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Short Note: MECHANICAL ENGINEERING

Design and Fabrication of Semi-Automated Punching Machine

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Abstract: During or after the university practical examination, it is mandatory to punch the records. The process of punching the records using human effort becomes tedious and also manual punching does not completely pierce the records till the end. In each session during the practical examination there will be average of 35 records and considering the college with more than 6 departments with an average of 200 students in each year, the numbers of records exceed 5000 every semester. In order to eliminate the inconvenience caused during the punching of the record note books, this design helps to save time and exclude manual labour. It uses a punching mechanism coupled with a loading and unloading assembly to punch holes in notebooks. It can also be used for multi purposes such as blanking, piercing, etc. by changing the appropriate tool for operation. It can also be used to punch sheet metals. The movement of the work is controlled by pistons and sensors. The work is secured by clamps and the punch, presses against it at a controlled pressure. The punch is again retrieved to its original position during which the clamps relieve and unload the work. The pressure is modified for different operations. Thus the project aims to reduce human effort.
Keywords:

1. INTRODUCTION

1.1. Hydraulic Punching Machine

A hydraulic punching machine is a type of machine press used to cut holes in material. It can be small and manually operated and hold one simple die set, or be very large, CNC operated, with a multi-station turret and hold a much larger and complex die set. The hydraulic punching depends on Pascal's principle the pressure throughout a closed system is constant.

Pascal's Law: Pascal's law states that pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure variations (initial differences) remain the same.

Hydraulic Punch Press: Hydraulic punch presses, which power the ram with a hydraulic cylinder rather than a flywheel, and are either valve controlled or valve and feedback controlled. Valve controlled machines usually allow a one stroke operation allowing the ram to stroke up and down when commanded. Controlled feedback systems allow the ram to be proportionally controlled to within fixed points as commanded. This allows greater control over the stroke of the ram, and increases punching rates as the ram no longer has to complete the traditional full stroke up and down but can operate within a very short window of stroke.

2. ADVANTAGES OF HYDRAULIC MACHINES

Full Power Stroke: The full power of a hydraulic press can be delivered at any point in the stroke. Not only at the very bottom, as is the case with mechanical presses.

Built-in Overload Protection: A 100-ton hydraulic press will exert only 100 tons of pressure no matter what mistakes you make in set-up. When a hydraulic press reaches its set pressure, that's all the pressure there is. The relief valve opens at that limit and there is no danger of overload.

More Control Flexibility: Hydraulic press power is always under control. The ram force, the direction, the speed, the release of force, the duration of pressure dwell, all can be adjusted to fit a particular job. Jobs with light dies can be done with the pressure turned down. The ram can be made to approach the work rapidly, then shifted to a slower speed before contacting the work. Tool life is thus prolonged. Timers, feeders, heaters, coolers, and a variety of auxiliary functions can be brought into the sequence to suit the job. Hydraulic presses can do far more than just go up and down, up and down.

Greater Versatility: A single hydraulic press can do a wide variety of jobs within its tonnage range. Commonly seen are

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deep draws, shell reductions, urethane bulging, forming, blank and pierce, stake, punch, press fits, straightening, and assembly. They are also used for powered metal forming, abrasive wheel forming, bonding, broaching, and ball sizing,

Safety: No manufacturer will claim that hydraulic presses are safer than mechanical presses. Both types of machines are designed and built to be safe if the controls and safety features built in are used properly.

3. COMPONENTS

Hydraulic Pump: Hydraulic pumps supply fluid to the components in the system. Pressure in the system develops in reaction to the load. Pumps have a power density about ten times greater than an electric motor.

*Direction Control Valves***:** Directional control valves are one of the most fundamental parts in hydraulic machinery as well and pneumatic machinery. They allow fluid flow into different paths from one or more sources. They usually consist of a spool inside a cylinder which is mechanically or electrically controlled. The movement of the spool restricts or permits the flow, thus it controls the fluid flow.

Actuator: An actuator is a type of motor that is responsible for moving or controlling a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure and converts that energy into motion. An actuator is the mechanism by which a control system acts upon an environment.

Reservoir: The hydraulic fluid reservoir holds excess hydraulic fluid to accommodate volume changes from cylinder extension and contraction, temperature driven expansion and contraction, and leaks. The reservoir is also designed to aid in separation of air from the fluid and also work as a heat accumulator to cover losses in the system when peak power is used.

Accumulators: Accumulators are a common part of hydraulic machinery. Their function is to store energy by using pressurized gas. One type is a tube with a floating piston. On one side of the piston is a charge of pressurized gas, and on the other side is the fluid. Bladders are used in other designs. Reservoirs store a system's fluid.

Hydraulic Fluid: Also known as tractor fluid, hydraulic fluid is the life of the hydraulic circuit. It is usually petroleum oil with various additives. Some hydraulic machines require fire resistant fluids, depending on their applications.

In addition to transferring energy, hydraulic fluid needs to lubricate components, suspend contaminants and metal filings for transport to the filter.

