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ANALYZE OF THERMOPLASTIC FLOWING IN PRODUCT FOR AUTOMOBILE INDUSTRY BY PLASTIC ADVISER.

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ABSTRACT
Paper deals with analyze of thermoplastic flowing in product which is using in automobile industry made by injection molding. Analyze was made by software Plastic adviser which is used for determination of flow properties of thermoplastic materials. Knowledge of flow properties of thermoplastic materials give us a good starting position for design of thermoplastics products which will be made by injection molding. Task of this simulation was review location change of injection channels into injection mould by injection molding. Simulated thermoplastic material is using for made of light cover in automobile.
Keywords: thermoplastic, simulation, injection molding

1. SIMULATION OF INJECTION MOLDING
We know predicting with safe expectation results of all technological processes in mechanical production in many cases. It was using simulation approaches and simulation models in cases that by influence of some values is not possible to assemble stable mathematical model that structure will be the same with structure of technological process and which will be absorb all of the definitive impacts. Technological process simulation provides realization of experiments without real intervention to the operation.

Simulation process consists of theses stages:
- specification of knowledge object (determination of project requirements),
- specification of simulation system on observed object,
- creating of actual vision about simulated system and its movement,
- creating of simulation model,
- verification of simulation model accuracy,
- verification of simulation model verity,
- using of verified simulation model in knowledge process [1]

2. MATERIAL OF SELECTED THERMOPLASTIC PRODUCT
Material is low-viscous, easy formability polycarbonate (PC) MAKROLON 1260, amorphous thermoplastic, medium solid (E = 2000-2200 MPa) with advanced strength (Re = 55-60 MPa). Permanent thermal stability it up to 100 °C, deflection temperature under load is up to 135-140 °C. It has very good electro-insulating properties. PC is very hard inflammable and it fires very slowly. It has lower resistance against the UV radiation and atmospheric conditions effect. It is chemically resistant against to the soft acids, petrol’s, oils. It doesn’t resistant to alkalis, majority of solvents and hot water. It has difficult workability considering lower fluidity and diathermy liability and consecutive degradation. Melt flow rate index is mentioned by temperature 300 °C.

3. PRODUCT ANALYSE BY PRO/E PLASTIC ADVISOR

By simulation software Plastic Advisor 7.0, which is part of CAD/CAM system Pro/Engineer Wildfire 3.0 we can make analyze of modeled parts. Designer can find by means of simulation optimum gate location, choose material of part and to observe behavior of existing material. He can to observe by different production temperatures creating of some sinks or if is possible to begin some empty places.

3.1. Analýza času plnenia formy

Analyze of fill time simulate us filling of mold cavity and we can determine how much time is needed for this filling. Figure 1 shows model of simulated parts with simulation of fill time.

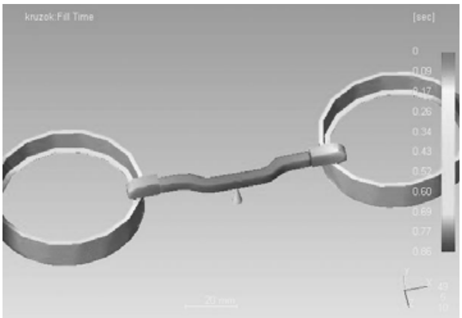

Figure 1. Simulation of fill time.

Fill time is depending on injection speed that from speed of screw movement which is depending on technological parameters especially on melting temperature T_{tav} = 300 °C and on injection pressure p = 50,72 MPa. At the beginning of filling the melting speed has not arrive high values that not rise into part high orientation of macromolecules and high interior stress. It means that it has been continuous accumulation. Fill time is range from a split second to a few seconds. It should be full sail that injected melt by contact with cooling mold are cooled and decrease of fluidity. Flowing starts in gate place and finish in part marginal. Mold is fully filled in time t = 0,86 sec. which is represent on figure 1. Mold temperature is much lower than melt temperature what means the melt by contact with mold surface stiffen immediately and it makes layer of stationary solid. Mold filling is attached by quick change of pressure, temperature and melt viscosity. These changes are higher with complex form.

3.2. Analyze of injection pressure

Melt is injected into mold cavity by pressure 50,72 MPa. This optimum pressure depending on melt temperature T_{tav} = 300 °C, especially on its viscosity, on the length of melt flowing, on wall thickness and on part segmentation. Pressure value is affected by mold temperature in range from 70 °C to 120 °C. Total filing of mold cavity have to realize equally quickly that we have to prevent from quickly cooling and early solidification.

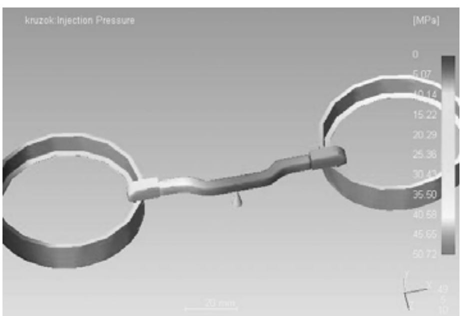

Figure 2. Simulation of injection pressure.

Figure 2 shows course of injection pressure. The highest injection pressure is in gate location 50,72 MPa, and it is diminishing gradually in direction of melt flowing.
On the end of filling is needed to change injection pressure to pressure drop. It could be to arrive for unfilled part by low pressure.

3.3. Analyze of freeze time

Solidification is begins in moment of melt freeze into the down runner. Down runner connecting mold cavities with cavity of melting chamber and if the melt into the runner is in liquid state screw can in pressure drop stage influenced pressure conditions in mold cavity. Connection between molten chamber and mold cavity is aborted in time of melt is solidified. Freeze time is representing on figure 3. Freeze time is depending on cooling time and pressure drop in mold cavity.

