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DESIGN & FABRICATION OF PNEUMATIC POWERED HACKSAW

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Abstract

In mass production industries and workshops, there is frequent need of cutting objects in a very quick manner so as to meet fast processing tasks. This study aims to create a proto-type Pneumatic powered hacksaw that utilizes pneumatics components to provide motion to blade, solenoid valves, an air compressor as a source of power and a programmable logic controller (PLC). This helps in reducing the overall cost of the hacksaw right from designing to manufacturing since expensive electronic circuits are not used. When compared to motorized hacksaw this pneumatic hacksaw with simultaneous and sequential pneumatic circuits is capable of performing the same task automatically with assistance of even an unskilled labour which in turn reduces the running cost of the machine.

Keywords: pneumatic cylinder, air compressor, pneumatic hacksaw, reciprocating motion, micro controller, programming.

Introduction

Pneumatic hacksaw is a metal cutting machine which uses pneumatic power to cut metals. This machine involves the use of piston cylinder arrangement and a system to provide compressed air for its working. The machine is aimed at achieving mass production along with better and efficient way of handling work piece. It is used for cutting both hard and soft metal. Pneumatic hacksaws can be either gravity fed or use hydraulic arrangement for feeding purpose. The solenoid controlled pneumatic cylinder provides a way of controlling the machine by a micro-controller, thus enabling automation to cutting operation.

Literature review:

The hacksaw is the metal cutting machine tool intended to cut the workpiece in to desired shape and size by applying pneumatic pressure. Hacksaws are used cut thin and soft metal which further goes to various secondary manufacturing operations to make a final product. Power hacksaw was invented in 1920 in the United Stated to overcome the difficulty in manual cutting. Majority of power hacksaw machines used in industries are generally electric motor driven, which requires electric power making operation costlier. The developed pneumatic hacksaw machine is driven from air compressor which supplies compressed air in the range of 4 to 6 bar.

Automation now a days plays an important role in mass production. The conventional manufacturing operation is automated to achieve certain objectives such as good product quality, increase efficiency of the plant, reduced production cost, reduced the fatigue of workers, reduced material handling and less maintenance.

Pressurised gases are used in pneumatic system to transmit and control power the medium used in these systems is essentially air. The added advantage of using air is it's availability along with its low cost. Pneumatics is having following advantages

- Pneumatic system uses air which can be freely exhausted to the surroundings without processing and hence the need of special reservoirs.
- Ease in designing pneumatic systems.
- Economical operation.
- System is easier to operate.
- Air is available free of cost
- Air is non toxic and non inflammable [1]

Pneumatics is playing a critical role in field of development and other complex automated applications. One of the requirements of pneumatic system is continuous supply of compressed air in sufficient quantity and at a pressure to operate the system. Whenever setting up of any pneumatic system is undertaken the supply of compressed air is the first and primary requirement to be fulfilled. The main part of any pneumatic system is the availability of compressed air, which can be supplied either with a rotary or reciprocating compressor. The compressor is an arrangement of elements which takes air at atmospheric pressure and delivers it at higher pressure. The capacity of compressor is the amount of air that it actually delivered after compression to the pneumatic system. The efficiency of compressor used should also be taken into account while designing a pneumatic system. The compressibility of the air was first investigated by Robert Boyle in1962, and it was found that the product of pressure and volume of a particular quantity of gas/air is constant.

This is usually written as:

$PV = C$

Or $P_1V_1 = P_2V_2$

In above equation the pressure is the absolute pressure which is about 101 KPa.

Any gas can be used in the pneumatic system, but air is the mostly used . [1]

Description of equipments used in proposed work:

The following components were used to make the power hacksaw.

