JURNAL

DESIGN OF A SCISSOR LIFT MECHANISM USING A HYDRAULIC SYSTEM ON A THREE-WHEEL MOTORCYCLE

Diajukan Sebagai Salah Satu Syarat Untuk Memperoleh Gelar Sarjana Teknik Pada Program Studi Teknik Mesin Fakultas Teknik Universitas Muhammadiyah Sumatera Barat

Oleh:

AGUSTIAN FAJAR
20160026

PROGRAM STUDI TEKNIK MESIN

FAKULTAS TEKNIK

UNIVERSITAS MUHAMMADIYAH SUMATERA BARAT

2024

HALAMAN PENGESAHAN

JURNAL

DESIGN OF A SCISSOR LIFT MECHANISM USING A HYDRAULIC SYSTEM ON A THREE-WHEEL MOTORCYCLE

Oleh :

AGUSTIAN FAJAR
20160026

Disetujui Oleh :

Dosen Pembimbing I

Ir. Rudi Kurniawan Arief S,T.,M.T. Ph.d
NIDN : 1023068103

Diketahui Oleh :

Dekan Fakultas Teknik UM Sumatera Barat	Ketua Program Studi Teknik Mesin
DR. Eng. Ir. Masril, S.T., M.T NIDN : 1005057407	Ir. Rudi Kurniawan Arief S,T.,M.T. Ph.d NIDN : 1023068103

LEMBAR PERNYATAAN KEASLIAN

Saya yang bertanda tangan dibawah ini:

Nama Mahasiswa	: Agustian Fajar
Tempat dan Tanggal Lahir	: Joho, 1 Agustus 2001
NIM	: 20160026
Judul Skripsi	: Design Of A Scisssor Lift Mechanism Using A Hydraulic System On A Three-Wheel Motorcycle

Menyatakan dengan sebenarnya bahwa penulisan Skripsi ini berdasarkan hasil penelitian, pemikiran, dan pemaparan asli dari saya sendiri, baik untuk naskah laporan maupun kegiatan yang tercantum sebagai bagian dari Skripsi ini. Jika terdapat karya orang lain, saya akan mencantumkan sumber yang jelas.

Demikian pernyataan ini saya buat dengan sesungguhnya dan apabila dikemudian hari terdapat penyimpangan dan ketidakbenaran dalam pernyataan ini, maka saya bersedia menerima sanksi akademik berupa pencabutan gelar yang telah diperoleh karena karya tulis ini dan sanksi lain sesuai dengan peraturan yang berlaku di UM Sumatera Barat.

Demikian pernyataan ini saya buat dalam keadaan sadar tanpa paksaan dari pihak manapun.

Bukittinggi, 31 Agustus 2024

Yang membuat pernyataan,

METERAI TEMPEL 486FDALX138324070

Agustian Fajar

20160026

DESIGN OF A SCISSOR LIFT MECHANISM USING A HYDRAULIC SYSTEM ON A THREE-WHEEL MOTORCYCLE

*1Agustian Fajar,2Rudi Kurniawan Arief

1Department of Mechanical Engineering, Faculty of Engineering, Muhammadiyah University of West Sumatra, Bukittinggi, Indonesia

