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Review IJSMFE

Air-driven Sheet Metal Cutting System

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Abstract

A fundamental component of all industries is the sheet metal cutting process. Typically, medium- and small-sized businesses will use a manually operated sheet metal cutting machine. Our product, "PNEUMATICALLY ACTUATED SHEET METAL CUTTING," was designed and constructed to cut GI sheet metal with less time and high prison. Typically, sheet metals are cut manually, which takes more time and lacks accuracy. Further hydraulic devices are available for cutting sheet metal. But cutting heavy metal is the only application for this pricy method. We use a pneumatic method to cut sheet metal simply. A pneumatic hand lever with a two-way control valve is used to operate it. The control valve is operated by compressor power. Any automated device designed to maximize the efficiency of man, machine, and material resources. A double acting pneumatic cylinder powers the sheet metal cutting machine. The moving cutting tool is attached to the piston. It is employed for cutting thin sheet metal.

Keywords: Compressor, pneumatic cylinder, shearing cutter, DC valve, Metal Cutting

INTRODUCTION

The most significant procedure in the sheet metal sector is shearing. This is a multipurpose device that works well for horizontal sawing. However, benders and sheet cutters work in many different sectors. That equipment need labor from humans to operate [1]. Our goal in designing the Pneumatic Shearing machine was to make it simple to operate and maintain. The metal first undergoes plastic deformation because to the pressure of the punch during the shearing process. A little amount of plastic deformation occurs in the metal adjacent to the cutting edges due to the die and punch having very little space between them. Sheet metal is, to put it simply, metal that has been formed into thin, flat plates. One of the fundamental forms in metalworking, it may take on a multitude of shapes when bent and carved. Numerous everyday items are made from the substance. Parts thicker than 6 mm (0.25 in), notwithstanding wide variations in thickness, are categorized as plates; extremely thin thicknesses are categorized as foil or leaf. Sheet metal is available as flat slabs or as coiled strips. A continuous sheet of metal is fed through a cylindrical slitter to create the coils [2]. The gauge of the sheet metal indicates its thickness. Steel sheet metal is typically used in gauges between 8 and 30. The metal is thinner the higher the gauge number. Nonferrous metals, like aluminum and copper, also have unique symbols; for example, gauge measures thickness in ounces, but is measured in ferrous (iron-based) metals. Sheet metal can be formed from a wide variety of metals, including steel, aluminum, nickel, copper, brass, titanium, and nickel. Silver, gold, and platinum are significant sheet metals for ornamental applications (platinum sheet metal is also employed as a catalyst). Moreover, sheet metal is utilized in the production of numerous other products, including hospital tables, car bodies, airplane wings, and roofs for buildings [3]. Iron and other elements with a high magnetic permeability are sheets that

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make up laminated steel cores.

Types of Cutting Machines

Pneumatically Operated

With the use of a pneumatic double acting piston and cylinder unit combination and a foot-operated direction-controlled valve, the header advances both on both sides in this manner. High pressure air is utilized in this kind of device as the working fluid to transfer power and motion [4].

Hydraulically Operated

Using a foot-operated direction control valve and a pneumatic double acting piston and cylinder unit combination, this is how the header advances both upwards and downwards. High pressure air is utilized in this kind of device as the working fluid to transfer power and motion [5].

Rack and Pinion Operated

Here, the rack and pinion 3 system is used to manually lower and raise the header. In this instance, the necessary pressure is manually provided to the rack by hand using a pinion and leaver arrangement. Given that the equipment is robust and demands a lot of pressure, it is inappropriate [6].

Spring Operated

Although their constructions are different, spring-operated machines function similarly to rack-and-pinion machines. Here, the heating handle must be manually raised and lowered. This requires excessive pressure to operate, and if not done correctly, there is a chance that the work piece may be damaged.

Carefully choosing materials that balance design and safety is necessary for the preparation of any machine part [7]. The following factors determine the choice of material for an engineering application:

1. *Availability of material*
2. *Suitability of the material for the required component*
3. *Cost of the material.*

Various operations to be performed during our experimentation:

1. Cutting
2. Welding
3. Grinding
4. Drilling

Cutting

The process of cutting involves removing portions of the work piece by moving a instrument for cutting in a straight direction. For cutting the mild steel bars, we use a mobile hand saw.

