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POLYMER INJECTION MOLDING PROCESS SIMULATION.

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Abstract: *Simulation analyse of injection molding is a good tool for improving the quality of plastic products and manufacturing equipment. It is an instrument to reduce the time to prepare new products for market. Because of, many kinds of products are demanded, not only thermoplastic material is injected in the plastic industry. Next injected material with interesting properties is rubber compound. This paper shows differences during preparing, setting and controlling and it s compares results for both types of analyse. These received data should be help and very important advantages to understanding this process.*
Key words: *Simulation, rubber compound, thermoplastics, injection molding*

1. INTRODUCTION

Injection molding is now a well-established fabrication process in the environmental industry. It has more advantages in most situations over the older processes of compression and transfer moulding. These advantages comprise reduced labor cost, better dimensional control, shorter cure times for injection moulding of rubber and shorter cooling time for injection moulding of thermoplastics. Among thermoplastic and elastomeric injection moldings are many differences which are described below.

The injection molding is a cyclical process, each cycle comprising several operations: feeding, melting and homogenization of polymer grains inside the plasticizing cylinder, mold closing, injection under pressure of melt in mold's cavities and cooling or heating of polymer inside the mold, mold opening and ejection of molded part. In figure 1 there is shown time influence for each parts of cycle. It is necessary to realize, that rubber injection molding cycle is several times longer than for thermoplastics materials as it will be seen later during setting of process parameters.

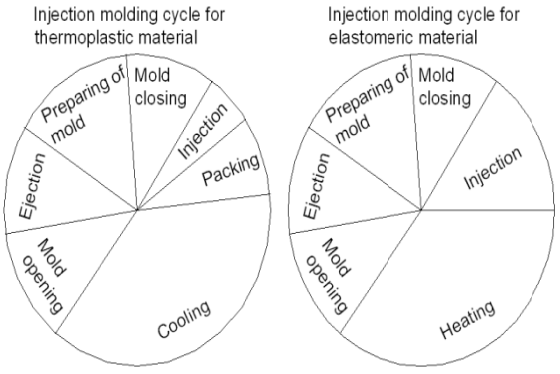

Fig. 1. Differences in injection molding cycles

During injection molding process, melt is subjected to more severe processing conditions than during the compression or transfer molding. Values of temperature, pressure, and shear stresse are higher, though cure times are shorter at rubber compound. Control over process variables can be more precise. The cycle time can be minimized by independently controlling barrel temperature, screw speed, mold temperature, cooling or heating and injection pressure. That is the reason why the analysis of injection moulding process should be improved and understood as well.

In technical industry there are plenty of materials. Basic differences in process settings characterizing the molding cycle between each type of polymeric material are shown in following table.

Type of polymer	Family name	Mold surface temperature [°C]	Melt temperature [°C]
Elastomer	EPDM	150	90
	NBR	140	85
	NR	140	85
	SBR	140	85
Thermoplast	ABS	50	250
	ABS 20%	50	230
	PA6	65	250
	PC	82	299
	PE	52	220
	PP	50	230
	TPE	45	250

Tab. 1. Processing temperatures

For experiment there were used two various materials from different family (thermoplastic material and rubber compound) with similar properties as can be seen in Tab.2., but setting is opposite.

	Density [kg/m^3]	Hardness [Shore A]	Tensile strength [MPa]	Elasticity [%]
EPDM compound	1220	65	25	460
TPE-Hytrel 7246	1260	72	53	740

Tab. 2. Physical properties of chosen material

2. PROCCES SETTING

These simulations of injection moulding process were optimized to finally form several times. Profitable last setting is shown in Tab 3.

Process parameters	TPE - Hytrel 7246	EPDM compound
Filling time [s]	0,777	18
Pressure controlled - filling [%]	99	99
Melt (mass) temperature	250	100
Uniform wall temperature [C]	45	180
Ejection temperature[C]	130	-
Packing [s]	10	-
Cooling [s]	175	-
Heating [s]	-	600
Post-Curing [s]	-	300

Tab. 3. Process parameters of chosen material

3. RESULTS

Plenty of useful results as temperature, pressure, clamping force, shear stress, cure rate, in each layers or in sensor which can be aplicated to the individual places are showed by computational program Cadmould.