Author's email:
1fajaragustian287@gmail.com; 2rudikarief@umsb.ac.id

*Corresponding author: 1fajaragustian287@gmail.com

Abstract. *The purpose of this study is to design and analyze the scissor lift mechanism with a hydraulic system that can be applied to a three-wheeled motorcycle using SolidWorks software. Tricycles are a means of transportation that is widely used for logistics activities, delivery of goods and materials, but have limitations in terms of load and access to high places. Therefore, the development of an integrated hydraulic scissor lift system is an important solution to improve the performance of three-wheeled vehicles. The design process begins with 3D modeling of the main components such as the frame, scissor arm, hydraulic cylinder, and platform using the capabilities available in SolidWorks. Structural analysis and kinematic simulation were carried out to ensure the strength, stability and performance of the scissor lift system. The results showed that the designed hydraulic scissor lift system was capable of lifting loads of up to 1000 kg on a tricycle with a maximum height of 3 meters. Load analysis using the finite element method showed that the main components were able to withstand the load with a sufficient safety factor. Simulation of the scissor lift movement also proved that hydraulic control could move the arm synchronously and in a controlled manner. The design of a hydraulic scissor lift system using SolidWorks has proven effective in visualizing, analyzing, and optimizing designs before the manufacturing stage. Further development could improve energy efficiency, add safety features, and expand applications to other types of vehicles.*

Keywords: *Scissor Lift, Hydraulic System, Three-Wheel Motorcycle, SolidWorks, Design, Structural Analysis*

1. INTRODUCTION

In the era of globalization and rapid industrial development, the need for effective and efficient tools is increasing. Scissor lifts are tools used in various industries. Scissor lifts are tools used to lift heavy objects to a certain height using a scissor-shaped mechanism (Görkem Dengiz et al., 2018). This tool is widely used in various industries such as construction, warehousing, and automotive to facilitate tasks that require lifting and moving heavy objects (Manoharrao & Jamgekar, 2016) . Scissor lifts are widely used in various industrial fields such as maintenance, construction, and material handling. Several physical areas such as mechanical, hydraulic, and control systems combine to form the complexity of a scissor lift (Ogbemhe et al., 2024) Scissor lifts are used in the automotive, transportation, development, waste management, and mining industries as an effective way to raise and lower products and inventory (Arunkumar et al., 2021). An innovative technology that increases the mobility and flexibility of scissor lifts is their integration into electric tricycles. Tricycles that are often used to transport goods can be equipped with scissor lift functions to increase their functionality (ALVALI et al., 2021).

The hydraulic system that operates the lifting platform is automated through the use of proximity sensors and actuators automatically. The scissor lift mechanism with a hydraulic system on a three-wheeled motorcycle is an innovative technology that aims to improve the operational efficiency and flexibility of this vehicle(Rankhambe et al., 2020). The most important mechanism is the scissor lift, whose force directly affects the performance of the entire equipment and determines the lifting height of the platform and the position of the hydraulic cylinder (Ciupan et al., 2019). This mechanism allows users to easily raise and lower objects, reducing the need for manual labor and increasing worker safety. In the industrial sector, hydraulic scissor lifts are easy to use, do not require routine maintenance, and are capable of lifting heavier loads. The main disadvantage of this device is the high initial cost. Despite the low operating costs, the use of scissor lifts on tricycles can support logistics and distribution processes and optimize operating time and costs(Firmansyah01 & Pranoto02, n.d.).

The study begins with a literature review of the Scissor Lift mechanism and hydraulic system, followed by the design of the mechanism and simulation stages (Kiran Kumar et al., 2016). Performance analysis is then carried out to evaluate the system's load-lifting capabilities and ensure its safety and reliability. The results of this study are expected to be the basis for further development and practical application of this field(Arunkumar et al., 2021).

2. LITERATURE REVIEW

This literature review aims to provide an overview of previous studies related to the design of scissor lift mechanisms with hydraulic systems on three-wheeled motorcycles. The aspects discussed include the working principles of scissor lifts, the application of hydraulic systems to lifting mechanisms, and the application and analysis of tricycle performance.

2.1 Scissor Lift

Scissor lifts are used for pneumatic, pressure-operated, or precise enlargement. The jacks controlled by the pressure factor have several functions such as bed arrangement, vehicle stacking and work arrangement, production line elevation, and distribution line (Arunkumar et al., 2021).

The design is done by considering the hydraulic scissor lift as a portable, compact and very suitable tool for medium load applications. The design and drawings of the hydraulic scissor lift are made based on solid work with appropriate modeling and imported into Ansys Workbench for integration and analysis. The scissor lift force analysis includes total deformation load and equivalent stress (Kiran Kumar et al., 2016).

