ISSN: 2581-1274

Reverse Engineering in the Manufacturing of Lorry Wheels in Palm Oil Processing

Mahmud [a,1,*], Zulfadli [a,2], Hamdani [b,3], Azwar [b,4], Sariyusda [b,5],

[a] *Aceh Polytechnic, Jl. Politeknik Aceh, Pango Raya, Ulee Kareng Banda Aceh 23119, Indonesia*
[b] *Lhokseumawe State Polytechnic, Jl. Banda Aceh-Medan Km. 280,3, Buketrata, Kota Lhokseumawe, 24301, Indonesia*
[1]*mahmud@politeknikaceh.ac.id *;* [2] *zulfadli@politeknikaceh.ac.id ;* [3] *hamdani@pnl.ac.id ;* [4] *azwar@pnl.ac.id ;*
[5]*sariyusda@pnl.ac.id ;*
*Corresponding author

ARTICLE INFO

Article history:
Published

Keywords:
Lorry Wheel
Reverse Engineering
CAD
Palm Oil Processing
Design

ABSTRACT

The reverse engineering process in development is widely used to carry out the reverse engineering process for the design of certain products, in this study the reverse engineering process on the palm oil lorry wheel is to improve the design as well as a combination of materials to increase the life of the lorry wheel product in the palm oil processing. The process of scanning the surface of the lorry wheel using camera and the reverse engineering process is carried out by measuring the precision of the lorry wheel by measuring using a precision measuring instrument, data obtained by measurement and reconstruction model. data obtained by measurement and reconstruction model using CAD software and CAE software used to analyze the CAD and CAE software are used to analyze the design results after the reverse engineering process. reverse engineering process. So, it is necessary to develop a reverse engineering system design that will be useful in terms of efficiency and service life of the lorry wheel, in the design of this lorry wheel uses CAD and CAM software to model the lorry wheels with simulation and analysis systems. The next process is to modify and remanufacture the lorry wheel model using machine tools so that the prototype of the manufacturing process can be tested. so that the prototype of the manufacturing process can be tested on the lorry to see the durability of the reverse engineering product. to see the durability of the reverse engineering product. The results of this research showed that the reverse engineering data can be interpolated for further CAE process.

I. Introduction

The manufacturing process and the development of products for manufacturing are experiencing very rapid growth, this also applies to the palm oil processing support industry. It has a very significant impact on the phases of developing a design into a product, which affects the process of machining and the manufacturing procedure of the product[1], that a conventional manufacturing process, the product it is manufactured takes a long time, the evolution of the manufacturing process is resulting in several creative techniques, both in regards to hardware as well as software, primarily to accelerate the switch from conventional modern manufacturing[2].

Reverse methods of engineering have become increasingly common as modern manufacturing advances. The term of reverse engineering remains unchanged: rebuilding, redesigning, renewing, and obtaining to the previously product[3]. However, the reverse engineering in the manufacturing process could be accomplished with materials which are solid or existing in form as a final product, it can be studied using the scanning method and converted into 3D images, and can be redesigned on a computer with CAD programs and simulation using CAE software, then going through manufacturing using CAM programs. This stage of finishing enables the production or redesign of a damaged product that loses original design drawings because of being discontinued[4].

The method of reverse engineering has been commonly utilized for mechanical products that are commonly utilized in industry, the application of new analyses including scanning, and the application of high resolution (HR) microscopes additionally greatly facilitates the reverse engineering process currently being carried out[5, 6], in some previous studies the reverse engineering process on lorry products has been carried out, but the case in this study is different because of the use of lorry wheels, In previous research, the reverse engineering solve was applied to railway lorry wheels; however, this study addresses lorry wheels used in the palm oil processing industry[7][8][9].

The primary variation is the handling of the existing conditions of the lorry wheels, especially that used in palm oil processing, that is must be frequently flared less than the melting point. In the sterilization station or boiling procedure. the lorry lugging fresh fruit bunches will enter the boiling station and will boil together with the fruit.