Welding

The method of welding involves using heat to fuse two or more pieces together. High temperatures create a pool of molten material that welds and cools to produce the connection. Compared to the parent metal, this may be stronger [8]. To form a weld, pressure can be used either alone or in conjunction with heat. joining metals in contrast to non-melting brazing and soldering methods. The base material is melted during the high-heat method called welding. usually in conjunction with filler materials. High temperatures create a pool of molten material that welds and cools to produce the connection. Compared to the parent metal, this may be stronger. Pressure is another tool that can be used alone or in conjunction with heat to form a weld. In order to prevent contamination or oxidation of the melted and filler metals, a shielding gas may also be used. Heat is also used in connecting plastics welding, albeit not in solvent welding, for joining elements to one another. It is accomplished in three steps: first, surfaces are prepped, then heat and pressure are applied, and lastly, the materials are allowed to cool to fuse. Joining methods for plastics can be classified as internal or external heating methods based on the specific

process used. various kinds of joints used in welding Welds In accordance with Configuration Welding slot A fillet weld is deposited around the edge of the opening in a single component to form a joint with the surface of the other component that is visible through the hole, joining the two overlapping components together. Weld plug Weld formed by using filler metal to seal a hole in one work piece's component, connecting it to the surface of an overlapping component that is visible Considering Penetration Complete Penetration Weld Weld Joint, in which the root fusion is complete, and the weld metal totally enters the joint, through the hole (the hole may be circular or oval). The term "complete joint penetration weld" is also recommended. Partial Penetration Weld: This type of weld is created when the weld metal is purposefully left partially penetrated. Another name for this type of weld is partial joint penetration (PJP) [9].

Welding Types

There are numerous types of welding processes, each with specific methods and industry warnings. These include:

Arc Welding

Many typical manual, semi-automated, and automatic procedures fall under this category. These include stick welding, tungsten inert gas (TIG) welding, also known as gas tungsten arc welding (GTAW), flux cored arc welding (FCAW), gas metal arc welding (GMAW), shielded metal arc welding (SMAW), submerged arc welding (SAW), gas welding, and plasma arc welding (PAM). These methods, which usually involve the use of a filler material, are employed to join metals such as titanium, cobalt, nickel and copper alloys, aluminum, stainless steel, and cobalt. Many industries, including oil and gas, electricity, aerospace, automotive, and more, use arc welding technologies [10].

Friction Welding

Mechanical friction is used in many welding processes to fuse materials. This can be done in a number of methods on various welding materials, such as wood, steel, and aluminum. As the materials cool, the heat from the mechanical friction softens them and they unite to create a bond. How the joining is accomplished will depend on the particular technique. Examples of mechanical procedures used are friction stir welding (FSW), friction stir spot welding (FSSW), linear friction welding (LFW), and rotary friction welding (RFW). When friction welding, filler metals, flux, or shielding gas are not required. Because friction is perfect for combining lightweight aluminum alloys that would otherwise be "non-weldable," it is widely used in aircraft applications. In addition to being utilized in many industries, friction techniques are also being investigated as a nail-and adhesive-free way to join wood [11].

Electron Beam Welding

A high-velocity electron beam is used in this fusion joining procedure to fuse materials together. The constituent parts melt along when the electrons' kinetic energy is transformed to heat when they collide with the work constituents. To keep the light source from dissipating, electron beam welding (EBW) is done in a vacuum (using a vacuum chamber). EBW is widely employed in many typical applications, such as joining thick sections. This implies that it can be used in a variety of industries, including nuclear power, aircraft, motoring and rail.

Laser Beam Welding

This method, which combines a laser to produce concentrated heat perfect for barrow, deep welds, and high joining rates, is used to connect thermoplastics or metal pieces. This method is ideal for big volume applications, such those in the automotive industry, because it can be easily automated and has a fast-welding speed. Unlike electron beam joining, which must be done in a vacuum, laser beam welding can be done in the open.

Resistance Welding

This is a quick procedure that is frequently employed in the car sector. This process can be classified into two categories: resistance spot welding and resistance seam welding. Spot welding applies heat to

a tiny region while the work parts are fastened together using heat delivered between two electrodes. Comparable to spot welding, seam welding uses rotating wheels in place of the electrodes to create a continuous, leak-free weld [12].

Grinding

A grinding wheel or grinder is the cutting tool used in the abrasive machining process of grinding. Cutting and grinding are related because grinding is a true metal-cutting grinder, whereas cutting is frequently done in mineral processing facilities. Workpieces that require high surface quality and precise shape and size are finished through grinding. In certain roughing applications, it can quickly and accurately grind large amounts of metal

Grinding Machines

The majority of grinding machines operate by removing material from the work piece with an abrasive wheel. Usually composed of aluminum oxide or diamond, the abrasive wheel rotates at a high speed. The material is actually removed from the work piece by the abrasive particles on the wheel. Grinding machines come in a variety of forms, each having a special set of wheels for removing material from flat surfaces. Surface grinders are machines that are used to remove material off flat surfaces. The cylindrical grinder, which is another popular kind of grinding machine, is used to remove material from cylindrical surfaces. Smooth finishes can be produced with extreme precision in the grinding process. However, depending on the kind of grinding machine being used and the materials needed, it can also be quite costly and time-consuming. Requirements for Using Abrasive: The kind of material being worked on, the kind of gritty being used, the abrasive's speed, and the pressure being applied all affect the abrasive's operation. The following general rules apply, and each application's proper abrasive state must be found via experimentation:

1. Abrasive materials must be harder than the work piece material which will be used for grinding.
2. Abrasive materials softer than the work piece material when used for polishing.
3. Abrasive materials with a Mohs hardness of 9 or 10 are used for lapping. The coarser the abrasive, the higher the speed and the lower the pressure.
4. The finer the abrasive, the lower the speed and the higher the pressure.
5. Abrasive materials with a low friability are used for grinding, and those with a high friability are used for polishing.

Almost all drilling machines operate on the same basis. The associated stepped pulley rotates as a result of the spindle rotating when the motor receives power. A stepped pulley, which may be flipped to change the rotating speed, is fastened to the opposite end. For optimal power transmission between the stepped pulleys, a V-belt is fitted. The spindle is now attached to the drill bit that was inserted into the fixed work piece. The drill bit revolves as a result of the pulleys' rotation. Using a hand wheel, the spindle is lowered to progress the drilling operation. The spindle is raised by rotating the hand wheel following the drilling of the hole. A drill is a rotating end cutting tool that has one or more cutting lips and one or more helical flutes to let cutting fluid and chips flow through. Drills are widely employed in manufacturing, building, the metalworking process, and woodworking. The most often used drill bit is the HIGH-SPEED STEEL drillIn order to drill cylindrical holes in a work piece, a drilling machine rotates a tool bit quickly and lowers it into the target area at a predetermined tool speed and feed rate. Using vices and clamps, the work piece needs to be firmly secured to the drill table during drilling operations. Certain specialist drills are made to drill horizontally, however the majority of drilling machines are set up with the drill in the vertical position. Usually, this orientation makes it possible to drill deep holes in lengthy sections where it would be impractical to organize vertically. The part will need to be realigned if drilling is to be done in a different orientation. For varying cutters or materials, the machine speed can be adjusted. Drilling machine operation principle: Almost all drilling machines operate on the same basis. The associated stepped pulley rotates along with the spindle when the motor receives power, as seen in the picture below. A stepped pulley, which may be flipped to change the rotating speed, is fastened to the opposite end. For optimal transfer of force between the stepped pulleys,

a V-belt is fitted. The spindle is now attached to the drill bit that was inserted into the fixed work piece. The drill bit revolves as a result of the pulleys' revolution. Using a hand drive the spindle is lowered to progress the drilling operation. The spindle is raised by rotating the hand wheel following the drilling of the hole. Activities carried out with the Drilling Machine While its main function is drilling, this machine can also be used for a number of other related operations on holes that need the use of other equipment. A list of different drilling machine procedures to make different kinds of holes is provided below. Drilling Drilling is a cutting technique that involves creating a circular hole in solid materials by spinning a drill bit. Usually, the drill bit is a multi-point rotating cutting instrument. At rotational speeds ranging from several hundred to several thousand revolutions per minute, the bit is forced up against the work piece. reaming Remapping is a high-precision hole-finishing technique using a multi-edge tool. Close dimensional precision, outstanding hole quality, and a high surface finish of the previously drilled hole in the work piece are made possible by the high penetration rates and shallow cuts made during the reaming process [13]. Countersinking is the technique of making a hole larger at one end so that it has a conical form. A V-shaped edge is produced close to the hole's surface via countersinking. Deburring drilled or tapped holes and making sure fasteners are firmly positioned in the holes are two common uses for it. Spot facing is the process of creating a smooth edge on a cylindrical work piece. This process entails squaring and polishing the top surface of the hole intended for a screw head or nut. End-mill cutters can also be used for this. Lapping is the act of employing a device called a tap to initiate the process of establishing internal threads. This enables the hole to be tapped and then a cap screw or bolt to be threaded into it.

ADVANTAGES, DISADVANTAGES AND APPLICATIONS

Advantages

- Pneumatic is more efficient in the technical field
- Quick response is achieved
- Simple in construction.
- Easy to maintain and repair
- Cost of the unit is less when compared to other machine
- No fire hazard problem due to over loading
- Comparatively the operation cost is less
- The operation of cutting is faster because the medium used to operate is air
- Continuous operation is possible without stopping

Disadvantages

- While working, the compressed air produces noise therefore a silencer may be used.
- High torque cannot be obtained
- Load carrying capacity of this unit is not very high.

