PROCEEDINGS
ISBN: 978-602-98756-9

DESIGNING ELECTRICAL PROPULSION SYSTEM FOR KATINTING BOAT

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Abstract

One of the major problems of world community today is the dependence on fossil fuels. In addition to the more expensive price, the scarcity of fuels is also be a major obstacle, especially for remote area society. In Sorowako, many people work in water transportation services use gasoline or diesel engine to drive their boats. They also have similar problems that affect to their daily income. One alternative to be a solution for this case is using electrical energy as driver of the boat replacing fossil energy. Therefore, this research presents the propulsion systems of Katinting boat driven by motor DC. The model of propulsion system to designed and developed is a vertical shaft transmission that similar with outboard motor model. The primary source of propeller power is a motor DC. Motor's shaft is connected by pulley and belt to gear box shaft. Two accumulators is used in series connection to supply voltage 24 volts for motor. Performance test of propulsion system shows that the vertical shaft type gives 3992 rpm in propeller shaft. Running test on the small Katinting boat provides the average speed of boat on the water surface is about 1,6 m/s.

Keywords: *propulsion system, motor DC, Katinting boat, transmission shaft, gear box*

Background

Boat or ship is used to denote a vehicle employed to transport goods and persons from one point to another over water. This kind of transportation is very common used by the people of Indonesia, especially in coastal sea or lake. One of the traditional boats used in Sorowako is Katinting boat, as a means of transportation as well as for fishing. The propulsion system of this kind of boat consists of motor or engine, transmission system, shaft, and propeller. The main type of engine used on this boat is internal combustion engine (motor such as diesel engines and gas turbines).

One of the disadvantages using motor fuels is dependence on fossil fuels that connected to fuel shortages and high prices. In the terms of environmental safety, fossil fuels combustion takes a big proportion to global warming. To overcome these problems one alternative that can be offered is to use direct current motor as the prime mover of boat replaces the gasoline or diesel engine.

Electric propulsion system has been being used since 1930 especially after the development of Electric motor. Propulsion system with DC motor used at relatively low power while AC motor used in power above 10.000 HP. Theoretically, using of electric motor is more advantageous because it has several advantages such as: high efficiency, more resistant to vibration or shock, have longer life, and easier to control motor rotation. For the reason of reducing carbon dioxide (CO2) emissions, trend of using electric motor driven system in automobiles engines include in electric propulsion system for ships or boats.

This research presents a simple model of electric propulsion system driven by direct current motor. Mechanical power transmission from motor shaft to propeller using combination of pulley-belt and gear box. This electric propulsion system can be apllied in a small traditional boat in order to reduce fuel consumption as well as reduce emissions.

Method

Based on experimental research, the methods that are used for conducting this research are review of corresponding literature, design alternative and proposed model of electrical propulsion system, manufacture the mechanical components, install electrical and mechanical parts, test the parts and the whole system, and analyze the results of testing. The small boat using internal combustion engine is used as a comparison to measure the performance of electrical propulsion system.

The electrical propulsion system is designed in such a away to replace the conventional system using internal combustion engine. Therefore, this design should be used to drive a Katinting boat. The boat that used as a comparison is a small Katinting with the size of 650 cm x 80 cm x 60 cm, using 5 HP internal combustion engine. Based on the interview with the owners and users of boats in Sorowako area, on average, the boat can reach 5 km distance in 40 minutes with gasoline consumption as much as 3 liters.

a. Proposed Model

The primary components of simple electric propulsion system are DC motor as prime mover, transmission system, gearbox, and propeller. This propulsion system is designed by considering function of primary components, as shown in Figure 1.

