DESIGN AND DEVELOPMENT OF BRAKE CYLINDER FRONT AXLE USING SINGLE OPERATION DIE

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Abstract: -The aim of the project is to design a brake cylinder front axle, a component which is used in heavy trucks. The involves to calculate the force required for the manufacturing process by using 'Hydraulic press'. For this process, Extra Deep Drawing cold rolled (EDD-CR-4) material is used. CR-4 is preferred for drawing operation and it possesses high ductility. Extra deep drawing steel is used to achieve a very low carbon content. In this manufacturing process, the involved operations are blanking, cutting, drawing, trimming, punching, folding, coining etc.,.

Hydraulic press is a device which uses a hydraulic cylinder to generate compressive forces. Hydraulic cylinder works as a mechanical actuator which is used to give a unidirectional force through a unidirectional stroke. Hydraulic press works on Pascal's principle, i.e., the pressure through out in a closed system is constant.

Some of the applications of hydraulic press are:

- Deep drawing operation
- Blanking and punching operation
- Metal forming operation

In the hydraulic press, the single operation die is used. In this simple dies or single action dies can perform single operation for a single stroke of the press slide. The operation may be forming or cutting.

The brake cylinder front and rare axle parts are employed in heavy duty vehicles eg. Bulldozers, heavy trucks.

INTRODUCTION

Hydraulic press is a tool to produce compressive force by means of fluid. It depends upon Pascal's principle that the pressure throughout an enclosed entity is constant. By means of hydraulic system larger forces can be produced in contrast with mechanical and electrical systems. Such forces can be used for the presswork application such as blanking, punching, piercing, coining, trimming etc.

Press work is a method of mass production involving the cold working of metals usually in the form of thin sheet or strip. Press working is one of the extensively employed methods of fabricating parts of intricate shapes with thin walls. Press working processes make use of large forces by press tools for a short time interval which results in cutting or shaping the sheet metal since, press working does not involve heating of parts, close tolerances and high surface finish can be obtained on the part. Since presses can produce components fairly fast rates, the unit cost of labour for operating the press is fairly low.

Press working forces are set up, guided and controlled in a machine referred to as a press thus an attempt has been made to atomize the process of press work using hydraulic mechanism in press machine. The inputs and outputs of the control system including hydraulic mechanism are solely mechanical such as rotating shafts or reciprocating plunger. The prime importance of implementing the system is the moment of the mechanical devices can be operated by means of hydraulic components such as actuators to initiate the moment which could be in the form of lever to apply manually or by means of switches to operate automatically.

The direction control valves have been implemented to control the direction of piston movements and regulate the same. Thus the mechanism has been simplified with the use of hydraulic equipments. Moreover, the use of pressure and direction control valves makes it easier to regulate the forces and control the speed of the setup.

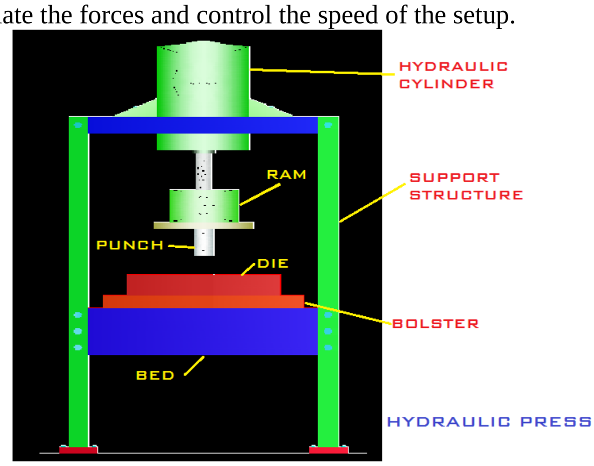

Fig.1.Hydraulic press and its accessories.

II. Functions of brake cylinder front axle

It must hold and guide the brake pads. With the assistance of one or a number of pistons. It also converts the hydraulic pressure in the brake system into a mechanical force which presses the brake pads against the brake disc. These are located near to the wheel, on the left and right of the front axle.

In automotive engineering, the master cylinder is a control device that converts non-hydraulic pressure (commonly from a driver's foot) into hydraulic pressure. This device controls slave cylinders located at the other end of the hydraulic system.

As piston(s) move along the bore of the master cylinder, this movement is transferred through the hydraulic fluid, to result in a movement of the slave cylinder(s). The hydraulic pressure created by moving a piston (inside the bore of the master cylinder) toward the slave cylinder(s) compresses the fluid evenly, but by varying the comparative surface-area of the master cylinder and/or each slave cylinder, one can vary the amount of force and displacement applied to each slave cylinder, relative to the amount of force and displacement applied to the master cylinder

The most common vehicle uses of master cylinders are in brake and clutch systems. In brake systems, the operated devices are cylinders inside of brake callipers and drum brakes; these cylinders may be called wheel cylinders or slave cylinders, and they push the brake pads towards a surface that rotates with the wheel (this surface is typically either a drum, or a disc, a.k.a. a rotor) until the stationary brake pad(s) create friction against that rotating surface (typically the rotating surface is metal or ceramic/carbon, for their ability to withstand heat and friction without wearing-down rapidly). In the clutch system, the device which the master cylinder operates is called the slave cylinder; it moves the throw out bearing until the high-friction material on the transmission's clutch disengages from the engine's metal (or ceramic/carbon) flywheel.

