PROPULSION STIMULUS

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
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CERTIFICATE

This is to certify that the Research work titled PROPULSION STIMULUS: Additional / Emergency power supply for small-load marine vehicles that is being submitted by Aryan Singh, Pratyush Verma and Rahul Singh Pokhariya is in partial fulfillment of the requirements for the award of Bachelor of Technology, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

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Internal Examiner External Examiner

Approval Sheet

This thesis/dissertation/project report entitled PROPULSION STIMULUS: Additional / Emergency power supply for small-load marine vehicles by Aryan Singh, Pratyush Verma and Rahul Singh Pokhariya is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

In recent years, marine transportation has dug its way into the lives of ordinary people and manufacturers with the need of quick & economic transportation system for small goods. Although, marine transportation may have some tempting perks and joys but it comes with a hefty package of complications & dangers as well. A blown engine, a broken shaft, a tethered propeller, or cracked hull, happens to be the few most common complications of a marine voyage. An emergency power supply system for such vehicles, i.e. small-load marine vehicles, turns out to be a must. This dilemma is quite solvable with a simplistic setup that is light enough to be carried in the storage and yet powerful enough to give significant thrust to the boat. This research is, although, a mere prototype of a rendered model but is significant in understanding the dynamics of using an external & portable power supply on small-load marine vehicles. The design of the propeller blade is made with the existing modifications and specifications (Epps et al. 2015). Most of the marine manufacturers focus on improving the efficiency or improving the designs of different sections of the power supply setup such as propeller blade efficiency, weight capacity, outboard efficiency, or material for the propeller blade. This made it even more essential to come up with a power supply system that helps with the variety of emergencies as mentioned above or even act as an additional power supply to those small-load marine vehicles which require a specific amount of thrust to help them avoid any probable calamity.

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Chapter 1 Introduction

1.1 Project background

Similar to automobiles, majority of the small-load marine vehicles / boats use an engine to generate power. They use similar fuels and nearly the same mechanism to transmit the power generated by the engine. In modern times, majority of the boats use outboard motors. An outboard motor is simply an engine with a shell that transmits power to the propeller by means of a crank shaft, a gearbox & a tail shaft (Mishima et al. Nov 1999).

1.2 Research purpose and meaning

This type of power supply system grew rapidly amongst the variety of boats such as fishing boats, dinghy boats, deck boats, Bowrider boats, cuddy cabin boats, centre console boats, trawler boats, game boats, motor yacht boats, runabout boats, wakeboard / ski boats, pontoon boats, etc. As it grew popular amongst a vast variety of boats / small-load marine vehicles, the inevitable drawbacks soon started emerging to the surface. Boat motors came with an interesting set of drawbacks such as the expensive material used for making the propeller blade, propeller wear, novice dry-docking, physical damage, repair requirements, edge chipping, etc. (Mayor HG, Jan 2013)

1.3 Objective of study

Since the discovery of the very first boat (Lawler A, June 2002), researchers have converged their vision on extent of load efficiency of boats, extent of fuel efficiency of boats, or propeller efficiency etc. But when it comes to worst case scenarios, only a handful of studies come up.

An individual whose daily work is on a small-load marine vehicle faces a significant number of challenges such as:

- Abrupt loss of power in both internally or externally powered boats
- Fracture or failure of propeller blade
- Fracture or failure of transmission shaft(s)
- Failure of motor setup while start-up
- Errors in power supply chain.

These hindrances mark the need of the hour for small-load marine vehicles. It is, although, a challenge to overcome all of these interferences in one go or with a single study. Keeping the parameters in mind, an optimal solution would be to have an additional or emergency power supply system. This prototype is designed with the same principles and parameters. An in-depth study is laid out further in this research.

Chapter 2 Literature review

2.1 Introduction

The marine system & equipment manufacturers may not degrade the quality of the equipment they manufacture but they certainly haven't observed these little discrepancies that occur rather frequently in small-load marine transportation systems. These problems may seem little but they are certainly not as the scale at which the small-load marine vehicles are used (commercially & non-commercially) has been increasing since the very beginning. And subsequently a number of obstacles are present in every path. These obstacles need to be taken into concern and worked upon to reduce their impact on the marine voyage. This research is not to bring the flaws of marine industry in the light, rather to enlighten that aspect of this industry which lost its value with time.

