Design and Fabrication of Electromagnetic Punching Machine

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Abstract- *The greatest challenge faced by an engineer is to overcome the energy wasted due to friction in any mechanical process. In a conventional punching process, mechanical or hydraulic force is used to operate the punch which involves large amounts of metal to metal contact in the drive system components, as well as inaccuracy in the control of the punching forces at the micro level. The micro punching setup is designed to punch small parts at a precisely controlled rate of power consumption and thus the process becomes a low friction, high efficiency process.*

Punching Machine is one of the principle machines in paper cutting industry & sheet metal industry. It is mainly used as the name indicates to cut strips. So we have made a machine and made it multipurpose & should be used to cut the card board , asbestos sheets, papers, foam, thin plastic sheets. The machine is simple to maintain, easy to operate. Hence we tried our hands on "Electromagnetic punching machine." Electromagnetic punching machine is working on the principle of electromagnetism. This type of punching machine is used to punch basically card board, asbestos, sheets, papers, foam, and thin plastic sheets.

Keywords- Electromagnetism, Punching Machine, Hydraulic, Fabrication, Electromagnet coil.

I. INTRODUCTION

Punching is a forming process that uses a punch press to force a tool, called a punch, through the work piece to create a hole via shearing. Punching is applicable to a wide variety of materials that come in sheet form, including sheet metal, paper, vulcanized fibre and some forms of plastic sheet. The punch often passes through the work into a die. A scrap slug from the hole is deposited into the die in the process. Depending on the material being punched this slug may be recycled and reused or discarded. Punching is often the cheapest method for creating holes in sheet materials in medium to high production volumes. When a specially shaped punch is used to create multiple usable parts from a sheet of material the process is known as blanking. In metal forging applications the work is often punched while hot, and this is called hot punching.

General types of punching machines involved are-:

1. Hydraulic Punching machine
2. Pneumatic punching machine
3. Manual Punching machine
4. Electromagnetic Punching machine

Electromagnetic Punching is metallic forming manner that uses a punch press to force a tool, known as punch. This form of punching machine is used to create a hollow in thin cork sheet, asbestos, plastic sheet and greater material as in line with the ability of electromagnet. Commonly in conventional punching method like mechanical, hydraulic and pneumatic pressure is used to operate the punch in which creates massive amount of friction. Punching is the most inexpensive technique for creating holes in sheet metallic for medium to high production prices. Electromagnetic machine is somewhat more advantageous. Friction loss is very minimum because of little or no steel- metallic touch within the force device, the pressure created per punch can be controlled precisely as it is an electrical technique, it is very compact device, fast and accurate over and over again without variation. As well as take a less time of work than the manual punching machine.

II. LITERATURE REVIEW

Mr. Yogesh D. Pethkar, Prof. A. A. Patil [1]

This paper represents the Fabrication with Design of Electromagnetic Punching Machine The objective of this project work is to design a prototype machine of punching system using electromagnetic principle. This system is designed to cut soft materials i.e. Aluminium. C Cross sectional Beams are used to design the frame. Punch with different Punching die is considered in this project work. Coils are used for storing energy which are of wire diameter 2mm. Experimental Test is conducted to study its performance. The test results shows that, these types of machines can be

implemented in all Small scale industries which results into control of accuracy of parts and Power Consumption.

Prof. Fodase G. M [2]

The author focuses on development of electromagnetic multipurpose Punching machine. These types of machines are developed for applications like paper cutting industry and sheet metal industry. Crank lever mechanism is used in collaboration with Solenoid circuit to perform the punching operation. These types of machines results into Better product quality and low amount of wear due to less metal to metal contact.

Kundan Kumar [3]

This paper develop Design and Fabrication of Auto Roll Punching Machine.The Project is based on principle of rolling mechanism using chain drive, CAM, Punches, Hoses and motor. CAM converts rotary motion to linear motion of the tool and this helps in punching operation. Thus the project work reduces manpower and production time.

