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Design analysis of hydraulic lifter spreader assy LRT using finite element method

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Abstract

Spreader Assy is an integral part of the Jabodebek LRT train delivery. This part serves as an elevating device for the carriage. The installation of the spreader assembly to the train body poses a hazard to operators and work instruments, is too lengthy, and does not adhere to the Standard Operating Procedure (SOP). This issue is due to the implementation of the spreader assembly, which is still supported by crowbars, wood, and an iron plate. This study's objective is to analyze the design of the hydraulic lifter for the operator's convenience and safety when installing the spreader assembly. Hydraulic jack, base plate, and lifting plate are the primary components of this instrument. Based on FEA analysis, the stress that occurs in the hydraulic lifter construction after receiving the spreader assy load of 225.18 kg is between 3,312,239 N/m2 and 6,624,476 N/m2, whereas the yield strength of the SS400 material is 250,000,000 N/m2 because the stress is greater than the yield strength of the material. Since the maximum value is still well below the material's yield stress, it can be concluded that the hydraulic lizfter construction can safely support the burden of the spreader assembly.

Keywords:
spreader assy, hydraulic lifter, FEA, hydraulic jack

1 Introduction

Light Rail Transit (LRT) is a type of rail mass transit that combines the characteristics of trams and rapid transit. LRT is a reliable mode of public transportation in Jakarta, Indonesia. Using a truck, the LRT train was shipped to Jakarta.

Lifting the train onto the vehicle using a crane and a tool called a spreader assembly is the first step in sending the train. Installed beneath the carriage body to serve as a lifting device, the spreader assembly prevents the train from moving during the hoisting process. The procedure of attaching the spreader assembly to the carriage body is depicted in Fig. 1; the spreader assembly is indicated by the arrow.

In the process of lifting the LRT train, installing the spreader assembly on the body of the train involves the use of crowbars and timber, which poses a risk of injury. The risk of peril is the crowbar breaking and the operator being injured. Workplace incidents may result from the misuse of equipment whose functions and standard operating procedures are not followed [1]. Therefore, it is necessary to design a specific lifting device for the installation process of the assy spreader to the train body[2].

A number of previous studies on lifting aids have been conducted by a number of researchers. A study discusses the stress analysis performed on multistage hydraulic cylinders used in bridge hydraulic cylinders.

Fig. 1. Installation of spreader assy

Composed of a solid rod and a hollow cylinder, this structure was analyzed using the Finite Element Method [3]. The other research discusses the modification of a bottle jack to lift a load with a small lifting gap that actually cannot be lifted by the jack by changing the size of the reservoir tank, and hydraulic cylinder diameter and adding a bracket. The result of this research is that the modified bottle jack can lift the load safely because the hydraulic specifications have been adjusted to the needs [4]. Design of H type of hydraulic system lifter in a car wash with a maximum capacity of 2.5 tons [5], the study of a 2-ton capacity bottle hydraulic jack on the effect of variations in the installation position of the manometer, oil SAE, and distance [6]. Design of Hydraulic Lifting Platform for Production Process Aids at PT Wijaya Karya Industri & Construction of Steel Fabrication Factory 2 Tangerang [7], and design and build a modification of manual hydraulic jacks to electric ones [8].

There is considerable research on FEM simulation application [9-10]. The research in this paper is a design analysis of a hydraulic spreader assembly lifter used specifically for LRT trains operated in Jakarta, Indonesia, which makes this study unique. Using the finite element method, this study will analyze the design of the LRT hydraulic lifter spreader assembly.

2 Research methods

The research method follows a flowchart which can be seen in Fig. 2. The research methodology consists of: (i) Design concept which specification needed for the hydraulic lift, (ii) 3D design using CAD software, (iii) Material and component selection based on specification, (iv) Design analysis using FEM and CAD software as a tool and (iv) Hydraulic spreader assy lifter fabrication.

