Journal of Polish CIMAC
Gdansk University of Technology
The Faculty of Ocean Engineering and Ship Technology

STATISTIC DETERMINATION OF MAIN PROPULSION POWER AND TOTAL POWER OF ONBOARD ELECTRIC POWER STATION ON ANCHOR HANDLING TUG SUPPLY VESSELS AHTS SERVICING OIL RIGS

Zygmunt Górski , Mariusz Giernalczyk

Katedra Siłowni Okrętowych
Akademia Morska w Gdyni, ul. Morska 83, 81-225 Gdynia, Poland
Tel.:+48 58 6901324, +48 58 6901307
e-mail: zyga@am.gdynia.pl , magier@am.gdynia.pl

Abstract

The paper presents statistic method of preliminary determination of main propulsion power and total power of onboard electric power station for AHTS (Anchor Handling Tug Supply Vessel) type ships servicing oil rigs. At the beginning a characteristic and classification of AHTS vessels was presented. Also analysis of AHTS main propulsion plants and onboard electric power station was executed. Conventional and diesel-electric propulsion plants were taken into consideration as well as propulsion plants equipped with fixed pitch and controllable pitch propellers. Statistic methods elaborated in Marine Power Plants Department of Gdynia Maritime University make possible in quick and simple way to determine parameters of ship energetic system. Good accuracy of methods is confirmed by coefficients of regression determination and coefficients of correlation. Statistic methods also make possible to forecast the development trends in energetic systems construction of ships, which can be built in the future. Elaborated dependencies of main propulsion power and total power of onboard electric power station are not universal and should be determined separately for every type of ships. In this paper results concerning AHTS tugs servicing oil rigs are presented.

Keywords: *oil rig service tug AHTS, main propulsion power, electrical power, statistics*

1. Introduction

Tug boats are seagoing vessels designed for towing marine objects not equipped with propulsion plant, assisting seagoing vessels during berthing and leaving harbours, assisting vessels during manoeuvres, towing and protecting defected ships, participating in rescue operations etc. Tug boats are commonly driven by diesel engines. Usually the tug boat is equipped with high power engines (from a few to a dozen or so thousand kW) incommensurate with tug boat dimension. It makes possible to achieve very high towing force (from a dozen to even above hundred tons). A serious development of tug boats group has been observed in last years. New types of tugs were constructed according to new tasks often very specialized, for example AHTS (*Anchor Handling Tug Supply*) vessels used for oil rigs maintenance. Objects of analysis are AHTS vessels used for oil rigs servicing. These vessels are fitted for operation at open sea mainly for oil rigs general service. However their versatility make possible also other marine objects service and assistance. The main task of AHTS vessels is oil rigs and other marine objects high accuracy anchor handling (about a few meters). Oil rigs can be fitted with 4 to 12 anchors. AHTS vessels are equipped with two main winches – towing and anchor handling as well as a number of smaller winches and auxiliary capstans. The majority of these vessels are also equipped with dynamic positioning system DP, which makes possible precise approach to objects and keeping a long stay at one position. Many of them are additionally equipped with special deck and engine equipment for example heavy cranes for heavy constructions handling, flat cargo deck, helicopter landing platform, deep water robots, high capacity firefighting pumps, cargo tanks etc. This equipment can perform many additional tasks as follows:

- firefighting,
- heavy objects transport,
- supply of oil rigs and other objects with solid materials (e.g. cement, special mud used as lubricant in drilling works etc.),
- supply with liquid or gas stock (oil, fuel, fresh water, liquid chemicals etc.).

Supplied materials are carried on deck in containers, on pallets, in baskets, in potable tanks and in bulk, whereas oil, fuel, cement, water, drilling mud etc. are carried in built in tanks.

AHTS vessels are usually equipped with multi-engine conventional diesel and diesel-electric propulsion plants. In conventional diesel propulsion the main engine power is delivered to propeller and often also to shaft generators and firefighting pumps.

All AHTS vessels are fed with diesel oil so there the steam is not used and boiler rooms are not installed. Some heaters used on AHTS are electrical type.

2. Analysis of AHTS vessels energetic systems

The target of this research is analysis of main propulsion plants and onboard electric power stations of AHTS vessels servicing oil rigs and elaboration of formulas describing dependencies of main propulsion power and onboard electric power station on basic dimensions of vessel by using statistic methods.

