Design of Hydraulically Operated Compression Molding Machine for Fiber Reinforced Polymer Composite

[1]A.D. Jadhav, [2]Prof. G. S. Jagushte, [3]A.C. Turalkar, [4]O.D. Helekar, [5]A.C. Gole

[1,3,4,5]UG Student, [2]Assistant Professor, MechEnggDept, RMCET, Ambav, Maharashtra, India.

[1]aniketdj8297@gmail.com, [2]jagushteganesh99@gmail.com, [3]akashturalkar93@gmail.com,

[4]om1507h@gmail.com, [5]ashutoshgole097@gmail.com

Abstract: This paper mainly contains Fabrication of Hydraulically Operated Compression Molding Machine for Polymer Composite. Now a days, the natural fibers from renewable resources act as reinforcing material for polymer composites which alters the use of carbon, glass and other fibers. Among various fibers coconut fiber, jute, cotton are widely used natural fiber due to its advantage like easy availability, low density, low production cost and satisfactory mechanical properties. The main purpose of using this machine is to make small sized less complicated components from easily available natural fibers. Its major components parts mainly include hydraulic jack, frame, pistons and compression cylinder.

Keyword*: *Natural Fiber, Epoxy Resin, Fiber Reinforced Composite, Compression Moulding and Test Specimen

I. INTRODUCTION

Compression moulding is one of the most common processes used to mould composite material. Compression moulding machine are being used in industries for manufacturing the components of composite. Some of the machines are pneumatically operated moulding machines and some machines are hydraulically operated moulding machine. The process of compression moulding is done to step; preheating and pressuring .The hydraulic machines are used for some applications where high pressure or high load is required for manufacturing the components. Composites are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other material to serve specific purpose and exhibit desirable properties. The natural fibers composite is CO2 neutral and consume low energy for production. They are less abrasive, pleasant to handle & good to specific thermal properties. Compression moulding machine is used to prepare the FIR composites for testing. This machine is specifically designed for replacement of metal components with any other composites. The hydraulically operated compression moulding machines are most commonly found in industries. The primary advantage of process is it can mould large fairly intricate parts. Compression moulding is a method suited for moulding of high strength fiber reinforcement.

II. METHODOLOGY

1. Literature review related to different type of mold and die

2. Collect Design the project.

3. Manufacture that project by using C-channel, hydraulic system and Fasteners

4. Different machines are used for manufacturing that project for welding-electric arc welding machine, for cutting abrasive cut-off machine, for drilling use DRO drilling machine etc.

5. After that testing the specimen in firm.

Compression moulding is a well-known technique to develop a variety of composites products. In these methods the matched metal moulders used to fabricate composite product. Compression moulding is suited for moulding of complex & high strength fiber reinforcement. The cost of this moulding method is lesser than transfer moulding and injection moulding. In this method the upper plate is movable and base plate is stationery.

Reinforce element (Natural Fiber) and matrix (Epoxy) are placed in the lower die. Heat and pressure is applied as per the requirement of composite for a definite period of time. Due to application of pressure and heat, the material placed in dies/moulds flows and acquires the shape of the mold cavity. Curing of the composite may carried out either at room temperature or at some elevated temperature. After curing, mold is ejected and composite product is extracted by dismantling split die for further processing. Following factors are must be consider for compression moulding methods. [5]

- Material
- Shape
- Pressure
- Temperature
- Thickness of part
- Cycles time

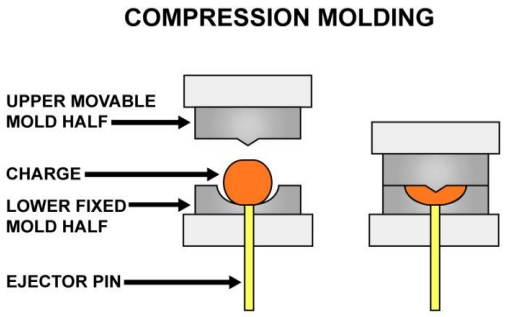

Fig 1- Compression Moulding Process

III. MATERIALS

Composite material is a material made from two or more constituent material with significantly different physical or chemical properties. Combine fiber with a thermosetting material to produce composite material with help of the composite molding technique.

