Design and Fabrication of Pneumatic Sheet Metal Cutting and Bending Machine

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Abstract—Use of aluminum is increased now days in many industries like automobile, packaging, medical etc. The reason behind this is that the aluminum made things are quiet easier to manufacture, handle and reliable to use. So the aluminum 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 and bending machine. The bending machine is one of the most important machine tool in sheet metal work shop. It is primarily designed for bending. The bend has been made with the help of punch which exerts large force on the work clamped on the die. 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. Automation in the modern world is inevitable. Any automatic machine aimed at the economical use of man, machine, and material worth the most. In our project is solenoid valve and control timing unit is used for automation. The sheet metal cutting machine works with the help of pneumatic double acting cylinder. The piston is connected to the moving cutting tool. It is used to cut the small size of the sheet metal. The machine is portable in size, so easy transportable. The bending machine is designed in such a way that, it works automatically. The automation strategy, when implemented is believed to result in reduced cycle time, costs and improved product quality. Other possible advantages are repeatability, increased productivity, reduced labor and integration of business systems. The manually operated machine is converted into pneumatically operated machine by applying proper design procedure. 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, Bending Force, Pneumatic System, IC Timer Circuit, Solenoid Valve.

I. INTRODUCTION

The shearing machine and bending machine is most important in sheet metal industry. This machine should be used for straight cutting machine with wide application. But in some industry hand sheet cutter and hand bender are used. For that machine to operate the human effort are required. The machine should be simple to operate and easy to maintain, hence we tried out to develop the Pneumatic Shearing and Bending Machine.

In shearing operation as the punch descends upon the metal, the pressure exerted by the punch first cause the plastic deformation of the metal. Since the clearance between the punch and the die is very small, the plastic deformation takes place in a localized area and the metal adjacent to the cutting edges.

In bending operation the bend has been made with the help of punch which exerts large force on the work clamped on the die. The bending machine is designed in such a way that, it works automatically. The machine is designed by observing the factors to improve the efficiency and to reduce the cycle time by producing quality output. Automation of machine is achieved with the help of pneumatic system. This involves the design of an efficient system which reduces the human effort and help to increase production output. It also includes pneumatic system, pneumatic component and shearing die and bending die.

II. LITERATURE REVIEW

Sheet metal bending is one of the most widely applied sheet metal forming operations. The understanding of the bending mechanics is aimed at obtaining two kinds of information important for industrial applications. The first one is the springback prediction for die design and shape control. The second is an estimation of the bend force for selection of press capacity, strength analysis and design of dies. Vallance and Matlock (1992) studied the friction behavior of zinc-based coated sheet steels and laboratory scale friction analysis techniques that involve sheet sliding over cylindrical dies. Wenzloff et al (1992) introduced a new test procedure for the bending under tension friction test. Mai Huang and Gardeen (1994) presented a literature review of the springback of doubly curved developable sheet metal surfaces and provided a bibliography on the springback in sheet metal forming. Reviewing the literature, it is found that researchers have been studying the phenomenon of springback for nearly six decades. There have been diverse efforts to evaluate and/or decrease springback in the sheet metal forming industry for a long time. Perduijn and Hoogenboom (1995) derived a simple explicit bending couple curvature relation for small and larger curvatures and they verified the model with experimental results**.** A simple approach for calculating bendability and springback in bending based on the normal anisotropic value, strain hardening exponent and sheet thickness has been presented as described elsewhere by Daw Kwei Leu (1997).

You-Min Hang and Daw-Kwei leu (1998) described the effects of process variables like punch radius, die radius, punch speed, friction coefficient, strain hardening exponent, normal anisotropy on V-die bending process of steel sheet. Sanchez (1999) focused on a systematic analysis of testing equipment as a measurement system of the friction phenomena on sheet metal under plane strain. It provides experimental references in order to optimize the usage of lubricants and sheet metal. Weilong Hu (2000) proposed anisotropy hardening models with simple loading conditions that include exponential hardening model, linear hardening model and multi linear hardening model. Samuel (2000) analyzed the springback in axisymmetric U-bending processes with a finite element program and discussed the effect of tool geometry and blank holder force on the final shape after springback.

Aleksy et al (2001) conducted experiments on springback for dual phase steel and conventional high strength steel for a hat channel section with varying cross sections. They described the methodology of experiments and discussed springback related results. Livatyali and Altan (2001) presented experimental investigation to determine the influence of die corner radius, punch radius, punch-die clearance, pad force and sheet material on springback in straight flanging. Leo De Vin (2001) described the problems related to an oversimplification of the air bending process and explained the consequences of applying models, standards or thumb rules. Streppel et al (2001) conducted the experiments on air bending that address the required punch displacement and the sheet length correction. Draw bend test for various die radii, friction coefficients and tensile forces was conducted by Cardeen (2002).