To fulfil these requirements the “reference list” of 28 of AHTS vessels was prepared where basic construction parameters were listed. From construction parameters these ones were analysed which are logically and functionally tight with energy demand for ship main propulsion and ship electric network.

The executed analysis of “reference list” shows that basic construction parameters of AHTS vessels are:

- overall length 65 ÷ 85 m,
- breadth 14 ÷ 18 m,
- draught 4,5 ÷ 7 m,
- bollard pull 100÷200 tons,
- designed towing winch pull usually is two times higher than bollard pull and amounts 150÷500 tons,
- maximum sailing speed when at sea 13÷17 knots,

- main propulsion usually consists of two powerful medium speed diesel engines 2000÷5000 kW each; on the largest 4÷6 medium speed diesel engines are installed; engines drive propellers via reduction gear or operate in diesel-electric system,
- AHTS vessels usually are driven by two controllable pitch propellers (sometimes fixed pitch propellers) working in Kort nozzle,
- due to high power anchor handling winches AHTS vessels are equipped with high power onboard electric power stations; usually they consist of two shaft generators 1500÷2500 kW each and additionally 1÷3 diesel generators 200÷800 kW each; if shaft generators are not installed there are 2÷3 diesel generators; each AHTS vessel is equipped with emergency diesel generator, which is used as port generator when berthing,
- when diesel-electric propulsion system is used 4÷6 main diesel generators are installed 2000÷3000 kW each and one auxiliary generator about 400 kW; each diesel-electric propulsion driven AHTS is equipped with emergency generator about 175 kW.

Fig. 1. AHTS vessel CBO Chiara sailing at sea

Typical AHTS vessel CBO CHIARA is shown in figure 1 [9]. The vessel overall length is 80 m, breadth 18 m, draught 6,6 m, sailing speed at open sea 13 knots. The vessel is equipped with two medium speed diesel engines driving two controllable pitch propellers working in nozzles, two shaft generators 1200 kW each, two diesel generators 350 kW each, one harbour/emergency diesel generator 120 kW, two firefighting pumps capacity 3600 m^3/h each. Dynamic positioning system DP consists of one bow thruster, one rudder propeller and two stern thrusters shown in fig. 2.

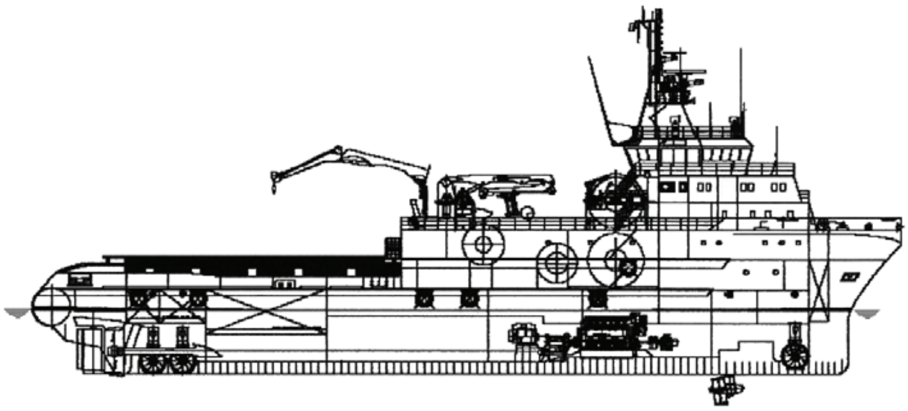

Fig. 2. Longitudinal section of AHTS vessel CBO Chiara.

3. Analysis and determination of main propulsion power

One of the basic parameters of AHTS vessel is bollard pull. During the analysis of AHTS vessels construction it was confirmed that main propulsion power N_w [kW] is the function of bollard pull U [tons] as well as product of hull main dimensions L*B*T [m^3]. Analysis were executed according to linear regression pattern using least squares method. Results are shown in figure 3. High values of regression determination coefficient and correlation coefficient are to be noticed.

