УНИВЕРЗИТЕТ У НИШУ
МАШИНСКИ ФАКУЛТЕТ
Катедра за производно-информационе
технологије и менаџмент
29. 01. 2014.

НАСТАВНО-НАУЧНОМ ВЕЋУ МАШИНСКОГ ФАКУЛТЕТА УНИВЕРЗИТЕТА У НИШУ

Предмет: Мишљење Катедре о научној заснованости теме магистарске тезе кандидата Саше Николића, бр. индекса 559/97 и предлог ментора.

Студент магистарских студија Саша Николић бр. индекса 559/97 дана 28. 11. 2013. године поднео је захтев за одобрење теме магистарске тезе под радним насловом „МОДЕЛИРАЊЕ ПРОЦЕСА ИЊЕКЦИОНОГ БРИЗГАЊА ПЛАСТИЧНИХ МАСА У ЗАТВОРЕНИМ АЛАТИМА“. На седници Катедре за производно-информационе технологије и менаџмент, одржаној 29. 01. 2014. године, извшена је промена радног наслова предложене теме магистарске тезе у „МОДЕЛИРАЊЕ ПРОЦЕСА ИЊЕКЦИОНОГ БРИЗГАЊА ПОЛИМЕРНИХ МАТЕРИЈАЛА“ и за ментора предложен др Саша Ранђеловић, ванр. проф. Машинског факултета у Нишу, ужа научна област: Производни системи и технологије.

В. Д. шефа Катедре за производно-информационе
технологије и менаџмент

др Драгољуб Лазаревић, ред. проф.

UNIVERZITET U NIŠU
MAŠINSKI FAKULTET

Pošto sam položio sve ispite predviđene programom magistarskih studija na Mašinskom fakultetu u Nišu podnosim

ZAHTEV

za odobrenje izrade magistarske teze pod naslovom :

MODELIRANjE PROCESA INjEKCIONOG BRIZGANjA PLASTIČNIH MASA U ZATVORENIM ALATIMA

(uža naučna oblast: proizvodni sistemi i tehnologije. FEM analiza procesa strujanja plstičnih masa. prerada plastičnih masa.)

Kao potencijalnog mentora predlažem dr Sašu Ranđelovića. vanrednog profesora.

Uz zahtev prilažem kratak prikaz predmeta istraživanja. primenjenih metoda i naučni cilj rada.

28.11.2013.
612-796/13

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559/97

Naslov teme:

MODELIRANJE PROCES INJEKCIONOG BRIZGANJA PLASTIČNIH MASA U ZATVORENIM ALATIMA

Predmet i cilj rada :

Današnji proizvodi predstavljaju sintezu i rezultat vrlo brzih i produktivnih tehnologija. Tržište neminovno smanjuje životni ciklus proizvoda tako da se traže tehnologije koje će takve zahteve realizovati na što kvalitetniji i jeftiniji način. Kastimizacija proizvoda dolazi do punog izražaja čime se ispunjavaju diversifikovani zahtevi potrošača koji danas mogu biti ispunjeni u potpunosti uz vrlo male troškove. Kao odgovor na postavljene zahteve u poslednjih dvadeset godina svedoci smo vrlo brzog razvoja tehnologija injekcionog brizganja. Svojim razvojem, pored jednostavnih, one su u prvi plan izbacile proizvode vrlo složenih geometrija napravljenih od novih materijala koji pokrivaju jedno sasvim novo područje tehnoloških zahteva.

Sve ove činjenice navode na zaključak da tehnologije injekcionog brizganja zahtevaju visok nivo znanja i iskustva. S jedne strane to su plastični materijali sa svojim mehaničkim, termodinamičkim i hemijskim karakteristikama na povišenim temperaturama, ali i konstruktivna rešenja alata kao direktna posledica zahtevane geometrije gotovog proizvoda. Model ovako opisanog procesa nimalo nije jednostavan jer njegova multidisciplinarnost navodi na zaključak da se radi o velikom broju parametara koje je potrebno zadati, pratiti i kontrolisati u vrlo kratkim vremenskim intervalima. Iskustva pokazuju da ovako složene tehnologije prati ne mali broj problema i grešaka za koje treba predvideti prava rešenja odnosno smanjiti rizik od njihovog nastajanja.

Metode koje se primenjuju :

Detaljna analiza procesa injekcionog brizganja i uticajnih parametara navodi na zaključak da je konstruktivno rešenje alata u najvećem broju slučajeva uslovljeno geometrijom, dimenzijama i zahtevanim kvalitetom gotovog dela. Raspored masa gotovog dela, njihova veličina i konfiguracija definišu šupljinu alata dok se naknadno dodaju ostali prateći elementi.

