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FABRICATION OF A PNEUMATIC SHEET METAL CUTTING MACHINE

Khagendra Barman [1], Md. Nesar Ali [2], Md Rayhan Hasnat [3], Dr. S. M. Humayun Kabir [4]

[1, 2, 3] Graduate, Chittagong University of Engineering & Technology (CUET), Bangladesh

[4] Professor, Chittagong University of Engineering & Technology (CUET), Bangladesh

knb.barman@gmail.com [1], nesarali455@gmail.com [2], rayhan1103082@gmail.com [3], humayun@cuet.ac.bd [4]

Abstract: *Sheet metal is simply a metal formed into thin and flat pieces. It is one of the fundamental forms used in metal working and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate. Sheet metal also has applications in car bodies, airplane wings, medical tables, roofs for buildings (Architectural) and many other things. Sheet metal of iron and other materials with high magnetic permeability, also known as laminated steel cores, has applications in transformers and electric machines. There are three primary procedures in Layout. They are Parallel, Radial, and Triangulation. The major aim to our experiment is to study about pneumatic control system, study about double acting cylinder, study about the advantage of pneumatic hand operated valve and study about high speed blade.*

Key words: Sheet Metal, Magnetic Permeability, Triangulation, Pneumatic, Valve, Cutting Machine.

1. INTTRODUCTION

Sheet metal is simply a metal formed into thin and flat pieces. It is one of the fundamental forms used in metal working and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate. Sheet metal is available in flat pieces or as a coiled strip. The coils are formed by running a continuous sheet of metal through a roll slitter. The thickness of the sheet metal is called its gauge. Commonly used steel sheet metal ranges from 30 gauge to about 8 gauge. The larger the gauge number, the thinner the metal. Gauge is measured in ferrous (iron based) metals while nonferrous metals such as aluminum or copper are designated differently; i.e., Copper is measured in thickness by ounce. [1] There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium. For decorative uses, important sheet metals include silver, gold and platinum (platinum sheet metal is also utilized as a catalyst). Sheet metal also has applications in car bodies, airplane wings, medical tables, roofs for buildings (Architectural) and many other things. Sheet metal of iron and other materials with high magnetic permeability, also known as laminated steel cores.

2. LITERATURE REVIEW

There are many sheet metal cutting processes. Laser sheet metal cutting process is one of them. Many researchers have investigated experimentally the effect of various process parameters on the different quality characteristics in the laser cutting of different categories of materials. Rajaram have found the influence of laser power and feed rate (cutting speed) on the kerf width in the laser cutting of 1.27 mm thick 4130 steel. Joseph Bramah patented the hydraulic press in 1795. While working at Bramah. Henry Mausdlay suggested a cup leather packing. Because it produced superior results, the hydraulic press eventually displaced the steam hammer from metal forging. Hydraulic power was used extensively in Bessemer steel production. Hydraulic power was also used for elevators, to operate canal locks and rotating sections of bridges. Some of these systems remained in use well into the twentieth century. Harry franklin was called the "Father of Industrial Hydraulics" by ASME. [2] Pneumatics was first documented by Hero of Alexandria in 60 A.D, but the concept had existed before then. Pneumatic devices are used in many industrial applications. Generally appropriate for applications involving less force than hydraulic applications, and typically less expensive than electric applications, most pneumatic devices are designed to use clean dry air as an energy source. A pneumatic system is a system that uses compressed air to transmit and control energy. In the big industries sheet metal cutting machines are very much important to cut the sheet metal as a large amount. As a simple pneumatic sheet metal cutting machine could not afford much in these big industries. It works for simple sheet metal cutting.

3. METHODOLOGY

The main goal of project studies is to study about pneumatic control system. Then, to study about double acting cylinder. Then, to study about the advantage of pneumatic hand operated valve. Then, to study about high speed blade. Then, to design & fabrication pneumatic sheet metal cutting machine. Then, collecting the proper components. Then, machining them. Then, assembling the all components to a proper shape. Finally, Completion the process to make a proper pneumatic sheet metal cutting machine.

