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PLASTIC PART DEVELOPMENT USING ADVANCED TECHNOLOGIES AND TOOLS

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ABSTRACT
This paper aims to show possibilities of usage of technological and mechanic analyses for GIT injecting of plastic parts and for plastic parts overmoulding in the stage of designing the part as well as in the stage of tool construction. We use a design of an office chair arm-rest as an example. The example shows not only advanced injection technologies but also the FEM analyses integration in each step of design and tools development.
Keywords: injection molding, design, mechanical analysis, injection analysis, polypropylene

1. INTRODUCTION
Polymer injecting is a flexible production method for production of thin-wall plastic parts. Injecting enables to produce complex geometry of a part in an automatic cycle with low energy consumption and in a short-term cycle. Complex geometry means not only production of individual parts but also joining several parts in one unit. In this way we can minimise assembly costs and also minimise faults arisen in assembly at the same time. Polymer injecting includes a whole range of technological variants that enable production of plastic parts injected from several types of polymers with different properties, combination of polymer with metal parts or inorganic materials. No finishing operations and automatic production cycle or in some case assembly with maximum usage of automatization and robot usage are the main requests for a polymer injection method. To fulfil these main requests it is necessary to prioritize modern tools enabling a complex analysis of the plastic part itself as well as an analysis of the production process.
This paper aims to show possibilities of usage of technological and mechanic analyses for GIT injecting of plastic parts and for plastic parts overmoulding in the stage of designing the part as well as in the stage of tool construction. We use a design of an office chair arm-rest as an example.

2. AN OFFICE CHAIR ARM-REST DESIGN
When designing the office chair arm-rest we used an existing design consisting of two parts: a bracket for fastening the arm-rest to the frame of the chair and of the arm-rest itself. The bracket is made of tin 4 mm thick, 60 mm wide and 200 mm long. The bracket and the chair are joined with 2 screws and the arm-rest is also joined with 2 screws. The arm-rest is in direct contact with an arm and also forms an aesthetic aspect of the chair. it is made of PP with usage of GIT technology. The arm-rest's height is 270 mm, length is 300 mm and the diameter of the profile part is from 30 to 45 mm. At the bottom side there are two metal inserts with inner thread for joining the bracket overmoulded (Fig. 1)
A new design of the arm-rest replaces the tin bracket with a plastic injected part. Then the arm-rest is injected directly on the plastic bracket. The arm-rest will be injected by GIT method and it will fulfil all requirements for rigidity of the product. We suppose that all loads will affect the bracket. (Fig. 1)
Polypropylene Niplene PP HD120M will be used for the arm-rest injection and PP Niplene F 30 AGR filled with 30% glass fibre will be used for the bracket injection.

Figure 1: Original and new design of the office chair arm-rest injected with polypropylene

3. MECHANICAL ANALYSIS OF THE PART

Mechanical analysis was done for static stress in temperature up to 60°C within elastic deformation for three types of load from 500N to 1000N. The joint of the bracket and the chair frame by screws was replaced by a constrain taking 6 degrees of freedom away. (Fig. 2)

In the bracket design the dimensions of the part with minimum amount of material used are the key factors. There were made many versions of the design. It was very difficult to make the design so that it fulfils the technical specifications. Table 1 gives mechanic properties of the used polymers upon Moldflow MPI 5.1 database. Mechanic analysis was done with Cosmos Design Star 3.1 [2,3]

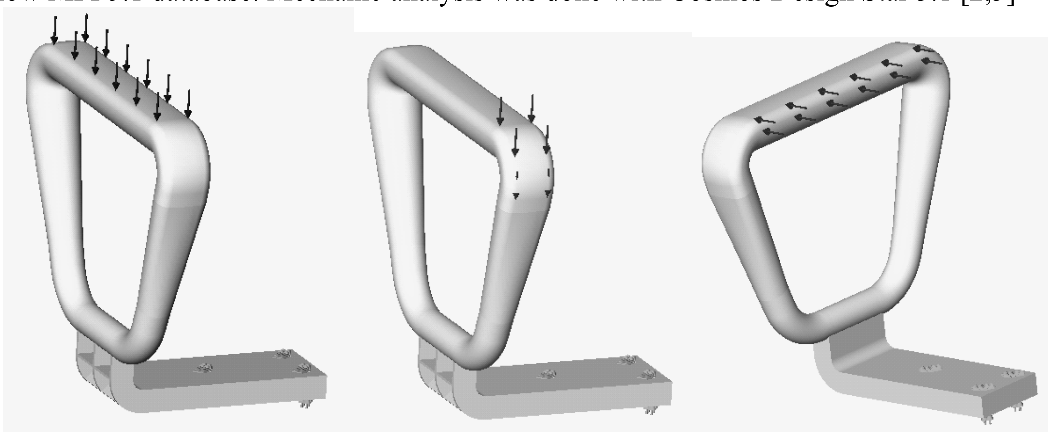

Figure 2: Calculated load of the arm-rest of 1000N, 1000N, 500N in the order of the figures

Table 1: Mechanic properties of the polymers used

Polymer	**PP HD 120M**	**PP Niplene F 30 AGR**
Elastic Modulus E [MPa]	1340	5188
Shear Moodulus G [MPa]	481	1225
Poisson Ratio ν [1]	0,392	0,437
Tensile Strenght σ_P[MPa]	35	100

4. ANALYSIS OF THE BRACKET INJECTION

Moldflow MPI 5.1 solver was used for the analysis of the bracket. A hot runner is designed for the bracket mould. The runner of the hot gate has diameter of 6 mm and length of 82 mm. The hot runner gets narrower from diameter of 6 mm to diameter of 3.5 mm it is 6 mm long.

