New Clues in Sciences 1 (2011) 115-122

Available at woaj

New Clues in Sciences

Journal homepage: www.woaj.org/NCS

Design and implementation of a Portable Hydraulic Blanking Press

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ARTICLE INFO

Article history:
Accepted:
Available online: 3 December 2011

Keywords:

Blanking,
Piercing,
Blanking punch,
Blanking die,
Maximum blanking force,
hydraulic jack,
presses.

ABSTRACT

The design, construction and performance evaluation of a portable blanking press was carried out. The aim was to design and fabricate a portable blanking press and to carry out performance evaluation of the fabricated press. This was achieved by blanking mild steel sheet of 100mm and 50mm diameter having a maximum thickness of 2mm by using the two sets of 50mm and 100mm punches and dies respectively and also checking the force required for blanking through a pressure gauge attached to the press. The experimental setup described a blanking press in which a hydraulic jack of a piston and cylinder arrangement is coupled with a pressure gauge. The piston and the press ram are one unit. The ram is actuated by oil pressure on the piston in the cylinder and transmits the action of the ram to the punch which engages the sheet metal and passes through a conforming die. The calculated maximum forces required blanking 2mm mild steel sheet of 50mm and 100mm diameters with the use of their respective punches and dies were determined to be 135.11KN and 270.21KN respectively, while the experimental values were 150KN and 300KN respectively.

1. INTRODUCTION

In today's highly competitive industrial environment, sheet metal working through dies and press machines serves as one of the most expedient manufacturing systems for mass production of sheet metal components (Johnson, 1982). An important activity during the manufacture of these components is to identify the presses from those available on the shop floor on which the given job is possible, and then to select the optimum from the identified alternative press machines. The manual method of press operation is tedious and time consuming, and often does not yield optimum results (Sharma, 1996).

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Metal forming presses are used for many different applications including drawing, progressive forming and shearing. Each application requires different press characteristics for maximum productivity in order to ensure the equipment would satisfy its intended application in the future. Blanking is the operation of cutting a flat shape from sheet metal. The article punched out is called the 'blank' and is the required product of the operation. The perforated metal left behind is discarded as waste. It is usually the first step of series of operations. Blanking can also be defined as a cutting, shearing or punching operation on a piece of material to form a net shape or part (Bradock, 1989).

Blanking presses for cutting blanks from sheet material are well known. Metal cutting is a cold working operation in which sheet metal in cut to specified shape. The force applied may be tensile, compressive or shearing or a combination of all the above. The blanking process which involves shearing and tearing of sheet metal is a process by which sheet metal of specified thickness is separated by means of two cutting blades known as blanking punch and die, causing the metal to deform under applied pressure to the point where the shear stress of the metal is exceeded and then rupture under a greatly reduced load (Pollack, 1975). The design of blanking press for laboratory use is a way of performing all the rigorous operations faster and also with great ease. To set up a complete industry to replace the traditional methods of production would require machines for such operations as blanking, forming, stamping and polishing. The tools to perform these various processes would be carried out on manual, hydraulic or pneumatic presses. The design of the blanking press for which is considered here operates with the use of a hydraulic jack (Khurmi *et al*, 2004).

2.0 Materials and Methods

Design Consideration

In this work, the following factors were considered before adopting the layout of the material used.

1. Economy of the Material: The method of minimizing the waste between blanks should be employed.
2. Direction of Material Grain: This factor is to be considered if the cut blanks have to undergo any subsequent operation, such as bending, or deep drawing. When the sheet metal is rolled in the mill, a fibre is produced in the direction of strip length. During subsequent bending operation on the blank, to obtain maximum strength from bent parts, the bends should be made across the strip or at right angle to the fibre.
3. Arrangement of Tool: In order to get a well shaped blank, the whole set should be arranged in such a way that the punch moves freely but at close tolerance in the die (Khurmi *et al*, 2004).

Design Analyses and Calculations

Determination of Blanking Force

The maximum force required to cut a circular blank is given by

$$F_{\max} = \pi D t \tau_s = P.t.\tau_s ,$$

(Antony *et al*, 1991) (1)

Where:
D = Diameter of the circular blank (mm);
t = Thickness of the material (mm);
τ_s = Shearing strength of the material (N/mm2);
P =Perimeter of the section to be blanked.
From Eq. (1), the maximum blanking force is determined to be 270KN.

Determination of Workdone to make a Cut

Energy in press work or the Workdone to make a cut is given as

$$E = F_{\max} Ktn ,$$

(Ostergaard, 1963) (2)

Where:
E = Workdone (J);
K = Percentage penetration required to cause rupture (%);
n = Factor of safety.
The workdone to make a cut is determined using Eq. (2) to be 438J.

