2321-8045 Science Park Research Journal Vol-1, Issue-48, 19th June 2014

Original Article

"Development Of Temperature And Pressure Variable Pneumatically Operated Compression Molding Machine"

Eranna. H

ABSTRACT

This paper deals with the Development of Temperature and Pressure variable pneumatically operated compression molding machine. The purpose of developing this machine is to prepare the FRP composite samples for testing purpose. Now adays many researchers working on composite material, during their research work they need to prepare the samples of composites with different composition at different temperature and pressure for the purpose of testing.In such cases the developed temperature and pressure variable pneumatically operated molding machine is useful for the research workers and also for the manufacturer of small sized less complicated plastic components.The low density, high strength andhigh stiffness to weight ratio, fiber reinforced composite materials are manufactured by this machine are low cost.

Keywords:

Pneumatic cylinder, thermocouple, glass, asbestos and Nichrome heating elements.

Eranna. H

From
M.Techscholor, Product Design and Manufacturing, Dept. IEM
Sri Siddhartha Institute of Technology, Tumkur, Karnataka.

The Article Is Published On June 2014 Issue & Available At www.scienceparks.in

DOI:10.9780/23218045/1202013/49

1.Introduction

The compression molding process is especially used when the density and material type required remain uniform throughout the part and will be molded all at once. There are many types of hydraulic molding machines using in industries, some of them are automatic and some of them are semiautomatic. The hydraulic machine can be used in some applications where there is a requirement of high pressure or high load for manufacturing the components, these high capacity molding machines cannot be installed in small scale industries, because the cost of the high capacity hydraulic molding machine are too expensive for the preparation of small sized FRP composite laminates and also a skilled operator is required to operate these high capacity hydraulic machine.To overcome these problems there is a need for the development of low cost pneumatically operated molding machine. This machine finds application in small scale industries for the production of FRP composites. The initial cost of machine is low and the maintenance cost is minimal.

II.Scope Of The Present Work

The purpose of this machine is to prepare FRP composites. The pressure can be varied as per the requirement and the temperature can be controlled automatically by using temperature sensors. Dies of machine can be changed as per the requirement. By changing the dies; this machine can also be used for any other pressing applications. The pressure can be varied from atmospheric pressure to 8 bars. Since the pneumatic machines uses compressed air to perform work, there is no health hazards. This machine is well suited for small scale industries and the cost is less. The working fluid need not to be stored because the air is available in nature.

III.concept Development Of Pneumatic Molding Machine

An AUTOCAD model shown in fig 1 is developed by considering the above mentioned needs of customers (researchers, small scale industries).

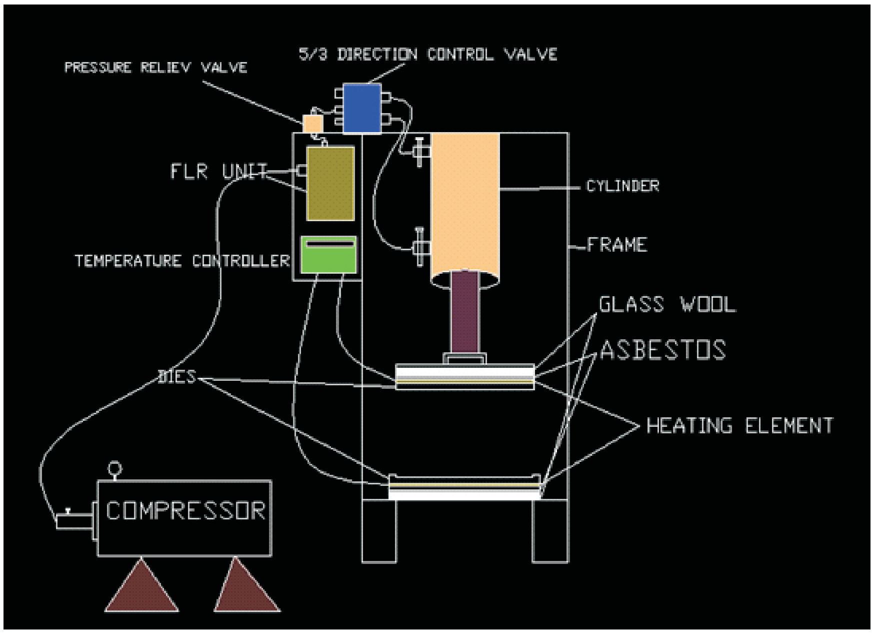

Fig 1: A CADD model of pneumatically operated pressing machine

The figure 1 shows the pneumatically operated compression molding machine. The required load can be applied by means of pressurized air. The temperature can be controlled automatically by using temperature controlling unit, pressure can be varied by using pressure controlling unit which consists of FRL unit.