1. Air compressor
2. Filter, Regulator and Lubricator (FRL) Unit
3. Solenoid valve
4. Pneumatic cylinder
5. Connectors
6. Speed control mufflers
7. Micro-controller (Arduino Uno)
8. Connecting pipes
9. Control panel [1]

Air compressor: As the name indicates it is air compressing unit which is used to raise the pressure of air to a desired limit. Air enters into the compressor at atmospheric pressure; it is then compressed by the reciprocating piston in a piston cylinder arrangement as in reciprocating compressor.[2]

FRL unit: FRL unit is used to pre-condition the air entering into the pneumatic cylinder from the compressor. It is very essential that clean air flows into the pneumatic cylinder for its efficient working and longer life. FRL unit ensures that air free from dust particles at required pressure enters into cylinder. Lubricating oil is also mixed with the air with the help of lubricator to get friction free working.[4]

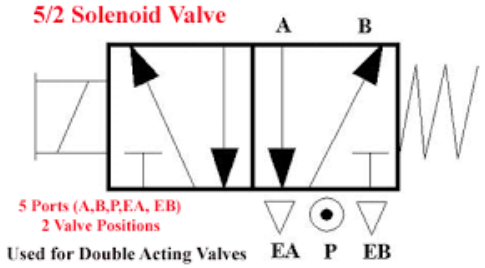
Connectors: These are the components which connects air compressor with the cylinders and solenoid valves so that flow of air can be supplied to entire pneumatic circuit. [4]

Control panel: It consists of arrangement of components which controls the operation of machine in an efficient and comfortable manner. It houses the micro-controller unit, pressure gauge and switches for turning on/off the machine.

Connecting pipes: These are the pipes through which air flows from the compressor to various pneumatic components which control the operation of machine. It is made of polyurethane.[6]

Solenoid valves: These valves control the flow of high pressure compressed air by allowing it to flow through a definite port. Solenoid valves are both manually and electrical operated and hence these can be automated.
A 5 ports 2 positions solenoid controlled valve is used to control the input and output of compressed air into the pneumatic cylinder. There are two outlet ports one side of the valve and three ports on another side, out of which one is inlet port and other two connects the outlet ports to atmosphere, each separately and therefore termed as exhaust ports. Two positions in the valve are concerned with operation of solenoid valve. In one of the positions the one of the two outlet ports is connected to inlet port and another outlet port is connected to exhaust and hence the compressed air is available at one port which can be guided to the pneumatic cylinder port.

In another position the second outlet is now connected to the inlet port and the first outlet is now connected to the exhaust. So in this position the connections are reversed and when connected to the pneumatic cylinder the piston moves in reverse direction.It is also shown in the diagram below:



a. 5/2 Solenoid valve diagram

Speed control muffler: This is a mechanical component which is used to control the rate of flow of air from any port or into the port. It can be used to control the speed of the piston during its reciprocating motion in the pneumatic cylinder due to compressed air. [1]

Micro-controller(Arduino-UNO): Arduino-Uno is a microcontroller based on ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It can be programmed using C language and can be easily used to provide cyclic analog inputs to solenoid valve for its operation.

Description of Pneumatic Hacksaw Components

Pneumatic cylinder: These are cylindrical components which converts the pneumatic power into reciprocating motion with the help of a reciprocating piston cylinder arrangement. The description of the cylinder is given below:

Piston rod- MS hard chrome plated
Piston- Aluminium
Medium- Air
Bore diameter- 25 mm
Stroke length- 250 mm, 150 mm, 50 mm
Maximum Pressure -12 bar
Operating temperature- 0˚C-85˚C
Type- Double acting

Air Compressor: An air compressor is a mechanical device which takes the ambient air at atmospheric pressure and compresses it to high pressure.
Compressor may be classified in two general types:

1. Turbo compressor

2. Positive displacement Compressor

Positive displacement compressors have more success rate over turbo compressor owing to its high compression and are widely used in industry.

The different types of positive compressors are:

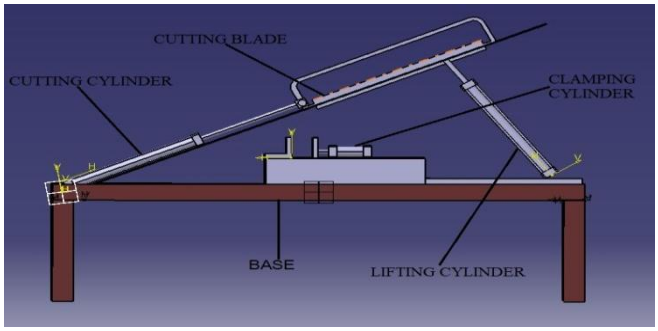
1. Reciprocating Type
2. Rotary Type

The characteristic of turbo compressors is that they are used where large capacity of air is required at low discharge pressures. The pressure developed in these compressors is inadequate to run pneumatic components and hence these are seldom used. One way in which they can be used is by multi-staging them together.[2]

