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Operational Characteristics and Determination of Resistance for Effective Powering and Propulsion of Fishing Boats of Lower Perak River of Malaysia

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ABSTRAK

Kertas kerja ini melaporkan beberapa kajian kes terhadap ciri-ciri rintangan dan kejangan tipikal bot-bot kecil yang digunakan oleh nelayan di hilir Sungai Perak, Malaysia. Matlamat kajian ini ialah untuk menyediakan satu kaedah yang lebih baik dan efisyen bagi menentukan rintangan dan kejangan bagi kuasa dan dorongan yang berkesan bagi bot kecil. Anggaran terhadap ciri-ciri kipas enjin yang sesuai telah dilakukan menggunakan rajah siri SK. Kecekapan proses penukaran kuasa enjin kepada kuasa tujahan yang efektif boleh dipertingkatkan dengan memilih gabungan enjin dan parameter kipas yang sesuai. Kuasa yang diperolehi oleh enjin dalam kajian kes ini didapati berada di antara 6.4 kW hingga 7.4 kW untuk kelajuan kipas 1000 rpm dan 3000 rpm; dan dengan kelajuan bot, Vs = 8.5 knot. Oleh itu nisbah kuasa-anjakan bot berubah daripada 1.28 kW/ton kepada 1.5 kW/ton; bergantung kepada kelajuan kipas. Usaha telah dijalankan untuk memperolehi kuasa enjin dan dorongan yang sesuai bagi bot-bot kecil dengan tujuan untuk mengurangkan kos penggunaan bahan api.

ABSTRACT

The case study of a resistance and propulsion characteristics of a typical small traditional fishing boats of lower Perak River of Malaysia is reported in this paper. The aim of this study is to provide a better or more efficient method of determining the effective powering and propulsion of fishing boats. For the estimation of propeller characteristics, the propeller "SK" – series diagrams were used. The results of the calculations show that the efficiency of the conversion process of the engine power into the effective thrust can be improved by proper selection of the engine, propeller and its parameters. The power requirement of the engine according to the calculation was found to be 6.4 kW and 7.5 kW for the propeller speeds of 1000 rpm and 300 rpm respectively for Vs = 8.5 knots. Thus the power-displacement ratio varies from 1.28 kW/ton depending on the propeller speed. Efforts have been made for proper powering and propulsion of the traditional fishing boats in order to minimize the fuel cost.

Keywords: Fishing boats, fishing gear, propeller characteristics, resistance and powering

INTRODUCTION

The fishing sector plays an important role to national economy. It is most frequently measured by the contribution to GNP, the number of fishermen employed and the nutritional aspects such as annual per-capita of fish consumption and the percentage of protein intake contribution by fisheries products. Fisheries sector contributes approximately 2 % of the gross domestic product of the Peninsular Malaysia. In 1996 the total production from fisheries sector amounted to 1,239,434 tones valued at RM 3.84 billion, while in 1973, the quantity of fish caught was 365,000 tons valued at Ringgit Malaysia, RM 0.884 billion (Department of Fisheries, Malaysia 1996). The aim of this study is to provide a better or more efficient method of determining the effective powering and propulsion of fishing boats. This paper is restricted to consider the traditional fishing boats of the Lower Perak River of Malaysia.

Characteristics of Traditional Fishing Boats

Normally, wooden boats with a variety of size and shape are used for fishing in almost all over the world. However, there is a recent trend in using polymeric-based composite material in building small and medium sized boats Sapura *et al.* (1999). Most often, the boats are grouped into the vessel size, power unit, type of gear and the operating distance from shore. For example, Indonesia classified the boats based on size and whether or not the vessel is mechanized. Thailand's distinction between small-scale and large-scale is based on the type of fishing gear used. In the Philippines, all fishermen using vessels over 3 tons are considered commercial whereas the fishermen using vessels of less than 3 tons are considered municipal fishermen. Hong Kong and Singapore classified the fishing boats as inshore and offshore fisheries. Malaysia takes into account vessel displacement, type of gear used, and area fished (Smith 1983).