Table 1: list of material

Thermosetting	Epoxy, polyester, unsaturated polyester,
Reinforcement	Natural plant fiber like cotton, sisal, jute, banana, coconut.

IV. SELECTION OF MATERIAL

4.1 RESIN

Epoxy resin have important role in composite polymer because of their superior mechanical and adhesive properties. Epoxy is versatile resins. Epoxy is either any of the basic components or cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyepoxides. Epoxy resins are thermosetting resins, which is used in hold the high performance fiber reinforcement combined with composite material and which cure by internally generated heat at certain temperature. Epoxy system consists of resins and hardener, when these two parts mixed together with causing chemical reaction and gives hardens material.

Properties and characteristics of Epoxy

The primary reason for epoxy's popularity is its superb mechanical strength.

It has excellent resistance to chemicals.

It has Low curing contraction.

It has excellent resistance to heat.

It has excellent adhesive strength.

Applications of Epoxy resins

The applications for epoxy-based materials are extensive and include coatings, adhesives and composite material. Epoxies are frequently used in aerospace and defence, chemical plant, biology and high performance automotive applications.[3]

4.2 NATURAL FIBRES

The natural fibres are directly obtained from nature. This termed as natural fibres. Natural fibres are obtained from plants, animals and mineral sources. Natural fibres are very attractive in the various composite industries. Natural or Plant fibres are usually composed of cellulose in their structural formation and are also called as vegetable fibres. The properties of natural fibres are comparable to synthetic fibres like glass fibres, carbon fibres. The advantages of natural fibres are easy availability, ease of separation, their specific strength properties, light weight, enhanced energy recovery, low density, good thermal and mechanical properties, renewability and biodegradability etc.

The properties of natural fibres can be depending on the age, source and separating techniques of the fibres. The natural fibre containing composites are more environmentally friendly and used in transportation and military applications and packaging. The ecofriendly nature of natural fibre composite should be created the most important role towards increasing the social awareness to the general consumers about the environmental problem.

Table 2: Mechanical Properties of natural fibres

Fiber name	Gauge length (mm)	Tensile strength (Mpa)	Tensile modulus (Gpa)	Elongation at break (%)
1.Cotton	-	350-500	9-15	3-10
2.Coconut	100	450-575	2-3	20- 30
3.Jute	60	393-773	10-30	1.5-1.8
4.Banana	150	570-690	17-28	3-4.3

4.2.1 COTTON

Cotton is a soft and ribbon-like natural fibre mostly composed of cellulose and that grows in a protective capsule around the seeds of cotton plant. The cotton plant can grow up to 10 m high and domesticated to range between 1-2 metres. Comparison of Cotton is weaker than other natural fibres. There is much type of varieties in cotton likes white, reddish, tawny, grey, chamois, etc. but generally used in white type variety. Considering length of the fibre is long fibres measures from 28-50 mm and short fibres measures about 18-28 mm. It is soft and can absorb moisture readily or up to 20% of its dry weight. The characteristics of cotton fibres are good resistant to alkalis and cold weak acids, good conductor of heat and is extremely susceptible to any biological degradation. The application of Cotton fibre is used as yarn and threads wide range of clothing like shirts, jeans, socks, towels etc. and also used to make paper coffee filters, tents etc.

4.2.2 COCONUT

Coconut is a natural fibre obtained from the husk of the fruit of the coconut. The fibres are material found between the hard, internal hard shell and the outer coat of a coconut. This fibre is thick and strong. This natural fibre is composed of cellulose and lignin. There are two types of coconut fibres, one brown and another white, which is depends on the nature and colour of the coconut. The brown type of coconut fibres are harvested from fully ripened coconuts and are thick, strong and high abrasion resistance. While white fibres extracted from immature coconut. These kinds of fibres are smoother, finer and weaker than the brown fibres. These fibres are ranging in length from 4-12 in (10-30 cm). These fibres are waterproof and not affect by salt water. Brown fibre is obtained by the method of harvesting fully matured coconuts Major use of these fibre is in rough manufacturing. Coconut fibre can hold large quantity of water like sponge. It is used as replacement for traditional pitting soil mixtures.

