Design of Software for Calculation and Analysis Engine Propeller Matching

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Abstract. The criteria of a good ship are not only could floating in the sea, but it should have a very complex construction development planning. Longitudinal and transversal strengths, stability, flood, bulkhead, ship motion etc. were interrelated criteria that should be calculated for safety and comfort of the ship, passenger and cargo passenger. Matching point is an operating point of main engine same with the load character of propeller. In another word, the operating point of main engine rotation, where absorbed power by propeller is equal by produced power by main engine, and deliver equal speed with planned service speed. One step in ship design evaluating is EPM (“Engine Propeller Matching”). The lack of available software to analyze relationship between characteristics of propeller with main engine and hull, causing the calculation of EPM (Engine Propeller Matching) takes more time. Java is a very popular application, especially for enterprise application. So, that Java applications can be used to build a programming language of Engine Propeller Matching.

1. Introduction
An efficient ship using main engine to generate power that is able to deliver a speed service as planned. Adji [1] define match point is rotation main engine operating point where absorbed power by propeller is equal with produced power by main engine and generate an equal speed with planned speed service.

Information technology development resulted in computer capability increasing, that allows ship designing process can be done in a relatively short period. This was supported by software development to running a complete numerical analysis such as C++, Java, Vb.Net, Delphi, Fortran, Matlab and others. Steps of design related to one another makes it possible to create a program that have integrated for design so that the evaluation can performed simultaneously.

Java is a programming language for all requirements, concurrent, class-based, object-oriented and designed independently. One of method in java language programming executes a block of statements repeatedly until the specified condition returns false. In general, statements are executed sequentially: The first statement in a function is executed, followed by the second, and so on.

Basically, this study focused on how the combine method for-loop in java to find a match point engine and propeller matching [2].

1.1. Engine propeller matching
In general, ships that move in fluid with a certain speed, will make a resistance force opposite to the direction of ship movement. The amount of drag force that occurs should be able to be overcome by the thrust force of the ship generated from propeller. The power delivered to propeller from the Shaft
Power, while the Shaft Power itself is sourced from the Brake Power (P) which is the output power of the ship's motor [3].

1.2. Characteristics of ships hull
One of the most influential stages in Engine Propeller Matching analysis process is the modeling stage of the ship's design. This is because Ship Body Characteristics have a direct effect on the characteristics of the propeller. This ship's resistance is the inhibitory force of the fluid medium through which the vessel operates at a certain speed. The total inhibitory force is the sum of all components drag force working on the ship.

1.3. General characteristics of propellers in the open water curve
Forces and moments produced by propellers can be described in the most basic form that presented in a series of non-dimensional characteristics. This characteristic is used to describe in general the performance of a propeller [4]. These characteristics are:

   Thrust Coefficient:
   \[ KT = \frac{T}{\rho n^2 D^4} \]

   Torque Advance Coefficient:
   \[ K_0 = \frac{Q}{\rho n^2 D^5} \]

   Advance Coefficient:
   \[ J = \frac{V_a}{nD} \]

   Cavitation number:
   \[ \sigma = \frac{P_0 - e}{\frac{1}{2} \rho V^2} \]

   where:
   \[ D \] = Diameter of propeller
   \[ V_a \] = Advanced velocity of fluid flow
   \[ n \] = Propeller rotary speed
   \[ \rho \] = Fluid density
   \[ P_0 - e \] = Static pressure fluid around propeller

1.4. Hull and propeller interaction
Hull and Propeller Interaction is approach to obtain the performance characteristics of propeller for condition behind the ship. The method is by calculation as following [5]:

\[ T_{ship} = \alpha V_{n}^\lambda \frac{1}{(1-t)(1-w)^2} \]

\[ T_{ship} = T_{propeller} \]

\[ T_{propeller} = KT \rho n^2 D^4 \]
\[ KT = \frac{\alpha V^2}{\rho n^2 D^4 (1 - t)(1 - w)^2} \]  

where:

\( \alpha \) = Constant  
\( t \) = Thrust deduction factor

1.5. Java programming desktop

The Java programming language was originally created by James Gosling in 1995 as part of the Sun Micro system Java Platform. Java syntax is much derived from C and C++ but is simpler and has access to a more limited OS. This is because Java have been intended as a programming language that is simple enough to learn and easy to read. The Java application is written as a .java extension that is compiled into file .class. This .class file is a byte code that works in all Java Virtual Machines, regardless of its OS or processor architecture. Java is a language intended for all needs, concurrent, class based, object oriented and designed to be independent of the environment in which the application is run.

2. Design of System

System was designed to obtain a match point between the hull, propeller and main engine. It is the point where power absorbed by propeller is equal to power produced by main engine and produces the ship speed approaching speed planned. The system of application can be seen in Figure 1. The data that have been collected will be processed, as for the stages in the data analysis include: Presentation of Ship Data, Steps of workmanship, Open water diagram readings, Calculation of total ship resistance, Calculation of power main engine, Propeller characteristics calculation, Engine rotation calculation, Load propeller calculation, Determination engine propeller matching and Engine graph propeller matching [6].