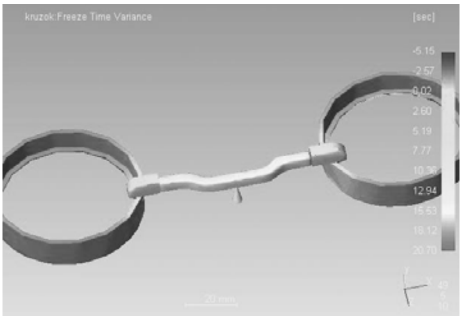

Figure 3. Simulation of freeze time.

3.4. Analyze of air traps

Air traps are closed blown spaces into the part wall. It could be rise in place with bigger wall thickness. Cooling melt solidifies with mold face in contact area and makes compact cover. During next solidify it can be shrinkage in the direction of external shell. In the end material is dehiscence in middle plane and it makes cavity. Till the molten plastic filling mold cavity air situated into the mold is pressed. Air traps pressure in mount up while it raise air impress through the air runner. High pressure of air trap could be making scrap, small weld or small black part splashes.

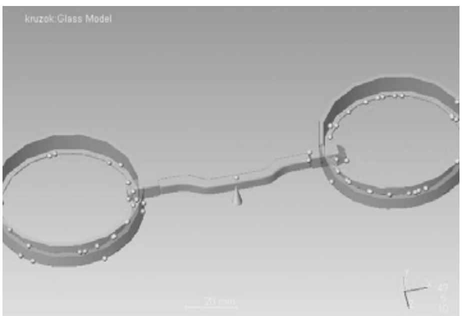

Figure 4. Simulation of air traps.

Air traps showed on figure 4 define where the flows are finished or where the welding lines are making. First are in places where the flow is separated that fill part with melt. Next are situated on part radius and the last are where the welding line is making. Based on this analyze designer know specify where is needed to place air runners.

3.5. Analyze of skin orientation

Skin orientation (Fig. 5) showing us by which direction will be melted material flowing in mold cavity that we determine if this direction is correct. Material is flowing from sprue through the mold cavity and it is stopped when the both flows are connected. We can see this also on animation of fill time. If the material has no correct skin orientation it could be conduce to make a scrap. Skin orientation is depending on injection pressure and injection speed and also on temperature of molten material.

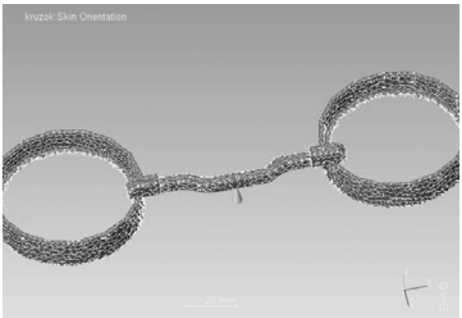

Figure 5. Simulation of skin orientation.

4. CONCLUSION

Software choose optional sprue location, determined model filling depending on time, also determined place of welding lines, air traps, observed temperature course in time of mold filling and also observed cooling quality. Software consequently makes analyze which is needed for evaluation of technological conditions quality and for comparison with parameters received from production. We determined by this analyze that it could be arrive to problems with quality and in special cases also for make a scrap. We determined that the most reason is injection pressure and cooling quality. Therefore we had to increased injection pressure what raise up increase of other parameters which are in interaction with this parameter especially pressure drop. After the increase of injection pressure molten material filled up the whole mold cavity, flowed equally into the mold cavity. Also it was shorten cooling time. Next it was needed to correct volume of injection molten mass. After the volume mass increase it was lengthens total injection cycle about few seconds. Therefore simulation has big contribution for using injection molding operation that it brings decrease in costs, loss of time for development of new product and increase of reliability, safety and ecological parameters and also increase of production effective.

5. REFERENCES

[1] Baron, P., Novák-Marcinčin, J.: Počítačová simulácia činnosti bionických výrobných systémov. Nové smery vo výrobných technológiách, FVT, Prešov, 2000.,
[2] Běhálek, L.: Heat-pipe and high-conductivity materials in cooling system of injection mould. Strojírenská technologie, UJEP Ústí nad Labem, 2008.,
[3] Běhálek, L., Lenfeld, P., Ausperger, A.: Bewertung der Effektivität von Temperiersystemen in Spritzgiesswerkzeug bei der Gasinjektionstechnik, Technomer 2003, Chemnitz, 2003.,
[4] Daneshjo, N.: Modelovanie a simulácia, Strojárstvo, 2003.,
[5] Dobránsky, J., Fabian, S.: Simulation of using injection channels by injection molding. Annals of DAAAM for 2007 & proceedings of the 18th International DAAAM Symposium : Intelligent Manufacturing & Automation: Focus on Creativity, Responsibility, and Ethics of Engineers, Zadar, Croatia, 2007.,
[6] Nováková, J., Brychta, J., Čep, R., Očenášová, L.: Formulated Axioms and Laws of Creatics for Practice. ERIN, periodic of Slovak University of Technology in Bratislava, 2008.,
[7] Svetlík, J.: CAD/CAM system in real conditions. Trendy v systémoch riadenia podnikov: 10. medzinárodná vedecká konferencia, Vysoké Tatry - Štrbské Pleso, 2007.
[8] Stejskal, T.: Modely vzniku porúch vo výrobných a robotických systémoch. Acta Mechanica Slovaca. 2008.
[9] Saloky, T., Vojtko, I.: Simulation of discreet neuron with prediction. Acta Mechanica Slovaca. 1997.