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Design, Construction and Performance Evaluation of Hydraulic Cylinder Liner Puller

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Abstract: *The demand for pullers, for pulling cylinder liner, has been on the daily increase, which in turn propel massive production of pullers in order to meet this demand. The difficulties associated with the traditional method of pulling cylinder liner is quite enormous. In this research, hydraulic cylinder liner puller was redesigned and constructed to improve the processes involved in the removal of cylinder liner. The puller uses hydraulic principle to pull the cylinder liner, and it consists of some components namely; the upper and lower flange, pulling rod, center rod, hooking plate, pin, main plate, stands and a bottled hydraulic jack. The materials used for the construction is quite affordable and available. The device was tested in two different engine position (that is at 90^o and 180^o) and their pulling time was recorded. The device was found to work effectively at 90^o during which a pulling time of 116 seconds was obtained. The design shows that the puller has efficiency of 64%.*

Keywords: *hydraulic jack, pulling rod, centre rod, hooking plat and main plate.*

1.0 Introduction

A cylinder liner is the central working part of a reciprocating engine or pump, the space in which a piston travels. A cylinder liner is a cylindrical part to be fitted into the bore of the engine block to form the cylinder walls. It is one of the most important functional parts that make up the interior of an engine. These sleeves are press-fitted into the cylinders, and a considerable force is required to remove them (Clark, *et al*, 1988).

A cylinder liner puller is a device that is used to extract the liners from the engine block. Many reciprocating type engines and particularly internal combustion engines have engine block construction which includes removable cylinder sleeves or liners.

In the normal course of using the engine, the piston rings wear the walls of the cylinder, and eventually the walls become so worn as to require replacement of the cylinder liner and this requires removal of the cylinder liner and the piston and connecting rod. Thus, removing a cylinder liner involves large number of man hour (Ferguson, 1977).

In a bit to reduce the labour involved in removing and subsequently replacing the cylinder liner, came the manufacturing of various tools, some of which use hydraulic as designed by Twogood, *et al*, 2002. And many others use nut and threaded bolt as designed by Ferguson, 1977, *et al*, 2002.

Many of these devices consisted of stationary equipment, and a constant problem with these tools has been the question of how most effectively and efficiently to "hook" the sleeve in order to allow the tool to pull it out of the cylinder (Twogood *et. al*, 1986).

1.1 Literature review of Cylinder and Cylinder Liner Pullers

A cylinder liner puller is a mechanical device used to pull or remove the cylinder liner from the engine block, so as to allow engine maintenance that has to do with replacing the liner when it is worn out. The use of cylinder can be traced back to 1680, when Denis Papin, (1647-1712), who was a French physicist, a mathematician and an inventor, invented a design for a piston-and-cylinder engine. He was best known for his pioneering invention of the steam digester, the forerunner of the pressure cooker. In the mid-1670s, Papin collaborated with the Dutch physicist Christian Huygens on an engine which drove out the air from a cylinder by employing gun powder inside it. Realizing the incompleteness of the vacuum produced by this means and on moving to England in 1680, Papin devised a version of the same cylinder that obtained more complete vacuum from boiling water and then allowing the steam to condense (http//:www.wikipedia.com, 2021).

Many other engines developed by different inventors make use of piston and cylinder setup, among which include; Thomas Newcomen's, the inventor of atmospheric engine in 1747 which became the first commercially successful engine and also Watt engine, developed in 1774. The entire above early engine type make use of non-removable dry cylinder sleeve. In the earliest decades of internal combustion engine development, cylinders were usually cast individually. A liner cylinder block, features cylinder walls that are entirely removable, which fit into the block by means of special gaskets. They are referred to as "wet liners" because there outer side comes in direct contact with the engine coolant (http//:www.wikipedia.com, 2021).

In 1915, C. S. Wright designed a manually operated cylinder liner extractor which was mainly used for pumps and the like. His invention is one of the early cylinder liner puller devices which use bolt and threaded shaft in extracting the cylinder. J. J. Santiago in 1931, also designed a liner puller which is used for pulling sleeve of both pumps and internal combustion engine. His design was filed in 1929 and was approved as a patent in 1931. A. P. Ridenour also designed a liner puller which was filed in 1929 at Los Angeles and was approved as a patent in 1930 (http//:www.uspatent.com, 2021). Heimbach et al (1937) patented a design of cylinder sleeve press and removal device which was particularly adapted for pressing sleeve into cylinder block of either pump or internal combustion engine and for removing the same when desired.

2.0 Description of Cylinder Liner Puller

Ferguson (1977) described cylinder liner puller as a device which is supported atop a cylinder block which has lugs or jaw that is used to engage the underside of the cylinder wall ridge resulting from deposits of carbon and wear by piston rings. Screw force is applied to the jaws by tightening the nut on the threaded shaft which pulls the cylinder sleeve and subsequently the piston. The device is commonly used in pulling dry sleeve, and there must be an excessive wear of the cylinder liner for this device to work effectively. This device utilizes the principle of nut and threaded shaft in pulling out liners.