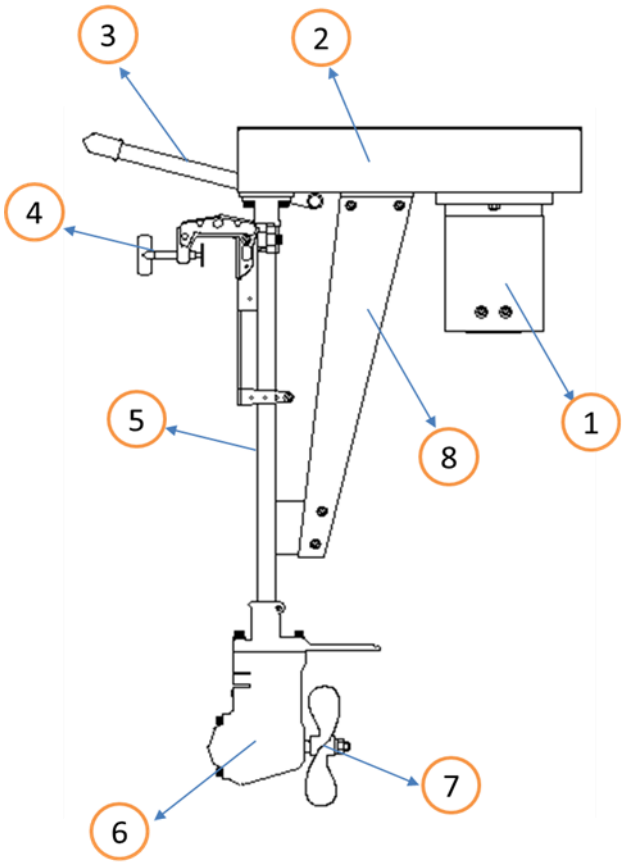

Figure 1. Design of Simple Electric Propulsion System

The parts of electric propulsion system as shown above are:

1 : DC motor
2 : pulley and belt transmission
3 : propeller steering
4 : clamp mounting machine
5 : shaft
6 : gear box
7 : propeller
8 : retaining plate

b. Electrical Components

The electrical system in this propulsion system consists of battery, potentiometer/rheostat as voltage regulator, and motor. The following tabel describes the specification of motor used in this design.

Tabel 1. DC Motor Characteristic

Parameters	Unit	Value
Power	Hp	0.75
Max voltage input	V	24
Nominal current	A	25 - 33
Shaft rotation	rpm	2150
Motor dimension (diameter . length)	mm	145 × 208
Shaft dimension (diameter . length)	mm	16 × 60
Weight	kg	11

Battery used as a source of electrical energy is a 12-volt 50-Ah battery. Two batteries in series connection is used to meet the voltage requirement. The mechanism of motor speed control is simplified by adjusting the input voltage that are inserted to the motor.

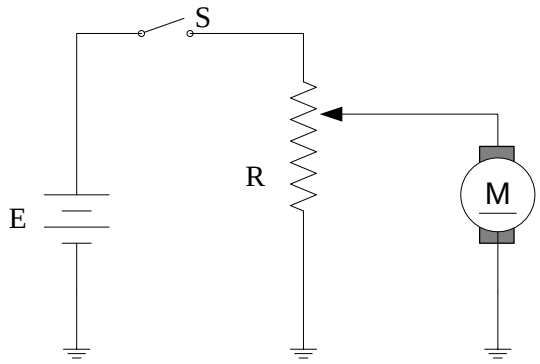

Figure 2. Electrical Circuit Diagram

Electrical circuit diagram of motor DC starting is shown in Figure 2 above. A 1KΩ – 200 W variable resistor or rheostat rotary type is used to adjust the voltage input of motor. Rheostat is an electrical device which has adjustable resistance value. There are three terminals of rheostat that are low resistance side, wiper (sliding contact), and high resistance side. Low resistance and high resistance terminals are connected to positive (through the switch) and negative of power supply respectively. The positive input terminal of motor is connected to the wiper of rheostat. When wiper of rheostat is turned to the high resistance side then voltage input to the motor is minimum, and in the contrary when it reach the low side, motor obtain maximum voltage input. By adjusting the

position of wiper, it can be set the amount of voltage and current inserted to the motor.

c. Mechanical Component

The design as shown in Figure 1 is an outboard model. Therefore, it needs mechanical parts that suitable for this model. These parts include pulley, belt, shaft, gear box, and propeller. Most of these parts were calculated with applied statics.

The torque produced in the shaft of motor should be transmitted and changed its direction from horizontal rotation on motor shaft to vertical rotation on propeller shaft. Pulley and belt system is applied to transmit rotation from motor shaft to gear box. Gearbox construction consists of two straight bevel gears mounted perpendicular.

