COMPUTER AIDED ENGINEERING IN THE INJECTION MOLDING PROCESS: DETERMINATION OF SPECIFIC HEAT CAPACITY OF A THERMOPLASTIC

M.A. PEYDRO[1], D. JUAREZ[1], M.A. SELLES[1], S. SANCHEZ-CABALLERO[2]
[1] Instituto de Tecnología de Materiales, Universidad Politécnica de Valencia, Alcoy (Spain)
[2] Instituto de Diseño en la Fabricación, Universidad Politécnica de Valencia, Alcoy (Spain)
mpeydro@mcm.upv.es

Keywords: Specific Herd Capacity, Thermoplastic, ABS, Simulation, Injection Molding.

Abstract: One important property of thermoplastics is specific heat capacity. This property, along with others, determines the solidification time of the material inside the mold. In this work the most precise process was used. Finally, Computer simulation was used to determine optimum process conditions and ie, the injection pressure and cycle time.

1. INTRODUCTION.

The injection molding process of thermoplastic materials is an important process in the manufacture of a lot of products. There is currently a lot of research into the optimization of the process parameters using computer aided simulation. The study of materials is useful to obtain accurate simulation data. One important property of thermoplastics is specific heat capacity. This property, along with others, determines the solidification time of the material inside the mold. There are four ways of determining the specific heat capacity using the DSC (Differential Scanning Calorimetry), Mettler Toledo [5]. In this work the most precise process was used. Finally, Computer simulation was used to determine optimum process conditions and ie, the injection pressure and cycle time.

2. EXPERIMENTAL

For the determination of specific heat capacity the DSC (Differential Scanning Calorimetry) Mettler Toledo, S.A.E. ®, model 821e, type of power compensation was used, Fig. 1a. To weigh the samples the precision scale AG245 of Mettler Toledo was used, with characteristic of 0.01 mg of precision and with a maximum weight of 41g., fig 1b. The norms ISO 11357-1 and 11357-4 were used.
The software used in the computer aided simulation of the injection molding process is the "Plastics Insight 6.1 of Moldflow"®, Fig. 2. By means of this program we carried out several simulations at different times of injection. Optimum process conditions were obtained, obtaining the graphs of injection pressure and cycle time and the graph of temperatures in the injection point.

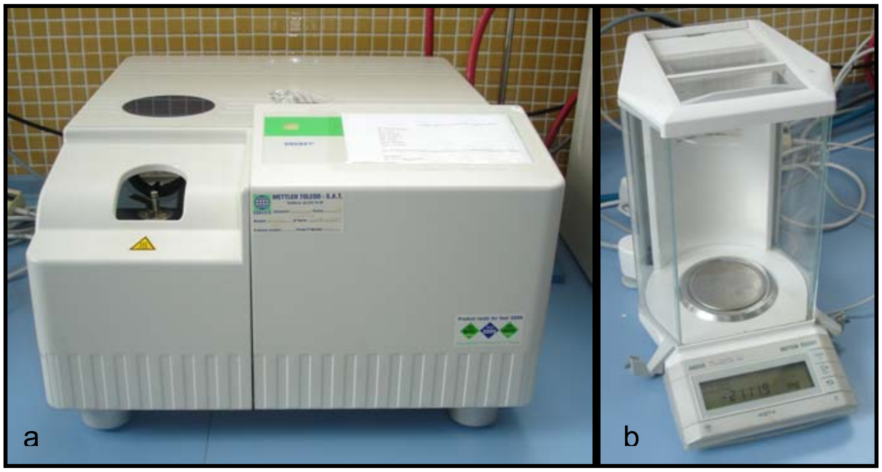

Figure 1. DSC and scale.

