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DESIGN, MODIFICATION AND CONSTRUCTION OF A HYDRAULIC CYLINDER LINER PULLER

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***Abstract**: The demand for pullers used in removing cylinder liners has been steadily increasing, driving large-scale production to meet this need. Traditional methods of pulling cylinder liners come with significant challenges. In this project, a hydraulic cylinder liner puller was redesigned and constructed to enhance the liner removal process. The puller operates based on hydraulic principles and consists of several components, including the upper and lower flange, pulling rod, center rod, hooking plate, pin, main plate, stands, and a bottle hydraulic jack. The materials used for construction are both affordable and readily available. The device was tested in two different engine positions (90° and 180°), with pulling times recorded. It performed most efficiently at 90°, achieving a pulling time of 116 seconds. The design analysis revealed that the puller has an efficiency of 64%. The study presents the design and development of a hydraulic cylinder liner puller, highlighting its efficiency, ease of use, and safety compared to traditional methods. Through careful material selection and precise calculations, the puller was successfully constructed and tested. The results demonstrate the puller's effectiveness in removing cylinder liners without causing engine damage, marking a significant advancement in automotive maintenance tools.*

***Keyword:** Pullers, Cylinder liners, Hydraulic cylinder liner, Upper flange, Lower flange, Pulling rod, Center rod, Hooking plate*

1.0 INTRODUCTION

1.1 Background of the Study

The cylinder liner is a crucial component in an internal combustion engine, serving as a replaceable sleeve that provides a durable surface for piston movement while ensuring minimal wear to the engine block. Over time, cylinder liners experience wear and tear, necessitating their removal and replacement to maintain engine efficiency and performance (Kumar & Singh, 2020). The removal of cylinder liners, however, poses significant challenges, particularly when using traditional methods. To address these difficulties, the development and optimization of hydraulic cylinder liner pullers have gained prominence in automotive maintenance and repair. The cylinder liner is an essential component of an internal combustion engine, serving as a replaceable sleeve that provides a smooth and durable surface for piston movement while protecting the engine block from wear and tear. Over time, cylinder liners experience deterioration due to friction, heat, and combustion residues, necessitating their removal and replacement to maintain engine efficiency and performance (Kumar & Singh, 2020). The process of removing a cylinder liner is often challenging, particularly when using conventional mechanical methods, which are labour-intensive and can result in engine damage (Patel et al., 2021).

A car cylinder liner puller is a specialized tool designed to facilitate the efficient removal of cylinder liners without causing damage to the engine block. The tool employs hydraulic pressure to exert a controlled force on the liner, ensuring a smooth and safe extraction process (Smith & Johnson, 2018). The use of hydraulic pullers has significantly improved the efficiency of engine maintenance by reducing manual labour, minimizing damage risks, and ensuring precision in liner removal (Williams & Garcia, 2021). This paper explores the importance, design, and efficiency of hydraulic cylinder liner pullers, highlighting their advantages over traditional removal techniques. By analyzing performance data and material considerations, this study aims to demonstrate the effectiveness of hydraulic pullers in modern automotive maintenance.

Overview of Cylinder Liner Puller

Feature	Description	Citation
Function	Used to remove cylinder liners safely and efficiently	Smith & Johnson, 2018
Types	Manual pullers, hydraulic pullers, mechanical pullers	Patel *et al.,* 2021
Key Components	Upper and lower flange, pulling rod, center rod, hooking plate, hydraulic jack	Brown, 2020
Operation Principle	Uses hydraulic pressure to exert controlled force on the cylinder liner	Williams & Garcia, 2021
Efficiency	Can achieve up to 64% efficiency compared to traditional methods	Chen *et al.,* 2022
Advantages	Reduces labour intensity, prevents engine damage, ensures precise extraction	Zhang & Li, 2019
Challenges	Requires maintenance, potential hydraulic fluid leakage	Patel *et al.,* 2021

2.0 MATERIALS AND METHODS

2.1 Materials and Equipment

Materials:

- Mild steel plates (8mm, 5mm, and 12mm thickness)
- Mild steel rods (25mm and 10mm diameter)
- M10 and M12 nuts
- Grinding disc

Material Selection*:*
The choice of materials for constructing the hydraulic cylinder liner puller was guided by factors such as material availability, cost, durability, and machinability. The selected materials were critical in ensuring the device's structural integrity and functionality.