Based on the case study of lorry wheels in palm oil processing, it must conduct a reverse engineering study to identify the future development potential of lorry wheels used in the palm oil processing industry. The objective of this study is to reverse engineer the lorry wheels and specifications. The specimens used in this study are lorry wheel samples from the production of lorry wheel component suppliers for palm oil processing, as well as prototype lorry wheel specimens, that will be simulated and analysed using reverse engineering methods. To identify the compatibility of the model of design materials and the lifetime use of the lorry wheels, which will be conducted during the reverse engineering process.

II. Method

Lorry wheel product development is an engineering method developed to reverse engineer a lorry wheel product that is often damaged and requires the most common repairs due to use in the palm oil processing industry. There is several reverse engineering methods used, some of the stages carried out in this study are as follows:

A. Data Collection Process

The process of taking process data from the shape of the lorry wheels that have been used in the processing process at the palm oil mill. The next process is cleaning the lorry wheels for the next process, the lorry wheels are cleaned from the dirt that sticks to the lorry wheels.

B. Workpiece object

The workpiece object used in this research is the wheel part of the lorry transporting Fresh Fruit Bunches, the selection of wheel parts used is wheel. The selected Fresh Fruit Bunch transport lorry part has the consideration of the same design form such as the large size of the lorry, the complexity of the workpiece, the workpiece details, and the dimensions of the workpiece so that the results obtained have different dimensional measurements. The lorry wheels were also selected because they have large dimensions and are not too complicated, but require high accuracy on the part of the wheel that rubs directly against the rail to produce a lower error.

C. Camera Specifications

The camera specifications used with are smartphones with a camera size of 64 MP Triple Camera, taking photos there are settings made to produce images as needed. In the camera settings used in this study, settings are used that are adjusted to the environment where the pictures are taken.

D. Camera Settings

Settings in shooting are very important to simplify the process and make the resulting mesh results better. In this research, the shooting setup used is using the help of a turn table and the background using plain colours to facilitate the next process.

E. Camera settings to the object

The lorry wheel to be photographed is in the centre by rotating the camera mount by 360 degrees and adding angles to the flage and wheek parts of the lorry wheel that are still not captured by the camera.

F. Dimensional Measurement

Dimensional measurements are taken to obtain size data. Measurements are made using manual methods on the lorry wheels. Measurements with direct contact are made by determining the parts of the wheel to be measured and the parts of the flange to be measured.

G. Mesh and Sold Surface Modelling

The process of making solid modelling and mesh has been made using CAD 3D Modelling software basically can be processed in software for analysis, but the mesh produced will be easier to do the redesign process if it has a format according to the needs, processing the mesh into a surface form is done using CAE software.

III. Results and Discussion

The process of analysis and discussion related to the reverse engineering process can be seen in the flowchart in Figure 1:

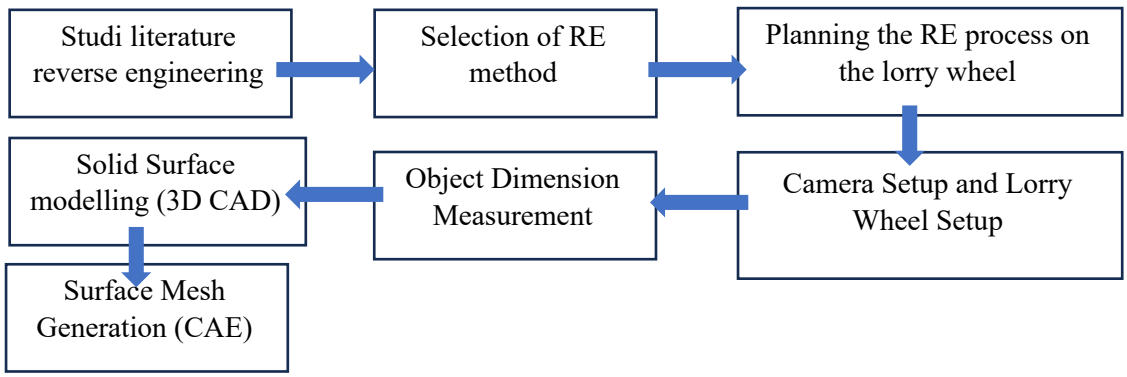

Fig1. Flowchart of reverse engineering process on lorry wheels

The reverse engineering method is carried out with a physical measurement process using measuring equipment such as digital calipers, micrometers to obtain the exact dimensions of the lorry wheel components, including diameter, rim width and so on. photogrammetric technology can be used to create 3D models for further analysis. Use of CAD software to create a three-dimensional (3D) model of the lorry wheel based on the detailed physical measurements taken. This process includes modelling for flange and wheel models. For details of the lorry can be seen in the example of the lorry wheel standardization image. which is the 6 standardization of lorry wheels used by PT Perkebunan Nusantara IX for QC passes of Fruit Lorry as in the following figure 2 [2].

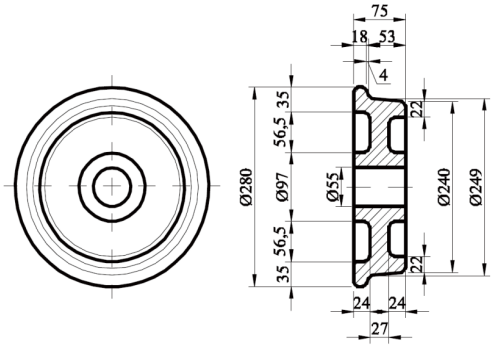

Fig 2. Standardisation of Lorry Wheels used in Palm Oil Processing Plant

The first stage, identifying the product, is to select the lorry wheel to be analysed. The lorry wheel is a component that already exists and is used in palm oil processing plants, and information related to the use of the lorry wheel, such as the load received by the lorry wheel, the operating speed of the lorry wheel, the environmental conditions where the lorry wheel operates. In the following figure 3 is the condition of the lorry wheels that have been used from the company PT. Mora Niaga Jaya.

Fig 3. Process of identifying Lorry Wheel Products

The second stage, conducting Mapping and Physical Measurements such as taking pictures from various angles of the lorry wheel to facilitate overall visualisation. then the dimensional measurement process uses measuring instruments such as calipers to obtain the physical dimensions of the wheel, including diameter, width, thickness, and other design details. the last process carried out is 3D geometry mapping with photogrammetry technology to produce a 3D model of the lorry wheel being analysed. As shown in Figure 4 to Figure 8.

Fig 4. Physical Measurement Process of Flange Section

Fig 5. Physical Measurement Process of Hub section

Fig 6**.** physical measurement process of rim section

Fig 7**.** physical measurement process of tread section

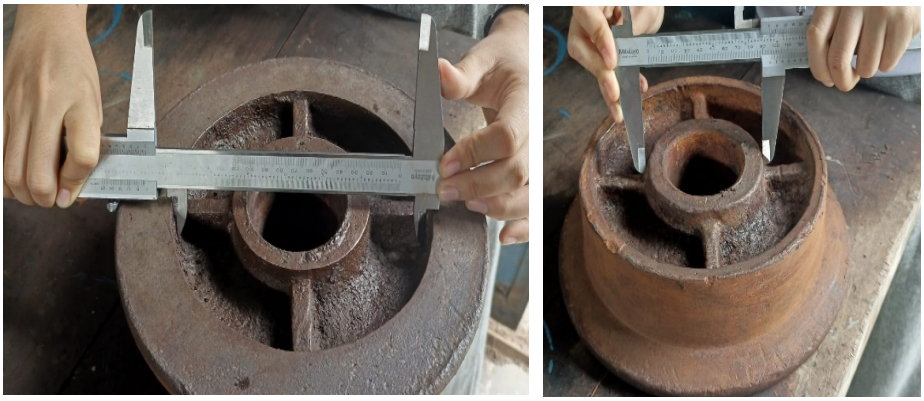

Figure 8. physical measurement process of web section

The process of identifying the material of the lorry wheel to find out the material used in the lorry wheel, which is made of cast iron material. The use of CAD software to create a 3D modelling model based on the physical measurement data obtained. Data from physical measurements and 3D models can be used to generate accurate 3D CAD models.