Design And Fabrication of Pneumatically Actuated Sheet Metal Cutting Machine

Sketching

Draw the general design and the cutting machine's measurements first. This covers all of the parts, including the cutting tool, base, cutting arm, and pneumatic cylinders.

Creating 2D Drawings

Make thorough 2D drawings of every component using AutoCAD. Be mindful of assembly details, clearances, and measurements

Assembly Drawing

Create an assembly drawing by combining the designs for each individual component. This will demonstrate how each component fits together and moves in relation to the others.

Pneumatic System Design

Design the pneumatic system, taking into account the cylinders, valves, tubing, and connectors. Make sure the system has adequate force and speed to complete the cutting task.

Mechanical Design

Create any guides, supports, and linkages that are necessary for the cutting motion. Ensure that everything proceeds precisely and without hiccups.

Safety Elements

To guarantee safe operation, include safety elements including sensors, emergency stop buttons, and guards (Figure 1).

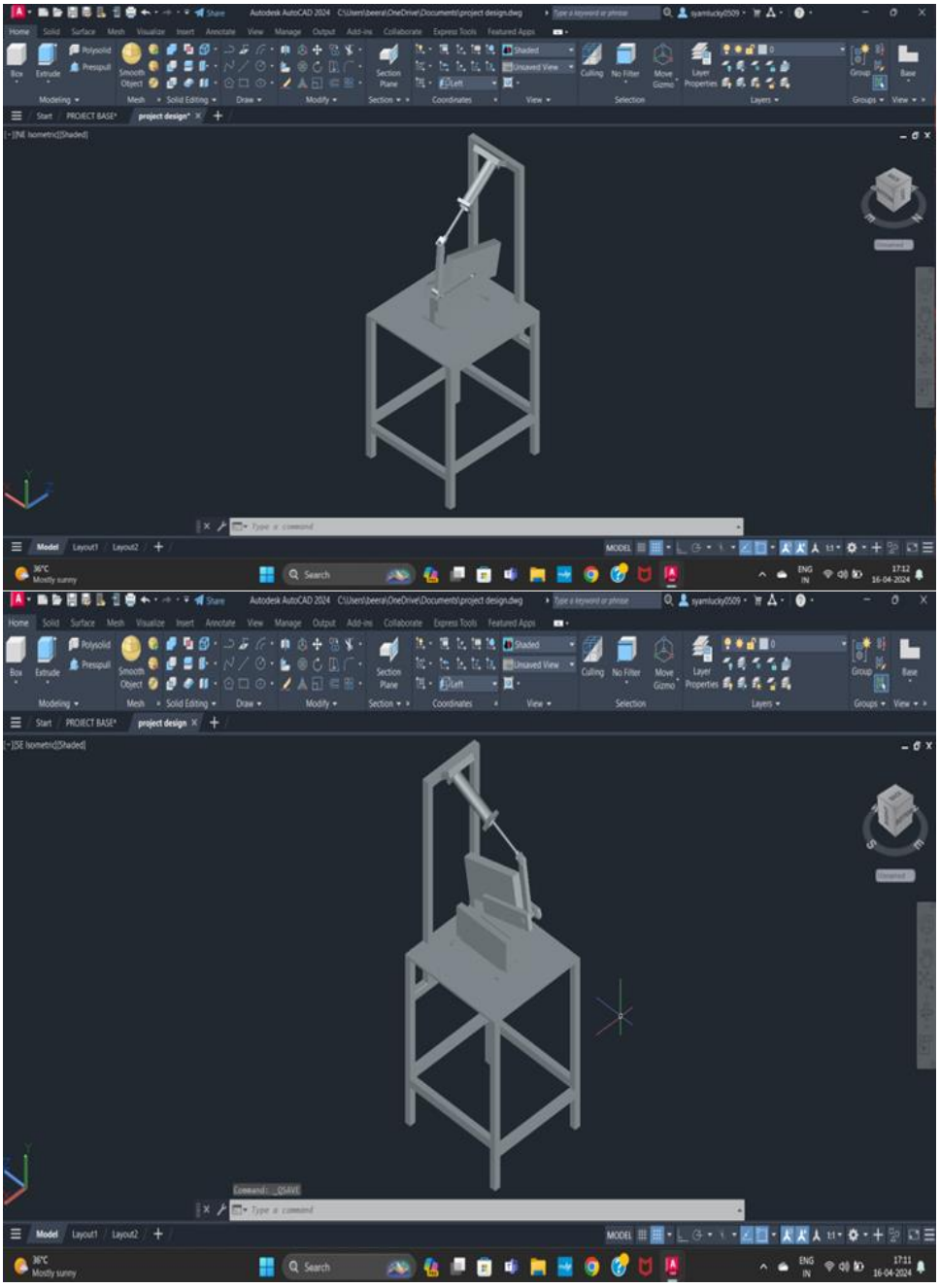

Figure 1. Auto cad design of pneumatically actuated sheet metal cutting machine.