2.2. DESIGN OF CYLINDER FRONT AXLE

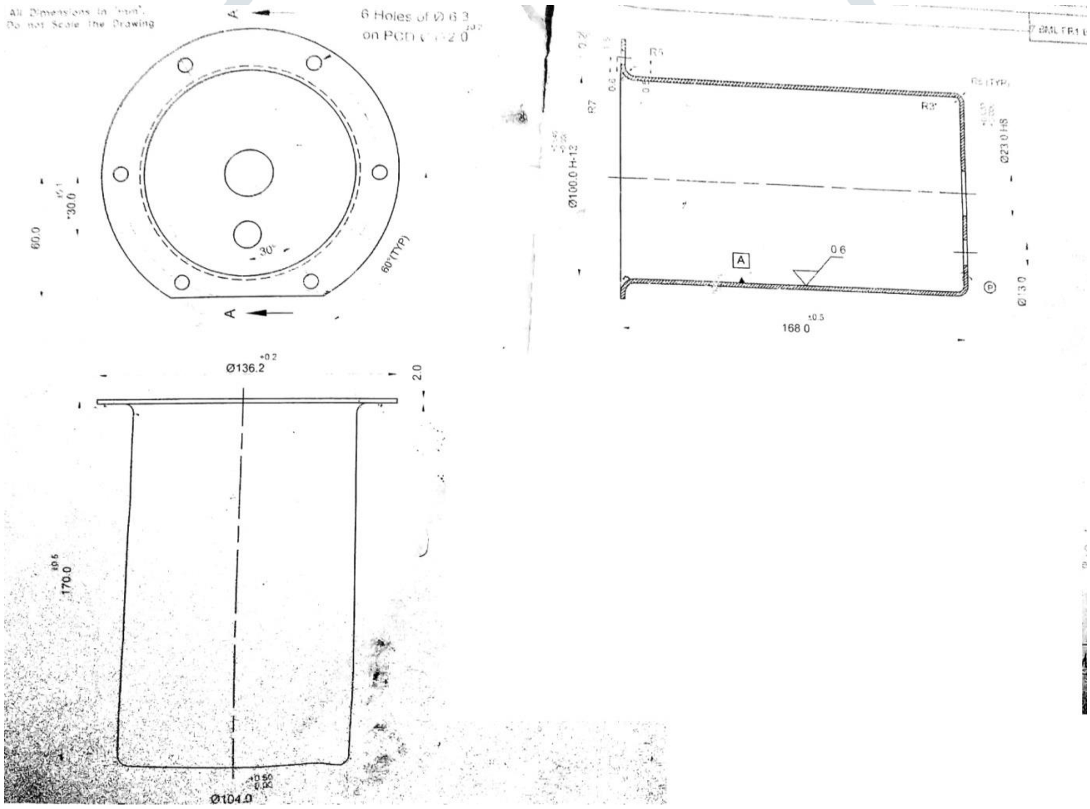

Fig.2.cylider front axle.

Fig.3.The process of fabrication

CALULATIONS

Blank diameter of cylinder cup
Inside diameter of cup(d) – 100mm
Out side diameter of cup(D) – 104mm
Height of the cup (h) – 170mm with collar
Height of cup (h) – 168 without collar
Thickness of the collar and sheet thickness – 2mm
Radius of the curve – 5mm
Diameter/ radius ratio = $\frac{100}{5}$ = 20
When the $\frac{d}{r}$ ratio is less than 20 (d/r >20) then,
Blank diameter (D)= $\sqrt{d^2 + 4dh - 0.5\, r}$

D = 277.84mm

By adding allowances (approximately 30mm) the value which can be taken by practically is

D= 277.84 ~320mm

PUNCH RADIUS
Rp = 3t to 6t
Thickness = 2mm
Rp= 3*2= 6 Rp= 6*2= 12

DIE RADIUS
=0.035[50+(D-d)]$\sqrt{t}$ (or)
= 4t to 8t
=4*2 =8mm

Die Punch clearance (per side)
C= t*[1 +0.035$(\beta - 1)^3$]
To get β value for 2mm thickness of steel
$\frac{d}{t} = \frac{100}{2}$ =50; so β value will be 1.8
C=2*[1+0.035$(1.8 - 1)^3$]
C= 2.03~ 2.4

Number of draw operations required
$\lambda = \frac{h}{d} = \frac{168}{100} = 1.68$
for the value 1.68, 3 number of draws are required.
Specific gravity of steel = 7.8 gm/cc^2
Diameter of the die = Punch diameter +2*sheet thickness + clearance
= 100+ 2*(1.08t)
=100+ 2*(1.08*2)
= 104.32mm.

