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Design and Fabrication of Electromagnetic Embossing Machine

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Abstract: Conventionally, many manufacturing industries embossing operation is carried out using jigs and fixtures by means of machine and this machine may be mechanical, pnuematic, hydraulic. The running cost for this machine is high and so electromagnetic embossing may be considered as the best preferable option for embossing action.In this machine electromagnetic operation is carried out using aluminium sheets and soft materials.In this electromagnet is made using copper wire and the operation is carried out using plunger core for this.The core hits the surface of the sheet and emboss the image formed on it. The sheet is passed through roller mechanism.

Keywords: Copper wire, Electromagnet, Iron core, Spring, Sheets.

1.0 INTRODUCTION

In today's practical and cost conscious world, sheet metal parts have already replaced many expensive cast, forged, and machined products. The reason is obviously then relative economy of operation, easier implementation for mass production, as well as greater control on the technical parameters. Our main aim is to develop a low cost, efficient, low power consuming embossing machine for lower capacity works like plastic embossing and aluminum foil embossing as well. Thus it creates either raised or recessed relief images and designs in paper or other materials. An embossed pattern is raised against the background. Sheet metal embossing is a stamping process for producing raised and shunken image as per the design. Embossing which is done by foil stamping is called foil embossing.

2.0 LITERATURE REVIEW

Ekta Tripathi and Pawan Chaudhary [1], a sorting and stamping machine have main task of sorting letters according to the pin codes. This method is highly efficient in sorting printed letters occupies very little space and is a one-time investment that provides invaluable future returns.

Pawan Koppa et al. [2], the idea behind this project is to develop atomize sequence of stamping using PLC in electro pneumatic stamping machine. An automatic stamping machine working on the principle of electro-pneumatics and PLC was successfully designed and developed.

Arun et al. [3], the press is the punching machine tool designed to punch blank of sheet by applying mechanical force or pressure. The presses are exclusively intended for mass production and they represent the fastest. By using PLC as the controller of the system, good control over the system can be achieved, manufacturing lead time of the system can be reduced.

Andrea Dallan [4], the cutting technologies by punching and stamping will be taken into consideration in these machining due to their similarities. The structure of the production costs and the hourly cost of punching from sheet, punching from coil and stamping with press and die has been analyzed.

Anuroop Athalye [5], the price of bought out parts are depends on their cost of manufacturing. If we analyze the scope of cost reduction in bought out parts, then it can improve the overall profit of that product. The paper is based on cost reduction techniques at supplier end for reduce overall cost of the final product & also contributes to improve in value of the product.

3.0 OBJECTIVES AND METHODOLOGY

3.1 Objectives

The main objective of this proposed work are as follows:

- To design and fabricate an electromagnetic embossing machine.

- To develop a low cost, efficient, low power consuming machine for lower capacity work like plastic embossing and aluminum foil embossing.
- To implement automation by adding roller and feeder mechanism.

3.2 Methodology

- At first cast iron frame is made with given dimension, after that it is covered with MDF (Medium Density Fiberboard) on top and bottom plate where the bottom plate supports the die which is resting on it.
- The plate is cut with saw cutter and is arranged with fixed positions with the help of studs, nuts and bolts. Similarly, bobbin is supported in the top frame of the MDF sheet. While winding copper coils in it, glass wool and laminated sheets are wound on it.
- Then plunger is allowed to pass through electromagnetic action with helical spring inserted in with. At last the embossing tool which is attached in the bottom of the plunger and is allowed to punch in the specimen placed above the die.
- The sheet is passed through roller which is driven by motor so automatic feeding can be done.

4.0 WORKING PRINCIPLE

Whenever the electricity is supplied to the electromagnet it gets magnetized and pulls the iron core at the top of the plunger unit makes the plunger moves in downward direction suddenly thus the embossing tool get pressed against the work piece thereby embossing operations is carried out and when the electrical energy is cut off the plunger regains its position using spring tension thus the embossing operation is carried out. This machine does not require electricity for return stroke. Fig. 1 represents the expected electromagnetic embossing machine model. When the electric current is supplied in the machine the copper coils get excited then electromagnetic force is generated which pulls the plunger downwards. The spring which is attached in with the plunger gets moved downward. Here the middle plate helps in controlling the force which is hitting the specimen. When the middle plate is extended towards the tool, less force is generated from the plunger and again when the middle plate is not extended further more force is generated which hits the specimen with highly generated force.

