Design of Pneumatic Punching Machine

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Abstract : This project work deals with the design of pneumatically controlled small scale punching machine to carry out piercing operation on thin sheets (1-2 mm) of different material like aluminum and plastic having tensile strength of 180N/mm^2 and 90 N/mm^2.The compressed air from the compressor at the pressure of 8 to 12 bar is passed through a pipe connected to the solenoid valve, so the press force(cutting force +stripping force) is 10350N.Reduction in punching force requirement being the main aim of this project work is obtained by modification in punch tool design i.e. by provision of shear on punch face. Subsequently it results in reduction in amount of punching force requirement. And further a SOLIDWORKS model of the machine is developed on the basis of calculations with respect to punching force requirement

Key Words - **Punching Force, Automated punching machine, Pneumatics, 5/2 double acting Solenoid Valve, Stripping force**

I. INTRODUCTION

Pneumatic punching machine is always a better choice than a hydraulic punching machine for the production of similar products if it is suited for the method [1]. It is comparatively more economical for production of large quantities of products as it uses compressed air rather than some hydraulic fluid which is rather expensive. A pneumatic punching machine uses compressed air to generate high pressure to be applied on the piston. A solenoid valve controls the directional flow of air into and out of the cylinder. Polyurethane tubes are used for pressure transmission from the pneumatic cylinder to the punch assembly. The high pressure air fed to the punch, forces it on the material and as the punch descends upon the sheet, the pressure exerted by the punch first cause the plastic deformation of the sheet. Since the clearance between the punch and the die is very small, the plastic deformation takes place in a localized area and the sheet material adjacent to the cutting edges of the punch & die edges becomes highly stressed, which causes the fracture to start on both sides of the sheet as the deformation progresses.[2]

1.1 PRINCIPLE OF WORKING

Initially starting with air compresses, its function is to compress air from a low inlet pressure (usually atmospheric) to a higher pressure level. This is an accomplished by reducing the volume of the air. [4]

Air compressors are generally positive displacement units and are either of the reciprocating piston type or the rotary screw or rotary vane types. The air compressor used here is a typically small sized, two-stage compressor unit. It also consists of a compressed air tank, electric rotor and pulley drive, pressure controls and instruments for quick hook up and use.

1.1.1 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 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. To perform any applicable amount of work then, a device is needed which can supply an air tank with a sufficient amount of air at a desired pressure. This device is positive displacement compressor. A positive displacement compressor consists of a movable member inside housing. The compressor has a piston for a movable member. [5] 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.

II. COMPONENTS OF PNEUMATIC PUNCHING MACHING

This section provides brief explanation in fabrication of Pneumatic Punching Machine

2.1 Pneumatic cylinder. It is a mechanical device which uses compressed air to get the required reciprocating linear motion. A Standard tie rod double acting cylinder is used, which has a Stroke length of 200mm and a bore diameter of 32mm.it has an operating pressure ranging from 1-10 bar.

Fig.1: double acting cylinder

2.2 5/2 double acting Solenoid Valve

It is a five port two position valve having one output and two inputs. The body is made up of anodized aluminium. The seals are made up of nitrile rubber. It has an operating pressure of 1-10kg/cm^2 .The operating temperature varies from 5°-55^o c. coil voltage operates in the voltage range of 12V-230V and air is used as operation medium

Fig .2: 5/2 double acting solenoid valve

2.3. Hoses

H**oses** are used to transfer air from compressor to solenoid valve and then to cylinder. It is made up of polyurethane tubes and its diameter varies from 5-6mm and has a length of 10mt.

Fig .3: Hoses

2.4. Connectors.

These act as a intermediate between double acting cylinder and hoses, it directs the compressed air to the cylinder byprovides tight seals. Its applications are limited to low pressure, some of the Key features includes durability, high performance, perfect finish.

Fig.4: Connectors

2.5. Assembly

Frame is supported by L-angles**.** Rollers are clamped to the frame, they are 4 in number and it directs the aluminum sheets towards punching area. Double acting cylinder is mounted on the frame, which gives the desired punching action.

Fig.5: Assembly

III. CALCULATION

The entire calculations in pneumatic punching machine is shown in below section

3.1 Force Calculation for existing punch design

Terms and formulae used:

- Cutting force: **-** The force which has to act on the stock material in order to cut the blank or slug.
- Stripping force: **-** The force developed due to the spring back (or resiliency) of the punched material that grips the punch.
- Cutting force = L x t x T_{max}
- Stripping force =10% -20% of cutting force
- L= Length of periphery to be cut in mm
- t= Sheet thickness in mm
- T_{max}= Shear strength in N/mm^2

The formula to calculate the press force is as follows-

• Press force = cutting force + stripping force

3.2 Sample Calculation for Aluminum Sheet

Here is a sample calculation to calculate the punching force required for different thickness of aluminum sheet.

