

DESIGN ANALYSIS FOR COMPONENTS OF PNEUMATIC INJECTION MOULDING MACHINE USING PRO-E

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ABSTRACT

Design optimization of any machine aims to reduce failures due to process tolerances. Computer Simulation and Computer designing are used to access the fitness of a design for mass production. Computer Model simulates the behavior of machining parts from geometrical and material parameter of the input parameters to output parameters. The emphasis of this work is on the design of machine components of Pneumatic Injection Moulding Machine. In this study the various components of machines are designed using Pro-E. This machine is used to mould Plastic into usable form and shape and most effective for small scale industries where small size plastic components are to be manufactured.

KEYWORDS – Injection Moulding, Pneumatic, Pro-E, Design

INTRODUCTION

Injection Moulding is a manufacturing process for producing parts from both thermoplastic and thermosetting plastic materials. Material is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the mold cavity [1]. The plastic injection moulding industry has evolved over the years from producing combs and buttons to producing a vast array of products for many industries including automotive, medical, aerospace and consumer products [2]. The Machine parts analysis using feature based methodology. This approach allows robust design of part components. This is also useful for parting plane and product layout [3].

LITERATURE SURVEY

There are different type of Compressed Injection Moulding machines are available in market, but they are mainly used for mass production in large scale industries due to high cost of machine components, high pressure and more space required. According to customer reviews the needs have been identified as mainly cost, easy to operate, better product quality and suitable for used in small scale industries [4].

The pneumatic Moulding Machine Consist of various components. There are mainly two cylinder used upper Cylinder & Lower Cylinder, Compressor, pressure regulator, Direction control Valve, clamping holder, nozzle, cylinder guide, coupling, Flow control Valve.

The Computational analysis using 3 D Modeling CAD and Pro-E in manufacturing of machine is help to design perfect components and parts with minimum modification and also reduce the time and cost. Analysis provides an insight into the nature of processing and consequently offers valuable input towards the design of mould.[8]

MACHINE COMPONENTS

The pneumatic Moulding Machine Consist of various components. The Machine is mainly divided into two units –Injection unit & Clamping Unit. Injection Unit having components are Cylinder, Barrel, Screw, Backflow Prevention Valve, Nozzle & Heater. Clamping unit consist of Clamp, Exhaust Valve & Die Assembly parts.

A. Injection Cylinder

There are many types of injection cylinders that supply necessary power to inject resins according to the characteristics of resins and product types at appropriate speed and pressure. This model employs the double cylinder type. Injection cylinder is composed of cylinder body, piston, and piston load. [5]

Design of Cylinder consist of – (a) Cylinder Thrust (b) Air Consumption (c) Mounting



Fig. 1 Injection Cylinder CAD Design & Actual Cylinder with Control Valve

Cylinder Thrust is a function of piston diameter. Operating air pressure and the frictional resistance (though in the case of static thrust, the frictional resistance is zero). Cylinder thrust can be calculated by the following formula.

Let,

F_w = Cylinder thrust for forward stroke in kg.

F_R = Cylinder thrust for return stroke in kg.

D = Diameter of piston in cm.
d = Diameter of piston rod in cm.
P = Operating air pressure in "bar".

Thrust in forward Stroke

$$F_w = \pi/4 \times D^2 \times V$$

Thrust in Return Stroke

$$F_R = \pi/4 \times (D^2 - d^2) \times P$$

For Upper Cylinder

$$F_w = \pi/4 \times 10^2 \times 3.1 = 247.7 \text{ kgf}$$

$$F_p = \pi/4 \times (10^2 - 2.5^2) \times 3.1 = 228.25 \text{ kgf.}$$

For lower Cylinder

$$F_w = \pi/4 \times 5^2 \times 1.7 = 33.37 \text{ kgf}$$

$$F_p = \pi/4 \times (5^2 - 2^2) \times 1.7 = 28.03 \text{ Kgf.}$$

The aim is to reduce the manual pressure, so therefore selecting the Cylinder with the pressure of 8 bar (8kgf/cm.²), dia. 50 mm. and stroke of 160 mm. from the standard piston thrust chart. The air consumption data for cylinder is required in order to estimate the compressor capacity [5].