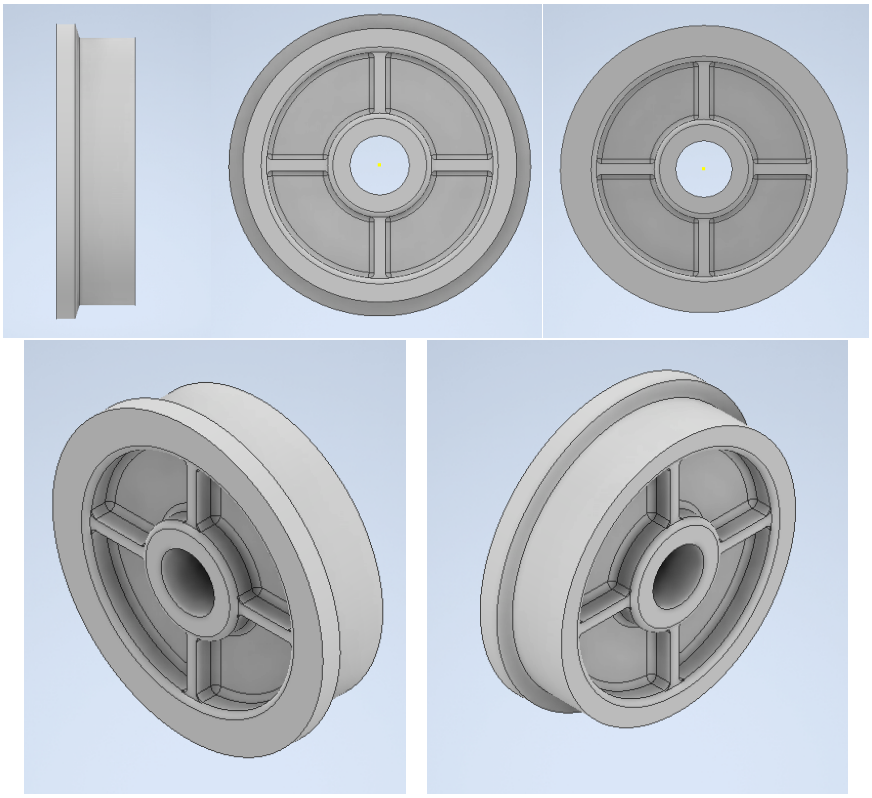

Fig 9. 3D model modelling with CAD Software

Using the reconstructed 3D CAD design to create a prototype lorry wheel. This lorry wheel prototype is used for further testing, to ensure the fitment of the lorry system as well as its durability against operational conditions.

