

Design and Fabrication of Pneumatic Auto Sheet Metal Cutting Machine Using Solar Energy

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Abstract—Use of aluminium is increased now days in many industries like automobile, packaging, medical etc. The reason behind this is that the aluminium made things are quiet easier to manufacture, handle and reliable to use. So the aluminium goods manufacturing industries are striving hard to produce good quality products at large scale and cheaper cost. Hydraulically operated machines are too costlier for small scale and medium scale industries. This paper deals with pneumatically operated cutting machine. The manually operated machine is converted into pneumatically operated machine by applying proper design procedure. The design was drawing back using CREO software. At the end of task, the conclusion is made and several recommendations are suggests to make an improvement about the result and the project for future study.

Keywords— *Cutter, Cutting Force, Shear on material, Pneumatic System, IC Timer Circuit, Solenoid Valve, Solar Panel, Modeling in CREO(PRO-E).*

I. INTRODUCTION

This project is study about the design and fabrication of pneumatic cutting machine which shows capability to design more than one concept and fabricate the machine using a variety of machine. Other than that, it is important to studies on pneumatic and cutting force analysis which are the main topic for this project. So, at the end of this project, we will practicing on how to build and steps to follow to complete the requirement for this project. Pneumatic systems use pressurized gases to transmit and control power. As the name implies, pneumatic system typically use air (rather than some other gas) as the fluid medium because air is safe, low cost and readily available fluid.

The solar pneumatically cutting machine is designed using various components. The components are pneumatic cylinder, pressure regulator, Solenoid/direction control valve, flow control valve, compressor, mounting table, solar panel. The solar panel charge the battery that runs the compressor. The cylinder is used for up and down motion of the cutting blade which performs the cutting operation on the sheet of aluminium material. The compressor provides compressed air to the cylinder, which causes movement of the piston rod. Different pneumatic systems work efficiently at different operating pressure. Hence selection of pressure regulator of

right range is important for efficient working of pneumatic system. Pneumatic automation components extensively use sealing material made out of rubber compounds. For efficient and trouble free working of these seals, they need to be oiled or lubricated to reduce friction and corrosion. Solenoid/Direction control valve is used to control the direction of the air.

A device which gets heated by the sun's energy is called solar heating device. All the solar heating devices are designed in such a way that they help in collecting as much sunlight as possible. The solar heating devices such as solar cooker, solar water heater and solar cells have greatly helped in solving the energy problem, its consumption and future energy demands of our country. Solar energy also reduces our dependence on fossil fuel .It is a device which converts solar energy directly into electricity. Since solar energy is a light energy so we can say, "Solar cell is a device which converts light energy into electrical energy.

II. DESIGN PROCEDURE

A. Material Selection

To prepare any machine part, the type of material should be properly selected, considering design, safety .The selection of material for engineering application is given by the following factors:-

- 1) Availability of materials
- 2) Suitability of the material for the required components.
- 3) Suitability of the material for the required components.
- 4) Cost of the materials.

The machine is basically made up of mild steel.

The reasons for the selection are

Mild steel is readily available in market .It is economical to use and is available in standard sizes. It has good mechanical properties i.e. it is easily machinable .It has moderate factor of safety, because factor of safety results in unnecessary wastage of material and heavy selection. Low factor of safety results in unnecessary risk of failure. It has high tensile strength. Low coefficient of thermal expansion.

The materials of the sheets to be cut are taken as aluminium and plastic as they are replacing many metals in the present scenario because of their distinguished properties and features.

TABLE 1 : Specifications

SHEET METAL MATERIAL	ALUMINIUM
THICKNESS	0.5 mm
LENGTH OF CUT	25 mm
Max. SHEAR STRENGTH OF ALUMINIUM	30 N/mm ²

B. Force Calculation

Force required to cut the Sheet = $L \times t \times T_{max}$

For sheet of 0.5 mm thickness,

$$\text{force required} = 25 \times 0.5 \times 30 = 375 \text{ N}$$

This is the force required to cut the sheet metal, however the initial force required to cut the sheet is more and it is 140-150% than we calculated,

Therefore, max force required to cut the sheet = 525 – 562.5 N

Now we have chosen 12 volt DC Air Compressor that develops a pressure of 10.34 bar (150psi).