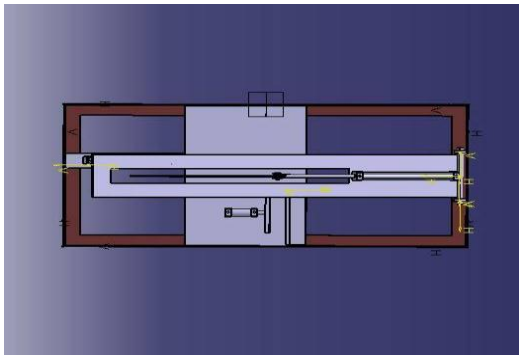
Hacksaw blade: A high speed steel blade can be used to saw a work piece. The blade is connected to the end of the piston rod of pneumatic cylinder which is in reciprocating motion with the piston. In this way the reciprocating motion of the piston can be transferred to hacksaw blade.
Automatic pneumatic vice: The vice in which the work piece is to be held during cutting is also made automatic using a pneumatic force for clamping it in the vice. A pneumatic cylinder is used to clamp the work piece between a fixed plate and another plate fixed to the end of piston rod of pneumatic cylinder. The piston rod moves outward and holds the work piece during cutting. Also the speed control mufflers are used to provide gradual movement to the piston rod so that it does not strike the work piece.

Design and Drawings of Machine

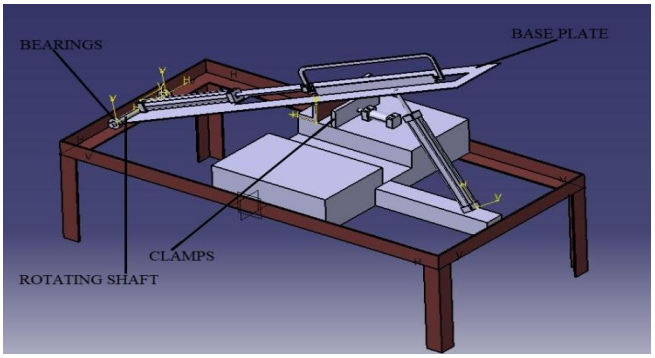
Drawings of Pneumatic hacksaw machine: The pneumatic hacksaw machine when viewed from different angles is shown below:



b. Front view



c. Top view



d. Isometric view

The above shown views of the machine are drawn on mechanical designing software CATIA-V5.

Designing calculations of machine:

a. General specification of base:

Length of base : 1000mm
Breadth of base : 500mm
Height of base : 250mm

b. Design calculations of pneumatic cylinder:

The Work piece chosen for doing calculations is Aluminum 6061 round bar having diameter 30 mm which have shear strength of 207 MPa.
Now, after going through extensive literature review it was found that force required to cut an aluminium work piece = 300 N.

$$\text{Force (F)} = \text{Pressure(p)} \times \text{Area(A)}$$
$$300 = \pi/4 \times d^2 \times p \times 10^5$$

Where, d = Diameter of pneumatic cylinder (in m)
p = Pressure required inside pneumatic cylinder (in bar)

Taking, Pressure p= 6 bar, we can find the dia d,

$$300 = \pi/4 \times d^2 \times 6 \times 10^5$$
$$d = 25 \text{ mm}$$

Taking length of cutting stroke of pneumatic cylinder = 250mm

Therefore, taking into account the results of above calculations, the best suited pneumatic cylinder specification which is available in market is (250 mm * 25 mm). Here 250mm is the stroke length of the pneumatic cylinder and 25mm is diameter of its piston.

c. Design calculation for port opening time:

The cutting velocity for machining aluminum was found to be 65 strokes per min with 8-10 inch stroke from literature which is equivalent to 0.27 m/s when 250 mm stroke length of pneumatic cylinder is considered.

Cutting velocity = Speed×Stroke length
Where, speed is in strokes per min
So, cutting velocity = 65×0.250/60
= 0.27 m/s.