2.1 Hydraulic Jack System and its Basic Components

The hydraulic jack consists of the following components.

1. **Hydraulic pump:** Hydraulic pumps supply fluid to the component in the system.
2. **Control Valve:** Directional control valves route the fluid to the desired actuator.
3. **Reservoir:** This assist to hold excess hydraulic fluid to accommodate volume changes from cylinder extension, contraction, temperature driven expansion and leaks. The reservoir is also designed to aid in separation of air from the fluid.
4. **Pump:** The pump sucks fluid from the reservoir when on, suction or intake stroke then creates pressure on its power/down stroke pushing the fluid.
5. **Check valve:** This allows fluid to pass from the reservoir to the pump then checks off the return port to the reservoir and direct the pressurized fluid.
6. **Ram piston:** This is forced out or upwards as the main cylinder is filled with pressurized fluid.
7. **Released valve:** When the released valve is opened, the fluid is ported back into the reservoir.

2.2 Principle of Operation of a Hydraulic Cylinder Liner Puller

The main plate is supported by four stands which are movable. Two flanges are connected one at the top of the main plate and the other below the main plate by means of a pulling rod. A center rod is fastened to the middle of the bottom flange, at the end of which a hooking plate is freely connected by means of a pin (clevis arrangement) and a hydraulic jack is placed in between the upper flange and the main plate.

In operation, the device is placed on top of the block engine, on the cylinder whose liner is to be removed and the freely connected hooking plate is rotated to, say 60^0 about the pin to allow insertion into the cylinder liner. At the bottom of the cylinder liner, the hooking plate turns to horizontal position by gravity thereby hooking the bottom of the cylinder liner and by applying the hydraulic jack force, the cylinder liner is simultaneously removed. The hydraulic cylinder liner puller can be shown below in plate 1

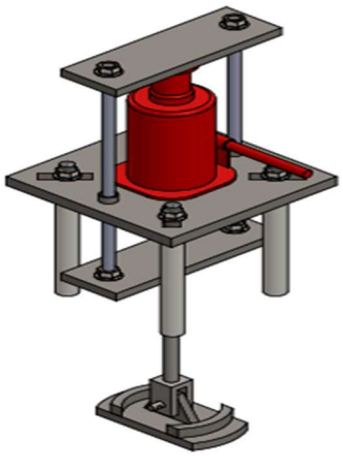

Plate 1: Hydraulic cylinder liner puller

2.3 The Construction of the hydraulic cylinder liner puller

The design and construction of hydraulic cylinder liner puller involved different processes which include; bench work, machine work and welding work. Components of this machine that required these various processes are elaborated below:

1. **Pulling and center rods:** The operation involved include; measuring and cutting at a length of 310 mm and 205 mm. An external thread (M10) was then made at one end of each rod using diestock.
2. **Flanges:** Two flanges were produced using a mild steel plate of 210 mm x 70 mm x 10 mm. Operation involved include; marking out, milling, and drilling.
3. **Hooking plate:** Operation carried out on the hooking plate include; marking out, milling, grinding, drilling and welding. It is made up of mild steel plate of 122mm x 70 mm x 8 mm.
4. **Main plate:** It is made of mild steel plate of 210mm x 210 mm x 8 mm. The formation process include; marking out, cutting, milling, chain drilling and filling.
5. **Stands:** The stands are mild steel rod of 25mm in diameter obtained from a vehicle shock absorber known as shock strut. The machining process involved with this part is cutting to a required length.

3.0 Performance Test

The testing of the hydraulic cylinder liner puller was carried out to establish its quality and performance. The test was carried out by considering two engine positions i.e. at 180^o and at 90^o. First, the engine was placed at its normal seating position that is (180^o) and the puller device was connected, ready to pull the liner. The time taken to remove the liner at 180^o was recorded as 285s and the time taken to remove the liner at 90^o was 116s.

3.1 The efficiency of the machine is calculated as follows;

$$\eta = \frac{Work\ input}{Work\ output} \times 100$$

Work input = Effort × distance moved

Work output = Load × distance moved

3.2 Discussion

From the results obtained in the performance test, it is seen that the time required to pull out the cylinder liner differs because of the engine position. When the engine was positioned at 180^o, a pulling time of 285 seconds was obtained while at 90^o, a pulling time of 116 seconds was obtained. This means that pulling at 180^o consumes more time because of the horizontal positioning of the pulling device and the position of the user, while at 90^o consumes less time because the pulling device had good position as well as the user. The efficiency of the machine was obtained to be 64%.

3.3 Conclusion

A hydraulic cylinder liner puller was redesigned and constructed using locally available material. The machine was tested and found to work effectively at vertical (90^o) position, and has an efficiency of 64%.The materials used for the construction is quite affordable and available. The effect of these considerations led to the development of an efficient, reliable and affordable hydraulic cylinder liner puller device which can serve personal or industrial needs.

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