Free Air Consumption in forward Stroke = $\pi/4 \times D^2 \times (p+1) \times L \div 100 = 5 \text{ ltr.}$

Free Air Consumption in Return Stroke = $\pi/4 \times (D^2 - d^2) \times (p+1) \times L \div 100 = 4 \text{ ltr.}$

Where D= diameter of piston, d= Diameter of Piston rod, L=Piston Length and P= Air Pressure

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 5 + 4 = 9 Liters.

B. Barrel

Nitride Steel barrel are used for Iupilon /Novarex plastic resins is good. The Barrel consists of cooling water channel, heater bands, Thermocouple whose function is to note the temperature in various section of barrel. The time it takes for the plastic material from entering the barrel to the nozzle is called the residence time [6].

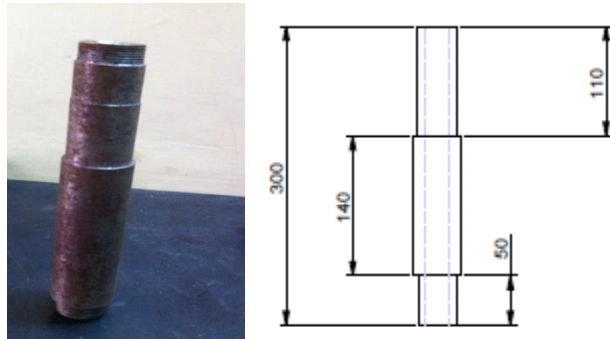


Fig.2 Barrel & Barrel Pro-E Design

C. Nozzle

Nozzle is located at the end of barrel which provides melt can leave barrel and enter into the mould. melt can be heated here by friction and conduction from a heater band before entering the relatively cold channels in the mould. Contact with the mould causes heat transfer from the nozzle and in cases where it is excessive it is advisable to withdraw the nozzle from the mould during the screw-back part in the moulding cycle. Otherwise the plastic may freeze-off in the nozzle [6].

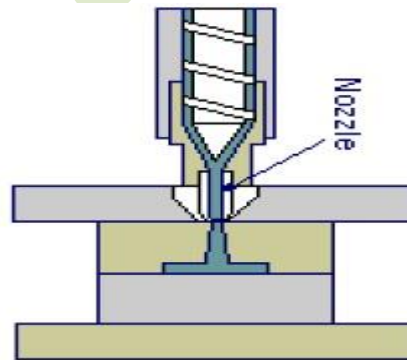


Fig. 2 (A) Nozzle or Rocket (Used in Pneumatic Injection Moulding Machine) (b) Nozzle with barrel in processing position Source: Ref.[1]

D. Clamp Holder

Clamping is used to keep the mould tightly closed under sufficient pressure to let the molten plastic fill in the cavity without leaking during the injection process.

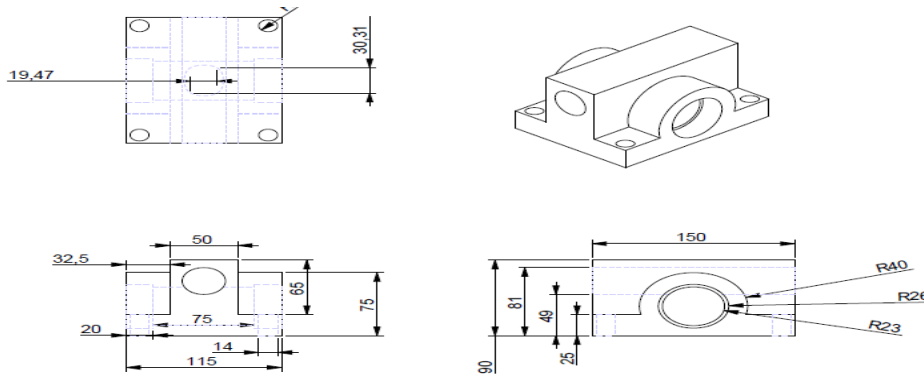


Fig. 3 Clamp Holder Design

E. Flow Control Valve

Flow control valve is used to maintain the effective injection pressure by preventing a part of measured resin from backflow through the ditch of the screw at the time of injection. The structure of this valve is indicated in Fig.1. It can be understood that it is easy for resin stagnation with this valve structure.

