ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 6, June 2013

Experimental Investigation and Fabrication of Pneumatic Punch

A. K. Gupta[1], P. Bharadwaj[2], S. Sahgal[3], P. M. Pradhan[4]

Student, Department of Mechanical Engineering, Sikkim Manipal Institute of Technology, East Sikkim-737132, India[1,2,3]

Assistant Professor, Department of Mechanical Engineering, Sikkim Manipal Institute of Technology, East Sikkim-737132, India[4]

Abstract: This paper presents the investigation, design and fabrication of blanking of thin sheet (0.1-2 mm) of different sheet material. The blank diameter is considered as 10 mm. The study helped to evaluate the influence of tool clearance, burr formation, sheet thickness, punch/die size and blanking layout on the sheet deformation. The punch load variation with tool travel and stress distribution in the sheet has been obtained. The results indicate that a reduction in the tool clearance increases the blanking load and formation of burr increasing or decreasing at different pressure. The objective of this paper is to study the behaviour of punch and formation of burr.

Keywords: Blanking, Burr formation, Sheet thickness, Punch load variation, Tool travel

I. Introduction

The pneumatic press makes an important contribution to the output of engineering work shops and is indispensable for the cheap production of large quantity of similar articles when the type of articles concerned is suited of this method of production. A pneumatic press utilizes a compressed air source to control operation of piston for high pressure to obtain desire component by using press tools. The press includes a piston operated by the compressed air source to drive a piston rod to operate the press. This pneumatic press is suitable for small press tool works. It works on the principal of compressed air. A compressor plant, pipe lines control valve, drive-members and related auxiliary application. The air is compressed in an air compressor and for the compressor plant, the flow medium is transmitted to the pneumatic system, it is of vital important that the pressure drop between generation and consumption of compressed air is kept very low, it has been seen that pipeline fittings and joints are mostly responsible for drop in pressure, if any in pneumatic system.

In a blanking or punching operation, the sheet gets deformed gradually during the forward punch stroke. At times, there is a much localized plastic deformation near the punch and die edges. At a certain stage of the punch travel, this localized deformation gives way to origination of cracks. With a further forward punch travel, these tool edge cracks propagate through the sheet thickness leading to complete separation. J. Gresham, W. Cantwell, M.J. Cardew Hall, P. Compston, S. Kalyanasundaram [1], experimentally found that blank-holder force has a significant effect on the failure mode of the metal–composite system with lower forces resulting in wrinkling as the dominate mode and higher forces resulting in splitting and fracture. A. A. Ambekar, S. K. Maiti, U. P. Singh, P. P. Date, K. Narasimhan [2], showed the influence of various process parameters on sheet metal blanking. Most machining operations do not often produce smooth or well-finished edges on parts. Instead, parts will most likely end up exhibiting ragged, protruding, sometimes hardened, material along edges, known as burrs. Burr formation affects work piece accuracy and quality in several ways; dimensional distortion on part edge, challenges to assembly and handling caused by burrs in sensitive locations on the work piece and damage done to the work surface from the deformation associated with burr formation. A typical burr formed on a metal component due to the exit of a cutting edge can range in shape and size from small and uniform (as in a “knife burr”) to rather large, non-uniform in shape and many millimetres in length. D. Dornfeld and S. Min [3] explained the burrs in conventional machining, process planning for burr minimization as well as micromachining applications. Prof. T. Z. Quazi, R. S. Shaikh [4] discussed the effect of potential parameters influencing the blanking process.

II. Experimental Work

TABLE I Specification Of The Project

Maximum stroke length	200 mm
Size of the bed	200 mm x 175 mm
Maximum height of press tool that can hold	110 mm
Maximum moving mass	40 kg
Maximum force	15 kN

A. Design and development

The design is either to formulate a plan for the satisfaction of a special need or to solve a problem. If the plan result in the creation of something having a physical reality, then the product must be functional, safe, reliable, competitive, usable, manufacturable and marketable. A design imperative can be expressed as follows:

- Invent alternate solution.
- Through analysis and test, simulate and predict the performance of each alternative, retain satisfactory alternative, and discard unsatisfactory ones.
- Choose the best satisfactory alternative discovered as an approximation to optimality.
- Implement the design.