C. Designing of a cylinder

Since the max force required to cut the sheet = 562.5 N

And pressure applied by 12 volt compressor = 10.34 bar

Therefore,

Force applied by the cylinder,

$$F = (\pi/4) \times d^2 \times p$$

$$562.5 = (\pi/4) \times d^2 \times (10.34/10)$$

$$\rightarrow d = 26.3 \text{ mm}$$

For safety, we have taken the cylinder of diameter 30 mm.



Fig 1 : Piston Cylinder

D. Solenoid Valve

The directional valve is one of the important parts of a pneumatic system. Commonly known as DCV, this valve is used to control the direction of air flow in the pneumatic system. The directional valve does this by changing the position of its internal movable parts. This valve was selected for speedy operation and to reduce the manual effort and also for the modification of the machine into automatic machine by means of using a

solenoid valve. A solenoid is an electrical device that converts electrical energy into straight line motion and force. These are also used to operate a mechanical operation which in turn operates the valve mechanism. Solenoids may be push type or pull type. The push type solenoid is one in which the plunger is pushed when the solenoid is energized electrically. The pull type solenoid is one in which the plunger is pulled when the solenoid is energized. The name of the parts of the solenoid should be learned so that they can be recognized when called upon to make repairs, to do service work or to install them.

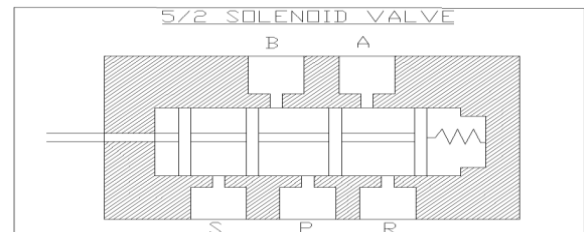


Fig 2 : Sectional view of solenoid valve



Fig 3 : Solenoid Valve

E. IC Timer Circuit

The IC 555 circuit is a highly stable controller capable of producing accurate time delays or oscillations. In this timing operations, the time is precisely controlled by one external resistor and a capacitor, by the operation as an oscillator, the free running frequency accurately contributed with the external RC constants. The internal resistors act as a voltage divider network, providing $(2/3)V_{cc}$ at the non-inverting terminal of the upper comparator and $(1/3)V_{cc}$ at the inverting terminal of the lower comparator. In most applications, the control input is not used, so that the control voltage equals $(2/3)V_{cc}$. Upper comparator has a threshold input (pin 6) and a control input (pin 5). Output of the upper comparator is applied to set (S) input of the flip-flop. Whenever the threshold voltage exceeds the control voltage, the upper comparator will set the flip-flop and its output is high. A high output from the flip-flop when given to the base of the discharge transistor saturates it and thus discharges the transistor that is connected externally to the discharge pin 7. The complementary signal out of the flip-flop goes to pin 3, the output. The output available at pin 3 is low. These conditions will prevail until lower comparator triggers the flip-flop. Even if the voltage at the threshold input falls below $(2/3)V_{cc}$, that is upper comparator cannot cause the flip-flop to change again. It means that the upper comparator can only force the flip-flop's output high.

To change the output of flip-flop to low, the voltage at the trigger input must fall below $+(1/3)V_{cc}$. When this occurs, lower comparator triggers the flip-flop, forcing its output low. The low output from the flip-flop turns the discharge transistor off and forces the power amplifier to output a high. These conditions will continue independent of the voltage on the trigger input. Lower comparator can only cause the flip-flop to output low. it is concluded that for the having low output from the timer 555, the voltage on the threshold input must exceed the control voltage or $+(2/3)V_{CC}$. This also turns the discharge transistor on. To force the output from the timer high, the voltage on the trigger input must drop below $+(1/3)V_{CC}$. This turns the discharge transistor off.