Determination of the Clearance between Punch and Die

The clearance between the punch and die is given by

$$C = 0.0032t\sqrt{\tau_s} ,$$

(Joseph, 1977) (3)

Where:
C = Clearance between the punch and die.

From Eq. (3), the clearance between the punch and die is determined to be 0.13mm

Design of the Diameter of Die

The diameter of the die can be determined from

$$B = D - 0.051 , \qquad (4)$$

Where:
D = Diameter of the circular blank (mm);
B = Diameter of Die (mm).
The diameter of the die is determined using Eq. (4) to be 100mm.

Determination of Diameter of Punch

The diameter of punch is given by the relation

$$D_P = D - 2C , \qquad (5)$$

Where:
DP = Punch diameter (mm).
The punch diameter is determined in Eq. (5) to be 99.74mm.

Determination of Diameter of Ram

The ram diameter can be determined from

$$d = \sqrt{\frac{n 4 \tau_s \pi D t}{\pi \sigma_e}} ,$$

(Edward, 1991) (6)

Where:
d = Diameter of Ram (mm);
σ_e = Elastic Limit of material (MN/m2).
Using Eq. (6), the ram diameter is determined to be 50mm.

Determination of Spring Rate

The spring rate, K_w is determined using the expression

$$K_w = \frac{w}{\delta} , \qquad (7)$$

Where:
K_w = The spring rate;
w = Force acting on spring (N);
δ = Deflection of spring (mm).
The spring rate is determined in Eq. (7) to be 3.333.

Determination of Spring Index

This is determined using the expression

$$C = \frac{Ds}{ds} , \qquad (8)$$

Where:
C = Spring index;
D_s = Diameter of spring coil (mm);
d_s = Diameter of wire of spring (mm);
Using Eq. (8), the spring index is determined as 6.0

Determination of Thickness of Cylinders

The thickness of the pump cylinder and load cylinder are determined from the relation

$$t_c = \frac{p_r d}{2\sigma_{tall}} ,$$

(Flim *et al*, 1995) (9)

Where:
t_c =Thickness of cylinder (mm);
P_r = Operating pressure (N/mm2);
σ_{tall}=The allowable circumferential stress for the material of cylinder (N/m2).
The thickness of the cylinder of the cylinder is determined using Eq. (9) to be 13.749mm.
The fundamental equation for calculating the theoretical maximum blanking forces is given by

$$F_{\max} = \pi D t \tau_s = P.t.\tau_s$$

Where:
D = Diameter of the circular blank (mm);
t = Thickness of the material (mm);
τ_s = Shearing strength of the material (N/mm^2);
fP =Perimeter of the section to be blanked.

3.0 Results

Tests were carried out using the two set of 100mm and 50mm punches and Dies to blank 0.5mm, 0.75mm, 1.0mm, 1.5mm, 1.75mm, and 2mm thicknesses of mild steel sheet. The metal sheet was held between the punch and die, blanked out by upward movement of the ram. Successive blanking forces were checked on the pressure gauge attached to the press. It was noticed that, when the two cutting edges of the punch and die come in contact with the metal, cutting did not take place. The pressure was applied by pumping the hydraulic jack manually. This pressure was needed to compress the metal to its rupture point thereby making the initial cut in the sheet metal. Compression had already taken place followed by rupture of the metal and blanking could progressively go on without much hindrance.

Table 1: Blanking forces using a set of 50mm punch and Die.

Metal thickness (mm)	Calculated Values (KN)	Experimental values (KN)
0.50	33.78	40.00
0.75	50.66	58.50
1.00	67.55	70.00
1.50	101.33	115.00
1.75	118.22	125.50
2.00	135.11	150.00

Table 2: Blanking forces using a set of 100mm punch and Die

Metal thickness (mm)	Calculated Values (KN)	Experimental values (KN)
0.50	67.55	72.00
0.75	101.33	110.00
1.00	135.11	150.00
1.50	202.66	215.75
1.75	236.44	250.50
2.00	270.21	300.00