Velocity of cutting blade (m/s) taking N=50 cycle per min:

$V = 2L \times N /60,$

Where L is length of stroke

$V = 2 \times 0.250 \times 50 /60$

$= 0.41$ m/s.

As, the above calculated cutting speed is greater than the speed required, therefore it can be used for cutting the aluminium work piece.

Now, Piston will have a speed of 0.41m/s and stroke of 250mm.

So, Time required by the piston to travel from one end to another can be calculated using formula:

Time, T1= Distance/ Speed

= 0.250/0.41

= 0.60975 sec.

Hence, Inlet port opening time for this cutting velocity is 0.609 sec.

Programming of Arduino

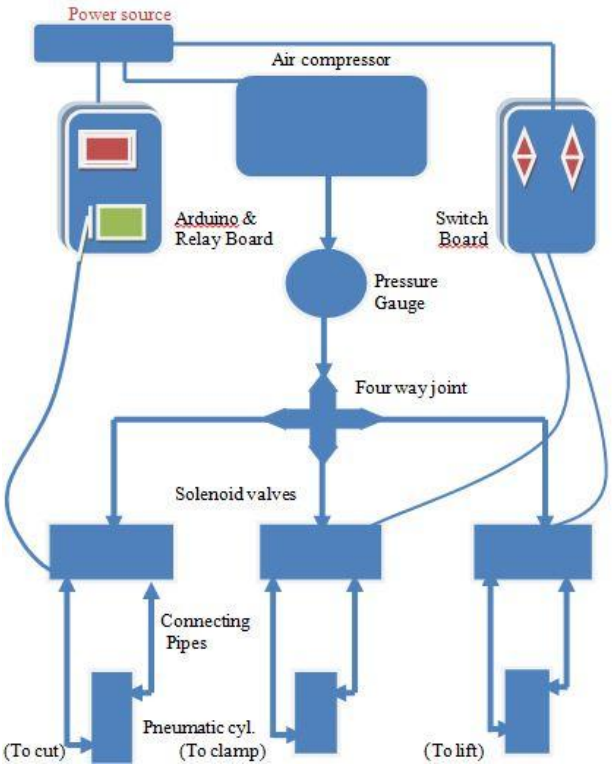
Programming for the arduino is given below-

```
void setup()
{
    pinMode(7 , OUTPUT ) ;
          // Signal output at digital bit 7

}


void loop()
{
digitalWrite(7 , HIGH ) ;
                              // Give high logic to pin 7
  delay( 60 ) ;          // Wait for 60 milliseconds
  digitalWrite( 7 , LOW ) ;
                              // Give low logic to pin 7
  delay( 60 ) ;          // Wait for 60 milliseconds

}
```

The above code is executed again and again for continuous working.

The forward and backward motion of the cutting blade during the cutting of work piece is a continuous motion which changes direction in each stroke. The Pneumatic cylinder is provided with the compressed air through one port for moving the piston of pneumatic cylinder. The solenoid valves are used for doing this purpose of controlling the compressed air supply the input ports of pneumatic cylinder. There are two out ports in the solenoid whose opening and closing is controlled using an electric signal. This electric signal can be sent from the relay which can further be controlled using a microcontroller. Here in the above code, the meaning of providing high input signal to pin is that the circuit is closed and the solenoid valve is provided with true signal and hence it rests at position corresponding to true signal. Now after 60 milliseconds, the control goes to the low output signal. This means that the relay circuit is turned off and the false valve is transferred to the solenoid valve. There solenoid valve rests at the position corresponding to the false signal. The code is repeated again and again and therefore the signal to the solenoid valves changes continuously. This changes the direction of motion of piston regularly at a certain interval.

Circuit Diagram & Working



d. Circuit diagram

The main power source of the hacksaw is compressed air from reciprocating compressor. The compressed air coming from compressor is sent to the pressure gauge where it measures the operating pressure of air to be supplied to the cylinder. The output of the pressure gauge is connected to T-joint, hence it becomes the inlet source of air to two solenoid valves. Each solenoid valve is connected to their cylinders by hose pipes. Cylinder hence can perform the function of pressing and sucking

The pressurized air from the regulator enters the pneumatic cylinder providing reciprocating motion which can be thus utilized in first cylinder by providing motion to the blades for cutting, the reciprocating motion in the second pneumatic cylinder is utilized for clamping the work piece and the third cylinder utilizes the reciprocating motion by pushing the base plate to its initial position for cutting next part of work piece.