3.1 Working Flow Chart:

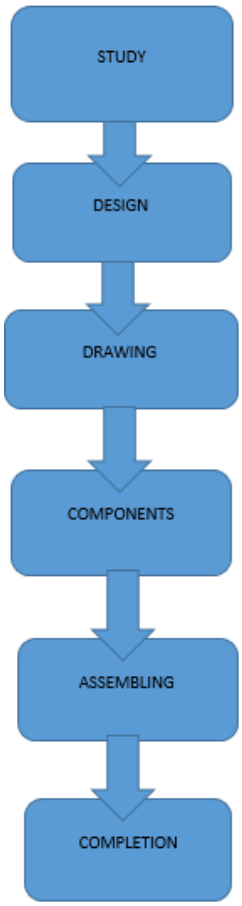

Fig 1: Flowchart for fabrication of sheet metal cutting machine.

3.2 Operation:

The most common cutting processes are performed by applying a shear force, and are therefore sometimes referred to as shearing processes. Cutting processes are those in which a piece of sheet metal is separated by applying a great enough force to cause the material to fail .When a great enough shearing force is applied, the shear stress in the material will exceed the ultimate shear strength and the material will fail and separate at the cut location. This shearing force is applied by two tools, one above and one below the sheet. Whether these tools are a punch and die or upper and lower blades, the tool above the sheet delivers a quick downward blow to the sheet metal that rests over the lower tool. A small clearance is present between the edges of the upper and lower tools, which facilitates the fracture of the material. The effects of shearing on the material change as the cut progresses and are visible on the edge of the sheared material. When the punch or blade impacts the sheet, the clearance between the tools allows the sheet to plastically deform and "rollover" the edge. As the tool penetrates the sheet further, the shearing results in a vertical burnished zone of material, finally, the shear stress is too great and the material fractures at an angle with a small burr formed at the edge. The height of these portions of the cut depends on several factors, including the sharpness of the tools and the clearance between the tools. [1]

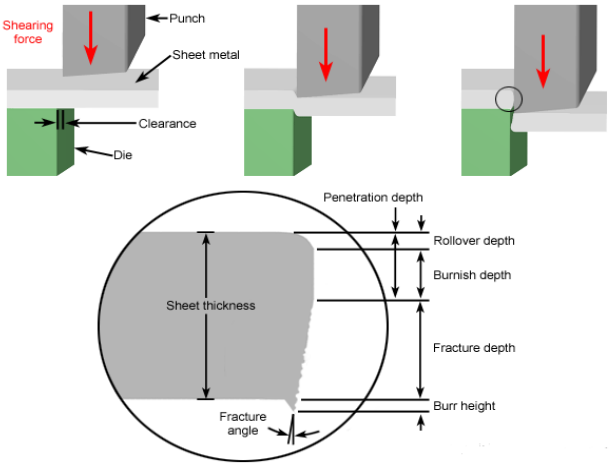

Fig 2: Sheet metal cutting operation

3.3 Required Components:

The common components of this pneumatic sheet metal cutting machine are double acting cylinder, pneumatic hand operated valve and high speed steel blade, air pipe etc.

3.3.1 DOUBLE-ACTING CYLINDER:

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for out-stroke and one for in-stroke as shown in Fig 3. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. [3]

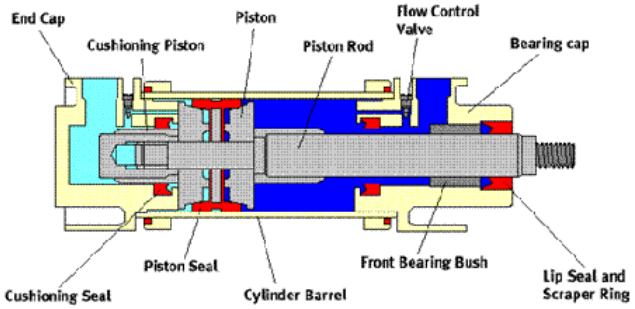

Fig 3: Double acting cylinder

3.3.2 PNEUMATIC HAND OPERATED VALVE:

3.3.2.1 2/2 DIRECTIONAL CONTROL VALVE:

The structure of a 2/2 directional control valve is very simple. It uses the thrust from the spring to open and close the valve, stopping compressed air from flowing towards working tube 'A' from air inlet 'P'. When a force is applied to the control axis, the valve will be pushed open, connecting 'P' with 'A' as shown in Fig.4. The force applied to the control axis has to overcome both air pressure and the repulsive force of the spring. The control valve can be driven manually or mechanically, and restored to its original position by the spring. [3]