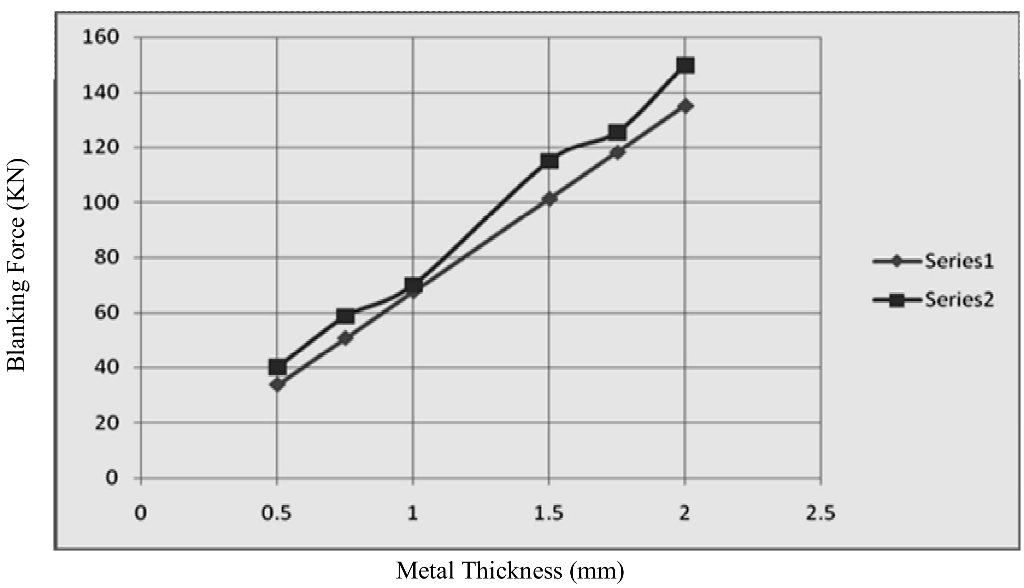

Fig. 1 Graph of blanking forces against metal thickness (50mm punch)

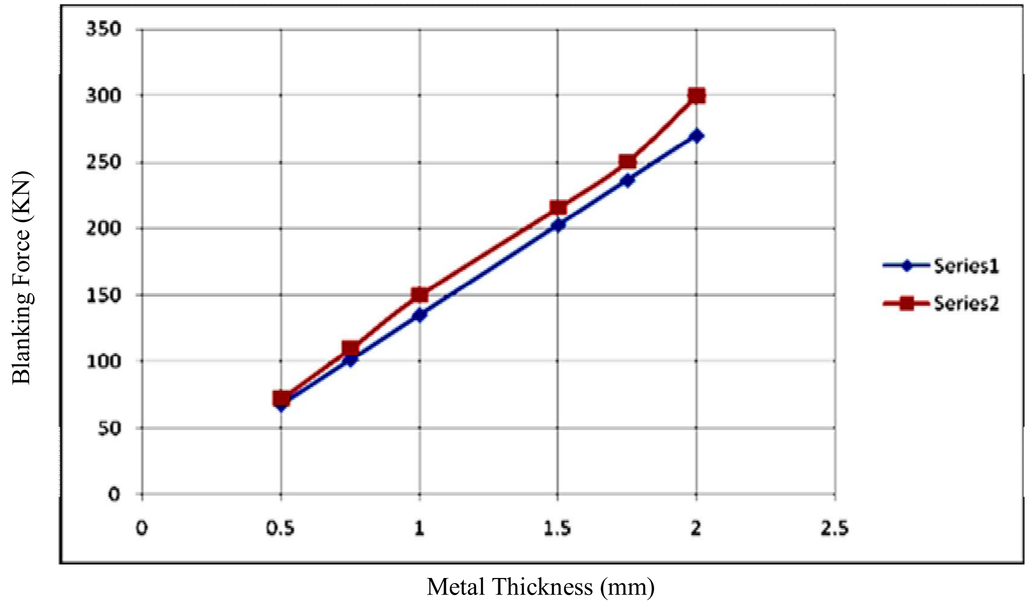

Fig. 2 Graph of blanking forces against metal thickness (100mm punch)

Table3. Blanking Forces with Displacement of the punch (1mm Thick metal sheet)

Displacement(mm)	Blanking Forces (KN)
0	0
0.01	50
0.09	60
0.1	70
0.2	70
0.21	90
0.22	100
0.3	110
0.3	140
0.3	150
0.4	150
0.6	150
0.83	150
1	170
1	170

Table 4.Blanking Forces with Displacement of the punch (2mm Thick metal sheet)

Displacement (mm)	Blanking force (KN)
0	0
0.01	50
0.08	60
0.1	68
0.2	70
0.21	92
0.23	100
0.31	110
0.31	145
0.31	150
0.39	150
0.6	150
0.85	150
1	171
1	171
1.01	172
1.08	174
1.1	180
1.2	186
1.22	190
1.23	195
1.3	200
1.31	200
1.31	200
1.4	250
1.65	290
1.9	300
2	300

