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PRELIMINARY ESTIMATION OF SHIP WEIGHT

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ABSTRACT

The balanced evaluation between the ship displacement and the weight components is an important objective of the initial ship design stage. The present paper deals with the new PHP-Ship Weight computer code, developed in the Research Centre of the Faculty of Naval Architecture, "Dunarea de Jos" University of Galati. This numerical instrument is based on parametric models for light ship and deadweight components and is currently being used by students in order to develop their specific knowledge related to the initial design process.

Keywords: ship displacement, weight components, initial ship design.

1. INTRODUCTION

The initial ship design process is very important in order to reach the standard of hydrodynamic performance. The selection of the main dimensions of the ship and the form coefficients is a decisive step, greatly impacting on ship resistance, propulsion and manoeuvring performance. In order to increase the efficiency of the initial ship design, a preliminary hydrodynamic platform PHP was put together in the Research Centre of the Faculty of Naval Architecture, "Dunarea de Jos" University of Galati. By means of the PHP-Ship Dimensions module, the selection and checking of the main dimensions and form coefficients are performed and the displacement equation is verified. Then, on the basis of specific hydrodynamics modules, the ship resistance, propulsion and manoeuvring performances are estimated.

For merchant ships, the displacement Δ is usually divided into the light ship weight Δ_g and the deadweight D_w [1]

$$\Delta = \Delta_g + D_w \tag{1}$$

The light ship weight has the following components [1]

$$\Delta_g = M_c + M_m + M_{ai} + M_\Delta \tag{2}$$

where M_c is the structural weight, M_m is the propulsion system weight, M_{ai} is the outfit and hull engineering weight and M_Δ is the displacement reserve.

The main components of the deadweight are [1]:

$$D_w = M_u + M_{cm} + M_e + M_{re} + M_b \tag{3}$$

where M_u is the payload weight, M_{cm} is the fuel weight including lube oil and fresh cooling water, M_e is the crew and luggage weight, M_{re} is the provisions and stores weight and M_b is the water ballast weight.

The balance between the ship displacement and the weights mentioned above has to be verified by means of parametric models for the weight components ([2], [3], [4], [5], [6]). As a consequence, the new software module PHP-Ship Weight, included in the PHP platforme, was devised.

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The following chapter deals with the parametric models used to estimate the light ship weight components.

2. LIGHT SHIP WEIGHT

The structural weight may be estimated by using the relation [6]

$$M_c = k \cdot E^{1.36} \cdot \left[1 + 0.5 \cdot (C_B^1 - 0.7)\right] \quad (4)$$

where k is the structural weight coefficient [1], E is Lloyd's Equipment Numeral and C_B^1 is the block coefficient calculated for 80% of the ship depth D.

The propulsion system weight is divided into the weight of the main engine M_{mp} and the remainder of the machinery weight M_{mr} [6]

$$M_m = M_{mp} + M_{mr} \quad (5)$$

The first component may be calculated by the following expression

$$M_{mp} = 12 \cdot \left(\frac{P_B}{RPM}\right)^{0.84} \quad (6)$$

where RPM is the main engine revolution and P_B is the brake power, estimated by using the Hansen relation function of the ship speed v

$$P_B = 0{,}0175 \cdot v^3 \cdot D_w^{1/2} \quad (7)$$

The remainder of the machinery weight is estimated by the expression

$$M_{mr} = c_{mr} \cdot P_B^{0.7} \quad (8)$$

where c_{mr} is a specific coefficient depending on the ship type [3].

The outfit and hull engineering weight is computed by means of the relation [6]

$$M_{ai} = C_0 \cdot L_{pp} \cdot B \quad (9)$$

where C_0 is the coefficient of the outfit weight [3], L_{pp} is the length between perpendiculars and B is the ship breadth.

The displacement reserve may be calculated on the basis of the relation

$$M_\Delta = \Delta_g - \left(M_c + M_m + M_{ai}\right) \quad (10)$$

where the light ship weight is the following difference

$$\Delta_g = \Delta - D_w \quad (11)$$

The checking condition of the displacement reserve takes the following form

$$M_\Delta = \left(2\% \div 5\%\right) \cdot \Delta_g \quad (12)$$

The following chapter shows the relations used to determine the deadweight components.

3. DEADWEIGHT COMPONENTS

The payload weight may be calculated on the basis of the cargo deadweight coefficient η_u ([1], [3])

$$M_u = \eta_u \cdot \Delta \quad (13)$$

The weight of the fuel, lube oil and fresh water is given by the sum of the following components

$$\mathrm{M_{cm}} = \mathrm{M_{comb}} + \mathrm{M_{um}} + \mathrm{M_{am}} \quad (14)$$

where M_{comb} is the fuel weight, M_{um} is the lube oil weight and M_{am} is the fresh water weight.

The fuel weight depends on a safe coefficient k_M, the autonomy A and the specific fuel rate b_c

$$M_{comb} = \frac{k_M \cdot A \cdot b_c \cdot P_B}{1000 \cdot v} \quad (15)$$

The lube oil and fresh water weights may be estimated by the following recommendations

$$\frac{M_{um}}{M_{comb}} = 0{,}015...0{,}060 \quad (16)$$

$$\frac{M_{am}}{M_{comb}} = 0{,}05...0{,}20 \quad (17)$$

The crew and luggage weight is estimated on the basis of the relation

$$M_e = m_e \cdot n_{me} \quad (18)$$

where m_e is the mean weight of a member of the crew together with luggage and n_{me} is the crew number.