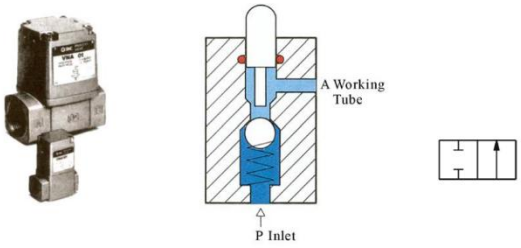

Fig 4: 2/2 directional control valve

3.3.2.2 3/2 DIRECTIONAL CONTROL VALVE:

A 3/2 directional control valve can be used to control a single acting cylinder (Fig. 5). The open valves in the middle will close until 'P' and 'A' are connected together. Then another valve will open the sealed base between 'A' and 'R' (exhaust) as shown in Fig 5.The valves can be driven manually mechanically, electrically or pneumatically. 3/2 directional control valves can further be divided into two classes: Normally open type (N.O.) and normally closed type (N.C.). [3]

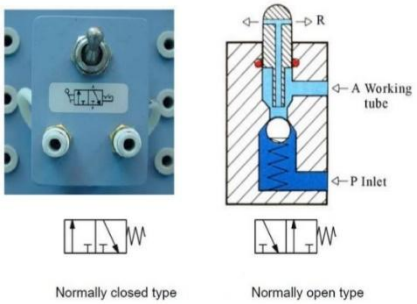

Fig 5: 3/2 Directional control valve

3.3.2.3 5/2 DIRECTIONAL CONTROL VALVE:

When a pressure pulse is input into the pressure control port 'P', the spool will move to the left, connecting inlet 'P' and work passage 'B'. Work passage 'A' will then make release of air through 'R1' and 'R2'as shown in Fig 6. The directional valves will remain in this operational position until signals of the contrary are received. Therefore, this type of directional control valves is said to have the function of 'memory' [3]

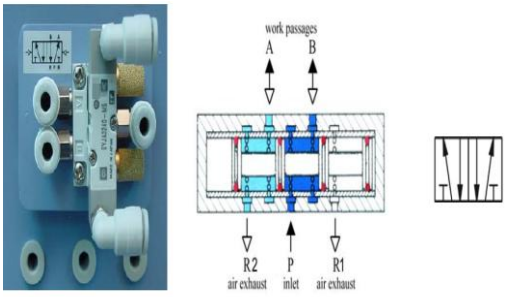

Fig 6: 5/2 Directional control valve

On the other hand there exists many important components like: High speed steel blade, Special Air pipe, Stainless Steel and most important Air compressor.

3.4 Pneumatic Transmission of Energy:

The reason for using pneumatics, or any other type of energy transmission on a machine, is to perform work. The accomplishment of work requires the application of kinetic energy to a resisting object resulting in the object moving through a distance. In a pneumatic system, energy is stored in a potential state under the form of compressed air. Working energy (kinetic energy and pressure) results in a pneumatic system when the compressed air is allowed to expand. For example, a tank is charged to 100 psi with compressed air. When the valve at the tank outlet is opened, the air inside the tank expands until the pressure inside the tank equals the atmospheric pressure. Air expansion takes the form of airflow. A positive displacement compressor basically consists of a movable member inside a housing. The compressor has a piston for a movable member. The piston is connected to a crankshaft, which is in turn connected to a prime mover (electric motor, internal combustion engine). At inlet and outlet ports, valves allow air to enter and exit the chamber. [4]

3.5 Controlling:

3.5.1 CONTROL OF PNEUMATIC ENERGY:

Working energy transmitted pneumatically must be directed and under complete control at all times. If not under control, useful work will not be done and machinery or machine operators might be harmed. One of the advantages of transmitting energy pneumatically is that energy can be controlled relatively easily by using valves.

3.5.2 CONTROL OF PRESSURE:

Pressure in a pneumatic system must be controlled at two points - after the compressor and after the air receiver tank. Control of pressure is required after the compressor as a safety for the system. Control of pressure after an air receiver tank is necessary so that an actuator receives a steady pressure source without wasting energy.

3.5.3 CONTROL OF PRESSURE AFTER A COMPRESSOR:

In a pneumatic system, energy delivered by a compressor is not generally used immediately, but is stored as potential energy in air receiver tank in the form of compressed air. In most instances, a compressor is designed into a system so that it operates intermittently. A compressor is a device that usually delivers compressed air to a receiver tank until high pressure is reached, then it is shut down. When air pressure in the tank decreases, the compressor cuts in and recharges the tank. Intermittent compressor operation in this manner is a power saving benefit for the system. A common way of sensing tank pressure and controlling actuation and de-actuation of relatively small (2-15 HP) compressors, is with a pressure switch.