For draw -1
Assume d= 150mm
From the relation $\lambda = \frac{h}{d}$ = 0.75
$\frac{h}{150}$ = 0.75
h= 75mm
Die of die = 150+2*(1.13*2) = 154.52mm
C= 2[1+ 0.035 $(1.5 - 1)^3$] = 2.008 mm clearance

For 2nd draw
Assume d = 125
$\lambda = \frac{h}{d}$ = 0.5
h = 62.5mm
diameter of the die = 125+ 2*2.015
= 129.03mm

For 3rd draw
Required diameter is 100mm
Diameter of the die = 100+2*4.03 = 108.06mm
Required height = total height – (sum of height of draw 1 and 2)
= 168-(75+62.5)
=30.5mm

Weight of the blank
W= specific gravity of steel *volume
= specific gravity * area * thickness
= 7.8* $\frac{\pi}{4}(d^2)$ * thickness

= 7.8 * 3.14*(32^2) *0.2
= 1254.62gm = 1.25462 kg.

Forces and energy required calculations

Force required for drawing

F_d= πdt $\{\frac{(S_u+S_y)}{2}\}$ Kg (without collar)
= π* 100*2* ($\frac{85+25}{2}$)
= 34557.51kg = 34.557 tons

Machine capacity

Capacity of the machine is = 1.5* F_d
= 1.5 * 34.557
=51.83tons ~ 52 tons

Maximum drawing force = bottom tearing force
(f_d)max = πdt S_u
= π*100*2* 25.17
= 15.814 tons
(or)
F_d = ($\frac{D}{d}$-0.3)(πdtS_u)
= ($\frac{320}{100}$ − 0.3)(π*100*2*23.17)
= 45.862 tons

Blank holding pressure

F_b = 0.3F_d = 0.3* 45.862
= 13.75tons

Total pressure required for drawing with blank holder
F_n= 1.3F_d
= 1.3 *45.862
=59.6206 tons

Coining operation

Fig.4.Coining Operation

Force required for coining
F_c = A*P_c
P_c = surface pressure of steel = 35kg/mm^2
A = $\frac{\pi}{4}$ (d^2) = $\frac{\pi}{4}$ (68^2)
= 3631.68 mm^2

F_c = 3631.68* 35
= 127.108 tons
Blanking operation

Fig.5.Primary process.

Shear force (F_{sh}) = ($\frac{k*l+S_{sh}}{1000}$)

K= 1.1 to 1.5
S_{sh}= 36 Kg/mm^2
L= 5mm
F_{sh} = $\frac{1.5*5*2*36}{1000}$
= 0.54 tons
Punch through force (F_p)
F_p = n*F_{p1}
F_{p1} = 0.1*F_{sh}
= 0.1*0.54 tons = 0.054tons
F_p = n*F_{p1}
= 6*0.054 = 0.324tons
Ejection force
F_{ej} = 0.1*F_{sh} = 0.054 tons
Hole flanging
t=2mm
A= 40.6mm
B= 45mm
H= 7.5mm
d= 25.6mm from the figure
force required for direct flanging and piercing
F_f = (2-2.5)πdt S_{sh}
= (2-2.6)π* 25.6* 2*36 =2.895 tons.

Fig.6

Fig.7

Force required for hole flanging after pre- piercing the hole

F_f= (1.5-2)πdt S_{sh}

=(1.5-2)π*25.6*2*36

= 2.895tons

Blanking operation for hole

Diameter = 6.3mm

Push through force

F_p= n*F_{p1} (n= number of holes)

$F_{sh} = (\frac{\pi}{4}d^2)*S_{sh}$

= $\frac{\pi}{4}(6.3^2)$* 36

= 1.122tons

F_{p1} = 0.1 * F_{sh}

= 0.1 * 1.122

= 0.112

F_p= 3* 0.112 = 0.336tons (n= 6/2 = 3)

For a 6 hole

$F_p = 6 * 0.112 = 2.016$ tons

<u>Hole size Before piercing</u>

=40.6- 2(7.5)

d= 25.6mm

shear force for blanking

F_c = A*P_c

P_c = surface pressure of steel = 35kg/mm^2

F_c = $\frac{\pi}{4}(d^2)$*P_c

= $\frac{\pi}{4}(25.6^2)$ *35 = 18.015 tons

Punch through force

F_p = n*F_{p1}

F_{p1} = 0.1 * F_{sh}

= 0.1 * 18.015 = 1.8015

F_p = n*F_{p1}

= 3* 1.8015 = 5.4045

Ejection force

E_{ej} = 0.1 * F_{sh} = 0.1 * 18.015

= 1.8015ton

Punch diameter = 25.6mm

Die diameter = 25.6+ 2*(2.19)

= 29.38mm.

CONCLUSION

Brake cylinder front axle is designed with 2mm thickness of the cylinder, this is a component which is used in heavy trucks and also calculated the forces required for the manufacturing process by using ‘Hydraulic press’.

Extra Deep Drawing cold rolled (EDD-CR-4) material is used. CR-4 is preferred for drawing operation and it possesses high ductility. Extra deep drawing steel id used to achieve a very low carbon content. In this manufacturing process, the involved operations are blank cutting, drawing, trimming, punching, folding, coining etc.,.

The brake cylinder front and rare axle parts are employed in heavy duty vehicles eg. Bulldozers, heavy trucks.

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REFERENCE

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