COMPONENTS

Mild Steel Rods

The most popular type of steel nowadays is mild steel, also called low carbon steel or plain carbon steel, which is iron with a small amount of carbon. It is strong and durable but not easily tempered. Its low cost and suitable material qualities make it suitable for a wide range of uses. Mild steel is ductile and malleable due to its 0.05–0.30 carbon content (Table 1). Although mild steel has a low tensile strength, it is cheap and easy to work with; surface hardness can be increased by carburizing the steel (Figure 2).

Figure 2. Mild steel rods.

Table 1. Properties of mild steel.

Specification	Value
Length of the blade	6inches
Blade material	Alloy steel
Length of the cutter	25cm
Width of the cutter	12cm
Height of the cutter	20cm

Shearing Utter

This cutting technique, also known as die cutting, removes the necessity for burning, melting, or chip-making when cutting stock (Table 2). Shearing is the precise term for the action that occurs when the cutting blades are straight (Figure 3).

Figure 3. Shearing cutter.

Table 2. Specifications of shearing cutter.

Properties	Value
Yield strength	370 N/mm²
Tensile strength	440 N/mm
Shear modulus	80 Gpa

Compressor

The air at high pressure is provided by a compressor. It is propelled by an electric motor. The compressor feeds air into the cylinder's inlet. As the name implies, an air compressor is a device that compresses air to increase its pressure. An air compressor takes in ambient air, compresses it, and then transfers the compressed air—which is sent to a storage vessel at high pressure—to another location. It can then be sent to a place that requires compressed air via a pipeline. Since compressing air requires work to be done on it, the compressor must be powered by a prime mover (Figure 4).

Figure 4. Compressor.

Pneumatic Cylinder

An apparatus that transforms fluid power into mechanical force and linear motion is a cylindrical component. These cylinders are widely utilized in industrial pneumatic systems. Other names for these cylinders include linear and circular motors. Pneumatic cylinders are designed to be used in many situations. Pneumatic engines have a wide range of applications. We will discuss a little bit about double acting cylinders since our system uses them. The pressurized fluid flow is transformed into a push or pull on the piston rod by pneumatic cylinders. Double-acting cylinders can be used to apply fluid force to the moveable element in two locations. In an independently acting cylinder, the force of compressed air propels the piston in two different directions. They are employed expressly (Figure 5). The piston must operate on the advance and return movements simultaneously. The stroke length is theoretically infinite, however considerations of bucking and bending must be made before determining a precise size for the piston diameter, rod length, and stroke length. The cylinder, which takes in air under pressure and uses it to push the piston back and forth, is an essential component of any pneumatic system. The pressure of the atmosphere multiplied by the cylinder's area equals the force acting on the piston (Table 3).

Figure 5. Pneumatic cylinder.

Table 3. Specifications of Pneumatic cylinder.

Specification	Value
Quantity	*1*
Total Length	375mm
Bore	40mm
Stroke	200mm
Piston Rod Diameter	20mm
Max Working Pressure	8 bar
Weight	3kg

Directional Control (DC) Valve

The directional valve is one of the most important parts of a pneumatic system. This valve, sometimes referred to as a DCV, regulates the pneumatic program's air flow direction. The internal moving pieces of the unidirectional valve are rearranged to achieve this. This valve was selected in order to facilitate rapid operation, reduce the need for manual labor, and use a solenoid valve to turn the machine into an automatic one (Table 4). Electrical energy is converted into force and straight line motion by a device known as a sole noid. They also serve as the power source for a mechanical system that controls the valve mechanism (Figure 6).

Figure 6. Directional control (DC) valve.

Table 4. Specifications of Directional Control (DC) Valve.

Specification	Value
Quantity	*1*
Operation	Manual Type
Number of Ports	*5*
Number of Positions	3
Construction	Sliding spool type

Polyurethane (PU) Connectors

PU connector" is the term used to describe a polyurethane (PU) connector. The versatile polymer polyurethane is well-known for its resilience to chemicals and scratches and also for its flexibility. PU connectors are used in a wide range of industries and applications where a stable and flexible connection is required. They are utilized in fluid-tuning systems such as hydraulic or pneumatic systems, as well as cable assemblies for electrical or electronic applications. PU connectors provide a secure and leak-proof connection while allowing for flexibility and mobility in the connected components (Figure 7).

Polyurethane (PU) Pipe

Pipes made of polyurethane (PU) are made of PU material. One of the most well-known properties of synthetic polymer polyurethane is its resilience to chemicals and wear (Table 5). PU pipes are widely used in many different applications where toughness and flexibility must be combined (Figure 8).

