PERFORMANCE ANALYSIS OF THE ELECTRIC TROLLEY OF OXYGEN CYLINDERS BASED ON THE ROAD SLOPE

Costantinus Oei[1*], Maran Gultom[1], Obet Takke Ranteallo[1], Thobby Wakarmamu[1], Marthen Liga[1], Endang Hartiningsih[1], Johni Jonatan Numberi[1], Akbar Silo[1]

[1] Magister Program of Renewable Energy Engineering, Cenderawasih University, Jayapura 99224, Indonesia

*Email: ocostantinus@gmail.com

ABSTRACT

The demand for efficient distribution of oxygen cylinders at Abepura Regional General Hospital (RSUD Abepura) has been steadily increasing due to the growing needs of staff members and patients who expect high-quality service within the hospital premises. In response to this demand, this study aims to propose a transportation system that is not only automated but also time-saving, with the ultimate goal of enhancing medical services in a more efficient, eco-friendly, and safe manner. One of the main challenges faced in the distribution process is the hilly terrain surrounding RSUD Abepura. The presence of these hills makes it difficult to manually distribute the heavy 72 kg gas cylinders, which is the current method employed at the hospital. To overcome this challenge, this research suggests implementing an innovative solution—an electric trolley—that can effectively facilitate the distribution and flow of oxygen cylinders at RSUD Abepura. The findings of this study conclusively demonstrate that the electric trolley is not only a suitable but also a convenient solution for the operators and medical staff involved in the distribution process. By utilizing the electric trolley, they can distribute oxygen cylinders without facing any hindrances posed by the uphill roads, ultimately resulting in significantly improved time efficiency and service effectiveness at RSUD Abepura.

Keywords: Electric trolley performance, oxygen cylinder, inclination, efficient distribution.

INTRODUCTION

Abepura Regional General Hospital (RSUD Abepura) has uneven and uphill floors. This condition also applies to the roads leading to and from the oxygen production room. One of the rooms that is uphill and far from the oxygen production room is the perinatology room, which requires approximately 15 cylinders of oxygen per day. On the other hand, the process of distributing oxygen cylinders still relies on a manual gas cylinder transportation device (trolley). The current oxygen trolley is made of iron material and weighs 12 kg without any load. However, the weight of an oxygen cylinder with its contents is 60 kg, resulting in a total weight of the transportation device with the oxygen cylinder and its contents being 72 kg. The existing gas cylinder trolley is still manual and has three wheels, which are prone to tipping over and pose a high risk for the cylinder pushers and nurses.

With the current conditions, the cylinder pushers and nurses often complain of fatigue and pain in specific parts of their bodies [1]. The use of the gas cylinder transportation device can have long-term health effects on the cylinder pushers and nurses, such as hernias, back pain, and fatigue. Considering the priority of health effects in life, human energy can be reduced by utilizing renewable energy with the help of electric motor energy [2], [3]; However, on the other hand, the automotive world continues to increase, especially in the fields of fuel and combustion engineering [4]–[6], design and manufacturing [7], intelligent cars [8], [9], and electric vehicles [10].

An electric motor energy is a device that converts electrical energy into mechanical energy [11]. Electric motors are divided into two types: AC motors and DC motors. AC motors operate using AC voltage (Alternating Current), while DC motors require a supply of direct current voltage in order to convert field coil voltage into mechanical motion energy [12].

Various studies have been conducted regarding the development of trolley transportation devices [13] to meet user needs. Additionally, brushless DC controller-based trolleys have been developed to enhance user satisfaction (operators) and improve mobility and productivity within companies [14].

Until now, trolley development continues in order to improve existing designs and increase user satisfaction with the transportation device (trolley) while reducing complaints and bodily discomfort [15].

Therefore, the objective and benefits of this research are to obtain a gas cylinder transportation device as an operational tool and to improve the efficiency and effectiveness of medical personnel at RSUD Abepura. Furthermore, it serves as a reference for the development of automotive technology, specifically in the design and development of electric motors.

