DEVELOPING A METHOD FOR PRODUCING HOLE OVER CIRCULAR PROFILE OF DOOR CLOSER HOUSING BODY

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Abstract: Since the invention of electric drill in 1889, the drilling mechanism has undergoing tremendous modifications over the past few decades. With the increasing complexity in design of various industrial components, the drilling processes has to be upgraded to meet the new requirements. A simple technique for achieving this without much investment was to develop drill attachments. But for more precise control and close tolerances, a specialized drill jig has to be developed based on the component to be machined. An example of such a complex component is the Hydraulic Door Closer. The holes provided in the door closer housing body needs to be drilled internally and cannot protrude out of the external surface of the housing body. Such a restriction makes it necessary for a specialized tool or jig to serve for this purpose. Thus we have used the door closer housing body and developed a jig that can provide internal holes of minute diameter in the walls of the compact circular bore of the door closer housing body. This improved jig has been designed to provide holes with much more accuracy, closer tolerances and better surface finish to eliminate any further machining done onto the bore to clear the damages caused by the drilling tool currently being used to carry out this operation. The application of this jig is not just restricted to door closer but can be incorporated in various other industrial applications, with a few minor modifications.

Index Terms **- Punch, Press, Drilling, Jig, Door closer, Circular profile, Compact space.**

I. INTRODUCTION

The consumer's demand for manufactured goods has been increasing rapidly over the years. Thus, to meet this requirement, manufacturers have introduced new and innovative methods of manufacturing high quality products at a faster rate. Since last few decade industries and engineers are focusing on multiple use and compact products. To overcome or fulfill these requirements there is a need of robust design and reliable tools which can perform in such compact space and on different profiles. Different operation or processes like Micro-Drilling, Boring, Welding etc. on a compact profile can only be performed by a skilled worker and require expensive machineries there by increasing machining and production cost. Compact products may have fragile nature and only skilled worker can perform different operation. These modern concepts have necessitated the need for more cheaper and reliable work-holding devices and tools. An example of such a compact product is the Hydraulic Door Closer housing body.

II. DESCRIPTION OF HYDRAULIC DOOR CLOSER

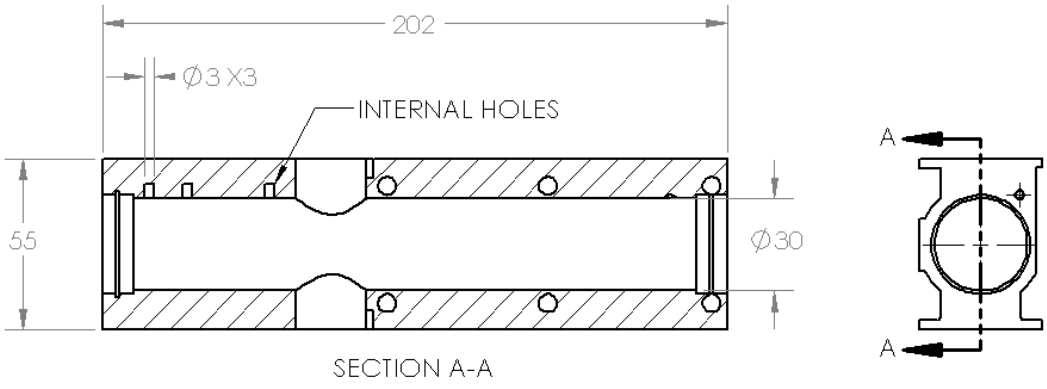

Fig.1 Door Closer Housing Body

The Door closer opted for the Jig development process is the DC-2000 Series Door Closer manufactured by MM Efficient Gadgets LLP, India as shown in Fig 1. The hydraulic door closer is simple and easy to work with. One end of the hydraulic door is attached to the door, and the other end is attached to the door frame. When the door is opened, the hydraulic door closer pulls the door and closes it rather than slamming the door. This happens because the closer has a sealed tube which contains a spring, so that the closer can work properly like how it is supposed to work. It includes a fluid-filled chamber which releases the pressure to close the door in a slow manner rather than banging it. Inside the cylinder is a spring. If the spring was the only thing inside the cylinder you would get a door that slams shut and is annoying. So there is also an oil cylinder. When you open the door, the cylinder fills with oil. When

the door is closing, the spring pushes a piston, which forces the oil out of the cylinder through a small hole. Door closing velocity is adjusted with the help of valves, through which flows the oil.

