DESIGN CONSIDERATIONS IN THE FORMING OF AUTOMOBILE PARTS

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ABSTRACT
Manufacturing is the main stay of any Nations economy, and the process of manufacturing starts with the production of machine components which is made possible through putting ideas into design and a method of manufacture is determined. This work presents the design of a machine for forming the Back- Plate of a brake pad through stamping and punching. The tools used are called dies and are made having the specific shape that needs to be formed.

Keywords: Design, Machine, Backplate, Breakpad, Dies Stamping Punching.

INTRODUCTION

Metal forming is one manufacturing method among many, in order to manufacture a machine component, such as a wheel suspension arm of a car, one can choose metal forming, casting, or machining as the shaping method. These three shaping methods can be considered competing processes. The method chosen will usually be the one that provides a product, with proper functions and properties at the lowest cost. Operations called stamping ,pressing and sometimes drawing involves clamping a sheet material at its edges and forcing it into a die cavity with a punch or a mechanical, manual, hydraulic press. The sheet metal is stretched rather than squeezed between the tools .This tools are called Dies and are made having the specific shape that needs to be formed.

A stamping press is a metal working machine tool used to shape or cut metal by deforming it with a die. Some of the key stamping press types are mechanically-driven presses, hydraulically-driven presses and servo-driven presses.

Stamping Mechanically-driven presses are powered by a motor that runs the machine's large flywheel. The press's flywheel works by storing kinetic energy, which is then transferred through the gearing into the pressslide. This paper analyzes the design considerations of the punch or stamping press.

Mechanical presses consist of:

- Motor
- Fly wheel
- Clutch/brake system
- Helical gears
- Connecting rods
- Slide (ram)
- Bolster plate
- Counterbalance system

