Modeling and Analysis of an Injection MOULD Deploying CREO Parametric and Analysis System

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Abstract

Plastic injection molding process is an important processing operation in plastic industry. However, lack of expertise and skill in mould designing and fabrication and control of injection molding machine will lead to imperfect plastic products. Designing of a mould is very important task involving significant decisions with implications to productivity and yield quality. In this research paper, the failure analysis of a mould of vertical plastic injection molding machines utilized locally in Pakistan for production of plastic cups was investigated. After structural and thermal analysis of a mild steel mould in analysis system (ANSYS), it was found that a designed mould for polypropylene cup will not face any failure.

Keywords: *Injection Molding Process, Mould, Modeling, Analysis, CREO parametric, ANSYS.*

1. Introduction

Moulds have been costly to fabricate and they are used where hundreds of products are being produced. Typical moulds are made from aluminum, beryllium-copper alloy, hardened steel and pre-hardened steel. Generally steel moulds are expensive to construct, but their higher initial cost will be offset by their longer lifespan. Tool design is driven by the complexity of part design. Optimizing both tool design and part design can increase the quality of part and lifespan of the tool.

To date, several researchers modeled, analyzed and constructed injection moulds for different products. Mohd Jamshed et.al.., carried out research on design and analysis of plastic injection mould for production of cam bush having submarine gate. Auto desk mould flow plastic insight was used for mould flow analysis for cam bush cooling system location, filling rate and location of submarine gate[1].

S.H.Tang et.al.., published their research work in which design of plastic injection mould was presented for warpage testing specimen and to perform thermal analysis for the mould. Design of mould was done through software known as Unigraphics, version 13.0 and thermal residual stress analysis was done using LUCAS Analyst, version 13.5[2].

K.K.Alaneme carried out research on the indigenously produced mould dies of punching machine used for the production of cable trays. The failure investigation was done using hardness test, visual examination, chemical composition determination and micro structural examination[3]. S.H.Tang et.al.., deployed Taguchi method for reducing warpage in the design of plastic injection mould. From results they concluded that melt temperature is the most critical factor on the warpage and filling time slightly affected on warpage[4].

Silvia Barella et.al.., investigated the damages and failure on a copper mould whose sides are layered with chromium. In analysis they pointed out that failure origin is caused by working conditions and copper wear is due to high zinc content of the liquid steel[5]. D.M.Yakovleva et.al.., presented analysis of moulds failure under pressure. They found that main reasons are chemical and physical activity of the casting alloy, nature of material used and cyclic temperature-power loading intensity. Maximum level of stress occurred at the contact surfaces during filling and concise exposure of melt in the mould[6].

Xi-Ping et.al.., carried out research on thermal and stress analysis of rapid electric heating cycle of injection mould for LCD TV panel. Through finite element simulation, deformation of the mould and the reason that source the large thermal stress were analyzed[7]. Similarly many other researchers carried out research on injection moulds[8-17]. In this research, failure analysis of mild steel mould to be used in vertical plastic injection molding machine is carried out.

2. Methodology

Overall methodology of a research project is given below. However this research paper is only focused on modeling and analysis of an injection mould.