Mr.M.S.Wani, Shubham Jagtap, Saurabh Kothawade [4]

Author has used the principle of Electromagnetism to create a force which is used to cut a strip. They have made this machine for 'SI Inter pack'. This machine is used to cut the cardboard, Asbestos sheet, Foam, etc. This setup helps to improve the accuracy. In this setup, Electric current is passed to coils which leads to attraction of punch and ultimately punching operation.
This is used to minimize the friction effect and reduce manpower.

Swati N. Datey, Akhilesh A. Solanke, Rajat D. Kokate, Lokesh N.Chawhan, Akash Bhoyar, Ajay Wankar[5]

The project work is based on embossing operation which is accomplished by the principle of electromagnetics. Here a plunger is used for vertical motion of tool. Various components used in this work are embossing tool, plunger, housing, electromagnet, etc. Spring is used for the purpose of retraction of tool. It has advantage over various types of machines like less capital cost, less skilled labour, can be fixed in small space, long working life, etc. The author has specifically used the model for embossing operation on very thin aluminum sheet or other soft materials.

III. PROBLEM STATEMENT

The punching of different sizes of sheets & card board is the requirements for different types of Industries. The punching is the major operation performed in industry, and to perform this operation in mass number, the man power is required which results in to high cost of production, more time required to complete the operation, affect the accuracy of product. So for automation in system we are trying to do a work on new system in punching. This paper proposes an approach that aims to provide the force required for punching by electromagnetic attraction. By manipulating electromagnetic attraction, frictional losses are drastically reduced. The electric supply can be accurately controlled to generate the correct amount of force required.

IV. DESIGN METHODOLOGY

Initially our design work started by rough sketching of machine on a page. The next step was implementing the thoughts on paper through a 3D model design. This model was further checked and analysed for stresses deformation and failure. Once the model was safe against failures, the feasible and appropriate design was finalized for fabrication.

Fig-3D model of EPM

The punching machine that we fabricated consist of punching tool and chuck to hold it, push rod, transverse plate, return springs, metal blocks and an external support structure(frame). When the setup is connected to a 230 volt, supply, the coils are supplied with electricity and the magnetic field is developed around the coil. The electromagnetic core which is within the magnetic field gets magnetized and in turn it exerts a force proportional to the electricity and attracts the block and transverse plate. The tool is held with the help of chuck. Thus when the plate moves towards the core, the push rods transmit the motion onto the punching tool with the same force developed by the electromagnet. The punching tool moves downward and punches the surface of the sheet. The tool and sheet are then separated by means of return springs. The springs are initially compressed during the forward stroke.

When the electric supply is cut off, the magnetic field ceases and after the electromagnet loses its magnetization, the spring retracts, moving the punching tool away from the work piece and the cycle is completed. The punched work piece is removed from the punching machine and another is loaded. This procedure is repeated in order to obtain subsequent punches.

V. DESIGN CALCULATIONS

• **Force required for punching-**

Let material be steel with thickness t=2mm

σ_{sh}=482.63mPa

Therefore, F=π×2×10-2×10×10-2×482.63 …….(For circular hole)

F= 30.324KN

This is force required for punching.

• **Force produced by Electromagnet-**

General power consumption of oven= 2500 to 5000 W

Current = 2500/230v = 10.869 Amp

Current required to drive the oven is only 10.869 to 21.73 (Approx.)

$$B=\frac{\mu NI}{2L}$$

μ=Permeability of core=1.256 × 10-6

N=1000 ……assume

I=10.89 Ampere

L=14 mm

Therefore, B=0.488 Wb/meter square.

$$F=\frac{B^2A}{2*\mu 0}$$

B = 0.488 Wb/meter square.

μ0= 4 π × 10^{-7}

A=0.7 × 0.9 m^2

Therefore, F=59.816 KN

This is the force produced by electromagnet

(Fproduced)max > (Frequired)max

Therefore design is ok.