2.2 Reviews

1. Marine Propulsion System

A propulsion transmission for a ship having a reversibly driven propeller shaft with a fixed pitch propeller and a torque converter of the single stage and fixed housing type for driving the propeller in the reverse direction. A planetary gear system is provided for driving the ship in a forward direction and a disengage-able friction plate type brake is connected between the transmission housing and the planetary gear system and for forward drive. The brake is engaged to anchor a portion of the planetary gear system to drive said propeller shaft in a forward direction. The brake is disengaged when the torque converter is driving the propeller shaft in the reverse direction. One embodiment of the invention also includes a friction plate type clutch connected between the planetary gear system and the propeller shaft for transmitting power to the propeller shaft in a forward direction when the brake is disengaged.

James B Black, 17 July 1984

2. Wind Turbine Propulsion of Ships

In this paper, the benefits and limitations of wind turbine propulsion of ships are discussed. When designing the wind turbine blades for a wind turbine-powered vessel, the objective is to maximize the net forward force i.e. water propeller force minus the force on the wind turbine. This objective results in a different blade design than that of modern commercial horizontal-axis wind turbines.

- OPTIMAL WIND TURBINE DESIGN

Axial momentum theory Consider a wind turbine-powered ship that is sailing at an angle θ 0 to the apparent wind, the true wind direction relative to the ship course is θ. The wind speed is W and the ship speed is u, which together give the apparent wind speed U. From axial momentum theory (Hansen, 2008), the component of the force on the wind turbine parallel to the ship’s course is given by FW = 2ρaU 2 a (1 − a) Acosθ where ρa is the mass density of air, A is the turbine rotor disk area, and ‘a’ is the axial induction factor.

Blade element theory Blackford’s approach is applied to design the wind turbine blades for a notional wind turbine ship. The apparent wind speed, with respect to the wind turbine powered vessel, is given by U = W (1 + f 2 + 2f cos θ) 1/2, where f = u/W is the ship speed to wind speed ratio.

- FUEL SAVING FOR A NOTIONAL WIND TURBINE SHIP

In the following calculations, a 150 m long ship with the same hull as studied in is theoretically fitted with a four-bladed 39 m diameter horizontal-axis wind turbine for auxiliary propulsion, and set to sail the route Peterhead - Bremerhaven – Peterhead, This route is chosen primarily due to the weather stations in close proximity to the route, for which statistical wind data is available. The route is divided into 8 legs, where the wind data for each leg is taken from the closest weather station.

- ■ COMPARISON WITH WINGSAILS

The fuel saving attained for the optimized notional wind turbine ship is compared with that of a notional ship of the same dimensions, using wing sails instead of a wind turbine for auxiliary propulsion. The maximum possible sail area for a particular ship, is SA = K · D2/3, (34) where D is the volume displacement of the ship, and K is a constant.

Wind turbine diameter vs power output for Vestas’ wind turbines, and ship length vs required propulsive power for scaling of a VLCC hull.

Eirik Bøckmann, Sverre Steen, June 2011

3. SHIP PROPULSION SYSTEM

During the past decade various types of ships have been used in shipbuilding depending on their purposes (ships for special purpose, tankers, passengers’ liner and etc.).Correct choice of propulsion system has to be made in initial designing in order for the ships to achieve their purposes. Electrical propulsion has been recently given advantage over mechanical propulsion, the final choice depending on flexibility, safety, cost, maintenance cost, use of propulsion power, etc. An optimum propulsion system can be chosen taking into account the basic purpose of the ship, as well as the significant parameters. Electrical propulsion implies three levels of conversion: generator - electric motors – static converters. Electrical power sources feeding the propelling shafts can be a storage battery, a combination of diesel generator and a storage battery or combustible cell. Electric generators are driven by means of turbines and diesel-engines (turbo-generator and diesel generator). The so-called combined propulsions have been recently employed. They include an electric motor supplied from a separate source being added to the direct propulsion. This electric motor gives additional power to the propelling shaft, otherwise driven by a turbine or diesel engine. Parameters important for the dimensioning of propulsion engines

