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FABRICATION OF PNEUMATIC SHEET METAL CUTTING MACHINE

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ABSTRACT: The idea of the project generated due to a manual sheet metal sheering machine in workshop of our college. In that machine sheet metal is placed in between the two sheering blades of machine and lever is pulled down to move the upper movable blade and cut the work-piece. But in that machine large force is required which can make tire to a worker who continuously works on it for mass production in large scale industry so to reduce the human efforts pneumatic machine should chose. In an effort to respond to the need of small scale industries how cannot afford the gigantic and very expensive model sheet cutter, it thus becomes necessary to design and construct a pneumatically operated sheet cutter. This will go a long way in enhancing out small scale industries that are interested in the production of such machines. It will also boost our technological know-how and mitigate against expensive importation of cutting equipment

DESIGN AND CALCULATIONS

Design of Cutting Blades The blades are designed with the purpose of cutting work piece of width 25mm and thickness 0.5mm. The dimensions are taken to ensure smooth running of the machine and reducing the weight of the machine.

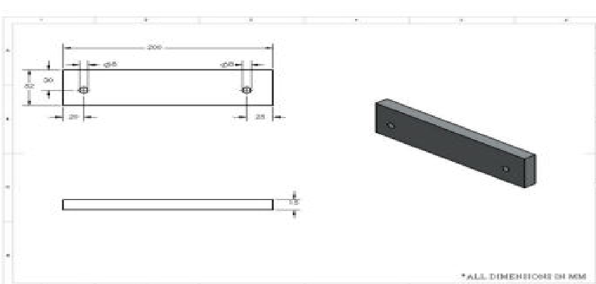

Fig 1: Upper Blade Design

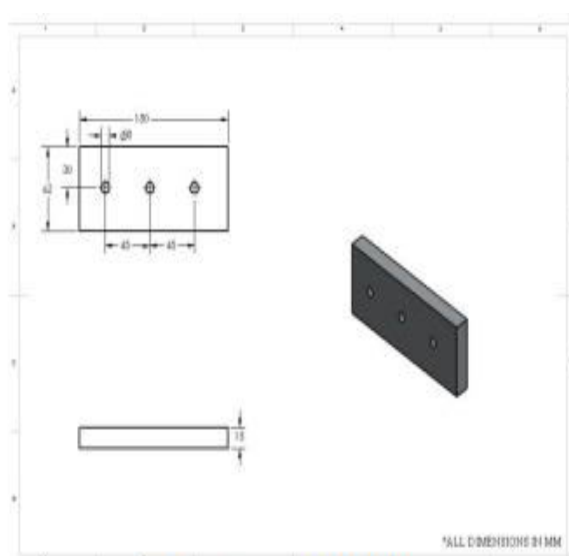

Fig 2: Lower Blade Design

Process Sheet for Cutting Blades

Table 1: Process sheet for cutting blades

SQ.no	MACHINE	OPERATION	TOOL
05	-	Check dimensions and mark accordingly	Vernier Callipers & Ruler
10	Abrasive Cutter	Cut two pieces of 210x65mm	Abrasive cutting wheel
15	Milling machine	Mill the work piece to 200x52 and 150x62	Multi point milling tool
20	Drilling machine	Drill holes of diameter M8 as specified in design	M6 drill bit
25	Grinding machine	Surface grinding	Grinding wheel
30	-	Hardening (heat treatment)	Furnace
25	-	Inspection	Vernier Callipers

Clearance between Blades Calculations

Recommended clearance is calculated by

C = a×t

Where; C = clearance, a = allowance,

t = stock thickness Sheet metal group allowance 1100s and 5052s Aluminum alloys a=0.045 Now stock thickness t=0.5mm {1mm=1000 μ m},

Clearance c= a*t= 0.045×0.5=0.0225mm

Cutting Forces Calculations

Shear Force (F) = S×L×T

Where, S= shear strength of material, L=length of cut edge, T= stock thickness S= shear strength of material {Aluminum --- 90MN/mm} T=0.5mm, L=25mm Shear Force (F) = 25×0.5×90 = 1125N