B. Design considerations

Sometimes the strength required of an element in a system is an important factor in determination of the geometry and the dimension of the element. In such a situation we say that strength is an important design consideration. When we use the expressions design consideration, we are referring to some characteristic which influence the design of the element or perhaps, the entire system. Usually quite a number of such characteristics are taken for consideration in a given design situation, many of the important ones are follows-
Strength/Stress, Distortion/Deflection/Stiffness, Wear, Corrosion, Safety, Usability, Utility, Cost, Processing, Weight, Life, Noise, Shape, Size, Control, Thermal properties, Surface.

Fig. 1 Experimental Setup of Pneumatic Punch

- Top plates and cylinder tightened with nut and bolts.
- U-channel and top plates welded by electric arc welding. Type of joint is lap joint.
- Piston rod and tool holding plates are welded by electric arc welding. Type of joint is single U-butt joint.
- U-channel and base plate welded by electric arc welding. Type of joint is lap joint.
- Slotted plate and base plate is tightened with L-N screw.

C. Procedure for material selection

The first step in any material selection problem is to define the needs of product. Without prior basis about material or method of fabrication, the engineer should develop a clear picture of all the characteristic necessary for this part to adequately perform its intended function. These requirements will fail into three major areas-

- Shape or geometry considerations
- Property requirement
- Manufacturing concerns

III. CALCULATIONS

Cutting force is the force which has to act on the stock material in order to cut the blank or slug. This determines the capacity of the press to be used for particular tool. The first step in establishing the cutting force is to determine the cut length area for straight cuts are performed in the shearing and some cut off operations, the area to be cut is found by multiplying the length of cut by stock thickness.

ISSN: 2319-8753
International Journal of Innovative Research in Science, Engineering and Technology
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Cutting force $= L \times S \times Tmax$
Stripping force =10% -20% of cutting force
L = Length of periphery to be cut in mm
S = Sheet thickness in mm
$Tmax$ = Shear strength in N/mm^2
$Tmax$ = 80% of tensile strength
The formula to calculate the press force is as follows-
Press force = cutting force + stripping force

A. Force calculation

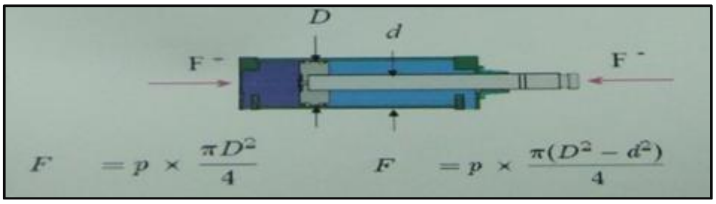

Fig. 2 Force calculation for double acting cylinder

Calculation for specification of the double acting cylinder in this project:-
We know the force required = 14000 N
Working pressure =12 bar
To find the Bore diameter of the cylinder we use the following formula:-
$F = \frac{\pi}{4} \times D^2 \times P$ ... (1)
$14000 = \frac{\pi}{4} \times D^2 \times (12/10)$
$D^2 = (14000 \times 40)/(3.14 \times 12)$
D^2= 14862
D=121.9 mm.
According to the formula bore diameter of the cylinder is = 121.9mm
As per the standards bore diameter = 125 mm
According to the bore diameter,
Piston rod diameter is= 32mm
Stroke length=200mm

