Career Episode 3

Design and Fabrication of Power-Pole Marine Propulsion Unit

A) Introduction

[CE 3.1] I undertook this Marine Engineering project at MANET, India.

Project Name: Design and Fabrication of Power-Pole Marine Propulsion Unit

Duration: [Date] – [Date]

Location: MANET, Pune, India

Position: Marine Engineering Student

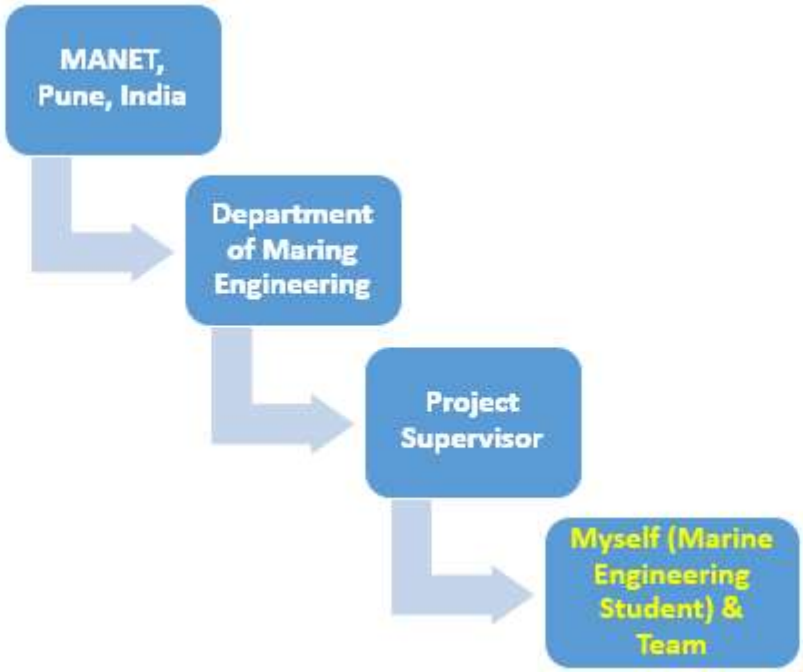
B) Background

[CE 3.2] The ship's heart is the marine propulsion system and its reliability has a direct impact on the determination of the ship's operational cost and safe navigation. The space need, economy, propulsion efficiency, and reliability are the main elements of the system of marine propulsion. The propulsion of marine is a mechanism mainly utilized for moving a ship across the water. Mechanical systems are mainly utilized from most modern ship propellers which consisted of the motors mainly propelled via propeller turning. The power transmission is done from the propeller which converts the rotational motion into the thrust with the pressure difference mainly occur among the rear and forward surfaces of the blade of air-foiled shape which results in accelerating the water behind the blade.

[CE 3.3] The project was the power pole marine propulsion unit design and fabrication which included the selection of materials, methods utilized, drawing of production and the electric propulsion drive components selection. I applied the electric propulsion principle operation along with an electrical power voltage of 220V with the current of 5A while setting the power factor at the 0.89 value which was converted into the 0.75kW mechanical output power. I used the power formula mainly for driving the shaft for the effective power production of 0.5kW for propelling the vessel. I calculated the output powers, forces, and effective power.

[CE 3.4] I worked on the propeller efficiency and applied the effective speed for the electrical motor. I obtained the results which indicated the variations in the voltage range from 220V to 240V as the shaft power and effective power mainly ranged from 0.75 to 0.8 kW.

[CE 3.5] The chart for position illustration:



[CE 3.6] My work responsibilities were:

- I implemented the design based on selecting the materials for the propeller in which alloy of aluminum worked as the main design content.
- I did the mounting of the electric motor which was of 1Hp rating and it was connected on the frame end with the propeller shaft which was connected with the flange usage.
- I applied Marine Engineering understanding for carrying out mandatory calculations resulted in getting the results in terms of output power and propeller speed.
- I analyzed the electrical propulsion system principle in which the propeller motor drive shaft worked at the constant speed.

C) Personal Engineering Activity

[CE 3.7] I designed the propulsion system in which I worked on setting the input conditions which included voltage, current and input power. I obtained the output parameters utilizing my marine engineering understanding which resulted in the efficiencies, losses, power of shaft, and speed determination. I also worked on material selection for the propeller in which aluminum alloy worked as the main design element because of its bending stresses and compressive stress. I selected the shaft which was chrome and nickel in addition to the mild steel. I selected the motor which was manufactured from the industry based on the supported specifications. I also worked on setting the electrical motor drive dimensions. I obtained the motor design main dimensions as shown in the table.