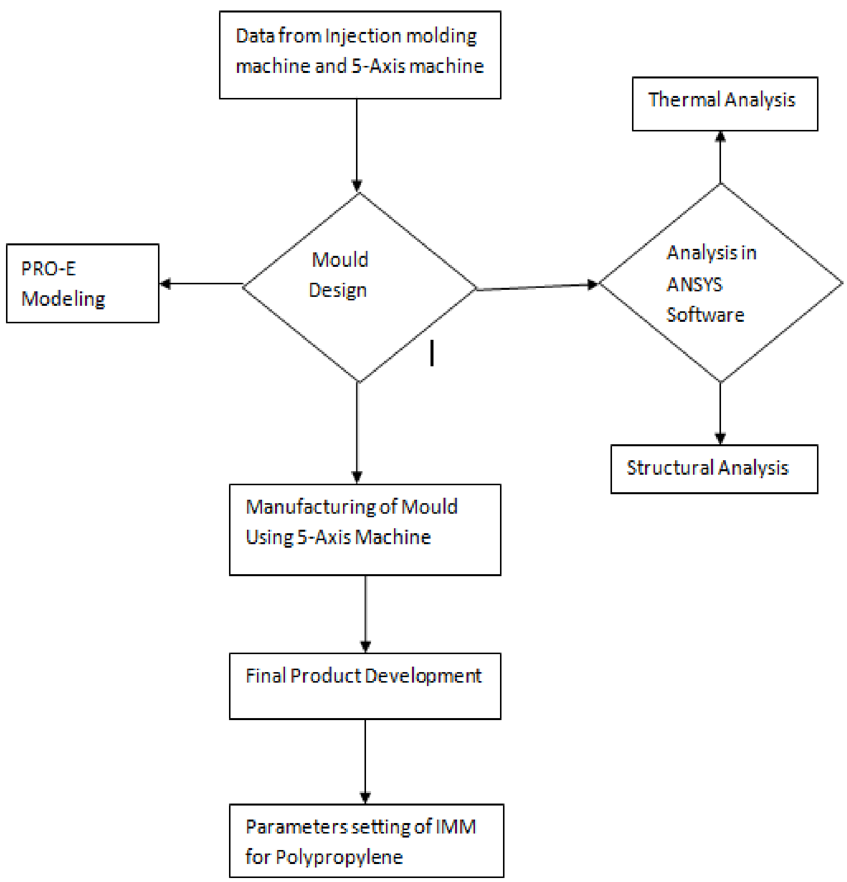


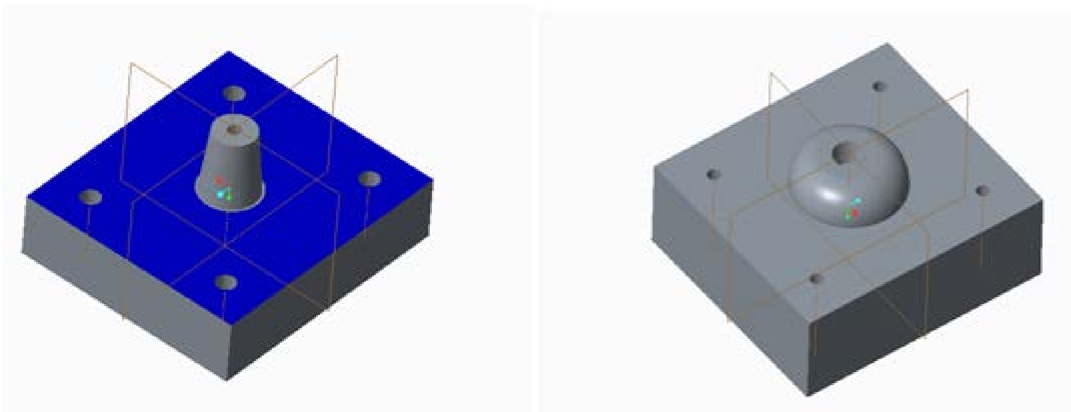
Fig. 1 Flow chart of complete research project

Keeping in mind the specification of vertical plastic injection molding machine, first model of a mould is developed in CREO parametric and then same mould is analyzed in ANSYS.

2.1 Mould Modeling in PTC CREO

For the analysis or designing of a mould in ANSYS software, first we did modeling in PTC CREO. We modeled cope and drag separately and then assembled it to make a complete mould. After making model, we generated drawings of cope and drag. Exploded drawing of a complete drawing was also developed to understand and visually see the overall model.

Models of cope and drag and the final assembly of a mould are given below.



