REDUCE FUEL OIL CONSUMPTION BY MODIFICATION OF PROPELLER

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ABSTRACT

After a certain time of operation, the conflict between Main engine, Propeller and Hull of ships have occurred, it causes decreasing of engine output and increasing the fuel consumption. Thus, it makes ship's operation cost increasing respectively upon age of ships.

For solving this problem, researches have been conducted in Japan. That proved the best solution to reduce fuel consumption of the aged ships is modification of propeller. The modification of propeller of ship can be made in serveral following methods: Diameter cut (avoiding the torque rich by reducing the Propeller diameter), Twisted blade (twisting the blade at each blade root to get reducing of pitch) and Edge cut or Modification of edge.

According to current situation of Vietnam, Maritime Research Institute (MRI) – Vietnam Maritime University (VIMARU) found that Edge cut method would be the most applicable method

This Edge cut method has been applied to the merchant ship Glory Star (16.800 MT) in Ho Chi Minh city (Vietnam) from October 24th to December 24th 2012. As the result, calculating method of the edge cutting amount of propeller's blades upon the actual conflict situation of Main engine, Propeller, Hull and the experiment have been studied, developed and obtained.

Keywords: *Main engine; Propeller; Hull; Output; Fuel rack index; Fuel consumption; Confliction; Blade; Edge; Pitch.*

1. RELATIONSHIP OF MAIN ENGINE - PROPELLER - HULL

1.1 Design point

Designated problem for a ship begins from defining the most basic features, which consists of water occupied volume (equivalent to the cargoes loaded) & its speed. Base on its foundation, a designer starts to draw the curve of hull, calculate resistant, choose engine, propeller & operating modes…

M.E is chosen to assure the suitability between its effective output & thrusted power of propeller, overcoming the resistance & keep the speed of ship. Turning speed of M.E has to be compatible with turning speed of propeller at which the thrusted output reaches largest.

On the power curve particularity N-n, a design point A will normally satisfy following conditions [1]:

- Full loaded ship sailing in normal marine condition;
- At the norm revolution speed n_n Output of M.E reaches at $N = 0.95N_n$
- Speed of the ship will reach the designed value & some other features.

At the design point A, operating mode of M.E (diesel engine) is correlatively at the revolution n_n & fuel rack index (see figure 1).

During the actual operating period, there are many factors affected which make the operating point between Diesel engine & Propeller be not the point A. Combination as initial design does not keep stable & becomes 'confliction'.

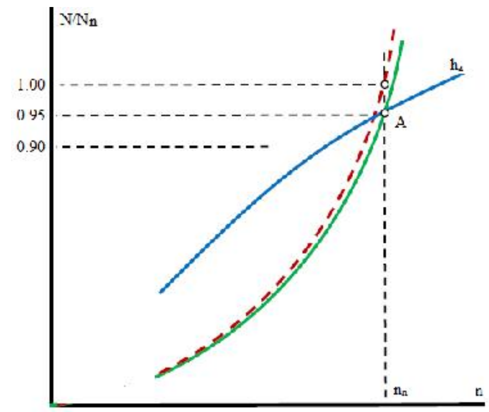

Figure 1 Combined point between Main engine - Propeller in designing

1.2 The loss of M.E's output

Since the technical condition of M.E is decreased, the operating output will be lowered, which means that at the normal operating condition, while keeping the fuel rack index, the engine's output will be decreased. On the graph of figure 2, while keeping the fuel rack index h_a (point A) unchanged, since the output decreased, it makes the turning speed of Propeller be decreased from n_n to n_1 (point B). This fact is described in the figure 2: at point B, the output of M.E provided to the propeller N_b correlatively at the revolution speed n_1. However, at the turning speed n_1 the actual fuel rack index of M.E is not h_b but h_a (point B_1). So, the amount of loss of output is δN (see figure 2). The amount of fuel correlatively with the difference between h_a and h_b (at turning speed n_1) may be understood as the loss of fuel consumption increased [4].

