The influence of the mold quality and injection pressure on the product quality

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Abstract. This study deals with the study of the influence of injection pressure parameters and the quality of the surface of the mold cavity on the final quality of the product surface. This issue represents a significant problem, especially in the area of the mold production and the determination of its product price. The final price is closely linked just to the surface quality. This study is concentrated on three basic qualities of machining, namely Ra 0.1, Ra 0.8 and Ra 1.6. The possibilities of the replication of the surface of the mold cavity are then combined with various values of injection pressure, which has also the inconsiderable influence on surface replication. Total results show the influence of injection pressure and its most suitable value for obtaining the best identities of both surfaces.

1 Introduction

Polymeric materials already found their irreplaceable place in the area of construction products of the daily use. These products with their character belong to very cheap group of materials especially because of the reason of the minimal waste, which is recyclable already in the production. Their importance is also in the area of machining, which is not almost used and thereby next production costs are not increased. Short terms of production belong to other of the advantages of the polymeric material production. More complicated and time consuming are the activities that precede this very fast and relatively productive production, and that is the design and manufacture of an injection mold that acts as a tool in this process.[1-2]

The injection mold is a complex system of precisely manufactured parts that fit together and each performs its unmistakable function. The mold production is a financial and time-consuming process in which we try to ensure production according to the drawing documentation. For the correct operation of such a complex system, we can use a number of simulation programs that help the engineer to verify the functional movement. Next necessary part of the simulation software is used to verify the melt behaviour of the polymer in the mold cavity, thereby verifying the correct polymer flow in the whole volume of the product. These simulation systems are based on mathematical algorithms whose calculation is dependent on the accuracy of input information. These calculations are not able to realistically simulate the surface quality of the product despite their high reliability and consequent match of the product with simulation results. Calculations occur between the ideal planes of mold walls, with the failure of the quality of the surface treatment which arise from the mold cavity itself. To fulfill simulation requirements, it would be necessary to calculate and most importantly the boundary simulation conditions which the operator assigns to set at least basic surface roughness parameters on the basis of which the simulation itself would be performed. This small but very practical part of the mold production cannot be used for the simulation but only for the practice, which is based on the experience of the workers who prescribe the requirements of the designers for the surfaces of the manufactured parts quality. The example of the results of the simulation program for injection can be seen in Figure 1. From the picture it is easy to deduce the actual action of mold filling but because of the calculation algorithm it is impossible to deduct the quality of the surface from the surface on the edge of the solidified melt.[3-4]

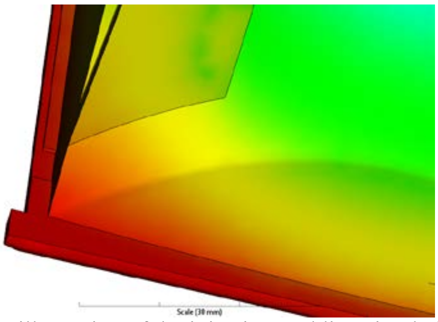

Fig. 1. The illustration of the injection molding simulation.

This small but remarkable detail applies especially to the surfaces of components that are artistically processed and therefore have a significant influence on the overall

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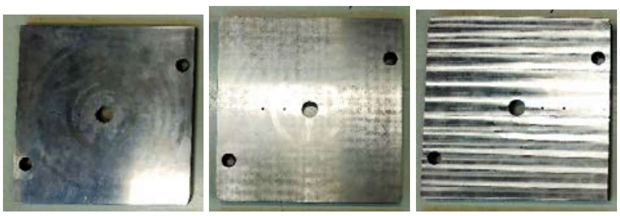
function of the components. In the case of designing and processing such designed surface surfaces, templates or special techniques for molding the mold cavity using etching are often used to protect against abuse. In addition to these special techniques, the molds are machined and finished by conventional machining techniques such as milling, grinding and other finishing operations. Also the surface quality and the price associated with achieving the desired quality are closely related.

2 Methods

In order to verify the need of finishing the surface of the mold cavity and the inlet system of the mold, the mold cavity shape was chosen. It is primarily intended to measure the fluidity of the polymeric material in the mold cavity. This mold was then completed with a removable plate, which was produced with various surface quality and different technology. Injection was carried out on an Arburg Allrounder 470C injection machine, which can be seen in Figure 2.