RESEARCH METHOD

The schematics of research materials and equipment can be seen in Figures 1 and 2. Furthermore, this research has two variables, namely the independent variable and the dependent variable. The independent variable is the variable that influences the occurrence of changes or the emergence of the dependent variable. The dependent variable is the variable that is influenced or caused by the presence of the independent variable. Therefore, this study involves three variables, which are:

- The independent variable is the distributed oxygen cylinder.
- The dependent variable is the distance traveled, terrain conditions, and cylinder weight.
- The control variable is the required electrical energy.

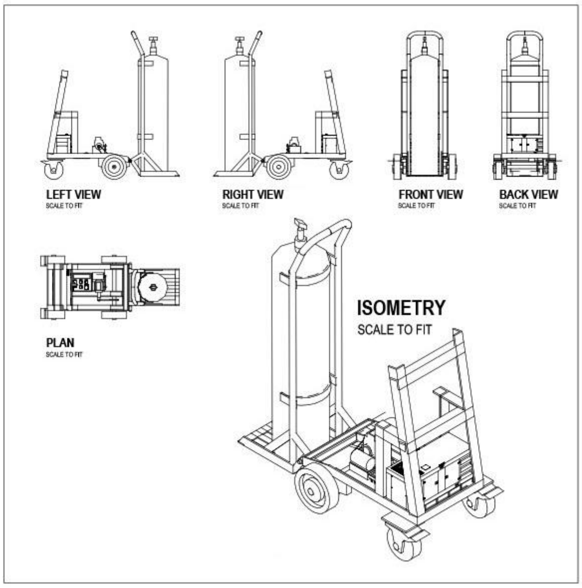

Figure 1. Oxygen cylinder as a test material

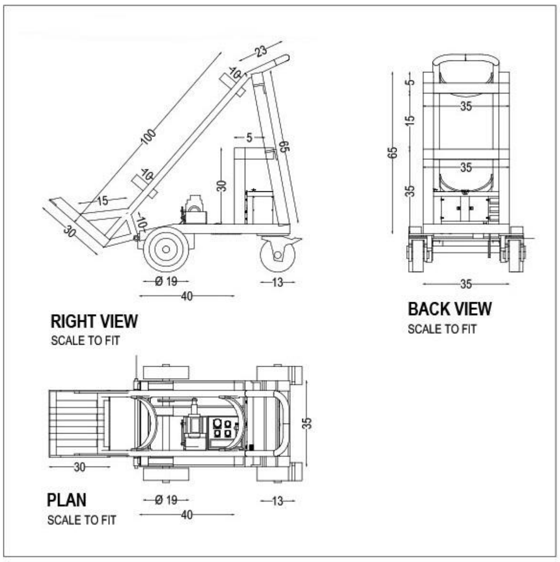

Figure 2. Details of the electric trolley test equipment

Research instruments are tools or facilities used by researchers to collect data, making their work easier and obtaining better, more accurate, complete, and systematic results that are easier to process. The research instruments used in this study are:

- Ammeter, used to measure the magnitude of current.
- Multitester, used to measure the magnitude of voltage.
- Stopwatch, used to measure the running time of the trolley.
- Inclinometer, used to measure the road inclination.

RESULT AND DISCUSSION

Figure 3 shows the condition of the Abepura Hospital which has an uneven road structure and has many roads or paths that go up and down; Apart from that, it can also be seen that the means of transporting oxygen gas cylinders (trolley) is operated manually (driven) using human power.

Figure 3. Road condition (left) and manual gas cylinder trolley (right) at Abepura Hospital.