Changes in the ship's resistance caused by the change of speed, waves, wind etc. further lead to a change in the propeller's speed and, consequently, the drive power. The ship's propulsion system has to adapt to these changes in load. In order for the electrical propulsion engines to be properly dimensioned, extreme points of engine driving process have to be taken into account. The maneuvering of reversal of the engine, whether it is done for stopping or changing from ahead to astern, is an important consideration concerning the safety of ship while landing, as well as avoiding accidents at sea. While maneuvering or altering the ship's direction the ship has to be slowed down and the ship's mass in motion, the propeller and the shaft's mass, as well as mass of water pressing against the shaft and the propulsion rotor mass, have to be brought to a stop, then reversed in the opposite direction and accelerated. The operational processes required at such maneuvering have been analyzed and various methods for calculating the propulsion system moments in particular stages have been elaborated and developed.

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Chapter 3 Problem description

3.1 Problem description

Abrupt loss of power in small-load externally or internally powered marine vehicles. Fracture or failure of propeller blade in both externally or internally powered marine vehicles. Fracture or failure of power transmission shaft in internally powered small-load marine vehicles. Failure of motor setup while start-up in externally powered marine vehicles. Errors in power supply chain in electrically powered small-load marine vehicles.

Chapter4 Methods & materials

For designing a marine component it is necessary to keep a couple of factors in prime consideration (Mayor HG, Jan 2013). These factors are:

- Corrosion-free materials
- Repair precautions
- Aqueous-rebellious materials
- Cavitation & ventilation specifications in propeller
- Ergonomics
- Aerodynamics & hydrodynamics

The factors mentioned above will be, step by step, put into use in the following study.

Firstly, an electric motor is required. As an engine occupies a hefty volume, also it would require some fuel which will make the setup all the more complex to handle. An electric motor on the other hand would be a fraction of the weight and would only require a battery as a power source. A motor would require some certain specifications, mentioned below:

- Max. 120 amps power draw
- Range ~ 1000 rpm
- Connection slots for a Li-Po battery (standard)

A 3-D representation of the designed electric motor with the transmission shaft is presented as follows:

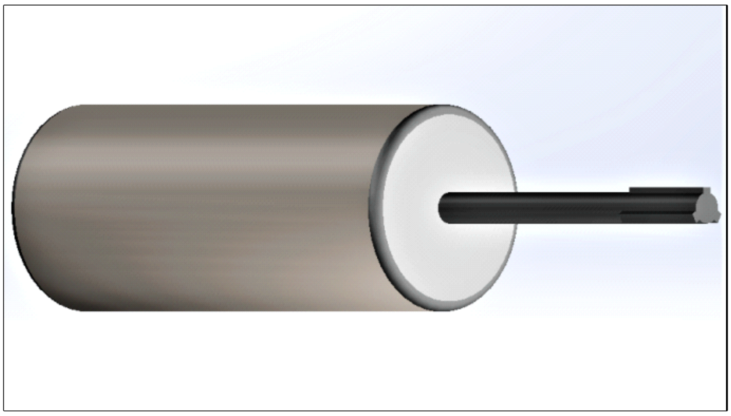

Figure 4.1 Electric motor attached with a transmission shaft.