IV. Design Of Machine Components.

Selection of cylinder

a). Cylinder Thrust

The cylinder thrust is a function of piston diameter, operating air pressure and the frictional resistance. The following calculation shows the minimum force that can be applied on the material by using this cylinder.

Let

P	=	Pressure	=	0.3 MPa
D	=	Diameter of bore	=	0.05 m

Thrust in Forward Stroke:-

$FW = P \pi D^2/4$

$FW = (0.3*10^6 N/m^2)\ p\ (0.05\ m^2)/4$

$FW = 589$ N.

Thrust in return Stroke:-

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

$F_R = (0.3*10^6)\ p\ (0.05^2 - 0.015^2)/4$

$F_R = 535.76$ N.

b). Air consumption

This calculation includes consumption of air during forward as well as return stroke, theoretically consumption of air can be calculated by using following formulas.

Let,

Cw= 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:

$$Cw = \{\frac{\pi}{4} \text{ x } D2 \text{ x } (P + 1) \text{ x } L\} \div 1000$$

$$Cw = \{\frac{\pi}{4} \text{ x } 25 \ (3 + 1) \text{ x } 10\} \div 1000$$

Cw =0.785 Liters

Free air consumption in liters for return stroke:

$$Cw = \{\frac{\pi}{4} \text{ x } (D2 - d2) \text{ x } (P + 1) \text{ x } L\} \div 1000$$

$$Cw = \{\frac{\pi}{4} \text{x } (25 - 2.25) \text{ x } (3 + 1) \text{ x } 10\} \div 1000$$

Cw = 0.714 Liters

Hence for one complete cycle of operation for this cylinder (i.e. forward stroke + return stroke) the free air consumption will be 0.785 + 0.714 = 1.5 Liters.

III.CONSTRUCTION AND WORKING OF MOLDING MACHINE

Pneumatically operated molding machine is developed by using following components

Pneumatic cylinder	5. Heating elements
FLR unit	6. Thermocouple
5/3 Direction control valve	7. Flow control valves
Die Material	8. Packing materials: Glass wool and Asbestos Sheet

Once the composite material is placed in shell type lower die, the upper die is closed on lower die by means of air cylinder which is controlled by 5/3 direction control valve. The required pressure is applied by using FRL unit which is provided with a pressure gauge. The heating coils are used to heat the dies and the temperature is automatically controlled by using temperature sensors, asbestos and glass wool are acts as insulating materials. Flow control valves are used to control the flow rate of air.

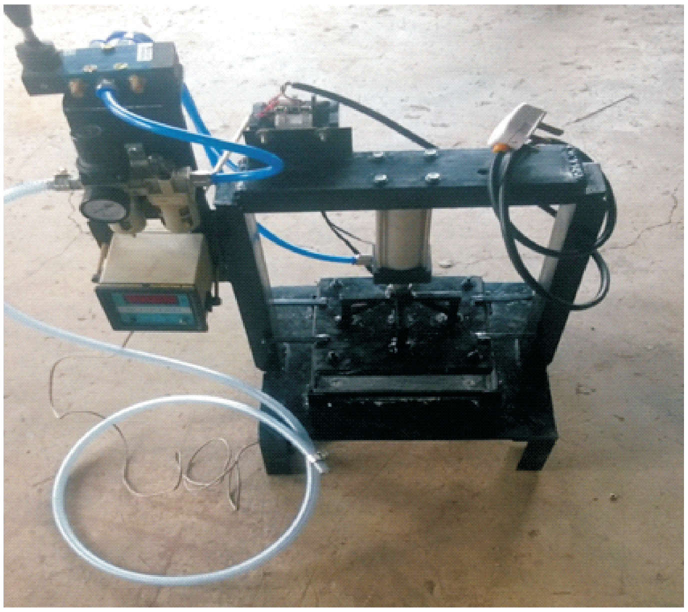

Fig 2:Working model

V.COMPOSITE MATERIAL PREPARATION

a)Thermoset Laminate

The fig 3 shows the fiber reinforced composite prepared by using pneumatically operated compression molding machine under the pressure of 0.5MPa and at the temperature of 50^0 C. The material was kept under pressure of 0.5MPa for 1 hour 30 minutes and heated under the temperature of 50^0 C for 40minutes.

Jute fiber	=	23.5%3 (layers)
Sisal fiber	=	36.4% (4 layers)
Polyvinyl alcohol	=	40%

Fig 3: Thermoset laminate

b)Thermoplastic laminate

The fig 5 shows the glass fiber reinforced composite material prepared under the pressure of 0.6MPa and at the temperature of 90^0C.The material was kept under the pressure of 0.6MPa for 2 hour and heated at 90^0C for 1 hour. The composition of material is as follows.

