

Design Improvement of Heavy Vehicle Jack for Small and Medium-sized Enterprises (SME's)

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ABSTRACT – This paper presents a study on a product designed to assist in the repair of tractor gearboxes. Currently, repairing and assembling tractor gearboxes is a difficult and complex task that requires multiple tools and high skill levels. The study focuses on the design of a tractor gearbox stand, which can help mechanics in the separation and installation of the gearbox. The stand is intended to make the process of separating and reassembling the gearbox easier and safer. Currently, mechanics use various tools, such as floor jacks, which increase the risk of accidents. The tractor gearbox is often stored on a jack, posing a high risk of falling during work. To improve the process, three conceptual designs for the gearbox stand were proposed and analyzed based on functionality, stability, machinability, and safety. The proposed improvements aim to enable the stand to securely support the heavy tractor load, reduce the number of workers needed from five to two, and improve safety features. By using a single tool, the tractor gearbox stand, the work process can be simplified. The study was conducted at Jabatan Pertanian Negeri Melaka, specifically within the maintenance department, where heavy machinery is serviced. Feedback from workers at Jabatan Pertanian Negeri Melaka helped refine the design. The final design aims to simplify the mechanic's tasks, especially during gearbox removal, and reduce the number of workers required. This project is expected to enhance safety during operations and improve efficiency in tractor gearbox maintenance.

KEYWORDS : *Tractor gearbox stand; safety factor; design*

1.0 INTRODUCTION

The research conducted on heavy machinery workshops identified numerous challenges associated with working on tractors. This is because there are no special tools to use in doing any work. For example, in the work of separating and assembling tractor gear boxes. This work is very difficult to accomplish because there are no special tools used in the work. The mechanic who does this will use a lot of equipment such as a floor jack in performing this task. With the use of such tools, the risk of accidents is high. For example, a tractor gear box may slip from the floor jack and cause damage to the machine as well as injury to the workers. Some of the problems that encountered in doing the tractor gearbox partition work were as follows:

- i. The use of large numbers of workers in the work of separating and assembling tractor gear boxes.
- ii. The separation of tractor gearboxes requires a prolonged amount of time.
- iii. Less safety aspect as there is no special tool used for the work of separating and assembling tractor gearbox.

Based on the problem statement identified in this research, an idea was developed to create a tool that mechanics can use for the separation and assembly of tractor gearboxes. The project is a product innovation tractor gearbox stand that involving separation of tractor gearbox during maintenance. The project is created intended to provide convenience to the mechanics of doing work on a tractor. The objectives of this study are:

- i. To design a tractor gearbox stand that enhances the safety and efficiency of tractor gearbox servicing by providing adjustable height and stability features, reducing the risk of accidents during the process.

- ii. To develop a functional prototype of the tractor gearbox stand that can support heavy machinery, capable of reducing manpower and time required for gearbox maintenance by at least 30%.
- iii. To integrate a stable and adjustable tractor gearbox stand into the existing workshop setup, ensuring seamless compatibility with current machinery and tools, while improving overall operational safety and efficiency.

The tractor gearbox stand is a stand that is adjustable to the front and back of the roll bar. It is to simplify the process of separating and unloading the tractor gearbox. It will be adjustable and moveable to the site provided. Works such as power take-off (PTO) maintenance, clutch replacement and so on can be done when the tractor is upgraded to this tractor gearbox stand. Tractor gearbox stand is used exclusively for heavy machinery, tractor. This project is working on is a tool that will facilitate the work of separating and replacing the tractor gearbox, clutch conversion and power take off (PTO) maintenance. The project will also ease and simplify gearbox partitioning.

In addition, this tool will also minimize the use of employees to perform certain tasks. This is because using the current way to separate the gearbox will take at least 5 to 6 people to execute it. However, with the use of the stand that we will be doing this, the workers used to do tractor gear box splitting work will be reduced to just 2 or 3 people. Furthermore, with this tool, time will be used well and work can be done quickly and safely. The tools and materials we will use to implement this tool are angle bar, absorber, scissor jack, bearing and so on. This tool can be uninstalled after you finish using it. This will make it easier for worker to storage or move it somewhere else.

The study focusses on improving the design of a tractor gearbox stand, with an emphasis on practicality and industrial applicability. The study, conducted in partnership with Jabatan Pertanian Negeri Melaka, aims to improve the stand's functionality and efficiency. It aims to improve workshop operations and contribute to advances in heavy machinery maintenance practices in the agriculture sector by addressing issues encountered during the separation and assembly of tractor gearboxes.