Figure 7. Polyurethane (PU) Connector.

Figure 8. Polyurethane (PU) pipe.

Table 5. Specifications of Polyurethane (PU) pipe.

Specification	Value
Pipe overall length	3000 mm
Diameter	8 mm
Thickness	1 mm

WORKING PRINCIPLE

The inflatable machine features straight-edge blades on both the upper and lower ends, a measuring mechanism for precise sheet positioning, a table with support arms for holding the sheet, and stops or guides for sheet security. The table also includes the two-way directional valve. The two-way directional valve has the cooling system attached to it. A piston serves as the compressor's moving part. The stroke of the piston is attached to the crankshaft, which is connected to the engine's starter (an electric motor or internal combustion engine). Air enters and exits the chamber by valves at the entry and outlet ports. When the compressor is turned on, compressed air enters the pneumatic cylinder through the inlet. The sheet is inserted between the top and bottom blades. When force is applied to the upper blade, the bottom blade stays in place. The upper and bottom blades are slightly offset, varying

from 5 to 10% of the thickness of the sheet. In order to minimize effort, the upper blade is typically slanted such that the cut can move from one end to the other. The piston advances together with the pneumatic hand lever's forward motion. The blade at the top cuts the material and presses it on the sheet. The pneumatic hand-operated lever will move backward, returning the upper blade to its initial position (that is, upward movement). After cutting the material, turn off the compressor by moving the pneumatic hand lever to the usual, or mid, position. The main layout of the machine is depicted in the accompanying Figure 9.

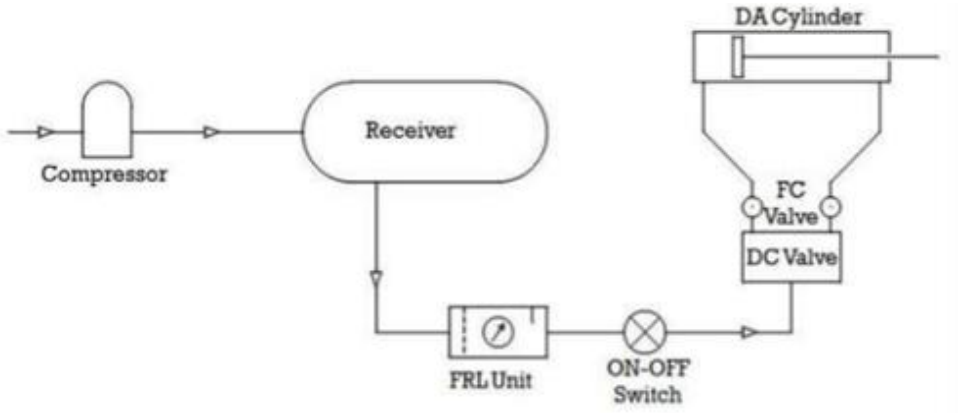

Figure 9. General layout.

The air pressure in the receiver tank can reach as high as 8 bar when the air compressor is first turned on. The supply air is made ready for industrial use at the manifold after passing through a FRL device. A separate supply is taken out of the manifold and linked to an ON/OFF switch so that the machine can run without the compressor.

Position A: Compressed air is then sent through the pipe to the machine's Direction Control Valve. The circuit schematics that are not activated are shown in position 'A'. In this position, the piston is locked and steady. Right now, every port is closed (Figures 10 and 11).

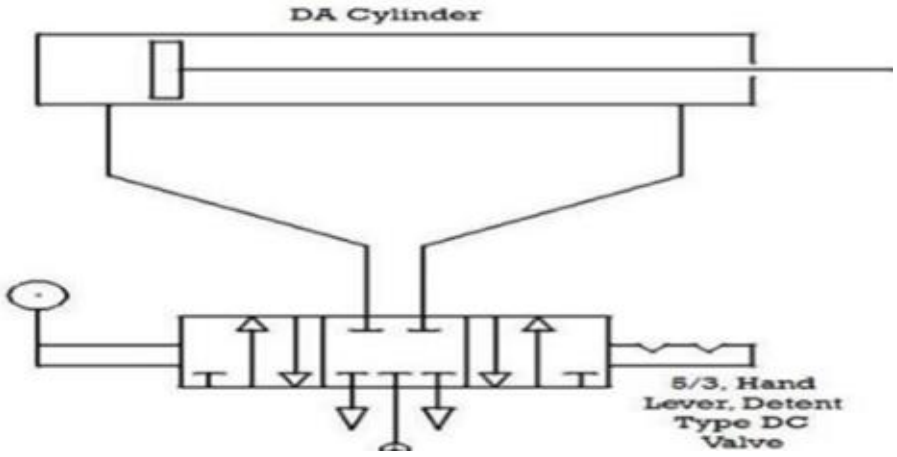

Figure 10. Position A.