Items	Numbers and weights
Weight stator iron (kg)	10.1
Weight magnet (kg)	11
Outer rotor diameter (mm)	50
Coil pitch	4
Stator diameter	20
No of stator phase	3
Slots/pole and phase	4

[CE 3.8] I analyzed the quasi-propulsion coefficient in which the propulsion system efficiency was calculated as the useful power ratio provided to the system and was defined as follows:

$$\eta_D = P_E/P_D$$
$$= P_E/P_D = (RT \times V)/\omega \times MD = (RT \times V) / (2\pi\, MD\, n)$$
$$= (R \times V)/ (T \times VA) \times (T \times VA) / (Q\, W) \text{ - - - - - - - - -- -}$$

I set the quasi propulsion coefficient and this was utilized for taking into account the overall system shaft line and the stern tube mechanical efficiency. I also included the stern tube efficiency and shaft bearing limits in the propulsive coefficient and mainly defined as:

$$\eta_P = P_E / P_S = (P_E / P_D) \times (P_D \times P_S) = \eta_D \times \eta_S = \eta_H \times \eta_O \times \eta_R \times \eta_S \cdot$$

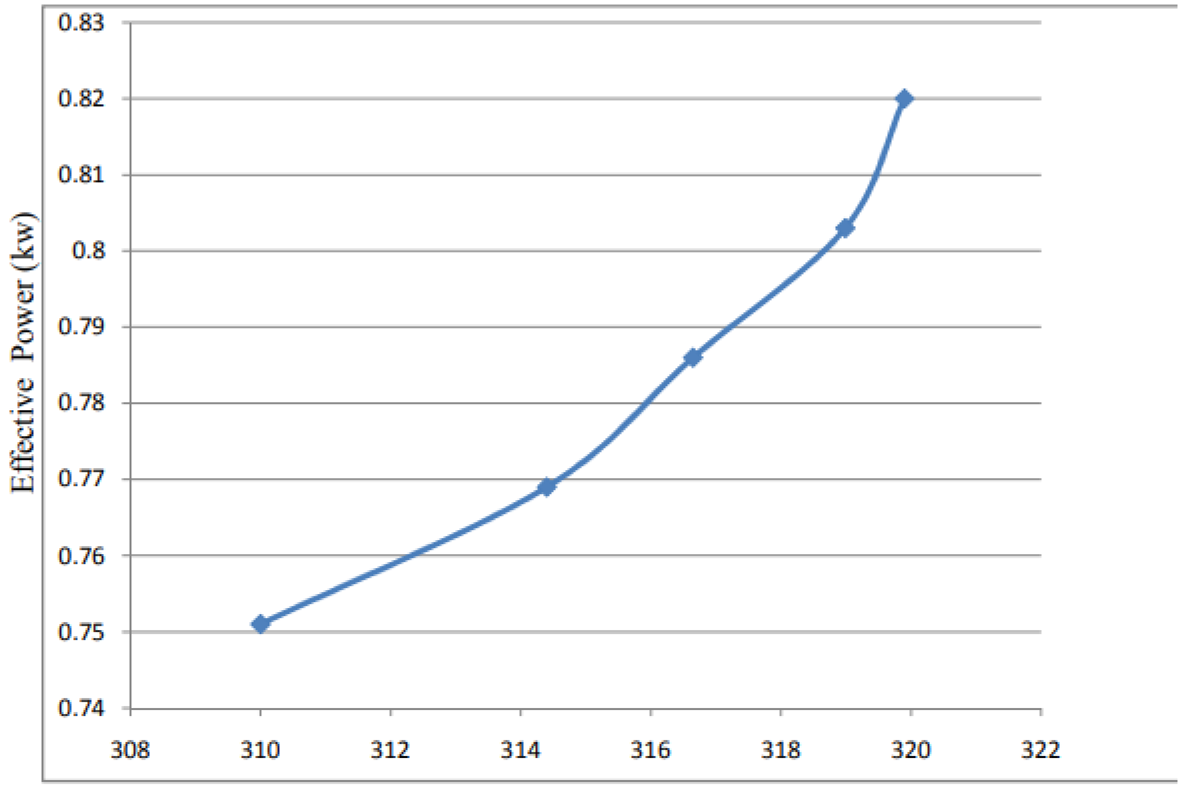
[CE 3.9] I worked on the components assembly on the frame in which the assembling of the components was done to the frame in which there was the inclusion of the propeller shaft, electrical motor drive, nuts, bearings, flanges, and other related components. I mounted the electrical motor with 1HP on the frame right end side and the propeller shaft was connected with the usage of the flange. I utilized the bearings for the tail shaft which were not mainly worked as the stern tube resulted in bearing the limit due to the unavoidable coupling to the vessel. I used the bearing which was similar to the utilized bearings in pumps and the coupling arrangement was based on the flanged mainly integrated with the loosed shaft depending on the requirements. There was the flange that was forged and integrated with the thickness of the shaft and it was based on determining the coupling face concepts. I also worked on the tapered utilizing the concepts related to the marine engineering field. I obtained the flange thickness which was 0.8 times. I worked on the fitting objects with the smooth finishing.