Inclination 0°

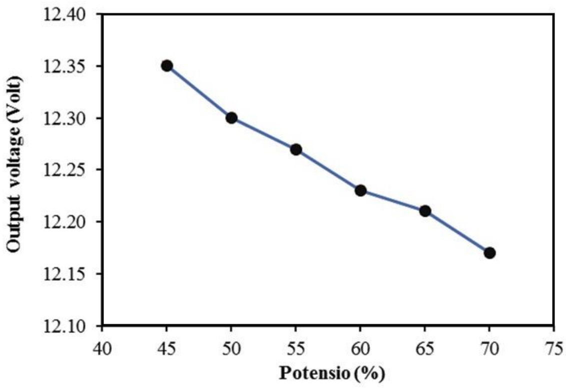

Figure 4. Comparison of the output voltage and the percentage of the potensio at a slope of 0°

From Figure 4 it can be seen that there is a consistent relationship between the magnitude of the applied voltage and the percentage of potential valve opening on the electric trolley. Moreover, it is also seen that the greater the percentage of potentiometer valve opening, the lower the generated voltage used. Conversely, the smaller the percentage of potential valve opening, the higher the generated voltage used.

At the potential valve opening of 45%, the voltage used reaches its highest point of around 12.35 Volts. This shows that at this percentage of openings, the flow of electricity that enters the electric trolley system becomes more limited, so that the voltage used also increases. On the other hand, at a potential of 70%, it can be seen that the used voltage reaches its lowest point around 12.18 Volts. This shows that at a greater percentage of valve opening, the incoming electricity flow becomes greater, so that the applied voltage becomes lower. This analysis is in accordance with previous studies on the effect of valve opening and ignition degree, and discussed from another perspective [16], [17].

These results indicate that the adjustment of the potentiometer valve opening on the electric trolley has a significant effect on the amount of voltage or power used. By manipulating or varying the potentiometer valve opening, the user or operator can control the amount of voltage generated by the electric trolley according to specific needs and requirements.

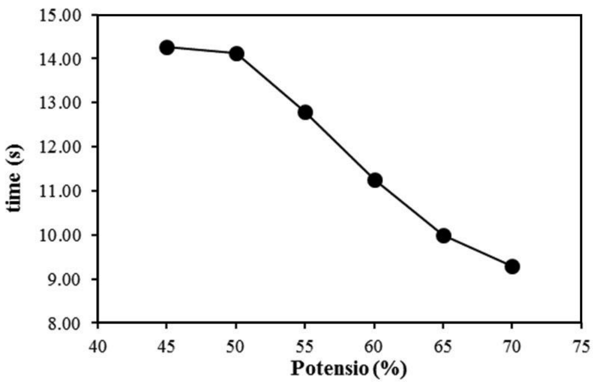

Figure 5. Comparison of operational time and potensio percentage at 0° slope

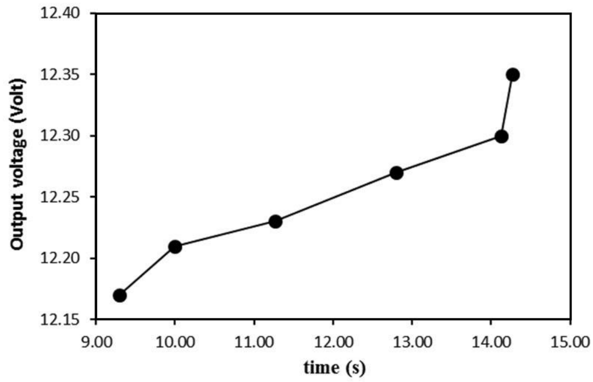

Figure 6. Comparison of output voltage and operating time at 0° slope

On the other hand, from the observations it is also seen that there is a visible relationship between the potential valve opening and the operating time and the voltage used by the electric trolley. The larger the potentiometer valve opening, the operational time of the electric trolley tends to decrease, while the voltage used increases with time.

Furthermore, Figure 5 shows that the larger the potentiometer valve opening, the shorter the operating time of the electric trolley. At the highest potential valve opening, the operational time reaches around 9.4 seconds, while at the lowest potential valve opening, the operational time reaches around 14.3 seconds. This shows that the larger the potentiometer valve opening, the faster the electric trolley operates.