A. Cope B. Drag

Fig.2 Cope and Drag

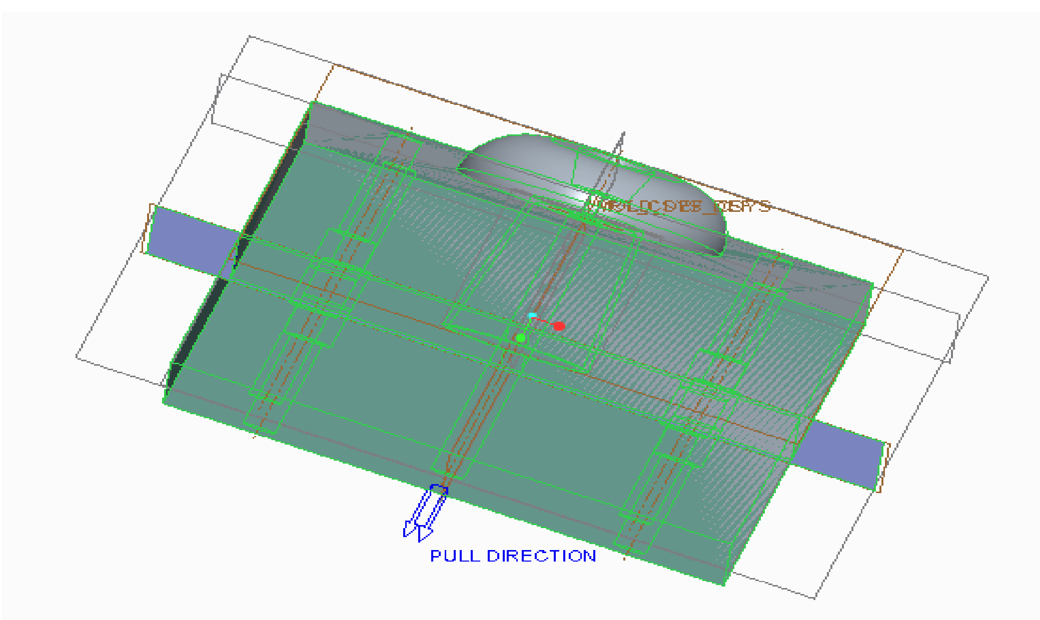


Fig. 3 Final model of a mould

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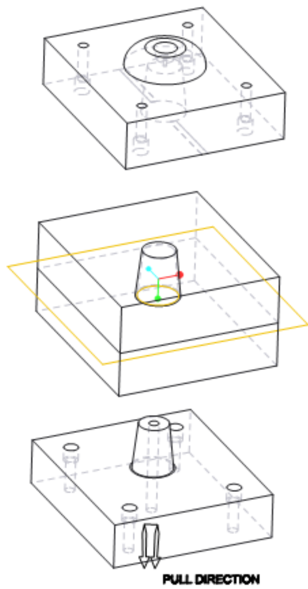

Fig. 4 Exploded drawing of a mould

Mould will be rectangular in form. Length of a die is 239.52 mm (9.4 in) and its breadth is 212 mm (8.34 in). Generated drawing of a cope and drag is given below.