3. Methods

This study begins by entering the type of propeller into the database which will be used in this software. Database storage using Xamp™ and PHPmyadmin™. Coding process method for-loop java using NetBeans™. Result of running process can be seen in the Figure 1. For-loop method process contained in the data input form. The data will be looping are propeller-type, propeller diameter, and speed service. Figure 2 shows data input form.

![Figure 1. Main form](image-url)
4. Testing Application/Software

4.1. Data collection

Testing application/software engine propeller matching begins with input data dimensions of the ship and the selection of methods of calculation of ship resistance to be used. The steps can be seen in Figure 2.

![Form dimension of the ship and the selection of ship counting method of ship resistance](image)

**Figure 2.** Form dimension of the ship and the selection of ship counting method of ship resistance

The process of calculating the total resistance of the ship by the system is pressing execute button and will end with the main machine input form as shown in Figure 3.

![Machine input form](image)

**Figure 3.** Machine input form

On the input form, machine will calculate the characteristics of the main engine to be used during the sailing vessel. The input form of this machine in addition to the characteristics of the engine that was also provided tables for input data gear reduction.
4.2. Output testing results applications software

Output of application/software testing results include:

The calculation of total ship resistance barriers. The total vessel barrier will be displayed by the application in the form of a table based on the variation of the speed covered in the input form. The results of the total ship resistance calculation can be seen in Figure 4.

![Figure 4. Form calculation of total ship resistance](image)

Calculation of propeller characteristics. In the form of propeller characteristics will show the type of propeller that can be installed on the ship. Database application provides 8 (eight) types of propeller type B-series that can be selected that is B335, B350, B365, B380, B440, B455, B470 and B485. The type of propeller to be displayed by the application is a non-cavitation propeller type, have a maximum diameter and has a power that is smaller than the main engine power at the time of operation at the speed service.

![Figure 5. Form characteristic propeller](image)
Engine and propeller matching calculation form displays a match at the operating point where operation of engine power rotation was absorbed by propeller same with power produced by the main engine. The result of calculation is seen in Figure 6.

![Figure 6. Engine and propeller matching.](image)

Form of the Engine and Propeller matching, there are graphics buttons displaying KT-KQ-J chart which will automatically determine the point J (advanced coefficient) which is the intersection between KT propeller and KT ship. The view of graphical can be seen in Figure 7.

![Figure 7. KT-KQ-J Graph form](image)

5. **Comparative Result**
To obtain the validation of the calculation results, a comparison of the calculations results is made. The results of the calculation from application compared with the results of the calculation of ship have been operating. The data can be seen in the Table 1.
Table 1. Ship data

| Ship Name: KM. Sungai 75 |
|-------------------------|
| Ship type               | Car ferries                 |
| Resistance Method       | experiment result from      |
|                        | towing tank                 |
| Propeller type          | B-Series                    |
| Lwl                    | 20.453 m                    |
| Lbp                    | 18.95 m                     |
| H                      | 2.7 m                       |
| T                      | 1.9 m                       |
| B                      | 8 m                         |
| Cb                     | 0.6                         |
| Cm                     | 0.929                       |
| Cw                     | 0.9                         |
| V                      | 11.22 Knot                  |
| Lcb                    | -0.965                      |
| D                      | 1 m                         |

5.1. EHP calculation
Result of comparison of EHP calculation can be seen in Table 2 as follows:

Table 2. EHP Calculation

| Speed (Knot) | Experiment | Software | Difference | Percentage |
|--------------|------------|----------|------------|------------|
| 10.13        | 124.14152  | 131.3765 | 7.23       | 0.07       |
| 11.22        | 247.1784   | 232.8634 | 14.32      | 0.14       |
| 11.63        | 302.69488  | 320.3255 | 17.63      | 0.18       |
| 12           | 365.48036  | 386.6642 | 21.18      | 0.21       |

From the calculation result in Table 2 the percentage difference in vessel service speed is 0.14%. This is due to differences in formulas used by the shipyard and application. Application gives a value of 1 + 20% Resistance on sea margin, while testing shipyard adds 15% EHP to get BHP on service condition.

5.2. Propeller calculation
The result of comparison of propeller calculation can be seen in Table 3 as follows:

Table 3. Propeller Calculation

| Calculation | Prop.Rps | Ae/A0 | Eff. (%) | Trust (kN) | Cavitation |
|-------------|----------|-------|----------|------------|------------|
| Ship yard   | 10.6900  | 0.7000| 0.5311   | 21.8390    | No         |
| Software    | 10.6909  | 0.6999| 0.4600   | 28.3733    | No         |
| Difference  | 0.00070  | 0.0000| 0.0711   | 6.53426    |

From the result of calculation of propeller in Table 3, the percentage of difference that is higher is in the thrust generated by propeller that is reaches 0.06%, while the rotation and propeller efficiency is close to 0%. Based on the calculation Propeller type B-470 can be used because of both calculations of shipyard and application does not occur cavitation.
6. Conclusion

Conclusion that can be taken from this research is as follows:

• Application/software has been able to produce match point between propeller and main engine mounted on ship.
• Using this application in the analysis of engine and propeller matching can reduce errors in manual readings.
• This application can accelerate the calculation and analysis of engine and propeller matching in which 8 (eight) types of B-Series propellers can be calculated/running for ± 60 seconds.

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