Filters: Filters are an important part of hydraulic systems. Metal particles are continually produced by mechanical components and need to be removed along with other contaminants. Filters may be positioned in many locations. The filter may be located between the reservoir and the pump intake. Blockage of the filter will cause cavitation and possibly failure of the pump.

Pistons: The main function of the piston is to separate the pressure zones inside the barrel. The piston is machined with grooves to fit elastomeric or metal seals and bearing elements. These seals can be single acting or double acting. The difference in pressure between the two sides of the piston causes the cylinder to extend and retract.

4. TYPES

1) Single stage regulator:

High pressure fluid from the supply enters into the regulator through the inlet valve. The gas then enters the body of regulator, which is controlled by the needle valve. The pressure rises, which pushes the diaphragm, closing the inlet valve to which it is attached, and preventing any more fluid from entering the regulator.

Double stage regulator:

Two stage regulators are two single stage regulators in one that operate to reduce the pressure progressively in two stages instead of one. The first stage, which is pre-set, reduces the pressure of the supply gas to an intermediate stage; gas at that pressure passes into the second stage.

Check Valve: A check valve, clack valve, non-return valve or one-way valve is a valve that normally allows fluid (liquid or gas) to flow through it in only one direction. Check valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave. There are various types of check valves used in a wide variety of applications. Check valves are often part of common household items. Although they are available in a wide range of sizes and costs, check valves generally are very small, simple, or inexpensive. Check valves work automatically and most are not controlled by a person or any external control; accordingly, most do not have any valve handle or stem. The bodies (external shells) of most check valves are made of plastic or metal. An important concept in check valves is the cracking pressure which is the minimum upstream pressure at which the valve will operate. Typically the check valve is designed for and can therefore be specified for a specific cracking pressure.

Solenoid:

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

Pressure Regulation:

The pressure regulation is the process of reduction of high source pressure to a lower working pressure suitable for the application. It is an attempt to maintain the outlet pressure within acceptable limits. The pressure regulation is performed by using pressure regulator. The primary function of a pressure regulator is to match the fluid flow with demand. At the same time, the regulator must maintain the outlet pressure within certain acceptable limits. When the valve V1 is closed and V2 is opened then the load moves down and fluid returns to the tank but the pump is dead ended and it leads to a continuous increase in pressure at pump delivery. Finally, it may lead to permanent failure of the pump. Therefore some method is needed to keep the delivery pressure P1 within the safe level. It can be achieved by placing pressure regulating valve V3. This valve is closed in normal conditions and when the pressure exceeds a certain limit, it opens and fluid from pump outlet returns to the tank via pressure regulating valve V3. As the pressure falls in a limiting range, the valve V3 closes again. When valve V1 is closed, the whole fluid is dumped back to the tank through the pressure regulating valve. This leads to the substantial loss of power because the fluid is circulating from tank to pump and then pump to tank without performing any useful work. This may lead to increase in fluid temperature because the energy input into fluid leads to the increase in fluid temperature. This may need to the installation of heat exchanger in to the storage tank to extract the excess heat.

5. COMPONENTS INVOLVED IN THE DESIGN

Frame:

Frame is the major body part of the machine which hold the other components. It is designed in such a way that it could withstand pressure up to 80 bar. The frame weight is approximately 100 kg. The frame is made up of IS 75 MS.

Motor and Reservoir:

Motor is used to actuate the fluid flow through the tubes at optimum pressure of 20 bar at 10 litres per minute. It is used to circulate the fluid through the tubes and pistons and to feed them back to the reservoir. The reservoir is mounted just above the bottom of the frame and the motor is mounted above the reservoir. The reservoir has the capacity to store 45 litres of oil. (It is filled with 40 litres of SAE 40 oil). The motor power is approximately equal to 2HP.

Solenoid Valve:

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. In the case of a two-port valve the flow is switched on or off. The voltage required to operate this valve is just 24V. Hence, we use a step-down transformer in the electrical circuit specially to operate this valve.

Pressure Regulator:

The pressure regulation is the process of reduction of high source pressure to a lower working pressure suitable for the application. It is an attempt to maintain the outlet pressure within acceptable limits. We need a peak pressure of 60 bar when the punching operation is taking place and for the next cycle we require only 20 bar pressure. Hence, in order to reduce the peak pressure a pressure regulator is used.

5/2 DC Valve:

Directional control valves are one of the most fundamental parts in hydraulic machinery as well and pneumatic machinery. They allow fluid flow into different paths from one or more sources. They usually consist of a spool inside a cylinder which is mechanically or electrically controlled. The movement of the spool restricts or permits the flow, thus it controls the fluid flow.

Piston and Cylinders:

Piston and Cylinders are the operating elements in the machine. It is actuated by the fluid flow through it. Here we are using two piston and cylinder in which one is used to provide feed mechanism and theotherpiston is used in punching operation.

Tool:

The punching can be of any shape based on the requirement. It might be a tapered section, rectangular in shape etc. Here we are using a tapered section in order to punch a hole. The tool screw's helix angle is measured to be . The tool holder is simply a groove with thread of same pitch as such of the tool. The tool clearance can be made adjustable.