**Table I
 Flow Rate & Defective phenomena Ref. [8]**

Defective phenomena results from too slow flow rate of resin	Defective phenomena results from too fast flow rate of resin
Flow mark Transcription defect of mold surface Weld line Short shot	Jetting mark Gas burn Sink mark due to trouble of air purge

F. Heater

The Plastic resins are moulded at high temperature. the heater with heat capacity can be heated to about 150-200°C is used, and a band heater is usually used.

G. Collar

Collar is the channel along with the molten plastic first enters the mould through the cylinder pipes. It delivers the melt from the nozzle to the runner system.

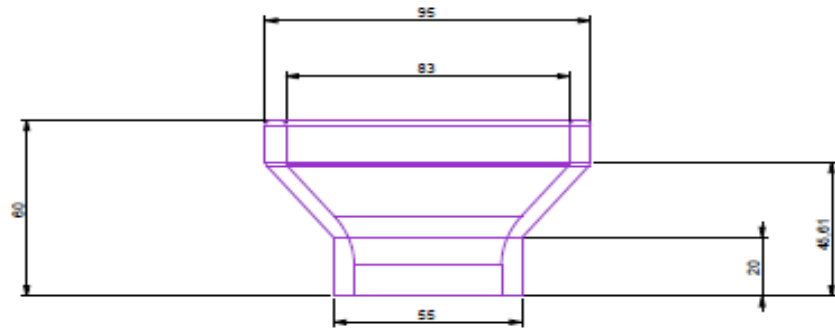


Fig.4 Collar with Pro-E Design

H. Die

A die is usually made in two halves and when closed it forms a cavity similar to casting desired. One half of the die remains stationary is known as “*cover die*” and the other movable half is called “*ejector die*”. The die casting method is used for castings of non-ferrous metals of comparatively low fusion temperature and this process is cheaper and quicker than permanent or sand mould casting. Most of the automobile parts are made with this process. This die is made from mild steel using CNC fabrication on it. Core is male portion of the mould forms the internal shape of the moulding. Cavity is the female portion of the mould, gives the moulding its external form of the part. [7]

Size = Square Flat plate (.20 m. x .20 m.), Thickness = .10 m., Material Used = Mild Steel,

Size of Cavity = 7.5 gm/cm³

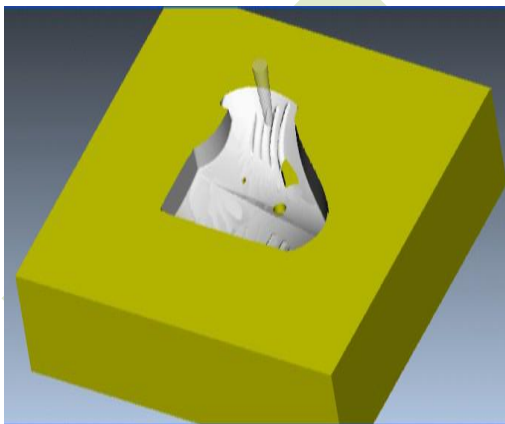


Fig.5 Cavity NC Check in Pro –E



Fig. 6 Die Core & Cavity using in moulding Machine

ASSEMBLING OF MACHINE

Machine cannot create energy by itself. Therefore machine requires prime mover. In most of machines prime mover is an electric motor 3 phase induction motor in case of injection moulding machine. In this machine electrical energy is converted into mechanical energy by using pneumatic compressed system. For the Pneumatic compression injection Cylinder with control Valve is used. FRL unit is used for filtration, regulation and lubrication of the compressed air. Temperature sensors is used for controlling the temperature of dies, asbestos and glass wool for the insulation between piston rod and dies, a frame is used for the equal distribution of load on the material to be produced by using this machine. Molding compound is placed in an open and heated mold cavity. The mold is closed and the pressure is applied to force the material to fill the entire mold cavity. The heat and pressure is maintained until the plastic material is cured. Once the material is cured it is removed from the mold for finishing.