• Total length of cut, L =50 mm.
• If Sheet thickness, t = 1mm.
• Maximum tensile strength of aluminum, T_{max}= 180 N/mm^2
• Total cutting force = L x t x T_{max}
• Total cutting force = 50 × 1 × 180
• Total cutting force = 9000 N
• Stripping force = 15% of the cutting force= 1350 N
• Press force = Cutting force + Stripping force= 9000 N + 1350 N= 10350N

3.3 Reduced force calculation:

Force required is reduced which can be seen by the formula,

Where,

$$F = \frac{Fmax * K * t}{(K * t) + I}$$

F=Reduced Force after providing shear in Newton(N)

F_{max}= Maximum force required to punch the sheet of thickness t in Newton (N)
K= Percentage Penetration
t= Thickness of sheet in mm
I= Amount of shear given to the tool (in terms of t) in mm
Aluminium sheet

- For I=t/5 & K=0.6 F=0.75F_{max}
- For I=t/4 & K=0.6 F=0.705F_{max}
- For I=t/3 & K=0.6 F=0.643F_{max}
- For I=t/2 & K=0.6 F=0.545F_{max}
- For I=t/1 & K=0.6 F=0.375F_{max}

3.4 Modification in Punch Design:

Shearing of Punch: If the face of the punch is normal to the axis of motion, the entire perimeter is cut simultaneously. By tilting the punch face on angle, a feature known as shear, the cutting force can be reduced substantially. The periphery is now cut in a progressive fashion, similar to the action of a pair of scissors or the opening of a beverage can.[3]

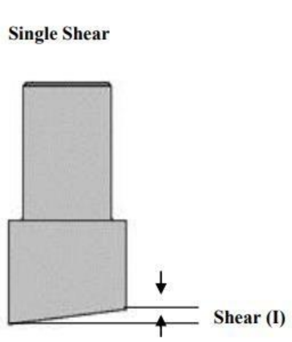
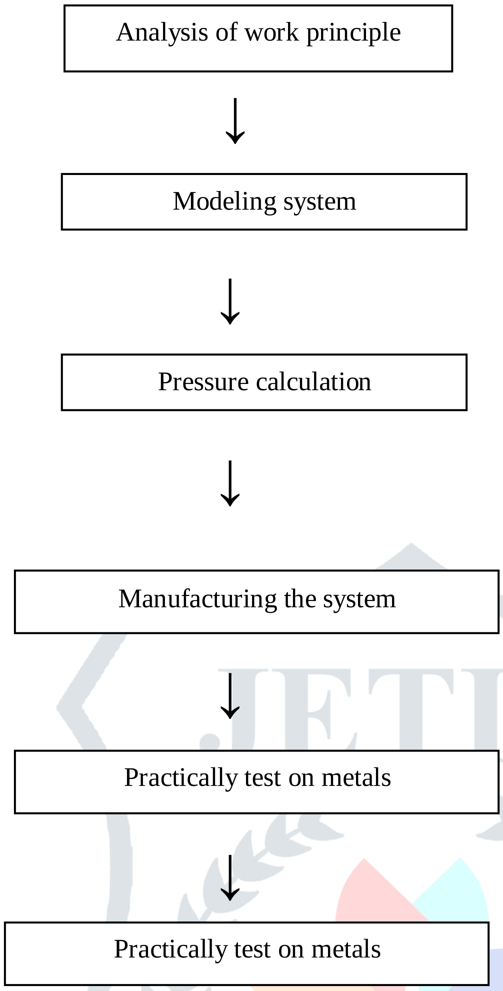


Fig.7: Punch tool design

IV. DESIGN PROCEDURE

- Recognition or need of pneumatic punching machine
- Analysis or design processment of raw material required for punching machine
- Fabrication and building up the model as per dimension and cad model
- Testing of the given machine for different sheet thickness (2-3mm) and tool diameter of 7mm

V.METHODLOGY



VI. 3D CAD MODELS

Fig 8 shows the isometric view of the punching machine having length 500mm, width 500mm, height 450mm.It has a roller chain of length 400mm, It has 4 rollers used to move the sheet, The approximate sheet size used for punching varies from 1-2.5mm.Standard tie rod double acting cylinder is used having a stroke length of 200mm and a bore diameter of 32mm,which has operating pressure ranges from 1-10 bar.

