Design And Automation of Plastic Injection Molding Machine

Under The Valuable Guidance of

Prof A. G. Barad

Department of Mechanical Engineering (SRPEC)

Prepared By:-

Prashant B. Kakadiya (130783119003)
Keyur G. Patel (130783119017)
Karan V. Prajapati (130783119024)
Vikas B. Sathawara (130783119028)

Group No:-12

OUTLINE

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- Project background
- Working principle
- Literature review
- Research gap
- Objective

- Methodology
- Required parts
- Part drawing
- Scope of project
- Conclusion
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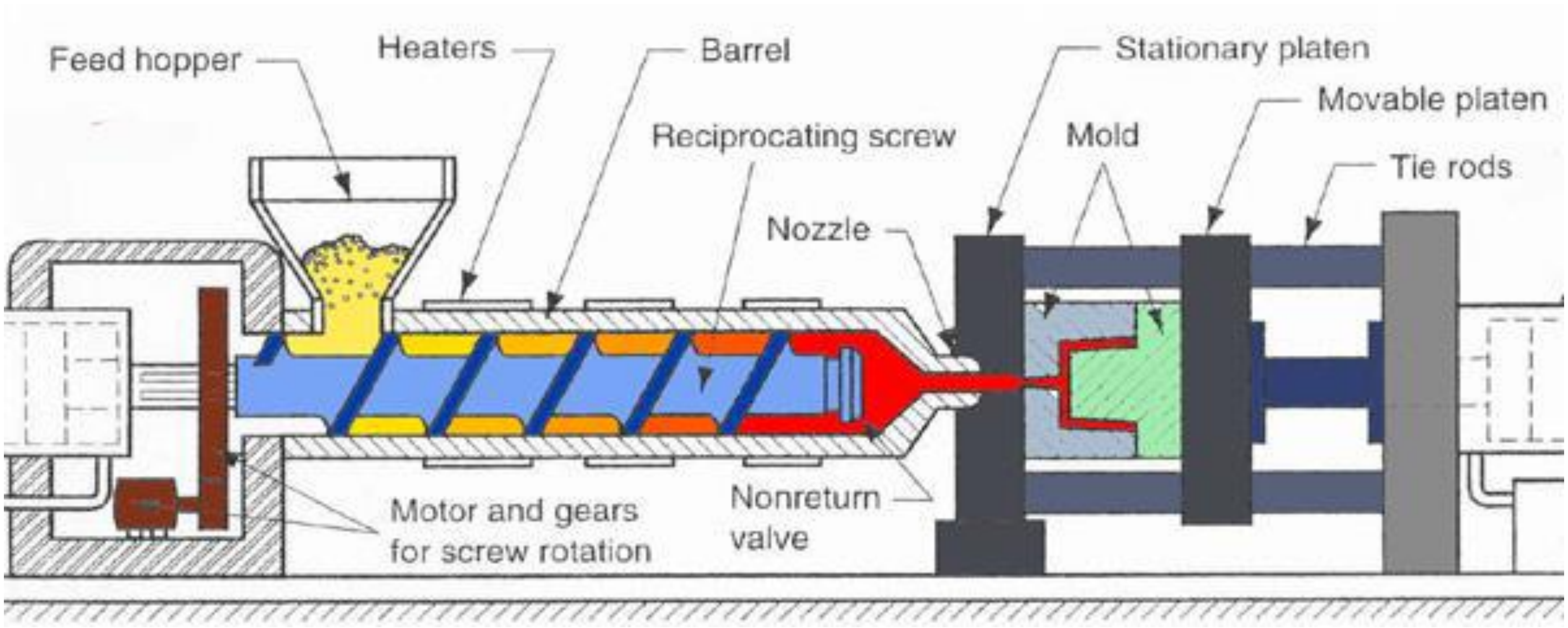
PROJECT DEFINITION

- For small scale industry the requirement of semiautomatic plastic injection machine demand with low cost day by day increasing so there is need of solution so our project is based on Design and Automation of Economical Plastic Injection Molding Machine for small industry.

PROJECT BACKGROUND

- Now a days there are many methods to develop plastic parts like bottle caps, mobile phone parts, electronic housings, containers, automotive interiors and most other plastic products.
- Molding process are industrial process in which plastic parts are created by injection of molten metal in mould.
- The machine cost was reduced by developing this machine. In project lots of important information was gathered from research papers and patents. According to that research different components of machine were designed.

