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Design & Fabrication of Pneumatically Operated Plastic Injection Molding Machine

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Abstract*-The use of plastic is increased now days in many industries like automobile, packaging, medical, etc. The reason behind this is that the plastic made things are quiet easier to manufacture, handle and reliable to use. So the plastic goods manufacturing industries are striving hard to produce good quality products at large scale and cheaper cost. The hydraulically operated machines solve the problem, but they are too costlier for small scale and medium scale industries. This paper deals with design and fabrication of pneumatically operated injection plastic molding machine. The manually operated machine is converted into pneumatically operated machine by applying proper design procedure.

Keywords: **Design Using CAD, Fabrication, Injection Molding, Plastic Molding.**

I. INTRODUCTION

In Pneumatically operated plastic injection moulding machine moulding operation is done with the help of compressed air. It is cheaper than hydraulic machine and more efficient as compared to manual machine. So it solves the problem of small and medium scale industries very well. In pneumatically operated plastic injection machine two pneumatic cylinders are used. One for injection of plastic and other for automatic opening of the die [4]. The finished product is too hot to touch. So automatic die opening mechanism is required [5]. The advantage of this machine is, productivity is increased as compared to manual machine, space required is less as compared to other machine, there is no problem of oil leakage and fire hazards and the cost is very less as compared to hydraulic machine. In manual machine there is a problem of automatic removal of product. This problem is solved in pneumatic machine by using pneumatic cylinder. The main components are developed using CAD NX4 software.

II. DESCRIPTION

The pneumatically operated injection plastic moulding machine is fabricated using various components. The components are pneumatic cylinders, upper cylinder(100×160mm) and lower cylinder(50×80mm), pressure regulator, 5/2 direction control valve, flow control valve, FRL unit, frame, barrel, temperature controller, compressor, mounting table, angle plates, Allen bolts. The upper cylinder is used for up and down motion of the plunger which injects the plastic material in to barrel. Lower cylinder is used for automatic opening of the die. In manual machine the provision for automatic removal of product is not present. In pneumatic machine it is made available using lower cylinder. The compressor provides compressed air to both the cylinders, which causes movement of the plunger. FRL unit is used for filtration, regulation, and lubrication of the compressed. Air filter removes all foreign materials and allow dry, clean air to flow without restriction. Once the compressor air has been properly cleaned, it is necessary to regulate it to the required level of pressure regardless of fluctuations in compressed air main line. Different pneumatic systems work efficiently at different operating pressure. Hence selection of pressure regulator of right range is important for efficient working of pneumatic system. Pneumatic automation components extensively use sealing material made out of rubber compounds. For efficient and trouble free working of these seals, they need to be oiled or lubricated to reduce friction and corrosion. To lubricate compressed air actuated equipment, the most efficient and economical method is to inject the lubricant in to the compressed air that powers this equipment. 5/2 direction control valve is used to control the direction of the air.

A. List of components

Upper cylinder
Lower cylinder
5/2 Direction control valve
FRL Unit
Flow control valve
Pressure Regulator
Die Assembly
Mounting table
Mounting plates
Hexagonal nuts & bolts

III. 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, F_W = Cylinder thrust for forward stroke in kg.
F_R = Cylinder thrust for return stroke in kg.
D = Diameter of piston in cm.

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

Thrust in Forward Stroke:-

$$F_W = \frac{\pi}{4} \times D^2 \times v$$

Thrust in Return stroke:-

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

For upper cylinder (10×16cm)

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

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

For lower cylinder (5×8cm)

$$F_W = \frac{\pi}{4} \times 5^2 \times 1.7 = 33.37\ kgf$$

$$F_W = \frac{\pi}{4} \times (5^2 - 2^2) \times 1.7 = 28.03\ kgf$$

The aim is to reduce manual pressure which is maximum 20kg, therefore by selecting 10 bar (10.19kgf/cm^2) 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,

C_W = Air consumption for forward stroke in liters.
C_R = 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:-

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

Free air consumption in liters for return stroke:-

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

For upper cylinder (10×16cm)

$$C_W = \left\{\frac{\pi}{4} \times 10^2 \times (3.1+1) \times 16\right\} \div 1000 = 5.15\ Liters$$

$$C_W = \left\{\frac{\pi}{4} \times (10^2 - 2.5^2) \times (3.1+1) \times 16\right\} \div 1000 = 4.83\ Liters$$

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 5.15 + 4.83 = 9.98 Liters. This much of free air consumption in number of stroke per minute is done by upper cylinder.

