

APPLICATION OF CAX SYSTEM FOR DESIGN AND ANALYSIS OF PLASTIC PARTS MANUFACTURED BY INJECTION MOULDING

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Abstract. The purpose of the paper is to present the design of a new plastic part and injection process simulation. Workflow in virtual modelling and simulations in CAX system was presented on an example of the trolley plastic car for kids. The model of the plastic car was designed and simulated to determine the injection parameters in SolidWorks environment. Based on the 3D model of the product the mould tool was created. From the virtual testing the most suitable injection point location, material temperature as well as the fill time and required injection pressure have been specified. With these results the designers can avoid anomalies or defects in real plastic things with the actual injection process parameters, like: air traps, weld lines and sink marks. Such analyses allow the designer to develop a proper mould 3D model, to save the mould setup time as well as to reduce the cost for manufacturing the mould.

Keywords: injection moulding, mould design, plastic parts, CAX, SolidWorks.

Introduction

The plastic manufacturing process plays an important role in the nowadays industry. Metal ores are difficult to obtain from natural sources. Among other things, this is why the manufacture of plastic products is desirable [1]. The technology of the tool and die fabrication in plastic injection is one of the world's fastest growing industries [2;3]. More than 80 % plastic goods are manufactured using injection moulding. Parts obtained from the injection moulding process are widely used in agricultural machines (e.g. tractors, harvesters, balers) as well as garden and breeding equipment. For good quality production and due to saving the time of new product launch on the market the design process and many analyses should be carried out using CAX tools.

Computer aided techniques (CAX) are widely used in the mechanical engineering branch [4-7]. The main advantage of using the CAX systems is a shortening of the product's time development. The ability to perform many types of CAE analyses [8-16] allows to better fit the project assumptions. The applications of CAX systems used in manufacturing and CNC area are outlined in many papers [17-21]. Today mold design requires a complex CAX system with simulation of the injection process [22-24]. It allows predicting of defects in early stage of the part design and their elimination [25-28].

The aim of this paper is to show the design workflow of a new plastic product in CAX system, on an example of a trolley car for kids, and testing the injection moulding, using CAE software, for obtaining the proper process parameters and the final plastic part without manufacturing defects.

Materials and methods

The products such as trolley plastic cars for kids are available at the market in many designs and colours (Fig. 1). The toys for children, which are made from plastic material, more and more can be found at the market. The reason for that is economical benefits and easy mass production. Injection moulding process is a high production process that can be used to produce plastic parts with complex geometry. Each toy consists of several parts, which then assemble into a more complex toy, or a toy from one part that itself represents a single complete product. There are many companies, which produce plastic toys and trolley plastic cars for kids, such as the companies: Lego, Faro, Dede etc. Some of the trolley plastic cars, which exist at the market, are shown in Fig. 1. Children's toys are produced in mass production according to the needs for them and daily use in children play time. In view of the child's joy and child's injudiciousness, toys are breaking daily, which leads to great production of these products. One of the best business ideas is the production of toys, but given the large number of companies in the world, i.e. of competitive companies, it is hard to get through the market. Therefore, the design is in the first place, because every child wants a unique and beautiful toy, but the parents are the ones who buy it, they see other factors, such as the price, safety and quality.



Fig. 1. Trolley plastic cars for kids at the market

According to the above mentioned designs of trolley cars (Fig. 1), a new design was created with a modular approach. Fig. 2 shows a new concept of a trolley plastic car in different scenarios in 3D views and terms of use, which is based on the design style functionalism. The 3D solid model of the trolley car is made in parametric 3D CAD modeller SolidWorks [29-32]. In the design the social, economic and technological factors are incorporated [33].

The designing of an injection moulding tool is based on interactive analyses of all design parameters and the manufacturing process needed to define a complex shape of the mould's core and cavity. Multibody techniques [34] and special mold features were used in 3D modelling. Fig. 3 shows the mold tool only for the chassis of the trolley plastic car for kids. CAD software SolidWorks and add-in Mold Tool were used in creating a 3D model of the car's chassis plastic part according to the mold design principles and CAD model of the mold tool, which is shown in Figure 3. The model was formed by surface modelling. Simplicity of the modelling is in using a standard surface tool by using Boolean operations, such as addition, subtraction or intersection. The designed 3D model of the car's chassis has to satisfy all the design principles for injection moulding in order to fulfil its function correctly. The result of this phase is obtaining a 3D solid model of the plastic part with all necessary plastic part geometrical principles and obtaining of 3D solid model of the mold tool.

CAX tool utilized virtual testing of the injection moulding process. After obtaining the CAD model of the plastic part car's chassis, virtual testing of the injection moulding process can be performed in the module SolidWorks Plastics. The injection moulding process is a complex process that involves a series of sequential process steps. The different phases of the injection moulding process include the mold filling phase, the packing phase, the holding phase, the cooling phase and part ejection.

