DESIGN CONCEPTS OF EJECTION SYSTEMS FOR INJECTED LARGE DIMENSIONS PARTS

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ABSTRACT: This paper presents a design methodology for the pneumatic ejection system corresponding to an injection mold used for manufacturing injected large parts (Φ600x445 mm) with thin walls. The injected part has a mixed profile (linear and curved). The design of the ejection system depends upon the value of the mold force (which is analytically computed). This system (i.e. ejection system) contains: a pneumatic ejector, an air valve and a special blowing system. The model of the pneumatic ejector used in this study was patented by the authors in 2012.
KEY WORDS: Thin-wall injected part, Pneumatic ejector.

1 INTRODUCTION

During the process of plastic injection, it aimed to obtain a reduced injection time, resulting as a direct consequence of this fact an increased productivity. Achieving a short injection cycle requires appropriate design of the injection system, cooling system and ejection system. Injected thin-wall parts are revolution parts having a tapered shape and up to 3 mm wall thickness. The profile of this part is linear, curvilinear or combined. From this category of products we can enumerate the following: buckets, flower pots, bowls, boxes, and other many molded parts. During the injection process, these parts are shrinking on the mold core, creating vacuum. In order to make these types of products there are used pneumatic ejection systems (pneumatic ejector, air valve and the blowing system). There are some important advantages in using pneumatic ejectors:

Reducing the axial dimension of the mold by reducing the number of plates required to build it (this aspect is important when a large series of molds are considered); Compact pneumatic ejectors will occupy less space from the entire volume of the matrix and the space saved can be used to achieve a more efficient cooling of the mold (this will conduct to a shorter injection cycle time); The large acting speed of these pneumatic ejectors will conduct to a small ejection time and therefore a reduced total time for an injection cycle.

The air valves mounted both on the core and on the nest of the injection mold prevent the forming of the vacuum and the injected part will be more easily removed.

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2 THE PRODUCT AND THE INJECTION MOLD

The Φ600 flower pot (Fig. 1) is a thin-wall injected part made of polypropylene, having a combined profile (i.e. a part of the profile is curved, while the other is linear). The relative large size of this product (Φ600x445 mm) requires an injection mold having a design with a single nest.

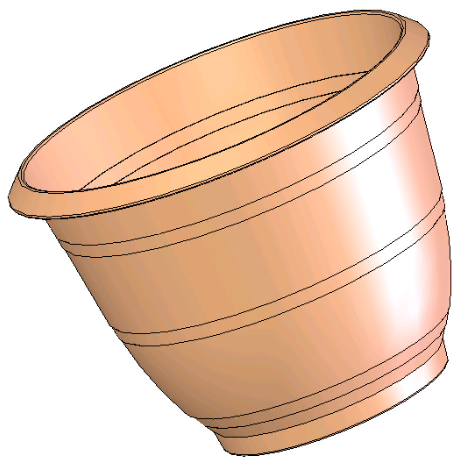
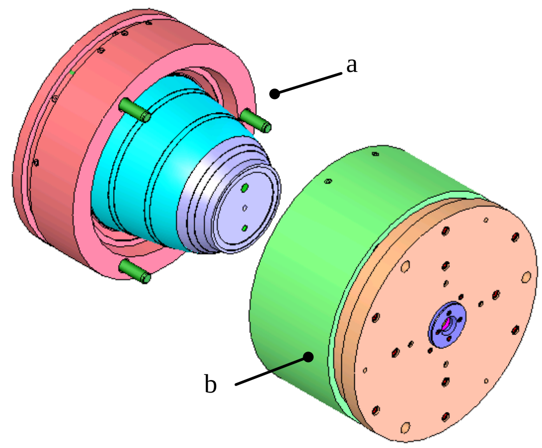


Figure 1**. Flower pot Φ600**

The injection mold (Fig. 2) has two parts: a fixed one and a mobile one. The product is made into the cavity between the forming elements, which are the nest, and the core. The injection process is punctiform and the nozzle is equipped with an antechamber thermally insulated. The fitting of the two half-molds is performed through a tapered surface. The half-molds are guided by three leader pins and three leader pins bushing. The leader pins belong to the mobile part and the leader pins bushing belong to the stationary part of the injection mold.



a – the mobile part of the injection mold; **b** – the fixed part of the injection mold.

Figure 2. Injection mold for flower pot Φ600

The injection mold uses a water cooling system. In the fixed part, the cooling system has three circuits, two for the cavity and one for nest cap. The circuits for the cavity contain six channels with baffle.

The cooling circuit for the cap was made with drilled channels. In the mobile part there are three cooling circuits that have a channel with baffle.