Table 2. Specification of Transmission System

System	Specification	Driver	Driven
Pulley – belt	Pulley diameter	175 mm	50 mm
Gearbox : perpendicular type of two bevel gears	Number of teeth	12	24
	Conical angle (α)	27^o	63^o
	Cutter modul	1.5	1.5

There are two transmission system used in the propulsion system. First, transmission system from the motor shaft to the propulsion shaft (gearbox in) uses pulley and belt.

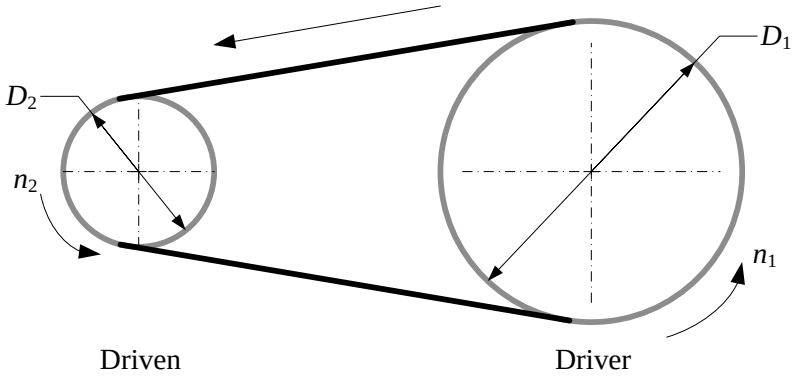

Figure 3. Pulley – Belt System Construction

The transmission ratio of pulley-belt system can be determined according to Equation 1.

$$i = \frac{n_1}{n_2} = \frac{D_2}{D_1} \quad (1)$$

Where:

i : transmission ratio (speed ratio)
n_1 : rotational speed of driver pulley
n_2 : rotational speed of driven pulley
D_1 : diameter of driver pulley
D_2 : diameter of driven pulley

The second transmission is from the shaft to propeller uses bevel gears. Bevel gears change the horizontal rotation of shaft to vertical rotation on propeller.

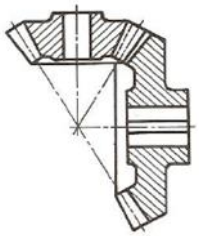

Figure 4. Bevel Gear Construction

The transmission ratio of gearbox system can be obtained by the following fomula.

$$i = \frac{n_1}{n_2} = \frac{z_2}{z_1} \quad (2)$$

Where:

i : transmission ratio (speed ratio)
n_1 : rotational speed of driver gear
n_2 : rotational speed of driven gear
z_1 : number of teeth of driver gear
z_2 : number of teeth of driven gear

From Equation 1 and 2, and using data presented in Tabel 2, calculation of transmission ratio of pulley-belt system gives result consecutively as follows:

Pulley-belt system : $i = \frac{D_2}{D_1} = \frac{50}{175} = 1 : 3{,}5$

Gearbox : $i = \frac{z_2}{z_1} = \frac{24}{12} = 2 : 1$

The shaft mounted on driven gear fitted with propeller. A propulsor or propeller is needed to propel the ship or boat. Its function is to create required thrust T for moving ship at a specific speed v and overcoming the resistance which is applied from water to the ship body. All propulsion devices operate on the principle of imparting momentum to a working fluid in accordance with Newton's laws of motion. The force required to produce the momentum change in the working fluid appears as a reaction force on the propulsion device, which proportional to the thrust produced by the propeller.

Figure 5. Fixed Pitch Propeller

Propeller types and dimensions greatly affect the determination of the propulsion power boats. The commonly used propeller for boat is propeller with fixed pitch (fixed pitch propeller, FPP). FPP is used for a boat with relatively low rpm and high torque, more economical in fuel consumption, and noise or vibration and cavitations is minimal. This kind of propeller usually designed individually so it has special characteristics for

particular boat will have a value of optimum efficiency. Propeller used in this design has two blades with outside diameters up to 8 inch. The steering propeller serves to drive the propellers when direction of boat will be changed.