2.0 LITERATURE REVIEW

2.1 PTO (Power Take Off)

A power take-off or power takeoff (PTO) is any of several methods for taking power from a power source, such as a running engine, and transmitting it to an application such as an attached implement or separate machines. Most commonly, it is a splined drive shaft installed on a tractor or truck allowing implements with mating fittings to be powered directly by the engine. Semi-permanently mounted power take-offs can also be found on industrial and marine engines. These applications typically use a drive shaft and bolted joint to transmit power to a secondary implement or accessory.

In the case of a marine application, such shafts may be used to power fire pumps. In aircraft applications, such an accessory drive may be used in conjunction with a constant speed drive. Jet aircraft have four types of PTO units: internal gearbox, external gearbox, radial drive shaft, and bleed air, which are used to power engine accessories. In some cases, aircraft power take-off systems also provide for putting power into the engine during engine start. The PTO rotational speed was specified as 536 ± 10 rpm; the direction was clockwise. The speed was later changed to 540 rpm.[1]

2.2 Tractor Gearbox Stand

Nowadays, to service tractor gearbox there are still using hydraulic stand 3 tone. After doing some research on heavy machinery workshops. From the finding of separating tractor gear boxes, they are very difficult to separate and service, as it requires a lot of workers and it is less secure.

Furthermore, the problem that employees face is that it takes time to do the work of separating the gearbox for a long time. The work is done using a lot of manpower. While it takes a lot of people to do the work, it still takes a long time to get it done.

Next, safety issues while doing tractor gearbox partition work. According to the research that have been conducted, the risk of accidents while doing this work using the current method is high risk. Figure 1 shows tractor gearbox stand using normal hydraulic stand.



Figure 1: Basic Hydraulic Stand [1]

2.3 Tractor

In agricultural mechanization, tractors as a vehicle or machine has contribute so much to improve the productivity and effectiveness of the agricultural heavy work [2]. Tractor is said to be a huge contribution in modern developing countries that replace the conventional method that use animals or human forces to do the work. The limitation of animals and human forces has led to the invention of tractor to overcome hard work and taking a long time during farming. There have two types of tractor engines which are petrol and diesel engines. Both has its advantages and disadvantages but majority of agricultural machinery using diesel engines as shown in Figure 2 because it is easy to repair and maintain, good and has solid construction and can deliver more power at low speed [3].



Figure 2: Dimension of tractor.

The development of agricultural machines such as tractor has brought new demand in farming industries and agricultural workers. The farmers themselves must know about energy, mechanical forces and have mechanical skills. It is important that farmers know how to maintain, safely operate and repair the tractor [4]. Safety, convenience and comfortable must be taken into consideration while performing a job in workplace to ensure worker safety and comfort [5]. Safety in workplace must be the first thing to consider because it is involving the human life. Similar to the current servicing work of tractor gearboxes, proper and working equipment should be used to ensure that the work is done safely.

2.4 Detail Drawing of Concept Design

The structure analysis is done using analysis software which is CATIA V5 CAD software. The detail drawing is drawn using CAD software to illustrate the shape and dimension of the design. Three concept designs was drawn using CAD software.

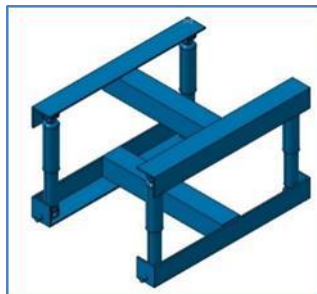


Figure 3: Concept design A

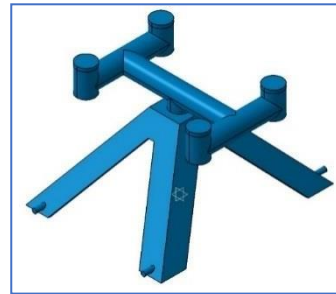


Figure 4: Concept design B

Figure 3 shows drawing of concept design A. It has tough structure where it is support by four shock absorber. It uses angle iron as the main structure and use rectangular hollow section iron as center structure. It has large contact area at the top for ease of positioning the tractor gearbox. The center of the main structure will support by bottle jack for ease of height adjustment. Each side of the design has two solid shafts iron for installation of wheel. It will be used for ease of movement during separation. It uses thickness of 5 mm for angle iron and rectangular hollow section iron. The whole concept design A will use mild steel as its material. The advantage of this design lies in its flat shape, allowing it to fit various types of tractors. However, its larger size may pose challenges when positioning it beneath a tractor.