Results and discussion

The 3D modelling of the plastic part car's chassis was performed with SolidWorks surface and the virtual testing that simulates how the melted plastic part in the injection moulding process was performed with SolidWorks Plastics. The main goal of the application is prediction of defects on the part and moulds in the manufacturing process. The virtual testing of the injection moulding process is performed with analysis: Flow, Pack, Cool and Warp.

The model of the plastic parts car's chassis can be meshed using the shell or solid mesh model. In this study the model of solid mesh was selected, which provides better accurate results from the shell

model of meshing. In the setup of the virtual testing of the injection moulding process the material ABS from SolidWorks database was selected.



Fig. 2. Different 3D views and terms of use of new design of trolley plastic car

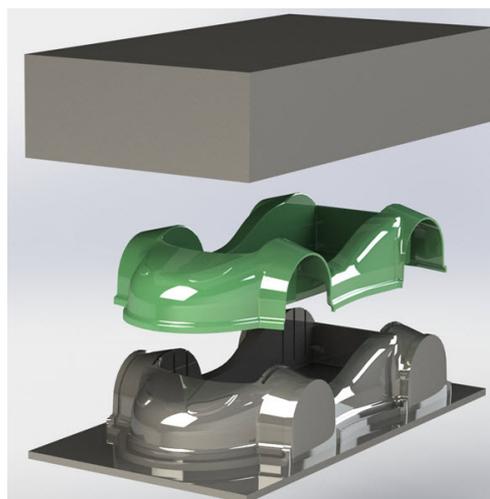


Fig. 3. Injection mold core and cavity

Fig. 4 shows the 3D solid model with the gate location placing on the model. The number of the gate location is 5 for faster filling stage of mold. Fill time (Fig. 5) is the time taken to fill up the part inside the cavity and it is 3,43 sec. Next the air traps (Fig. 6) and weld lines (Fig. 8) were presented.

The cooling time at the end of the filling process is 34,8 (Fig. 7), which is without an additional cooling system in this study. Sink marks are shown in Figure 9 and volumetric shrinkage is shown in Figure 10. The injection maximum pressure (Fig. 11) at the end of fill for hold of the closed mold parts is 79,2 MPa (red colour).