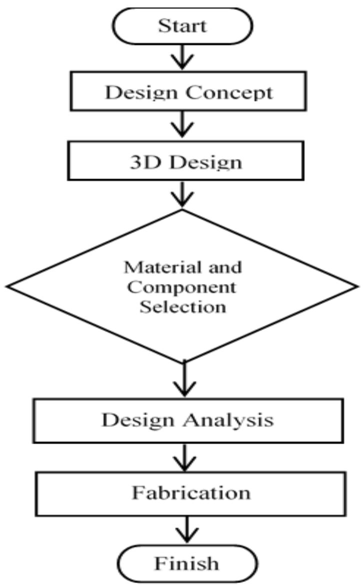

Fig. 2. Design flow chart

2.1 Design concept

The design concept includes information regarding required lifting aid. The hydraulic lifter is required to install the SS400 iron plate and 225.18 kg spreader assembly. Eq can be used to compute the burden of a spreader assembly eq. (1). Where m is the spreader assembly mass and g is 9.81 m/s^2 gravity acceleration.

$$F = m.g \quad (1)$$

This spreader assembly installation tool's design concept incorporates both 3D and 2D (drawing) designs. The first stage of the design concept is to collect information regarding problems in the spreader assembly installation process, the required design dimensions, and the necessary components. The determination of this problem will serve as a guide for the creation of the initial design, which will be a 2D sketch of the supplied problem-solving solution. The creation of this 2D illustration includes the machine's dimensions according to field measurement data as well as the machine's supporting components.

2.2 3D Design

The following phase of the design concept is 3D design. Design is the implementation of the design concept, which is visualized in 3D using Solidworks software and depicts the functioning mechanism of the tool using motion animation. The production of hydraulic lifter tools is tailored to the conditions and requirements of the field. The design is then analyzed to produce a superior concept by considering the availability of components and materials in the industry.

2.3 Material and component selection

Multiple alternative designs for the spreader assembly installation tool are manufactured to determine the optimal design for the industry. Each alternative design is first discussed with the engineering staff and division chief in order to make the best design selection for industry implementation [11]. This alternative design

was made by considering the ease of handling for the operator, the simple form of the tool, the limited area for placing the tool, and the components that are already available at PT INKA Multi Solusi Service. The next process is welding SS400 iron that has been cut, welding is carried out in the welding certification room guided by a welder from PT INKA Persero, the type of welding used is Metal Inert Gas (MIG). The next process after all components are welded is assembly or assembly, which is inserting a hydraulic jack into the bracket that has been made.

2.4 Design analysis

The design analysis was conducted using the FEM method and CAD simulation software. The hydraulic spreader assembly lifter's stress and strain were simulated using FEM analysis based on the spreader assembly load and lifter design.

Calculated stress occurred in the hydraulic spreader assembly lifter based on Eq (2). Where F is the spreader assembly load and A is the hydraulic spreader assembly lifter's cross-sectional area.

$$\sigma = F/A \quad (2)$$

2.5 Fabrication

The last step is the fabrication of a hydraulic spreader assy lifter. Manufacture process consists of plate cutting and welding.

3 3. Results and discussion.

3.1 Component spreader assy

The speeder assy is one of the tools for lifting the train onto the truck, in this case, the Jabodebek LRT train. One side of the spreader assy will be bolted to the carriage body and the other side will be tied with a rope that is connected to the crane. The Jabodebek LRT spreader assy is made of SS400 iron plate with a total weight of 225.18 kg, Fig. 3 shows the total weight of the spreader assy after it is calculated using the Solidworks application. Fig. 3 shows the total weight of the spreader assy after it is calculated using the Solidworks application.

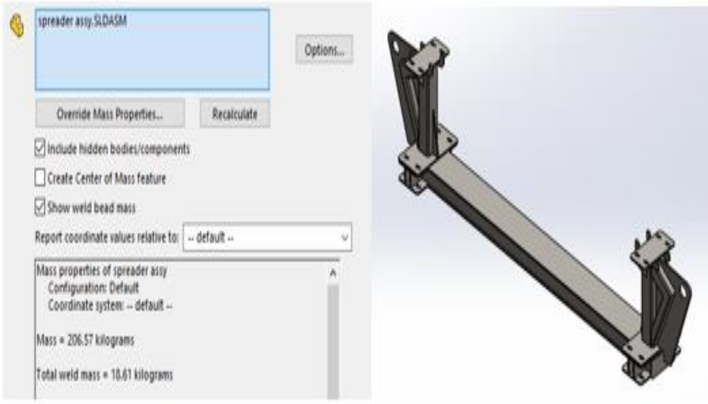

Fig. 3. The total weight of the LRT spreader assy

The process of installing the spreader assy before it is ready to be lifted with the carriage has several stages, namely preparation of tools and spreader assy, assembling the spreader assy, and installing the spreader assy to the body of the train. The following is the flow of the spreader assy installation process to the carriage body before the improvement is carried out.