Meanwhile, Figure 6 shows that there is an increase in the applied voltage along with the increasing usage time of the electric trolley. At the beginning of the operational time of about 9.4 seconds, the voltage used is around 12.17 Volts. However, as time goes by until it reaches 14.3 seconds, the used voltage increases to around 12.35 Volts. That is, the longer the electric trolley is used, the higher the generated used voltage will be.

These results indicate that the potential valve opening and operating time of the electric trolley have an influence on the generated applied voltage. The larger the potentiometer valve opening and the longer the operating time, the higher the voltage used generated by the electric trolley. This needs to be considered in setting up and using electric trolleys to ensure that the voltage used remains within safe limits and according to operational needs [18].

Inclination 5°

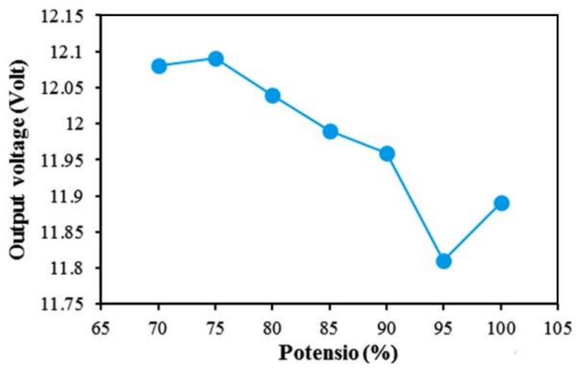

Figure 7. Comparison of the output voltage and the percentage of the potential at a slope of 5°

Figure 8. Testing the performance of the electric trolley on a road slope of 5°

Furthermore, the performance test of the electric trolley was carried out on a hospital road with a slope of 5°, and it was found that the slope factor of the hospital road plays an important role in the performance and operation of the electric trolley.

Figure 7 shows that the relationship between the applied voltage and the valve opening of the potentiometer has a trend similar to that seen in Figure 4. However, there is an interesting phenomenon that can be seen, namely a sudden voltage spike at 95% potentiometer. This shows that the degree of inclination of the hospital road has a significant effect on the performance of the electric trolley.

This analysis is supported by the results of tests and observations which can be seen in Figures 9 and 10. Figure 9 shows that the larger the potential opening, the operational time or travel time of the electric trolley decreases. This indicates that the electric trolley can operate faster with a larger potential opening. Meanwhile, Figure 10 shows a sudden voltage spike at a shorter operational time. This shows that when the electric trolley passes through areas with steeper slopes, the applied stress increases significantly.

In addition, these results also show that the use of electric trolleys in conditions with steep slopes requires a greater electric current to maintain the stability and performance of the machine. This analysis is in accordance with previous research on electric vehicle operations which is discussed from another point of view [19], [20]. The voltage spike on a steep slope can be interpreted as an attempt by the machine to overcome a greater challenge in moving the trolley.

