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Development of an Improved Hydraulic Bearing Pusher and Remover

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Abstract:- This paper presents the development of an improved hydraulic bearing pusher and remover that uses electric motor for its operation. The conventional approach to removing a bearing from its shaft requires hammering or using more force which is a challenging one. This method damages the bearing surface, may render the bearing unusable and uses more human force. The use of hydraulic system in place of this eliminates the limitation of the conventional methods of bearing removal. The development of an electronically powered lever-operated hydraulic bearing puller makes bearing removal faster, safer, require lesser human force, and prevents damages to the bearing surface. Mild steel was used for the fabrication because it satisfies design requirements for strength, stiffness, and machinability. The developed hydraulic bearing pulling machine components includes; frame, cylinder mounting table, hydraulic cylinder, working table/bed, hydraulic tank, electric motor and hand lever. Several design equations were used in the design of the machine's component pieces. The FEA shows a maximum stress of the structure to be 1.613MPa which is low when compared to the yield strength of the material for the frame (Mild Steel) and its maximum factor of safety to be 1.052 which shows that the structural beam is capable of bearing the stress without failure. The average bearing removing time for the developed bearing puller was 15min which makes the developed machine a more efficient and faster means of bearing remover. The primary goal of this project is to reduce the amount of human labor, time required and eliminate damages when removing and installing a bearing.

Keyword:- *Hydraulic Bearing Puller; Electric Motor, Directional Control Valve, Lever, Bearing Removal, Hydraulic Machines, FEA, Hydraulic Cylinder.*

I. INTRODUCTION

A bearing is a machine element mostly seen in rotating members of a machine system that reduces friction and constrains the relative motion (to the desired motion) between the moving parts. Bearing is used in the steering system, transmission systems, engines, and other parts of an automobile where rotation is involved, which makes the automobile industry the most user of bearing among others such as the aircraft industry, service centers, and places where precision is required. Bearings are designed and manufactured to exact precise tolerances and very fine and perfect surface finishes. It is of utmost importance to preserve the geometrical precision and surface integrity of ball and roller bearing raceways, as well as the rolling elements (Chen, Y.et al., 2016; Khurmi and Gupta, 2005).

The most commonly used method (hammering) in the installation and removal of a bearing from a shaft, engine, etc. is tasking and tedious as it involves human effort, which increases the chances of damaging the bearings. Moreover, this bearing removal method can be categorized as an occupational hazard and is unsafe. Occupational hazards have long been a concern in the engineering industry (Suryawanshi, *et al*, 2015; Johnson *et al.*, 2016; Kumar *et al.*, 2013).

A hydraulically operated bearing puller is a device or machine that facilitates effortless removal of bearings from shafts, requiring minimal human effort through the utilization of a puller arrangement and supporting device. (Mohan, 2015; Throat, 2013) Suryawanshi *et al.*, (2015) explained hydraulic bearing puller and pusher as a valuable tool which is designed for the sole purpose of removing and installing bearings onto shafts effortlessly

Existing hydraulic bearing pushers and removers have their limitations, such as being difficult to use or not being able to handle a wide range of bearing sizes. Different hydraulic bearing pushers and removers were developed to address the challenges faced by previous bearing pullers and removers (Kumar *et al.*, 2013). These tools use hydraulic pressure to push or pull the bearing out of its housing, making the process more efficient and less damaging. Indicating the limitation of previous bearing puller and removers, (Mohanraj, 2015) noted that improved bearing puller and removers should be designed to meet the following specific requirements of the application; such as being able to handle a wide range of bearing sizes and being easy to use. It was furthermore said that the design should also take into account the size and weight of the tool, as well as its safety features. Computer-aided design (CAD) software can be used to create a 3D model of the hydraulic bearing pusher and remover, which can be used to create a prototype. The prototype should be tested to ensure that it meets the requirements of the application and that it is safe to use as advised by (Choudhury *et al.*, 2016).

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(Chen *et al.,* 2016) developed a hydraulic bearing removal tool that used a hydraulic cylinder and a self-centering system to remove bearings with minimal effort and maximum safety. (Kim *et al.,* 2018) developed a hydraulic bearing extractor that used a hydraulic pump and a hydraulic ram to apply force to the bearing and remove it from the shaft.

II. METHODOLOGY

Taking into consideration recommendation by previous researchers, the improved hydraulic puller was modelled and designed using SolidWorks CAD application. In developing the puller, mild steels were been used which are locally sourced materials. Our material selections are due to various properties of mild steels which include strength, rigidity and machinability which are also very much available and cost efficient.

A. Design of Various Puller Elements

Some elements of the hydraulic bearing puller are developed and analyzed includes: frame, Hydraulic cylinder, Hydraulic tank, Electric motor, Hydraulic hose, Directional control valve, Lever and guide.