4.2.3 JUTE

Jute is extracted from the bark of the white jute plant, corchorus capsularies and small extended from tossa jute. It grows in rainy season. These are long, soft and shiny plant fibre, with length of 1-4 mm and diameter from 17-20 microns. It is one of nature's strongest vegetable fibres and a lingo-cellulosic fibre that is composed of partially plant fibre cellulose and partially wood fibre lignin. The length of the fibre depends on the climate and available soil condition. Jute is one of the most important natural fibres after cotton with high tensile strength, low extensibility and variety of uses. Jute fibre primary use is in fabrics for packaging wide range agriculture and industrial commodities that require making cloth for wrapping bales of raw cotton, sacs and coarse cloth. It is also used to make carpets, rugs, curtains, etc. jute is widely used because of its low cost.

4.2.4 BANANA

Banana fiber is a lingo-cellulosic fiber .It is obtained from the pseudo-stem of banana plant (Musa sepientum), it is bast fiber with relatively good mechanical properties. Banana Plant fiber can be easily blended with cotton fiber or synthetic fiber to produce blended fabric and textile. There are two method uses in banana fiber, Bacnis method and Loenit method. The characteristics of banana fiber has its own physical and chemical characteristics like highly strong fiber, smaller elongation, light weight, strong moisture absorption quality, absorbs as well as releases moisture very fast, its bio-degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber etc.[6]

V. CONSTRUCTION AND WORKING

Components required:

1. Hydraulic Cylinder
2. Heating Elements
3. Die According To ASTM Std.
4. Packing Material
5. Natural Fibre- Coconut Shell, Banana Fibre, Rice Husk, Jute.
6. Epoxy Material
7. Hardener

In compression moulding, uses specific amount of material (uncured resins and fibres) place into cavity of a matched mould in an open position. The mould is closed by bringing male and female halves together and pressure is applied to squeeze the composite material so it uniformly fills mould cavity. The cylinder is used for vertical and downward motion of plunger exerts the pressure on the composite material to be moulded. Epoxy and reinforced material is placed in an open heated mould cavity. The mould is closed and pressure is applied to fill the entire mould cavity. Material is removed from mould for testing and finishing.