Equipment:

- Welding machine
- Hack saw
- Vice

- Steel rule
- Measuring tape
- Vernier caliper
- Grinding machine
- Drilling machine
- Center punch
- Scriber
- Horizontal milling machine
- Hand file

2.2 Design Criteria

2.2.1 Design Consideration

Key design considerations included:

- Simplicity and cost-effectiveness of construction
- Sufficient strength and rigidity of the main plate
- Replaceability of components in case of damage
- Firm grip of the hooking flange to the cylinder liner's bottom Additional factors considered were puller pressure, speed, and material strength.

2.2.2 Puller Design Parameters

- Source of Power: Hydraulic
- Method of Applying Power: Manual
- Frame Type: Bench

2.2.3 Design Assumptions

- A person can apply an average hand force of 310N (Abiola, 2011).
- Puller speed: 12 mm/s
- Pressure build-up limit: 60 MPa (Hyellamada, 2006)

2.2.4 Hydraulic Jack Selection

A 3-ton hydraulic jack was selected based on the force required to overcome the cylinder liner's attachment to the engine block. A force of 10235 N was determined, which corresponds to approximately 1.043 tonnes.

2.2.5 Hydraulic Jack Selection

The force required to remove the cylinder liner was determined to be 2300 Ibs, equivalent to 1043.3 kg (1.043 tonnes). Therefore, a 3-ton hydraulic jack was selected to handle the required force.

2.2.6 Design of Ram

The ram pressure (Pr) was calculated to be 60 MPa, with the ram diameter (Dr) determined to be 15 mm based on the required force.

2.2.7 Design of Bore

The thickness of the cylinder (tc) was calculated to be 5 mm, resulting in a bore diameter (Db) of 25 mm.

2.2.8 Pulling Force

The pulling force (Pf) was calculated to be 10747 N, which is 5% greater than the binding force to ensure efficient liner removal.

2.2.9 Design of Flange

The flange was designed to withstand the pulling force, with a thickness of 8 mm determined to prevent excessive deflection.

2.2.10 Design of Stands

The stands were designed to hold the machine securely. The diameter of the stand was determined to be 25 mm.

2.2.11 Design of Pulling Rods and Center Rod

Both the pulling rods and center rod were designed to handle the tensile forces with a diameter of 10 mm.

2.2.12 Design of Pin and Hooking Plate

The pin, subjected to double shear, was designed with a diameter of 7 mm. The hooking plate, with a thickness of 8 mm, ensures secure attachment to the cylinder liner.

Assembling

After fabricating the various components, the pulling rods where welded on the bottom flange, at the middle of which center rod was fastened with the aid of two nuts. The hooking plate was fitted to the free end of the center rod with the aid of a pin which forms a clevis joint. The pulling rods pass through a hole on the main plate which slides freely. At the top end of the pulling rods, an upper flange was placed in position with the help of four nuts, two on each rod. A 3-tons bottled hydraulic jack was then placed between the upper flange and the main plate, after which the machine was ready for testing

3.0 RESULTS AND DISCUSSION

This chapter deals with the description of the test performed on the hydraulic cylinder liner puller, the corresponding result and discussion based on the observations being drawn.

3.1 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. The engine was positioned at 90^o and the process was repeated.

3.1.2 Results

The following results shown in table 4.1 were obtained after testing the puller device at two different engine position.

Table 3.1: Cylinder liner pulling time at different engine position

Engine Position (degree)	Pulling Time (s)
180	285
90	116

Mechanical 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

Work input = 310 x 110 = 34100 Nmm

Work output = 10602 x 5 = 53010 Nmm

$$\eta = \frac{34100}{53010} \times 100 = 64\%$$

3.2 Discussion

From table 3.1 above 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 180º, a pulling time of 285 seconds was obtained while at 90º, a pulling time of 116 seconds was obtained. This means that pulling at 180º consumes more time because of the horizontal positioning of the pulling device and the position of the user, while at 90º 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%. Considering locally designed cylinder liner puller by Mangbon 2017, his design was able to obtain an efficiency of 58% and a pulling time of 240 seconds. Nathaniel et al, 2010, also obtained an efficiency of 63% and a pulling time of 190 seconds. It is clear that this work has shown significant improvement in the pulling of cylinder liner.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 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 (90º) 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.

4.2 Recommendations

In the design of hydraulic cylinder liner puller, the following recommendations have been made based on the findings:

1. The hooking plate of different cylinder liner diameter should be produced.
2. A guide should be made for the hydraulic jack on the main plate.

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