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Design of Rotary Motor Wiring Diagram for Tugboat Ship Maneuvering System Using Cam Switch Control

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ABSTRACT: The maneuverability of tugboats is very necessary for narrow turning areas, so many tugboat maneuvering systems use motors which are currently applied with cam switches. It is important to plan a wiring system to anticipate disruptions to distribution electricity. Therefore, the electricity supply for the equipment can be met and run as expected. The aim of this research is to obtain rotary motor wiring diagram system for tugboat ship maneuvering system using cam switch control. The R&D (Research and Development) method combined with experiments was carried out to obtain an ideal rotary motor wiring diagram system based on the dimensions of the tugboat's engine room. In forward rotation for this motor is a decrease before stabilization occurs, the voltage is 18% meanwhile, reverse rotation experienced a decrease of 32%. This difference with motor if workload which is charged which also experiences variations, for forward rotation the increase is 48%, also for reverse rotation it is 43%.

KEYWORDS: Wiring Diagram, Cam Switch, Rotary Motor, Tug Boat.

1.0 INTRODUCTION

Tugboats are vessels used to guide and direct larger vessels to shifting on the port. The steering system on tugboats generally has the ability to rotate quickly and within the required time according to its accuracy. The maneuverability of tugboats is very necessary for narrow turning areas, so many tugboat maneuvering systems use motors which are currently applied with cam switches (Yuan et al., 2020). Tugboats have a design that is not too big but must be able to be arranged so that equipment, especially machinery, can enter and gain access easily (Özhan Doğan, 2023). Basically, the electrical system on a ship is the main factor of several important elements that support operational activities (Karatuğ et al., 2023; Sarıalioğlu et al., 2020). Therefore, if a disturbance occurs, it is feared that the ship will not be able to operate optimally. It is important to plan a wiring system to anticipate disruptions to distribution electricity. Therefore, the electricity supply for equipment can be met and run as expected (Abed, 2024; Pozo-Palacios et al., 2023).

Cam switch is component to facilitate the operation changing direction of rotational current on a motor. This tool is used to change the main circuit of an electric motor to forward and reverse . It is very appropriate for the need for turning around in the maneuver system, especially when tugboats are needed to pre-transfer and shift the ship to shifting from the port to the shipping route. In this way, it can simplify and lighten the operator's work and save time in operating the motor in the system. To overcome this, it is necessary to design a wiring diagram system. So research was prepared, design of rotary motor wiring diagram for tugboat ship maneuvering system using cam switch control.

2.0 REVIEW OF PAST WORK

Previous studies based on electrical system design to reduce excessive loads show that errors often occur in components in the ship's wiring system in the breaker and fuse section. The presence of a short circuit in the resistance line causes a decrease in voltage and results in more serious damage to motor (Sobri et al., 2021). Other studies in the same vein show that incorporating capacitor switching as a compensation technique improves system distribution stability (Shin & Kim, 2023). This planning is useful in planning and optimizing the electricity distribution system by comparing the load and existing capacitor limits (Gao et al., 2024). In other words, the electrical power system related to the cam switch will experience stable voltage if the voltage is under normal operating conditions (Acanfora et al., 2023). An electric power system becomes unstable when the voltage drops uncontrollably due to equipment shutdown, load increase or voltage control (Ganjian et al., 2024).

However, with the R&D (Research and Development) method, the wiring design can be planned well, including the process of providing electrical lines to the ship (Park & Oh, 2023). On Patrol Ships, previous research shows that this design can help provide accurate work estimates and can provide appropriate repair routes (Özhan Doğan, 2023). So it is necessary to develop and plan an appropriate wiring system. In line with this, a planning system for an electric motor network to make it easier to change the circuit with a cam switch needs to be developed.

3.0 MATERIALS AND METHODS

The flow of this research starts from the initial process of planning the ship design and engine room size, then continues with the study and initial planning of the performance concept of the cam switch, see Figure 1. Next, from this concept we arrange it in a wiring diagram design, then we apply it to the portable industrial transformers. The experimental settings are adjusted to the wiring diagram design carried out, whether the path is appropriate and the voltage connecting cable is in accordance with the electrical path. Then experimental testing was carried out during the experiment, the variable used was only the length of time of use according to the operating conditions of the tugboat for the ship maneuvering system. If it complies with the regulations and the data is read well, a comparison is carried out to determine the comparison for each condition, both forward and reverse.