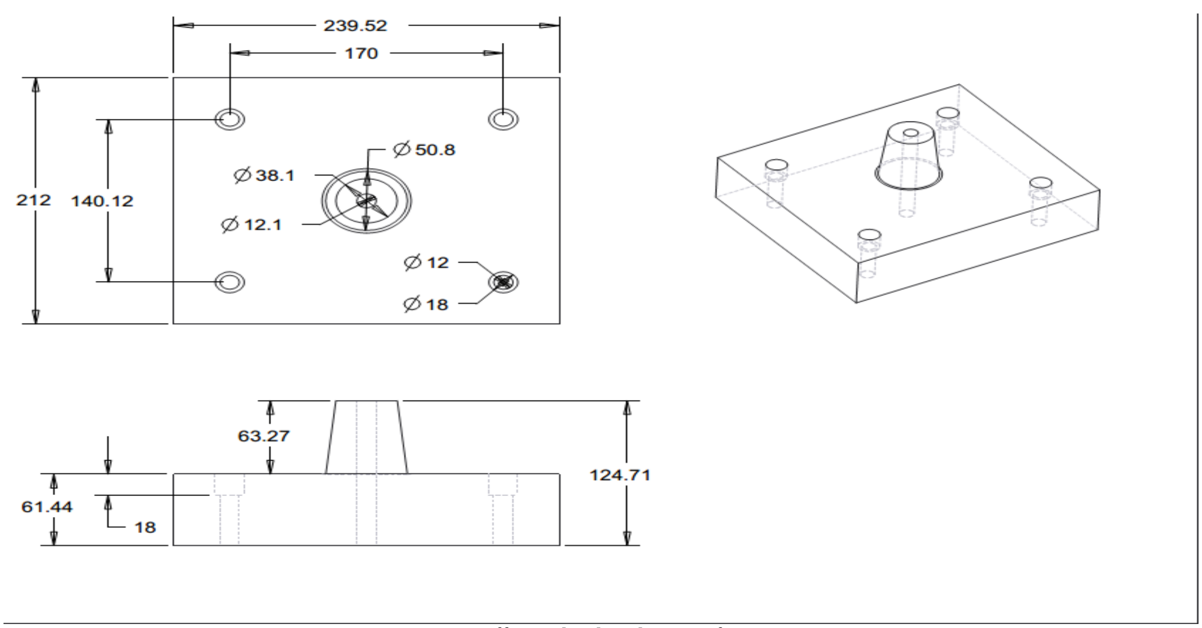

Fig. 5 Different developed views of a cope

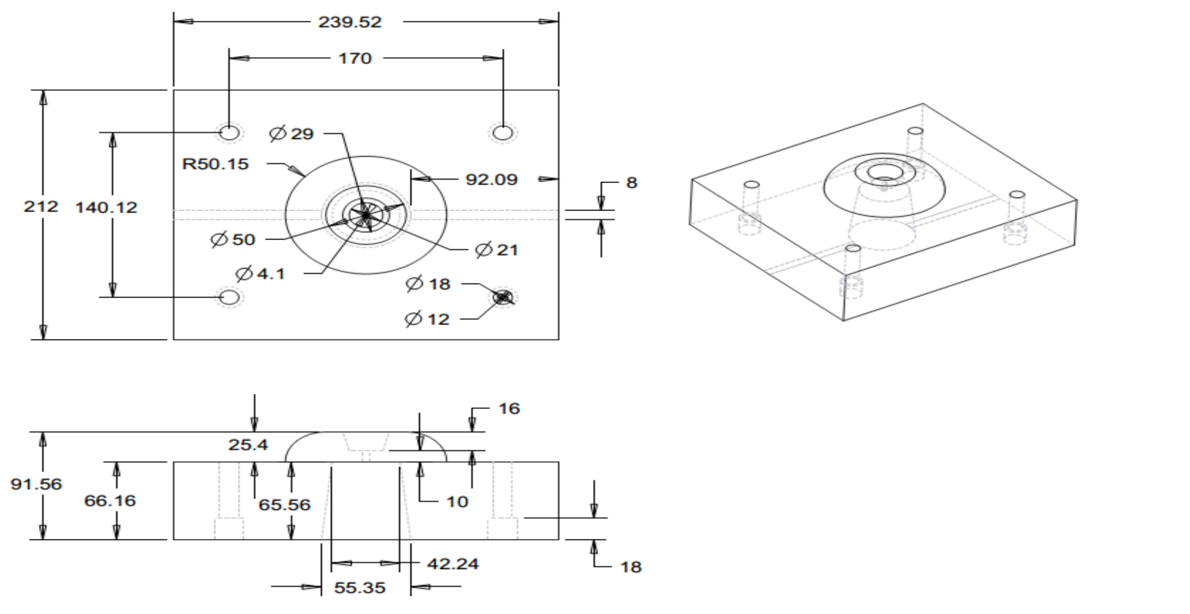

Fig. 6 Different developed views of a drag

2.2 Structural and Thermal Analysis in ANSYS

In analysis we are more interested in structural and thermal analysis. We want to know that the mould will face failure or not after applying temperature and pressure on a mould.

2.2.1 Structural Analysis

ANSYS structural analysis facilitates to deal with complex structural engineering complications and make better and quicker design decisions. As this mould is made for polypropylene cup and maximum pressure that we apply for polypropylene in vertical plastic injection molding machine is 55 bar.

After applying a pressure of 55 bar on a mould, the following stresses were found out.

1. Normal Stress
2. Maximum Shear Stress

The maximum normal stress that we got was $7.9666e^{8}$ and minimum normal stress was $-1.501e^{8}$.