For lower cylinder (5×8cm)

$$C_W = \left\{\frac{\pi}{4} \times 5^2 \times (1.7+1) \times 8\right\} \div 1000 = 0.42\ Liters$$

$$C_W = \left\{\frac{\pi}{4} \times (5^2 - 2^2) \times (1.7+1) \times 8\right\} \div 1000 = 0.35 Liters$$

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 0.42 + 0.35 = 0.77 Liters. This much of free air consumption in number of stroke per minute is done by lower cylinder. The figure below shows the CAD model of designed cylinder

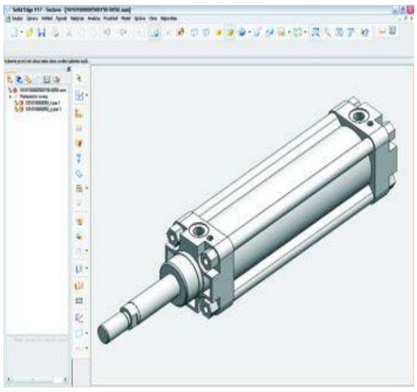

Fig 1 CAD Model of Cylinder

B. Design of Die

Upper die is the upper portion of a die set that corresponds with the lower die via blank holder and move down onto the work piece. The dimensions of the upper die and material specifications are as follows [3].

Length = 1650 mm
Width = 1170 mm
Height = 485 mm
Upper ribs = 230 * 200 mm
Side ribs = 460 * 200 mm
Material Used = High strength Steel
Density of Steel = 7.82708e-09 ton/mm^3
Poisson's ratio = 0.27
Young's Modula's = 19.98 Mpa

The Blank holder is used to prevent the edge of a sheet metal blank from wrinkling during deep drawing operations.

Length = 1650 mm
Width = 1215 mm
Height = 220 mm
Bottom ribs = 215 * 155 mm
Material Used = High strength Steel
Density of Steel = 7.82708e-09 ton/mm^3
Poisson's ratio = 0.27
Young's Modula's = 19.98 Mpa.

Lower Punch die is bottom part of the die assembly. It is the fixed part in die assembly and it is firmly fixed at the bottom.

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Width = 1215 mm
Height = 160 mm
Bottom ribs = 265 * 265 mm
Material Used = High strength Steel
Density of Steel = 7.82708e-09 ton/mm^3
Poisson's ratio = 0.27
Young's Modula's = 19.98 Mpa
The figure below shows the CAD model of designed die.

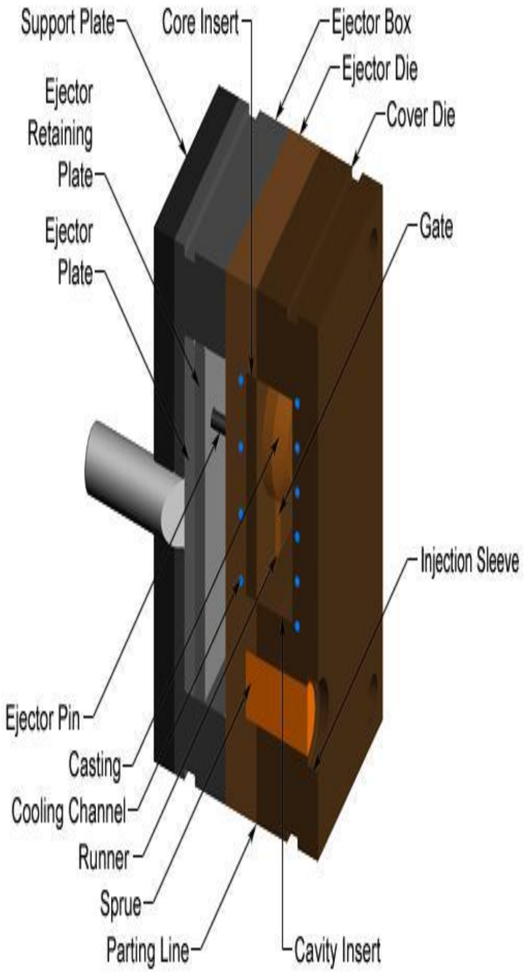

Fig 2 CAD Model of Die

C. 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

The figure 3 shows the CAD model of designed hexagonal nut and bolt.

