UNDER PEER REVIEW

DESIGN AND DEVELOPMENT OF A SCREW JACK: AN INPUT REPAIR TOOL FOR LIGHT VEHICLES

Abstract. Vehicular jacks are important repair tools in the automotive industry, particularly in Agusan del Norte, Philippines. The project study "Design and Development of a Screw Jack: An Input Repair Tool for Light Vehicles" aims to promote the proper use of repair tool that emphasizes safety and helpful to the light vehicle drivers, and address the problems arising from utilizing an improvised repair tool such as a piece of log, in a particular tire-changing operation and process such as hassle tasks, inconvenience, inappropriate lifting technique, and inefficiency. The new technology is a manually-operated repair tool or device used to lift light vehicles for repair purposes, such as tricycles, minivans, and jeepneys, and it consists of several parts such as a screw, head, spindles (double and triple), lever arm, ratchet, body, and a base. The objective of this study is to design and develop a screw jack and test its functionality based on the perception of automotive experts and light vehicle drivers. The project is a descriptive and developmental kind of research approach. The researcher utilized survey questionnaires to provide a precise representation of addressing the technical problem, that is, developing a new device that is functional and effective to address the recognized problems**.** The study is located in Baleguian, Jabonga, Agusan del Norte. Based on the data gathered, the project is functional; although defects were found during testing, those were still changed and revised so that the project performs as expected. The study reveals that the project research can be designed and developed to lift the loads of light vehicles with high functionality and safety in terms of utilization and satisfactory economy recognized by the evaluators. The proponent strongly recommends enhancing and improving features like handles and base capacity to make them more functional. Hence, the device is successfully developed.

Keywords: Vehicular Jacks, Screw Jack Design, Automotive Repair Tool, Light Vehicle Maintenance, Safety in Tire-changing Operation

1. Introduction

The vehicular Jack is an important repair tool in any automotive industry. It is commonly used to lift or lower vehicles for repair purposes like tires. Jacks have two types, namely mechanical and hydraulic jacks (Reed, 2023). A mechanical jack can be considered a light lifter tool. Using the mechanical principle, it pushes the ratchet wheel to rotate. It gives users ease of carrying and usage. One example of a mechanical jack is the screw jack. It is a manually operated tool that mostly contains screws and a rachet as its mechanism, specifically the mechanical principle (CreaLifting, 2019). On the other hand, hydraulic jacks can be considered heavy lifters as they allow the user to lift heavy equipment. These jacks are mostly automatically operated with just the use of a button through the concept of the Pascal principle, which emphasizes the use of a balanced pressure between the small and large pistons through exerting fluid acts (Jha et al., 2018).

Three factors are considered as to why manufacturing companies continue to produce different types of jacks. The first factor is the safety. The main use of jacks is to lift the load and not to hold it. Hence, safety precautions should be considered since jacks hold extreme pressure that might cause accidents (Dare, A.D., & Oke A.S, 2008). For instance, jacks are the main tools used in a road emergency, such as dealing with flat tires. A jack that is safe to use, especially in dark road areas, is essential, as well as a jack that is easy to use and is not bulky. Another factor is

functionality, which involves proper design that is not just physically ideal but also ideal for its functionality. Functionality plays an important role in maintaining the purpose of the Jack and securing the user and the vehicle to safety. The last factor is economic efficiency. Jacks that are budget-friendly are what most drivers need, especially light vehicle drivers. Since jacks are the main tools in repair, the demand for these is high, especially for vehicles.

1.1 Related Works

Shah, Shrivastava, and Ghatol (2010) conducted a comprehensive study on the "Design and Analysis of Screw Jack for Load Capacity 100KN." Their research focused on the stress and deformation analysis of different components of the screw jack, including the screw, nut, and housing, to ensure the structural integrity and safety of the Jack under high load conditions.

A first pinion gear having a hexagonal through bore is drivable and mounted to the intermediate portion of the crankshaft. The first gear is in driving engagement with a screw gear connected to the axial screw. At least one of the end bushings is to be removable to facilitate a gear drive disassembly. Rotation of the crank transmits rotation to the crankshaft and the first pinion gear, in turn transmitting rotation to the screw gear and the axial screw for telescoping movement of the Jack.