2.2 Hydraulic System on Scissor Lift

Scissor lifts are controlled by pneumatic or mechanically powered hydraulics for height adjustment. The most common industrial scissor lifts are driven by one, two, or three single-acting hydraulic cylinders, because they can produce large forces in a compact design. In a scissor lift, the hydraulic system uses pressurized fluid to actuate the hydraulic cylinders, which in turn move the scissor frame (Manoharrao & Jamgekar, 2016).

The drive mechanism for raising or lowering the platform can be hydraulic, pneumatic, or mechanical. Scissor platforms are also marked by the number of scissors. Use one or more scissors to lift different platforms to a certain height (Ciupan et al., 2019).

The study investigates the efficiency of hydraulic systems in lifting applications, including pressure drop analysis and design optimization to improve energy efficiency. For scissor lift systems, kinematic analysis is performed to select the type of piston and determine the piston force (Fp) before conducting a system analysis using the finite element method (Görkem Dengiz et al., 2018).

2.3 Implementation on Three-Wheeled Vehicles

Integrating the scissor lift mechanism into a tricycle can expand its functionality, especially in applications that require load lifting, such as in the agricultural, construction, and logistics industries. Automating the lifting mechanism increases cargo handling capacity. In addition, significant savings in labor and time can be achieved. Hydraulic scissor lifts can lift loads of up to 2 tons, increasing the efficiency of your material handling system by more than 60% (Rankhambe et al., 2020).

2.4 Studies Related to Design and Performance Analysis

Engineering design is an approach that considers basic concepts such as functionality, reliability, manufacturability, ease of use, and cost of the product being produced. Designing scissor lift mechanisms using hydraulic systems requires a comprehensive approach that includes mechanical, hydraulic, and structural analysis. Use simulation software such as CAD (computer-aided design) and CAE (computer-aided engineering) to model and analyze system performance (ALVALI et al., 2021).

2.5 Studies Related to Design and Performance Analysis

Engineering design is an approach that considers basic concepts such as functionality, reliability, manufacturability, ease of use, and cost of the product being produced. Designing scissor lift mechanisms using hydraulic systems requires a comprehensive approach that includes mechanical, hydraulic, and structural analysis. Use simulation software such as CAD (computer-aided design) and CAE (computer-aided engineering) to model and analyze system performance (Ogbemhe et al., 2024).

Hydraulic Scissor Lifts are designed to be simpler, reduce complexity, and reduce production time. In addition, hydraulic scissor lifts are easy to use, do not require regular maintenance, and can lift heavier loads (Firmansyah01 & Pranoto02, n.d.).

Solid body modeling, stress analysis, and kinematic scissor lift forces were performed using the static structure and rigid mechanics of mechanical systems by Ansys Workbench finite element software, and solid body modeling was created in SolidWorks (Solmazyiğit et al., 2022).

The scissor lift design must be properly designed to prevent equipment failure, in addition to other safety measures such as compliance with OSHA regulations, the use of fall protection equipment, proper maintenance and inspection before use, and the training of the Lift Model should be designed (Rashid et al., 2012).

3. RESEARCH METHODS

The purpose of this study is to design and analyze the scissor lift mechanism using a hydraulic system applied to a three-wheeled motorcycle. The research method used includes several stages, namely data collection, design, calculation, and structural analysis. Below are the steps of the research methodology carried out :

3.1 Tools

In this design, the tools used are as follows, namely :

1. Laptop Hp
   The laptop used is an HP laptop from the HP 14-fq0xxx series with an AMD Ryzen 3 3250U processor and 8 GB of RAM.
2. Software SolidWorks 2022
   SolidWorks 2022 is a computer-aided design (CAD) software provided by Dassault Systèmes SolidWorks Corporation. SolidWorks 2022 offers significant performance improvements, including more responsive load times, more efficient response times, and smoother overall performance. This allows users to work with more complex designs.