Fig. 2. Arburg Allrounder 470C.

Process conditions of the injection were set according to the manufacturer's recommendations with slight corrections so that the manufactured products correspond to the quality requirements in the production. To verify the effect, a total of three plates with different surface quality parameters were selected with a mean arithmetic deviation Ra 0.1, Ra 0.8 and Ra 1.6. According to the manufacturer's recommendations ABS and POM materials were dried for 3 hours at 80 °C before the injection molding. Because of the very good absorption of air humidity materials, dosing directly from the dryer to the hopper was used.



Ra 0.1 Ra 0.8 Ra1.6

Fig. 3. The surface of removable plates.

Removable plates of the various surface quality were gradually inserted into a universal frame which enabled the rapid replacement. As already mentioned, a spiral was used as a product. The design of the mold allowed a change in the size of the inlet channel. In this case, an inlet channel of 6 mm width was chosen, which did not limit the set parameters on the machine and thus the effect of the narrowed spaces in the mold cavity was excluded. Due to the nature of the product, only one ejector was used, which simultaneously served as an intake retainer, so as to guarantee the ejection position on the ejector side and to draw the conical inlet from the fixed mold part. An illustration of products can be seen in Figure 4, where we can see the different lengths that are caused mainly by the change of the materials that have been examined.

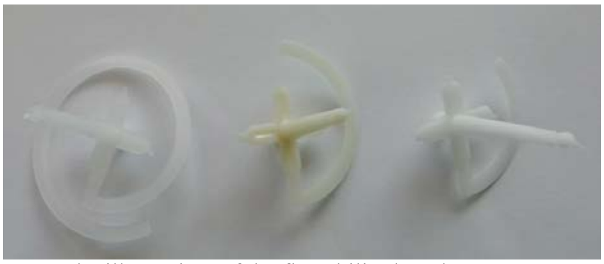


Fig. 4. The illustration of the flowability length.

PP, ABS and POM materials were selected for this article. For detailed information on the properties of the material, see table 1.

Table 1. The properties of injection molded materials.

Material	Density [kg/m^3]	Stress on Yield [MPa]	ITT [g/10min] [°C/kg]
PP	906	25	80 (230/2.16)
ABS	1040	44	3.2(200/5)
POM	1410	61	9 (190/2,16)

The test specimens were then measured on the TALYYURF CLI500 contactless tester from Taylor Hobson which can be seen in Fig. 5.

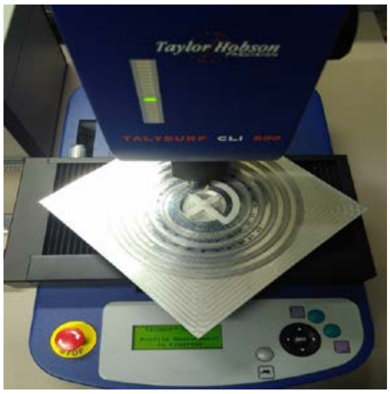


Fig. 5. Contactless roughness tester.

In Figure 5, it is possible see the method and the way of the measurement where the sample is placed in the measuring template so that the repeatability of the measurements in each of the locations is always guaranteed. The individual measuring points are then plotted in Figures.

Fig. 6. Measurement place on the product.

The result of one measurement can then be seen in Figure 7. Here we can see the measurement of the whole length after the removal of the shape of the part caused by the clamping. In the first graph, it is possible to see the roughness, the second shows the waviness of the entire profile. The material curve does not show the trend and corresponds to the chosen technology. The individual evaluation parameters are final and do not need to be further modified.

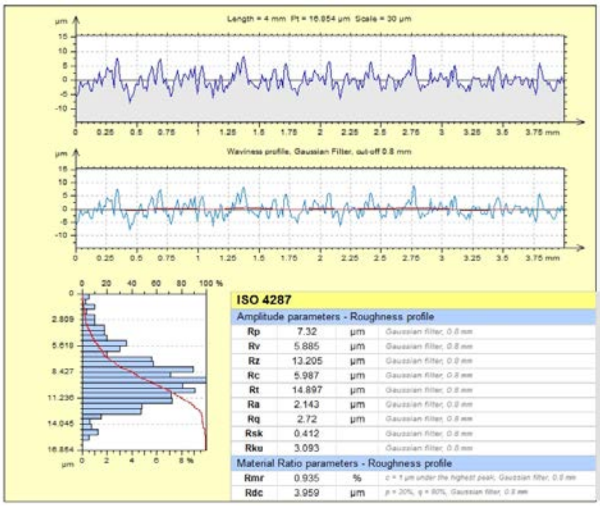


Fig. 7. The measurement result.