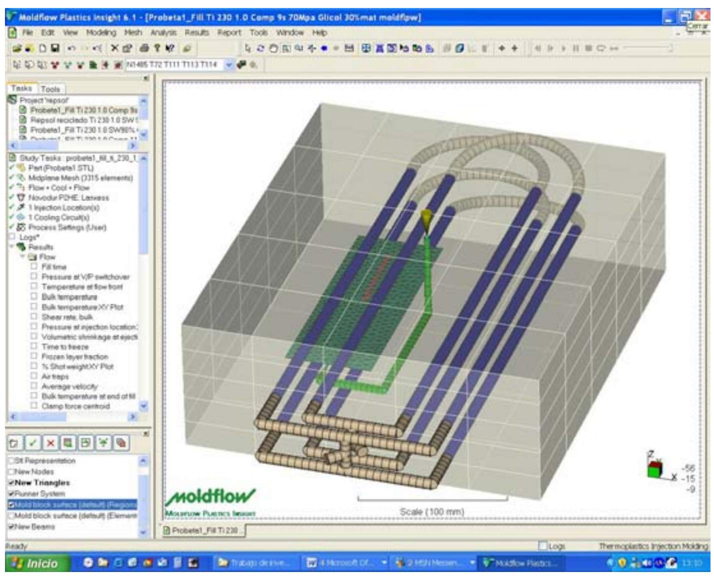

Figure 2. General image of the mold in the simulator "Plastics Insight 6.1 of Moldflow"®.

3. RESULTS AND DISCUSSION

The sapphire method for cp determination has been used for more than 30 years. The DSC signal of the sample is compared with the DSC signal of the calibration sample of known specific heat. Both curves are blank curve corrected (automatic blank curve correction). A total of three measurements are made: blank (empty crucible), sapphire (3 small sapphire disks of 4.8 mm diameter, like the calibration sample) and the sample itself. A blank curve correction is in this case also essential.

1) a blank run (empty pans in sample and reference holders);

2) a calibration run (calibration material in sample holder pan and empty pan in reference holder);

3) a specimen run (specimen in sample holder pan and empty pan in reference holder).

Based on the DSC principle (see ISO 11357-1) and the definition of specific heat capacity the following relations can be obtained:

$$c_p^{sp} = c_p^{cal} \cdot \frac{m^{cal} \cdot \left(P_{specimenrun} - P_{blankrun}\right)}{m^{sp} \cdot \left(P_{calibrationrun} - P_{blankrun}\right)} \qquad (1)$$

Once the DSC graphs are obtained and processed, to see figure 3a, the calibration cp is needed, in this case sapphire. The cp of the sapphire responds to the figure 3b. Once the graph of cp of the sapphire was been calculated, it is only necessary to apply the previous formula and the graph in figure 3c is obtained

When the new data of calculated specific heating capacity is introduced and the simulation is completed, the graph in figure 5 is obtained. In this figure the pressure-cycle time, and the graph of temperatures in the injection point the pressures can be observed. In it is observed in the instant of time 12 seconds (corresponding to a packing of 11 seconds) the temperature of the injection point this below the 105ºC (glass transition temperature) and therefore, the material one is not able to more packing. It is also observed that, on the 16 seconds, the piece is also below 90ºC (expulsion temperature) and the piece can be extracted.

