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Energy Control in the Ship's Power Plant and Its Influence on Maritime Safety

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ABSTRACT: In this work the TU (marine transport unit) needs for different types of energy are analysed in order to systematize the equipment of the TU engine room by type of energy produced. The mechanisms that provide TU with mechanical, thermal and electrical energy were identified.
Research on the technical requirements and algorithms for the implementation of major power generation mechanisms showed the dependence of the process of equipment preparation and commissioning on the availability of electricity. Based on the analysis, a hypothesis was adopted on initial electricity generation and guaranteed flow of this energy, which allows guaranteed generation of all types of energy on board and thus ensure safety without emergency navigation.

1 INTRODUCTION

The main factor in the design of a marine transport unit (TU) is at all times to ensure safe navigation and reliable operation of systems and mechanisms on board the TU.

An autonomous marine transport unit as a means of transportation and performing cargo transportation tasks or cruise voyages is equipped with equipment and mechanisms designed for the safety of navigation of the TU and its crew, providing for the energy needs of the TU and the needs of the service personnel who require normal living conditions and food [1]. On board the TU, this equipment and mechanisms are mainly located in the engine room of the TU and this complex in the maritime industry is called the ship's power plant (SPP) [2].

The SPP on a transport unit combines a set of equipment that generates the main energy flows – mechanical, thermal and electrical [3]. The source of energy on board the vessel is natural hydrocarbon fuel – oil refining products. On board, the generators of mechanical energy are the main and auxiliary engines, which can be internal combustion engines, steam or gas turbines.

2 MAIN

The main source of mechanical energy that ensures the movement of the TU is the main engine, the parameters of which are additionally determined by the criteria for ensuring the safety of navigation, the criteria for ensuring the speed characteristics of the vessel, the economic criteria for the operation of the main engine and a number of requirements that ensure normal maritime practice of operating the TU [5, 6].

To ensure preparation for working and operation of mechanical energy generators it are equipped with systems that ensure the operating parameters of the equipment of these generators during the work. Such systems include: fuel system; cooling systems;

lubrication systems; control and protection systems of the generator. It is necessary to note the peculiarity of preparation for operation of energy generators - this is the need for preliminary entry into working mode of the above systems.

Main boiler, auxiliary or exhaust gas boilers are used as thermal energy generators on board of TU. To ensure preparation for work and operation of thermal energy generators, it are equipped, like mechanical energy generators, with systems that ensure the operating parameters of the equipment of these generators during work operation. These are systems: air supply and exhaust gas supply, depending on the thermal energy generator, fuel, supply of the working environment, control and safety protection.

The flow of electrical energy (EE) on board a vessel is provided by a electrical power plant, the average statistical composition of which includes several diesel generators, exhaust gases-turbine generators and a shaft generator (SG) [7]. To ensure the preparation for work and operation of electrical energy generators, it are equipped with systems that provide the operating parameters of the equipment of these generators during work operation. This is the same as for mechanical energy generators: fuel, cooling, lubrication, control and safety protection, electrical energy parameter control systems.

3 RESEARCH RESULTS

Analysis of the structure of the modern ship's engine room as a source of energy flows [4] and the rules for technical operation of the equipment showed that, in accordance with the existing structure of the ship's engine room, for the preparation and launch of mechanical and thermal energy generators, it is necessary to have an EE flow that provides energy to the drive mechanisms and control systems and ensures the operation of the previously mentioned generators. In the existing hierarchy of energy flows on board the ship, the EE flow is primary. The presence of an EE flow on board determines the possibility of preparing all energy-producing equipment for the preparation for work and further control of the operation of energy generators by ensuring the balance of generated flows to external disturbances corresponding to the operational needs of the vessel [3,4]. In operational conditions, this provision on the control role of the EE flow in the vessel's energy supply system corresponds to ensuring the balance of energy flows to the vessel's needs in various modes of its operation while providing the mechanical and thermal energy generators with their operational characteristics due to the operation of automation systems and guaranteed stabilization of the EE flow.