Each measurement was repeated ten times in one area of the sample to eliminate the measurement error. The data were then checked for suspect values, and in case of detected discrepancies, the measurement was repeated.

3 Data of results

All processed results were always displayed depending on the surface quality of the removable plates. Earlier research has already shown that polymeric materials do not provide perfect flowability throughout the mold surface. For a more detailed description of these problems with the selected materials, injection molding pressures have been changed with the replacement of the plates, which should have a considerable effect on this imprinting. For all measurements, the parameters Ra, Rz and Rt were monitored, which are often monitored in production and are thus prescribed by mold designers.
The results of POM measurement for 20 MPa pressure can be seen in Figure 8.

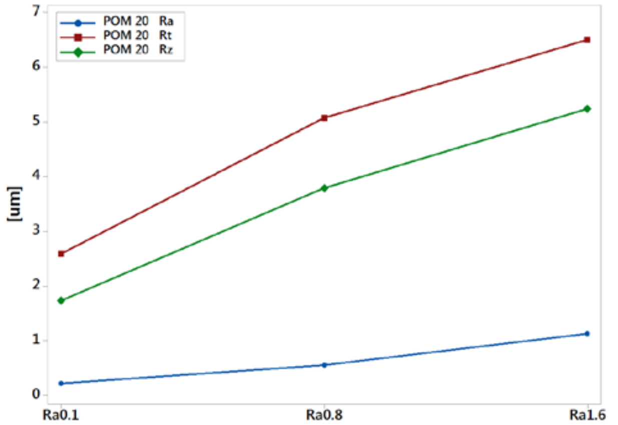


Fig. 8. The dependence of the surface quailty on the selected plate.

As can be seen in Figure 8, there is a clear trend of increasing average arithmetic roughness with the increasing value of plates at all monitored parameters. It is also possible to deduce from the graph the displacement of the individual measurement points to lower values, which is precisely due to the imperfect melt flow of the polymer melt.

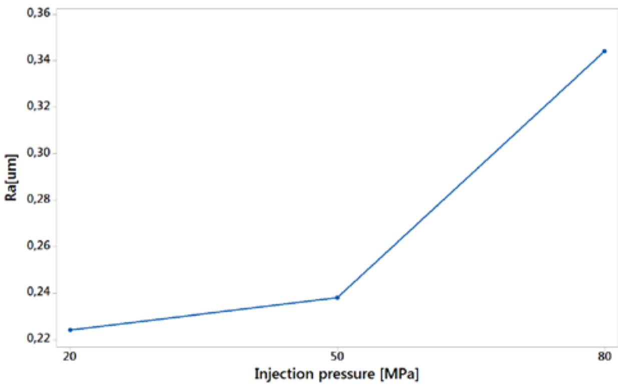


Fig. 9. The dependence of Ra on injection pressure

When comparing the influence of injection pressure on the resulting roughness of the surface, in the graph can be seen in an increasing trend, especially from 50 MPa. The displayed dependence is 0.1 µm for the used plate.

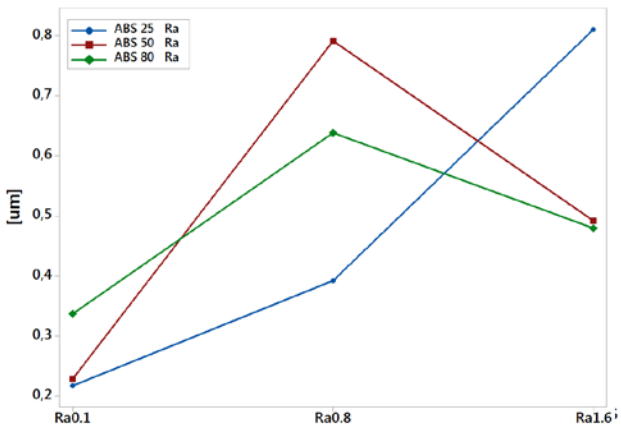


Fig. 10. The dependence of Ra parameter on the plate quality and pressure for ABS material.