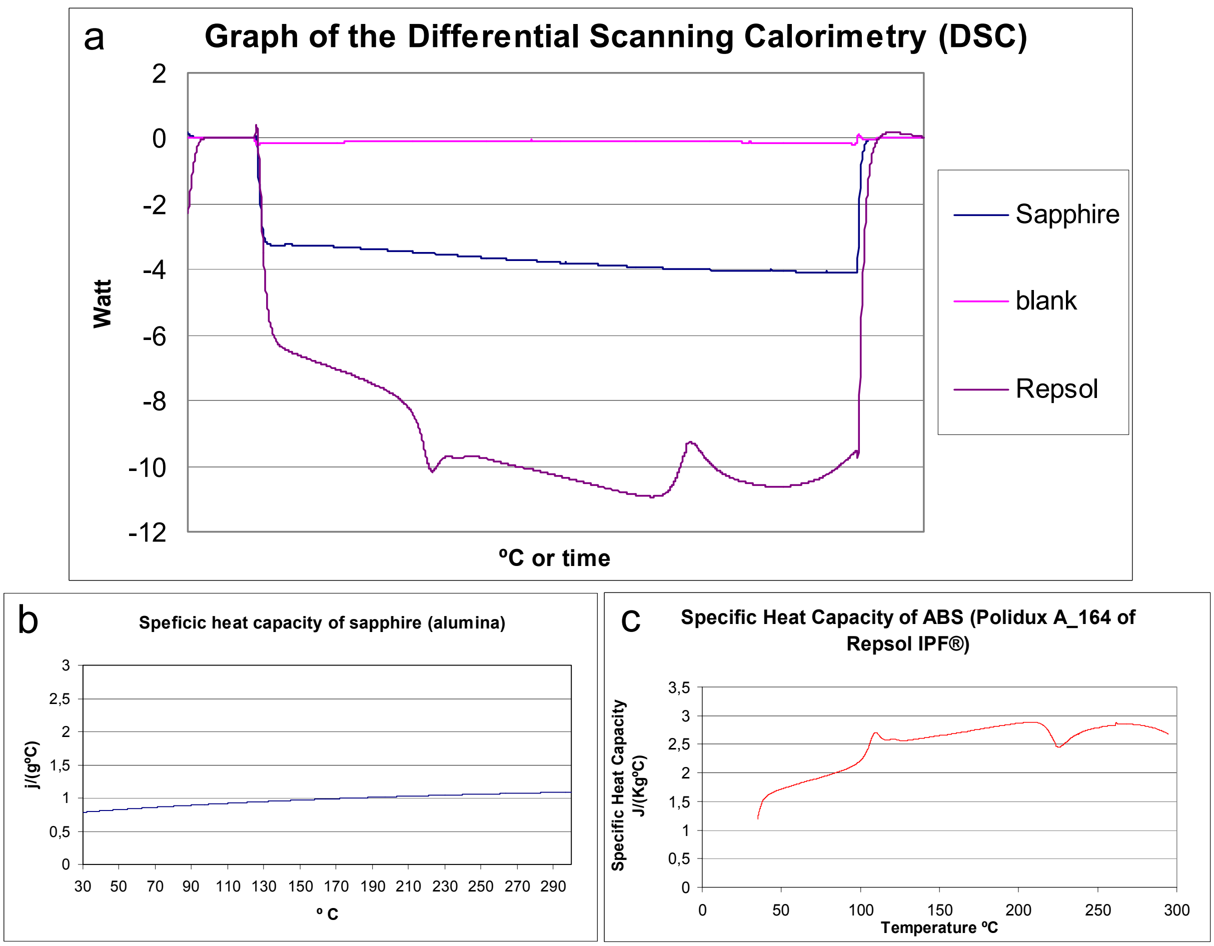

Figure 3. Calculate cp.