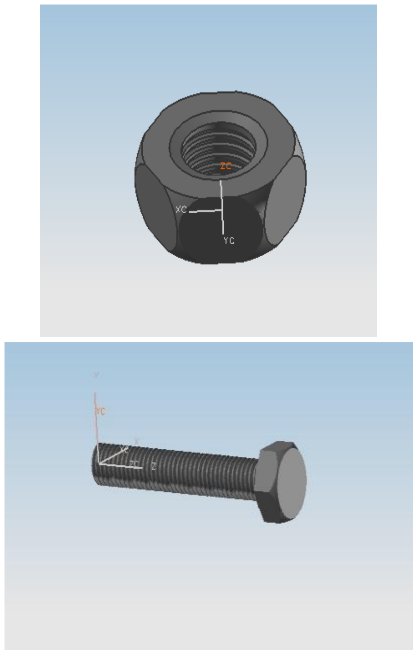

Fig 3 CAD Model of Hexagonal Nut and Bolt

IV. FABRICATION OF COMPONENTS

A. Fabrication of mounting plates for installing cylinder

The fabrication of mounting plates for installing cylinder is done with the plate of size 176.5×114.2×7mm for upper plate and 156.6×131.2×7mm for lower plate. The fabrication is done with electric arc welding process. The plates are shown in figure below.

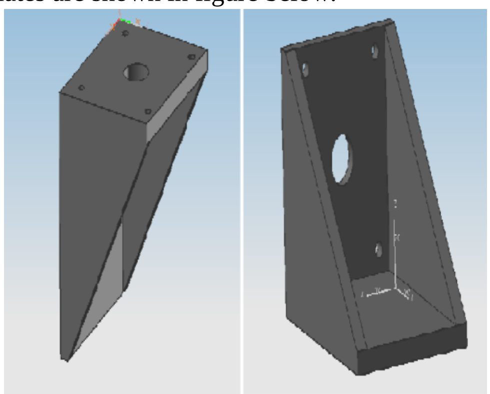

Fig 4 Cad Model of Plates Ued For Mounting Cylinders

B. Fabrication of mounting table and selection of frame

The fabrication of mounting table have been done with 35 × 3mm size of angle plate having 12 in numbers and the wooden plate is placed above the table for getting proper base to the machine. The material used is M.S. flat. Electrode arc welding is used for welding purpose. The frame of manually operated injection molding machine is used. The figure below shows the CAD model of the table and frame.

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Fig 5 Table and Frame

V. ASSEMBLY

After assembly the pneumatically operated machine is as shown below.

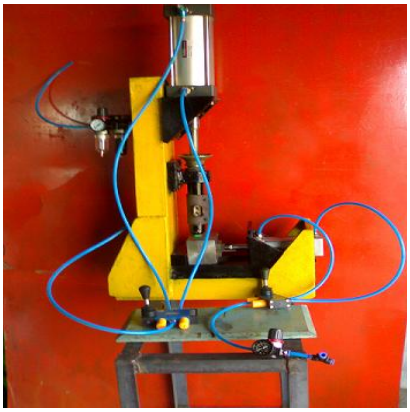

Fig6 Pneumatically Operated Injection Molding Machine

VI. WORKING

Working of pneumatic machine is as follows: Insert the plastic granules in the barrel from hopper. Heating coil is provided around the barrel which heats the plastic granules. The temperature of this heating coil can be control by dimmer of 1 amp (100^{o} c). The stopper is provided at the bottom of the barrel from its inner side to preventing molten material fall down. The stopper is attached in such a way that if pressure is provided due to the action of plunger molten material gets injected smoothly into the die. Spring is used to provide a clearance between barrel and the die. Compressor is attached to cylinder through 5/2 direction control valve which operate the cylinder. The 5/2 direction control valve is hand lever type of valve. At first stroke compressed air having pressure of 3.2 bar passes into cylinder (100×160) which pushes the plunger downward into barrel and molten material gets injected into the die. At the second stroke of cylinder (100×160) plunger moves upward. Due to removal of tension from spring, clearance is produce in between barrel and die. By using another cylinder (80×50) which also operated by 5/2 D.C. valve at a pressure of 1.7 bar attached horizontally at the bottom of frame. Die gets removed at first stroke. Due to this product falls down because of providing automatic feeding mechanism. Second stroke provided to close die and process continues.

VII. 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.

VIII. FUTURE SCOPE

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.

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