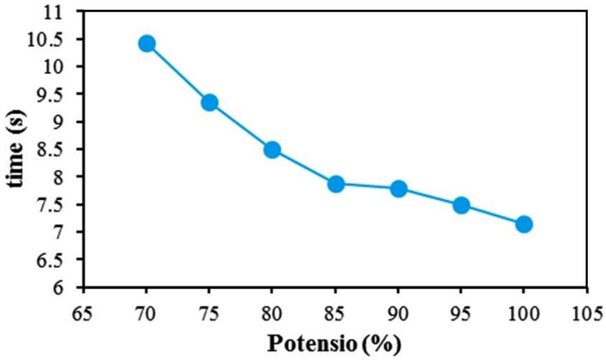

Figure 9. Comparison of operational time and potency percentage at 5° slope

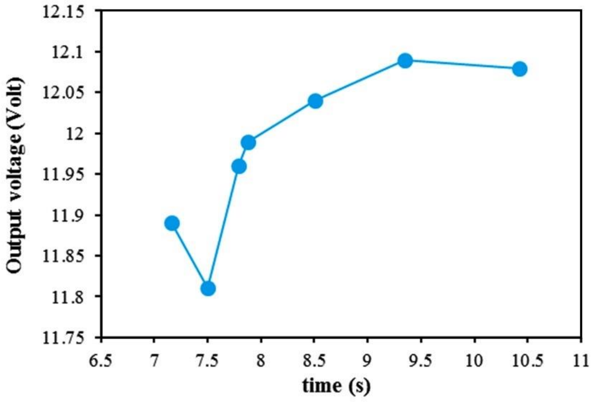

Figure 10. Comparison of output voltage and operating time at 5° slope

Figure 11. Testing the performance of the electric trolley on a road slope of 10°

These results have a very positive impact because they have great potential to become input and scientific information that is very important in designing strategies for using electric trolleys at the Abepura Regional General Hospital. Setting and selecting the right potentiometer valve opening can help improve the efficiency and performance of the electric trolley, especially when passing through areas with steep slopes.

Furthermore, an understanding of the voltage spikes that occur on steep slopes can also be considered in the maintenance of electric trolleys to ensure operational reliability and safety.

Moreover, by combining information from Figure 4, Figure 7, Figure 9, and Figure 10, it can be concluded that the potential valve opening, road slope, operational time, and applied voltage are interconnected and influence each other in the performance and use of electric trolleys.

Inclination 10°

Furthermore, testing the performance of the performance electric trolley was also carried out on a 10° slope of the hospital road (Figure 11). From the test results and observations it can be seen that the pattern is the same as the performance of the electric trolley at a slope of 0° and 5°. The difference is the amount of applied voltage generated at a certain time and potential.

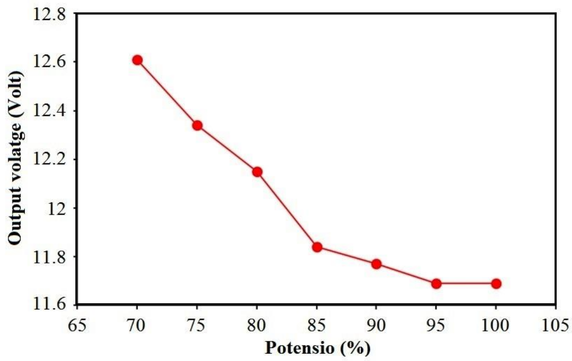

Figure 12. Comparison of the output voltage and the percentage of the potential at a slope of 10°

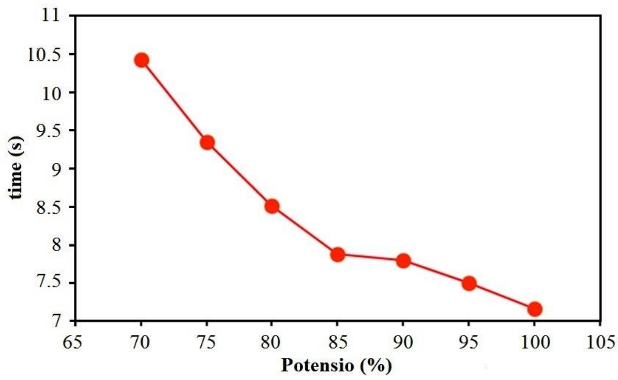

Figure 13. Comparison of operational time and potency percentage at 10° slope

These results indicate that the slope of the hospital road has a significant impact on the performance of the electric trolley. Even though the performance patterns are similar, at a slope of 10°, the applied voltage generated is higher than the other slopes at the same time and potential. This is shown in Figures 12, 13, and 14. Figures 12 and 13 show that the voltage and resulting operational time decreases with the percentage of a potential opening. These results indicate that as the slope of the road increases, the electric trolley requires a more excellent supply of electrical energy to run correctly.

As for Figure 14, the results show that the voltage used increases with increasing operational time. Once again, these results reinforce that the slope of the hospital road affects the energy and voltage requirements required by the electric trolley. The steeper the slope of the road, the higher the voltage required to maintain the performance and stability of the machine during operation.