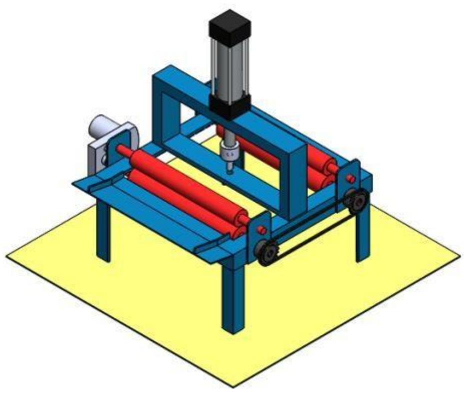


Fig.8 Isometric view

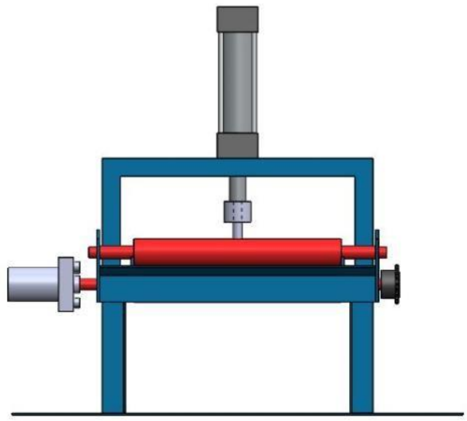


Fig.9 Top view

VII. ADVANTAGES OF PUNCHING MACHINE

Now a days almost all the manufacturing process is being atomized in order to deliver the products at a faster rate. The manufacturing operation is being atomized for the following reasons.

- To achieve mass production
- To reduce man power
- To increase the efficiency of the plant
- To reduce work load
- To reduce production cost
- To reduce the production time
- To reduce material handling
- To reduce the fatigue of worker
- To achieve good quality and good production less maintenance

VIII CONCLUSION AND RESULT

Pneumatically operated punching machine is suitable for small scale and medium size industries. Based on the shear provided on the punch face the punching force reduction of 25% to 60% thereby increasing tool life and reducing tool machining cost. Therefore with this force reduction we are able to easily punch sheets of thickness up to 2.25 mm for plastic sheet having tensile strength 90 N/mm^2 and up to 1.5 mm of aluminum sheet having tensile strength 180 N/mm^2.[6]

Assignment	Structural Steel							
Nonlinear Effects	Yes							
Thermal Strain Effects	Yes							
Bounding Box								
Length X	0.306 m	0.33 m		0.36 m		4.4e-002 m	1.27e-002 m	1.9179e002 m
Length Y	0.24 m	5.1386e002 m	3.8e-002 m			0.162 m	6.e-002 m	2.8e-002 m
Length Z	0.3 m	5.1386e002 m	3.8e-002 m			4.4e-002 m	1.27e-002 m	1.9179e002 m
Pr operties								
Volume	5.0117e004 m^3	1.9761e -004 m^3		2.3467e-004 m^3		2.8262e004 m^3	4.7118e006 m^3	2.2709e006 m^3
Mass	3.9342 kg	1.55 13 kg		1.8422 kg		2.2185 kg	3.6988e002 kg	1.7827e002 kg
Centroid X	7.7049e010 m	3.582e006 m	-1.1334e005 m	-8.9462e-006 m		-6.157e008 m	5.316e007 m	-2.1013e006 m
Centroid Y	3.3064e003 m	2.6197e002 m	2.6204e002 m	-1.0196e-002 m		0.15973 m	8.2e-002 m	5.5591e002 m
Centroid Z	4.8886e008 m	9.7496e002 m	-9.7502e002 m	9.7498e002 m	-9.7502e002 m	4.4852e008 m	-6.8958e007 m	2.7532e007 m
Moment of Inertia Ip1	4.5007e-002 $kg \cdot m^2$	2.0858e-004 $kg \cdot m^2$	2.0838e-004 $kg \cdot m^2$	3.0248e-004 $kg \cdot m^2$		6.8451e-004 $kg \cdot m^2$	1.1223e-005 $kg \cdot m^2$	1.08e-006 $kg \cdot m^2$
Moment of Inertia Ip2	8.6121e-002 $kg \cdot m^2$	6.9733e-003 $kg \cdot m^2$	6.9703e-003 $kg \cdot m^2$	8.1144e-003 $kg \cdot m^2$		4.5196e-003 $kg \cdot m^2$	1.1223e-005 $kg \cdot m^2$	5.8955e-007 $kg \cdot m^2$
Moment of Inertia Ip3	6.0781e-002 $kg \cdot m^2$	6.9732e-003 $kg \cdot m^2$	6.9702e-003 $kg \cdot m^2$	8.1148e-003 $kg \cdot m^2$		4.5196e-003 $kg \cdot m^2$	4.5399e-007 $kg \cdot m^2$	1.0797e-006 $kg \cdot m^2$
S tatistics								
Nodes	20470	2088	2095	1380		4202	854	12004
Elements	9501	1044	1039	645		2378	154	7934
Mesh Metric	None							