Concept design B is similar with design of jack stand where the difference is only it size as shown in Figure 4. On the top of the design, there has four support use to hold the tractor gearbox. It uses circular hollow section iron with thickness of 5 mm. Bellow structure design use angle iron as it structures with the shape of pyramid. The shape of the pyramid is used to stabilize the design. At the center of the design, there will be bottle jack to adjust the height of top support. It also has two solid shafts for installation of wheel for both sides. The material use for this design is mild steel [6]. This design offers the advantage of stability due to its pyramid shape; however, it lacks any adjustable elements.

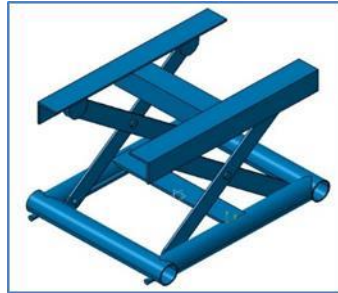


Figure 5: Concept design C

Concept design C as shown in Figure 5 use a concept of scissor jack. It use circular hollow section iron as it base with thickness of 5 mm. It use angle iron and rectangular hollow section iron for top supporter. The height adjustment use concept of scissor where it will be adjusted by using bottle jack at its centre. It also has two solid shafts for wheel installation at both sides. Mild steel will be use as its main material. This design offers stability and can fit various types of tractors, but it is overly complex and features a complicated mechanism.

3.0 METHODOLOGY

3.1 Survey and Observation



Figure 6: Jack stand used to hold the tractor during servicing work

In order to create a project, procedure or step plays a vital role in obtaining quality work that is able to meet the needs and comfort of the user. This is an important process as we will be able to see the cooperation that each member of the group will bring to the project. In the process there are several steps to take. It is a measure of measurement, cutting, welding, installation and even finishing. In each of these steps, each member of the group will play a role in ensuring that their tasks are completed within the time allotted.

The implementation process is the most important process in the process of implementing this project. In this process, each member of the group will take on their assigned tasks. This process starts with the measurement process, the cutting process, the welding and welding and finishing process. The idea to design tractor gearbox stand is generated through an observation and survey method at Sime Darby Workshop. The idea to invent a design of tractor gearbox stand was generated during the servicing of tractor gearbox at Sime Darby Workshop. The mechanics use jack stands to hold the separated unit of tractor while servicing tractor gearbox as shown in Figure 6. They use several jack stand to hold the separated unit of tractor because of the heavy weight. The total mass of tractor is almost 5000 kg and design of tractor gearbox stand must be

able to withstand the load. Current method uses by mechanics to separate the units of tractor is using human force.

Several mechanics were hold the separated units of tractor while the other mechanic put the jack stand below the tractor. This method uses much energy of mechanics during servicing because of high load of tractor [7]. The design of tractor gearbox stand need to meet the safety criteria which is it can withstand the weight of the tractor. To do so, in Table 1 shown the project analysis result and engineering analysis is applied to the design and calculated in analysis software [8].

Table 1: Project Analysis Results

Item	Used tractor gearbox stand	Without tractor gearbox stand
Load that can be accommodated	Min- 0 kg Max- 1500kg	Depending on the floor jack used .
Employee	Use 2 people to separate the tractor gear box	Use 5 people to separate the tractor gear box
Safety	Large stand surfaces reduce the risk of tractor from falling	A small floor jack tread causes the risk of a tractor falling is high.
Equipment	Using 1 tractor gearbox stand and 2 scissor jacks.	Uses 2 floor jack, 2 pipe and 2 safety stand .

4.0 CONCLUSION

Through this study, it can be concluded that an improved design provides a better solution for performing tasks. The current method of servicing tractor gearboxes appears hazardous, as there are no specific tools to secure the gearbox during separation and maintenance. Three conceptual designs were proposed and analyzed to determine the best option. In addition to the design itself, factors such as stability and the ability to securely hold the heavy tractor during separation and maintenance were considered. Given the weight of the tractor, assessing the product's performance under high load is crucial to ensure its safety before use. For future improvements, the performance of the product, particularly its structural capacity to bear heavy loads, can be evaluated using simulation software. This method is cost-effective and time-saving, as the design has already been drawn using CAD software, allowing for direct structural analysis with the necessary settings. Although based on simulation, the results can offer a reliable prediction for real-world applications [9]. It is hoped that any shortcomings or weaknesses in this study will be addressed to better meet user needs. Ultimately, the tractor gearbox stand design simplifies the mechanic's tasks, particularly in separating the tractor gearbox. Moreover, this project is expected to reduce the number of workers required and enhance safety during operations.

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