It follows from the results of the analysis that the period of mould cavity filling is 2.266 s, minimum pressure in the mould cavity is 48.33 MPa and necessary clamping force of the injection machine is 698 kN.

5. ANALYSIS OF THE ARM-REST GIT INJECTION

It is necessary to use the GIT method for injection of the arm-rest to reach the perfect quality of the arm-rest surface which is usually covered with leather face texture. This technology can have different options of gas injecting. We considered two options of gas injecting which are gas injection into the mould cavity and injection into the runner. The inlet for the gas injection must be located in a place where it will not be visible and where in would not be in direct contact with an arm. Such place is on the bottom side of the upper part of the arm-rest. The option of gas injection into the mould cavity is not convenient as the gas jet would have to go out of the injected part before the injected part ejection. We will use the option of gas injection into the runner for easier moulding of the injected part.

The process of gas injection into the runner is following: first the mould cavity is filled with the melt and then gas is injected. A hydraulic element must be placed between the gas inlet and the gate for the plastic. This element will close the runner after filling with melted polymer. Then gas injection can start. The runner into the runner system is closed for gas, therefore gas is forced to continue into the mould cavity. The runner system for the arm-rest is a combination of a hot runner and a cold runner. To make things clearer only the part of the model with the cold runner was analysed. (Fig. 3)

It was necessary to set the amount of injected polymer and the value of injected gas pressure for the analysis of the are-rest. The amount of the injected polymer was set from 65 to 75 % of the total volume of the injected part and the value of injected gas pressure from 8 to 16 MPa. In production of the arm-rest we will need a cavity to be made in 2/3 at the upper part. Chosen options and results of clamping forces are stated in the table 2.

Table 2: Cavity filling with the polymer melt and gas

Gas Pressure [MPa]	8	9	10	11	12	16
Gas volumetric ratio [%]	65	65	70	70	73	75
Clamping Force [kN]	228	257	286	315	343	457

The most advantageous option in which gas filled all places where needed is option 3. In this option polymer fills the cavity up to 70 % and then gas is injected under pressure of 11 MPa. Fig. 4 of the section through of the hand-piece shows the temperature field in the arm-rest injected part after filling of the mould cavity.

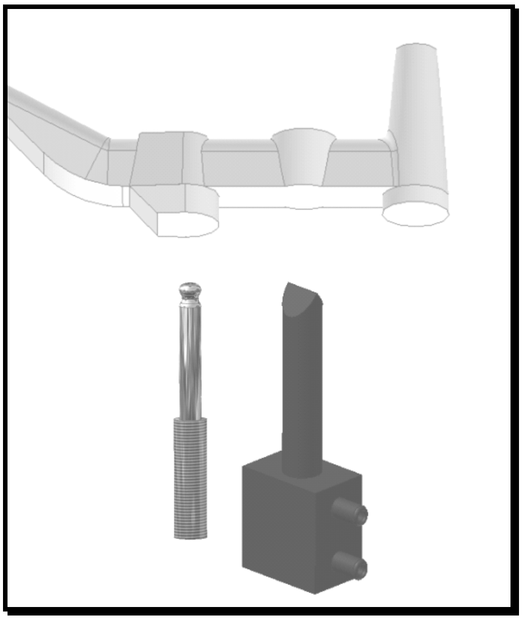

Figure 3: The runner with the gas inlet and the hydraulic element

Figure 4: Cavity made by gas in 33rd second of the injection cycle and temperature field in the part

What is important is the temperature on the surface of the bracket injected part inserted into the mould cavity before injecting. This temperature is from 160 to 200 °C. (Fig. 4) Presumably the bracket surface layer of PP will be melted and both polymers will be joined as well as the arm-rest polymer will be fixed into fibre filling in a way similar to Velcro fastener.

6. CONCLUSION

A new design of an office chair arm-rest was made so that assembly of the arm-rest with a bracket could be omitted. The bracket is joined with the arm-rest directly in form of the bracket overmoulding with the arm-rest material which leads to the labour force and production cost saving. The arm-rest is injected with GIT technology.

Mechanic and technological analyses were done with COSMOS/Design STAR 3.1 and Moldflow MPI 5.1 software. Analyses results were used in the arm-rest design and in mould construction. The technological analysis of the hand-piece was simulated with GIT method. The results achieved in the technological analysis can be used in production.

Design of the bracket injection mould was designed and then mechanic analysis of the mould was done. It follows from the analysis results that the frame of the injection mould must be changed. Then construction of the hand-piece injection mould was designed with GIT method.

The design and analysis of the injection mould is not included in this paper because of its extent, however, it is included in its presentation.

7. REFERENCES

[1] Osswald, T. A, at al: Injection Molding Handbook, Carl Hans Verlag, Munich 2002

[2] Halaška, P. Maňas, M. Sýkorová, L.: Using Moldflow, Mechanical and Thermal FEM Analyses for Injection Mold Design. In: *MicroCAD 2002 International Scientific Conference*, p. 43-47, University of Miskolc, Hungary, ISBN 9636615152

[3] Halaška, P. Maňas, M. Sýkorová, L. Mircena, P.: Moldflow and Mechanical Design Analses in Multicomponent Injection Molding. *Annuals of Oradea University*, Vol I, 2002, p. 177-182, University of Oradea, ISSN 1583-0721

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