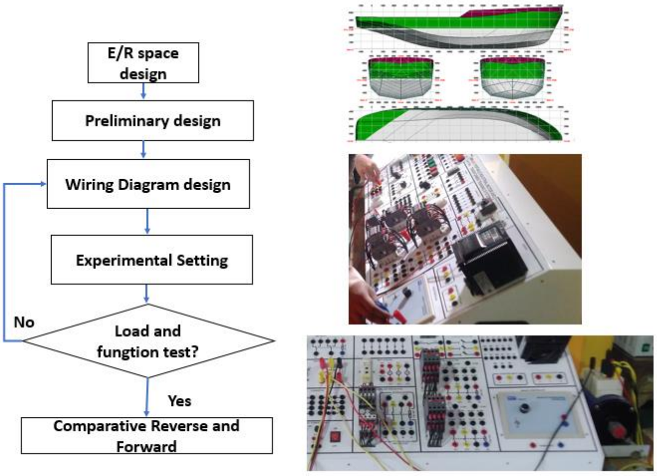

Figure 1. Methodology Flow

The planned tugboat model has a main size of no more than 30 meters, see figure 2. This tugboat is designed to have 2 propulsion systems or twins screws. The twins screw system is a propulsion system where double propellers support the ship to make it easier to maneuver with the reverse rotation of the propeller. In the design of this ship, the engine room is planned to be at the back of the ship.

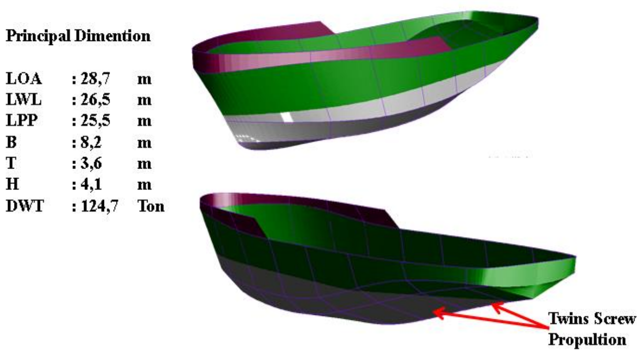

Figure 2. Desain of ship and Engine Room location

Mathematically, in planning the voltage distribution for cam switches, calculations can be carried out using an approach (Guo et al., 2023; Sarhadi et al., 2022; Yucesan et al., 2022).

$$I_i = \frac{\sqrt{P^2+(Q-Q_c)^2}}{V_i} \qquad (1)$$

Where I_i is s the magnitude of current in Amps, p is the active power , Q_c is relative power which use in cam swicth, V_i is voltage in the motor . On the other, to get the Load value for the voltage and current, the following equation is used:

$$X_c = \frac{V^2}{Q_c} \qquad (2)$$

Where X_c is load value for operation system. After the calculation values are obtained, they are grouped to be analyzed and compared. Before starting to plan, first create a wiring diagram concept according to the control cam switch. It is assumed that the motor is a 3 phase type, the source is adjusted to the conditions planned for the ship. The connection to the cam switch component is after the fuse so that the source goes directly to the motor, see figure 3.

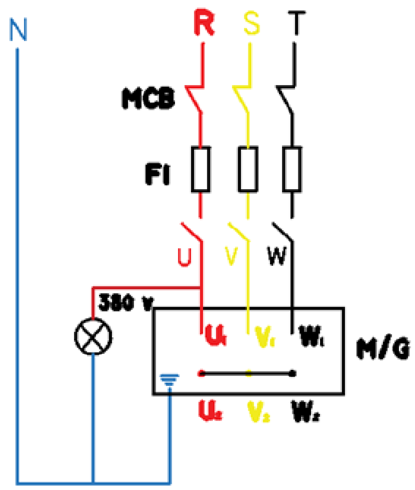

Figure 3. Wiring Diagram Concept

Then, after measurements and calculations have been carried out based on equations 1 and 2, they can be grouped and analyzed. In the comparison between voltage and usage time, there is a decrease and increase in voltage along with the current strength. The increase and decrease in voltage between the 20th and 80th minutes has a decrease in figure 4. In the forward rotation for this motor there is a decrease before stabilization occurs, the voltage is 18%, namely from 2.2 Kv to 1.8 Kv. Meanwhile, reverse rotation experienced a decrease of 32%. Namely from the initial condition of 2.12 Kv to 1.45 Kv.

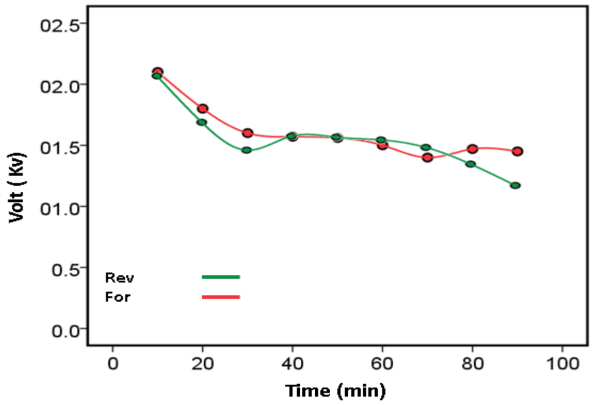

Figure 4. Volt and Time comparison

On the other hand, the increase occurs when the motor's operational performance load becomes longer, see Figure 5. In the graph showing this comparison, the peak is at minute 71 for forward motor rotation, where the highest value of the running load is 2.76%, so when compared with the initial condition was 1.43%, so there was an increase of 48%. This is in line with the reverse rotation, where the peak is at minute 82, the highest value of the load when running is 2.73% so that if compared with the initial condition, namely 1.55%, there is an increase of 43%.