Results and Discussion

There are two types of test has been performed in measuring the performance of electrical propulsion system that has been designed. The first test is mechanical testing and the second is running test on the water/lake.

Mechanical testing of transmission system has been done trough measuring the rpm using tachometer on the motor shaft, propulsion shaft (gear in) and propeller (gear out) at some inputs voltage of motor. The various input voltage is obtained by rotating the wiper of rheostat from the high resistance side to the low side. Terminal input of motor is connected with voltmeter to measure the input voltage. The data results shows in the following picture.

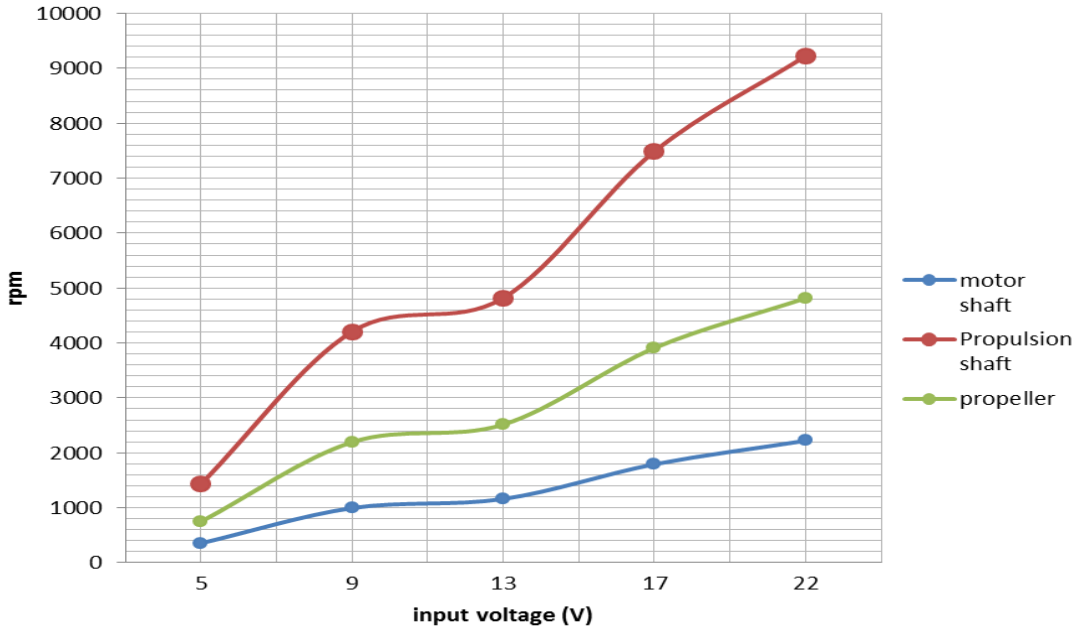

Figure 6. Measurement of RPM

Figure 6 presents the relation of the input voltage to motor DC and the rpm of each shafts of the system. The graph quite clearly shows that the increase of rpm proportionally affected by the increase of input voltage. By using Equation 1, Equation 2, and data results, it can be obtained the average ratio of two types of transmission system, consecutively as follows:

Pulley-belt system : $i = \frac{\bar{n}_1}{\bar{n}_2} = \frac{1392}{5320} = 1 : 3{,}82$

Gearbox : $i = \frac{\bar{n}_1}{\bar{n}_2} = \frac{5320}{2720} = 1{,}96 : 1$

Running test of propulsion system on the water using small boat with the size of 650 cm x 80 cm x 60 cm. The testing has been done by running the boats carry two passengers for a distance of about 100 meters. The time it takes to cover the distance is

measured manually using a stopwatch. The average time to travel 100 meters is about 1 minute or 60 seconds. It means that average speed of boat with electrical propulsion system on water surface is about 1,6 m/s or 5,76 km/hr. As a comparison, the same boat using conventional propeller system (using 5 HP internal combustion engine) can reach the speed od of 2,1 m/s or 7,6 km/hr.

Conclusion

The propulsion boat system using motor DC can be developed to replace the old model using internal combustion engine. This electric propulsion system is built in simple model by using locally available materials. The performance test shows that the average speed can be reached by this propulsion system is about 5.76 km/hr.

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