Injekciono presovanje plastomera je prvenstveno termodinamički proces. To znači da je pri analizi procesa neophodno sagledati sve tri veličine stanja iz p-V-T dijagrama: pritisak, temperature i specifičnu zapreminu. U toku brizganja bitno se menja temperatura plastomera, a sa njima i specifična zapremina i pritisak. Pod temperaturom se ne podrazumeva samo temperatura rastopa koja je p-V-T dijagramom funkcionalno povezana sa ostale dve veličine stanja, već i temperatura alata odnosno kalupne šupljine koja utiče na zapreminu u koju se ubrizgava plastomer.

Sasvim jednu novu dimenziju proces injekcionog brizganja dobija primenom numeričkih modela procesa. Metodom konačnih elemenata dobija se detaljna virtualana slika procesa u šupljini alata. Pruža se mogućnost praćenja ispune alata, analiza polja termodinamičkih veličina po zapremini plastomera kao i detaljna analiza alata.

Eksperimentalna analiza procesa na realizovanom modelu predstavlja verifikaciju projektovanih parametara na konkretnom primeru. Time se dobija prilika da se projektovani parametri provere, koriguju i potvrde u realnim uslovima.

Analiza mogućih grešaka na gotovom delu i predlog korektivnih aktivnosti samo su dobar način da se bilo koja tehnologija pa i ova dovedu na jednav viši nivo. Time se dobija prilika da se steknu nova iskustva i baza znanja upotpuni novim činjenicama i paramerima koji će biti od korisiti pri projektovanju bilo kog drugog proizvoda dobijenog ovom tehnologijom.

Veoma složeni i odgovorni proizvodi tehnologije injekcionog brizganja danas su toliko mnogo zastupljeni da nismo ni svesni gde su sve našli svoju primenu. Od vrlo zahtevnih proizvoda velikih gabarita (avio i autoindustrija), pa sve do mikrometarski preciznih komponenti najsavremenijih proizvoda (IT i bioinženjering). Njihova geometrija, cena i zahtevane osobine iziskuju izradu vrlo komplikovanih alata, a gotovo uvek se traže vrlo brza i što jeftinija tehnološka rešenja za koje ovakav pristup dokazano pruža najbolje rezultate.

Naučni doprinos :

U savremenoj visokoproduktivnoj proizvodnji procesi injekcionog brizganja su dosta zastupljeni tako da se radi o tehnologiji koja sve više postaje predmet istraživanja u mnogim naučnim radovima. Radi se o multidisciplinarnom pristupu koji nudi rešenja u oblasti projektovanja tehnologije i parametara procesa, konstrukcije alata za injekciono presovanje, FEM modeliranja strujanja plastičnih masa, praćenja i procesuiranja grešaka u procesu injekcionog brizganja, a sve sa ciljem da se generiše vrhunski proizvod.

Objavljeni radovi :

1. Saša Ranđelović, **Saša Nikolić**, Maldomir Milutinović, ANALYSIS OF INJECTION MOLDING IN THE DIE CAVITY WITH METAL INSERTS, 35. ICPE, 25-28. september, 2013, Kraljevo, Serbia

2. Saša Ranđelović, **Saša Nikolić**, Mladomir Milutinović, Analysis of thermodynamic parameters in the injection mold with metal inserts, 16th Symposium on Thermal Science and Engineering of Serbia, Sokobanja, October 22-25, 2013, Serbai

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University of Kragujevac,
Faculty of Mechanical and Civil Engineering Kraljevo

ANALYSIS OF INJECTION MOLDING IN THE DIE CAVITY WITH METAL INSERTS

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Abstract: *Injection molding of polypropylene technology when designing complex products has a broad representation. Inserting different metal elements in the cavity tools get more complex conditions fulfilled and melt flow near the contact surface. Constructive and technological solution tools directly causes variable field temperature and pressure variation within polypropylene continuum that is very difficult to be monitored and controlled. These problems lead to incomplete filling tools, poor quality parts almost as ultimately does not meet the initial requirements. The simulation models of these processes provide answers to many questions that can be solved very quickly on the basis of which the correction or a complete change of tools.*

Key words: *Injection molding, Tool, Temperature filed, Pressure filed.*

1. INTRODUCTION

New constructions of products and their individual constituent elements include a number of different materials and technologies. Often we find a combination of metal and plastic, metal and wood, metal and rubber products and so on. This gives products that meet the demands of the market with prices that are adapted to each customer. On the other hand, the designers and engineers of appropriate tools come in a situation where the combination of materials in the production process leads to various problems which must be solved specific methods that in the design phase. Simulation of flow in the phase polypropylene fill mold cavities with embedded metal elements is a challenge to obtain finished goods of satisfactory quality [1].