The crank provides an efficient way to change from one operating gear of the Jack to another. It facilitates operator use of the mechanical Jack to which it is connected to provide improved cranking and improved changing of one operating gear to another. The invention facilitates multiple working speeds and a drop leg speed to create a commercially valuable selection of working gear ratios and mechanical jack load capacities in a trailer (e.g., gooseneck, flatbed, etc.) operating environment.

Farooky et al. (2014) suggest mechanical jacks can be great if combined with a hydraulic jack. The principles of mechanical and hydraulic allow the device to lift heavier vehicles. This can be internalized with the use of pump plungers. Pump plungers will serve as drivers in opening the suction valve ball inside the cylinder and allow the oil to enter the pump chamber. This process results in pressure building throughout the cylinder as the plunger pushes forward, and the valves close since the oil moves through the chamber.

1.2 Prior Arts

Table 1. Conceptual Matrix

Features	Prior Art 1	Prior Art 2	Prior Art 3
	Screw Jack Assembly US20070181864A	High Lift Type Screw Jack CN210559088U	Screw Jack CA2492028C
(1) Screw	X	✓	✓
(2) Head	X	X	X
(3) Spindle (Double Thread)	X	X	X
(4) Spindle (Triple Thread)	X	X	X
(5) Lever Arm	X	X	X
(6) Ratchet	X	X	X
(7) Body	✓	✓	✓
(8) Base	X	✓	X

The matrix table compares some of the features of developed technology. It has similarities with other existing, closest prior arts (patented documents). However, there are differences in the characteristics that determine the uniqueness and newness of the technology.

2. Materials and Methods

2.1 Materials and Device Mechanism

A screw-type jack is a simple yet powerful lifting device commonly used in various industries and automotive applications. It utilizes the principle of a screw thread to convert rotational motion into linear motion, enabling the lifting of heavy loads with ease (***Figure 1)***. The basic design of a screw jack consists of a threaded rod or screw, a nut that moves along the screw thread, and a handle or lever to rotate the screw. This type of Jack provides a mechanical advantage, amplifying force, and efficient lifting operations (Shigley, 2014). One of the key advantages of a screw-type mechanical jack is its ability to provide precise and controlled lifting. The pitch of the screw thread determines the distance the load is lifted with each rotation, allowing

for accurate positioning and height adjustment. Additionally, the self-locking nature of the screw thread prevents the load from descending when the Jack is not in use, ensuring stability and safety during operations (Norton, 2013).

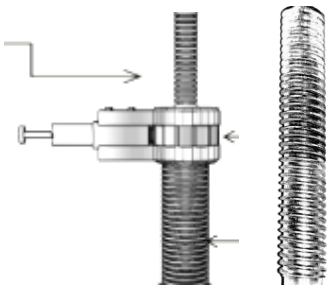


Figure 1. Screw Thread

The screw-type mechanical jack device is governed by a double and triple pitch of a square thread, which is used to drive the spindle in lifting an object that is safe to operate. The materials are made up of tool steel SAE 1095 and heat treated at a certain temperature level to attain the desired hardness so that it will resist when a load is applied during the operation. The device is user-friendly and can be manually operated. Typically, they have the same lifting speed as hydraulic jacks. Additionally, the manual operation of the handle or arm lever can be physically demanding, especially for lifting heavy loads. However, these limitations can be overcome by incorporating electric or motorized systems into the design (Oberg et al., 2016). Figure 2 shows all the parts of the device, which comprise different usefulness and purposes.