Clamp and Springs:

Clamp is a member of machine which holds the job before the punching is done. The clamps are actuated by the piston itself. The springs are provided in order to resist the load offered to the job and to provide safety to the clamp.

Sensors:

A metal detector is an electronic instrument which detects the presence of the metal nearby. The sensor helps to detect the piece of the material when it reaches the spot near the sensor. Hence the sensor determines the stroke of the both the pistons. Once the metal is detected though we give manual feed the piston would not go beyond the sensor. Hence the safety of the feed piston and punching piston is obtained. The supply to the sensor is given by the electrical panel and when it senses the metal it a light glows in red colour indicating the stroke is completed. The stroke length of the piston can be modified by changing the position of the sensors.

Design Calculation:

(i) The Force required to punch the Stainless steel sheet metal:

Punching Force = π x (D-d)/2 x t x σ
D=15mm=0.0015m
d= 0.5mm=0.0005m
t= 2mm=0.002m
π=3.14
σ=482.63MPa= 4.82×10^7 kg/m^2
Punching force = 3.14 x (0.0015-0.0005)/2 x 0.002 x 4.82×10^7
Punching force = 151.42 kg = 0.15 ton
Punching force = 0.15 ton

(ii) To find the pressure required for punching operation:

Pressure= (Material thickness x Perimeter x Stress Strength)/2
Material thickness = 14mm = 0.014m
Perimeter= 2(l+b)
Where,
Length of the job = 29cm= 0.29m
Breadth of the job= 23cm= 0.23m
Perimeter=2(0.29+0.23) = 1.04m
Stress Strength=825 N/mm2= 825 x 10^6 N/m^2
Pressure = (0.014 x 1.04 x 825 x 10^6)
Pressure=60.06 x 10^5 N/m^2 = 60.06 bar
Pressure = 60.06 bar

(iii) To find the flow rate of fluid:

Flow rate = (cylinder area x stroke length)
(231 x 60 / Time in sec for 1 stroke)

Diameter of the cylinder D=50mm
Cylinder Area= (π/4) x D^2= (3.14/4) x 50^2
Cylinder Area= 1963.49mm^2
Stroke Length of the piston=2mm (minimum consideration)
Time taken in sec for one stroke=2.5 sec
Flow rate = (1963.49 x 2 x 2.5)/ (231 x 60)
Flow rate = 2.66 gpm = 10.061 Lpm (1gallon=3.78litres)
Flow rate= 10.061 lpm

(iv)To find the Horse Power required to drive the motor:

Power= flow rate x pressure per square inch x 0.0007
Flow rate= 2.66 gpm
Pressure per square inch = 1000
Power= 2.66 x 1000 x 0.0007
Power= 1.862 HP
Power= 2 HP

(v)To find the cylinder output force:

Cylinder Output force= Pressure x Cylinder Area
Pressure = 60 bar
Cylinder = 1.963 x 10^{-3}
Cylinder Output force = 60 x 10^5 x 1.963 x 10^{-3}
Cylinder Output force = 11780.97 N
Cylinder Output force = 11.780 kN

Cascade Circuit:

Cascade method is found to be the simplest and easiest method of designing hydraulic logic circuits.

Advantages of using Cascade Method:

(i) Circuit design, drawing and checking can be accomplished very quickly.
(ii) Fault diagnosis and trouble-shooting are very simple.
(iii) Required task by each cylinder and their signal elements is fully ensured.
(iv) This avoids a problem that may occur because of air becoming trapped in the pressure line to control a valve and so preventing the valve from switching.

6. FABRICATION PROCESS

Fabrication process started with formation of frame using welding of the material 75IS mild steel with respect to design dimensions. The weight of the frame is approximately 150 kg. Then the motor is mounted above the hydraulic tank which has a power of 250 HP. The tank capacity is 45 litres and it is filled with SAE 40 oil. The flow tubes are connected with respect to the piston top and bottom positions. The rail is then mounted on the frame to provide feed to the job. It has a cross section of 500mm x 300mm. Then the piston and cylinders are mounted on the frame and the sensor place is provided to determine the stroke length of the piston and punch. Then the tool is mounted in the tool holder provided above the slot. The punching piston is supported with clamps and springs in order to withstand the load of the punch. Hardened steel material is used to make the tool and it is plated with zinc in order to avoid corrosion. It also included rough grinding for fine finish of the machine. The fabrication images are also included. The fabrication process included welding, gas cutting, bending, grinding, boring, taping, and threading processes (Fig. 1).

a

b

Fig.1. Fabricated punching machine

7. COST REPORT

Generally for making a punching machine it takes minimum of one lakh. Here we have optimised it to be around Rs. 69,000.

S.no	Description	Unit	Amount in rupees
1.	Frame cost	150 Kg x 60	9000
2.	Hydraulic power pack	1	22000
3.	Hydraulic oil	40 litres	4000
4.	Hydraulic piston	2	6000
5.	Electrical circuit		10000
6.	Labour cost		8000
7.	Transport cost		7000
8	Machining Cost		3000
		Total	69000