B. Cylinder thrust

Cylinder thrust for double acting in forward stroke -
From equation (1), $F = \frac{3.14}{4} \times (125)^2 \times \left(\frac{12}{10}\right)$
$F = 14726.21$ N
Cylinder thrust for double acting in return stroke -
$F = \frac{\pi}{4} \times (D - d)^2 \times P$
where D = Diameter of bore in mm.
P = Pressure in bar. (1 bar = 0.1N/mm^2)
d = Piston rod diameter in mm.
$F = \frac{\pi}{4} \times (125 - 32)^2 \times (12/10)$
F = 13761.1183 N
As per our consideration the maximum force exerted by our cylinder is 14726.2N

C. Theoretical Air Consumption

$$C = \left\{\frac{\pi}{4} \times D^2 \times (P + 1) \times L\right\}/1000$$

where, P= pressure in bar
D= Diameter of bore in cm.
L= Length of stroke in cm.

$$C = \left\{\frac{\pi}{4} \times 12.5^2 \times (12 + 1) \times 25\right\}/1000$$

C = 39.883 litres

D. Sample calculation for aluminium

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International Journal of Innovative Research in Science, Engineering and Technology
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If total length of cut, L =71.7 mm.
Sheet thickness, T = 0.8 mm.
Maximum tensile strength of aluminium, Tmax. = 180 N/mm^2
Total cutting force $= L \times T \times Tmax.$

$$= 71.7 \times 0.8 \times 180$$

= 10324.8 N
Stripping force = 15% of the cutting force
= 1548.72
Pressure force = Cutting force + Stripping force
=10324.8 + 1548.72
=11873.52 N

TABLE II CALCULATIONS FOR ALUMINIUM

Total length of cut (L) in mm	71.7	71.7	71.7	72	73	80
Al sheet thickness (T) in mm	0.8	0.9	1	0.9	0.9	0.9
Tmax. of Aluminium in N/mm^2	180	180	180	180	180	180
Total cutting force (N)	10324.8	11615.4	12906	11664	11826	12960
Stripping force (N) = 15% of cutting force	1548.72	1742.31	1935.9	1749.6	1773.9	1944
Pressure force (N) = cutting force + stripping force	11873.52	13357.71	14841.5	13413.6	13599.9	14904

As per our consideration we vary the thickness and length of cut and we observe that the length of cut should be less than 73mm. and thickness should less than 1mm.

E. Sample calculation for plastic

If total length of cut L = 71.7 mm.
Sheet thickness T = 1mm.
Maximum tensile strength of plastic,Tmax. = 90N/mm^2
Total cutting force= 6453 N
Stripping force = 967.95
Pressure force = Cutting force + Stripping force
= 6453 + 967.95
= 7420.95 N

TABLE III CALCULATIONS FOR PLASTIC

Total length of cut (L) in mm	71.7	71.7	71.7	71.7	72
Sheet thickness(T) in mm	1	2	2.1	3	1.9
Tmax. for plastic in N/mm^2	90	90	90	90	90
Total cutting force (N)	6453	12906	13551.3	19359	14158.8
Stripping force (N) = 15% of cutting force	967.95	1935.9	2032.69	2903.85	2123.82
Pressure force (N) = cutting force + stripping force	7420.95	14841.9	15583	22262.85	16282.62

As per our consideration we vary the thickness and length of cut and we observe that the length of cut should less than 72mm and thickness should less than 2.1mm.

F. Sample calculation for G.I. sheet

If total length of cut, L = 71.7mm.
Sheet thickness, T = 0.5mm.
Maximum tensile strength of G.I. sheet, Tmax. = 300N/mm^2
Total cutting force =10755 N
Stripping force = 1613.25
Pressure force = 10755 + 1613.25
= 12368.25 N

TABLE IV CALCULATION FOR G.I. SHEET

Total length of cut (L) in mm	71.7	71.7
Sheet thickness(T) in mm	0.5	0.6
Tmax. for G.I. sheet in N/mm^2	300	300
Total cutting force in N	10755	12906
Stripping force in N = 15% of cutting force	1613.25	1935.9
Pressure force in N = Cutting force + Stripping force	12368.25	14841.9

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
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As per our consideration we vary the thickness and length of cut and we observed that the length of cut should be less than 72mm and thickness should be less than 0.6 mm.