The housing body of the door closer comprises of 3 holes on the internal cylindrical wall of the bore, the roles of these holes is to transfer the fluid from one chamber to another through the valves while the door closer is in operation. The major obstacles in producing these holes are:

- The diameter of the holes is quite small (3mm).
- The holes should not protrude out from the external surface of the housing body. Thus, the holes cannot be drilled from the external surface of the housing body.
- Presently, no standard drill tool or drill attachment is available that can easily fit through the bore of such small diameter and produce a hole perpendicular to its axis of rotation, without damaging the bore's internal surface.

III. BRIEF DESCRIPTION OF THE JIG AND FIXTURE

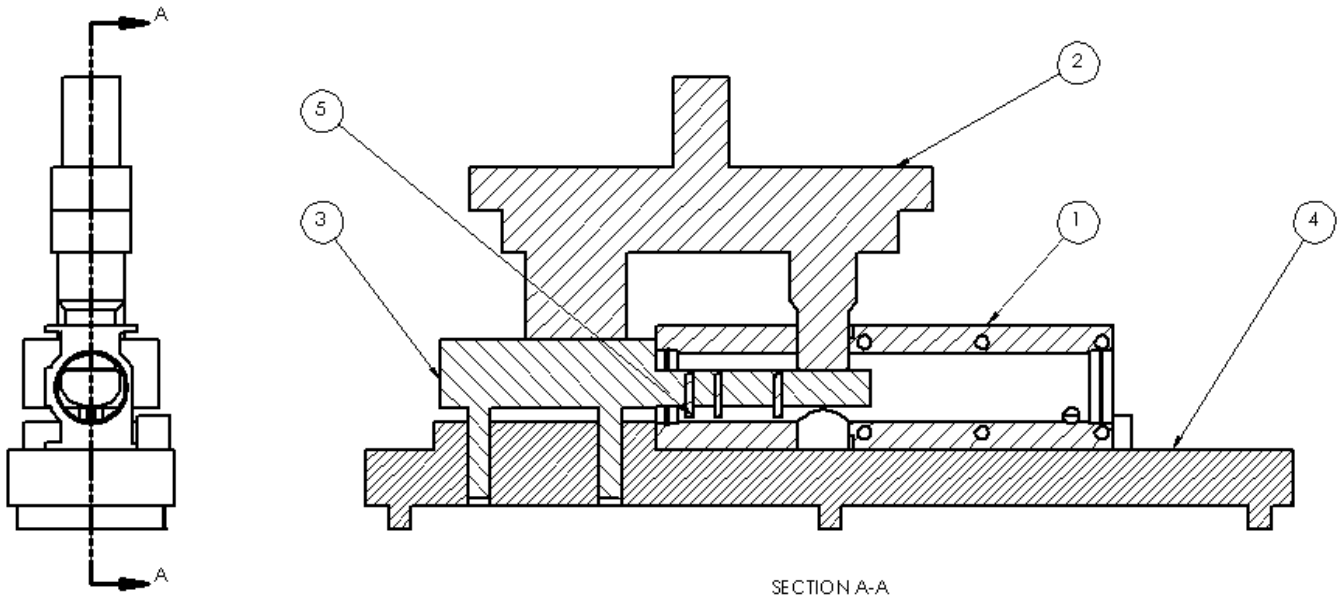

Fig.2 Assembly of Jig with Housing Body
1. Housing Body, 2. Press Plate, 3. Punch Plate, 4. Work Holder, 5. Punch Pin/Bit