Table no.1: structural analysis

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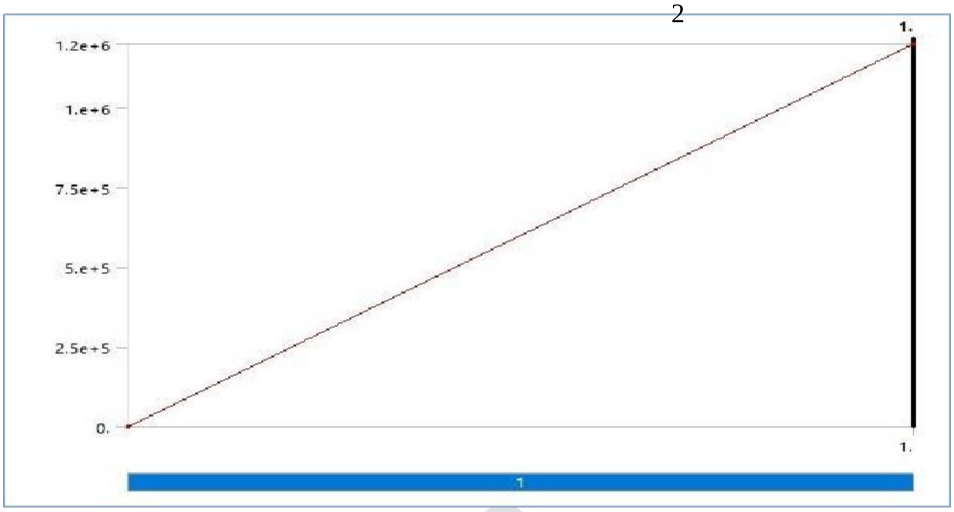


Model (B4) > Static Structural (B5) >pressure 2
Graph no:1

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 ohm m

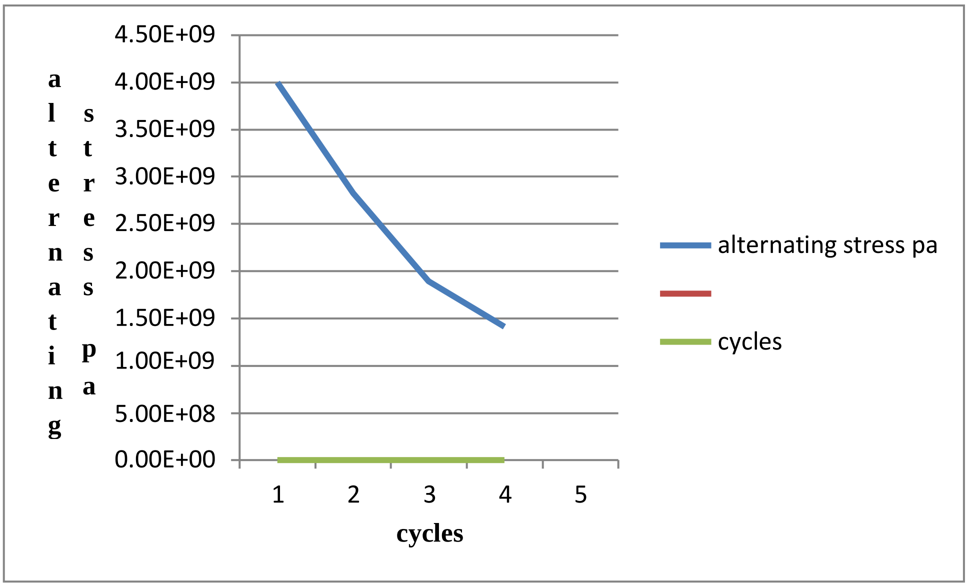
Table no 2: Structural Steel > Constants

Tensile Ultimate Strength Pa
4.6e+008

Table no 3:Structural Steel > Tensile Ultimate Strength

Alternating Stress Pa	Cycles	Mean Stress Pa
3.999e+009	10	0
2.827e+009	20	0
1.896e+009	50	0
1.413e+009	100	0
1.069e+009	200	0
4.41e+008	2000	0
2.62e+008	10000	0
2.14e+008	20000	0
1.38e+008	1.e+005	0
1.14e+008	2.e+005	0
8.62e+007	1.e+006	0

Table no:4 Structural Steel > Alternating Stress Mean Stress



Graph no:3 Alternating Stress vs Cycle

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