Position B: As can be seen in the image, the DC valve is at position "B," which is on the left. The exhaust port is connected to the rod end port, and the pressure and cap end ports are connected to each other. Compressed air is introduced to the cylinder's cap end, forcing the pistons outward. Forced out of the cylinder is the air that was previously inside the rod end side. The force exerted by the piston pushing outward drops the upper blade through the connecting link. Before the DC valve opens, the sheet is positioned between the top and bottom blades (Figures 12 and 13).

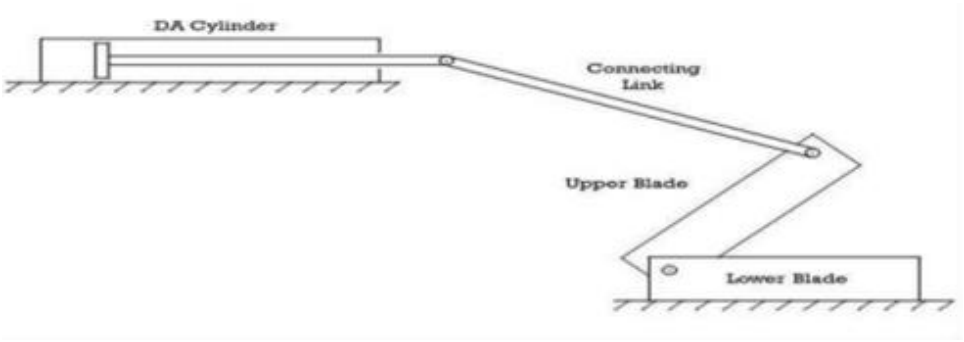

Figure 11. Machine Position ‘A’.

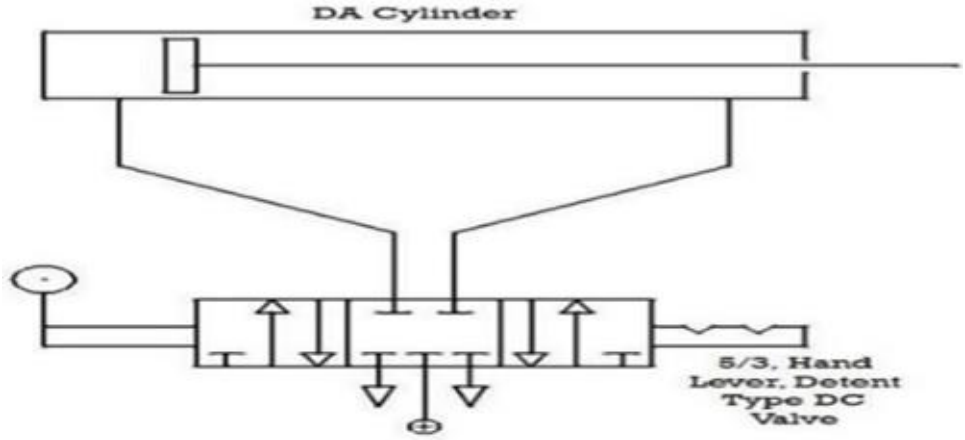

Figure 12. Position B.

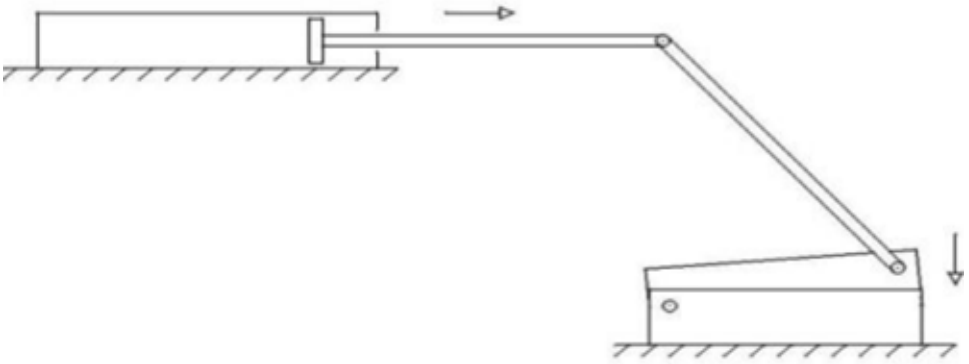

Figure 13. Machine Position ‘B’.

Position C: As can be observed in the picture, the DC valve has now been moved to position "C." There is a connection between the exhaust port and the cap end port and a connection between the rod end port and pressure port. As compressed air passes through the rod end and into the cylinder, it forces the pistons inward. There is a forced outflow of air from the cylinder's cap end side. When cutting large pieces of sheet metal, the smaller pieces are either removed and a new sheet is introduced for cutting, or the sheet is reinserted for cutting (Figures 14-16).