3.2 Design Concept

The scissor lift model chosen for modeling is a hydraulic cylinder-driven scissor lift model with two cross-scissor frames. The specifications of the scissor lift frame are as follows :

a) Scissor Lift Top Platform
Dimension : 2120 x 770 x 140 mm
b) Scissor Lift Arm
Dimension : 1955 x 70x 5 mm
c) Scissor Lift Bottom Platform
Dimension : 2120 x 770 x 70 mm
d) Iron Profile scissor arm lift
Dimension : 70 x 70 x 5 mm
e) Iron Top and bottom platform profiles
Dimension : 70 x 70 x 5 mm

The analysis method for determining the static strength of scissor elevators was carried out by simulation using SolidWorks 2022 software. The simulation steps carried out can be described as follows:

1. Modelling
2. Static Study
3. Material Selection
4. Focus placement
5. Load placement
6. Interpretation and Analysis of FEA results

3.3 Material

In this system, a square profile with dimensions of 70x70x5 mm has a material type AISI 1045 Steel scissor elements, the properties of AISI 1045 steel material according to the SolidWorks 2022 application are shown in the following table :

Property	Value	Units
Elasticity Modulus	205,000	N/mm^2
Poisson's Ration	0.285	N/A
Shear Modulus	80,000	N/mm^2
Mass Density	7,850	Kg/mm3
Tensile Strength	625	N/mm^2
Yield Strength	530	N/mm^2

3.4 Design

1. Motor Design

Figure 1. Isometric view of the three-wheel motorcycle

2. Scissor Lift Design

Figure 4. Platform scissor lift

3.5 Calculation

1. Lifting Force

$$F_L = m \times g \times \sin \alpha$$

$$= 1000 \text{ x } 9,8 \text{ x } \sin 45$$

$$= 8338,85 \text{ N}$$

2. Moment

$$M = F \,.\, x$$
$$= 10000\text{N} \,.\, 1{,}955 \text{ m}$$
$$= 1{,}955 \times 10^{7} \text{Nm}$$

3. Stress

$$\sigma = \frac{P}{A}$$
$$= \frac{10000\text{N}}{0{,}0049}$$
$$= 49 Nm^{2}$$

4. Strain

$$\varepsilon = \frac{\Delta L}{L_o}$$
$$= \frac{0{,}002}{1{,}955}$$
$$= 1{,}02302 x 10^{-6} Nm^{2}$$

5. Deflection

$$E = \frac{\sigma}{\varepsilon}$$
$$= \frac{49 Nm^{2}}{1{,}02302 x 10^{-6}}$$
$$= 4{,}78974 x 10^{-5} Nm^{2}$$

4. RESULTS AND DISCUSSION

To analyze the scissor lift system, the results of the study can be obtained using the FEA (Finite Element Analysis) simulation method in Solidworks 2022 software using the scissor lift platform analysis objects as follows :