. The provisions and stores weight is calculated by the expression

$$M_{re} = \frac{m_{re} \cdot n_{me} \cdot A}{24 \cdot v} \quad (19)$$

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where m_{re} is the value of the mean weight on the day of the provisions and stores.

The water ballast weight is the result of the following difference

$$M_b = D_w - (M_u + M_{cm} + M_e + M_{re}) \rangle 0 \quad (20)$$

and must be positive.

4. PHP-SHIP WEIGHT COMPUTER CODE

In order to estimate the weight components of the ship in the initial design stage, the PHP-Ship Weight computer code was developed in the Research Centre of the Faculty of Naval Architecture, "Dunarea de Jos" University of Galati. The flow chart of the code is shown in Fig. 1.

The input data module (Fig. 2) includes: the ship characteristics in the design theme (deadweight, design speed, autonomy and crew number), hull characteristics (displacement, length of waterline, length between perpendiculars, breadth, draught, depth and block coefficient), powering estimation (brake power and main engine revolution) and the specific coefficients of the weight components (coefficient of the remainder of the machinery weight, coefficients of lube oil weight and fresh water weight, coefficient of outfit weight and coefficients of crew weight and provisions / stores weight).

The computation module estimates the weight components of the light ship and deadweight, using the parametric relations described in chapters 2 and 3.

The output data module (Fig. 3) shows the corresponding results and typical diagrams.

The PHP-Ship Weight computer code was added on the PHP software platform and is used in teaching applications carried out in the Preliminary Ship Design Numerical Laboratory in the Naval Architecture Faculty.

5. CONCLUDING REMARKS

The evaluation of the balance between the ship displacement and the weight components is an important objective of the initial design stage.

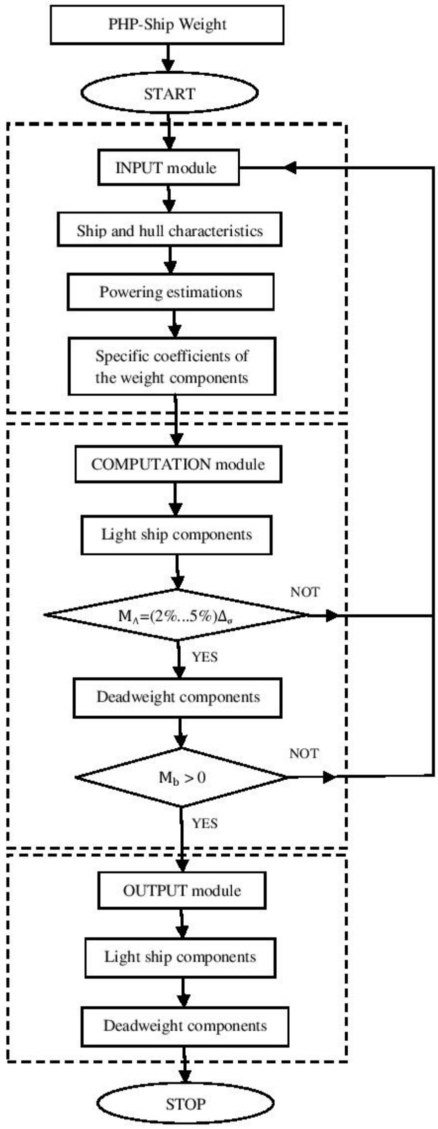

Fig.1. PHP-Ship Weight flow chart

Hence, a new PHP-Ship Weight software module was devised in order to estimate the components of the light ship and deadweight, and to check the conditions mentioned above (12) and (20) for the displacement reserve and the water ballast weight.

The computer code was included in the PHP preliminary hydrodynamic platform.

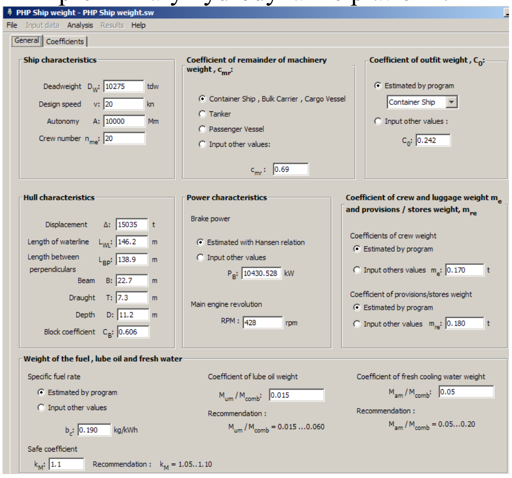

Fig.2. PHP-Ship Weight. Input data

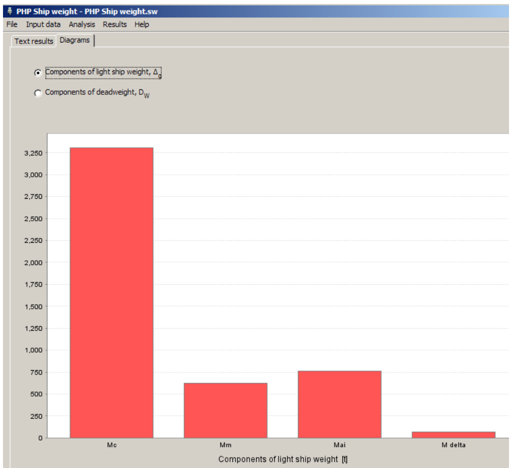

Fig.3. PHP-Ship Weight. Output data

The evaluation of the weight components is based on parametric models.

The new software is currently used by the students of the Faculty of Naval Architecture in order to develop their knowledge on the displacement evaluation and the weight components balance.

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