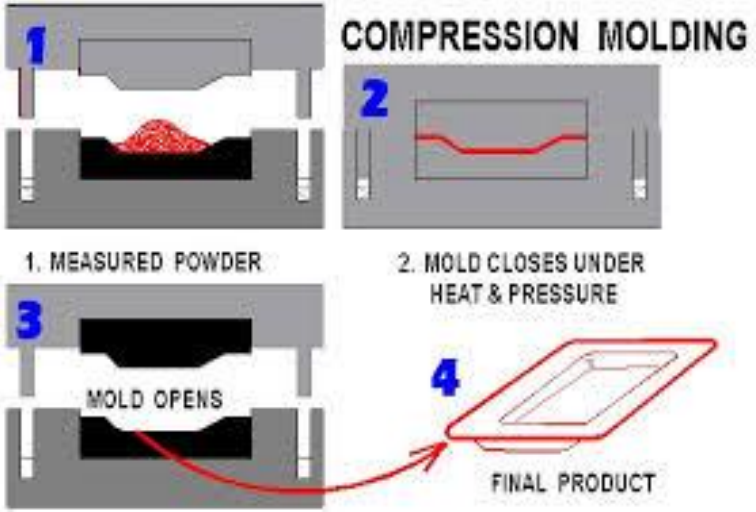
WORKING PRINCIPLE

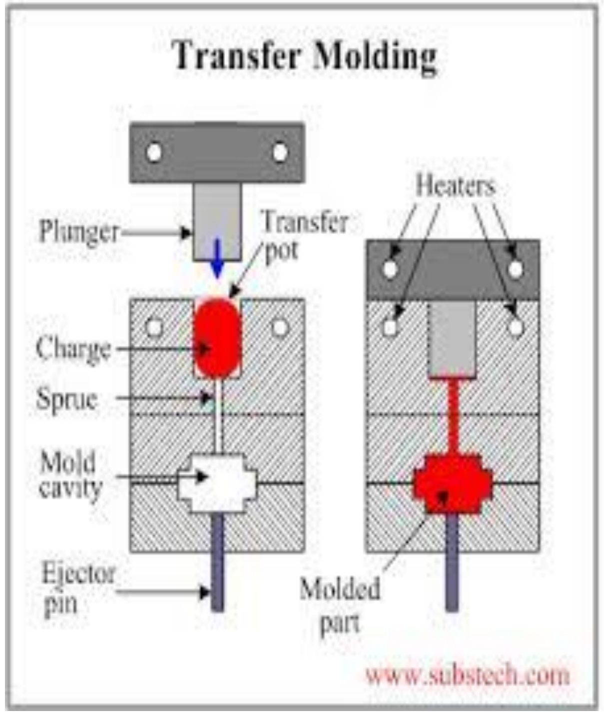


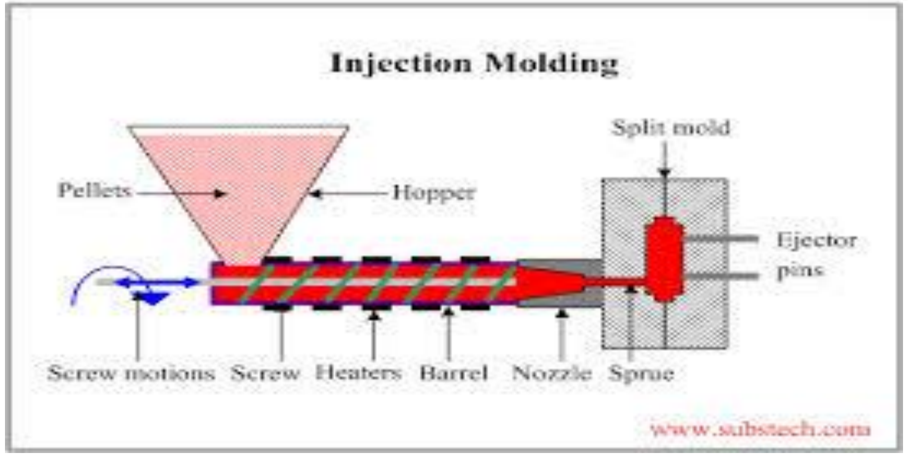
- Polymer material in form of pellets is fed into an extruder through a hopper.
- The material is then conveyed forward by a feeding screw and forced through a die, converting to continuous polymer product.
- Heating element placed over the barrel, soften and melt the polymer.
- The temperature of the material is controlled by thermocouples.
- The product going out of die is cooled by blown air or in water bath.
- Then mold is opened and product is taken out of the mold

PROCESSING METHODS

- Compression Molding
- Transfer Molding
- Injection Molding







PLASTIC MATERIAL

TYPES OF PLASTIC MATERIAL[w2]

I. **Thermoplastics**
II. **Thermosetting plastics.**

- **Thermoplastics:-**Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. They are easily molded and extruded into films, fibers and packaging. Examples include polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).
- **Thermosetting plastics:-**Thermosetting plastics which are formed by heat process but are then set (like concrete) and cannot change shape by reheating. They are hard and durable. Thermo sets can be used for auto parts, aircraft parts and tires. Examples include polyurethanes, polyesters, epoxy resins and phenolic resins.