RESULT

Table 6 show the cutting the sheet metal parameter and Figure 17 before and after cutting the sheet metal respectively.

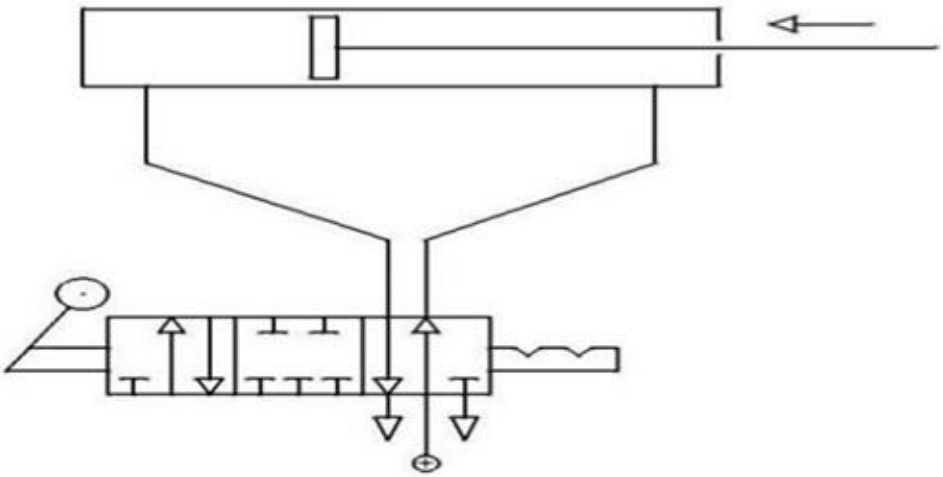

Figure 14. Position C.

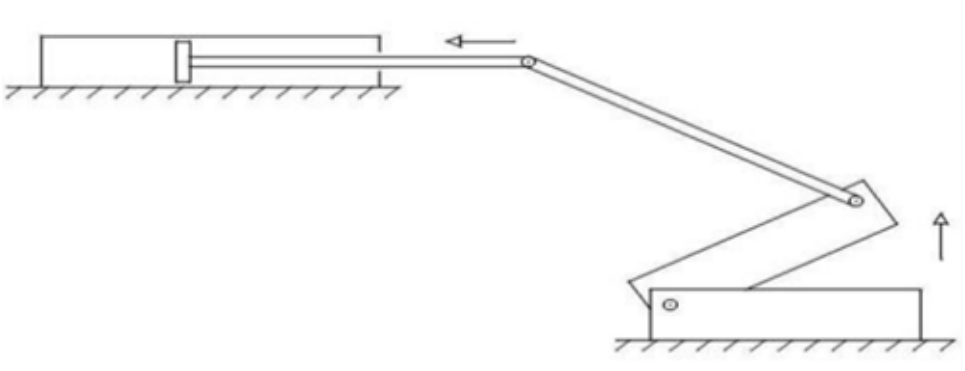

Figure 15. Machine Position ‘C’.

Figure 16. Final setup of pneumatically actuated sheet metal cutting machine.

Table 6. Cutting the sheet metal parameter.

S.N.	Pressure (bar)	Depth of the cut (mm)	length of the cut (cm)	Time (sec)
1	6-8bar	1mm	5cm	2sec
2	6-8bar	0.5mm	10cm	1sec
3	4-6bar	1mm	4cm	4sec
4	4-6bar	0.5mm	8cm	5sec

Figure 17. Before and after cutting the sheet metal respectively.

CONCLUSION

Engaging in project work is an excellent way to establish relationships with people in different industries. The operating environment of the device is appropriate. They are able to appreciate the difficulties in maintaining tolerances and quality. Let's add a few more words regarding our impression project work to the project's closing remarks. The primary advantage of our project is its flexible cutting length. The rapid operation is carried out using the timer unit. One instance of low-cost automation is this project. Pneumatic shearing machines are widely acknowledged to be significantly less costly than hydraulic shearing machines. The cutting thickness range can be increased by installing tougher blades and setting up a high pressure compressor. For tiny sheet metal fabrication businesses that cannot afford the pricey hydraulic shearing equipment, this machine is useful.. Pneumatic systems are used to operate train doors, mechanical clamps, and automated industrial lines. The technique of cutting sheet metal is essential to all businesses. Typically, medium- and small-sized businesses will use a manually operated sheet metal cutting machine. A double acting pneumatic cylinder powers the sheet metal cutting machine. The moving cutting tool is fixed to the piston. Without requiring a lot of human labor, metallic sheets can be cut to the minimal thickness with plate metal cutting tools.

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