Traditional fisheries are carried out in small-scale fishing units. They often consists of kin groups using small and occasionally powered boats. The fishing activity is often part-time, and household income may be supplemented by other activities of the fishermen. Gear, such as nylon netting, which may be made by machines, is usually operator-assembled. It requires minimal or no mechanical assistance to operate. Investment levels of the fishing implements are low. Catch per fishing unit and productivity per fisherman range from medium to very low. Traditional fishing communities are frequently isolated, both geographically and socially, and the standard of living of traditional fishing households is low to minimal.

The major problems that contribute to low income and low standards of living are limited fisheries resources, inadequate or improper uses of fishing implements (boats, engines, propeller, fishing nets etc.) and lack of market power.

Fishing Boats of Lower Perak River

A variety of fishing boats was observed during the case study in the lower Perak River of Malaysia. The fleet strength of the region is approximately 200.

The boats are usually made of locally available wood by local carpenters with their own individual initiative. The construction methods are relatively simple and skills are locally available. The total price of the boat with propulsion accessories is about RM 3000. The main technical drawbacks of implements are that they are based on non-standard design. The cheaper second-hand automobile engines, usually with the gearboxes, are installed. The design of the propeller is not based on standard criteria, the diameter, pitch, efficiency of the propeller are not at all considered. Consequently, each boat is not provided with matching and properly designed propeller resulting in uneconomical utilization of the engine power.

The purpose of study is to find out the power requirement and the optimum propeller parameters to improve the fuel efficiency for the operation of the fishing boats. Analysis is performed on the basis of the hull specification of a wooden boat, which is commonly found in the lower Perak River of Malaysia as shown in *Fig. 1*.

Fig. 1: A typical fishing boat in lower Perak River

a) Hull Specification

The following are the specifications of the hull of a selected fishing boat studied as shown in *Fig. 1:*

Length overall, m L_{OA} = 12.4

Length at waterline, m L_{WL}= 11.0

Breadth at waterline, m B_{WL} = 1.8

Draught, m T = 0.46

Displacement, tons D = 5.0
Speed, knots Vs = 7.5
Hull Form/form coefficient, ~ 0.55 (Anon 1990)
Fishing mode: Trawling net
Boat Class: Traditional rural boat builders (no classification)
The installed Engine of the boat: 3-cylinder Yanmar 25G, Rated Power 20 kW

b) Engine Specifications

During the case study, the authors observed a variety of second-hand, 2 to 4 cylinder engines in similar boat sizes. The rated power of engines was found from 10 kW to 35kW. Thus, boats were found in operation in a wide range of power-displacement ratio (from 2.o to 7). The similar situation was also observed by the other researchers (Overa and Ravikumar 1989) for the traditional fishing boats of Bay of Bengal. In most cases the boats were incorporated with the gearboxes, with the reduction ratio of 3:1. Propeller speed generally ranged from 800 to 1200 rpm. The authors also observed the different types of coupling arrangements from gearbox to propeller shaft. The most commonly used engine models are 3-cylinder Yanmar 25G and 4-cylinder Mazda.

Resistance and Powering

The power required to drive a fishing boat depends upon the resistance offered by the water, air, trawling gear, propeller efficiency, hull shape of the boat and also on means of transmission. The resistance of a boat depends upon multitude of factors such as geometrical configuration of the boat, its speed, properties of water etc. (Mollah and Sarkar 1990; Mollah 1983). Because of the complexity of the problem, it is very difficult to predict the resistance of a small fishing boat accurately. In general, there is no simple solution to this problem. If the resistance and propulsion tests are made with a model of the standard boat, it will be easier to predict the required power for propulsion with sufficient accuracy. However, this type of tests can only be performed in a well-equipped laboratory and may not be economically viable.

Many years of experience of authors shows that estimation of resistance by using the ITTC formulae and by Pampel method give quite satisfactory results (Mollah 1990; Kulagin 1974). Moreover, the total resistance, RT was analyzed for small boats (Mollah and Sarkar 1990) and it was reported that the total resistance obtained by both methods was almost the same up to the boat speed of 6 knots. But at higher speed the value of resistance obtained by the ITTC formulae was 3-5% more than the value obtained by the Pampel method.