This is the force required to cut sheet metal. Now we have selected a 12 volt Dc Air compressor that develops a pressure of 12bar, but we are limiting the pressure to 6bar. Pneumatic Cylinder Design

Since the max force required to cut the sheet = 1125N Pressure applied by 12volts compressor = 6bar Therefore, force applied by the cylinder F= π/4×(D2)×P Where, D = diameter of piston (mm), P= Pressure in(N/mm2) F= π/4*(D2)*P, D = $= \sqrt{\frac{1125*4*0.6}{\pi}}$ D = 48.86mm The pneumatic cylinder is fitted with a hinge and a rod end mounting on the other side as shown in fig 3 piston assembly.

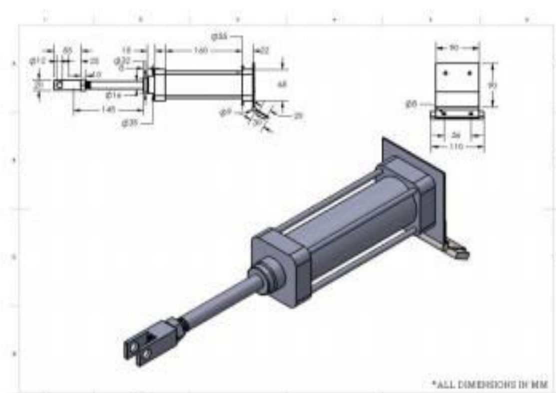

Fig 3: Piston Assembly CAD model

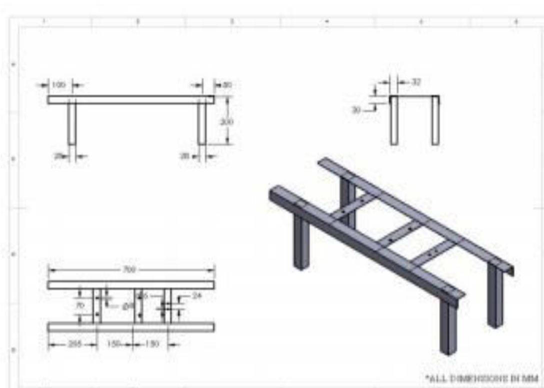

Fig 4: Base Frame Design CAD model

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Process Sheet for Base Frame

Table 2: Process sheet for base frame

SQ.no	MACHINE	OPERATION	TOOL
05	-	Check dimensions and mark accordingly	Vernier Callipers& Ruler
10	Abrasive Cutter	Cut 1x1inch MS rectangular pipes as per design specifications	Abrasive cutting wheel
15	Abrasive Cutter	Cut 1x1inch L shaped MS sheets as per design specifications	Abrasive cutting wheel
20	Welding machine	Weld the pipes to form the frame as shown in fig 4	Arc welding unit
25	Drilling machine	Drill M6 holes as per requirement	M6 Drill bit
30	-	Inspection	Vernier Callipers

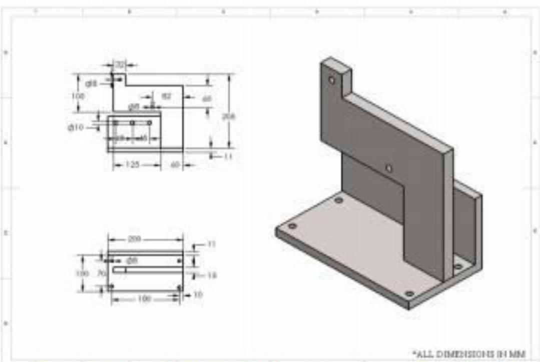

Fig 5: Support Structure Design CAD model

Process Sheet for Support Structure

Table 3: Process sheet for support structure

SQ.no	MACHINE	OPERATION	TOOL
05	-	Check dimensions and mark accordingly	Vernier Callipers& Ruler
10	Abrasive Cutter	Cut 1x1inch MS rectangular pipes as per design specifications	Abrasive cutting wheel
15	Abrasive Cutter	Cut 1x1inch L shaped MS sheets as per design specifications	Abrasive cutting wheel
20	Welding machine	Weld the pipes to form the frame as shown in fig 4	Arc welding unit
25	Drilling machine	Drill M6 holes as per requirement	M6 Drill bit
30	-	Inspection	Vernier Callipers