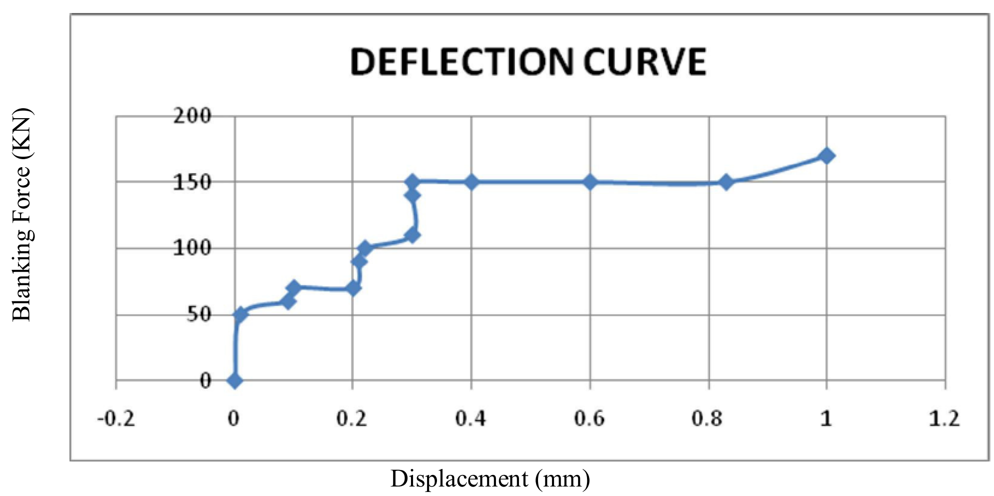

Fig.3 Graph of Blanking Forces (KN) against displacement (mm) (1mm Thick metal sheet)

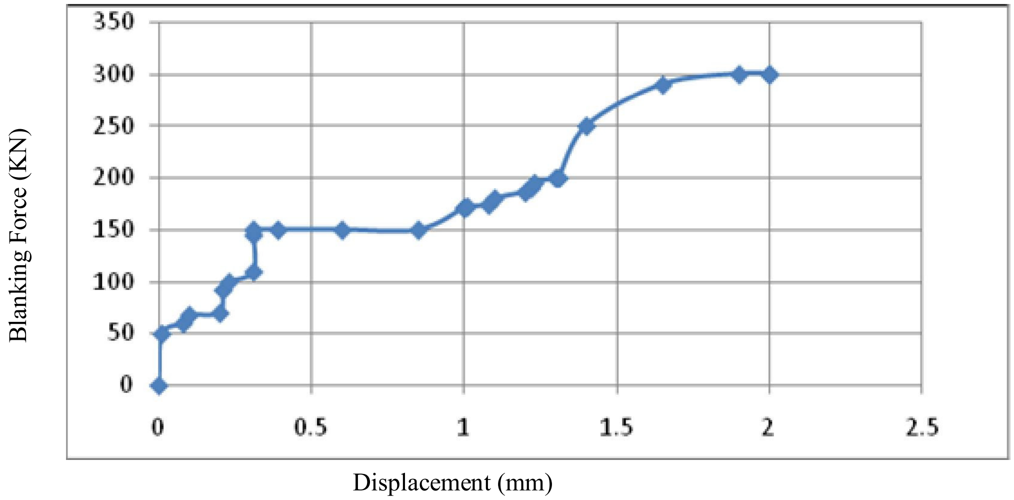

Fig.4 Graph of Blanking Forces (KN) against displacement (mm) (2mm Thick metal sheet)

4.0 Discussion

The ability of the machine to perform effectively determines the overall success of the project for high performance. The analysis of the various blanking forces was shown in table 1 and table 2 respectively. From the results, the blanking forces were plotted against sheet metal thickness as shown in Figs.1 and Fig.2. It could be observed that the analytical value gave a straight line graph showing that the blanking forces increases, with increase in metal thickness. It could also be observed from the tables and graphs of the experimental values that, there was variation in the values of the experimental blanking forces compared to that of the analytical values. The theoretical value of the maximum force required to blank 2mm mild steel sheet of 100mm diameter was 270.21KN as against the experimental value of 300KN. Also, the theoretical value of the maximum force required to blank 2mm mild steel sheet of 50mm diameter was 135.11KN as against the experimental value of 150KN.These variation in results was due to friction between the punch and die surface, which could occur due to work hardening of the material or insufficient lubrication of the cutting tools prior to blanking.

Experimental blanking forces for both 100mm and 50mm punch and die were higher than the theoretical values as shown in the tables and graphs respectively. Also, it could be observed from the graphs of blanking forces against the displacement of the punch (Figs. 3 and 4) that, there are variations in the graphs compared with the theoretical graphs of blanking force against the displacement of the punch. This could be due to friction resulting from work hardening of the punch and die. The maximum depth of penetration of the punch that could be formed is less with friction than without it.

5.0 Conclusion

In conclusion, the project was successful to a great extent. Various design considerations and ideas have been optimally and carefully put together in order to successfully design, construct and carry out performance evaluation of the press. The variation in the calculated results and the experimental values indicated how successful the project was. This work could serve as a teaching aid in laboratories and workshop practical. It could also be concluded that a portable inverted blanking press could be fabricated with the use of hydraulic jack with a little cost implication compared with the use of hydraulic pump.

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