2. INJECTION MOLDING OF POLYPROPYLENE

Injection molding is a manufacturing process in which plastic material spews into usable products for the general purposes of the appropriate standard and acceptable performance. Each plastic material, depending on the species and type, can be correctly processed within a certain range of temperatures and pressures, which are key parameters for the processing of plastics. Melt temperature is the temperature at which the material changes from a solid state to a liquid, and then crystalline regions of material softens and begins the process flow. Generally, this occurs at temperatures in the range 120-350oC, the temperature is controlled by cylinder, nozzle temperature, the screw speed, back pressure and residence time [2]. About 70% of the heat needed to melt the plastic material is formed warming, the friction that occurs within the material. Therefore, it is difficult to measure the temperature of the melt and it can not be directly controlled by the thermostat on the control panel. The remaining 30% of the heat is obtained by means of electric heaters, which ensures the required temperature for the flow of plastic material.

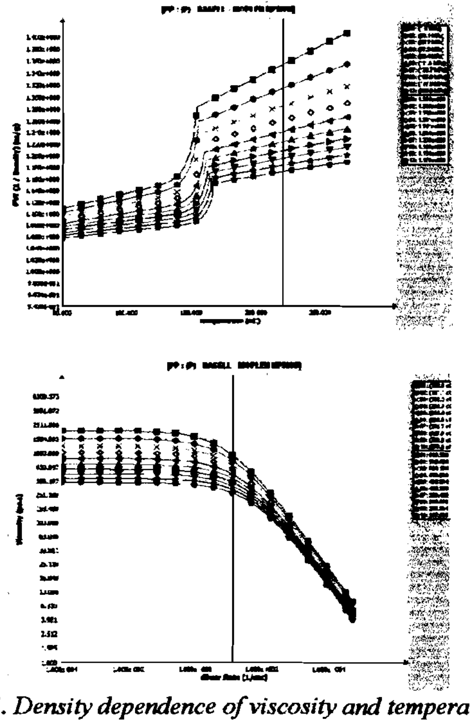


Fig. 1. Density dependence of viscosity and temperature of polypropylene

Thermal properties of the material are equally important for its processing and the characteristics of the finished part. Thermal properties of plastic materials are phase and relaxation transitions, thermal stability, heat capacity, and thermal conductivity. For practical application of this material, it is important to know the temperature of the softening temperature limit usability, as well as mechanical properties change depending on the temperature.

Thermodynamic properties of molten plastic material, such as viscosity, enthalpy and specific gravity, changing the temperature of the melt at the same time. It is therefore very important to maintain a constant temperature of the melt in the injection molding process, the melt because the temperature variations that there are some common mistakes at work, such as the short burning of short injections, poor surface appearance of bubbles visible flow lines, and so on. [2, 3].

The mold temperature is the one that is required to maintain the surface of the mold cavity at a temperature at which the cooling of the polymer melt and the transition to the solid state. Die temperature can range from 0 to 150oC and depend on the temperature of the coolant flow, distribution of cooling channels in the tool and the degree of heat plastic material. Heat transfer can be satisfying when it is a new tool, but decreases over time due to the effects of corrosion and the formation of deposits in the channels. The heat transfer from the plastic material varies, depending on the location and thickness of the part and the mold wall temperature is not identical, and thus the degree of cooling is not uniform. These problems can cause a variety of defects in molded parts. In many injection molding machine applies hydraulic pressure to suppress the screw relative to the molten material. The molten material is forced to the nozzle, distribution channels and pouring system fill the mold cavity, where it forms a compression molds. Depending on time, full melt and solidify in the mold cavity, but the pressure is not uniform throughout the molded part.

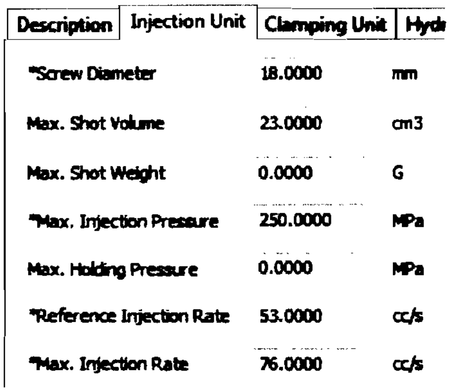
The highest pressure at the start of pouring system, and the lowest at the farthest point in the mold to be filled last. In order to provide compensation for the collection of materials, apply additional pressure which after filling mold cavity subsequently added material in the mold to fill the space that occurs due to shrinkage caused by cooling pallet material. At the same time, to reduce shrinkage in the mold, the pressure is reduced to a minimum, which provides additional flow, to reduce the possibility of errors in the finished part.

3. FEATURES TOOLS AND PROCESS PARAMETERS

Process analysis of complex molding elements made on the types of tools pneumatic hose ø10 polypropylene with a metal insert.