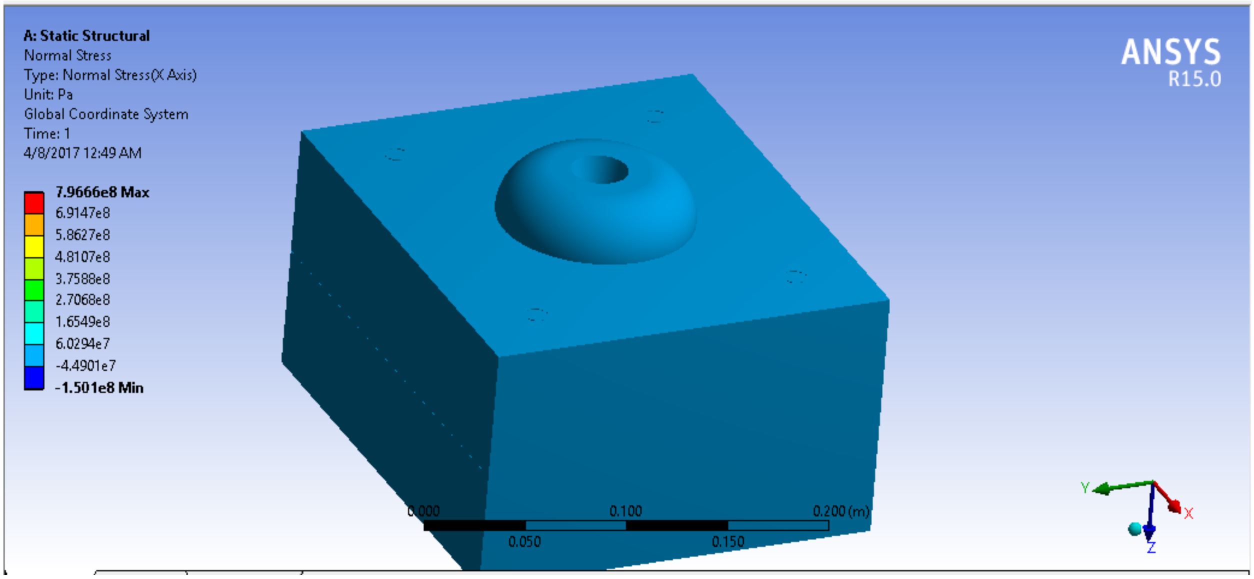

Fig. 7 Normal stress at 55 bar

The maximum shear stress that we got was $5.819e^{8}$ and minimum shear stress was 111.07.

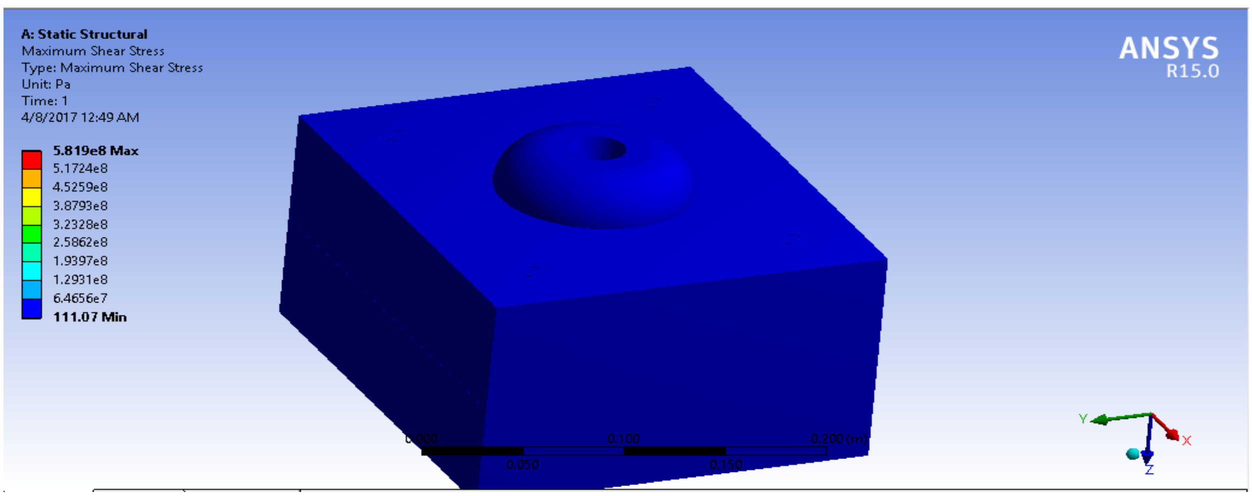

Fig. 8 Shear stress at 55 bar

2.2.2 Thermal Analysis

Reaction of heat and thermal management of structures is more critical when performance limits are nudged further by the demand to have smaller, lighter and more efficient designs. Conduction, convection and radiation are more evident, but the need to include the effect of thermal energy from friction and power losses means that the analysts need to have more tools at their disposal to simulate thermal models precisely.

