2025 10th International Conference
on Energy Efficiency and Agricultural Engineering
5-7 November 2025, Starozagorski Bani, Bulgaria

Computational Creation Of The Line Of Operating Modes Of Turbocharger Of Modern Marine Diesel Engines

Hristo Hristov, Hristo Milushev and Milen Bonev

Ship repair Department and Electrical Engineering Department, Nikola Vaptsarov Naval Academy, Varna, Bulgaria
h.hristov@nvna.eu, h.milushev@nvna.eu, m.bonev@nvna.eu

INTRODUCTION

The paper reveals a mathematical description of the processes in a turbocharger with a constant pressure turbine of a marine diesel engine. Turbocharger is investigated when changing the mode factors. The calculation method is indicated, i.e. the smallest deviations method. Standard assumptions are used to maintain the level of accuracy and to simplify the mathematical model.

MATHEMATICAL MODEL OF A MARINE DIESEL TURBOCHARGER WITH ISOBARIC TURBINE

Mathematical model (MM) is implemented with a software product that, based on the input data, draws graphs of the turbine efficiency, the turbine flow characteristic, the compressor flow characteristic, and the compressor dimensionless characteristic. The indicators of the modelling sub-objects are presented in the block diagram in Fig. 1. The aim is to prepare a dynamic model of the turbocharger at different operating modes of the internal combustion engine, i.e. modelling the change in the air parameters after the compressor as a function of the exhaust gas parameters at the turbine inlet, which in turn are a function of the operating mode of the marine diesel engine. The input data for the turbine model are Gg1 [kg/s], Tg1 [K] and Pg1 [MPa] of the gas at the turbine inlet, and some overall dimensions such as diameters, areas, etc. The characteristics of the compressor and turbine can be presented on a single graph axis – Fig. 2.

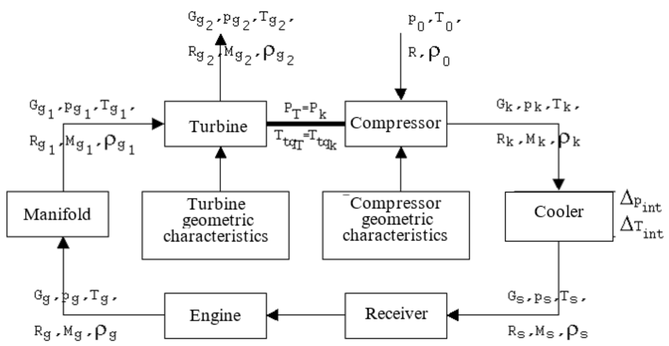

Fig. 1. Model indicators block diagram

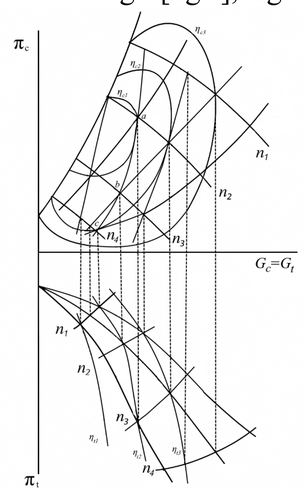

Fig. 2. Coordination of compressor and turbine nominal characteristic

CALCULATION OF TURBOCHARGER USING THE METHOD OF LEAST DEVIATIONS

During the design and in the process of bench tests of the marine diesel engine, situations often arise in which the turbocharger indicators turn out to be different from those expected. To assess these small changes in the turbocharger indicators, the method of least deviations is used. To obtain the equations in small deviations, the algebraic equations of the turbocharger in an established operating mode are used as the basis. In an established operating mode of the turbocharger, it is determined by the following equalities:

$$P_c = P_t;\ n_c = n_t;\ G_c = \frac{G_{g1}}{\beta_t}$$

The expression for the turbine power has the following form after using the method :

$$\delta P_t = \delta G_{g1} + \delta T_{g1} + K_1 \delta \pi_t + \delta \eta_t;$$

$$\delta P_t = \frac{dP_t}{P_t} \sim \frac{\Delta P_t}{P_t}$$

The characteristics of the gas turbine presented in the perimeter of the similarity are as follows:

$$\delta \pi_t = K_2 \delta \bar{G}_{g1} + K_3 \delta \bar{n}_t;$$

$$\delta \eta_t = K_4 \delta \bar{G}_{g1} + K_5 \delta \bar{n}_t;$$

The air flow rate provided by the compressor is determined by expression, and accordingly in the form of least deviations:

$$\delta G_c = \delta P_c + \delta \eta_c - \delta T_0 - K_6 \delta \eta_c$$

The influence coefficients are determined graphically by Fig.3 an have the following form:.

$$K_2 = \left(\frac{\pi_{t1} - \pi_{t0}}{\bar{G}_{g1.1} - \bar{G}_{g1.0}} \right) \frac{\bar{G}_{g1.0}}{\pi_{t0}};;$$

The maximum permissible deviation value δxch, at which the use of the method is permissible, is:

$$\delta x_{ch} = \sqrt{\frac{\Delta max}{N_2}}$$

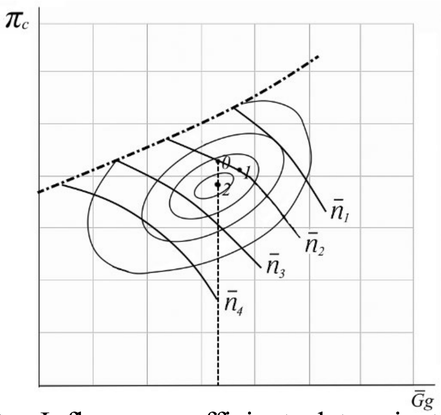

Fig. 3. Influence coefficients determination according to compressor characteristics

CONCLUSIONS

In coordinating the characteristics of turbocharger and diesel engine can be assisted the retrofit, i.e. selection of a turbocharger based on real marine diesel engine when the resource of the old one is exhausted, utilization of available reserve characteristics of the piston part in order to increase the effective power.

The presented MM saves time and resources in the design and research of the common work of marine diesel engine - turbocharger facilitates diagnostics, operation and improves the quality of education.

ACKNOWLEDGMENT

This article was financed by the Ministry of Education and Science under the National Science Program "Security and Defense", carried out in implementation of the National Strategy for the Development of Scientific Research 2017-2030 and adopted by Decision of the Council of Ministers No. 731 of October 21, 2021. The material reflects only the author's opinion and the Ministry of Education and Science is not responsible for the content.