount of glass-fiber present in the thermoplastic strip. It is prove that the increase of GF results in higher values of adhesion strength.

Conclusions

The results of the peel test shows that both temperature of the mold and the thermoplastic insert before performing the LSR overmolding have an important influence on the adhesion strength between the two materials. The increase of temperature leads to a better adhesion between the thermoplastic and the LSR.

The cure time also have an important role in the adhesion strength. In excess, the material starts to adhere to the mold, which was a big problem to releasing the parts. It is also proved that the increase of the cure time, in a controlled way, leads to an increase of the adhesion strength between the thermoplastic and the LSR.

The influence of the glass-fiber present in the thermoplastic strips is also relevant. The part with a higher amount of glass-fiber shows better properties of adhesion.

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