THERMOPLASTIC PROPERTIES[w2]

Plastic Names	Products	Properties
Polyamide(nylon)	Bearing, gear wheels, casings for power tools, curtain rail fittings and clothing	Creamy colour, tough, fairly hard, resists wear, self-lubricating, good resistance to chemicals and machines
Polymethyl methacryate(acrylic)	Signs, covers of storage boxes, aircraft windows, covers for car lights	Stiff, hard but scratches easily, durable, machines and polishes well
Polypropylene	Medical equipments, laboratory equipment, plastic seats, rope, keychen	Light, hard but scratches easily tough, good chemical resistance
Polystyrene	Toys, especially model kits, plastic boxes and containers	Light, hard, stiff, transparent, brittle, with good water resistance
Low density polythene(LDPE)	Packaging, especially bottles, toys, bags	Tough, good resistance to chemicals, flexible, fairly soft, good electrical insulator
High density polythene(HDPE)	Plastic bottles, tubing, household equipment	Hard, stiff, able to be sterilised

THERMOSETTING PROPERTIES[w2]

Plastic Names	Products	Properties
Epoxy resin	Adhesives, bonding of other material	Good electrical insulator, hard, brittle unless reinforced, resists chemicals well
Melamine formaldehyde	Laminates for work surfaces, electrical insulation, tableware	Stiff, hard, strong, resists some chemicals and strains
Polyester resin	Casting and encapsulation, bonding of other materials	Stiff, hard, brittle, good electrical insulators
Urea formaldehyde	Electrical fittings, handles and control knobs, adhesives	Stiff, hard, strong, good insulator

POLYPROPYLENE MATERIAL

- Polypropylene, a synthetic resin built up by the polymerization of propylene.
- Polypropylene is molded or extruded into many plastic products in which toughness, flexibility, light weight, and heat resistance are required.
- Polypropylene (pp), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.G., Ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes.
- Polypropylene has a variety of different unique properties that makes it invaluable in applications, where rigidity and stiffness are needed. As a result, polypropylene is used in everything from plastic containers to wall siding laminates.[W6]

CHARACTERISTIC

- Light in weight
- Excellent resistance to stress and high resistant to cracking (i.e. it has high tensile and compressive strength)
- High operational temperatures with a melting point of 160°C
- Excellent dielectric properties
- Non-toxic
- Easy to produce, assembly and an economic material
- It is often used in applications where rigidity and stiffness are needed. When polyethylene is incapable of providing mechanical properties that are specified, in many cases, it is polypropylene that takes its place. [w5]

SPECIFICATIONS OF PP MATERIAL

- Specific Gravity: 0.90
- Melting Point: 160°C
- Tensile Strength: 31.027 N/mm2
- Hardness: R95
- Rigid [w4]

LITERATURE REVIEW

Poonam G. Shukla, Gaurav P. Shukla et al. in 2013 introduced The pneumatic operated machine is most suitable for small and medium size industries. It eliminates all the drawbacks of manual machine. The productivity is increased, manual labor required is less, and problem of removal of finished product is solved because of automatic die opening mechanism. The operation is simplified. Hydraulically operated machine could solve the problem, but cost is too high to bear for small and medium sized industries. The hydraulic machine is used where large scale production is required. So pneumatic machine solves the problem very well. [1]

ERANNA. H et al. in 2014 introduced The Pneumatically operated compression molding machine is developed with low cost and well suited for production of small sized FRP composites. The FRP composites can be produced by using this machine with controlled temperature and pressure. The temperature can be controlled automatically and can be varied from atmospheric temperature to 2000 ^{o}C. The pressure can be varied from 0.1 MPa to 0.8 MPa. The tensile strength and hardness of the developed FRP composite are tested as per ASTM standard. [2]

S.J Bull et al. in 2000 introduced the Glass-filled polymers are known to produce considerable wear on the screws and barrels of injection moulding machines and several coatings and surface treatments have been used. In this paper they have developed a novel wear tester to simulate the conditions of wear which occur in the barrel of an injection moulding machine and used it to rank the coatings and surface treatments which are often used in this application. The tester concept is similar to that of the ASTM rubber wheel abrasion test except that the rubber wheel is replaced by a steel wheel heated to a fixed temperature. [3]

Egon Muller et al.in 2014 introduced that Most of industries believe in minimizing the waste of raw material in production system. This paper presents two methods of dualising the time and energy consumption in the plastic injection moulding process. Potentials for improving the process, from the viewpoints of energy and time, are highlighted. Based on the dual process analysis, improvement concepts are brought forward. The value stream mapping method can thus, while maintaining its inner logic, be extended to an energy value stream mapping method (EVSM). [4]