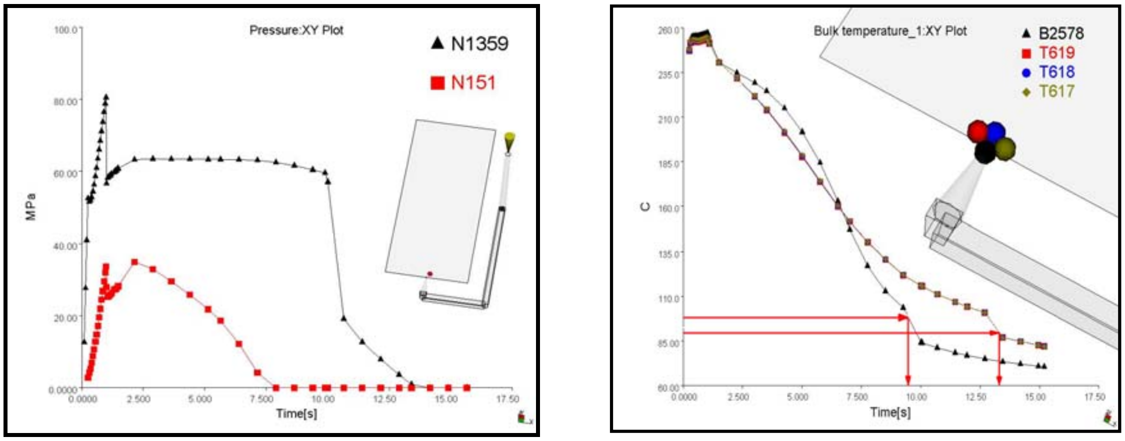

Figure 4. Graphic with data Software.

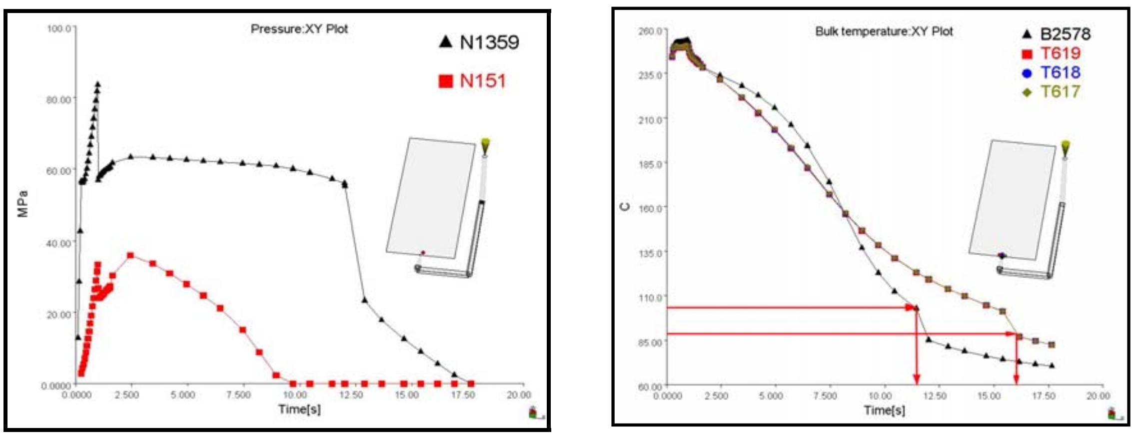

Figure 5. Graphic with data calculated with DSC.

4. CONCLUSIONS.

The results of this work show how a difference appears in the injection cycle time, using specific heat capacity data provided by software and the data calculated with the DSC.
The increase of the specific heat capacity of 50% (passing of 1800 J/(kg ºC) (data of the database of Molwflow) to 2716 J/(kg ºC) (date calculated)), causes lightly bigger pressures to be obtained in 3.7% in the one filled in the runner system and 2% in the packing of the piece. With regard to the time of packing, this increases 22% passing from 9s to 11s. This is logical since an increase of the specific head capacity means that the material needs more energy, and therefore more time, to heat. Equally, the piece needs more time to cool down.

5. REFERENCES

[1] R. Riesen, Simple determination of de thermal conductivity of polymers by DSC. Measuring specific heat capacity, User Com, 22, pp 19-23, 2005
[2] Plásticos - Calorimetría diferencial de barrido (DSC) - Parte 1: Principios generales, UNE-EN-ISO 11357-1:1997.
[3] Plastics - Differential scanning calorimetry (DSC) - Part 4: determination of specific heat capacity, ISO 11357-4: 2005.
[4] Plastics - Determination of the fluidity of plastics using capillary and slit-die rheometers, ISO 11443: 1995.
[5] Mettler Toledo, Measuring specific heat capacity. User Com, 7, 1998.
[6] H. Saechtling, International plastics handbook for the technologist engineer and user, Hanser/Gardner, 1995.
[7] H. Domininghaus, Plastics for engineers: materials, properties, applications, Hanser, 1993.