This electric motor is attached with a transmission shaft which has a customised hub connection for the propeller blade. This customised hub ensures a tight fitting of the propeller blade. Also, to lock the propeller with the transmission shaft either a nut & a bolt or a lock pin is required. A shell is also necessary for this motor before allowing the setup to be used under water. The motor shell is in a capsule form to allow it to overlap the drag created by the water. A 3-D representation of the designed motor shell is shown below:

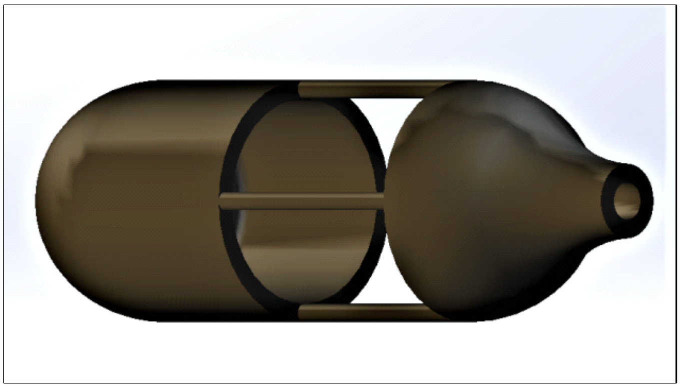

Figure 4.2 Motor shell prototype

The main component of this system is the propeller blade. The propeller blade is carefully designed with the existing standards. Some of the basic and highly important dimensions for a boat propeller are stated below:

- Max. 12 inch. Pitch
- Max. 18 inch. Diameter
- Max. 45 degrees Bend
- Max. 50 degree Twist
- 70 degrees Leading Edge
- 75 degrees Trailing Edge
- 79 degrees Blade Tip

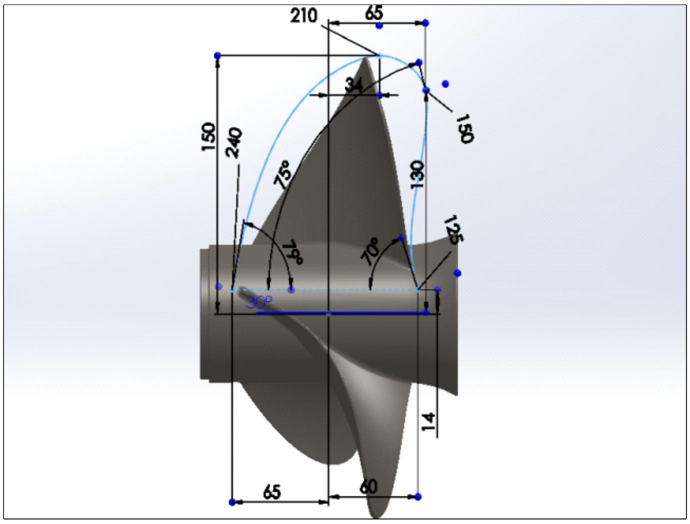

Figure 4.3 Leading edge, trailing edge, blade tip & other dimensions

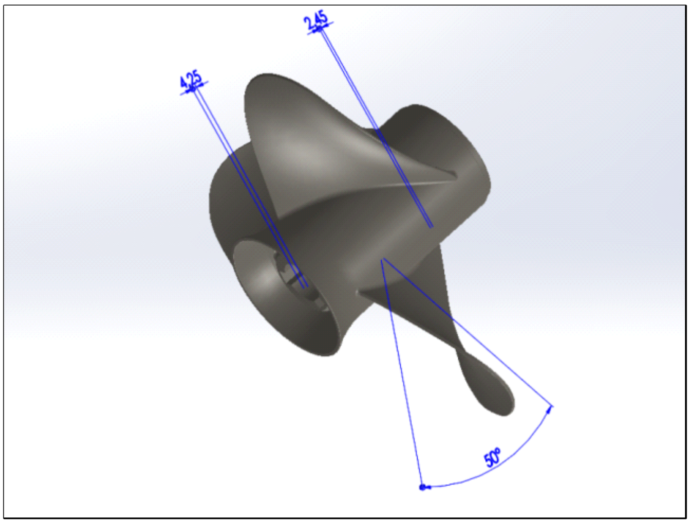

Figure 4.4 Standard propeller blade dimension (twisting)