William Liu et al. in 2014 introduced the failure of nozzle unit in the plastic injection molding machines was discovered to be cavitation erosion, rather than corrosion. Three types of erosion pits in different size order have been discovered: a large round pit with very smooth surface are in the size range of 1–2 mm, small round overlapping pits in the pattern of parallel line are approximately 100µm, and micro erosion pits are about 5µm. These different size order erosion pits might be associated with the different size order of bubbles imploding. The root cause of the bubble formation was the alteration in surface tension and the vapour pressures. The solution to the cavitation erosion with substituting stainless steel to aluminum has been successful. [5]

A.G. Gerber et al. in 2006 introduced a unique method of coupling computational fluid dynamics (CFD) to model predictive control (MPC) for controlling melt temperature in plastic injection molding is presented. The methodology is based on using CFD to generate, via open-loop testing, a temperature and input dependent system model for multi-variable control of a three-heater barrel on an injection molding machine. Results clearly show the benefit of temperature and input dependent system models for MPC control, and that CFD can be used to dramatically reduce the time associated with open-loop testing through physical experiments. [6]

G. Lucchetta et al. in 2006 introduced that the use of recycled polymers is widespread for the injection molding of many commodity plastic parts. Recycled polymers are usually blended with virgin polymers to obtain the best trade-off between cost and low melt viscosity. This last constraint is necessary to avoid short shots and to minimize the clamp force of the required injection molding machine and, therefore, the process cost. The current industrial approach to this problem is to select the polymer blend by trial and error. In this paper a new approach to the minimization of the overall manufacturing cost is proposed. It is based on a rheological model of the blend which has been developed from experimental tests according to the mixture design technique. The approach has been validated through an industrial case study. [7]

C. Medrea et al. in 2013 introduced that the present study is focused on the failure of a die used in plastic injection moulding. The die was made from AISI H13 steel and was intended for the production of plastic cups used for the outer closure of cylindrical aluminum cans in coffee packaging. In this die corrosion damage and wide crack are observed by necked eye. Visual inspection, macro-examination and microscopic observations of representative failed parts revealed that the failure was caused by corrosion that led to the total cracking of the die. The design deficiency and improper cooling conditions generated a complex fatigue-corrosion cracking mechanism that lead to the damage of the die after half of its predicted service life. [8]

RESEARCH GAP

- Presently, the injection molding machine is manually operated. Therefore, our objective is to increase productivity at low effort without affecting the injection molding machine. But, presently manually operated injection molding machine has less accuracy and more time consuming.
- So, we are going to develop the injection molding machine by use of automation.

OBJECTIVE

- Automation of efficient plastic injection moulding machine.
- It is suitable for small part production.
- Low in cost
- It takes low effort to run and less time to produce part.
- Very effective for batch production.

FLOW PROCESS CHART OF OUR PROJECT

Start

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Study of research papers and literature review

↓

Study of plastic injection moulding machine process

↓

Market survey of Automation

↓

Design calculations of Machine Component

↓

Part modelling in software

Study of Pneumatic system

↓

Apply Pneumatic system to the machine

↓

Check quality of the output part

↓

Finish

WORK PLAN FOR PROJECT WORK

	July	Aug.	Sep.	Oct.	Nov.	Jan.	Feb.	March	April
1) Definition									
2)Research paper									
3) List of required equipment									
4) Design & calculation									
5) Automation of Machine									
6) Assembly									
7) Report writing									

DESIGN OF MACHINE COMPONENTS

A. Design of Cylinder

Following points are needed to be considered while selecting a pneumatic cylinder [6].

1. Cylinder thrust.
2. Air consumption.
3. Type of mounting.

1. Cylinder Thrust

The 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, FW = Cylinder thrust for forward stroke in kg.

FR = 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:-

$$Fw=\frac{\pi}{4} \times D^2 \times p$$

Thrust in Return stroke:-

$$Fr=\frac{\pi}{4} \times (D^2 - d^2) \times p$$

For upper cylinder (10×15cm)

$$Fw=\frac{\pi}{4} \times 10^2 \times 3.1 = 247.47 \text{ kgf}$$

$$Fr=\frac{\pi}{4} \times (10^2 - 2.5^2) \times 3.1 = 228.25\ kgf$$

For lower cylinder (2.5×10cm)

$$Fw=\frac{\pi}{4} \times 2.5^2 \times 1.7 = 8.344 \text{ kgf}$$

$$Fr=\frac{\pi}{4} \times (2.5^2 - 1^2) \times 1.7 = 7.009\ kgf$$

The aim is to reduce manual pressure which is maximum 20kg, therefore by selecting 10 bar (10.19kgf/cm2) from standard piston thrust chart. Form that 100mm dia. Cylinder is suitable, from standard table we got the values for thrusts are, 628kgs in forward stroke and 590kgs in return stroke. This values are maximum from calculated therefore design is safe.