A jig is a device in which a component is held and located for a specific operation in such a way that it will guide one or more cutting tools to the same zone of machining. The usual machining operation for jigs are drilling and reaming. Jigs are usually fitted with hardened steel bushings for guiding drills or cutting tools. The most common jigs are drilling jigs, reaming jigs, assembly jigs etc. when these are used they are usually not fastened to machine tools or table but are free to be moved so as to permit the proper registering of the work and the tool. A jig's primary purpose is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. A jig is often confused with a fixture; a fixture holds the work in a fixed location. A device that does both functions (holding the work and guiding a tool) is called a jig. The most ideal method for achieving the required results was to develop an entirely new set-up to produce the holes in such compact space and complexity.

The Jig assembly in Figure 2 is an open type Jig in which machining operation is carried out on only one side of the workpiece. The material of the jig assembly can be changed as per load requirement. The design of the Jig assembly is simple and robust it can resist deflection based on different working loads. Loading and unloading of workpiece from the jig is quite easy as no external clamps are required in the assembly, the work holder and press plate itself acts as a fixture. The three part jig is designed while keeping in mind all the restrictions and can perform the intended task quite effectively. The jig primarily consist of three major components:

3.1 Work Holder

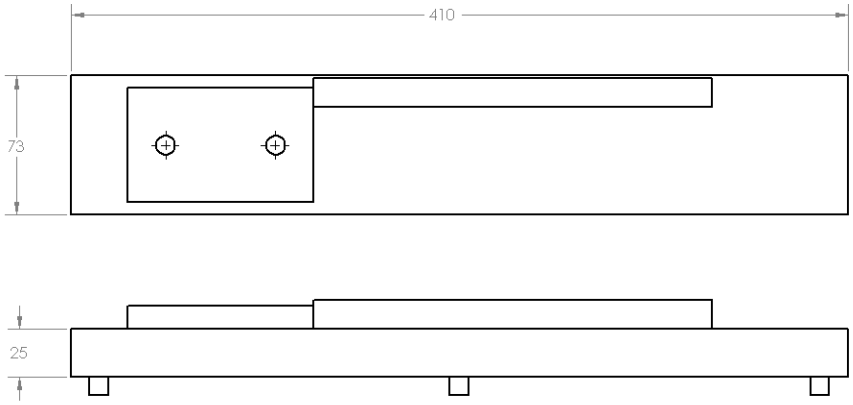

Fig.3 Work Holder

As the name suggests, the function of the work holder is to firmly grip the housing body into position as well as to provide a base support to the entire jig assembly. The function of the work holder is based on the 3-2-1 Principle. Any free body has a total of twelve degrees of freedom;

6 translational degrees of freedom: +X, -X, +Y, -Y, +Z, -Z.

And 6 rotational degrees of freedom:

- Clockwise around X axis (C-X)
- Anticlockwise around X axis (AC-X)
- Clockwise around Y axis (C-Y)
- Anticlockwise around Y axis (AC-Y)
- Clockwise around Z axis (C-Z)
- Anticlockwise around Z axis (AC-Z)

All the 12 degrees of freedom need to be fixed except the three transitional degrees of freedom (-X, -Y and -Z) in order to locate the work piece in the fixture. So, 9 degrees of freedom of the work piece need to be fixed. Rest the work piece on the bottom surface (XY), and fixed the +Z, C-X, AC-X, C-Y and AC-Y degrees of freedom. Rest the work piece at the side surface (XZ), and fixed the +Y and AC-Z degrees of freedom. Rest the work piece the adjacent surface (YZ), and fixed the +X and C-Z degrees of freedom. Thus, successfully fixating 9 required degrees of freedom by using the 3-2-1 principle of fixture design.