This paper considers both methods to predict the resistance of the boat and for powering calculations the higher resistance value was taken to have more power margins for more adverse conditions of the fishing boats.

The total resistance, RT is calculated from the ITTC formulae after estimating the wetted surface area (Kulagin 1974). The wetted surface area was obtained by the following equation:

$$S = [2T + 1.37 (C_b - 0.274) B_{WL}] L_{WL} \quad (1)$$

The value of C_b is 0.55 (Anon 1990) and

$$R_T = C_T \rho \frac{V^2}{2} S \quad (2)$$

C_T is calculated according to the methodology of Kulagin (1974).

According to the Pampel method, the required power to overcome the resistance and the total resistance is calculated by the following equations:

$$N_R = 0.735 \frac{W}{L_{WL}} \frac{V_S^3}{C_P} \frac{K}{\lambda} \sqrt{\Psi_1} \quad (3)$$

K is coefficient that considers the extended parts of the boat and the value of *K* is taken as 1.00 for a single propeller (Kulagin 1974). Similarly λ and ψ_1 were calculated according to the methodology described by Kulagin (1974).

and

$$R_T = \frac{N_R}{V} \quad (4)$$

The total resistance was estimated by above mentioned methods and subsequently the required power, N_E and N_R were also estimated. N_E is the required power to overcome the resistance of the boat and N_R is the required engine power to drive the boat effectively. It may be mentioned here that such calculations of course assume calm water conditions and power margins would need to be allowed for more adverse conditions. Therefore, the prime-mover has to provide 20% extra power margin than is required to overcome the resistance considering the propulsive efficiency. Moreover, the fishing boats are practically always required to operate in conditions which are different from the calm water conditions and the fishing boats often have the power requirements dictated by the trawl gear drag and speed of the trawl. The trawl gears and the trawling speed offer an additional 20% resistance to the boat (Fyson 1985).Thus, a prime mover of fishing boats require a total 40% extra power margin from the calculated one.

Propeller Parameters

The main purpose of the propeller is to convert the engine power into propulsive thrust. The rotational speed of the propeller is the most important factor to increase the efficiency of conversion process of the engine power into thrust. In general, the slower the speed of the propeller, the more efficient in converting the engine power into thrust. But the speed of the engine is too high for a direct drive. Therefore, a gearbox with suitable reduction ratio is one obvious solution for optimum utilization of the engine power and properly selected propeller parameters can improve fuel economy and speed. The larger diameter propeller is more efficient, but not always suitable for installations in small boats due to the shallow draught. Therefore it is better to select a propeller with the maximum possible propeller pitch. The propeller pitch is related to the power available, the reduction ratio used in the gearbox, and the speed of the engine. These parameters have to be assumed together to arrive at a satisfactory combination and to determine the diameter and pitch of the propeller. On the basis of these calculations the optimum propeller parameters were determined. A rough rule for the propeller diameter must be less than two-third of the draught aft (Kulagin 1974).

$$D_{\max} = \frac{2}{3} T_A \tag{5}$$

The propeller diameter and its pitch ratio H/D can be estimated as first approximation by the following equations:

$$D = \frac{\chi}{\sqrt{n_p}} \sqrt{\frac{N_R}{V_s}} \tag{6}$$

The value of coefficient χ depends on the disc ratio and number of blades of the propeller and was determined by using the table 16.2 (Kulagin 1974)

$$\frac{H}{D} = 1.65 \left(1 - 0.11 \sqrt{n_p} \sqrt{\frac{N_R}{V_s^5}} \right)^2 \tag{7}$$

On the basis of this approximate propeller diameter, five values of D were assumed within the range 0.7 – 1.4 times of D (original/initial) and the optimum propeller parameters (Pitch and efficiency) were determined.

For the estimation of propeller characteristics, the propeller "SK"-series diagrams were used (Anon 1990; Voitkunsky *et al.* 1973). The results of the calculations are shown in *Figs. 2* and *3*.