4.1 Equivalent Upper Bound Axial and Bending Stress

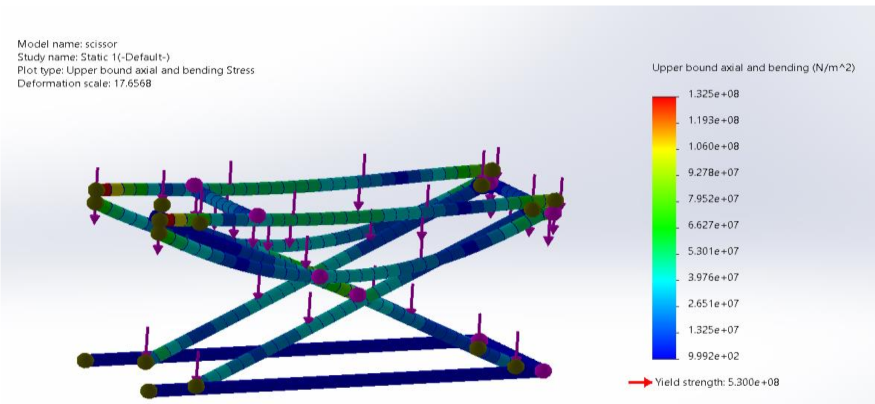

Figure 5. Result upper bound axial and bending stress simulation

The results of the stress analysis with AISI 1045 material on the scissor lift frame are able to withstand a material load of 10000N (1000Kg). In Figure 5, the results of the bending stress analysis simulation were obtained with the largest upper bound axial and bending stress value of 132.5 N/mm2, and the smallest upper bound axial and bending stress of 13.2 N/mm2. Meanwhile, yield strength is at 530 N/m2.

4.2 Total Deformation

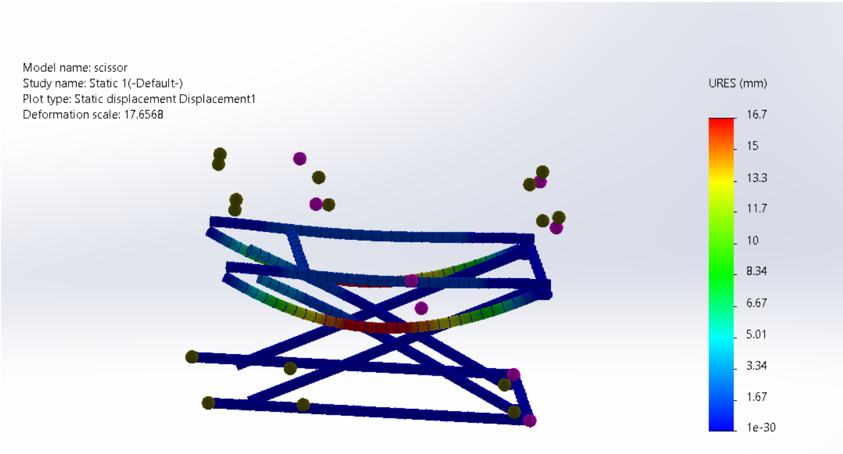

Figure 6. Result the displacement simulation

Based on Figure 6, the results of the displacement simulation on the scissor lift platform with AISI 1045 material produce a maximum displacement value of 16.7 mm marked by a red diagram where at that point a considerable load occurs. The minimum displacement value of 1.67 mm is indicated by a blue diagram where there is no excessive loading at that point.

4.3 Safety Factor

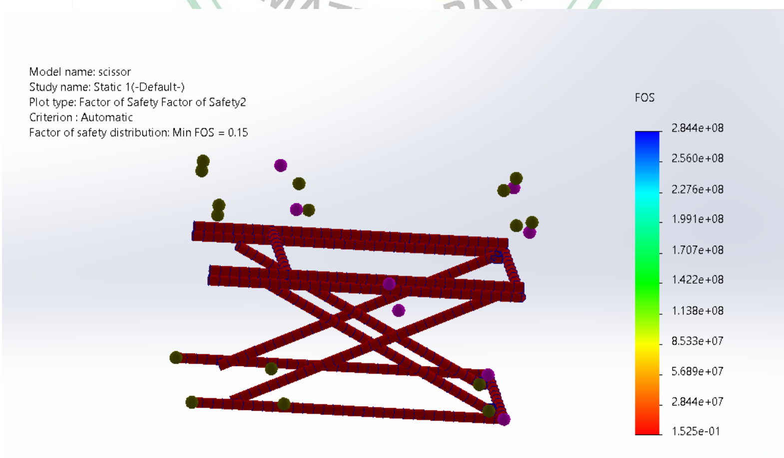

Figure 7. The safety factor simulation results

The following are the results of the simulation of the safety factor on the scissor elevator platform with AISI 1045 material. For the distribution of the minimum safety factor value that occurs on the scissor lift platform shown in figure 7, a value of 0.15 is obtained.