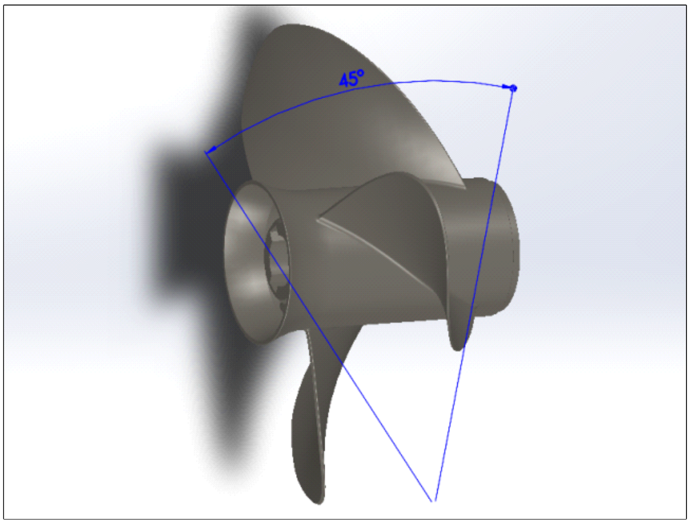

Figure 4.5 Standard propeller blade dimension (bending)

As of now, all the components of the setup are stated and studied. An assembly of these components will give us an illustration of how the actual setup would look. A 3-D representation of the assembled prototype is shown below:

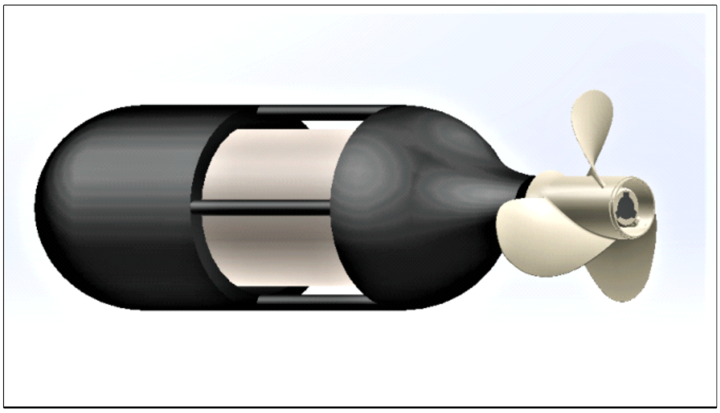

Figure 4.6 Assembled stimulus for additional / emergency power supply for small-load marine vehicles

A simulation for this prototype is illustrated below. The meshing is done keeping the area of application forces as the primary factor.

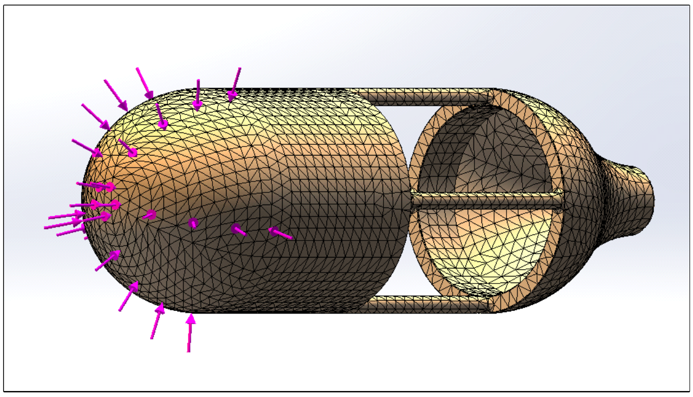

Figure 4.7 Meshed motor shell for the power supply prototype.