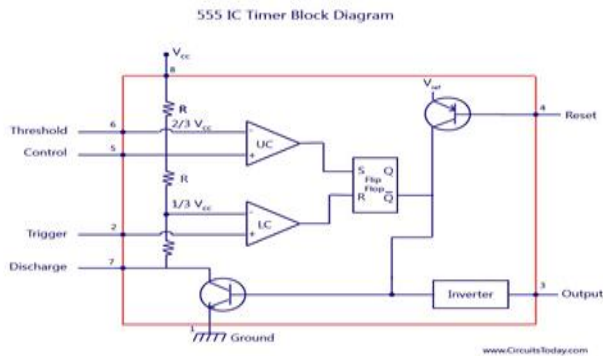


Fig 4 : IC Timer Circuit Block diagram

F. Solar Cell

To the supply the power to 12 volt battery. The solar panel required is of 12 volt that supplies the power to battery when the direct sun radiations falls onto the solar panel.

Solar panels generate free power from the sun by converting sunlight to electricity with no moving parts, zero emissions, and no maintenance. The solar panel, the first component of a electric solar energy system, is a collection of individual silicon cells that generate electricity from sunlight. The photons (light particles) produce an electrical current as they strike the surface of the thin silicon wafers. A single solar cell produces only about 1/2 (.5) of a volt. A structure that converts solar energy directly to DC electric energy. It supplies a voltage and a current to a resistive load (light, battery, motor).

$$\text{Power} = \text{Current} \times \text{Voltage} = \text{Current}^2 \times R = \text{Voltage}^2/R$$

The 3 basic types of Solar Panels:

Mono crystalline solar panels : The most efficient and expensive solar panels are made with Mono crystalline cells. These solar cells use very pure silicon and involve a complicated crystal growth process. Long silicon rods are produced which are cut into slices of .2 to .4 mm thick discs or wafers which are then processed into individual cells that are wired together in the solar panel.

Polycrystalline solar panels : Often called Multi-crystalline, solar panels made with Polycrystalline cells are a little less expensive & slightly less efficient than Mono crystalline cells because the cells are not grown in single crystals but in a large block of many crystals. This is what gives them that striking shattered glass appearance. Like Mono

crystalline cells, they are also then sliced into wafers to produce the individual cells that make up the solar panel.

Amorphous solar panels : These are not really crystals, but a thin layer of silicon deposited on a base material such as metal or glass to create the solar panel. These Amorphous solar panels are much cheaper, but their energy efficiency is also much less so more square footage is required to produce the same amount of power as the Mono crystalline or Polycrystalline type of solar panel. Amorphous solar panels can even be made into long sheets of roofing material to cover large areas of a south facing roof surface.

- Consumes no fuels/wood
 - No loss of trees & habitat
 - Trees sequester carbon
 - Generates no air pollution
- Generates no greenhouse gases
- Produces no smoke

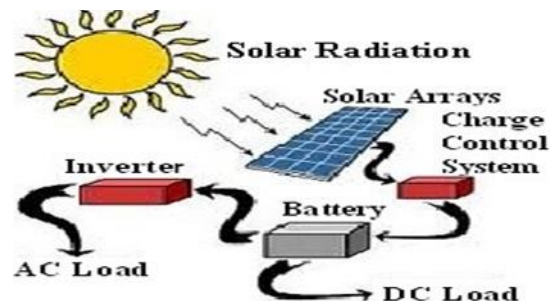


Fig 5 : Solar Power System

G. Battery

To run the 12 volt dc compressor the battery required to run this compressor is of 12 volt. Off grid solar power applications store the harvested energy in batteries for later use. Controlling the charging of the batteries and harvesting the maximum available power from the solar array is a key requirement for the charging system. For fixed, non-mobile applications, rechargeable lead acid batteries provide a good power-to-weight ratio. They also have high surge current capability and are well suited for driving DC motors for applications such as pumps that usually require high inrush currents. Photovoltaic technology combined with rechargeable lead acid batteries is a good solution for fixed location solar energy systems. When two dissimilar metal plates are immersed in acid they create a voltage. This voltage is created by the concentrating negative ions on the negative plates and positive ions on the positive plates. As batteries discharge the acid is turned to water and the lead plates are turned into lead sulfate. When both plates are turned to lead sulfate the battery is discharged or dead. One battery cell produce 2.1 volts and 6 cells are used in 12v battery to produce 12.6 volts.