RESULTS AND DISCUSSIONS

Figs. 2 and *3* show the mutual adjustment of power requirements and the propeller characteristics. The curve NR = f (n) is the power absorption at various speeds of the propeller. The power absorption of the propeller increases with the increase in propeller speed. The efficiency of the propeller is less at higher speed due to the excessive circumferancial losses of the propeller.

Fig. 3 shows that the propeller diameter and its efficiency increase with the decrease in propeller speed. The rate of increasing of its parameters is much higher with the decrease in propeller speed at 1000 rpm and lower. Therefore the further reduction of the propeller speed may not be suitable propeller diameter for installation in a small boat due to the shallow draught of the boat. The power requirement of the engine according to the calculation was found to be 6.4 kW and 7.5 kW for the propeller speed of 1000 rpm and 3000 rpm respectively for Vs = 8.5 knots (*Fig. 2*). Thus the power-displacement ratio varies from 1.28 kW/ton to 1.5 kW/ton depending on the propeller speed.

Considering a total of 40% more power margins (Fyson 1985) for more adverse conditions of the fishing boats, the required engine power would be 9.0 kW to 10.5 kW for the propeller speed of 1000 rpm and 3000 rpm respectively. The power prediction approaches of the principal author in his earlier publication agreed with the current result (Mollah 1990). Therefore, a single cylinder or 2-cylinder engine with 10 kW power range may be considered quite enough for the economical operation of the fishing boat. However it may require further study for the clarification of the estimated power requirements for the particular type and size of a boat.