Zafer Tekiner (2004) examined the springback of sheet metals with various thicknesses and properties in bending dies. Carlos Gomes et al (2005) investigated the variation of springback in high strength steels based on experimental and numerical analysis. Ihab Ragai et al (2005) discussed the effect of sheet anisotropy on the springback of stainless steel 410 draw bend specimens and lubrication. Ozgur Tekaslan et al (2006) carried out the experiment to determine springback of steel sheet with V-shaped die. Dongye Fei and Peter Hodgson (2006) investigated the springback behaviour of cold rolled transformation induced plasticity (TRIP) steels in air v-bending process.

Bruni et al (2006) investigated the effect of the process parameters on springback of AZ31 magnesium alloy in air bending under warm and hot forming conditions. Garcia Romeu et al (2007) presented new springback graphics for air vee bent sheet metal parts based on an experimental work. Se Young kim et al (2007) examined the effect of tool design and process parameters on the springback of GLARE and the parameters studied include punch radius, punch speed, forming load and forming temperature.

In shearing or cutting operation as or blade descends upon the metal, the pressure exerted by the blade first cause the plastic deformation of the metal. Since the clearance between the two blades is very small, the plastic deformation takes place in a localized area and the metal adjacent to the cutting edges of the blade edges becomes highly stressed, which causes the fracture to start on both sides of the sheet as the deformation progresses and the sheet is sheared.

Types of shearing Machine:
1) Pneumatically operated
2) Hydraulically operated
3) Rack and pinion operated
4) Spring operated

Brief description of all the types is as follows.

1) Pneumatically operated: - Here the advancement of the header is carried out in the upward and the downward direction using the pneumatic double acting piston and cylinder unit arrangement along with the foot operated direction control valve. In this type of machine high pressure air is used as the working fluid for the transfer of power and the motion.

2) Hydraulically operated: - Here the lowering and raising of the header is carried over using the hydraulic piston and cylinder arrangement. To actuate the piston and cylinder, the oil is allowed to enter the cylinder from front or the back side of the piston. But the oil is comparatively costlier and its leakage may cause so many problems.

3) Rack and pinion operated: - Here the lowering and the raising of the header are carried out manually using the rack and pinion arrangement. In this case the required

pressure is applied manually using direct hand pressure on the rack using pinion and lever arrangement. Since the machine is robust and requires large pressure, hence it is not suitable.

4) Spring operated: - The working of spring operated machine is similar to the rack and pinion operated machine but differs from it in construction. Here the lowering and the raising of the heating handle are carried out manually and it requires too much pressure for its operation and also there is possibility of having damage to the work piece if not handled carefully.

III. 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/mm2

B. Force Calculation for cutting opertion

Force required to cut the Sheet = L×t×Ꞇmax
For sheet of 0.5 mm thickness,
Force required = 25×0.5×30= 375 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 10% to 20% than we calculated,

Therefore, max force required to cut the sheet = 431.25N

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

C. Design of a cylinder for cutting opertion

Since the max force required to cut the sheet = 431.25 N

And pressure applied by 12 volt compressor =10bar

Therefore,

Force applied by the cylinder,

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

$$431.25= (\pi/4) \times d^2 \times (10/10)$$

$$\rightarrow d=23.43 \text{ mm}$$

For safety , we have taken the cylinder of diameter 24 mm.

D. Force Calculation for bending operation

Force required to bend the Sheet Metal = (L × K × σut × t) / (w)

Where, σut = Ultimate Tensile Strength of Aluminium(400N/mm^2)

K = Die opening Factor (1.33 for V-Bending)
w = Width of Die Opening, For value of K=1.33, w=16t

Force required = (25 × 1.33 × 300 × 0.5) / (16 ×0.5) = **623.44 N**
This is the force required to bend the sheet metal, however the initial force required to cut the sheet is more and it is 15% than we calculated. Therefore, max force required to cut the sheet = 716.96N

E. Design of a cylinder for bending operation

Since the max force required to cut the sheet = 716.96 N
And pressure applied by 12 volt compressor =10 bar
Therefore,
Force applied by the cylinder,
$F = (\pi/4) \times d^2 \times p$
$716.96= (\pi/4) \times d^2 \times (10 /10)$
$\rightarrow d=30.21$ mm
For safety , we have taken the cylinder of diameter 30 mm.

Fig 1 : Piston Cylinder

F. 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.

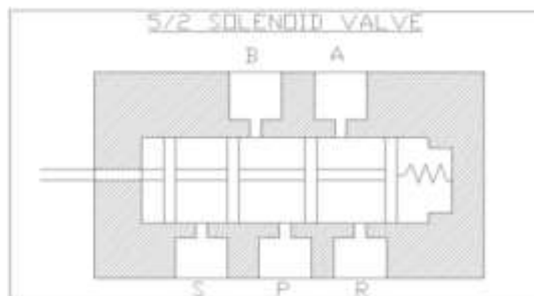

Fig 2 : Sectional view of solenoid valve

Fig 3 : Solenoid Valve

G. Battery

To run the 12 volt dc compressor the battery required to run this compressor is of 12 volt. 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. 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.