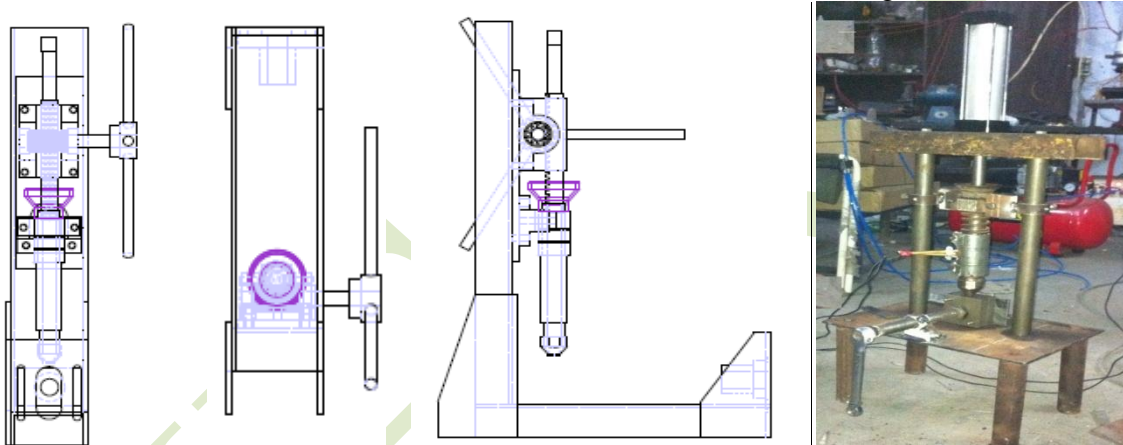


Fig. 7 Machine assembling Design with assembled Machine

After designing the mould components, with the parameters now manufacturing the die products according to the dimensions. The flow chart of the manufacturing process is given as :

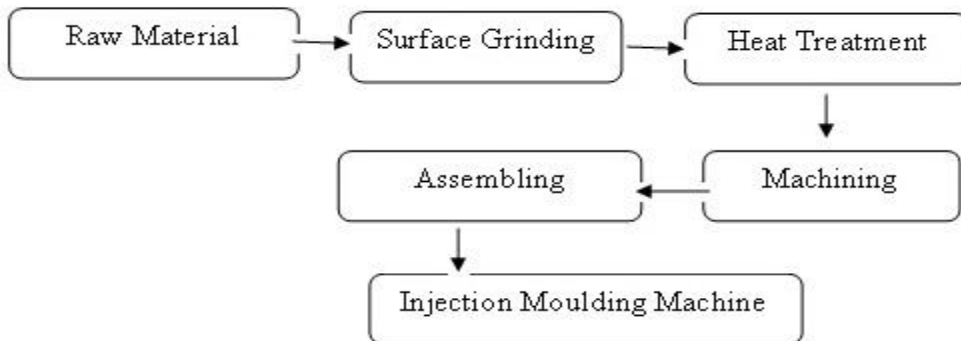


Fig. 8 Flow chart of manufacturing process of mould

CONCLUSION

Designing of machining components are considered very important task now a days. There are several Design analysis Software's are used. This design result can be used to pre-calculate the production & manufacturing process of machine in order to achieve faster breakeven point. Analysis/simulation provides an insight into the nature of processing and consequently offers valuable inputs towards the design of the Parts. This study is intended to be the stepping stone for incorporating more the use of Injection Moulding simulation software in the product design, mould design, and product development that involves the use of injection moulding process.

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