2. Air consumption

The air consumption data for cylinder is required in order to estimate the compressor capacity.
The calculations include air consumption during forward as well as return stroke.
The theoretical air consumption calculated from following formula,
Let, CW = Air consumption for forward stroke in liters.
CR = Air consumption for return stroke in liters.
D = Diameter of piston in cm.
d = Piston rod diameter in cm
L = Stroke length in cm.
P = Air pressure in bar.

Free air consumption in liters for forward stroke:-

$$C_r = \{\frac{\pi}{4} \times D^2 \times (P + 1) \times L\} \div 1000$$

Free air consumption in liters for return stroke:-

$$C_w = \{\frac{\pi}{4} \times (D^2 - d^2) \times (P + 1) \times L\} \div 1000$$

For upper cylinder (10×15cm)

$$C_r = \{\frac{\pi}{4} \times 10^2 \times (3.1 + 1) \times 15\} \div 1000 = 4.83 \text{ Liters}$$

$$C_w = \{\frac{\pi}{4} \times (10^2 - 2.5^2) \times (3.1 + 1) \times 15\} \div 1000 = 4.53 \text{ Liters}$$

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 4.83 + 4.53 = 9.36 Liters. This much of free air consumption in number of stroke per minute is done by upper cylinder.

$$CW = \{\frac{\pi}{4} \times 2.5^2 \times (1.7 + 1) \times 10\} \div 1000 = 0.132 \text{ Liters}$$

$$CW = \{\frac{\pi}{4} \times (2.5^2 - 1^2) \times (1.7 + 1) \times 10\} \div 1000 = 0.111 \text{ Liters}$$

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 0.132 + 0.111 = 0.243 Liters. This much of free air consumption in number of stroke per minute is done by lower cylinder.

B. Design of Hexagonal bolt & nut

For mounting the cylinders 8 hexagonal nuts and bolts are used. Hexagonal nut and bolt is designed using appropriate design procedure.

Design of nut Height of nut = T =D

Width across flats, W = 1.5D + 3 mm

Angle of chamfer = 30°

Radius of chamfer = R = 1.4D

Design of bolt All parameters are same as design of nut . Length of bolt <= 5D

Fabrication of mounting plates for installing cylinder

The fabrication of mounting plates for installing cylinder is done with the plate of size 140×140×10mm for upper plate and 140×140×10mm for lower plate. The fabrication is done with electric arc welding process.

PARTS

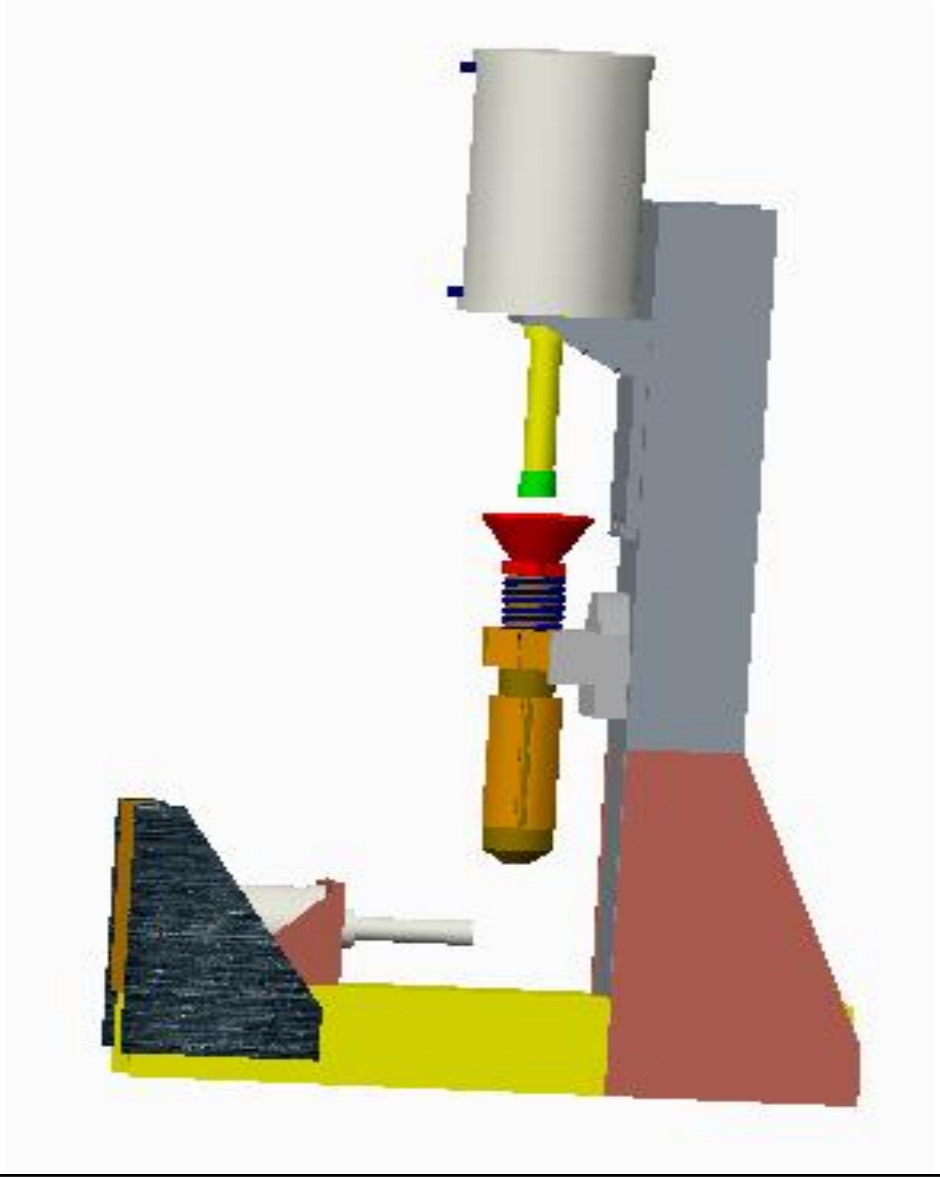
1. Body (column)
2. Pneumatic cylinder
3. Air compressor
4. Injection mechanism
5. Hopper
6. Helical compression spring
7. Heating coil
8. Flow control valve
9. Pressure Regulator