3.2 Improvement action

The design of the hydraulic lifter tool is a solution to the problems described in the problem identification section; the design of this hydraulic lifter tool aims to speed up the process of installing the spreader assembly by combining the process of leveraging and blocking that was performed prior to the improvement; the operator no longer needs to search for an iron wedge of the proper height; and this simultaneously reduces the risk of danger and defects in the telecommunications system. Fig. 4 is the design of the hydraulic lifter tool that has been authorized after going through the process of evaluating alternative designs and the mechanical analysis process.

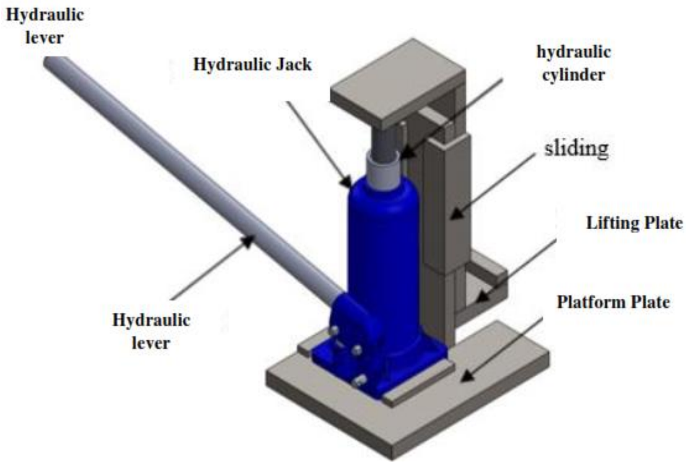

Fig. 4. Hydraulic Lifter Tools

3.3 The stresses that occur in the construction of hydraulic lifter tools

The results obtained from Finite Element Analysis are the stresses that occur in the construction after receiving a predetermined load. Fig. 5 is the result of the stress that occurs in the hydraulic lifter.

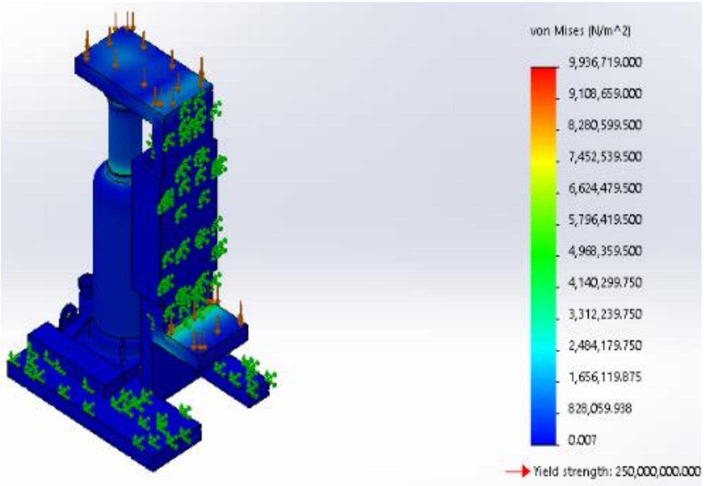

Fig. 5 The stress that occurs in the hydraulic lifter ool

Fig. 5 shows that the maximum stress load that occurs in the construction of the hydraulic lifter is between 3,312,239 N/m2 and 6,624,479 N/m2 (in the green area), while the yield strength or yield stress of the material is 250,000,000 N/m2. Since the maximum stress that occurs is still far below the yield stress value of the material, it can be concluded that the construction can safely support the load [11]. The safety factor (SF) can be calculated using Eq (3).

$$SF = \text{Yield strength/stress load} \quad (3)$$

3.4 Strain that occurs in the construction of hydraulic lifter tools

Strain is the increase in the length of material after being subjected to a force or load [12]. Strain calculated in the simulation using stress occurred in the hydraulic spreader assy lifter and its Young Modulus data [13]. The results of the strain that occurs after receiving a predetermined load can be seen in Fig. 6.