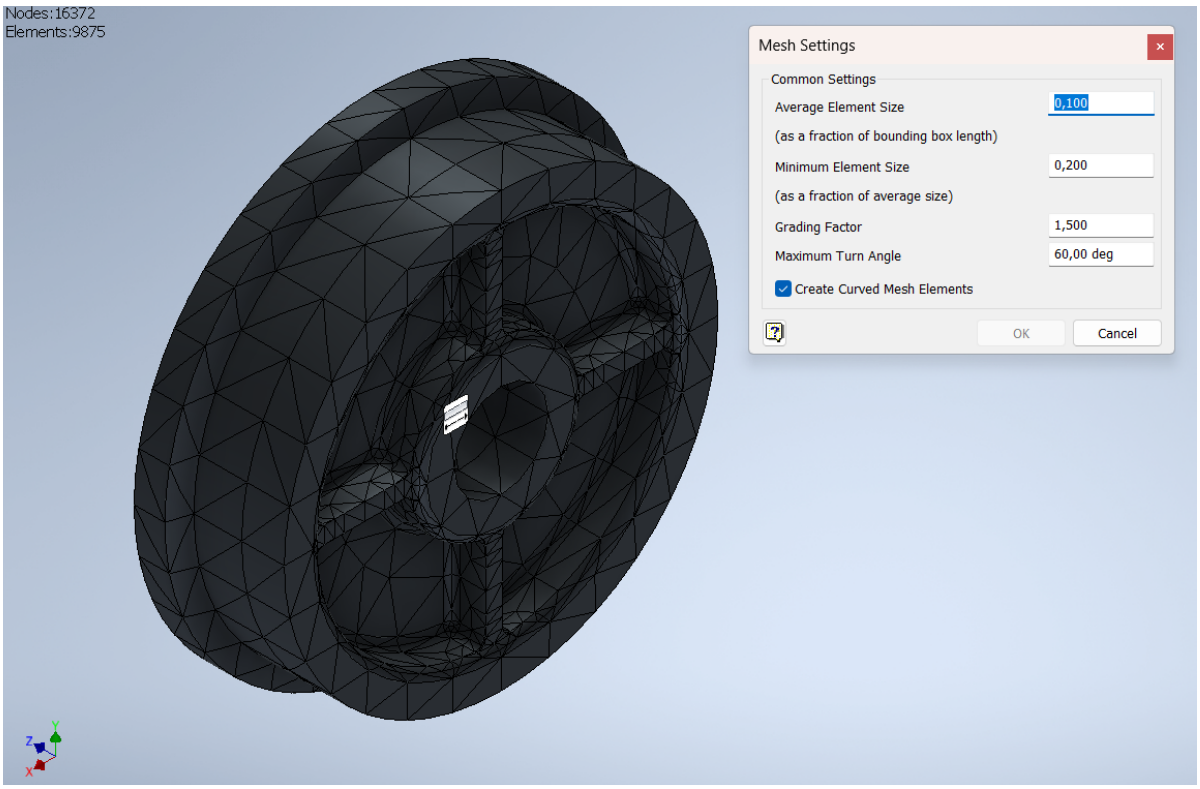

Fig 9. 3D Mesh modelling

Based on the Stress Analysis Report obtained with the settings in table 1.

Table 1. Setting Paramater

Physical		
Material	Iron, Cast	
Density	7,15 g/cm^3	
Mass	18,7981 kg	
Area	240094 mm^2	
Volume	2629110 mm^3	
Center of Gravity	x=0,000000000099933 mm y=0,00000000115295 mm z=-35,2239 mm	
Note: Physical values could be different from Physical values used by FEA reported below.		
Mesh settings		
Avg. Element Size (fraction of model diameter)	0.1	
Min. Element Size (fraction of avg. size)	0.2	
Grading Factor	1.5	
Max. Turn Angle	60 deg	
Create Curved Mesh Elements	Yes	
Material(s)		
Name	Iron, Cast	7,15 g/cm^3
General	Mass Density	758 MPa
	Yield Strength	884 MPa
	Ultimate Tensile Strength	120,5 GPa
Stress	Young's Modulus	0,29 ul
	Poisson's Ratio	46,7054 GPa
	Shear Modulus	7,15 g/cm^3

Reaction Force and Moment on Constraints

Constraint Name	**Reaction Force**		**Reaction Moment**	
	Component (X,Y,Z)	**Magnitude**	**Component (X,Y,Z)**	**Magnitude**
Frictionless Constraint:1	83954300 N	-83471900 N 604196 N 8965880 N	19179600 N m	1062700 N m 4514860 N m 18610300 N m

Result Summary

Name	**Minimum**	**Maximum**
Volume	2629110 mm^3	
Mass	18,7982 kg	
Von Mises Stress	41046,7 MPa	71500500 MPa
1st Principal Stress	-11281600 MPa	38616200 MPa
3rd Principal Stress	-51934600 MPa	9584950 MPa
Displacement	8673150 mm	44240200 mm
Safety Factor	0,0000106013 ul	0,0184668 ul
Stress XX	-42441900 MPa	35582200 MPa
Stress XY	-16261400 MPa	18420400 MPa
Stress XZ	-12677400 MPa	35537300 MPa
Stress YY	-34362500 MPa	31584000 MPa
Stress YZ	-19575300 MPa	20670900 MPa
Stress ZZ	-17965100 MPa	15382600 MPa
X Displacement	-44113600 mm	44111800 mm
Y Displacement	-44113400 mm	44112100 mm