This scientific information becomes very important in the operation of electric trolleys in hospitals. Proper arrangement and selection of potential needs to be considered to ensure optimal performance and efficient energy use on various road slopes. In addition, an understanding of the difference in applied voltage on various road slopes can assist in the maintenance and maintenance of electric trolleys to ensure good performance and prevent the risk of operational failure [21].

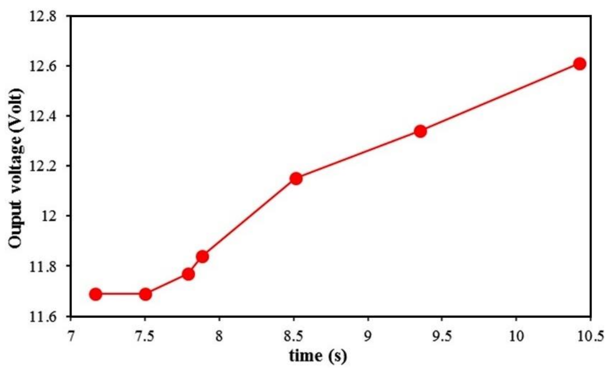

Figure 14. Comparison of output voltage and operating time at 10° slope

CONCLUSIONS

Research on the effect of the degree of inclination on the performance of the electric trolley has been completed, and found several important findings.

1. The incline of the hospital road has an impact on the energy and voltage demands of the electric trolley. As the road becomes steeper, a greater amount of voltage is necessary to sustain the machine's performance and stability during its operation.
2. This scientific knowledge holds significant importance in the functioning of electric trolleys within hospitals. It is crucial to carefully plan and choose the appropriate voltage requirements to guarantee optimal performance and efficient energy utilization across different road inclinations.
3. By understanding the relationship between the potentiometer valve opening and the applied voltage, appropriate adjustments can be made to meet the desired needs and specifications. The practical thing that can be done is by adjusting the potentiometer valve opening at a certain level, a used voltage can be generated that is in accordance with the operational needs of the electric trolley. This can help increase the efficiency and performance of the electric trolley in distributing oxygen cylinders at the Abepura Regional General Hospital.
4. For the future works, thus it is necessary to use differential components on the trolley's wheels so that the maneuverability of the trolley in dealing with various road conditions or terrain becomes more optimal. The trolley can quickly turn, go around bends or pass obstacles with better control. This will increase safety and comfort for operators or trolley users in carrying out their duties.

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REFERENCES

[1] O'Connor, M., McNamara, C. and Doody, O., 2023. Healthcare workers' experiences of caring for patients colonized with carbapenemase-producing Enterobacterales (CPE) in an acute hospital setting – a scoping review. *J. Hosp. Infect.*, Vol. 131 pp. 181–189.

[2] Riabov, I., Goolak, S., Kondratieva, L. and Overianova, L., 2023. Increasing the energy efficiency of the multi-motor traction electric drive of an electric locomotive for railway quarry transport. *Eng. Sci. Technol. an Int. J.*,

Vol. 42 pp. 101416.

[3] Ruvio, A. and Lamedica, R., 2023. Electric transportation. *Encycl. Electr. Electron. Power Eng.*, pp. 337–349.

[4] Nanlohy, H. Y., Wardana, I. N. G. Hamidi, N., Yuliati, L. and Ueda, T., 2018. The effect of Rh3+ catalyst on the combustion characteristics of crude vegetable oil droplets. *Fuel*, Vol. 220 pp. 220–232.

[5] Suyatno, Riupassa, H., Marianingsih, S., and Nanlohy, H. Y., 2023. Characteristics of SI engine fueled with BE50-Isooctane blends with different ignition timings. *Heliyon*, Vol. 9 (1) pp. e12922.