➤ *The Frame*

The frame serves as the primary structural foundation upon which the various machine elements are constructed. Its purpose is to accommodate the Cylinder/ram assembly, the pulling components, the control valve, and the work bed. When designing the frame, the primary factor to consider is the tension exerted on the pillars, while the remaining members of the frame are subjected to a straightforward bending stress. In this particular case, a $6mm$ C channel material has been selected. Given the inherent characteristics of the undertaking, the material of choice for the H-frame was mild steel, specifically IS2062 or AISI 1020. The design consideration encompasses a pair of vertical support beams, each measuring 3×5 (according to the ANSI standard inch), in the form of C-channels. The horizontal components consist of three components, namely: the fixed upper platen (which provides support for the hydraulic bottle jack), the adjustable middle platen (which carries the workpiece), and the fixed lower platen. The configuration is such that the hydraulic cylinder is positioned on the top platen, where it has been securely fastened. As the hydraulic cylinders ram extends, it encounters the movable platen and consequently the workpiece.

➤ *Hydraulic Cylinder Design*

The weight of hydraulic press cylinder was determined by applying Equation (3) according to Khurmi and Gupta, (2005)

Weight of cylinder (Wc) = $\rho_m V_c g$ (1)

where V_c is the volume of cylinder and

$$V_c = \pi(r_2^2 - r_1^2)h \quad (2)$$

Where h is the height of cylinder, r_1 is the internal radius, r_2 is the outer radius.

➤ *Hydraulic Press Piston Weight*

The weight of piston was determined from Equation (3)

$$\text{Density of metal } (\rho) = \frac{Mass\ of\ metal\ (m)}{Volume\ of\ piston\ (V)\rho} \quad (3)$$

But

$$\text{Volume of piston } (V_p) = \pi r^2 h \quad (4)$$

$$\text{Mass of Piston } M_p = \rho_m V_p \quad (5)$$

$$\text{And Weight of Piston } (W_p) = m_p g \quad (6)$$

Where density of metal ρ_m = 7850 kg/m3

➤ *Determination of Volume of Hydraulic Tank*

The volume of hydraulic tank was calculated using the volume of rectangle in equation (7);

$$V = lwh \quad (7)$$

where l is the length of the tank in metres, w is the width of the tank in metres, h is the height of the tank in metres.

➤ *Oil Flow Rate from the Hydraulic Tank to the Hydraulic Pump*

Using Khurmi and Gupta, (2005) the Oil flow rate of the hydraulic pump was determined using Equation (10):

$$Q = AV \quad (8)$$

where Q is the flow rate in m^3/s, A is the area of pipe in m^2, V is the velocity of flow in m/s.

➤ *Hydraulic Power Calculation*

Equation 11 was used to determine the hydraulic power of the machine,

$$\text{Hydraulic Power } (P_h) = Q\rho gh \quad (9)$$

where ρ is the density of oil (kg/m^{3}), g is the acceleration due to gravity (m/s^{2}), h is the differential head (m), Q is the flow rate (m^{3}/s).

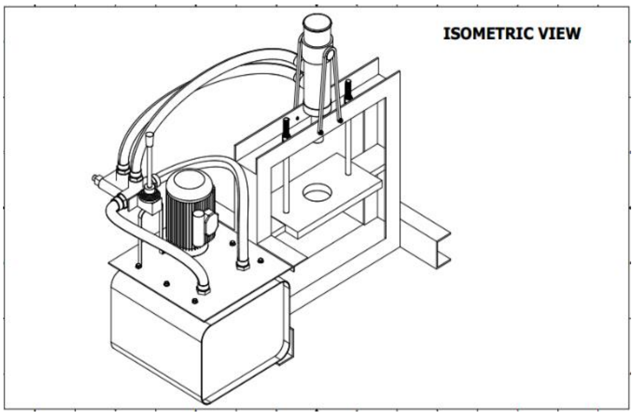

Fig 1: Isometric View

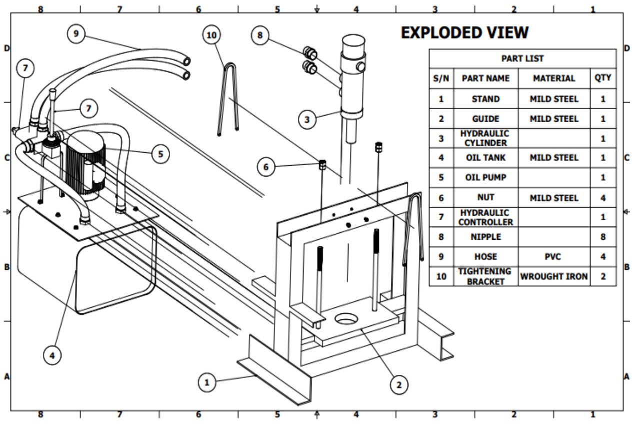

Fig 2: Exploded View and machine Parts

➢ *Directional Control Valve*

The procured directional control valve was used to make the hydraulic cylinder a two-way cylinder. Some of the design values obtained for hydraulic bearing remover machine are presented in **Table 1**.