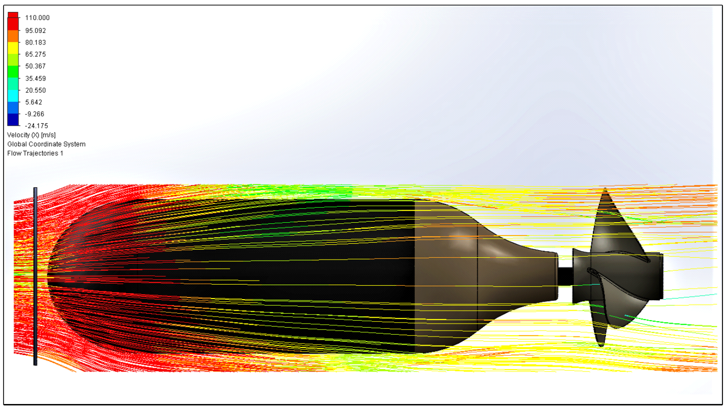

Figure 4.8 Flow simulation of the protoypte at 110 m/s max. velocity

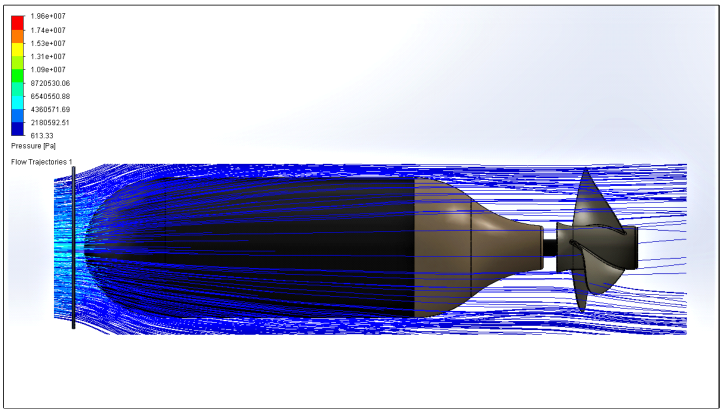

Figure 4.9 Flow simulation of the prototype at 19.6 MPa max. pressure

The flow simulation provides a visualisation of the velocity and pressure distribution on the rendered prototype. The simulation validates the prototype for the water flow under real-life conditions.

All of these components have been designed in rendering software to give an accurate visualisation of the actual components and the assembled stimulus. The materials required for different components are also different as their function differs largely with each other. A study for *material properties* is illustrated below with contrast to the previous works in the same field.

The *electric motor* for small-load marine vehicles is made with the same materials as a normal electric motor (dc) is made in general such as stainless steel casing, aluminium alloys of silicon or magnesium , copper wiring. The only difference being that the motor for small-load marine vehicles requires some lubrication, i.e. a composition of base oil, thickener and additives, to ensure that no quantity of water, that escapes the motor shell, enters the motor & cause any kind of failure in the electric pathway. Although the electric motor is completely sealed with a steel casing, the junction where the transmission shaft is connected to the motor is the only section which holds some amount of clearance. This clearance is then filled by a hydrophobic lubricant which provides both; a sealing from water & alien elements and reduced friction, heat & wear from the motion of the transmission shaft.

The *motor shell* is simple shell made out of light yet strong materials like the widely used aluminium alloys of copper or magnesium. But using these alloys will increase the shell weight significantly. An effective alternate to this is the "ABS (acrylonitrile-butadiene-styrene) or Zeloy which is manufactured by DuPont", as suggested by Sanshagrin S. in her US patent (2007) on outboard motor cowling.

The *propeller blade* is the most important part of the setup as the blade will give the proper thrust to provide the stated function for the objective problem. And for performing this function efficiently the blade needs to be corrosion-free to be operational in sea-water directly which is a corrosion accelerator. As Anish, naval architecture 2020, states that, "The materials used for making marine propeller are alloy of aluminium and stainless steel. Other popular alternative materials used are alloys of nickel, aluminium and bronze which are 10~15% lighter than other materials and have higher strength."

Chapter5 Results

- This may be a probable solution to an emergency power supply to the marine vehicles that might face a blown main motor, jammed propeller blade, faulty or broken shaft etc.

- It may also be used as an additional power supply when a marine vehicle is prone to lose power in the middle of its journey or a marine vehicle with high obstacle hindrance rate.
- It can be put into use at a variety of sites on a marine vehicle depending upon the function it is required to perform such as a small boat stuck in dense mud which is hindering its main motor to not function properly, in this scenario this setup can be used at an appropriate site to get the boat going. And as soon as the setup has played its role it can be ejected and kept in storage for future uses.

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