3.2 Punch Assembly

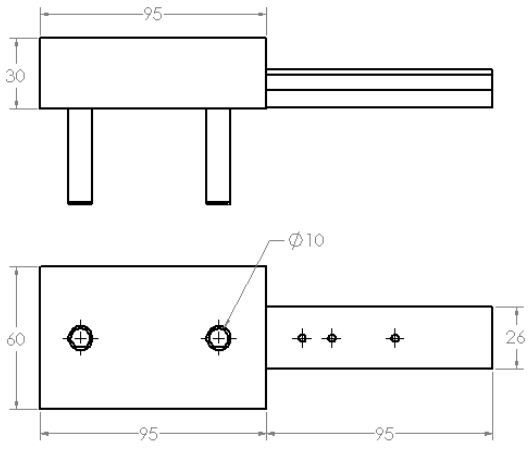

Fig.4 Punch Plate

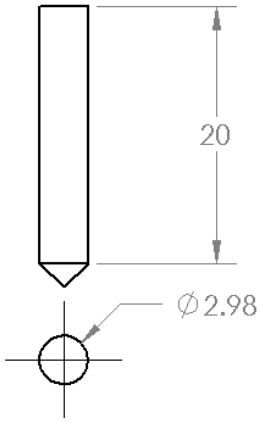

Fig.5 Punch Pin

3.2.1 Punch Plate

The punch plate is designed in such a manner that is firmly fits into the bore of the housing body. It also consists of clamping screws that holds the punch pin into their slots during the operation. The force is exerted by the press machine on the punch plate through the press plate which causes the pins to penetrate into the workpiece i.e. housing body.

3.2.2 Punch Pin

There are three punch pins, one for each hole, held into the plate by the clamping screws. These pins penetrates into the housing body on the application of force by the press.

3.3 Press Plate

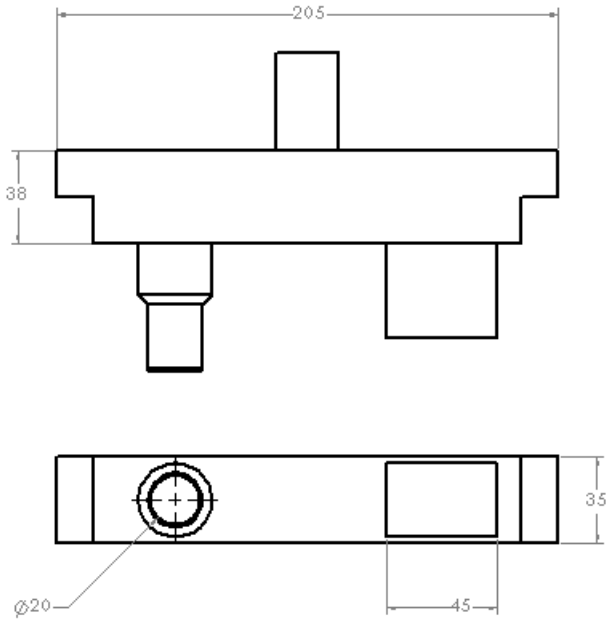

Fig.6 Press Plate

The press plate is located at the top and is in direct contact with the press machine. It is so designed that it transmits the force exerted by the press machine to the punch inside the housing body. The design of the press plate enables it to transfer the force directly onto the punch through the top hole without transmitting any load onto the top surface of the housing body. Thus prevents any deformation or damage to the housing body.

IV. SELECTION OF MATERIALS

There is a wide range of materials available for producing high quality robust tools that can withstand wear and tear. But the objective here is to opt for the material that is cost effective as the operation being performed is not much robust and can be carried out by simpler materials. The materials selected are listed below:

4.1 Aluminium 6063- T6

The housing body of the Hydraulic Door Closer is made up of Aluminium 6063- T6. Aluminium alloy 6063 is a medium strength alloy commonly referred to as an architectural alloy. It is normally used in complex extrusion processes. It has a good surface finish, high corrosion resistance, is easily suited to welding and can be easily anodized. It has good formability.