Z Displacement	3332230 mm	3342690 mm
Equivalent Strain	0,30712 ul	512,498 ul
1st Principal Strain	-2,4231 ul	396,534 ul
3rd Principal Strain	-486,441 ul	2,25431 ul
Strain XX	-281,667 ul	248,653 ul
Strain XY	-174,085 ul	197,198 ul
Strain XZ	-135,716 ul	380,441 ul
Strain YY	-241,609 ul	222,633 ul
Strain YZ	-209,561 ul	221,29 ul
Strain ZZ	-122,423 ul	88,0676 ul

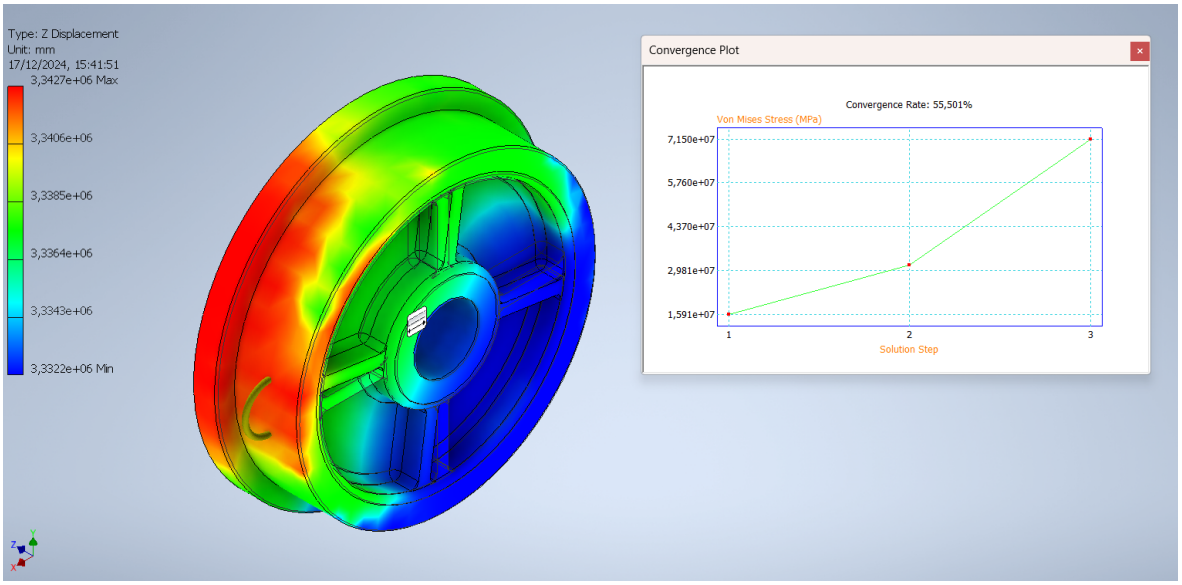

Fig 10. Stress Analisys Report

All data obtained during reverse engineering, such as technical drawings, materials used, and redesign results, must be well documented to become reference material for making lorry wheels in the future. measurement data in this reverse engineering research aims to obtain detailed data on the manufacture of lorry wheels, focusing on the design, materials, quality, and durability of the wheels used in the palm oil processing process. Accurate reverse engineering data will help produce more efficient lorry wheels with lower production costs..

IV. Conclusion

The manufacturing process, particularly in industries such as palm oil processing, is continually growing, with innovative methods being used to increase production efficiency. Conventional techniques, that are inefficient and costly in terms of resources will be replaced by more effective ways, like as reverse engineering. Reverse engineering is the process of examining old items (sometimes broken or discontinued) and rebuilding, redesigning, and improving them. This method generates digital models using technologies like as scanning, 3D modeling with CAD software, and simulation with CAE software, which are then utilized to direct manufacturing with CAM programs.