Fig 2. Finished complex elements with different connection size

For the simulation of the model of injection molding presses, injection molding manufacturer ARBURG, Allrounder A 270 A 350 - 70 (D18). More performance parts for injection molding and mold closing date at the following picture:



*Screw Diameter	18.0000	mm
Max. Shot Volume	23.0000	cm3
Max. Shot Weight	0.0000	G
*Max. Injection Pressure	250.0000	MPa
Max. Holding Pressure	0.0000	MPa
*Reference Injection Rate	53.0000	cc/s
*Max. Injection Rate	76.0000	cc/s

Fig. 3. Characteristics of the virtual model presses for injection molding

Design of the tool is derived from the four forms that provide an acceptable level of productivity. At the beginning of each cycle molding tool is inserted into the metal inserts that are watered polypropylene. Dimensions of form tools are linearly increased in all directions in relation to the finished part of the 2% or the percentage of shrinkage polypropylene process parameters: charging time tools 0,16sec, melting temperature 226°C, the temperature of 34°C.

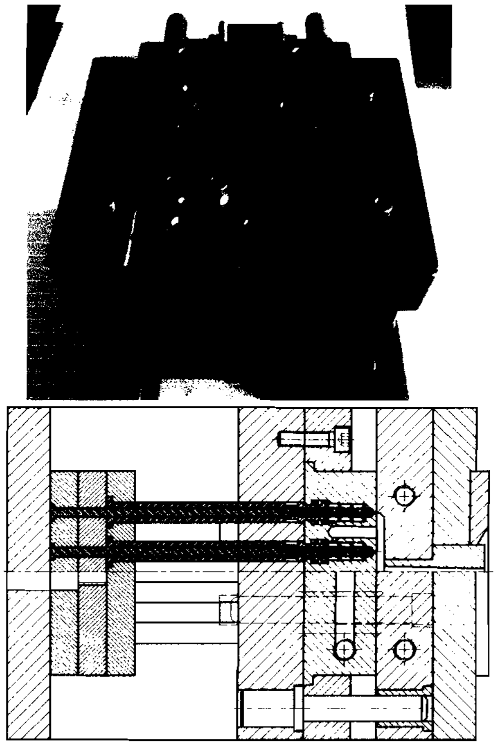


Fig.4. Layout tools and typical cross-section of tools for injection

The inlet system consists Column tapered channel that forms the fueling nozzle, fueling major branches that form a channel in the working plate fixed half of the tool, two distribution channels are formed in the slider and ulivci derived in a place that does not disturb the aesthetic appearance of part and its function.

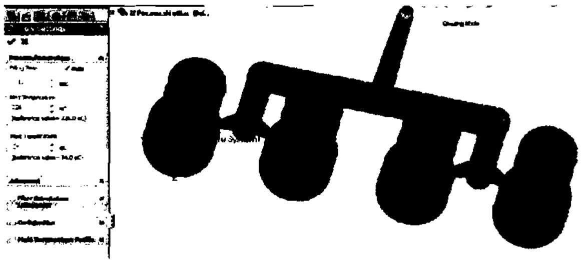


Fig.5. 3D virtual models of finished elements to the input characteristics of the process

4. SIMULATION RESULTS OF THE INJECTION MOLDING

In the described virtual model can monitor different parameters that greatly give a good picture of the process. One of the phenomena that occurs during injection of these elements is the appearance of uneven thickness of the finished parts, tools or incomplete filling of surfaces and areas where the volume is changing cross section (Fig. 6). Directly associated with this parameter is the time filling mold cavity, and part of the first volume of tools and where it comes to a halt. This gives opportunity to remove the virtual model of congestion and small cross-sections melt flow polypropylene to get an even fill throughout the volume [4, 5].

Fig.6. 3D model of change achieved thickness and time the fill tool

Critical locations in a tool which can cause delays of air are potential points that can disrupt the structure of the finished part. This kind of place it is necessary to eliminate completely resulting in a satisfactory quality of a finished part. The lines connecting the molten polypropylene are also a necessity for this type of technology. Their prediction, reducing their length and eliminating the causes smooth filling and avoiding possible defects in the structure of the finished work [6]. Therefore, a simulation model selected ten of the characteristic points of the filler system and the mold cavity (Figure 7) to the results of change of temperature and pressure melt may indicate possible errors in the phase of design tools for injection molding.

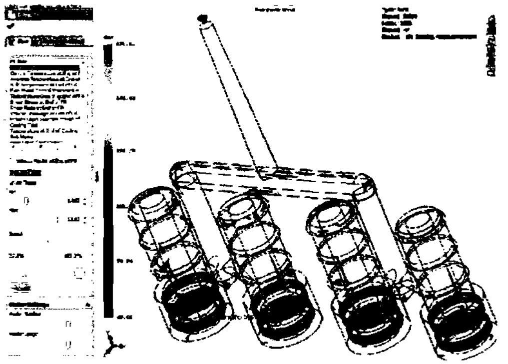


Fig.7. Analysis of the 3D model of merger lines and the potential place of residual air.