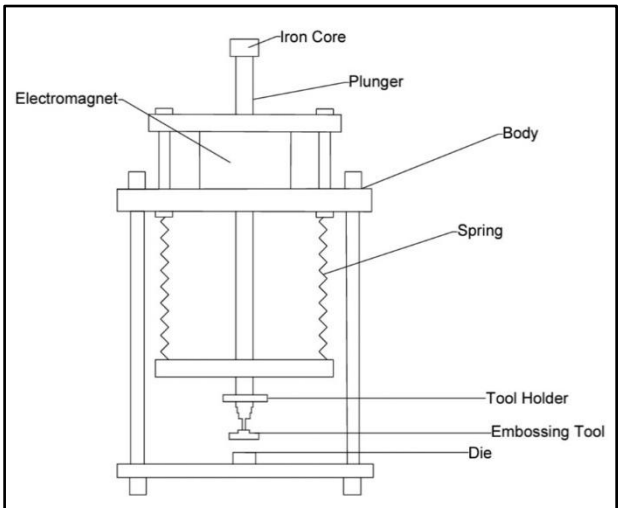

Fig. 1 Electromagnetic Embossing Machine Model

5.0 COMPONENTS

The components used in design and fabrication of electromagnetic embossing machine are as follows;

- Roller
- Copper Coils
- Bobbin
- MDF Sheets
- Plunger
- Springs
- Glass Wool
- Laminated Sheets

- Embossing Tool
- Die
- Current Source
- Battery
- Bearing
- Gear Motor
- Push Button
- Rubber Pad

6.0 FABRICATION DETAILS

The fabrication details of some of the parts of electromagnetic embossing machine are as follows:

6.1Fabrication of MDF Sheets

Two pieces of MDF sheets of large diameter is required and four holes from each corner of circular part to hold studs and nuts. The diameter of sheet for the plate is 160mm and its circular thickness is 11 mm. The inner hole diameter of this sheet is 50 mm. These MDF sheets are placed in both base frame top and bottom and after that it is fixed with nut and bolt. Similarly at the middle of the bottom plate die is fixed with nut and bolt attachment so that when plunger hits the sheet die should not jerk from its fixed position. The dimensional sketch to which sheets must be cut is shown in Fig. 2.

Fig. 2 Top Plate of MDF Sheets

6.2 Fabrication of Bobbin

The length of the bobbin is 70 mm for winding for copper. The inner circular diameter is about 51 mm and the outer circular diameter is about 150mm. The part below the lower end of bobbin spring attachment is made and is 40 mm below it. Bobbin is drilled to six different points so that the studs and nuts can be fixed and tightened with the top plate and with the middle plate as well to hold back the reciprocating motion. Here in bobbin glass wool is wrapped in properly so that no any loss take place. After that copper is winded around the bobbin. Similary, from the same point two connection of wires is taken out. Fig. 3 shows the bobbin arrangement which is made as per listed dimensions.

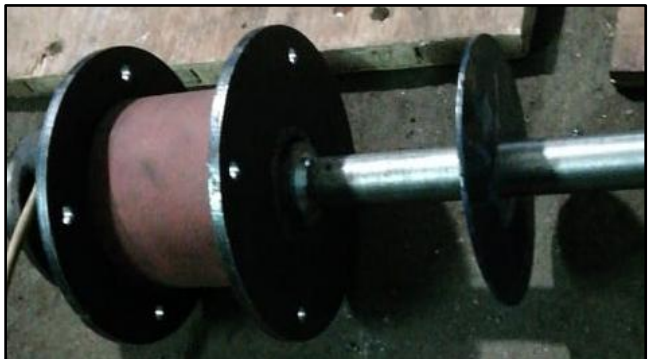

Fig. 3 Bobbin Arrangement

6.3 Fabrication of Plunger

The length of the plunger is about 160 mm long, steel rod is used in manufacturing of plunger with tool holder in attached with. Top end of the plunger is welded with iron core and bottom of the plunger is fitted with tool holder to grip embossing tool. Plunger is fitted inside with spring so that reverse motion after embossing

action takes place. The upto which the spring is fitted is 75mm on the top end with diameter 20mm and the bottom end with diameter having 12 mm till the length of 85mm. Fig 4 represents the plunger which is fitted with spring.