As a result of calculations the following formula was obtained:

$$N_w = 751{,}9 + 36{,}15 * U \ [kW] \qquad (1)$$

$$r^2 = 0{,}6908, \quad r = 0{,}8311$$

where: N_w *[kW]* – main propulsion power,
U[ton] – bollard pull.

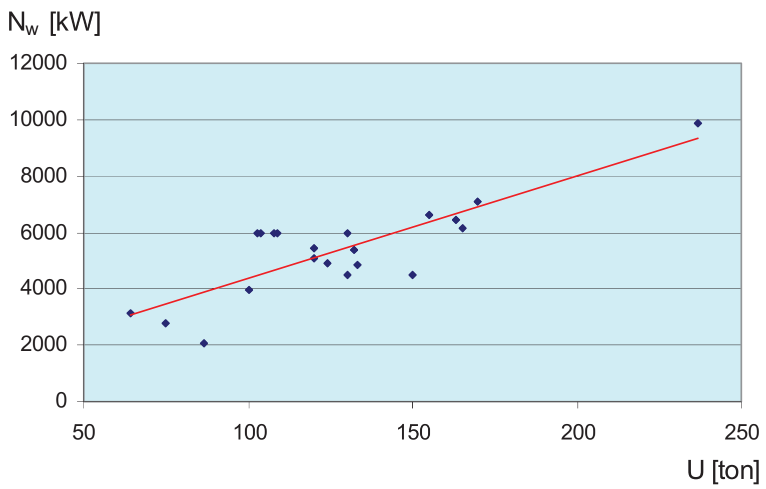

Fig. 3. Linear regression of dependency of main propulsion power on bollard pull N_w=f(U) for AHTS vessels

The second part of analysis was executed to determine dependency of main propulsion power on hull main dimensions. Also in this case analysis were executed according to linear regression pattern using least squares method. Results are shown in figure 4. Also here high values of regression determination coefficient and correlation coefficient are to be noticed.

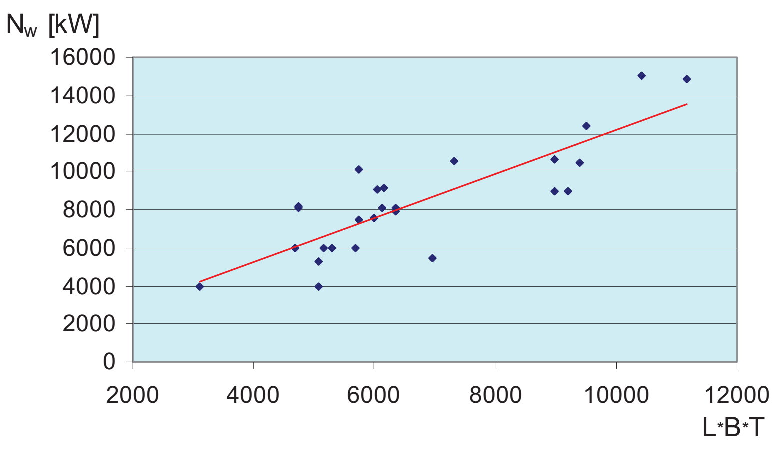

*Fig. 4. Linear regression of dependency of main propulsion power on hull main dimensions N_w= f(L*B*T) for AHTS vessels*

During calculations the following formula was obtained:

$$N_w = 611,5 + 1,161 * (L*B*T) \quad [kW] \qquad (2)$$

$r^2 = 0,7026, \quad r=0,8382$

where: N_w [kW] – main propulsion power,
L [m] – overall ship length,
B [m] – ship breadth,
T [m] – draft.

4. Analysis and determination of onboard electric power station

During the determination of electric power demand for AHTS vessels it was assumed that total power of electric generators (total power of onboard electric power station) is linear function of hull main dimensions. Thus analysis were executed according to linear regression pattern using least squares method. 23 vessels from reference list were taken into consideration. The following formula was obtained as a result of calculations:

$$\Sigma N_{el} = -2189 + 0,839*(L*B*T) \quad [kW] \qquad (3)$$

$r^2 = 7393, \quad r = 0,8598$

where: ΣN_{el} [kW] – total electric power of generators,
L [m] – overall ship length,
B [m] – ship breadth,
T [m] – draft.

Graphical solution of formula (3) is shown in figure 5. High values of regression determination coefficient and correlation coefficient confirm good accuracy of formula (3) and its usability in preliminary calculation of onboard power station.