Temperature field at the end of filling the mold is very important parameter that can be used to explain many of the tool and its contact surfaces with plastics. This field can be monitored at any time, but a moment of complete filling tools play a crucial role in the characteristics and quality of the finished part. It indicates a possible tool breakage, thermal expansion and deformation caused by inaccuracies of the finished part.

Fig.8. Flow temperature of the melt at the end of injection and just before the ejection of molded part from the mold cavity

Temperature field at the end of the cooling process gives us a picture of residual temperature stresses which can cause poor joint quality injected polypropylene metal insert. In fact at that point there should be a strong enough connection to guarantee the functionality and use of the finished part. The most common problem that occurs is that the sealing compound in place of polypropylene and metal insert is not good or that it is the site reduced elasticity of such a compound. In these cases, small stresses during operation leads to cracking, separation and separation of two different materials.

5. CONCLUSION

The presented analysis shows that the temperature and pressure of injection molding the most important parameters to be monitored and controlled. The chosen material simulation model PP BASSEL / moplene HP500N molded part ejection temperature of the tool is 99°C, and the result of simulation shows that the injection molded parts are cool to the tool during cooling of 8.23 seconds, the temperature of 226°C, the temperature below 80°C, which is quite satisfactory result. At the end of the injection mold cavity, more than 80% of the volume has the same temperature of 226°C, as the temperature of the melt at the start of injection. As for the rest, about 15% have only 1°C lower temperature than the majority 80%, while the remaining 5% in scattered areas has a lower temperature in less than 3°C which is an excellent result. Air inlet branch at the end of injection molding process remains high above 99°C which is not a real solution that can be the subject of further research.

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Analysis of thermodynamic parameters in the injection mold with metal inserts

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Abstract: The process of injection molding today is the widespread industrial technology market throws an increasing number of finished products. Although the process depends on a lot of the large number of technological parameters is necessary to continuously monitor key thermodynamic quantities, such as temperature, pressure, speed, melt etc. that have a decisive influence to the quality of the finished part and the productivity of the entire process. On the example of molding complex parts for wide use to analyze the parameters of the process.

Keywords: Injection molding, Temperature filed, Pressure filed.

1. Introduction

Injection molding of thermoplastics is principally a thermodynamic process and then the rheology. This means that the analysis process is necessary to consider all three sizes of state p-V-T diagram: pressure, temperature and specific volume. During the injection process a considerable change in field temperature of thermoplastics, and with them the specific volume and pressure. Under temperature is not just about the melt temperature of the p-V-T diagram functionally related to the size of the other two conditions, but the temperature of tool and mold cavity which affects the volume of which is injected polymer melts.

2. Thermodynamic properties of injection molding process

Injection molding is a industrial process in which molten polymer material inject into usable products for the general purposes of the appropriate standard and acceptable performance. Each polymer material, depending on the kind and type, can be correctly processed within a certain range of temperatures and pressures, which are key parameters for the processing of plastics. Melt temperature is the temperature at which the material changes from a solid state to a liquid, and then crystalline regions of material soften and begins the process flow. On the basis of differential approximation and physical models, there are different mathematical models for the process of injection molding [1]. Basic equations in differential form describing the changing field of physical quantities are:

Continuity Equation:

$$\nabla \cdot u = 0 \qquad (1)$$

Momentum Equation:

$$\rho \frac{du}{dt} = -\nabla p + \nabla(2\eta\dot{\gamma}) + \rho g \qquad (2)$$

Energy Equation:

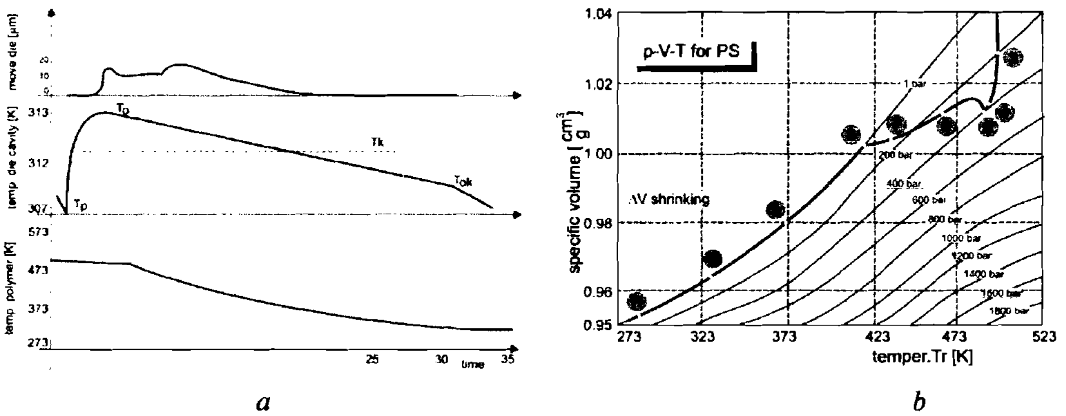
$$\rho C_p\left(\frac{\partial T}{\partial t} + u \cdot \nabla T\right) = \nabla \cdot (k\nabla T) + 2\eta\dot{\gamma}\dot{\gamma} \qquad (3)$$