Matrix	-	Polypropylene	-	5 layers=	75%
Reinforcement	-	Glass Fiber	-	4 layers=	25%

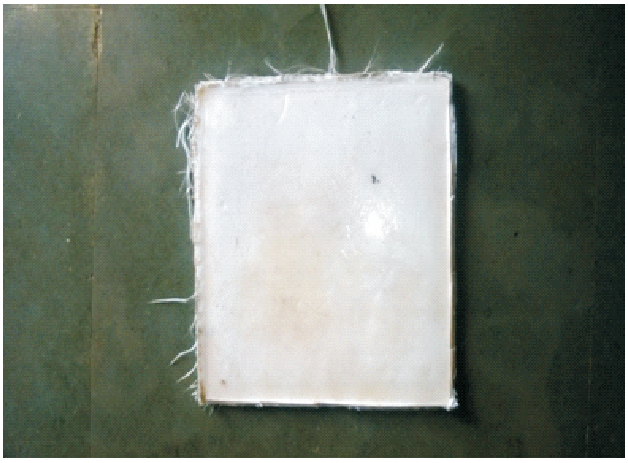

Fig 4: Thermoplastic laminate

VI.TESTING OF PREPARED FRP LAMINATES

Thermoplastic and thermoset plastics are prepared at different temperature and pressure by using developed pneumatically operated compression molding machine. The hardness test have been carried out by using 2.5mm diameter ball indenter as per ASTM E10 standard and the tensile test have been carried out by using Universal testing machine as per ASTM D638 standard.

a) Tensile test for composite 1 (Thermoset)

Width	=	24.3mm		=	0.0243m
Thickness	=	3mm		=	0.003m
F_y	=	216 kg	= 216 x 9.81	=	2119N
A_c	=	w x t	= 24.3 x 3	=	72.9 mm^2
σ_y	=	F_y / A	= 2119/72.9	=	29.0MPa
F_{max}	=	312 kg	= 312 x 9.81	=	3060.72 N
s_{max}	=	F_{max}/ A	= 3060.72 / 72.9	=	41.985MPa

b)Brinel hardness test for composite 1

$$BHN = \frac{2F}{\pi Di\left[Di-\left(\sqrt{Di2-d2}\right)\right]}$$

F	=	187.5 kg
Di	=	2.5mm
d	=	0.7mm

$$BHN = \frac{2 \times 187.5}{3.14 \times 2.5\left[2.5-\left(\sqrt{6.25-0.49}\right)\right]}$$

BHN = 477

c)Tensile test for composite 2 (Thermoplastic)

Width	=	19.4 mm		=	0.0194m
Thickness	=	7.5 mm		=	0.0075m
F_y	=	208 kg	= 208*9.81	=	2040 N
A	=	w x t	= 19.4*7.5	=	145.5 mm^2
σ_y	=	F_y / A	= 2040/145.5	=	14.02MPa
F_{max}	=	360 kg	= 360*9.81	=	3531.6 N
s_{max}	=	F_{max}/ A	= 3531.6 / 145.5	=	24.272MPa

d)Brinnel hardness test for composite 2

$$BHN = \frac{2F}{\pi Di[Di-(\sqrt{Di2-d2})]}$$

F = 187.5 kg
Di = 2.5mm
d = 0.9mm

$$BHN = \frac{2 \times 187.5}{3.14 \times 2.5[2.5-(\sqrt{6.25}-0.81)]}$$

BHN = 285

VII.COMPARISION OF RESULTS OBTAINED FROM TESTING

a) Comparison of yield strength of composite 1 and composite 2 at F_y

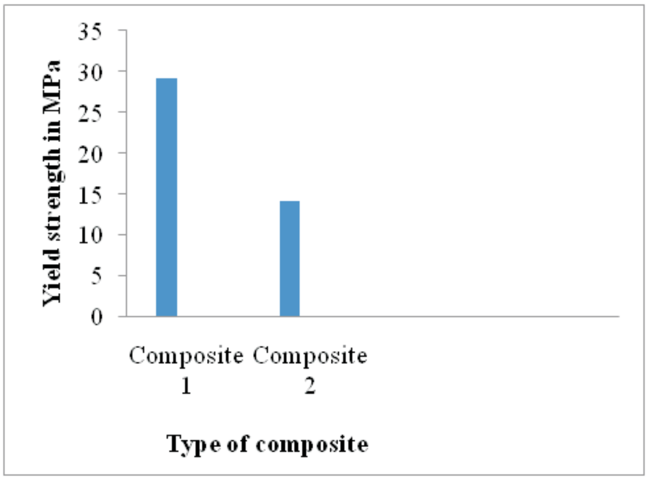

Fig 5: Yield strength of composites at F_y

The fig 5shows the yield strength of composite 1 and composite 2 at yield load.The composite 1 and composite 2 shows different tensile strength because both the composites made up of different composition. Composite 1 exhibit more yield strength than the composite 2.