3 EJECTION SYSTEM DESIGN

The ejection system works out the removal of the part after the injection mold is opened. Due to the large size of the injection mold (Φ840x759 mm) it was chosen a pneumatic ejection system. Using a mechanical ejection system would have increased the injection mold overall dimensions, making it impossible to mount it on the molding machine. When the injection mold is opened, the injected part does not come down from the injection mold core.

In the mobile part the ejection system is made from a valve air and a pneumatic ejector (patented by the authors in 2012) driven by compressed air.

At the end of the opening stroke the air comes in the injection mold through this valve and detaches the part. The part is detached in two phases. Firstly, is detached the bottom end of the part. For this reason, when the demolding force (i.e. the necessary force for detaching the part from the injection mold core) is computed, the contact surface area is the considered area.

At this point of designing the ejection system, the demolding force should be analytically computed and disposal system design must be calculated (analytical) releasing force. The demolding force F_D can be determined by relating to the shape and the material of the injected part.

A simplified sketch of the product profile is shown in Fig. 3. A part of the profile is linear and the other is curvilinear.

For this configuration, the demolding force can be calculated (Haragâş, 2008) with the following equation:

$$F_D = \pi \cdot \mu \cdot E_{(T)} \cdot \varepsilon_{(T)} \cdot h \cdot \left[2 \cdot \left(2 + \frac{a}{r_1} \right) \cdot \left[l_1 - a \cdot \left(\arcsin \frac{l_1 + b}{R} - \arcsin \frac{b}{R} \right) \right] + l_2 \cdot \left(1 + \frac{r_3}{r_2} \right) \right] \qquad (1)$$

where μ – coefficient of friction between the injected part and the injection mold core: $\mu = 0{,}31$ (Menges, 2001);

$E_{(T)}$ – Young's modulus of the injected part material at the demolding temperature (60ºC): E(T) = 1150 MPa (Sereş, 2002);

$\varepsilon_{(T)}$ – specific contraction of the material at the demolding temperature (60ºC): $\varepsilon_{(T)} = 0{,}01$ (Sereş, 2002);

h – thickness of the injected wall part (h = 3 mm);

a, b, r_1, r_2, r_3, R, l_1, l_2 – geometrical dimensions of the injected part.

The demolding force will be: F_D = 39440 N.

In order to detach the part, the following inequality should exist:

$$F_{det} = F_S + n \cdot F_a > F_D \qquad (2)$$

where F_S – ejection force (due to the compressed air which enters through the valve);

F_a – acting force of a pneumatic ejector;

n – pneumatic ejector numbers (in our case n = 1).

$$F_S = \frac{1}{4} \cdot \pi \cdot d_p^2 \cdot p_{air} \qquad (3)$$

$$F_a = \frac{1}{4} \cdot \pi \cdot D^2 \cdot p_{air} \qquad (4)$$

where d_p – bottom diameter of the product (injected part);

D – pneumatic ejector piston diameter;

p_{air} – air fllow pressure (p_{air} = 0,5…0,8 MPa).

The detaching force resulted after the calculus is: F_{det} = 38500 N.

The demolding force F_D is higher than the sum between the detaching force F_S and the ejection force. For this reason, the ejection system should be modified. This can be accomplished by making additional channels in the core of the injection mold (Fig. 4).