where:

u – velocity vector [mm/s]
ρ – density [kg m^{-3}]
p – pressure [Pa]
η - non-Newton viscosity [Pa s]
$\dot{\gamma}$ - strain rate tensor
g – body force vector
C_p – specific heat
T - temperature [K]
k – thermal conductivity [W·K^{-1}·m^{-2}]

3. Analysis of injection molding process with metal inserts

A comparative injection molding process diagram (Fig. 1). shows the change of pressure, temperature, and "breathing" mold (allowed to open the tool due to rising pressure) over time. The diagram is made on the basis of several measurements in one working cycle molding. On the basis of it can be explained by the thermodynamic processes that directly affect quality molded part, which is more or less applicable to a variety of materials, shapes and dimensions of molded parts [2].



a *b*

Figure 1. Comparative diagrams of changes in process parameters of injection molding

Complete thermodynamic process in the mold cavity can at the same time monitor both the comparative chart and the p-V-T diagram (Fig. 1b) where can see the change of specific volume with respect to temperature by the melt. The route of the injection illustrated on the diagram that shows the flow and pressure changes. At the same time they can meet the changes the injection pressure, the pressure in the nozzle and in the mold cavity during an injection cycle.

Injection process starts at point 1(Figure 2). It may take time from point 1 to point 2, which corresponds to the distance traveled polymer melts to the mold cavity. From point 2 to 3 is free volumetric filling mold cavity. When completely filled mold cavity (point 3) begins compression polymer melts between die plate in the cavity to the point 4 where is the highest pressure of the melt. The pressure in the mold cavity is growth to the point 5, when the injection machine switches to lower extra pressure. From that point on falling pressure in the mold cavity to the point 6 which reaches the value of the injection pressure. The pressure in the mold cavity decreases although when exposed to any pressure. Working pressure after reach 6 points up to a point 7 where there is a "sealing" the mouth when it is not possible to add the polymer melt in the mold. From point 7 to point 8 pressure decreases due to cooling.

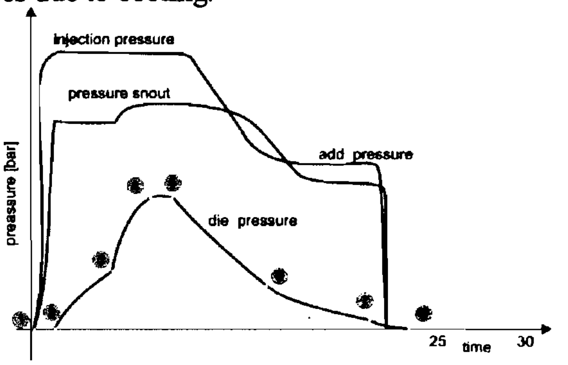


Figure 2. The change of pressure in the injection molding cycle time function.

At point 8 has reached atmospheric pressure when the workpiece apart from the mold cavity and begins its shrinking. It is not yet time to workpiece removed from the mold cavity. At point 9 is a hardening of the measurement point, and the suppression of the workpiece mold cavities occur only in item 10. Cooling of the workpiece from point 8 to point 11 is isobaric.

For more accurate control and monitoring of injection molding process of measuring the real tool should be as large as possible. In the case of complex elements with metal inserts task is even more difficult because the flow of polymer near metal surfaces depends on the characteristics of the loaded part. Geometry and quality of the metal surface, its temperature, the minimum and maximum wall thickness are the parameters that should be very much taken into account [1,2,3].