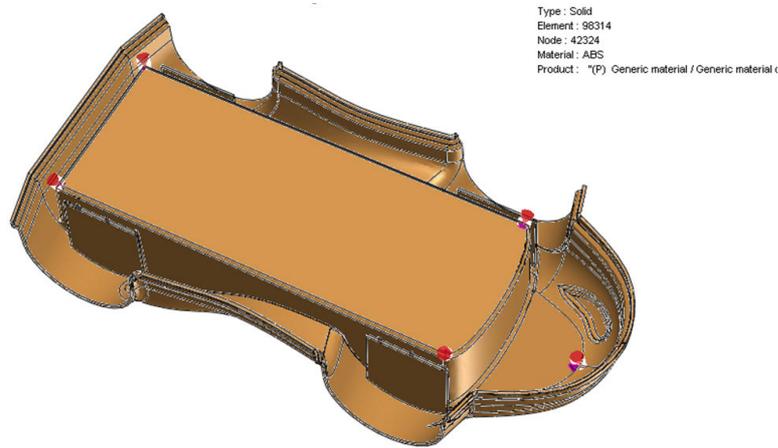


Fig. 4. Solid model with gate location

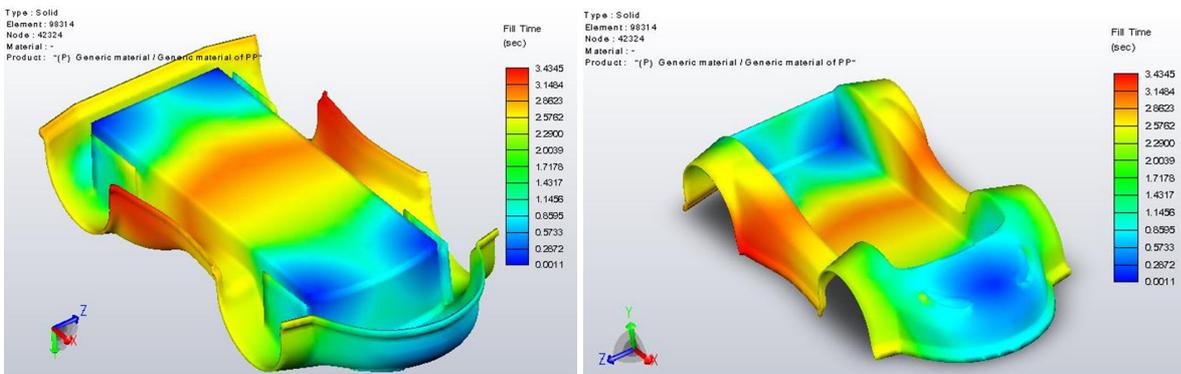


Fig. 5. Fill time of plastic part

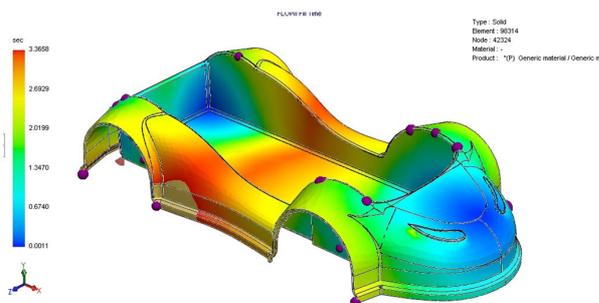


Fig. 6. Air traps

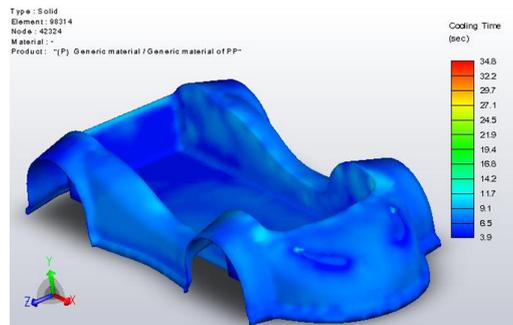


Fig. 7. Cooling time of plastic part

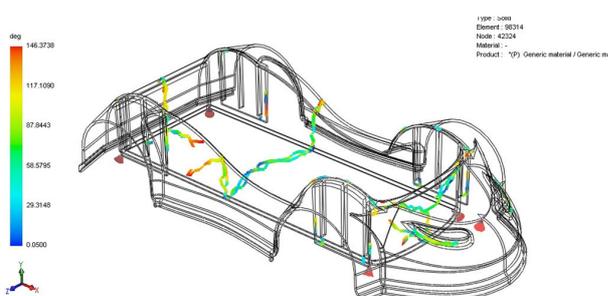


Fig. 8. Weld lines

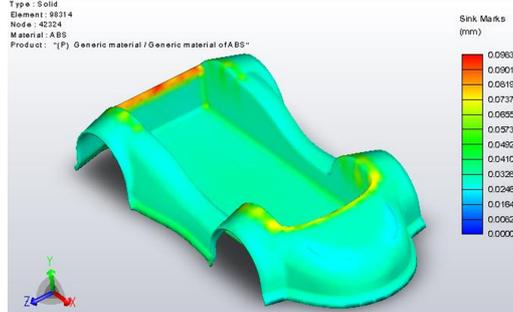


Fig. 9. Sink marks of plastic part

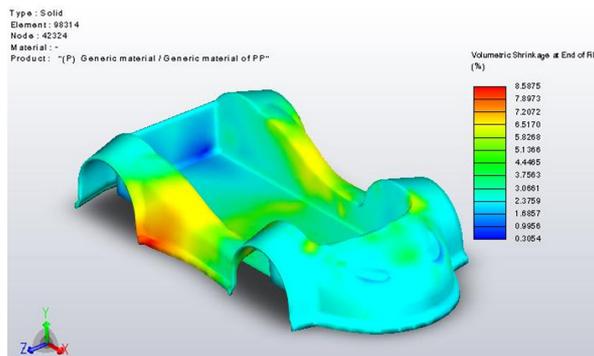


Fig. 10. Volumetric shrinkage at end of fill

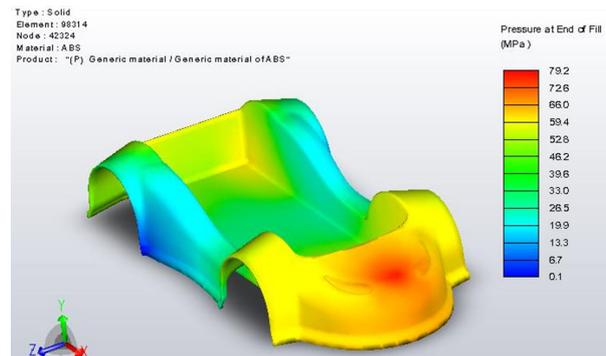


Fig. 11. Pressure at end of fill

Conclusions

In this paper the basic features in the design process of a plastic part for the injection moulding process using SolidWorks environment are presented. The case study was designing of a trolley plastic car for kids and virtual testing for the car's chassis with the injection moulding process in SolidWorks Plastics, which provides sufficient information about: the gate location, fill time, injection maximum pressure and the cooling time at the end of filling.

With these results the designers can avoid anomalies or defects in real plastic things with actual injection process parameters, like: air traps, weld lines and sink marks. Such analyses allow the designer to develop a proper mould 3D model, to save the mould setup time as well as to reduce the cost for manufacturing of the mould.

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