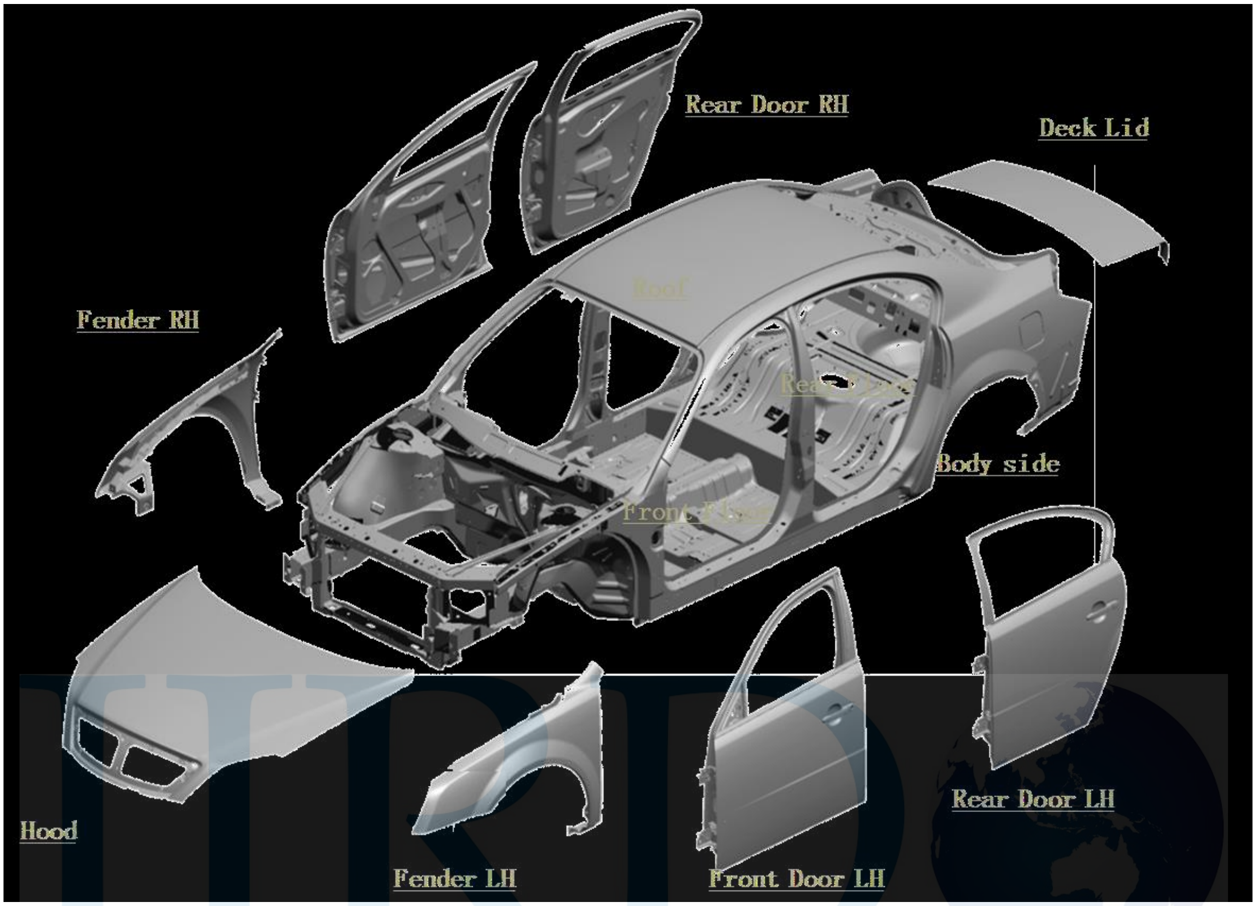


FIG. 1 AUTOMOBILE BODY THAT CAN STAMPED OR PUNCHED(Allen Bradley)

TYPES OF PUNCHING AND STAMPING PRESSES

The following are types of Punching and stamping press and the are classified by their mode of operation.

1. Manually operated presses
2. Mechanically operated presses
3. Hydraulically operated presses
4. Servo-driven operated presses

Fig 2 A STAMPING MACHINE SHOWING THE UPPER AND LOWER DIES(Allen Bradley)

3. DESIGN CONSIDERATION

PUNCH PRESS: In designing a punch press is important that consideration must be given to features like the frame, the slides and the die components. The frame must be rigid enough to withstand the punch load since any deflection in the frame would affect the die components and consequently the end product. The slides which control the ram must move in proper alignment to ensure that the upper and lower dies, held on the ram and the press bed respectively are in symmetry during the component production. The dies also apart from being worked to the correct clearance limits must also be given the correct heat treatment of temper hardness (Tempering) in order to ensure efficient Blanking operation. Another consideration has to do with the retraction of the punch from the die after the stamping or punching operation has been executed hence there is need to incorporate the inclusion of springs in the die in order to strip the stock material from the punch.

Consider a blank that has 2holes spaced 50mm apart and a diameter of between 3mm to 5mm.The holes would be produced in a single punching operation in order to ensure Location consistency

3.1 Punch and Die Design

The punch and die perform the hole blanking operation in the press and the force Fp needed to accomplish this is given by

$$F_p = Cst \quad ....(1)$$

Where C: Perimeter of the punched hole

S: shear force of the cut material

T: thickness of the material.

I. The shear strength of the plate based on 80% of its ultimate strength was 551MPa.However with sheet metal thickness at 1.2mm of the punch force Fp for blanking a 3mm and 5mm diameter holes were obtained as 6.231N and 10.386N respectively.

II. The maximum allowable length, of punch to guard against buckling is given by the formula [2]:

$$L = \frac{\pi d}{8}\sqrt{\frac{Ed}{st}} \quad ....(2)$$

ford/t ≥ 1.1

where d: diameter of punched hole

E: Modulus of elasticity of punch (206.8x103 MPa)

S: Shear strength of stock material (1.2mm)

Punch and die clearance was at 10% sheet metal thickness and was worked onto the punch because of ease of production. Shoulders on the punch and die steels enhanced their fastening onto their holders by means of collar plates.

Relief for drop through of the blanked slug was achieved by a 7mm hole on the reverse side of the die. For simplicity and ease of production, a fixed stripper plate which provided a space of 1.5mm between the die and the place for stock material insertion was provided. Stripping action was achieved by a spring incorporated on the slide. Total punch travel at 18.7mm was made up of (i) 15mm before contact with a stock material, (ii) 1.2mm to pass through stock material and (iii) 2.5 die bypass.

2.3 Slide Design

Two areas of prime consideration in slide design were the rigidity of the slide to safeguard it against bucking and proper tolerances between mating parts to ensure alignment of the punch and die during press operation.

For convenience and ease of manufacture, the press slide was of circular cross section, the punch force was provided manually by the blow from a hammer. Two springs were incorporated in the slide and held in position by shoulders and collars. The spring above the press crown provided the stripping force and that below limited the upward movement of the stride. The stride was considered a simply supported strut at both ends.

The length of the slide was 220mm and to guard against bucking the Rankine's formula [9] was applied. Material of construction is mild steel.

$$P = 3F_p \text{ .... (3)}$$

Where P: crushing load N.

O: crushing steel Pa (313 MPa)

A: area of cross section $\frac{(\pi d^2)}{4}$

a: a constant $\frac{1}{7500}$

I: effective length based on end conditions (220mm)

K: radius of gyration of selection. $\frac{(d}{L}$

P was taken at 3Fp (i.e. 31, 158N). Substituting the appropriate values into the above given equation gives d = 14 A slide of 25mm diameter was chosen for the application. The tolerance applied was of the close sliding fits (RC 1), to achieve accurate location without perceptible play [8].