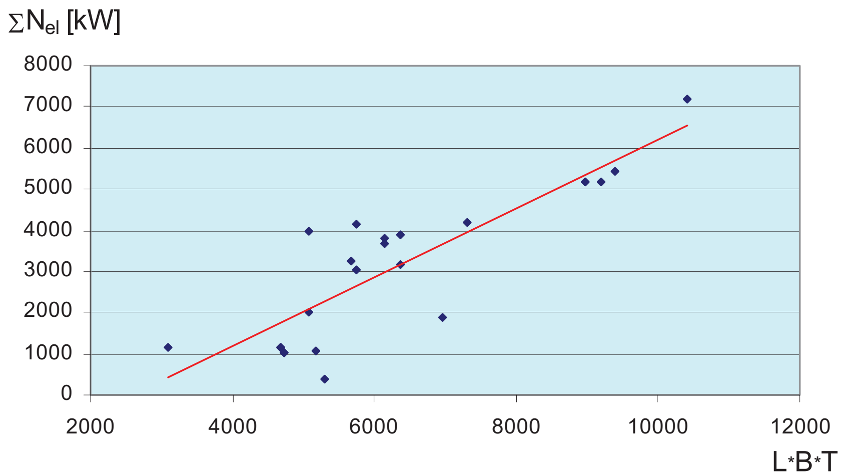

Fig. 5. Linear regression of dependency of onboard electric power station on hull main dimensions $\Sigma N_{el} = f(L*B*T)$ for AHTS vessels

The electric power described by formula (3) does not consist emergency generator. All AHTS vessels are equipped with emergency generator 65÷150 kW frequently used as harbour generator during vessel berthing.

5. Conclusions

Last years due to development of offshore oil industry the demand for AHTS vessels increases. These vessels are also built in Polish shipyards mainly in Remontowa Shipbuilding S.A. Gdańsk.

Contemporary AHTS vessels are examples of vessels equipped with complicated energetic systems including main propulsion and onboard electric power station. Main propulsion engines and electric power generators have incommensurable high power in relation to hull main dimensions. That is why formulas concerning other ship types can not be adopted. In contrary to other ship types in case of AHTS vessel the relation between main propulsion power and ship sailing speed was not observed. It is the result of situation that many additional machines besides thrusters are driven by main engines e.g. shaft generators, winches, dynamic positioning devices, pumps etc. During the operation near oil rig at vessel stay full power of main engines is supplied to these machines.

With reference to onboard electric power station it is not possible to state that total electric power depends on main propulsion power. It is the result of supply of bow and stern thrusters, winches, cranes and many other electric energy large consumers. Main engines also drive many machines, which are not driven by electric motors.

6. References

[1]. Balcerski A., Bocheński D.: *Układy technologiczne i energetyczne jednostek oceanotechnicznych.* Politechnika Gdańska. Gdańsk 1998.

[2]. Draper N.R., Smith H.: *Analiza regresji stosowana*. Warszawa 1973.

[3]. Giernalczyk M., Górski Z.: *Method for the Determination of energy demands for main propulsion and onboard electric power for modern harbor tug boats by means of statistics.* Journal of Kones Powertrain and Transport, European Science Society of Powertrain and Transport Publication, Vol. 19, No. 1, page 147 – 154, Warsaw 2012.

[4]. Giernalczyk M., Górski Z., Kowalczyk B.: *Estimation method of ship main propulsion power, onboard power station electric power and boilers capacity by means of statistics.* Journal of Polish Cimac, Energetic aspects, Vol. 5, No. 1, page 33 – 42, Gdańsk 2010.

[5]. Hewlett Packard : HP-65 Stat Pac 1, Cupertino, California, March 1976.

[6]. Michalski R.: *Ship propulsion plants. Preliminary calculations.* Szczecin Technical University. Szczecin (1997).

[7]. *Unification of ship engine room. Part V. Ship power plant.* Study of Ship Techniques Centre (CTO). Gdańsk 1978.

[8]. Urbański P.: *Gospodarka energetyczna na statkach.* Wydawnictwo Morskie. Gdańsk 1978.

[9]. www.estaleiroalianca.com.br