Maximum temperature that we apply for polypropylene in vertical plastic injection molding machine is 210 Ċ. After applying a temperature of 210 Ċ, we got maximum thermal strain of 0.002256 and minimum of thermal strain of -$6.0086e^{-16}$.

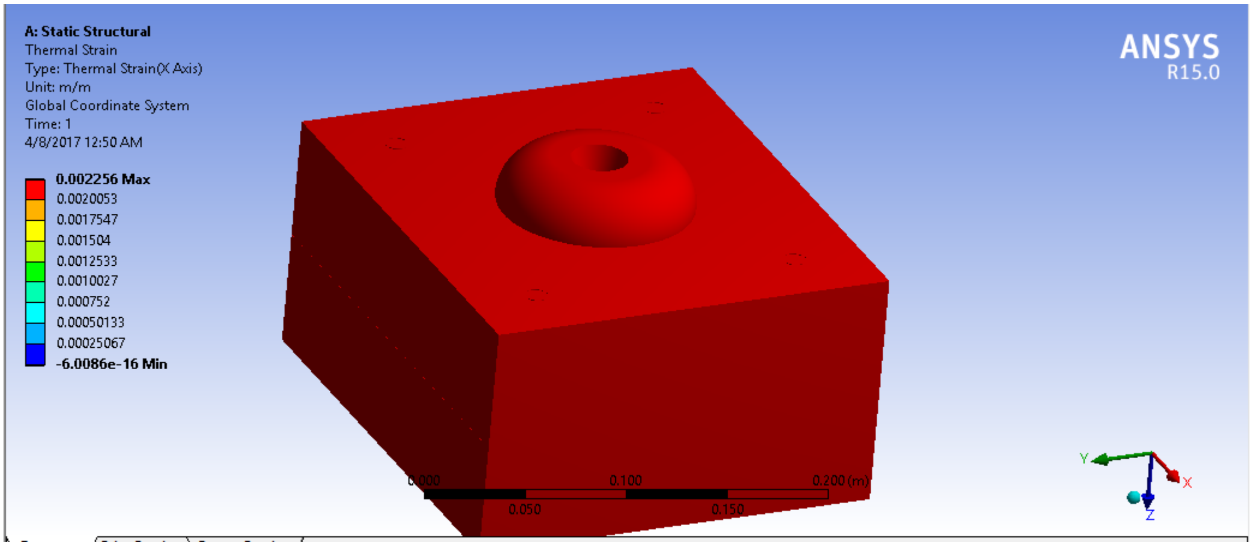

Fig. 9 Thermal strain at 210 Ċ

The above analysis was only being done for maximum pressure (55 bar) and maximum temperature (210 Ċ).

3. Results

From the results of structural analysis of the above two different types of stresses, we concluded that maximum and minimum pressure applied was 55 and 45 bar which is equal to 5.5MPa and 4.5MPa respectively is well below 250MPa (2500 bar) yield strength of mild steel. Hence, the mould made up of mild steel is not going to deform structurally.

Mild steel often melts at a temperature of 1370 degrees C (2500 degree F). Maximum temperature applied here is 210 degree C which is well below its melting point and thermal resistivity of mild steel is high as compared to the one that we got after applying 210 Ċ. Hence the mould is not going to melt or deform thermally and experiments could be carried out on it easily.

4. Conclusions and Future Recommendations

This research work was carried out to model and analyze a mild steel mould for vertical plastic injection molding machine. After modeling it in CREO parametric and then analyzing it structurally and thermally in ANSYS we concluded that this mould will not face failure and production could be done on it smoothly.

The same modeled and analyzed mould can be fabricated and then can be used in vertical plastic injection molding machine for production of polypropylene cups, and Parameters of vertical plastic injection molding machine can be optimized for polypropylene using same mould as well.

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