Fabrication of Portable Hydraulic Operated Compression Molding Machine With Pre-Heating Setup For Thermoset Polymers Composites

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Abstract- *Compression molding is a popular manufacturing technique for composite parts. In particular, the development of high-strength sheet molding compounds drove wide adoption of compression molding process in automotive and appliance applications. Introduction of molding materials for compression molding such as sheet molding compound and bulk molding compound are also available in the market. The presently various compression molding machines are available in different capacities & setups to obtain products of dimensionality, as it is important to optimize mold design and processing conditions, but still there is a gap in manufacturing portable machine with setups of under such categories of machines for fabrication of polymer based composites. Thus, design and fabrication of a portable hydraulically driven compression molding machine with preheat set up for polymer based composites has been done. The machine has ensured uniform load and proper distribution of matrix system has taken place, thus dimensional stability has been achieved.*

Keywords- Molding, Composite, Matrix, polymer.

I. INTRODUCTION

Compression molding is a closed-mold composite manufacturing process that uses matched metal moulds with the application of external pressure. In the compression molding process, an engineered composite layup is placed in the open mold cavity, the mold is closed, and consolidating force is applied. The pressure remains on the mold throughout the cure cycle, which usually occurs in an oven. The combination of heat and pressure produces a composite part with low void content and high fiber volume fraction—a near net shape finished component. Compression molding often yields composite parts that have the optimal mechanical properties possible from the particular combination of constituent materials.

Compression molding is a well known technique to develop variety of composite products. It is a closed molding process with high pressure application. In this method, as shown in figure 1, two matched metal molds are used to fabricate composite product. In compression molder, base plate is stationary while upper plate is movable. Reinforcement and matrix are placed in the metallic mold and the whole assembly is kept in between the compression molder.

Heat and pressure is applied as per the requirement of composite for a definite period of time. The material placed in between the molding plates flows due to application of pressure and heat and acquires the shape of the mold cavity with high dimensional accuracy which depends upon mold design. Curing of the composite may carried out either at room temperature or at some elevated temperature. After curing, mold is opened and composite product is removed for further processing.

In principle, a compression molding machine is a kind of press which is oriented vertically with two molding halves (top and bottom halves). Generally, hydraulic mechanism is used for pressure application in compression molding. The controlling parameters in compression molding method to develop superior and desired properties of the composite are shown in figure 2. All the three dimensions of the model (pressure, temperature and time of application) are critical and have to be optimized effectively to achieve tailored composite product as every dimension of the model is equally important to other one. If applied pressure is not sufficient, it will lead to poor interfacial adhesion of fiber and matrix. If pressure is too high, it may cause fiber breakage, expulsion of enough resin from the composite system. If temperature is too high, properties of fibres and matrix may get changed. If temperature is low than desired, fibres may not get properly wetted due to high viscosity of polymers especially for thermoplastics. If time of application of these factors (pressure and temperature) is not sufficient (high or low), it may cause any of defects associated with insufficient pressure or temperature. The other manufacturing factors such as mold wall heating, closing rate of two matched plates of the plates and de-molding time also affect the production process.

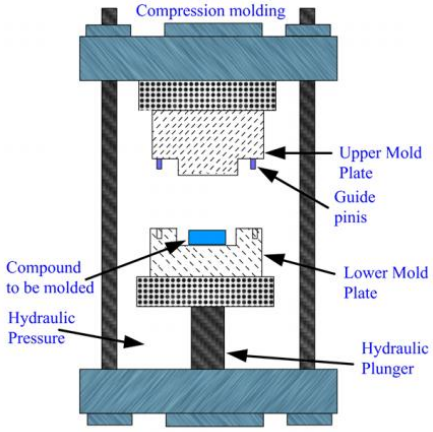

Figure.1 Compression Molding Machine

II. DESIGN ASPECTS

Product design deals with conversion of ideas into reality and, as in other forms of human activity, aims at fulfilling human needs. The project deals with a compression moulding machine to produce fiber reinforced polymer laminates of uniform thickness. The orthographic views of the portable compression moulding machine with pre-heating set-up has been shown in the figure 2 using solid edge software.