The second tested material was ABS. This material showed no longer such a significant dependence as the POM material where a growing trend can be observed at pressure of 25 MPa. For the remaining monitored pressure, this trend is not observed.

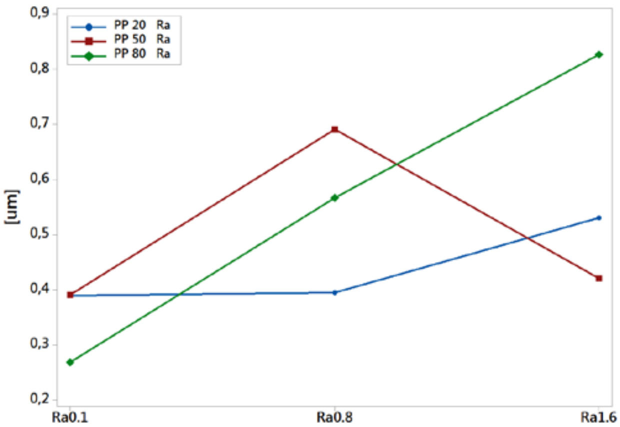


Fig. 11. The dependence of Ra parameter on the plate quality and pressure for PP material.

As can be seen in Figure 11, there is a slight dependence of 20 MPa pressure. At pressure of 80 MPa, we can see the increasing tendency of roughness with increasing roughness of the removable plate. No trend in measured surface quality can be observed at a mean pressure of 50 MPa. The last evaluated graph is the mutual combination of material choice and the injection pressure dependence on the surface quality parameter Ra shown in Figure 12. Here we can see that for all materials the best surface quality was found at injection pressure of 20 MPa (in the case of ABS 25 MPa). Specifically for ABS, the smallest roughness was measured, namely 0.392 µm. With this material, however, paradoxically, there is a significant increase in roughness at an injection pressure of 50 MPa, where the roughness value in the given case is even the highest of all the data compared. Conversely, the smallest roughness of the 50 MPa pressure injection surface was measured in POM samples. From a comparison of materials at injection pressure of 80 MPa, it can be said that the best surface quality was achieved by injection of polypropylene.

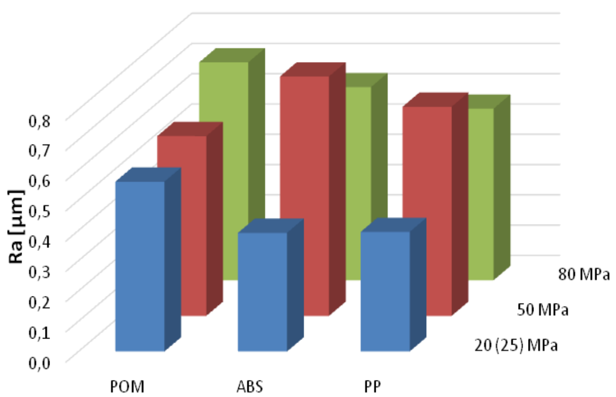


Fig. 12. The comparison of the dependence of injection pressure and the choice of the material on Ra at a plate Ra 0.8.

5 Conclusion

This article dealt with the issue of the replication the mold surface on the resulting product. Three types of removable plates with Ra 0.1, Ra 0.8 and Ra 1.6 roughness parameters were used to investigate this effect. Three materials were selected for the verification, namely ABS, POM and PP. Another change that was changed during the research was the injection pressure range from 20 MPa (25 MPa), 50 MPa and 80 MPa. All the observed results were found to show differences in the mold surface quality and the values measured on the products. The direct dependence of quality parameters between them, namely Ra, Rz and Rt, has also been confirmed. The influence of the injection pressure dependence only manifested itself in the POM material with an increasing trend. Other materials did not show any trend depending on injection pressure. From the above mentioned results it is also possible to assume that for all studied materials (ABS, POM, PP), the most suitable injection pressure was 50 MPa where the greatest consistency between the surface quality of the mold and the surface quality of the product occurred.

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