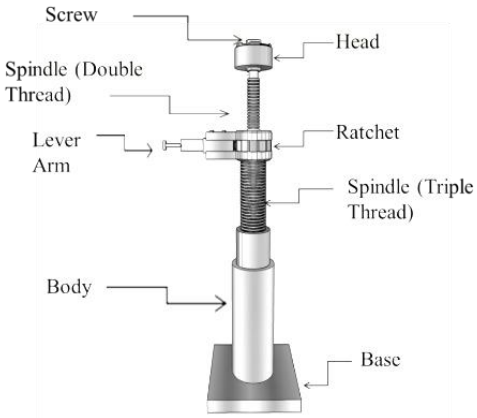


Figure 2. Parts of the Device

2.1 Device Utilization

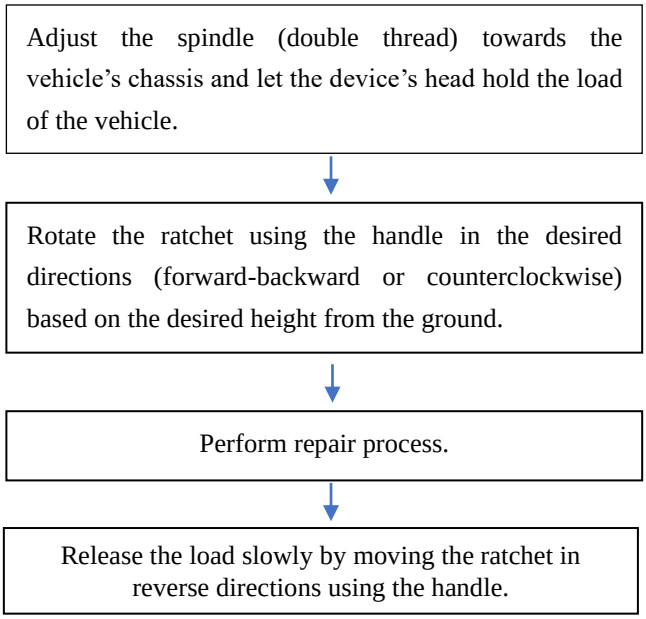
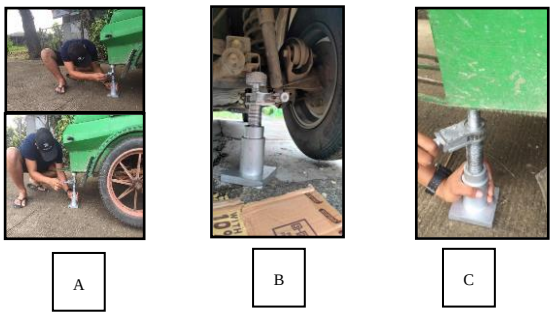


Figure 3. Process Flow of Utilizing the Device

2.3 Device Application

The device is designed to fit any light vehicle, which gives convenience and ease to the operator, as shown in (*Figure 4a)*. Its head, as the main receiver of the load, is secured from defects and sudden breakdowns. Its head is also supported by the device's body and base, which gives more strength and durability (*Figure 4b).* Figure 4c presents the ability of the device to lift strongly from the surface at the desired height of the tire. Hence, the device provides a safe and secured load lift and serves as the appropriate repair tool necessary for the repair operation.



A – Fit under the vehicle.

B – The head receives the load from the vehicle.

C – Adjust the height of the lift through the ratchet.

Figure 4. Application A, B, and C

The modification of the screw jack is designed to lift an object most safely and economically. The device will be designed efficiently such that it can help light vehicle drivers in a more convenient in their daily activities. It is maintenance-friendly, easy, and safe to operate. It will be made up of locally available materials, making it cost-effective. Once the proposed screw-type jack is realized and implemented, the light vehicle drivers in Baleguian, Jaboga, and Agusan del Norte could lift loads operations conveniently and safely. The device is easy to operate, cheaper than the existing one, and has additional features that could perform a variety of operations. Meanwhile, this project is intended for light vehicle drivers such as tricycles, jeepneys, and minivans in Baleguian, Jabonga, and Agusan del Norte. Screw jack, a type of mechanical Jack, is the center of this study. This Jack supports the needs of light vehicles that are sometimes ignored by the vehicle industry in providing repair tools such as Jack. Most of the time, tricycle drivers used improvised jacks, such as a piece of log, to lift their vehicle for repair. Using a piece of log to lift a load can result in an accident due to insufficient capacity to hold a vehicle made of almost hard metals and an imbalance in the size and shape of a log. Barangay Baleguian is one of the largest barangays in Jabonga, Agusan del Norte, containing various light vehicles for private service or livelihood. A safe, functional, and budget-friendly Jack is ideal for light vehicle drivers.

2.4 METHODOLOGY

The main aims of this study are to design and develop a screw jack and test its functionality for determining the safety precautions and economic efficiency in terms of the perception of automotive technologists or experts and light vehicle drivers. Developmental research, as opposed to simple instructional development, is the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet internal consistency and effectiveness criteria. Developmental research is particularly important in the field of instructional technology. The most common types of developmental research involve situations in which the product-development process is analyzed and described, and the final product is evaluated (Ritchey, 1994).