The punch steel holder made of mild steel was rigidity clamped onto the slide by means of a collar plate. Studs on the slides of the punch holder which move within vertical slots on the press frame uprights provided alignment for the punch steel during punching operation. The die steels were held onto the die holder which was bolted onto the bed of the press frame. The dimensions of the punch, and die holders were compatible with those of the press bed determined from punch load analysis.

2.4 Press Frame Design

The press frame is the supporting member of the press and was given close attention because it is on this feature that rigidity and die life and quality of finished product depends [2,4,5,6,]. Three aspects given attention were bed, the uprights and the crown.

In the straight sided press which was considered in this work, the slide and bed are within the uprights and the direction of feeding of stock material is from front to back only. Choice of this frame structure was also based on the fact that it provides the best conditions possible for maintaining die alignment. Frame distortion or deflection under load is straight in a vertical direction and in the same direction as the punch action and does not create alignment problems (6)

Frame design is based on the principle that at the instant when the punch and die are locked onto the stock material for punching, the frame, the slide and the die for a rigid system, and the frame should be strong enough to withstand the punch force within a specified deflection range. Deflections of frames in the range 0.083 to 0.125mm to the meter are commonly used (2).

The load used for design calculations for the press frame was taken at four times punch force (4Fp) at 42, 000N. This was to ensure the rigidity of the frame and its durability since operators in small scale manufacturing outfits have a tendency to abuse machines and equipment.

Figure 3 illustrates the frame of the press upon which the analysis is based. For the purposes of design calculation, the frame is viewed as being subjected to the following loading conditions:

(i) The bed and the crown are subjected to centrally acting point load.
(ii) The uprights are each subjected to a point load displaced from its vertical axis.

The press bed width was specified at 200mm and was assumed to be simply supported at both ends. The acceptable maximum deflection of the bed in accordance with that already discussed was given at 0.0166mm. The deflection, y, of the beam is given by the equation [9].

$$Y = \frac{Wl}{48EI} \qquad (4)$$

Where w: the load
L: the span
E: modulus of elasticity
I: second moment of area of the beam.

The material used is mild steel of E = 206. 8x 103 MPa and W = 42,000N, 1 = 200mm. Substitution of these values into equation 4 gave I =2 039 104mm^4 I is define by:

$$I = \frac{bh^3}{12} \qquad (5)$$

where b: width of the beam
h: depth of the beam

With b at 120mm, the thickness of the press bed was found to be 22mm. Mild steel material of 25mm thickness was selected for the press bed and crown.

The two uprights (struts) upon which the crown was hinged were of height 145mm and accommodated the lower spring, the punch and die and their holders and the slide travel to perform punching operation. The struts each carried a load of 2Fp, given at 21,000N. This load is eccentric to the major axis of the strut at a distance equal to 100mm, the midpoint of press crown.

The expression for determining the stress or acting on an eccentrically loaded strut is given by [9].

$$\sigma_r = \sigma_{d+}\sigma_b = \frac{W}{A} + \frac{W_e Z}{I} \quad \text{.................................(6)}$$

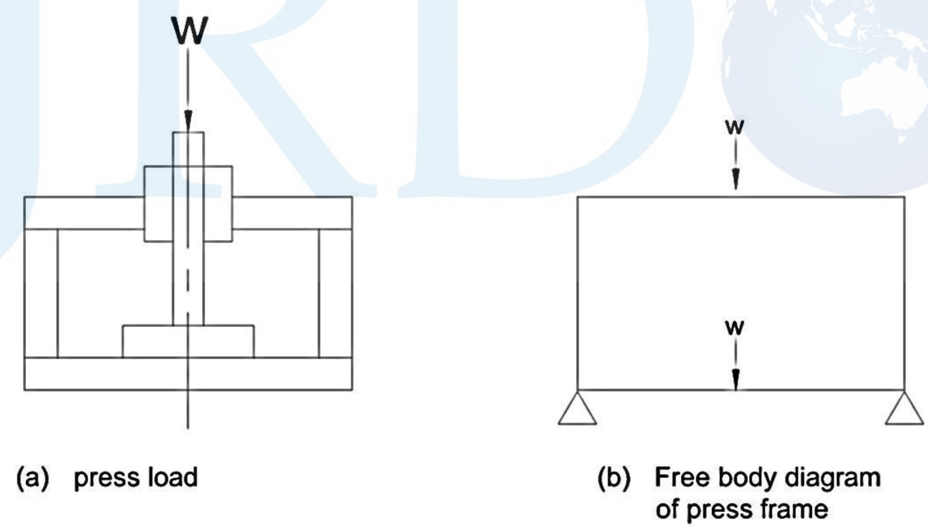
Where σ_d: direct stress
σ_b: bending stress
W: load on the strut
A: area of strut
e: eccentric distance at which load acts (100mm)
z: distance from the neural axis at which the eccentric load acts.
I: second moment of area of the section.