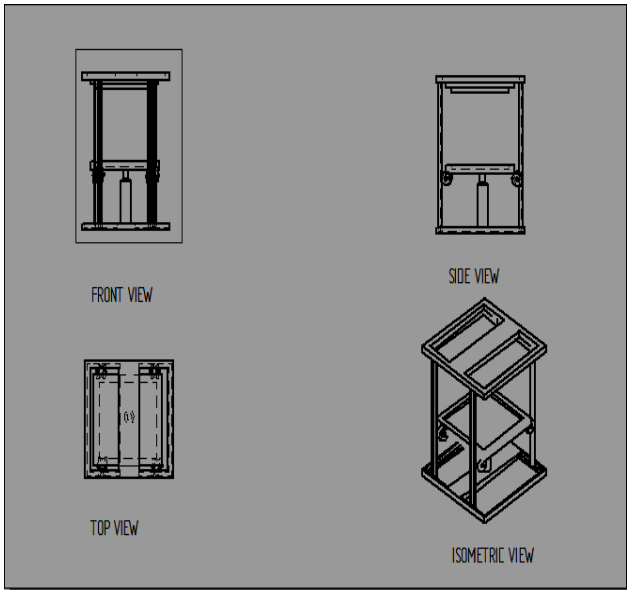

Figure 2. Orthographic Views of Compression Moulding Machine

DESIGN CALCULATIONS

- Area of the angular frame A = b * h
  = 419.1 * 533.4
  = 223.54 X 10^3 mm^2
- Volume of angular frame V = L * b * h
  =419.1 * 419.1 * 533.4
  = 93.68 X 10^6 mm^3
- Area of the male die A_m = b * h
  = 325.12 * 38.1
  = 12.38 X 10^3 mm^2
- Volume of male die V_m = L * b * h
  = 325.12 * 325.12 * 38.1
  = 4.0272 X 10^6 mm^3
- Area of female die A_f = b * h
  = 325.12 * 50.8
  =16.51 X 10^3 mm^2
- Volume of female die V_f = L * b * h
  =325.12 * 325.12 * 50.8
  =5.3697 X 10^6 mm^3
- Area of Punch A_p = b * h
  = 292.1 * 25.4
  = 7.419 X 10^3 mm^2
- Volume of punch V_p = L * b * h
  = 292.1 * 292.1 * 25.4
  = 2.1671 X 10^6 mm^3

- Angle of Angular Frame = 90^0
- Angle of Supporting V-rod = 45^0
- Clearances provided on either side of the die = 1 inches = 25.4 mm
- Area of wheels A_w = ??? Where dia D = 2.45 inches = 64.51 mm
  = π X 32.25^2
  = 3.2674 X 10^3 mm^2

Hydraulic Jack:

Piston diameter = d = 5 inch

- Area = $\pi d^2/4$ = 3.14 * 5^2 / 4 = 19.63 $inches^2$ = 498.602 mm^2
- Allowable load that can be lifted by the jack = F = 5000Kg = 5000 * 9.81 = 49050N
- Pressure exerted by the jack P = F/A = 49050 / 498.602 = 98.37 N/ mm^2

III. FABRICATION

The knowledge of manufacturing processes is of great importance for a design engineer.

Machining Processes: The processes used for giving final shape to the machine component, according to planned dimensions are known as machining processes. The common

operations used for this process are turning, planning, shaping, drilling, boring, reaming, sawing, broaching, milling, grinding, hobbing, etc.

Joining Processes: The processes used for joining machine components are known as joining processes. The common operations used for this process are welding, riveting, soldering, brazing, screw fastening, pressing, sintering, etc. Following fabrication processes were followed to manufacture machine. The table 1 shows the part list of the machine.

1. Machining
2. Welding
3. Mechanical Fastening

Table 1. Part list of the Machine.

Sl. No	Components	Quantity with its mass in kg	Dimensions & its Units
1.	Angular Machine Frame	1, 25Kg	L = 16.5 inches = 419.1mm b = 16.5 inches = 419.1mm h = 21 inches = 533.4mm
2.	Hydraulic Jack	1, 5Kg	5 Tonnes capacity
3.	Heater	1	L = 12.6 inches = 320.04mm b = 12.6 inches = 320.04mm Temperature (50°C-100°C)
4.	Male die(Punch)	1, 10Kg	L = 12.8 inches = 325.12mm b = 12.8 inches = 325.12mm h = 1.5 inches = 38.1 mm
5.	Female Die(Cavity)	1, 10Kg	L = 12.8 inches = 325.12mm b = 12.8 inches = 325.12mm h = 2 inches = 50.8mm
6.	Wheels	4	Diameter = 2.45 inches = 64.51mm
7.	Supporting V-Rod	4	L = 15mm b = 8mm h = 533.4mm