Fig. 4 Plunger with Spring

6.4 Fabrication of Frame Structure

The base framework of steel of dimensions 160x160x200mm is made using cast iron pipe. This support framework is from one side and the top and bottom plates are covered using 12mm MDF sheets of 160mm x 160mm size at the bottom plate supports the die. This die is used for resting the work piece. This frame is made up of steel pipe cutting with approved dimensions and welding it. The frame is drilled at the top end and bottom end of the pipe so that MDF sheets can be place with nuts and bolts. The four stands at the bottom is tightened with plastic pad. There is only two stands provided in between top and bottom plate so that no disturbances occur in between loading of sheets. The outer frame structure is shown in Fig. 5.

Fig. 5 Frame of Model

6.5 Fabrication of Embossing Tool

Embossing tool of different shapes and engraving designs are attached in tool holder and underneath that aluminum foil is kept where the embossing action need to be performed. Similarly die is kept so that no any distraction on the image occurs while pressing the tool against workpiece. Embossing tool is made up of hardened steel that has engraved image. This hits the surface of the aluminium sheet with high force which imparts the image formed over it. The bottom end of the tool is cylindrical in shape so that it is hold tightly with the plunger on its back end this can be removed with similar other type of tool with engraved images. Fig. 6 represents the embossing tool that is used in embossing operation on aluminium sheet.

Fig. 6 Embossing Tool with Holder Arrangement

6.6 Fabrication of Bush

This is another part that is used in bottom of the mid plate that provides grip so that plunger does not move out the setup. It is drilled from its circumference so that the bolt can be fixed on that end which grips the

tool so that holds the plunger tightly. Its outer diameter is 30 mm and its inner diameter is 20mm. Fig. 7 represents bush that is used in embossing machine.

Fig. 7 Bush

6.7 Fabrication of Roller

The rollers are usually made up of MS. There are altogether four rollers are used for passing the sheets through it. Rollers are 100 mm in length and 25 mm in diameter where bearing are fitted which is then connected with gear motor. Similarly, belt drive is used to roll the roller on other side which passes the sheet. Supporting stands are provided in the roller to hold it and then spline are made so that any thickness of the sheet can be passed over it.

Fig. 8 represents the roller used in machine.

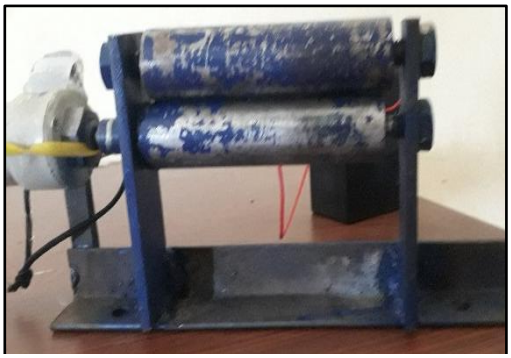

Fig. 8 Rollers with Supporting Frame

7.0 DESIGN CALCULATIONS

❖ The volume of small frame is calculated by Eq. (8.1).

V1 = l x b x h **…(7.1)**

Where,

l = length of smaller frame = 350 mm

b = breadth of smaller frame =40 mm

h = height of smaller frame =40 mm

V1 = 350 x 40 x 40

= 560000 mm^3

As there are six different frames we get V1,

V1 = 560000 x 6

= 3360000 mm^3

❖ The volume of large frame is calculated by Eq. (7.2).