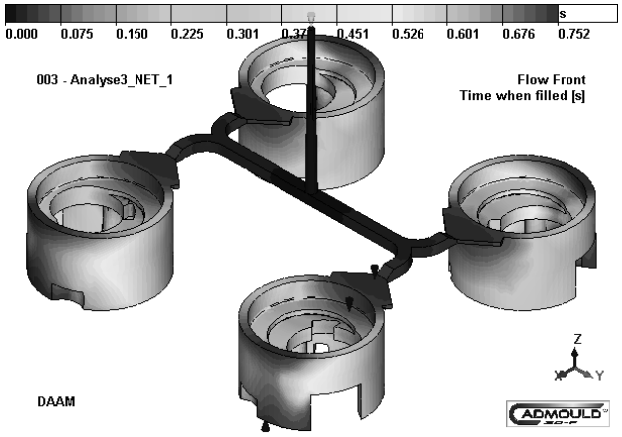

Fig. 2. Filling time for TPE - Hytrel 7246

The results can be displayed as a picture (graph or colour picture) or as a movie sample. In figure 2. and 3. flow of each material is shown and cure rate which is necessary to receiving required mechanical properties is shown in figure 4.

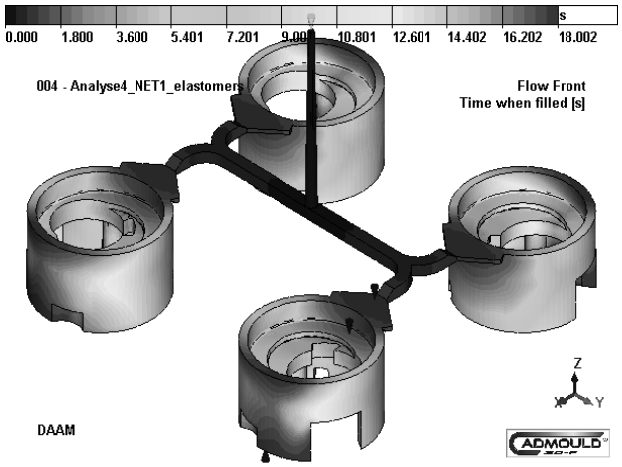

Fig. 3. Filling time for EPDM compound

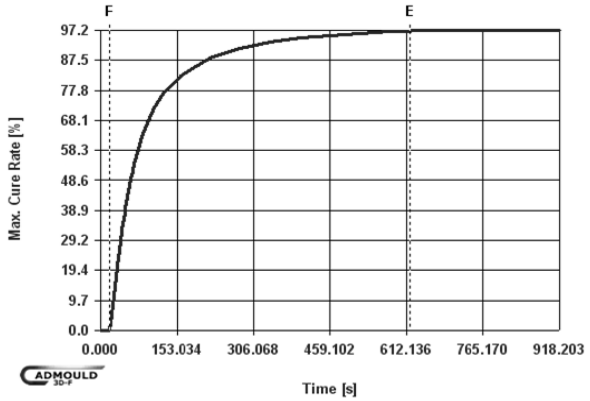

Fig. 4. Cure rate of EPDM compound

Results	TPE - Hytrel 7246	EPDM compound
Time when filed [s]	0,752	18
Filling + Packing [s]	175.98	-
Filling + Heating [s]	-	918,2
Max pressure (when filed) [bar]	694,474	285,143
Flow rate [cm^3/s]	119,104	5,133
Max cure rate [%]	-	97,2

Tab. 4. Review of chosen results

4. CONCLUSION

Cadmould seems as a good and interesting computational tool which can improve the quality of injection molding rubber or thermoplastic parts and expedite the preparation of new productions when analysis are used correctly, but also can reduce the costs associated with repairing molds. One of the big disadvantages during injection molding of rubber is receiving data. For thermoplastic material MFI (melt flow index) have to be measured and it is measured for each material and it is saved in material database with other properties. Because elastomeric compounds are mixed from several samples, so each compound is an original and each entering data have to be measured. It is difficult to obtain these data because each property has to be measured. Rubber Process Analyzer (RPA 2000) has been used for measuring the entering data.

5. ACKNOWLEDGEMENTS

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