TABLE V CIRCULARITY FORMED DURING PUNCHING AND VARIATION WITH RESPECT TO ORIGINAL DIMENSIONS

Pressure (bar)	Original radius (mm)	Material	Radius formed after punching (mm)	Variation in radius (Average radius taken) (mm)
8	5	G.I.	5.77	0.77
		Al.	5.65	0.65
		Plastic	5.25	0.25
10	5	G.I.	5.43	0.43
		Al.	5.37	0.37
		Plastic	5.16	0.16
12	5	G.I.	5.1	0.1
		Al.	5.09	0.09
		Plastic	5.03	0.03

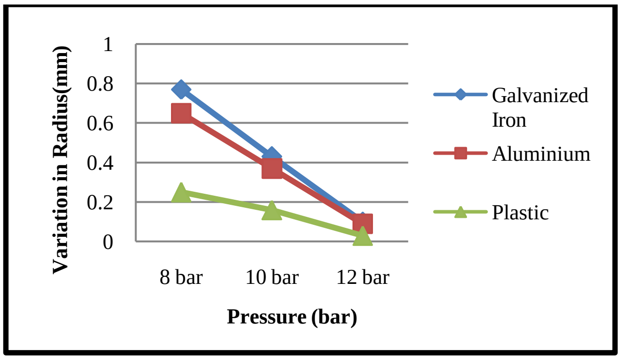

Fig. 3 Graph showing relation between pressure and variation in radius

The above graph indicates the relation between pressure and variation in radius. As per the analysis carried on sheets of Galvanized Iron, Aluminium and plastic it was found that as the pressure varies from 8 bar to 12 bar ,the variation of radius decreased with respect to the material and even it was found that the variation of Plastic material was lesser in all different values for pressure. So, if the pressure will be high then rapid cutting/blanking takes place and good quality of component is produced with less variation in radius.

TABLE VI STRAIGHTNESS FORMED DURING PUNCHING AND VARIATION WITH RESPECT TO ORIGINAL DIMENSIONS

Pressure (bar)	Original Dimension (mm)	Material	Dimension formed after Punching (mm)	Variation in Dimension (Average Dimension taken) (mm)
8	10	G.I.	10.9	0.9
		Al.	10.8	0.8
		Plastic	10.32	0.32
10	10	G.I.	10.64	0.64
		Al.	10.43	0.43
		Plastic	10.21	0.21
12	10	G.I.	10.21	0.21
		Al.	10.11	0.11
		Plastic	10.02	0.02

ISSN: 2319-8753

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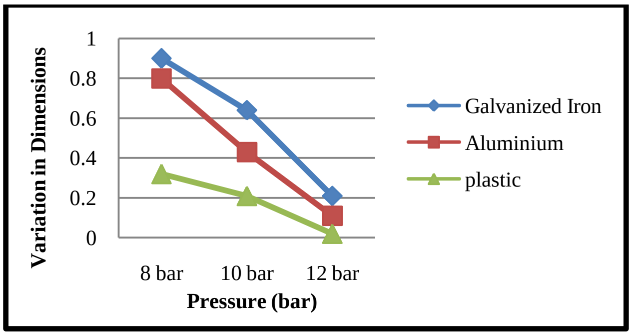

Fig.4 Graph showing relation between pressure and variation in dimension

The variation in dimension with respect to pressure was obtained as per the result analysis and it was concluded that the variation of dimension was lesser for higher values of pressure for all the three materials. As the variation in dimension is proportional to the straightness therefore we conclude that higher the pressure more will be the straightness and lesser will be the variation in dimension.