CONCLUSION

In this study, SolidWorks software was used to design and analyze the scissor lift mechanism with a hydraulic system that can be applied to a three-wheeled motorcycle. Based on the results of the structural analysis using FEA, the simulation of the upper axial stress and bending stress shows that the frame is very stable even though it is loaded with 1000 kg because the stress value does not exceed the yield strength value of the material.

Designing a hydraulic lift scissor system using SolidWorks proved to be effective in visualizing, analyzing, and optimizing the design before the manufacturing stage. Choosing the right material is also a key factor in increasing strength and resistance to corrosion and minimizing the total weight of the system.

REFERENSI

ALVALI, G. T., BALBAY, A., GÜNEŞ, S., YENİPINAR, B., ÇATALBAŞ, C., & ŞİŞMAN, T. (2021). Design and implementation of a three-wheel multi-purpose electric vehicle with finite elements analysis. *International Journal of Automotive Science and Technology*, *5*(2), 116–125. https://doi.org/10.30939/ijastech..871684

Arunkumar, G., Kartheeshwaran, R., & Siva, J. (2021). Investigation on design, analysis and topological optimization of hydraulic scissor lift. *Journal of Physics: Conference Series*, *2054*(1). https://doi.org/10.1088/1742-6596/2054/1/012081

Ciupan, C., Ciupan, E., & Pop, E. (2019). Algorithm for designing a hydraulic scissor lifting platform. *MATEC Web of Conferences*, *299*, 03012. https://doi.org/10.1051/matecconf/201929903012

Firmansyah01, D. B., & Pranoto02, H. (n.d.). *ANALISA KEKUATAN RANGKA DUDUKAN CYLINDER HIDROLIK SCISSOR LIFT*. Retrieved July 10, 2024, from https://www.neliti.com/publications/340385/analisa-kekuatan-rangka-dudukan-cylinder-hidrolik

Görkem Dengiz, C., Can Şenel, M., Yıldızlı, K., & Koç, E. (2018). Design and Analysis of Scissor Lifting System by Using Finite Elements Method. *Universal Journal of Materials Science*, *6*(2), 58–63. https://doi.org/10.13189/ujms.2018.060202

Kiran Kumar, M., Chandrasheker, J., Manda, M., & Kumar, D. V. (2016). Design & Analysis of Hydraulic Scissor Liftt. *International Research Journal of Engineering and Technology*. www.irjet.net

Manoharrao, S. A., & Jamgekar, R. S. (2016). Design and Analysis of Hydraulic Scissor Lift By FEA. In *International Research Journal of Engineering and Technology*. www.irjet.net

Ogbemhe, J., Ramatsetse, B., Mpofu, K., & George, O. A. (2024). Multi-Physical Modelling and Simulation of a Planar Translational Scissor Lift Mechanism for Maintenance of Rail Transmission Lines. *Procedia CIRP*, *121*, 174–179. https://doi.org/10.1016/j.procir.2023.09.246

Rankhambe, S. S., Balasaheb Bandgar, A., Kumbhar, H. N., Patil, V. T., & Patil, V. (2020). Design and Development of Hydraulic Scissor Lift. *International Research Journal of Engineering and Technology*. www.irjet.net

Rashid, H., Ariffin, M. K. A. M., Noh, M. H. M., Abdullah, A. H., Hamid, A. H. A., Jusoh, M. A. M., & Othman, A. (2012). Design review of scissors lifts structure for commercial aircraft ground support equipment using Finite Element Analysis. *Procedia Engineering*, *41*, 1696–1701. https://doi.org/10.1016/j.proeng.2012.07.370

Solmazyiğit, İ., Başkurt, R. C., Ovalı, İ., & Tan, E. (2022). Design and Prototype Production of Scissor Lift Platform 25 Tons Capacity. *The European Journal of Research and Development*, *2*(4), 326–337. https://doi.org/10.56038/ejrnd.v2i4.177