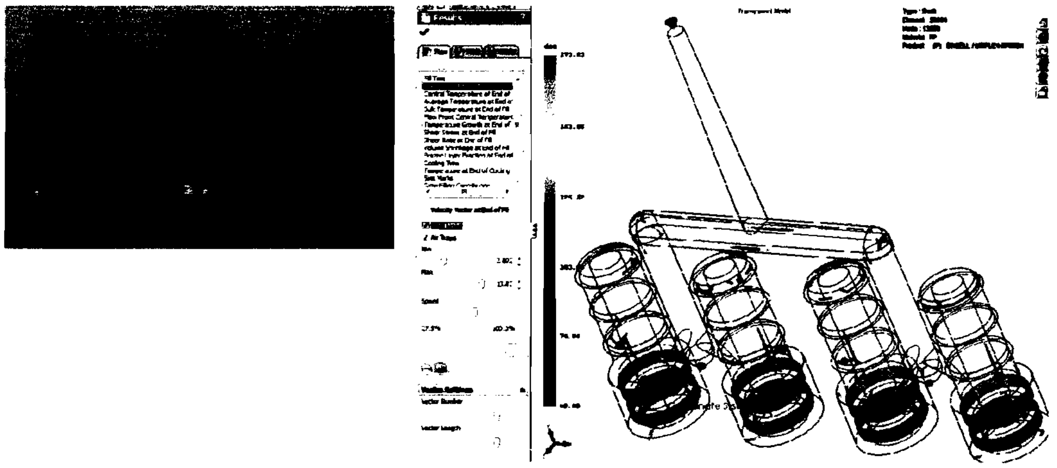


Figure 3. Finished part and FEM analysis of 3D models

This, in turn, limited the finished part geometry, tool designs and the machine so that a large part of the parameters taken from the assumption and experience. Operating pressure and temperature are the main parameters to be monitored on a larger number of measuring points in order to obtain the true picture of the size of the field changes within the mold cavity. Consequently, in a simulation model selected ten of the characteristic points in volume of finished elements, or the mold cavity (Fig. 3) to the results of change of temperature and pressure melt may indicate possible errors in the phase of design tools for injection molding.

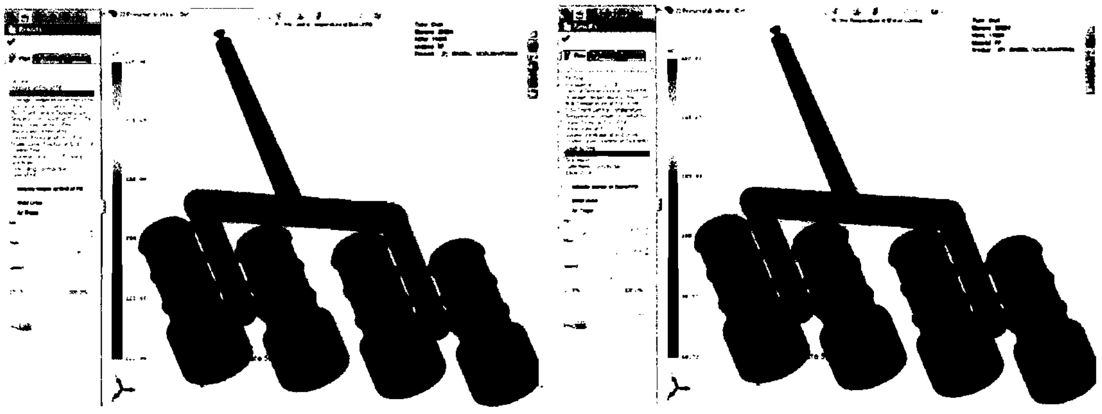


Figure 4. Flow temperature of the melt at the end of injection and just before the ejection of molded part from the mold cavity

In order to achieve a satisfactory quality of workpiece (surface appearance, material structure, mechanical properties, dimensional stability) additional condition is optimal process injection molding to the minimum amount of time, material and energy has been a feature for efficient use of materials that are processed. Therefore, the simulation model and analyze the most influential in the system size injection molding: mold cavity temperature, the pressure in the mold cavity, the melt temperature thermoplastics and injection speed.

Temperature mold cavity can be defined as the arithmetic mean temperature and the temperature touches upon the opening of the mold, as the temperature of a unique mold can not speak. The contact temperature is the highest temperature in the mold cavity, which is formed immediately after the injection of thermoplastics. Mold cavity temperature dependent thermal properties of the polymer melt, size and arrangement of channels for temper of the mold, it is also a dynamic function of the melt temperature, ambient temperature, temperature and velocity of the fluid cooler and residence time in the mold of the workpiece (workpiece cooling) [4].

The cooling rate is defined by the temperature difference between the melt and thermoplastic molding cavities per unit time. If you require a high crystality and good mechanical properties of the workpiece, then the cooling rate must be low, and vice versa can be applied high-speed cooling. In practice, to seek a compromise between quality and productivity.