[6] Nanlohy,H. Y., Wardana, I. N. G., Yamaguchi, M. and Ueda, T., 2020. The role of rhodium sulfate on the bond angles of triglyceride molecules and their effect on the combustion characteristics of crude jatropha oil droplets. *Fuel*, Vol. 279 pp. 118373.

[7] Tamjidillah, M., Subagyo, R., Isworo, H., and Nanlohy, H. Y., 2020. Modelling analysis of high effect of roll hoop main on the strength of student car formula chassis. *J. Achiev. Mater. Manuf. Eng.*, Vol. 100 (1) pp. 26–40.

[8] Marianingsih, S. and Utaminingrum, F., 2018. Comparison of Support Vector Machine Classifier and Naïve Bayes Classifier on Road Surface Type Classification. *3rd Int. Conf. Sustain. Inf. Eng. Technol. SIET 2018 - Proc.*, pp. 48–53.

[9] Marianingsih, S., Utaminingrum, F., and Bachtiar, F. A., Road surface types classification using combination of K-nearest neighbor and Naïve Bayes based on GLCM. *Int. J. Adv. Soft Comput. its Appl.*, Vol. 11 (2) pp. 15–27.

[10] Wang, F., Xia, J., Cai, Y., and Guo, J., 2022. Novel energy management strategy for a dual-motor hybrid electric vehicle considering frequency of mode transitions. *Energy Convers. Manag.*, Vol. 269 pp. 116106.

[11] Tian, Y., Zhang,Y., Li, H., Gao, J., Swen, A. and Wen, G., 2023. Optimal sizing and energy management of a novel dual-motor powertrain for electric vehicles. *Energy*, Vol. 275 pp. 127315.

[12] Cavagnino, A., 2023. Asynchronous motors. *Encycl. Electr. Electron. Power Eng.*, pp. 280–298.

[13] Gunawan, A. A. S. *et al.*, 2019. Development of smart trolley system based on android smartphone sensors. *Procedia Comput. Sci.*, Vol. 157 pp. 629–637.

[14] Oyejide, O. J., Okwu, M. O., Tartibu, L. K. and Olayode, O. I., 2020. Development of Sensor Controlled Convertible Cart-Trolley. *Procedia CIRP*, Vol. 91 pp. 71–79.

[15] Ngwako, M. T. and Nyandoro, O. T., 2021. Singular optimal control for a high precision linear DC machine haulage trolley. *IFAC-PapersOnLine*, Vol. 54 (11) pp. 25–30.

[16] Nanlohy, H. Y. and Riupassa, H., 2020. An Experimental Study on the Ignition Behavior of Blended Fuels Droplets with Crude Coconut Oil and Liquid Metal Catalyst. *Automot. Exp.*, Vol. 3 (2) pp. 39–45.

[17] Nanlohy, H. Y., Riupassa, H., Trismawati, T. and Panithasan, M. S., 2022. Gasohol Engine Performance with Various Ignition Timing. *J. Mech. Eng. Sci. Technol.*, Vol. 6 (1) pp. 48.

[18] Rahdan, P., Kasaeian, A., and Yan, W. M., 2021. Simulation and geometric optimization of a hybrid system of solar chimney and water desalination. *Energy Convers. Manag.*, Vol. 243 pp. 114291.

[19] Yusuf, J., Hasan, A. S. M. J., Garrido, J., Ula, S., and Barth, M. J., 2023. A comparative techno-economic assessment of bidirectional heavy duty and light duty plug-in electric vehicles operation: A case study. *Sustain. Cities Soc.*, Vol. 95 pp. 104582.

[20] Riupassa, H., Suyatno, S., and Nanlohy, H. Y., 2023. Identifying the Effect of Aromatic Compounds on the Combustion Characteristics of Crude Coconut Oil Droplet. *Eastern-European J. Enterp. Technol.*, Vol. 2 (6–122) pp. 6–14.

[21] Coşkun, G. and Bendak, S., 2023. Safety of hospital floor coverings: A mixed method study. *Saf. Sci.*, Vol. 163 pp. 106145.