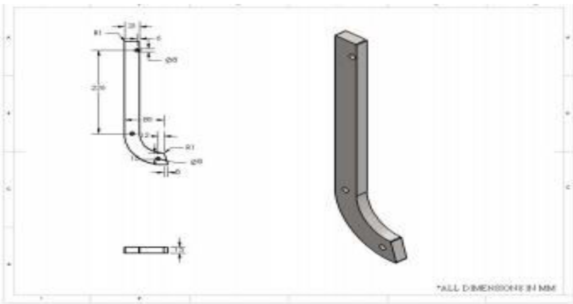

Fig 6: J- Link Design CAD model

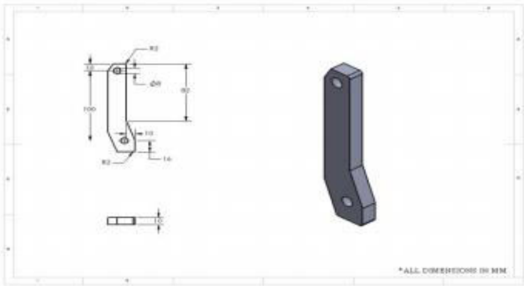

Fig 7: Twin Link Design

SELECTION OF CYLINDER MOUNTING TYPE There are three main categories of cylinder mounting shown in fig 8. The selection of these mountings depends on the application and machine configuration [4].

- Fixed Centre-line mountings
- Pivoted Centre-line mountings
- Fixed non Centre-line mountings

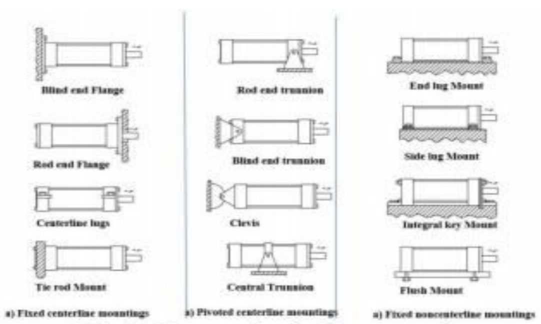

Fig 8: Types of cylinder mountings

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Fixed Centre-line mountings

In this mounting, the cylinder is supported along its centre line. The mounting bolts are thus subjected to shear or simple stress. This mounting needs accurate alignment. Misalignment is not tolerable.

Pivot Centre-line mounting

Many applications need rotational degree of freedom for a cylinder as it reciprocates. The pivot mounting can be clevis type or trunnion type. This mounting

permits rotational freedom in one plane. If universaljoint is used, greater degrees of freedom are possible

Fixed non Centre-line mounting

This mounting of cylinder introduces torque underloaded condition. The cylinder may rotate or bend about its mounting bolt when loaded. The stress level on the cylinder is higher as compared to the centerline mounting.

Following points should be considered while

mounting the cylinder.

1. Cylinders with Centre-line mountings tend to leanunder load.

2. Cylinder with non centre-line mounting generally require strong machine frames to resist bending moments

3. If the motion of the machine part acted on by the cylinder rod movement is essentially linear, a fixed mounted cylinder should be used.

4. If the cylinder has a long stroke, a pivoted mounted cylinder may be required to prevent the piston rod buckling. Where long stroke and fixed mounting are necessary , support is needed to prevent vibration and excessive sag

5. The mounting selection depends on the resulting force (compression or tension) in the cylinder rod. The blind end or cap flange mounting is best for compressive loads. The rod end or head flange mounting is best where the rod is in tension

6. Alignment problem are always critical. If misalignment can occur between the cylinder and machine part it moves, it is necessary to compensate for this in the selection of cylinder mounting. For example, a simple Centre-line pivot mounting will compensate for misalignment if it occurs in only one plane. Where misalignment can occur in more than one plane, the cylinder must be fitted with a universal (ball and socket) pivot joint. It is important that both ends of the pivot mounted cylinder should be supplied with flexible connections.