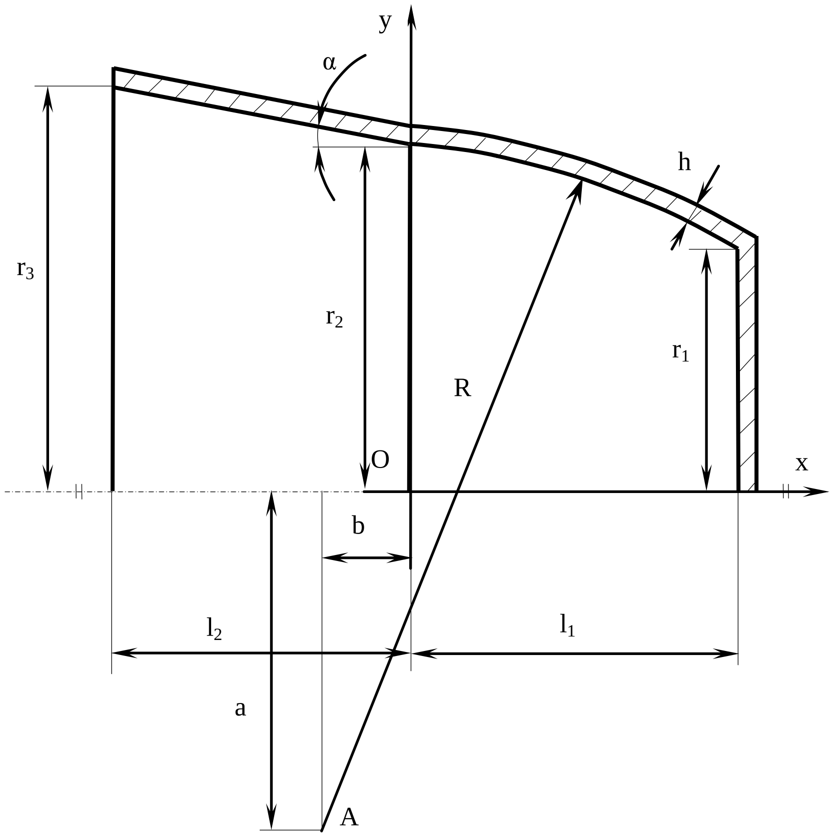
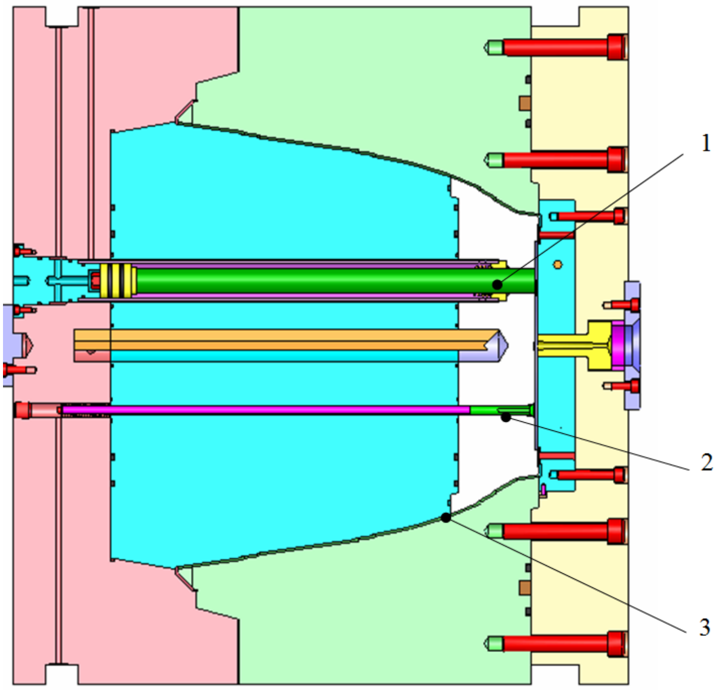


Figure 3**. The product profile**



1 – duble action pneumatic ejector; **2** – valve air; **3** – swelling system.

Figure 4. The ejection system of the flower pot Φ600

Through these channels the compressed air is introduced and the air valve is tripped, resulting the separation and the swelling of the product.

By adding the swelling system the design of the injection mold becomes complex. The core will have two parts. The method described here simplifies the design of the cooling system from the mobile part of the injection mold.

For the situation presented in this paper (i.e. an injection mold with large dimensions), selecting and designing this ejection system proved to be the correct design solution.

He proved his efficiency after the commissioning of the injection mold (Fig.5, Haragâş, 2007).

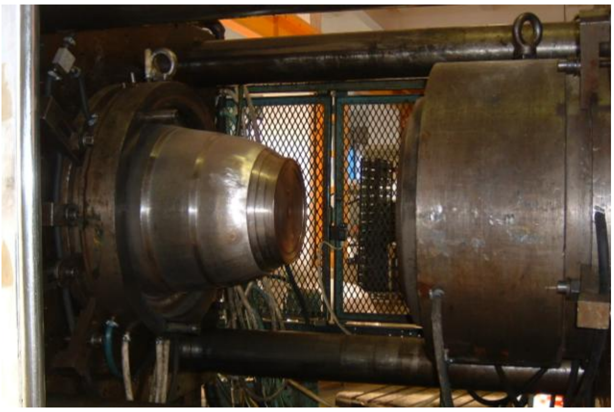


Figure 5. **The injection mold for the flower pot**

4 CONCLUSIONS

For the injection of thin-wall molded parts, the most efficient ejection systems are the pneumatic ones (air valves, pneumatic ejectors and possibly additional swelling systems).

The analytical calculation of the detaching force can offer (in the design phase of the mold) us the possibility to select a certain configuration for the ejection system.

The example described in this article proved a sustainable solution which has been validated in production.

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