Table 1: Design values for hydraulic bearing remover machine

S/N	Design Factor	Design Values
1	Volume of Hydraulic tank	25L
2	Weight of piston, W	3tons
3	Weight of Cylinder, W	10 tons
4	Velocity of flow of fluid, V	4.22m/s
5	Oil flow rate, Q	0.0013 m^{3}/s
6	Power, P	1hp
7	Frame Thickness	6mm

B. Detailed Drawings of the Machine

The detailed Isometric view and exploded view of the machine are shown in **Figure 1** and **Figure 2** respectively.

C. Machine Fabrication Processes

The Measurement, marking out, Cutting, Drilling, Welding, Fastening, Grinding and Painting are various processes used in the fabrication of the developed hydraulic press machine. Electric arc welding technique was used because of the ease of concentration of heat. Each component of the machine was made separately to ease assembling and disassembling of the machine. The base of the frame has a length of 365.8 mm, breadth of 365.8 mm and thickness of 6 mm. The vertical height of the frame was 609.6 mm, breadth of 609.6 mm and thickness of 6 mm which are all welded together to make one piece. The guide and work bed (an adjusted type) were fabricated separately and coupled to the frame. The frame stand was welded to the base of the frame to provide for stability of the machine during operations. Also, a 25L rectangular oil tank of was fabricated and attached to the frame using bolt and nut. This tank serves as oil reservoir needed for the hydraulic cylinder. A directional control valve with a hand operated lever was connected to oil tank with the aid of a pivot. To convey the hydraulic oil to the hydraulic cylinder, SAERI2 Pressure hose was fitted to the hydraulic oil tank. The hydraulic cylinder has a load capacity of 10 tons and was fitted with a directional control valve which makes it a double acting hydraulic cylinder and it mounted on the top part of the frame. The machine parts were firmly secured with bolts and nuts to ensure rigidity and support. The welded joints were grinded and the fabricated machine was painted with emulsion paint.

III. RESULTS AND DISCUSSION

Mild steel was used for the fabrication of majority of the developed hydraulic bearing pusher and remover. One important feature of this developed machine is the incorporation o; electric motor and directional control valve into the operation process of the machine. **Figure 3** shows the developed machine. **Figure 4** shows the hydraulic cylinder used, **Figure 5** shows the fabricated frame while **Figure 6** shows the electric motor with the control valve and lever mounted on the hydraulic tank. The machine frame, structural members, weld, and cylinder mechanism were inspected for any fault or leakages of hydraulic oil.

The developed machine was used by three (3) different people to pull three different bearing namely; piston connector, alternator end bearing and roller bearing three times. These same people were also timed when pulling the same bearing manually. The time taken to pull each bearing using the developed machine and when pulling manually were recorded, compared and analyzed. The average bearing pulling/removal time when using the developed bearing removal machine was 15minutes while that of the manual bearing pulling was 60minutes. The use of the developed hydraulic bearing remover shows a 25% pulling time reduction which makes it much faster than the traditionally method of bearing removal/ pulling. Moreso, the use of the electric motor and lever drastically reduce the use of human labor needed as the only human labor needed was for operating the developed machine and setting of the bearing. It also makes the operation much safer and more efficient. The FEA shows a maximum stress of the structure to be 1.613MPa which is low when compared to the yield strength of the material for the frame (Mild Steel) and its maximum factor of safety to be 1.052 which shows that the structural beam is capable of bearing the stress without failure.

Fig 3: Developed Hydraulic Bearing Puller/ Remover

Fig 4: Hydraulic cylinder used

Fig 5: Developed frame

Fig 6: Electric motor with hydraulic tank and control valve

IV. CONCLUSION

The development of an improved hydraulic bearing puller addresses the existing gaps in bearing removing during repair or maintenance of various machinery. The deployment or use of this developed machine offers significant benefits to maintenance industries especially automotive maintenance industries, particularly in pulling bearing faster, safer and limiting human labor. The electric motor incorporated into this machine make it an effective and secure bearing removal machine. Its user-friendly design, safety features, efficacy, and efficiency make it a good option for both professional and do-it-yourself applications. The assessment indicates that this hydraulic bearing puller guide has good durability, use, and functionality. For demanding applications, nevertheless, the power and speed could be increased.

The Finite Element Analysis, the design of the structural frame enables it to perform well if it is subjected to loads due to the weight of the hydraulic cylinder and work piece hanger. Also, the members located at left and right ends provides more rigidity to the frame, while the members at the base provide more stability to the structure.

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