TABLE VIIBURR FORMED DURING PUNCHING AND VARIATION WITH RESPECT TO ORIGINAL DIMENSIONS

Pressure(bar)	Material	Original Thickness (mm.)	Thickness after burr formed (mm.)	Variation in thickness (Average thickness taken)(mm.)
8	G.I.	0.5	0.72	0.22
	Al.	0.8	1.28	0.48
	Plastic	1	1.21	0.21
10	G.I.	0.5	0.61	0.11
	Al	0.8	1.02	0.22
	Plastic	1	1.16	0.16
12	G.I.	0.5	0.53	0.03
	Al.	0.8	0.87	0.07
	Plastic	1	1.04	0.04

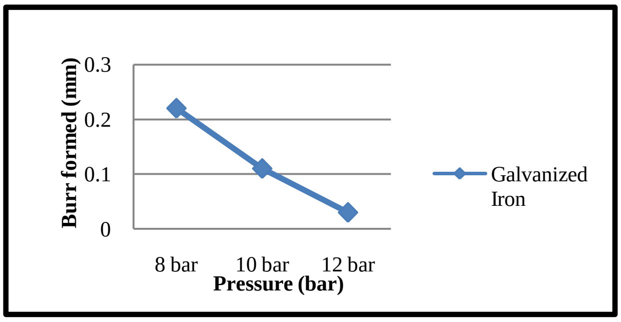

Fig. 5 Graph between pressure and burr formed for G.I.

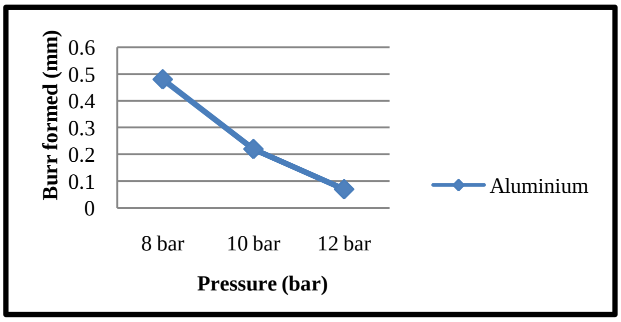

Fig. 6 Graph between pressure and burr formed for Aluminim

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
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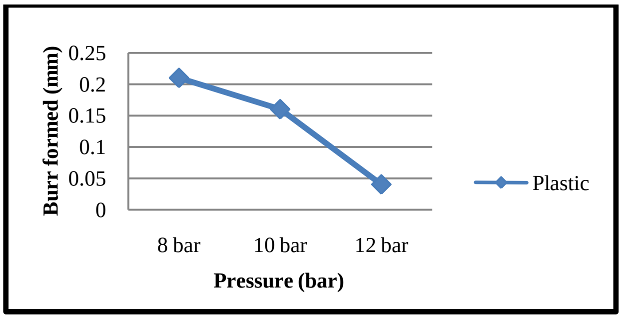

Fig. 7Graph between pressure and burr formed for Plastic

As the investigation was done in between various material with varying thickness and varying pressure, it was found that higher the pressure, lesser will be the burr formed and even it was seen that in plastic material the burr formation was decreased to higher extent as compared to Aluminium and Galvanized Iron.

IV. CONCLUSION

After experimental investigation and fabrication of pneumatic punch it was concluded that:

1) Circularity of various material sheets punched is proportional to the blanking pressure and further investigation revealed that the circularity embed on a plastic sheet material is more favorable than Aluminium and Galvanized Iron as the ability to resist same pressure is less in plastic material comparable to Aluminium and Galvanized Iron .
2) As per the graphs obtained between burr formation and pressure for Galvanized Iron, Aluminium, and Plastic in fig no. 5, 6, 7 respectively, we observe that burr formation is proportional to the pressure applied. So, graphically we see that less burr is formed in plastic as compared to Galvanized Iron and Aluminium.
3) The experimental investigation of the blanking process makes it possible to study the effects of process parameters such as the material type, the thickness of the sheet and their interactions on the geometry of the sheared edge especially the burrs height. As the result and graph obtained above shows that higher the pressure, lesser will be the burr formation and the burr formation of Plastic material is lesser as compared to Galvanized Iron and Aluminium.

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