• **Spring Design-**

Selecting material as stainless steel with σ_{ut}=530 N/mm2, G=75 Gpa

[τ]= 0.5*530 N/mm2=265 N/mm2

We chose the spring having,

L=110mm, D=40mm and

Number of turns=15

Assuming c=9

Therefore, d=4.44mm

$$K=\frac{Gd}{8c^3n}$$

Therefore K=3.806 N/mm.

Pcomp= K× (Li - L)

Force on spring when compressed = 3.806(110-50)= 228.36 N

$$\tau = Ks\times \frac{8Pc}{\pi d^2}$$ ….Ks =$(4C-1)/(4C-4)+0.615/C$

τ =90.04 N/ mm2< [τ]

Hence design is safe.

• Checking for buckling-

L/D=2.75<3

Hence no buckling will take place.

VI. COMPONENTS OF ELECTROMAGNETIC PUNCHING MACHINE

A. PUNCHING TOOL:

The punching tool is made of High Carbon Iron. It is used to punch the hole in the given work piece. When the work piece is kept in position, the punching tool Strikes the surface of the work piece and creates the required hole. The Chuck was used to hold the tool.

B. ELECTROMAGNET CORE AND WINDING:

The electromagnet core is made of Mild Steel. The force required for punching is obtained by manipulating the attractive force developed by the electromagnet. The Electromagnet was taken from an oven as it is much more powerful as compared to others. When electric supply is given to the electromagnet, it gets magnetized temporarily and attracts the Metal Block with great force. This force is transmitted to the punching tool, which in turn punches the work piece and creates the hole. Following this, the electric supply is cut off and the electromagnet gets demagnetized (Dimensions: Breadth=90mm, Length = 70mm).

The winding is done using copper wire. When electricity passes through these wires, it develops a magnetic field according to Faraday's left hand rule. The magnetic field produced by the winding, magnetizes the electromagnet. The force of attraction produced can be altered by adjusting the

number of turns in the winding and by adjusting the electrical supply given. This force produced is transmitted to the tool for the required punching operation (Dimensions: No. of turns/Coil = 1000, thickness of wire = 26 gauge, No. Of Coils = 2).

C. SPRING:

The spring is made of Stainless Steel 304. After the punching action, the spring is used as a return mechanism to push the punching tool up. When the tool has successfully punched the work piece, electrical supply to the electromagnet is cut off. The compressed spring now exerts force on the transverse plate and lifts it up, enabling the operator to remove the work piece and load another. Before punching, the spring keeps the transverse plate and punching tool up, so that the work piece can be loaded without hindrance (Dimensions: Outer diameter =20mm, Wire diameter =2.0mm, Height = 90mm).

D. Metal Blocks:

The Metal Block is made of Iron. Iron was chosen as it is a magnetic material. When the electromagnet gets magnetized, the metal block gets attracted to it It moves toward the electromagnet with great force and this is the force used for punching

E. Push Rod:

The punching tool is made of EN24 Steel. The function of the push rods is to transmit the force developed by electromagnetic attraction on the transverse plate to the punching tool. When the beam moves downward, the push rods move along with the beam with the same force and provides it to the punch tool which in turn punches the work piece.(Dimensions: Diameter =15mm, Length = 60mm).

Fig-: Components and parts of Machine

VII. FABRICATION PROCESS

A. Raw material purchase

The first step involved in the fabrication process is the acquirement of all the required raw materials. Mild Steel is the material used for most of the components. Iron, Ply wood and Stainless Steel is also obtained. After obtaining all the required raw materials, the various parts are machined.

B. Fabrication of rectangular components and frame

The various rectangular components like transverse Plate, top cover plate, bottom plate and side plates are machined to the required dimensions using a shaper and grinder. Then surface grinding is done to enhance the finishing of the components. Holes are drilled into the surface by the process of drilling and boring. The frame was built of mild steel and the legs were joined using welding.