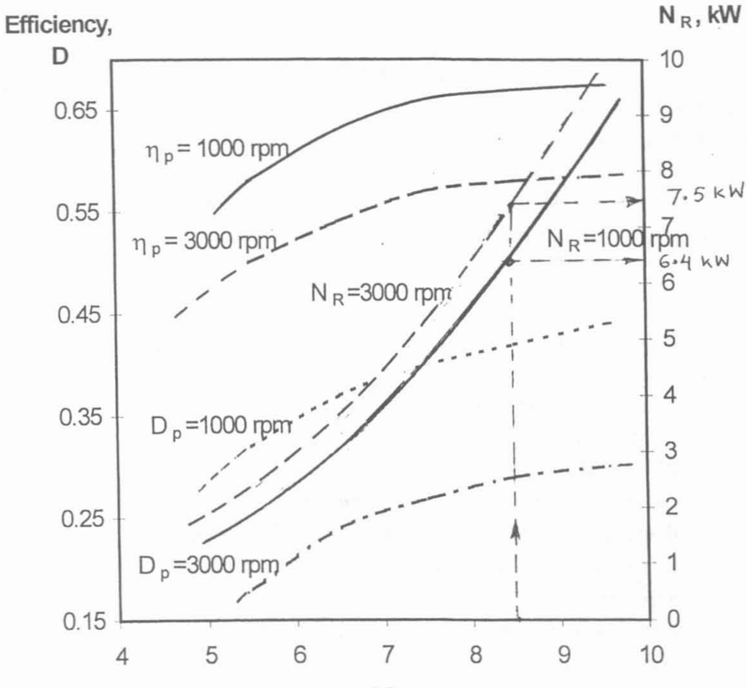

Fig. 2: Mutual characteristics of propeller and boat speed

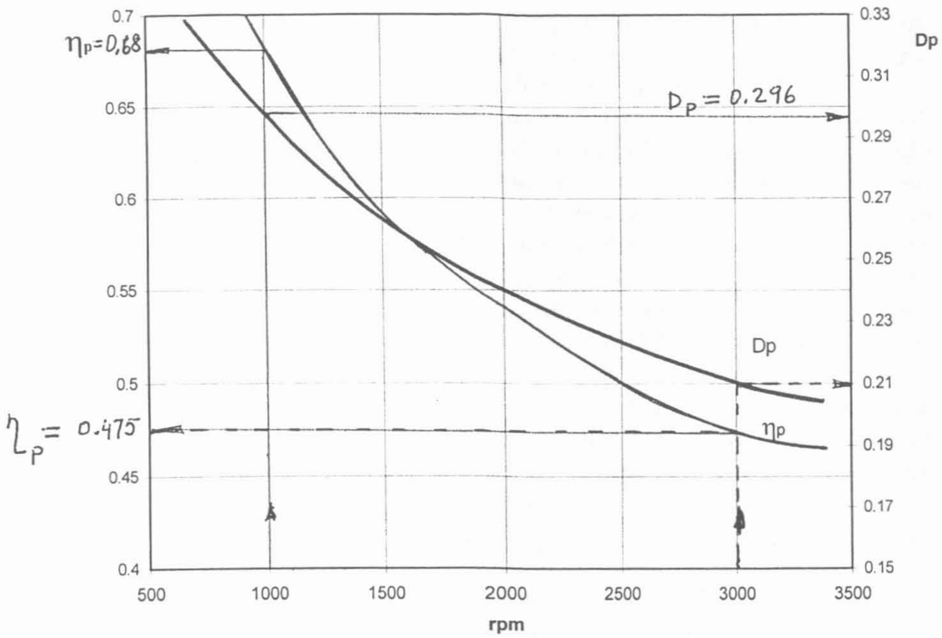

Fig. 3: Mutual characteristics of propeller and engine power

CONCLUSIONS

Proper matching of the engine, propeller and the boat size may improve the operational efficiency of fishing boats. The fishing boats are operating at higher power displacement ratio, resulting in the excessive fuel consumption of engines. Calculations show that an engine with 10 kW rated power may efficiently operate the above fishing boat.

Notations

C_b	Block coefficient
C_T	Total resistance
D	Propeller diameter.
H	Propeller pitch
H/D	Pitch ratio
K	Coefficient that considers the extended parts of the boat
N_R	Required engine power to drive the boat
N_E	Required engine power to overcome the resistance.
n_p	Revolution per minute of the propeller
RM	Ringgit Malaysia (1 USD = RM 3.80)
S	Wetted surface area
T_A	Draught at aft
V	Speed of the boat in m/sec

V_s	Speed of the boat in knots
W	Displacement, ton
χ	Coefficient which considers the length of the boat
ρ	Density of water
ψ	Wake coefficient
η_p	Efficiency of the propeller
λ	Coefficient which considers the overhanging parts

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REFERENCES

ANON. 1990. Yanmar Diesel Engine Instruction Book, Marine, no. 3, Yanmar Diesel Company Ltd., Japan.

DEPARTMENT OF FISHERIES, MALAYSIA. 1996. *Annual Fisheries Statistics,* 1996, Volume 1, Kuala Lumpur: Department of Fisheries Malaysia.

FYSON, J. 1985. *Design of Small Fishing Vessels.* Surrey: Fishing News Books Ltd.

KULAGIN, V.D. 1974. *Theory and Construction of Fishing Boat.* Ship Building, Leningard.

MOLLAH, M.A.H. 1983. Design of Power Installation of Transport Refrigerating Vessels, 9000 Tons Capacity, M. Sc. Engg. Thesis, Astrakhan Technical Institute of Fisheries, USSR.

MOLLAH, M.A.H. and M.A.R. SARKAR. 1990. Powering and propulsion of a country boat. *J. Ins. Eng.* **18(4):** 5-10. Bangladesh.

MOLLAH, M.A.H. 1990. Performance analysis of locally developed gearbox for the country-boats of Bangladesh. *J. Nat. Oceonographics and Maritime Ins. of Bangladesh (NOAMI)* **7(1&2):** 15-20.

OVERA, A. and R. RAVIKUMAR. 1986. Pivoting Engine Installation for Beach-landing Boats, Bay of Bengal Programme, Development of Small-Scale Fisheries, Madras.

SAPUAN, S.M., M.A.H. MOLLAH and M.H. YUNIN. 1999. Marine and shipping applications of polymer–based composites: a review. *Jurutera, Bull. Ins. of Eng. Malaysia* **(7):** 51-55.

SMITH, I.R. 1983. A Research Framework for Traditional Fisheries, International Center for Living Aquatic Resources Management (ICLARM), Manila.

VOITKUNSKY, Y.I, R.Y. PERSIC and I.A. TITOV. 1973. *Handbook of Ship Design.* Ship Building, Leningard.