b)Comparison of Ultimate strength of composite 1 and composite 2 at F_{max}

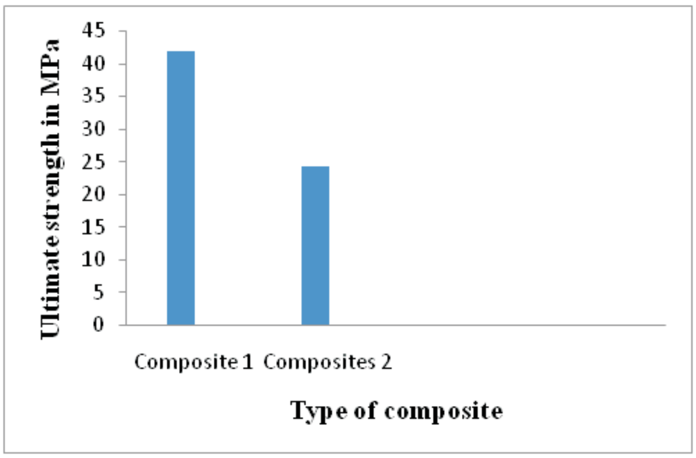

Fig 6 :Ultimate strength of composite at yield load (F_{max})

The fig 6 shows the tensile strength of composite 1 and composite 2 at maximum load.The composite 1 and composite 2 shows different ultimate strength because both the composites made up of different composition. Composite1 exhibits more tensile strength than the composite2.

a)Comparison of Hardness of composite 1 and composite 2.

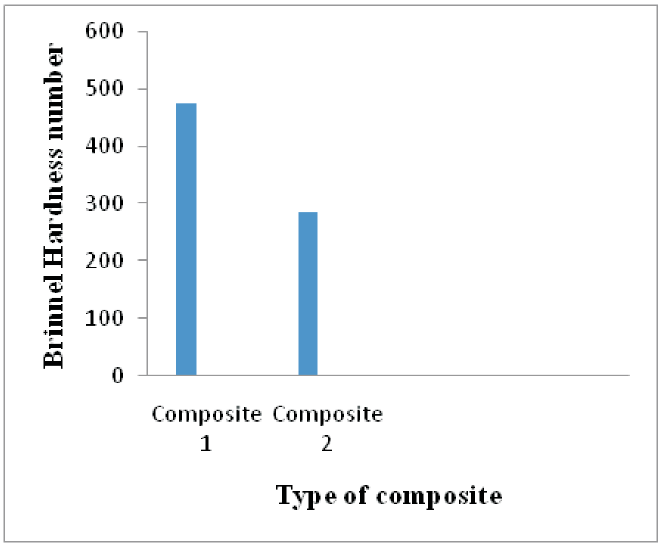

Fig 7: BHN of composites

The fig 7 shows the BHN of composite 1 and composite 2,the test is carried out at the load of 187.5 kg. The composite 1 and composite 2 shows different brinnel hardness number because both the composites made up of different composition. Composite 1 is exhibits more hardness than the composite 2.

VIII.CONCLUSION

1.The tensile strength and hardness of the developed FRP composites are tested as per ASTM standard.
2.The tensile strength and hardness of the developed FRP composites are in line with the result obtained by the other researchers.
3.FRP composite can be produced without ant air voids.
4.This machine can be used by the researchers for preparing FRP composites.
5.The temperature can be controlled automatically and can be varied from atmospheric temperature to 200^0 C.
6.The pressure can be varied from 0.1MPa to 0.8 MPa.

REFERNCES

1.Poonam G. Shukla andGaurav P. Shukla, "Design& Fabrication of Pneumatically Operated Plastic Injection Molding Machine",International Journal of Engineering and Innovative Technology (IJEIT), Volume 2, Issue 7, January 2013, PP 98-101.
2.Prof. A. R. Chaple, Prof. S.S. Khedakar, Prof. S.R. Dharmadhikari and Mr. N.R. Chaple, "Newly Developed Automatic Lay-Up Process for Manufacturing of FRP Sheets",International Journal Of Computational Engineering Research, Vol. 3, Issue 3, PP 92-97.
3.Oyetunji A. "Development of Small Injection Molding Machine for Forming Small Plastic Articles For Small-Scale Industries",Journal of Engineering Science and Technology, Vol. 5, No. 1 (2010),PP 17 – 29.
4.Martin M. Riara, Abdallah, S.Merenga, and Charles M. Migwi, "Creep and Recovery Behavior of Compression Molded LowDensity Polyethylene/Cellulose Composites",Journal of Polymers, Volume 2013, Article ID 209529, PP 1-6.
5.Felicia, O. Akerele, Nathaniel and C. Akhire, " Design and Construction of a Three- Mold Hydraulic Interlocking Brick Molding Machine",Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), Volume 4, Issue 3, Scholarlink Research Institute Journals, 2013, ISSN: 2141-7016, PP 527-532.