*In our project we have chosen the Pivoted Centerline mounting due to the following advantages in design and application.

- Compact machine.
- Compensation for misalignment between
- cylinder and links.
- Prevents rod buckling.

Delivers higher impulse at lower air pressure

FABRICATION AND ASSEMBLY

FABRICATION

The components of the project that were fabricated are given below.

- Base Frame
- Support Structure
- Cutting Blades
- J-link and Twin links

Base frame as shown in fig 4 was fabricated using 1inch x 1inch rectangular mild steel pipes according to the design parameters given in the previous chapter. The pipes were firstly cut according to the required lengths and then welded using arc welding apparatus. Later holes of sizes M4 and M6 drilled at the desired locations on the frame [3]. To fabricate the support structure (fig 5), initially two thick MS plates were cut of dimensions 200x100mm and thickness 11mm. These plates were then drilled\ with holes of dimensions M8 as per design requirements. Another plate of thickness 15mm was cut in the shape of alphabet 'z' with dimensions as specified in the design and holes were drilling accordingly. The three structures were then arc welded to form a single support structure. The structure was designed in a way that it can withstand impact loads to the sudden force applied by the high pressure cylinder. Along with this the piston subassembly was also attached to the structure using the help of a hinge

Fig 9: Base Frame

Fig 10: Support Structure with Piston Assembly

The cutting blades as shown in fig 11 are fabricated and heat treated and cut to dimensions 200x52mm and 150x62mm for upper blade and lower blades respectively. After this process holes of diameter M8 are drilled as per the specified design

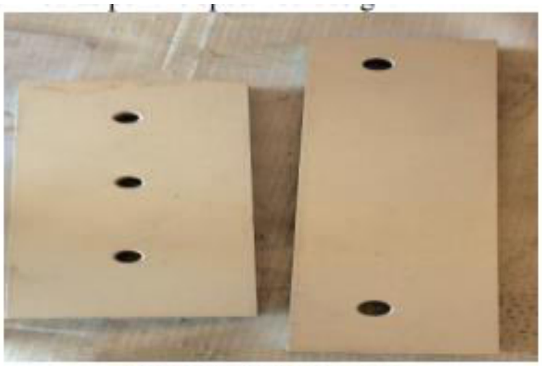

Fig 11: Cutting blades

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The J-link and twin links are also cut from plates of mild steel and fabricated as per the specified dimensions.

ASSEMBLY

The assembly of the machine is divided into steps to give a better understanding of the position and working of every component of the machine. The Support structure with piston sub-assembly is bolted onto the base frame with M6 bolts and nuts as shown in fig 12.

Fig 12: Structure onto Base frame mounting

The lower cutting blade is then firmly mounted onto the support structure using three M8 bolts and nuts. After the lower blade is fixed, the upper blade is bolted one end to the z-5. The J-link is then fixed on ends, one side to the Z-structure and the other side to the rod end of the piston as shown in fig 13.

Fig 13: J-link mounting

The twin links are mounted on either sides of the Jlink simultaneously adjusting upper blade to coincide the holes of diameter M8. The DC valve is mounted on to the base frame with two M4 bolts to hold it steady while operating. The inlet and outlets to the pneumatic cylinder is given from the DC valve using polyurethane pipes of 1mm diameter as shown in fig 14.

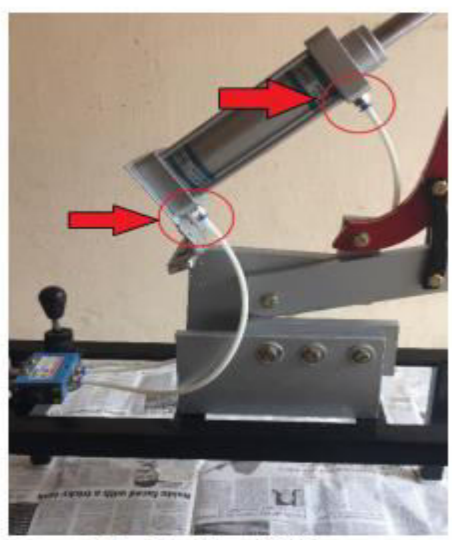

Fig 14: Pipe fittings

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The FRL unit is then mounted onto a SS plate which is in-turn mounted onto the base frame right below the DC valve as shown in fig 15

Fig 15: FRL Unit mounting

Main inlet and outlet pipes to the FRL unit are fitted to the pneumatic connectors on the left and right side respectively. The Sheet metal cutting machine is assembled as shown in fig4.14 and is ready to be tested.