III. WORKING PRINCIPLE

The compressed air from the compressor at the pressure of 7 to 10 bar is passed through a pipe connected to the Solenoid valve with one input. The Solenoid Valve is actuated with Control Timing Unit. The Solenoid valve has two outputs and one input. The air entering into the input goes out through the two outputs when the timing control unit is actuated. Due to

the high air pressure at the bottom of the piston, the air pressure below the piston is more than the pressure above the piston. The material is placed in between the fixed and moving cutter. When the piston is at the extreme point of the stock length, the exhaust valve is opened and the air is exhausted through it and the pressurized air come in at the top of the piston and it pushes the piston downwards. So the one side of the air is pulled downwards and the other side is lifted upwards. The time duration of the succeeding cutting is adjusted with the help of control timing unit.

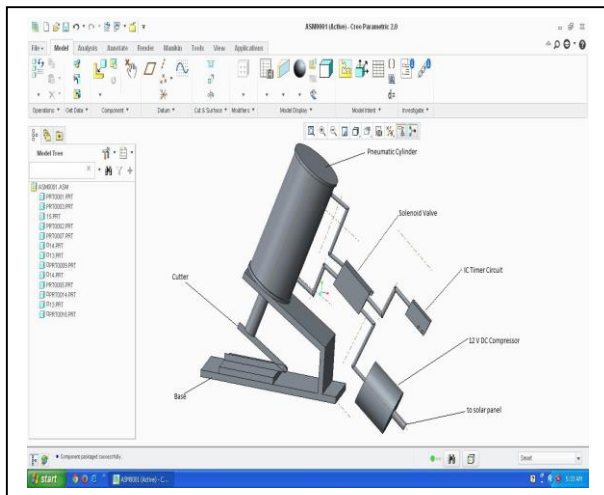


Fig 6 : Drawing in CREO(PRO-E)

IV WORKING MODEL OF PNEUMATIC AUTO SHEET METAL CUTTING MACHINE



Fig 7 : Working Model

V. CONCLUSION

After analysis and fabrication of pneumatic cutting machine using solar energy it was concluded that: After fabrication the machine run by using the solar energy which is the unconventional source of energy that may be used in small industries which eliminates the electricity to run the machine original foreign-language citation.

VI. FUTURE SCOPE

In this machine, compressed air is used to move the cutting tool for carrying out cutting operation using solar energy. After the completion of the cycle the air moves out through the out port of Solenoid valve. This air is released to the atmosphere. In future the mechanism can be developed to use this air again for the working of cylinder

REFERENCES

- [1] A.S. Aditya Polapragada & K. Sri Varsha , “Pneumatic Auto Feed Punching , cutting and Riveting Machine “, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 7, September - 2012 ISSN: 2278-0181.
- [2] P.M.Pradhan, “Experimental Investigation and Fabrication of Pneumatic Cutting tool”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, June 2013.
- [3] Pneumatic Systems (principles and maintenance) written by S.R. Majumdar.
- [4] E. Paul. Degarmo, “Shearing in Metal Cutting”, Pages 518-528, Materials and Processes in Manufacturing, Eighth edition, 2003, Prentice Hall of India Pvt Ltd.
- [5] K. Mahadevan, Design Data Handbook, Third edition, Reprint 2002, CBS Publishers & distributors.
- [6] Solar Energy". 2013 Journal Citation Reports. Web of Science (Science ed.). Thomson Reuters. 2014.
- [7] Fundamentals, modelling and application of solar energy written by G.N. Tiwari.