C. Fabrication of cylindrical components

The various cylindrical components such as push rods and core Spring guides are machined to the required dimensions on a center lathe using turning and facing operations.

Cylindrical grinding is done on the components to improve surface finish. A heat treatment process called blackening is done to improve surface hardness.

D. Purchase of accessory parts

The readymade components such as screws, nuts, bolts, and washer are purchased from the market. Readymade springs were purchased based on the spring design. The core winding was taken readymade from the transformer of oven.

E. Fabrication of punching tool setup

The punching tool setup comprises of the punching tool and a chuck. The components are machined to the required dimensions on a center lathe by turning and facing operations.

Grinding is done to improve the surface finish and sharpness of the tool. Surface grinding is done on the punching face of the punching tool to sharpen it and improve the punching action.

F. Assembly of fabricated parts

The plates are assembled around the frame setup with the aid of screws and bolts. The electromagnetic core is placed on the top of plate and fastened using screws. The push rods are connected to the punching setup at the middle and the metal blocks. The core winding is placed around the electromagnetic core. The spring bushes and springs are placed along with washers. The transverse plate is held in place with the help of washers and screws. The ends of the wires of the core winding are connected to a 230 volt, electric supply.

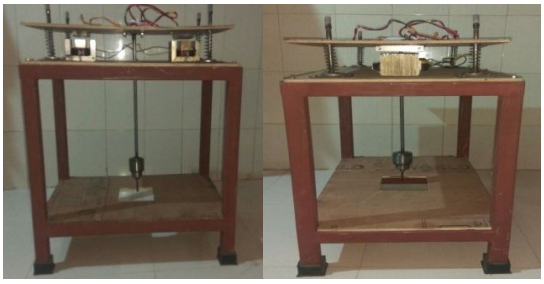

Fig-: Assembled EPM Model

VIII. CONCLUSION

The project work shows that this machine simultaneously solves some problems from various types of punching machines thereby exhibiting a good integrated result. This very basic and unique ability this machine exhibits can put itself at remarkable less in the industry. After clearing disadvantage associated with and after few further modification suggested in the relevant chapter, the project work thus execute can find its way directing in the industry for implementation. The project work being cost solution can work best in the industry and thus lower down production, manufacturing cost of goods thereby reduction in the cost of the product. Although the design criterions imposed challenging problems which, however were overcome by us due to availability of good reference books. The selection of choice raw materials helped us in machining of the various components to very close tolerance and thereby minimizing the level of wear and tear.

This machine can be fixed in less space as it is compact in size. Automating this unit gives a unique advantage of interfacing this unit in industrial automation unit. It gives fast production rate and virtually endless working hours. Does not require skilled labour as working is automated. Requires less capital investment. Requires low maintenance and has high rate of action. This very basic and unique ability and advantages can put it at remarkable use in the industry.

While concluding this report, we feel quite fulfill in having completed the project assignment well on time, we had enormous practical experience on fulfillment of the manufacturing schedules of the working project model.

IX. FUTURE SCOPE

The electromagnetic punching mechanism, though an innovative process, has potential for various improvements and innovations in the future in terms of viability for mass production, cost efficiency and performance efficiency. The following improvements and developments are suggested to transform the punching setup into a sustainable and efficient process: Therefore, we offer a scope for improvement and development of this process into a more viable one by directing future efforts into one of the following methods.

a) Using a magnet instead of a magnetic substance as of metallic block, when the current direction is reversed the magnetic force direction will also change and thereby the return stroke can be achieved without the use of a spring.
b) Different type of sensing mechanism can be used to sense the position of the tool and to turn on and off the input current supply accordingly.
c) An auto feed mechanism can be incorporated into this setup to provide greater scope for mass production. If we can accommodate the auto feed mechanism synchronized to time with the frequency of the punch stroke then punching operation can be done in less time and using less manpower and can make it viable in industries both economically and in terms of process efficiency.

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