VI. FABRICATION OF HYDRAULIC COMPRESSION MACHINE

6.1 CAD MODELS

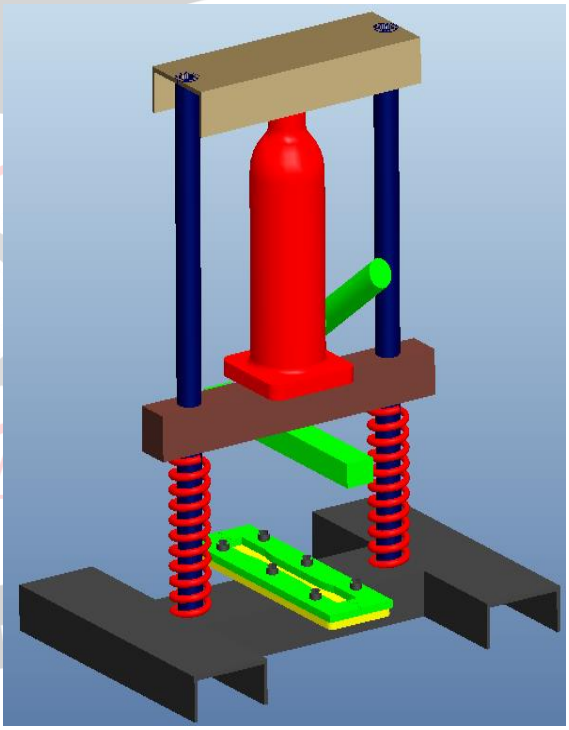

Fig. 2- CAD Model of the machine

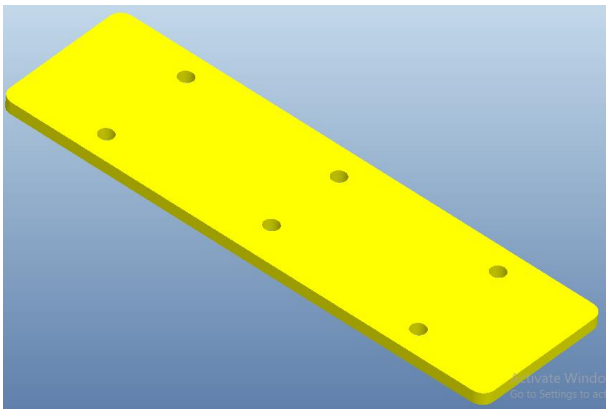

Fig. 3- CAD Model of the Base plate

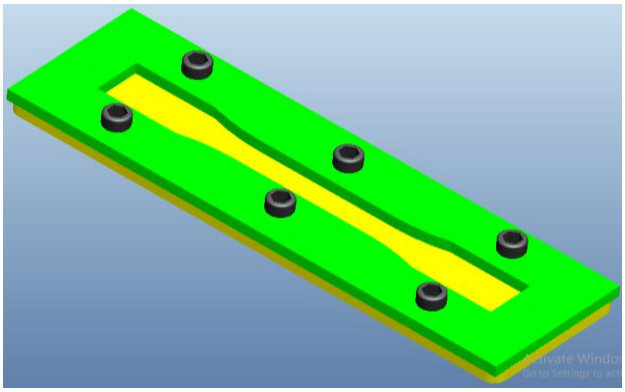

Fig. 4- CAD Model of the Die

6.2 DESIGN OF THE PARTS

Single acting cylinder:

Force exerted by single acting Hydraulic Cylinder can be expressed as

- $F = PA$
- $F = P \times \frac{\pi}{4} \times d^2$

Where,

- F = force exerted in N
- P = gauge pressure
- A = full bore area
- d = full bore piston diameter

Stiffness of helical spring

- $K = \frac{P}{\delta} = \frac{Gd^4}{8ND^3}$

Where,

- d = diameter of spring material
- D = coil mean diameter
- $D = \frac{D1+D2}{2}$
- G = shear modulus of elasticity
- N = no. of active windings
- δ = spring deflection

VII. CONCLUSION

The machine is very useful in converting natural fibers like jute, banana fibers and coconut shell to components which are used in various industrial applications. It is attempted to design a hydraulically operated compression moulding machine to manufacture specimens of different natural fibre reinforced polymer composite according to ASTM Standards to compare their mechanical properties.

REFERENCES

[1] Gbado Agidi, Tope Onatola, "Design and fabrication of hydraulically operated machine for making briquette from agricultural waste", *ISSN* 2354-4147, Vol.5 (3), pp. 121-129, March 2017.

[2] A. Manikandan, R. Rajkumar, "Evaluation of Mechanical Properties of Synthetic Fiber Reinforced Polymer Composites by mixture Design Analysis"

[3] S. Ramakrishnan, S. Joe Patrick Gnanaraj, "Machinability Studies of Jute and Cotton Reinforced Epoxy Composites", *ISSN* 2454-5392

[4] Dany Arnoldo Hernandez, "carbon fiber reinforced polymer and epoxy adhesive tensile testy failure analysis using scanning electron microscopy", May29,2017

[5] Prof. G. S. Jagushte, "fabrication of pneumatic compression moulding machine for FRP composite", *IRJET*, Vol.04, Issue07, July2017

[6] D. Chandramohan, "Review of Natural Fibers", *IJRRS*, Vol.08, Issue02, Feb2009

[7] H. Eranna, "Development of pneumatically operated moulding machine", *IRJET*, Vol.02, Issue04, 2014

[8] O. Nath, "Investigating the mechanical properties of polyster natural fiber composite", *IRJET*, Vol.04, Issue07, July2017

[9] A. S. Singha, "Mechanical properties of natural fiber reinforced polymer composite", Vol.31, Issue05, Octomber2008