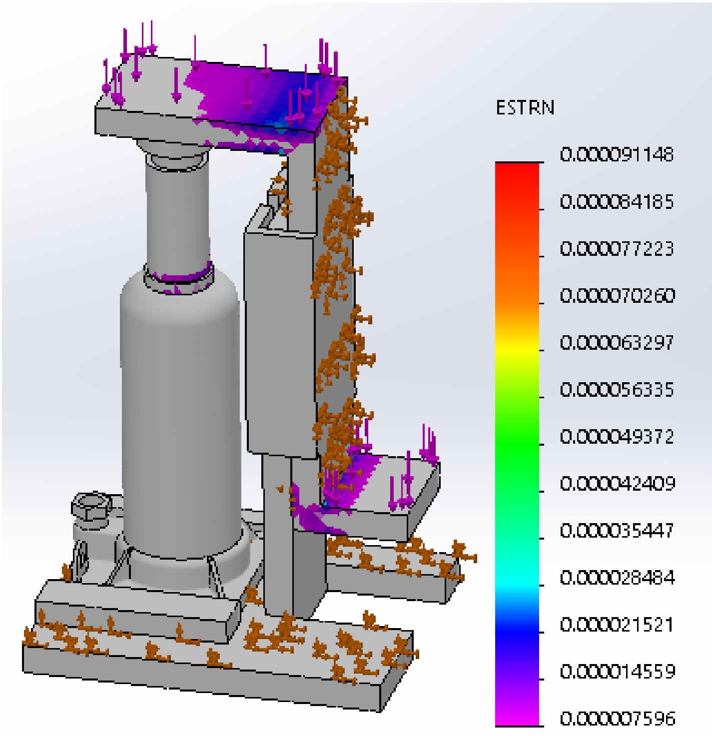

Fig. 6. The strain that occurs in the construction of hydraulic lifter tools

Based on Fig. 6 above, the strained areas are shown in purple and blue. The value of the strain that occurs is between 0.000007596 % to 0.000021521%.

3.5 Discussion on the planning of hydraulic lifter tools

Planning for hydraulic selection begins with knowing the load from the spreader assy, which is 1104,5 N the load from the spreader assy becomes the force acting on a large cylinder. Next, look for hydraulics that matches the desired specifications, which will later be selected for use in hydraulic lifter tools terms FT < Fm [14]. Table1 shows hydraulic specification planning data.

Table 1. Hydraulic specification planning table

r_1 (*mm*)	r_2 (*mm*)	F_1 (N)	F_2 (N)	FH_{andle} (N)
4	11	146,04	1104,5	13,49
6	13	176,72	1104,5	15,06
10	23	208,79	1104,5	16,19

Based on the data from Table 1, it can be concluded that using another hydraulic jack with a capacity of under 2 tons is still safe to lift the load of the spreader assy. The resulting lever force also meets the requirements, namely FT < Fm. The choice of a hydraulic jack with a capacity of 2 tons is due to adjusting the availability of goods in the industry [15]. The following are the specifications of the 2ton hydraulic jack used in hydraulic lifter tools (Table 2).

Table 2. Hydralic lifter tools

Dimensions P x L x T	:	150 x 120 x 200 (mm)
Max lifting capacity	:	2 Ton (19620 N)
Max lifting height	:	145 mm
Min lift height	:	12 mm
Cylinder dimension	:	D 23 mm / d 10 mm
Bracket material	:	SS400 t: 12 mm
Hydraulic type	:	Hydraulic bottle jack

The above specifications are obtained after the hydraulic lifter has been completed and has been tested, the specifications are following the initial planning made.

Fig. 7 shows the results of the design of the hydraulic lifter tool and at the same time the lifting position of the hydraulic lifter tool against the spreader assy. The hydraulic lifter assists in lifting the spreader assy until it reaches the train body and is then ready to be bolted to the train body [15]. The operator only needs to pump the lever to lift the spreader assy and the height can be adjusted. The process of prying and blocking before using the hydraulic lifter is eliminated.

Fig. 7. Results of the hydraulic lifter tool design

4 Conclusions

The finite element method was used to design the LRT hydraulic lifter spreader assembly, which led to the following conclusion: The main features of the hydraulic lifter tool are its dimensions, which are 150 mm x 120 mm x 200 mm, and the fact that its main material is iron SS400 with a thickness of 12 mm. It also comes with a hydraulic bottle jack that can lift up to 2 tons. The Finite Element analysis process showed that the hydraulic lifter can lift the spreader assembly load of 114.5 [N].

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