Table 1. Mechanical properties for aluminium alloy 6063- T6

BS EN 755-2 Tube Up To 25mm Wall Thickness	
Proof Stress	170 MPa
Tensile Strength	215 MPa
Elongation A50 mm	8 %
Hardness Brinell	75 HB
Shear Strength	152 MPa

4.2 EN8 Steel

The EN8 Steel is being used for making the three part jig assembly. All the three major parts of the jig are entirely made up of En8 Steel except the Punch Pins. EN8 steel grade belongs to the standard of BS 970-1955, which is a standard for wrought steel for mechanical and allied engineering purpose.

Table 2. EN8 Medium Carbon Steel Mechanical Properties and Hardness

Heat Treatment	Tensile Strength	Yield Strength	Hardness
	MPa	***MPa***	***HB***
Normalized	550	280	152/207
	510	245	146/197
Quenched	625/775	385	179/229
Tempered	700/850	465	201/255

4.3 High Speed Steel

The punch pins/bits used for producing the holes onto the housing body are made out of High Speed Steel. It has high toughness, retains its hardness at high temperatures, and good wear, tear and impact resistance. Also, it is possible to achieve specific properties by balancing the amount of alloying elements.

V. CALCULATIONS

The standard formulae for calculating the punching force required to produce the holes is explained below:

$$\text{Punching force} = \text{Perimeter (mm)} * \text{Thickness (mm)} * \text{Shear Strength (KN/mm}^2\text{)} \quad (1)$$

5.1 Perimeter

Assuming that the face of the punch pin/bit is flat circular instead of conical,

$$\text{Perimeter} = \pi * d \quad (2)$$
$$= \pi * 3$$
$$= 9.42 \text{ mm}$$

5.2 Thickness

It is the thickness that will be piercing through by the punching pin/bit and it is required to be 3mm.

$$\text{Thickness} = 3\text{mm}$$

5.3 Shear Strength

The shear strength of the plate or material to be punched is considered while calculating punching force. Here the component to be punched is housing body which is made up of Aluminum Alloy 6063- T6. Thus,

$$\text{Shear Strength} = 152 \text{ MPa}$$
$$= 0.152 \text{ KN/mm}^2$$

From Equation (1)

$$\text{Punching force} = 9.42 * 3 * 0.152$$
$$= 4.295 \text{ KN}$$

The above value of punching force is for single punching pin/bit. Since there are three punch pins/bits used in the design. Thus,

$$\text{Punching Force} = 4.295 * 3$$
$$= 12.886 \text{ KN}$$

Converting it into tonnage,

$$\text{Punching Force} = 1.31 \text{ tones}$$

However, this force value is an approximate value as we considered the pin/bit as flat circular shaped. The value obtained above is slightly higher than required value.

VI. SUMMARY AND CONCLUSION

The outcomes of the new jig design are:

- Ease to introduce a hole or a punch within a compact profile
- Avoiding wear and tear of both workpiece and tools
- Elimination of complex machines
- Elimination of need of skilled worker
- Environment friendly operation
- Easy adaptive method
- Elimination of human fatigue since operation is safe

From the new design adopted for the jig and the materials opted for various components it can be concluded that by the use of High Speed Steel and EN8 Steel for developing the punch pin/bit and jig assembly respectively, the jig can be developed with minimum effort and minimum cost as these materials are standard and readily available. Also it can be made without compromising with strength and durability of the components. In addition, this will help to achieve our primary goal i.e. to produce these holes in the compact space of housing body bore without damaging the workpiece and eliminating the need for any additional finishing operation. Based on the material selection and calculation, the punching force required for producing the holes is 1.31 tones. This amount of force can be achieved easily by the use of a simple 2 ton Hand Press. This has resulted in the reduction of set up cost as well as manual fatigue. Thus, collectively it can be said that the Jig has simplified the process and reduced the use of power tools in the production process of the Door Closer and improved the productivity.

VII. ACKNOWLEDGMENT

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