The maximum acceptable stress or on the strut is taken at one third the ultimate strength of the material (mild steel) given at 80MPa. The length of the cross-sectional area of the strut is taken at 120mm which is the width of both the press head and the crown, Z is given by half the width of the cross-functional area of strut, b/2; W=21, 000N; I = 120 B/12. Substitution of these values into equation 6 gave the value of …. As=40mm.

It is worthy to note that since the punching force is produced by a hammer which is manually actuated, the crown and uprights merely provide a guiding system to assure alignment of the punch and die steels. Consequently they are not as stressed as the press bed which bears the impact of the punching force. The uprights were therefore made of mild steel plates of rectangular cross-sectional area 25mm x 120mm.

Two vertical slots were cut on the inner face of each upright. The slots, each 8mm wide and 15mm deep, were spaced 52mm and in symmetry with the major axis of the uprights secure the press crown in position by bolting. The uprights were incurred to the press be by welding.

Fig 3 Press Frame Loading



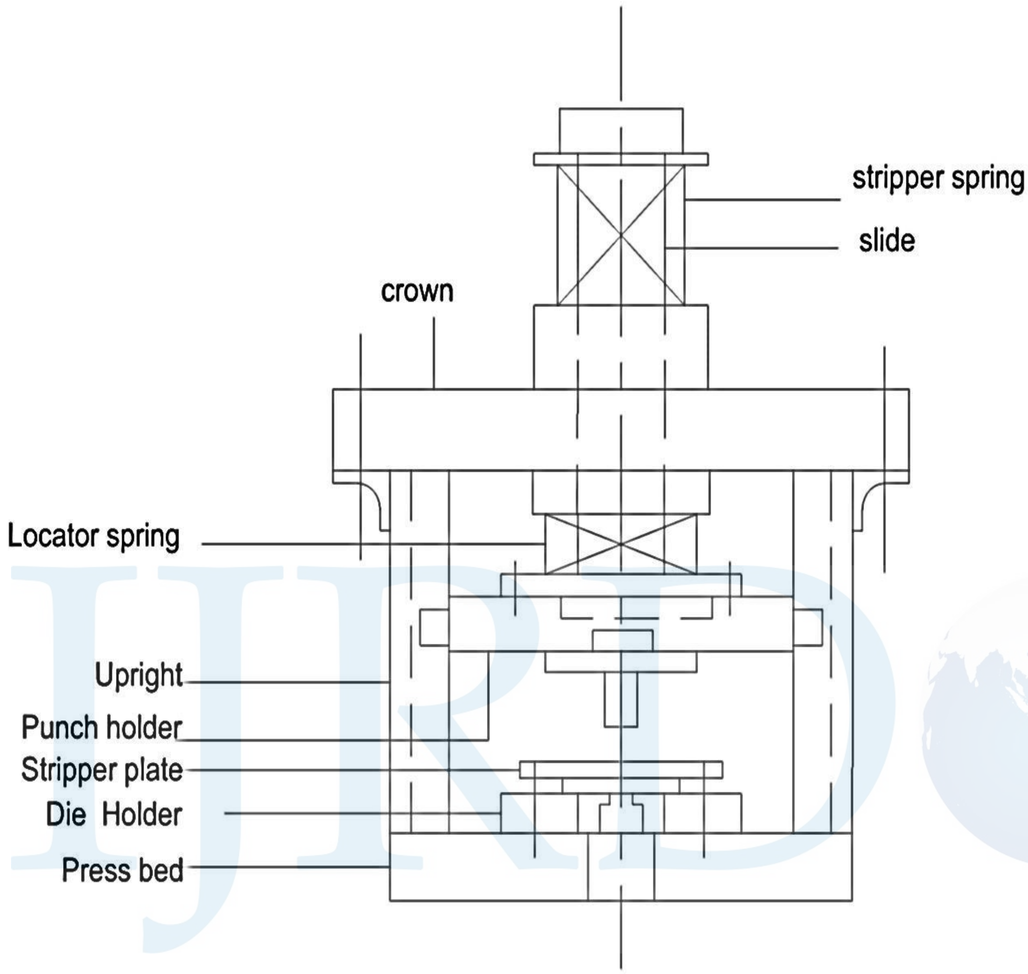


Fig 4 MANUALLY OPERATED PUNCH OR STAMP PRESS ASSEMBLY

CONCLUSION

The design of the punch or stamp press was undertaken in order to manufacture the base plate of automobile brake pad with medium carbon steel plates suitable for use by small scale manufacturers. This equipment is portable and robust and is capable of producing holes as designed in thirty base plate blanks in one hour. All the components used were sourced locally and with the use of this equipment there no need for any heat treatment of the blanks. Furthermore, the process of punching or stamping was simpler and quicker.

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