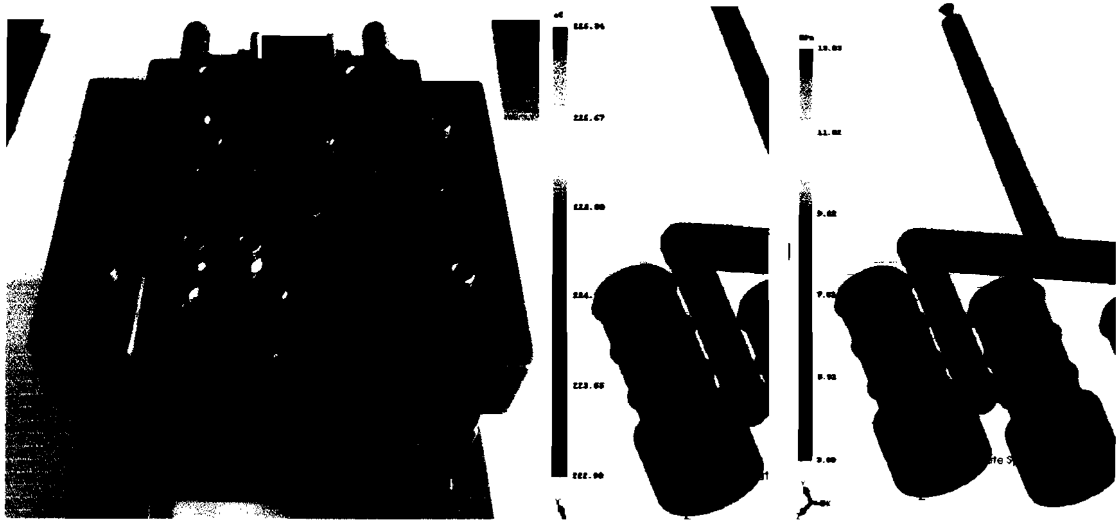


Figure 5. Upper tool and distribution of temperatures and pressures obtained by FEM analysis

The chosen material in the simulation model PP BASSEL / moplene HP500N molded part ejection temperature of the tool is 99°C, and the result of simulation shows that the workpiec are cooling to the tool during cooling of 8.23 seconds, the temperature 226°C, a temperature below 80°C, a very satisfactory result.

Constant temperature of the melt is a requirement for quality molded part. Temperature changes cause changes in the polymer melt, and all other thermodynamic properties: viscosity, specific volume, flow pressure, as well as mechanical and physical relationship workpiece and so on. Leading to changes in the cooling time, injection pressure and subsequent pressure. Lower temperatures polymer melts requires a higher injection pressure, higher speed and longer injection interval [5,6].

The result injection simulation (Fig. 5) shows that at the end of the injection temperature sufficient to melt and there is not much variation in temperatures melt in the mold cavity. At the end of the injection mold cavity, more than 80% of the volume has the same temperature of 226°C, what is the temperature of the polymer melts at the start of injection. As for the rest, about 15% have only 1°C lower temperature than the majority 80%, while the remaining 5% in scattered areas has a lower temperature in less than 3°C which is an excellent result. Temperature of sprue branch at the end of injection molding process remains high which is not a perfect solution, and it is necessary to reduce its volume to the amount of residual melt as small as possible in that area.

Injection speed is the speed at which the feed screw injection moving forward which polymer melt is injected into the mold. The higher speed of injection affects the speed of filling mold cavity of which is directly dependent on the quality of the workpiece. Simulation of injection molding, for selected parameters of process and characteristics of the machine, was obtained during injection of 0.16 seconds, which is considered very high speed. If there is a periodic injection should be injected slowly at first, then fast forward to the end of the injection phase again slowed. Since the selected machine has the possibility of periodic adjustments injection rate should seek constant speed of injection. It provides a consistent resistance during injection of the polymer melt into the mold of what designer can affect the shape, mold cavity geometry, types, dimensions and location of pouring system. Checking the uniformity of injection can be seen analyzing the distribution of the melt pressure in the mold cavity during injection (Fig. 5).

The pressure change in the mold cavity of the injection phase is defined by the speed of injection, the temperature and the properties of polymer melts and temperature mold cavity. In the subsequent phase of pressure, influence the size of the pressure in the hydraulic system, the duration of the subsequent pressure, temperature of polymer melts and temperature mold cavity. Correct flow pressure in the mold cavity to create the workpiece without overflowing the contour workpiece, reducing scrap, good filling of mold cavities, tighter tolerances and less workpiece injection molding cycle. At the stage of molding the pressure in the hydraulic system sets the maximum value of the injection molding that would not have a speed limit of injection. In contrast, the pressure in the system at the effect of subsequent pressure directly affects the course of melt pressure in the mold cavity, and thus the quality of the workpiece [5,6]. The timing of subsequent pressure should be chosen so that its completion will coincide with the moment of action "sealing" inflow when polymer inflow hardens in place so that prevents the further addition of the polymer melts in the mold.

4. Conclusion

The presented analysis shows that the pressure, temperature and speed of injection of injection molding process the most important parameters to be monitored and controlled. The chosen material FEM simulation model for PP BASSEL / moplene HP500N can be detected critical areas that potentially obstacles to obtaining satisfactory quality of a finished part.

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