The organization of the flow of EE on board the vessel is schematically shown in Fig. 1. On board the TU, the traditional main sources of the flow of EE are diesel generators and, in the running mode of the vessel, shaft and exhaust gases-turbine generators.

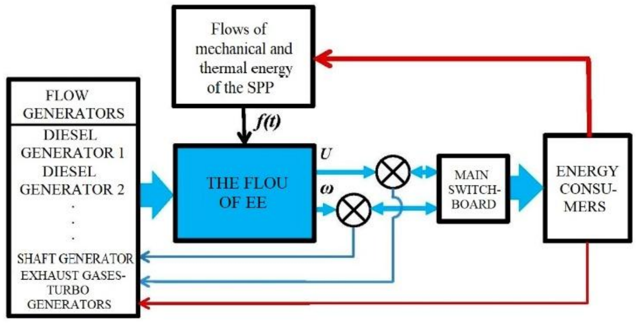

Figure 1. Schematic diagram of the formation of the EE flow;
where: U – voltage in the EE flow;
ω – frequency of voltage in the EE flow;
$f(t)$ – disturbance to the flow of EE caused by changes in mechanical and thermal energies;
– the flow of EE;
– control action of the flow of EE, organized by mechanisms and systems to ensure the balance of energy flows in the operating modes of the TU.

Figure 1.

The main adjustable parameters of the flow of EE are provided by voltage regulators of autonomous generators and speed regulators of drive mechanisms, and on the shaft generator by improving the design of the SG and its control drive, which ensures the maintenance of a frequency of the flow of EE [8].

The potential possibility of providing the flow of EE with the corresponding load current is organized by the automatic systems of the power plant by changing the power of the drive of the electric power generator and, if necessary, by switching the reserve generators to the general flow of energy. The main switch board (MSB) ensures switching of energy consumers and protection of the flow from emergency situations.

In the static load mode on the ship's power system, all flows are balanced and this operating mode does not arouse any particular research or scientific interest.

In transient modes of ship operation, the flows of all types of energy change depending on the actual tasks of the ship and, in accordance with operational needs, the processes that ensure the stabilization of the flow of EE in these modes of ship operation are of interest. This focus of research is justified by the influence of the dynamics of mechanical and thermal flows on the flow of EE and, accordingly, the influence of the flow of EE on the other flows [3,4]. In the basic diagram of the formation of the flow of EE, the dynamic processes of the flows are reflected as a disturbance (f(t) see Fig. 1).

The designers are constantly engaged in research and methods for ensuring the stabilization of the flow of electric power in various operating modes of the vessel, and the use of modern computer technology and new technologies allows for the provision of a reliable flow of electric power. A number of works are devoted to the directions of improving power plants on board the TU [7,8,9].

The use of electronic navigation systems of the vessel, remote automatic control systems, microprocessor systems for monitoring and controlling the operational parameters of the power plant on board the TU requires periodic monitoring and maintenance of this equipment. The methodology for assessing the performance and troubleshooting [10], developed on the basis of experience working with electronic objects and systems, allows for the systematization of testing and troubleshooting in this device.

4 CONCLUSIONS

In the framework of studies on ensuring the safety of navigation and based on the results of the conducted study of the interdependence of the generation of different types of energy on board the TU, a hypothesis was adopted, the essence of which is that the increase in the efficiency of the operation of the SPP in transient modes is carried out by balancing the energy flows of the vessel's operating modes by guaranteed stabilization of the parameters of the electric energy flow. By providing the vessel with a stable flow of EE to external disturbances, the condition of ensuring reliable generation of all necessary types of energy on board the vessel is achieved, subject to the reliable operability of the mechanical part of the SPP, and the compliance of its technical parameters with the required operating modes of the vessel. Thus, by ensuring a reliable flow of EE, the safety of navigation is improved.

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