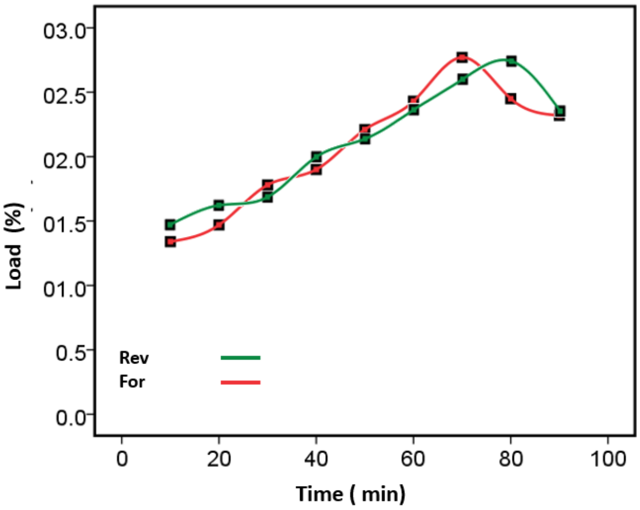

Figure 5. Load and Time condition

Then, if we compare the overall performance of the motor for reverse rotation conditions between load, volts and time during the test. The highest volt value is obtained from the largest load percentage and the longest period of time, see Figure 6. From this comparison image, it can be seen that the trend for the highest value of reverse motor rotation is directly proportional. The possibility of a decrease or increase only occurs for a few moments and then experiences constant operations.

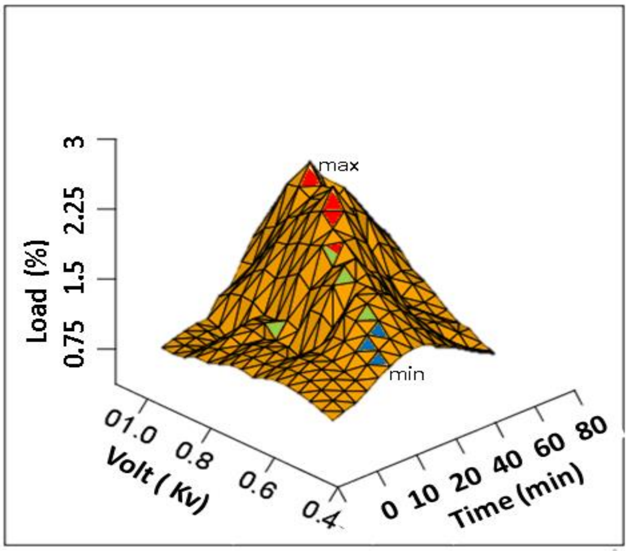

Figure 6. Graph of Reverse performace

In line with these results, the forward motor rotation also experienced a directly proportional comparison of values. This can be seen from the voltage value that occurs at the highest percentage of the load and over time it becomes more and more constant, see Figure 7.

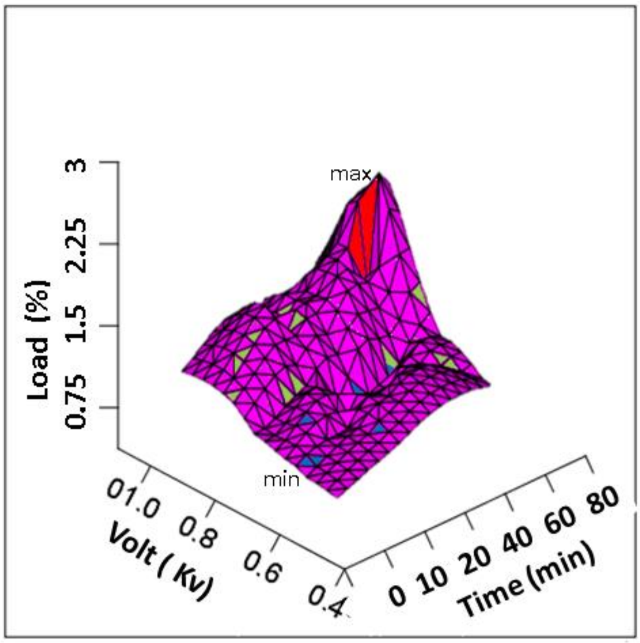

Figure 7. Graph of Forward performace

CONCLUSIONS

From the research results, it was found that designing a wiring diagram system using the research and development method provided a positive contribution to the cam switch module. The larger the load given, the voltage varies but ends up being stable. From the experimental wiring diagram design, it shows that the current flowing through the cam switch module is in accordance with the needs of the existing 3 phase electric motor. Based on the analysis, these results can be used as a reference for planning the wiring diagram design for the cam switch system for electric motors on tugboats. Tugboats generally have quite frequent operational maneuvering times so this wiring diagram system circuit model can be used as a reference with practical components that every tugboat can have at least.

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