[CE 3.10] I analyzed the electrical propulsion system principle of operation in which electrical motor drives the propeller shaft at the constant speed. I used the electrical motor which resulted in supplying electrical energy to the shaft of electrical propulsion resulted in driving the propeller blade. I researched well on such engine type in which the electric motor drive the propeller shaft turned on in one direction with the system electrical propulsion advent. I worked on the model which resulted in supplying electrical energy of 220V to the prime mover and it converted the electrical power to the mechanical power resulted in giving the motor rotatory motion. I connected the motor to the intermediate point which was for transmitting the energy to the propeller using a shaft and it produced different sources loss like inertial weight and fraction. The output powers and losses are shown in the table underneath.

S/N	SHAFT POWER P = $V_1 I_1 \cos\Phi$ kw	DELIVERED POWER $P_D = P_S \times \eta_S$ Kw	EFFECTIVE POWER $P_E = P_D \times \eta_D$ kw	LOSSES IN SHAFT $P_{D} - {}_S$kw	LOSSES IN PROPELLER $P_E - P_D$kw	SPEED IN PROPELLER n = $\sqrt[3]{(P_D/k)}$ kw
I	0.75	0.729	0.496	0.022	0.233	310.00
II	0.769	0.746	0.508	0.023	0.240	314.40
III	0.786	0.762	0.518	0.024	0.244	316.65
IV	0.803	0.779	0.537	0.024	0.249	318.99

The design complete view is below.

[CE 3.11] I used the electrical motor in the project which consisted of the 1HP output power with the input voltages which varied from 220V to 240V ranges and it was supported with the frequency of 50Hz. It was supplied from the 5A current. I carried out the necessary calculations and obtained the results which showed the output power values, propeller speed, and effective power results. I used the data for plotting the necessary relations among different parameters. I also noted that the increase in the voltage resulted in leading towards the increase in the propulsion system output power with the shaft and propeller transmission losses. I incremented the propeller speed with the shaft and propeller power transmission losses. I obtained the relationship among the propeller speed and the shaft power which resulted in enhancing the power of the shaft led to the enhancement in the speed of the propeller. It indicated the shaft power reduction with the reduction in the propeller speed decrement of the vessel. Moreover, it resulted in the reduction of the propulsion system's effective power.



[CE 3.12] I obtained the hydrodynamic losses which varied significantly and mainly dependent on the CPP operational condition utilized in the direct driven diesel solutions as compared to the varied speed fixed pitch propellers. These were normally utilized in the electrical propulsion and even in low load condition, I followed the thumb rule which indicated that the zero-load hydrodynamic losses for the CPP was equal to 15%. It considered to be zero for the FPP speed controlled unit. I obtained the CPP configuration of the propeller speed which was kept constant on the higher rotations per minute even when the demand of the thrust was zero. I used the variable speed drive which allowed the zero RPM at zero thrust demand. Moreover, I designed the propeller for higher speed transit which had lower efficiency at lowest speed.

[CE 3.13] Problem: The challenging part was carrying out the necessary propeller parameters calculations.
Solution: I implemented the appropriate calculations and attained the work results which mainly indicated the propeller speed, output power values along with the efficient power results. I made usage of the data which was mainly for plotting the results between various parameters.

D) Summary

[CE 3.14] During testing, I incremented the voltage which resulted in leading towards increasing the output power in the propulsion system. I noted the increase in the transmission losses which were with the increase in the output power. I obtained the graph among the effective power against the propeller speed which indicated the varying relation among the two parameters. I realized that the enhancement in the effective power resulted in an enhancement in the speed of the propeller. I also worked on an increased shaft power which led towards the increase in the propeller speed. It resulted in showing that the shaft power was directly related to the propeller speed. Thus, it showed that the shaft power reduction led towards the decrement in the vessel propeller speed and it also worked in the reduction of the propulsion system's effective power.