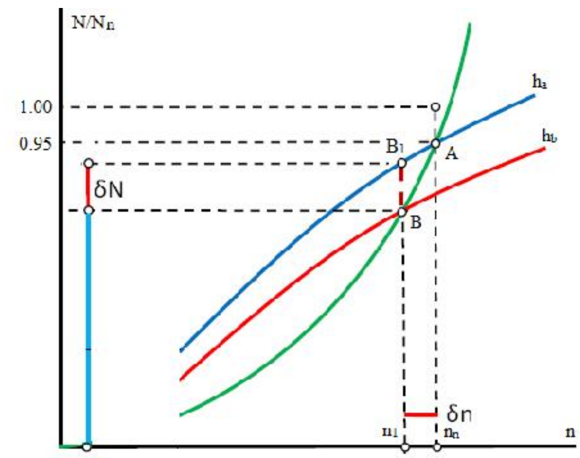

Figure 2 The loss of M.E output

(In fact of operating, correlative to the fuel rack index, engine may generate the output lower due to the inner leakage of Fuel Injection pump & quality of Fuel valve (Nozzle). Therefore, before performing an experiment of evaluating the decrease of output, the quality of Fuel Injection pump & Nozzle should be maintained in advance)

1.3 Heavy Propeller – Hull

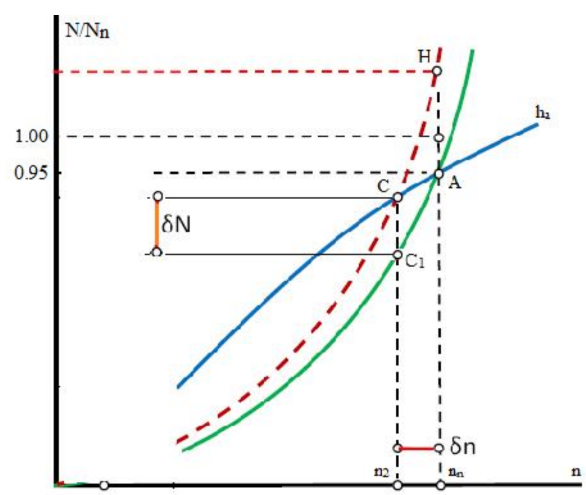

Figure 3 Operating main engine in heavy load or torque rich condition

The state of confliction may happen due to the bad weather condition, the resistance of Hull of the ship increases or Propeller becomes heavier. In these conditions, if M.E is kept operating at the fuel rack index h_a , its turning speed cannot reach the value n_n but can only reach the value n_2 (see figure 3). Comparing to the standard of Propeller's particularity (state of sea trial), the output of engine becomes larger in addition of δN (turning speed decreased around δn).

Operating main engine in this condition is very critical, if the operating revolution is increased, the output & especially the rotating torque will be increased very high (point H, figure 3). In some cases the crankshafts were broken, damaged the gears of gearbox,… & increased the fuel consumptions rather much.

2. MARINE DIESEL ENGINE OPERATION IN VIETNAM

Diesel engines installed on marine ships consist of two types: Propeller driven by Main Engine & Generating Engine driven by Auxiliary Engines. M.E is designed to drive directly or indirectly the Propeller (Fixed Propeller Pitch - F.P.P or Controllable Propeller Pitch - C.P.P). On the Vietnam's ships, about 95% M.Es drive the fix Propellers directly. From the beginning of 2000, there are significant numbers of medium & small newly built ships installed the medium speed engines driving the Propellers via Gearboxes [3].

The basic feature of M.E is that it operates according to curve of the Propeller, where the output used on Propeller is rated by power of three with the turning speed: $N = C.n^x$ ($x = 3$) & using heavy fuel oils (HFO). The most important parameters used to evaluate the operating condition of M.E are the turning speed & the fuel rack index (load indicator).

Most Diesel engines installed on ships in service for more than 5 years are all operated in both decreased & incurred the confliction to Propeller- Hull technical conditions [3].

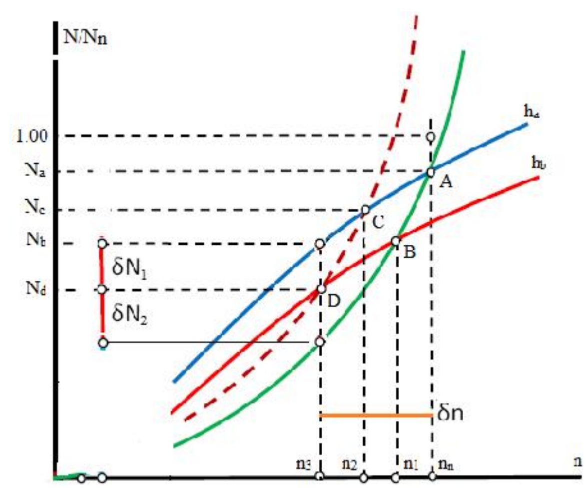

Figure 4 M.E is under output loss & confliction

The impacts concurrently by two factors as described above in figure 4 will move the operating co-operated point to point D (output N_d & turning speed n_3). Moreover, the effect of the fuel consumption is significantly reduced.