3.6 Diagram:

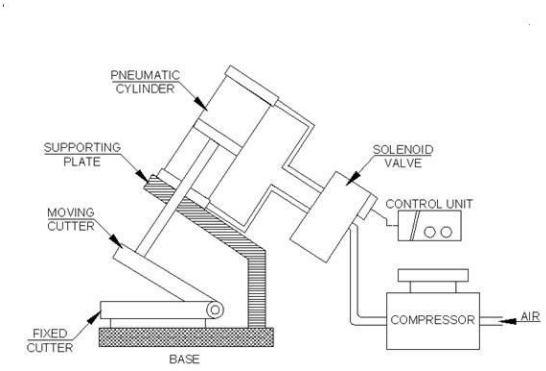

Fig 7: Diagram of pneumatic sheet metal cutting machine.

4. CONSTRUCTION

The pneumatic sheet metal cutting is supported by a table includes with support arms to hold the sheet. The table also includes the two way directional control valve. The two way directional control valve is also known as solenoid control valve. We used two way directional control valve that is connected with the compressor by air pipe. The compressor has a piston for a movable member. The piston is connected to a crankshaft, which is in turn connected to a prime mover. At inlet and outlet ports, valves allow air to enter and exit the chamber. When the compressor is switched ON, the compressed air is flow to inlet of the pneumatic cylinder. The sheet is placed between the upper and the lower blade. The lower blade remains stationary while the upper blade is forced downward. The upper blade is slightly offset from the lower blade, approximately 5 – 10% of the sheet thickness. Also the upper blade is usually angled so that the cut progresses from one end to the other, thus reducing the required force. When the pneumatic hand operated solenoid valve is moved forward, the piston starts moving in the forward direction. The upper blade which are then forced against the sheet, cutting the material. When the pneumatic hand operated lever is moved backward, the upper blade will come to the original position (i.e., the upper blade will move upwards).After the material is cut, adjust the pneumatic hand operated solenoid valve to the mid position (i.e., normal position) and then the compressor is switched off.

Fig 8: Real view of Pneumatic sheet metal cutting machine.

5. DATA ANALYSIS & RESULTS

5.1 CYLINDER THRUST:

Cylinder thrust for double acting in forward stroke. Then,

Cylinder thrust for double acting in return stroke -

$$F = (\pi /4) \times (D - d)^2 \times P$$

where D = Diameter of bore in mm.

P = Pressure in bar. (1 bar = 0.1N/mm^2)

d = Piston rod diameter in mm.

After putting corresponding values according to the equation we can get that as per our consideration the maximum force exerted by our cylinder is 10381.625N

5.2 THEORITICAL AIR CONSUMPTION:

$C = \{(\pi/4) \times D^2 \times (P + 1) \times L\}/1000$

where, P= pressure in bar

D= Diameter of bore in cm.

L= Length of stroke in cm.

Theoretical Air Consumption of our pneumatic machine was, C= C = 22.85litres.

5.3 SHEET METAL CUTTING FORCE:

Cutting force = $L \times S \times T_{max}$

Stripping force =10% -20% of cutting force

L = Length of periphery to be cut in mm

S = Sheet thickness in mm

T_{max} = Shear strength in N/mm^2

T_{max} = 80% of tensile strength

After putting corresponding values according to the equation we can get that aggregated cutting force of our Pneumatic Sheet Metal Cutting Machine was F= 10080 N

5.4 RECOMMENDATION

Pneumatic Sheet metal cutting machine is very cheap as compared to hydraulic cutting machine or laser cutting machine. The range of the cutting thickness can be increased by arranging a high pressure compressor and installing more hardened blades. This machine is advantageous to small sheet metal cutting industries as they cannot afford the expensive machine. Pneumatic sheet metal cutting machine can be used in various industries or workshops.

6. CONCLUSION

Pneumatic systems are used in controlling train doors, automatic production lines, and Mechanical clamps. The sheet metal cutting process is a main part of the all industries. Normally the sheet metal cutting machine is manually hand operated one for medium and small scale industries. The sheet metal cutting machine works with the help of pneumatic double acting cylinder. The piston is connected to the moving cutting tool. Sheet metal cutting machine can be used to cut the sheet metal of minimum thickness without manual hard work. This machine can also be installed in the lab for the experiment and demonstration to engineering students. In this project I have tried my best to fabricate a pneumatic sheet metal cutting machine which can cut the sheet metal in small pieces.

7. REFERENCES

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