Fig 4 : Battery

H. DC Motor

A stepper motor is an electromechanical device which converts discrete electrical pulse into discrete mechanical movements. The shaft or spindle of a stepper motor rotate at equal angle of increment called **steps** when electrical command pulses are applied to it in the proper sequence. The sequence of the applied pulse is directly related to the direction of rotation of motor shaft and its speed directly related to the frequency of input pulses and total radiation at a stretch is directly related to the number of input pulse applied. Stepper motors with steps of 12, 24, 72, 144, 180 and 200 per revolution are available resulting in angle of the shaft increments of 30°, 15°, 5°, 25°, 2° and 1.8° per step. Special micro-stepping circuitry is sometimes provided to allow many more steps per revolution and these circuitry offer 10,000 steps per revolution or even more.

Specification of DC Motor

- Length : 80mm
- Torque : 1.5kg.cm
- Shaft Diameter: 6mm
- Weight : 130.00g
- Supply Voltage: 12V
- Speed = 3.5 RPM

Fig 5 : DC Motor

I. AIR COMPRESSOR

An air compressor is a device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its upper limit the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank.

The most common types of air compressors are: electric or gas/diesel powered compressors. The power of a compressor is measured in HP (Horsepower) and CFM (cubic feet of air per minute). The gallon size of the tank tells you how much compressed air "in reserve" is available.

Gas/diesel powered compressors are widely used in remote areas with problematic access to electricity. They are noisy and require ventilation for exhaust gases. Electric powered compressors are widely used in production, workshops and garages with permanent access to electricity. Common workshop/garage compressors are 110-120 Volt or 230-240 Volt. Compressor tank shapes are: "pancake", "twin tank", "horizontal", and "vertical". Depending on a size and purpose compressors can be stationary or portable.

Fig 6 : Air Compressor

IV. WORKING PRINCIPLE

The sheet metal cutting and bending machine works with the help of pneumatic double acting cylinder. The piston is connected to the moving cutting tool. It is used to cut and bend the small size of the sheet metal. The machine is portable in size, so easy transportable.

The compressed air from the compressor is used as the force medium for this operation. There are pneumatic double acting cylinders solenoid valves, flow control valve and the timer unit is used. The arm from the compressor enters to the flow control valve. The controlled air from the flow control valve enters to the solenoid valve. The function of solenoid valves all of air correct time interval. The 5/2 solenoid valve is used.
In one position air enters to the cylinder and pushes the piston so that the cutting stroke is obtained. The next position air enters to the other side of cylinder and pusses the piston return back, so that the releasing stroke is obtained. The speed of the cutting and releasing stroke is varied by the timer control unit circuit. Next the same procedure repeats to bending machine operation.

V. WORKING MODEL OF PNEUMATIC SHEET METAL CUTTING AND BENDING MACHINE

Fig 7 : Working Model of sheet metal cutting & bending machine

VI. ADVANTAGES

- The pneumatic is more efficient in the technical field.
- Quick response is achieved
- Simple in construction
- Easy maintenance and repair
- Cost of unit is very less
- No fire hazard problem due to overloading
- Continuous operation is possible without stopping

VII. DISADVANTAGES

- Silencer must be used while compressing the air
- High torque cannot be obtained
- Load carrying capacity is low

VIII. APPLICATIONS

- This machine is very useful for small scale industries
- These machines used to cut the roller sheet metal
- All industrial application

IX. CONCLUSION

Now we know that Pneumatic cutting and bending machine is very cheap as compared to hydraulic cutting and bending machine. The range of the cutting and bending thickness can be increased by arranging a high pressure compressor and installing more hardened blades. This machine is advantageous to small sheet metal cutting and bending industries as they cannot afford the expensive hydraulic cutting and bending machine.

X. FUTURE SCOPE

Since old age man is always trying to gain more and more luxurious. Man is always trying to develop more and more modified technique with increasing the aesthetic look and economic consideration. Hence there is always more and more scope. But due to some time constraints, and also due to lack of funds, we only have thought

and put in the report the following future modifications.
1. It can be made rack and pinion operated or spring and lever operated, by replacing the pneumatic circuit by rack and the pinion arrangement by the square threaded screw and nut arrangement.

2. The place where there is scarcity of the electricity the electric motor operate compressor is replaced by an I.C. Engine installed compressor.

3. In this machine, compressed air is used to move the cutting tool for carrying out cutting operation. 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.

Thus in future there are so many modifications, which we can make to survive the huge global world of competition.

XI. REFERENCES

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