IV. WORKING OF MACHINE

The figure 3 shows the working of the portable compression moulding machine, the working and pre-setups to fabricate a fiber reinforced polymer composite laminate using portable compression moulding machine as follows: operation, firstly mixing of epoxy resin and hardner takes place, the mixture is in the ratio of 1:3. After mixing thoroughly, clean the surface of the work table using acetone solution. After cleaning, place a plastic stick file on to the surface and above it place a certain layers (about 15 layers) of glass fibres on to it. The glass fibre should be cut to the square cross section. The type of glass fiber is e glass fiber of 360gsm. Before placing the layer of glass sheet, coat the stick file with acetone and finely mixed epoxy solution. Then the single layer of glass fibre is placed above which the finely mixed epoxy-hardner solution is coated using the paint brush. Then another layer is placed and coated with the solution. This process is repeated until 15 layers of glass fiber. Depending upon the thickness the layers will vary. After placing the last layer again coat with the epoxy-hardner solution. Above which the plastic covers are placed. Then the substance is moulded using moulding machine. The substance is placed at the female die, where the die is inter-connected to the piston of the hydraulic jack. The compression molding machine is hydraulic driven. The top die or a punch is fixed to the housing of the machine structure. As the operator operates the hydraulic jack by the rod given at the side, the bottom die or a female die or a cavity die will starts moving towards top die or a male die in the upper direction. As the bottom die contacts with the top die, as a result of punch in the top die, impression will punch, the material will attain the shape of the cavity. A heater will be present beneath the bottom die as a result of which the pre-heating will be done using hydraulic compression moulding machine for easy curing. After the operation the pressure in the jack is released using knob due to which the piston will be travelling downwards as a result of which the bottom die will reach its original position.

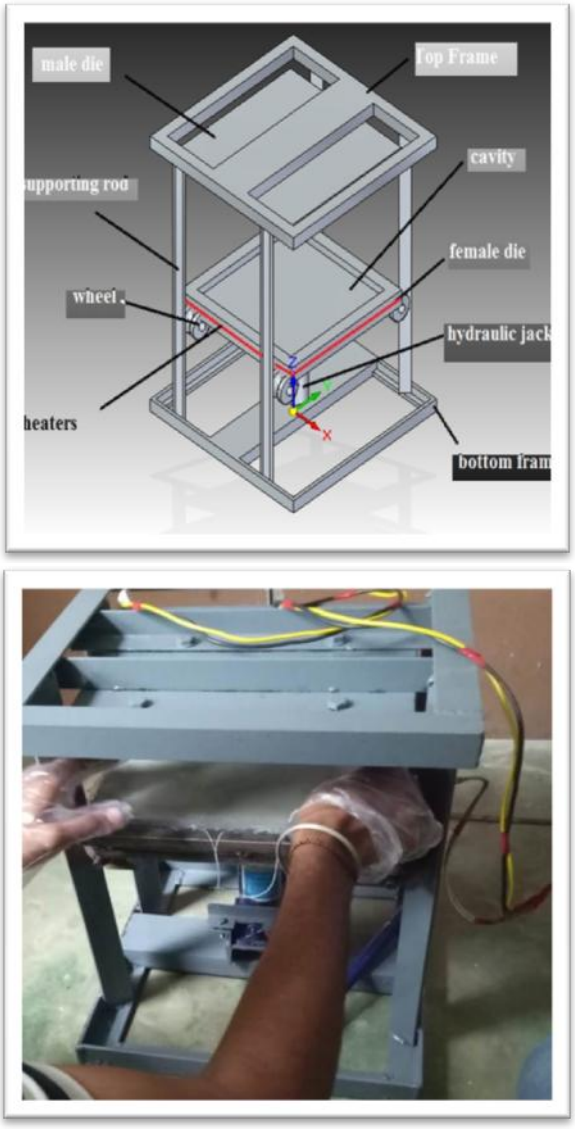

Figure 3. Portable Compression Moulding Machine

V. COSTING

Accounting the various cost of the project is an important part of the project, table 2 shows the costs involved in the project.

Table 2. Various cost involved in the Project.

Components	Cost (Rs)
Angular frame	1500
Hydraulic jack	2500
Disc	600
Male die	1200
Heater	4000
Wheels	800
Milling	1000
Labour	5000
TOTAL	Rs. 16600/-

VI. CONCLUSION

Successfully the portable compression moulding machine has been developed that is used to fabricate composite laminates. The following conclusions were drawn:

- Portable compression moulding machine can be easily handled.
- Good surface finish with different texture and styling can be achieved.
- High part uniformity is achieved with compression moulding process.
- Good flexibility in part design.
- Extra features like inserts, bosses and attachment can be moulded in during the processing.
- Raw material wastage is minimized when compared.

VII. ACKNOWLEDGEMENT

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