Two switches that are present on the control panel actuate the clamping and the lifting cylinders by turning them on/off.

Fabrication

List of materials and parts with their cost is listed in the table below:

S.No.	Part Description	Quantity	Material	Cost(Rs.)
1.	Double acting pneumatic cylinder	3	Al	3350
2.	Solenoid valve	2	Al	1200
3.	Flow control valve	2	Al	200
4.	Control Unit (Arduino)	1	Electronic	150
5.	Pipes	7m	PVC	150
6.	Table	1	M.S	1000
7.	T Valve	2	Plastic	50
8.	Pressure Gauge	1	Plastic	450
9.	Ball bearing slides	2	S.S	150
10.	Ball bearing	2	High Carbon steel	120
11.	Shaft Dia:15mm, length:200mm)	1	M.S	50
12.	Base plate (1000*150mm)	1	M.S	200
13.	Pneumatic cylinder mountings	4	M.S	100
14.	Relay	1	Electronic	50
15.	HSS Blade	1	HSS	20
16.	Blade frame	1	M.S	80
Total Cost(Rs.)				7,320

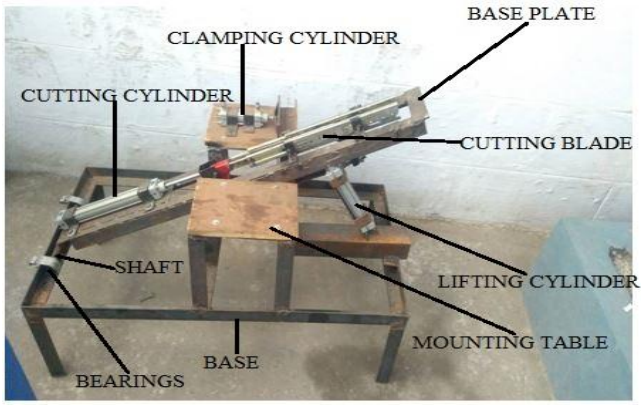
Table-1

Method of fabrication:

The fabrication of pneumatic hacksaw starts with the construction of base table.

1. Construction of base table
2. Construction of base plate
3. Construction of bearing housing and shaft
4. Construction of table for mounting workpiece
5. Preparation of clamps for holding pneumatic cylinder
6. Construction of control panel

After going through all the above listed construction phases, we will have the model of pneumatic powered hacksaw as shown:



e. Model of pneumatic hacksaw

Advantages

Some of the basic merits of the Pneumatic powered hacksaw are as follows:-

1:-Semi automatic machine, no need of man power during its working.

2:-It can work efficiently in the work environment which is not suitable for workers, like heated zone in industry, smoky gas area, toxic gases. Hence reduces life risk.

3:-Very helpful for the manufacturing industries having mass production.

4:-Reduces labour cost as only one worker can operate two or three machines simultaneously.

5:-Less power consumption as compared to other motorized power hacksaw.

6:-Once compressed air is available in the storage tank for the compressor machine can run without need of electric supply during long power cuts.

7:- Less costly than other power hacksaw.

Applications

Applications of Pneumatic powered hacksaws are:-

1:-Pneumatic hacksaw can be used in used in mass production industries for quick cutting operations.

2:- It can be used in automating the industry.

3:- It can also be used in the workshops.

4:- It can be used in locations where regular power cuts are seen.

5:- It can be used to reduce the labour cost and in areas where less labour is available.

Conclusion

The project carried out by us made an impressing task in the field of small scale industries and maintenance shops to make them automated. It is very useful for the workers to carry cutting operations with less fatigue and time. Our project is designed is to reduce the time and cutting power of the machine. It is very helpful at the place where operating condition and working environment are not so good having high temperature or smoky area where unwanted and toxic gas may be present and life risk can be reduced.

Hence, Pneumatic powered hacksaws can be very useful in modern world of automated industries.

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