In the palm oil processing business, reverse engineering is used on truck wheels, which are regularly damaged owing to use in extreme conditions such as high temperatures during sterilization. A study on reverse engineering these truck wheels seek to improve their design, durability, and performance. The reverse engineering method begins with the selection of old lorry wheels, followed by cleaning and obtaining detailed photographs with high-resolution cameras and a rotating setup that captures the object from various angles. To build accurate models, dimensions are systematically measured and improved with 3D scanning. CAD software is then used to process the measurements and generate a 3D model of the wheel.

Material analysis is also carried out, proving that the wheels are composed of cast iron. 3D models are used to produce prototypes, which are then tested for compatibility and endurance in the operational setting. The findings, including design modifications and material specifications, are documented for future manufacturing, ensuring improved performance, lower costs, and longer-lasting lorry wheels in palm oil mills.

Acknowledgment

I would like to thank Aceh Polytechnic for 2024th Internal Research Funding "Penelitian Dosen Asisten Ahli" and my deep thanks to PT. Mora Niaga Jaya Aceh Tamiang for their helps to research Material.

References

[1] Azhar Fachri, Ahmad Fathoni, & Yose Rizal. (2022). Karakteristik Kekerasan Dan Keausan Roda Lori Kelapa Sawit (Elaeis Guineensis) Kapasitas 2,5 Ton. *Jurnal Energi dan Inovasi Teknologi (ENOTEK)*, *2*(No. 1,), 16–20.

[2] Castelman, A. (n.d.). *Reverse engineering and certification of gin pole trucks*.

[3] Hakim, L. (2023). REVERSE ENGINEERING PADA KOMPONEN OTOMOTIF DENGAN METODE PHOTOGRAMMETRY. In *Jurnal Teknik Mesin S-1* (Vol. 11, Issue 1). https://ejournal3.undip.ac.id/index.php/jtm

[4] Amri, M., & Darsan, H. (2022). ANALISA KERUSAKAN PADA LORI PENGANGKUT TBS DI PT. KARYA TANAH SUBUR. *Jurnal Teknik Mesin*, *8*(2), 35–39.

[5] Lin, S., & Shi, X. (2021). Research on Application of Reverse Engineering and 3D Printing Technology in Object Recognition. *IOP Conference Series: Earth and Environmental Science*, *781*(2). https://doi.org/10.1088/1755-1315/781/2/022073

[6] Performa, I., Lori, P., Kegiatan, B., Rantawi, A. B., Ahdiat, ;, Siregar, L., Angraini, ;, Masau', A., Studi, P., Pengolahan, T., Perkebunan, H., Sawit, K., Kelapa, P., Citra, S., & Edukasi -Bekasi, W. (2018). Preventive Maintenance pada Pabrik Kelapa Sawit. *Jurnal Citra Widya Edukasi*, *3*.

[7] Sulfianto Rahmadani, V., & Kharisma Raharjana, I. (2015). PENERAPAN REVERSE ENGINEERING DALAM PENENTUAN POLA INTERAKSI SEQUENCE DIAGRAM PADA SAMPEL APLIKASI ANDROID. In *Journal of Information Systems Engineering and Business Intelligence* (Vol. 1, Issue 1).

[8] Thakur, A., Leake Gebremeskel, O., Gebrehiwot Hailu, M., & Leake, O. (2020). Reverse Engineering Approach in Modification of Three Wheeler Bajaj Chassis. In *Research Article Branna Journal of Engineering and Technology (BJET)* (Vol. 2, Issue 1). https://www.researchgate.net/publication/341575280

[9] Balkhaya, Nuzuli Fitriadi "Mechanical Characteristics Of Composite Materials Made From Polyester Resin Mixed With Cocopeat On Static Loads" J. Inotera, 2024, Vol.9, No. 1, PP. 170-177

[10] Wang, W. (2011). *Reverse Engineering: Technology of Reinvention*. CRC Press Taylor & Francis Group.