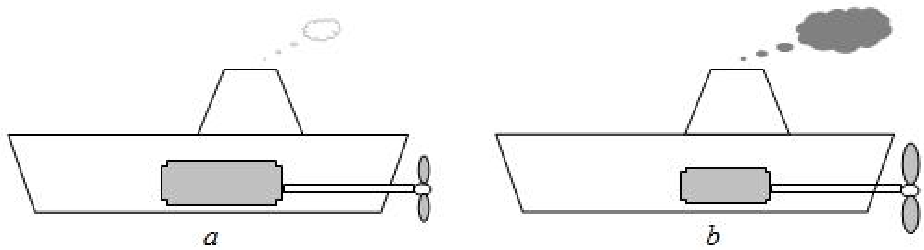

Figure 5 The relation between M.E - Propeller - Hull: a - at design & b - during operating

Phenomena relating to the heavy load (or torque rich) on M.E originated by Propeller - Hull is called the confliction between M.E - Propeller - Hull. If compare this to the initial design, M.E seems to be smaller while the propeller & hull seem to be larger & larger (see figure 5). To protect the engine, the operator often reduces the fuel control handle, therefore the revolution speed & output is decreased.

According to technical reports of some Vietnam shipowners, from year 2007, there is rather much of confliction happened right after launching or after operating in very short time [3].

3. RESEARCH ON CONFLICTION OF M.E - PROPELLER - HULL

3.1 Research in Japan

Researches which targeted to resist the phenomena of confliction between diesel engine-propeller-hull by Kawasaki Heavy Industries Maker, Kobelco Marine Eng., Kamome propeller Co.Ltd., ... [5] applied consist of:

- Diameter cut: this method is aimed to avoiding the torque rich by reducing the Propeller diameter. Due to cut off large amount of blade, it alters the Propeller moment of inertia so widely that it may affect on the Main Engine torsional vibration, and it may decrease the Propeller efficiency largely.
- Twisted blade: twisting the blade at each blade root to get reducing of pitch, by using of special equipment upon heat up at the workshop, had also been taken. This methods has disadvantage of possible residual stress caused by heat given to the material and complicated work to take off Propeller for measurement of blade pitch after the correction.
- Edge cut: with the point aimed at the alternation of Propeller performance caused by the variable shapes on the trailing edge, it has been developed to reduce the Propeller absorbing torque as said the ‘Edge cut’ or ‘Modification of edge’. In this case, it is required to carry out the complicated calculation for the hydrodynamic estimation on the alternation of Propeller performance. Nowadays, such complicated calculation is undertaken by computer within short time and the edge cut method has been undertaken widely.

All results of researches are approved about the quality from Class offices such as Nippon Kaiji Kyokai, American Bureau of Shipping, Lloyd’s Register, Germanischer Lloyd, ... [5].

3.2 Research in MRI – VIMARU

From year 2003, in the program co-operated with Japan (JICA), the officers of Vietnam Maritime University (VIMARU) are approached all the results studied by Japan & got the first step of research relating to the actual matters when operating ships in Vietnam.

Researches of Marine Research Institute (MRI) of VIMARU concentrates on the targets as below [3]:

- Overcome the confliction among M.E - Propeller - Hull;
- Minimize the loss of output of M.E by technical conditions;

MRI builds up steps to target on inspecting & defining the amount of loss of M.E output & degree of heavy load toward the Propeller - Hull. The standard data referred in ‘sea trial’ document is used to compare, evaluate to the actual data. Moreover, the data used to evaluate, calculate is chosen to not have used the complicated measuring equipments. For example: to determine the amount of fuel oil injected in a cylinder in one cycle or fuel rack index instead of measuring the effective output of M.E.