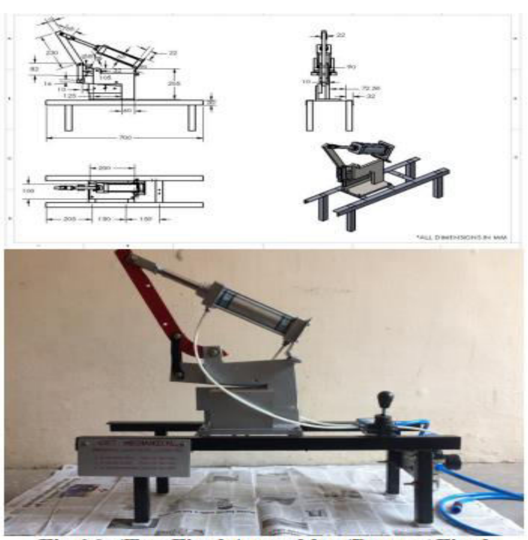

Fig 16: (Top Final Assembly; (Bottom)Final Assembly CAD model

TESTING AND RESULTS EXPERIMENTATION WORKING

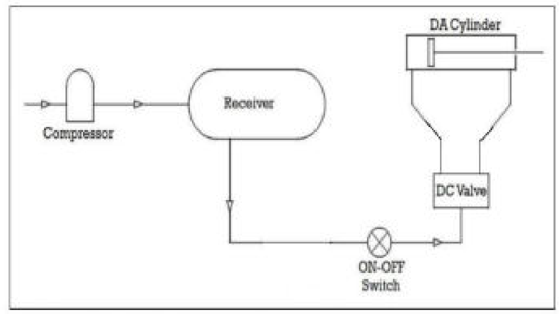

Fig 17: Schematic general setup layout

The figure 17 shows general setup layout of the machine. Initially the air-compressor is started and allowed the receiver tank air pressure to reach up to 6 bar. Outlet of the receiver is connected to the DC valve by pneumatic pipe. A butterfly valve is used to control the flow of the air (on/off). From the DC valve two pipes are connected to the Double Acting pneumatic cylinder. Using DC valve we can send the air to either forward or backward strokes.