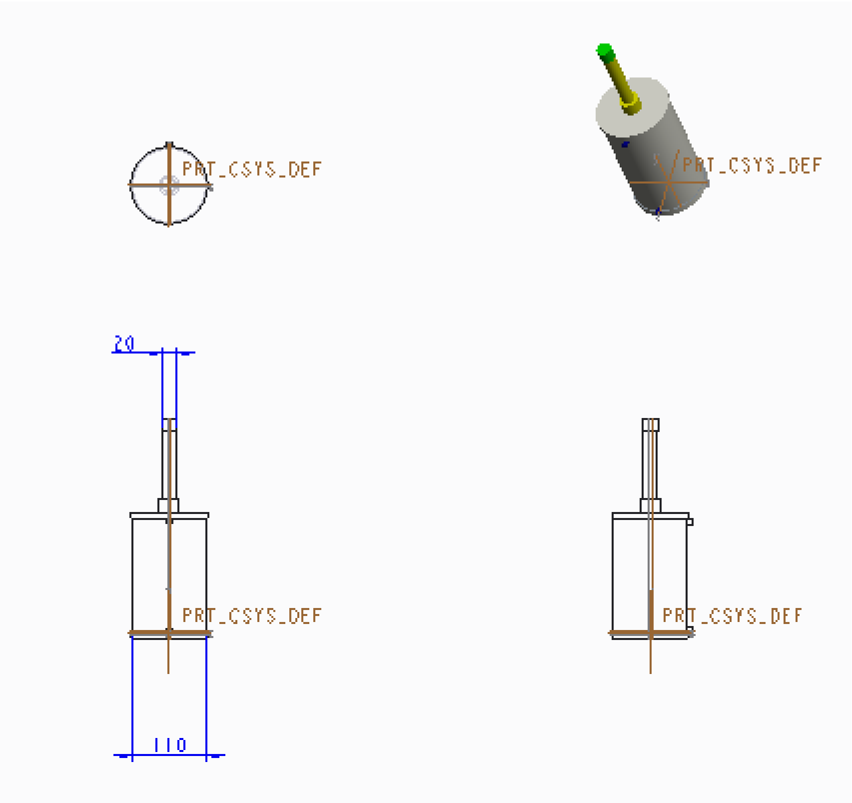
10. Temperature controller
11. 5/2 Direction control valve
12. FRL Unit
13. Die Assembly
14. Mounting table
15. Mounting plates Hexagonal nuts & bolts