Based on the data measured & calculated above, MRI builds up the below projects:

- Cutting & grinding the edge of propeller’s blades based on the confliction degree;
- Repairing the M.E to restore the output;

4. THE RESULT EXPERIMENTED SIGNIFICANTLY

In August 2012, shipowner K.Marine suggested to MRI researching to build up the plan to resolve the matter of loss output of M.E & confliction M.E - Propeller - Hull for the M/T Glory Star (16,800 MT).
All the major works related to the science project consist of :

- Approaching, handling documents & checking the actual condition of M.E of M/T Glory Star;
- Calculating the amount of loss of M.E output;
- Calculating the degree of confliction M.E - Propeller - Hull;
- Measuring all parameters of actual Propeller;
- Calculating the dimension needed cutting at edges & grinding blades of Propeller;
- Build up the repair project to restore the M.E output.

The contract was done at Hochiminh city (Vietnam) from October 24th to December 24th, 2012 with all related data as below:

4.1 Degree of confliction & amount of loss of M.E output

In fact, operating at turning speed from 470 to 472 rpm, M.E of M/T Glory Star has to be operated under the overload of output ranging from 12% to 15%, include:

- Degree of confliction M.E - Propeller - Hull in range from 7 - 9%
- Amount of loss of M.E output in range from 6 - 7%

Figure 6 M/T Glory Star 16,800 T (K. Marine)

4.2 The Propeller of G.S ship

The Propeller of M/T Glory Star is made by the drawing P-1030-G22 with specifications below :

- Diameter: 4,382 mm;
- Pitch ratio: 0.691;
- Number of blade: 5;
- Material: BRONZE GRASS 4;
- Total weight: 7,327 kg;
- Average pitch: 3,026 mm;

However, after inspecting actual specification of Propeller of M/T Glory Star at SG S.M factory on October 27th, 2012, some differences were found as below:

- The actual weight is more than 8,000 kg if compared to design 7,327 kg
- The actual average pitch blade measured is 3,080 compared to design 3,026

4.3 Modification on propeller

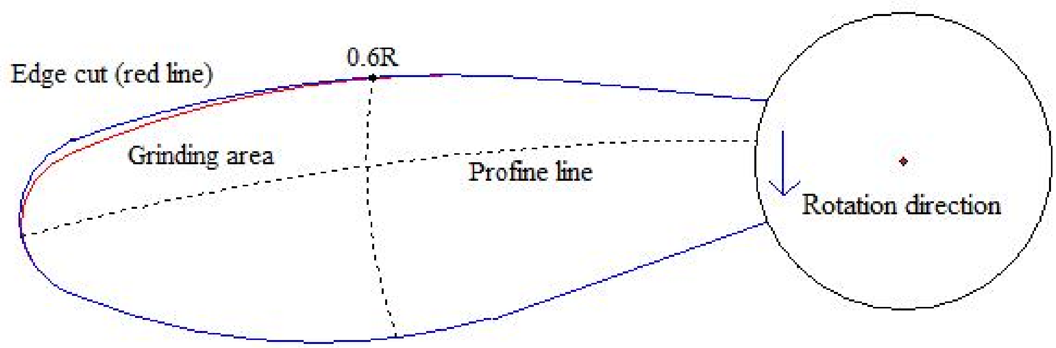

Figure 7 Deploy cutting the edge of propeller's blades

All blades of propeller described in figure 7, with the data relating to the degree of modification defined as follows (see figure 7):

1.1.1 Cutting edge of blade:

- Blade is cut at the area of escape edge (red line), start from 0.6R;
- The cut area got the maximum depth from 47 to 55 mm;

1.1.2 Grinding the blade:

- The area grinded defines at face side, limited by the profile line & cutting edge;
- Deploy grinding from deepest toward from cut edge to line profile;

4.4 Running test

After complete repairing, ship G.S was running test in ballast condition from Sai Gon to Dung Quat & in status of 13.000T from Dung Quat to Sai Gon. Measuring to define all parameters, the below results were found:

- The fuel rack index of H.P Pump reduced 4 - 5

(before: 37 - 39; after : 33 - 34);
- Fuel consumption per day reduced 2.0 - 2.5 MT (before: 17.09 - 17.69 MT; after: 14.37 - 15.16 MT);
- Speed of the ship changed slightly; other features of this ship are normal.

5. CONCLUSION & PETITION

MRI was on its first steps to complete as below:
- Built up the method to calculate the amount of edge cut (cutting, grinding) of propeller's blades depending on the degree of confliction M.E - Propeller - Hull.
- The results of qualitative (before) & quantitative (present) is quite suitable with the experiment.
- Modification of propeller's blades for old ships could improve the operating mode of M.E; reduce the fuel consumption but not decrease or slightly decrease the speed of ships.

6. REFERENCES

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