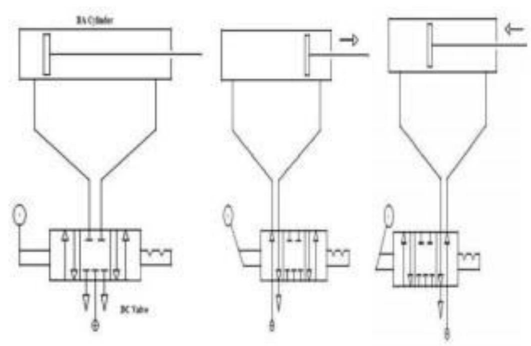

Fig 18: Position-A, B, C

At position ‘A’ figure 18 and shows the non-actuated circuits diagram. At this position the piston is steady and locked. All ports are in closed condition. DC valve is in neutral position. At position ‘B’, the DC valve is at left hand position as shown in figure 18.The cap end port & pressure port get connected to each other and the rod end port gets connected to the exhaust port. The compressed air comes in the cap end of the cylinder and pushes the pistons outwards. The air already present in the rod end side is pushed out of the cylinder. Then the piston moves outwards, the force is transmitted through the connecting link and the upper blade moves downwards. Before the actuating DC valve the sheet is inserted in between the upper & lower blades. As upper blade moves downwards, the stress is generated in the sheet metal and goes beyond ultimate shear stress of sheet metal. And thus the shearing action takes place[1, 2]. Now the DC valve is operated to come at position 'C', as shown in figure 18.The rod end port & pressure port get connected to each other and the cap end port gets connected to the exhaust port. The compressed air comes in the rod end of the cylinder and pushes the pistons inwards. The air already present in the cap end side is pushed out of the cylinder. Now the DC valve is operated to come at position 'C', as shown in figure 5.5 .The rod end port & pressure port get connected to each other and the cap end port gets connected to the exhaust port. The compressed air comes in the rod end of the cylinder and pushes the pistons inwards. The air already present in the cap end side is pushed out of the cylinder. The sheet metal is either again inserted for further cutting in case of large pieces; the small cut pieces are removed and the next sheet is inserted to cut.

SHEARING OPERATION

Several cutting processes exist that utilize shearing force to cut sheet metal. However, the term "shearing" by itself refers to a specific cutting process that produces straight line cuts to separate a piece of sheet metal [5]. Most commonly, shearing is used to cut a sheet parallel to an existing edge which is held square, but angled cuts can be made as well. For this reason, shearing is primarily used to cut sheet stock into smaller sizes in preparation for other processes. Shearing has the following capabilities. Sheet thickness: 0.005 – 0.25 inches Tolerance: 0.1 inches The shearing is performed on a shear machine, often called asquaring shear or power shear, that can be operated manually or by hydraulic, pneumatic, or electric power. A typical shear machine includes a table with support arms to hold the sheet, stops or guides to secure the sheet, upper and lower straight - edge blades, a gauging device to precisely position the sheet. The sheet is placed between the upper and the lower blade, which are then forced together against the sheet, cutting the material. In most devices, the lower blades remain 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. The knife edge and are available in different materials, such as low alloy steel and high carbon steel. When the pneumatic hand operated lever is moved forward, the

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piston starts moving in the forward direction.

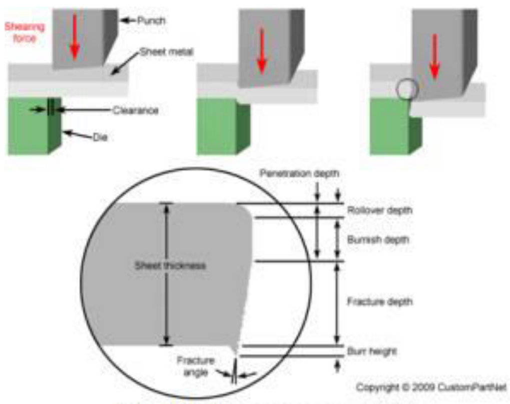

Fig 19: Shearing operation

TESTING

The pneumatic sheet metal cutting machine after assembly was tested as shown in fig5.7 with the help of portable air compressor which has a max output of 8bar. The aim of the project was to cut sheet whilst reducing the human effort and replace the manual operation with pneumatic operation. The samples used were Aluminum sheet of thickness 0.5mm and width 25mm. The operation was successful but the plate couldn't be cut in a single stroke and needed multiple consecutive strokes to get cut.

CONCLUSION

This work has met its objective to cut a sheet without human effort but operate manually. In an effort to respond to the need of small scale industries who cannot afford the gigantic and very expensive model sheet cutter, it thus becomes necessary to design and construct a pneumatically operated sheet cutter. This will go a long way in enhancing our small scale industries that are interested in the production of such machines. It will also boost our technological knowhow and militate against expensive importation of goods. This pneumatic sheet cutting machine is less expensive as compared to hydraulic sheet cutting machine. The range of cutting thickness can be increased by arranging the high pressure compressor is advantageous to small sheet cutting industries.

Future Scope

It can be made hydraulically power operated by installing the gear oil pump at the place of air compressor and pneumatic cylinder arrangement. It can be made rack and pinion operated or spring and lever operated, by replacing the pneumatic circuit by rack and pinion arrangement by the square threaded screw and nut arrangement. The place where there us scarcity of the electricity the electric motor operate compressor is replaced by an I.C. Engine installed compressor.

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