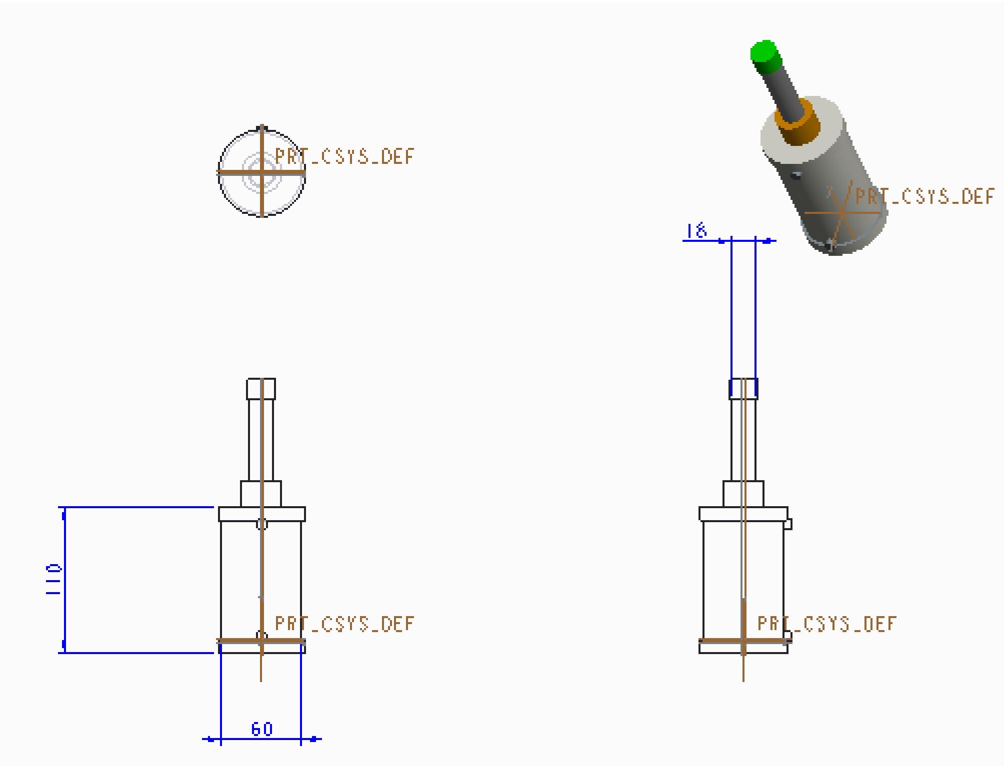
Machine Setup

Product

Complete Assembly

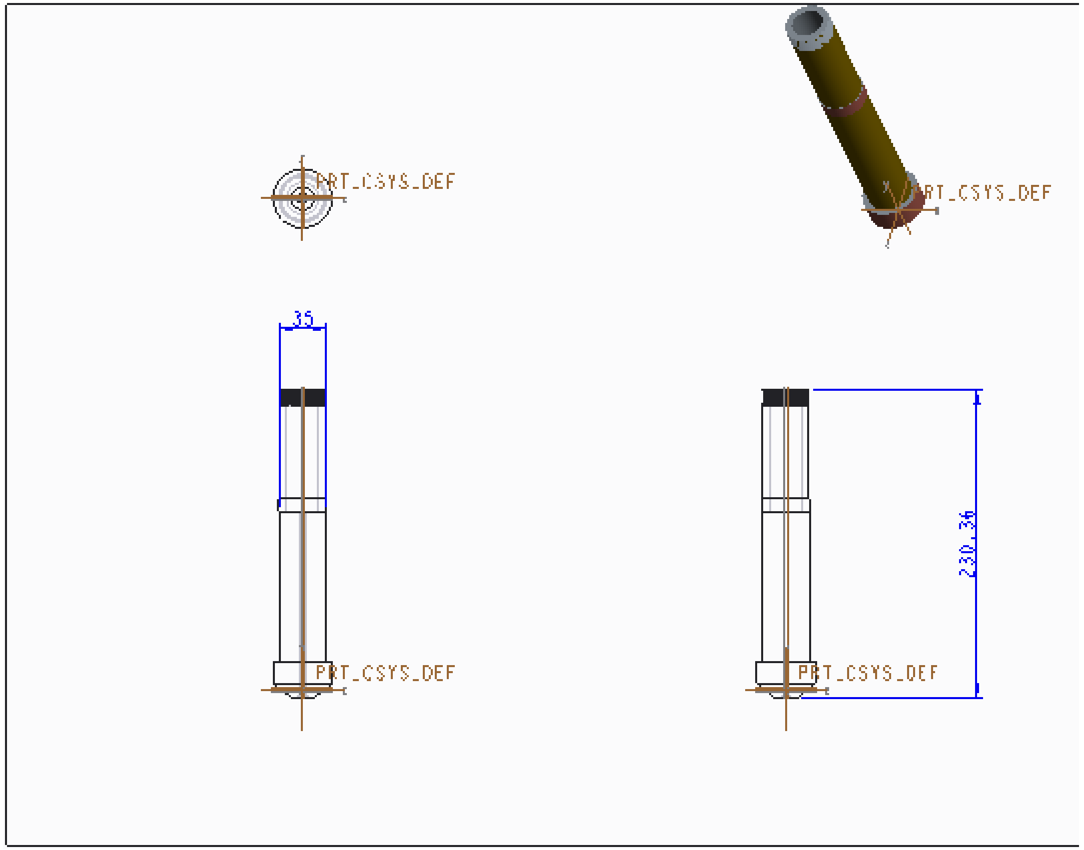




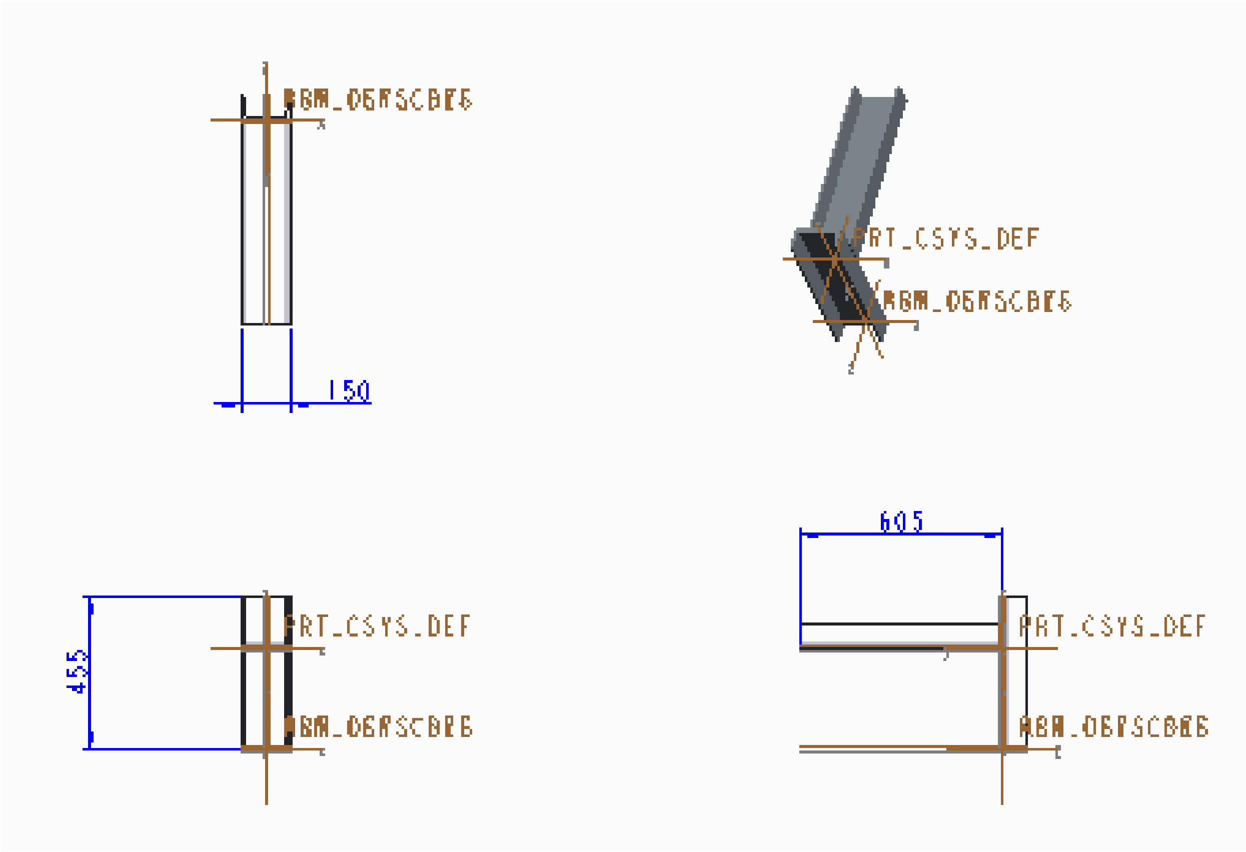


Upper Cylinder

Lower Cylinder



Barrel



Frame

ACTUATOR

Specification

Circular Diameter:-25mm,100mm

Stroke length of cylinder:-100,150mm

Pressure:-0.15-1.0Mpa

Port Size:-1/4

VARIOUS PROBLEMS AND SOLUTIONS

- Die setting
- Stop the molten material leakage in nozzle
- For Diff. die different arrangement of injection mechanism

SCOPE OF PROJECT

- In this machine cylinders are used for plunger movement and automatic opening of die. After the completion of the cycle the air moves out through the out port of 5/2D.C. valve. This air is released to the atmosphere. In future the mechanism can be developed to use this air again for the working of cylinders.

CONCLUSION

- The pneumatic operated machine is most suitable for small and medium size industries. It eliminates all the drawbacks of manual machine. The productivity is increased, manual labor required is less, and problem of removal of finished product is solved because of automatic die opening mechanism. The operation is simplified. Hydraulically operated machine could solve the problem, but cost is too high to bear for small and medium sized industries. The hydraulic machine is used where large scale production is required. So pneumatic machine solves the problem very well.

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Thank You!