This is the center of the research or study, which focuses on and cycles technology design, development, and revision. It is bending with analysis from the results of the varied tests, which need to be decided by its effectiveness in the field, specifically in the automotive industry. Thus, a significant benefit in the economy must scale, which could be based on how scarcities are supplied with the developed technology. The study used a Likert scale to determine the performance of the device.

Table 2. Scale in Testing the Device

Rating	Range	Descriptive Equivalent
5	4.50 – 5.00	Excellent
4	3.50 – 4.49	Very Good
3	2.50 – 3.49	Good
2	1.50 – 2.49	Fair
1	1.00 – 1.49	Poor

The research study used instruments such as a survey to gather data with the use of questionnaires from the evaluators and a questionnaire of the profile of the respondents. These instruments gathered the data to be used in this study. Surveys and questionnaires helped conclude the performance of the developed screw jack, and this was realized through the evaluators. The latter evaluated the project through perception, demonstration, recording, and videos. The research questions were categorized into (3) three parts --- functionality, economy, and safety. Research questionnaires were as follows:

A. Functionality

RQ1. The device can be fitted under the vehicle.

RQ2. The body can stand to secure the spindle threads while in extreme load.

RQ3. The spindle (double thread) can be rotated using the lever arm.

RQ4. The spindle (triple thread) can move upward and downward through the body with the use of a lever arm.

RQ5. The spindles can accommodate a height of approximately 7 inches.
RQ6. The ratchet can tighten the grip of the spindles.
RQ7. The head can accommodate the chassis of the vehicle.
RQ8. The device can carry out the whole procedure of changing tires.
RQ9. The level arm can secure the lock of the ratchet.

B. Economy

RQ10. Materials are available at a local market.
RQ11. The device can be developed time efficient.
RQ12. The economy in terms of labor.

C. Safety

RQ13. The device is free from defects.
RQ14. The device can cater to a load without accident.
RQ15. Absence of sharp edges.
RQ16. Absence of scrap metal materials.

The study utilized a descriptive measure by the presence of frequency counting, percentages, and weighted Mean. The results of this treatment are derived by calculating a percentage from a predetermined frequency, thereby determining the highest level of qualification among the respondents. In justifying the interpretation of the respondent's evaluation, a criterion is provided that serves as a basis and support in measuring the bearing of the technology.

The formula shows the calculation of percentages of frequency and the weighted Mean of the gathered data.

The Mean was calculated, and the weighted average was interpreted to determine the equivalent of the responses made. This computation is relevant to determine how effective and functional the completed tile grout dispenser is about the questionnaire items. Mean is the average score. Numerically, it is equal to the sum of the scores over the number of scores. Average is a single value that is meant to typify the list of values if all the numbers in the list are the same.

Where:

$\overline{X}$ = Mean
Σ= Sum of
f = Frequency
x = Scores of Distributions
N = Population

$$\text{Mean } \overline{X} = \frac{\Sigma\, xi}{N}$$

2.5 Evaluation

Letter of Permission and Research | Testing and Evaluation | Assessment and Rating

Ten evaluators are from the automotive industry. 2 were chief mechanics, four were motor pool mechanics, two were automotive electricians, and 2 were inspectors. Meanwhile, the other ten evaluators were well-experienced in driving and taking care of light vehicles. Among the evaluators from the automotive industry, four were in the range of 11-15 years in service, and six were in the range of 6-10 years in service. Among the light vehicle drivers, two were in the range of 1-5 years, five from 6-10 years, and three were in the range of 11-15 years in service.

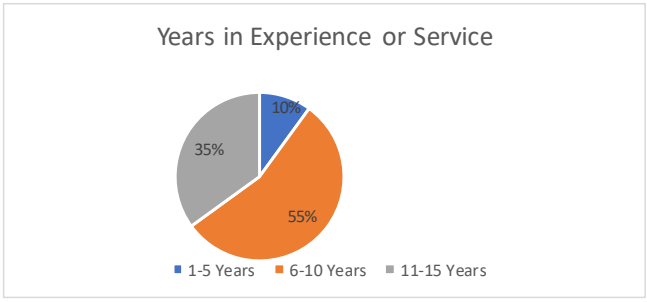


Figure 5. Evaluators' Profile (Expertise and Service)