V_2= l x b x h **…(7.2)**

Where,

l = length of larger frame = 450 mm

b = breadth of larger frame = 40 mm

h = height of larger frame = 40 mm

V_2 = 450 x 40 x 40

= 720000 mm^3

As there are two different frame we get V2,
Volume V_2 = 720000 x 2
= 1440000 mm3
Total Volume V= $V_1 + V_2$
= 3360000 + 1440000
= 4800000 mm^3
= 4800 cm^3

❖ The mass of steel is calculated by Eq. (7.3).

M = ρ × V **…(7.3)**

Where,
ρ = Density of Steel, 7.8 Kg/cm3
V = Total Volume
M = ρ × V
= 7.8 × 4800
= 37440 gm
= 37.44 Kg

❖ The volume of top & bottom sheet is calculated by Eq. (7.4).

V_3 = l x b x h **…(7.4)**

Where,
Material Used: MDF (Medium Density Fibre)
Density of Plate, ρ1= 840 kg/ m 3
Thickness = 10 mm
Area = 400 × 350 mm
Volume, V3 = 400 × 350 × 10 mm

❖**Electromagnet:-**

Current, I= 20 amp
Voltage, V = 220 v
No. of turns (N) = 1000
Diameter of rod (D) = 0.0508 m
The electric power, magnetic field intensity, magnetic flux density and force of an electromagnet are calculated by Eq. (7.5), Eq. (7.6), Eq. (7.7) and Eq. (7.8) respectively.

Electrical power, P = V × I **…(7.5)**

P = 220 × 20
= 4.4 Kw

Magnetic field Intensity, **H = N × I / length ...(7.6)**

H = 1000 × 20 / 0.1
= 200000 AT/m

Magnetic Flux Density, **B = H × μ o …(7.7)**

B = 200000 × 4π× 10^{-7} (μo = 4π 10^{-7})

Force , F = B2 ×A / 2 × μo ...(8.11)

= 0.2512 × 2.1 × 10-3 / 2 × 4π × 10-7
= 52.64 N

❖ The total force is calculated by Eq. (8.12).

Total force = Electromagnetic force + Self weight …(7.8)

= 52.64 + 19.52
= 72.16 N

8.0 RESULTS

Table 1. Results of Test Conducted

Sl. No.	Operation		Results
1	Cold Embossing	(i) (ii)	0.8 mm Al sheet is embossed with 72.16 N force. 1 mm Al sheet is embossed with 72.16 N force.
2	Hot Embossing	(i)	0.5 mm depth is embossed in plastic sheet of 3 mm thickness with 72.16 N force.

9.0 ADVANTAGES DISADVANTAGES AND APPLICATIONS

The advantages, disadvantages and application are listed below:

ADVANTAGES

The advantages of electromagnetic embossing machine are:

- It is simple in construction and working.
- Its capital investment is low.
- Its running cost is low.
- It requires very low space.
- It does not require skilled labor.
- It does not require periodic checkup and maintenance.

DISADVANTAGES

The disadvantages of electromagnetic embossing machine are;

- Less production rate.
- Less accuracy in the formation of image in sheets.

APPLICATION

The application of electromagnetic embossing machine are;

- Numbers on ATM cards.
- Dog Tacks.
- Expiry and manufacturing dates on food containers.
- Wedding Cards.

10.0 CONCLUSIONS AND FUTURE SCOPE

10.1 Conclusions

The project work and testing shown that this machine, simultaneously solved some problems from various types of embossing machines there exhibiting a good integrated result. This machine was fixed in less space, requires low maintenance, does not require skilled labor has high rate of action, has longer span of time, require less capital investment and low running cost hence can be implemented in the industry to help to lower down the production cost.

Automating this unit gave a unique advantage of interfacing this unit in industrial automation. For more fast production rate and virtually endless working hours. This very basic and unique ability this machine can put itself at remarkable less in the industry.

The project work can be cost solution, work best in the industry and thus lower down production, manufacturing cost of goods thereby reduction in the cost of the product.

10.2 Future Scope of Work

The project work can be taken under several modification and researches further and some can be modified on the following basis:-

- ❖ The flux of electromagnet can be increased by increasing size of the same and by increasing the coil turns. So this modification enables this machine to emboss harder materials such as steel.
- ❖ MDF can be replaced with aluminum.
- ❖ Overall capacity can be increased.

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