3. Results and Discussions

Table 3. Evaluation Results

Items		Mean		Grand Mean	Percentage	Descriptive Equivalent
		Automotive Expert	Driver			
A.	Functionality					
1.	The device can be fitted under the vehicle.	4.70	4.80	4.75	95%	Excellent
2.	The base can support the vehicle's load during repair.	4.00	4.50	4.50	90%	Very Good
3.	The body can stand to secure the spindle threads while in extreme load.	4.80	4.90	4.85	97%	Excellent
4.	The spindle (double thread) can be rotated using the lever arm.	4.00	4.50	4.75	95%	Very Good
5.	The spindle (triple thread) can move upward and downward through the body with the use of a lever arm.	4.80	4.50	4.65	93%	Excellent
6.	The spindles can accommodate a height of approximately 7 inches.	4.80	4.80	4.80	96%	Excellent
7.	The ratchet can tighten the grip of the spindles.	4.80	4.70	4.75	95%	Excellent
8.	The head can accommodate the chassis of the vehicle.	4.80	4.70	4.75	95%	Excellent
9.	The device can carry out the whole procedure of changing tires.	4.80	4.70	4.75	95%	Excellent
10.	The level arm can secure the lock of the ratchet.	4.80	4.70	4.75	95%	Excellent
			Total Grand Mean	**4.73**	**94.6%**	**Excellent**
B.	Economy					
1.	Materials are available at a local market.	4.70	4.50	4.60	92%	Excellent
2.	The device can be developed time efficient.	4.50	4.40	4.45	89%	Very Good
3.	The economy in terms of labor	4.50	4.40	4.45	89%	Very Good
			Total Grand Mean	**4.50**	**90%**	**Very Good**
C.	Safety					
1.	The device is free from defects.	4.80	4.70	4.75	95%	Excellent
2.	The device can cater to a load without accident.	4.70	4.70	4.70	94%	Excellent
3.	Absence of sharp edges.	4.80	4.80	4.80	96%	Excellent
4.	Absence of scrap metal materials.	4.70	4.80	4.75	95%	Excellent
5.	Provision for protection.	4.50	4.60	4.55	91%	Excellent
			Total Grand Mean	**4.71**	**94.2%**	**Excellent**
			OVER-ALL GRAND MEAN	**4.65**	**92.93**	**Excellent**

Table 3 shows evaluators' assessment of the device based on the research questions categorized into functionality, economy, and safety.

About ninety-five percent of the evaluators agreed that the device is functional and excellent based on its performance. They agreed on obtaining a high total grand mean of 4.73, which has a descriptive equivalent of excellent. Meanwhile, 90% agreed that the device is very good with its economy, and they agreed at a grand mean of 4.50. The economy category is lower than the grand Mean achieved by functionality. On the other hand, in the safety category, about ninety-five percent of evaluators agreed that the device is excellent in terms of safety. Evaluators agreed on the total grand Mean of 4.71. This is higher than the economy category and slightly lower than the functionality category.

Overall, evaluators agreed that they were highly satisfied with the performance and goals of the developed device. Hence, the evaluation has gathered an overall grand mean of 4.65 or 92.93% with a descriptive equivalent as excellent.

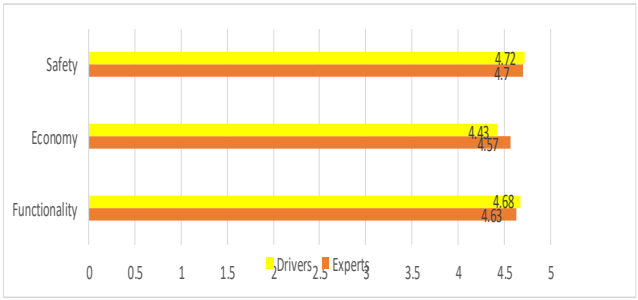


Figure 6. Evaluators' Agreement per Item

4. Conclusion and Recommendations

The developed device was evaluated and tested for its functionality. During its testing, slight adjustments were found. For example, turning the ratchet was slightly difficult because of the short handle. A handle was affixed to the extension tube as a solution to this problem, making turning more convenient. Another adjustment found was that the device's base sometimes moved when the ratchet was turned. The remedy to address this was to widen the

base to carry an extreme load and avoid movement.

Conclusion

Based on the findings of this study, different conclusions were derived, such as whether the screw jack can be designed and developed, whether the developed device is excellent or highly functional, safe, and economical, and whether the defects found while testing its functionality were made and have been done to be functional.

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