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Navigation's Safety Improving by Efficiently Analysis of the Ship's Power Plant Energy Flows Interconnection

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ABSTRACT: The operation of an autonomous movable objects, such as a sea transport vessels, implies the presence of a source of potential energy on board the vessel and the possibility of converting this energy into the work required for the autonomous movable object (vessel). Being an autonomous object, a transport vessel should be provided with energy for it moving, energy for heat exchange processes on board and electricity for powering electrical equipment, automation and navigation systems, and household needs on board. An analysis of the component of the engine room equipment made it possible to designate (combine) the generating equipment of mechanical energy flow, equipment which are generating the heat energy flow and equipment which are generating the electric energy flow. Based on the results of the research the relationships between the energy flows are identified connections and ways to ensure stabilization of energy generation on board the cargo vessel is outlined. Using the results of the research the relationships between the energy flows will reduce the likelihood of accidents on board a cargo vessel due to a stop in the generation of one of the energy flows and thereby ensure increased safety of man at sea. Taking into account the peculiarities of the distribution of energy flows in ship power plants can be an effective tool not only to improve the economic performance of it, but also to increase the safety of navigation and navigation in general, due to the reliable provision of uninterrupted and efficient operation of ship power plants.

1 INTRODUCTION

The history of the design of an autonomous movable objects, such as a transport watercrafts (TW) shows that the question of the choice the power plant equipment was posed to designers at all times very sharply [8, 9, 11]. The main parameters that determine the criteria for choosing equipment from the very beginning of shipbuilding are: ensuring all the energy needs of the vessel in all modes of operation; the overall minimization of the costs of the vessel for the period of its operation; the reliability of the operation and maintainability of the equipment. The article [2] presents the results of a study of 4 types of ship power plants for improving the configuration of power equipment according to the above criteria.

2 MAIN

The operation of a transport watercraft (TW) implies the presence on board of energy generators capable of providing energy needs, the bulk of which is necessary for moving the TW – that is energy consumption that occurs during the operational time of the vessel. To ensure this mode of operation of the vessel in accordance with the criteria noted above, a set of equipment is installed on board which includes the main generator of mechanical energy - the main engine (ME), the choice of which is additionally determined by the criteria for ensuring the speed characteristics of the vessel, economic criteria for the operation of the main engine, criteria for ensuring the safety of navigation and requirements ensuring normal marine practice of operating the TW. The article [4] presents the results of using a modern system of modeling and optimization of integrated marine energy systems in terms of energy efficiency, emissions, safety/reliability and costs both in stationary and in dynamic mode. The article presents the main characteristics and the approach to modeling, and the key features are illustrated in two studies on thermoeconomic design and optimization of the combined cycle system for large bulk carriers.

Currently, the main potential source of energy on board the TW is oil refined products (here in after referred to as fuel). All the main modern types of main engines [1, 6], are the technical means for converting the potential internal energy of fuel into the energy which is needed on board.

The Seagoing practice involves the use on board of TW not only the potential energy of oil products but also the potential energy of nuclear decay, solar energy, wind energy and other types of sources currently used in transport.

The practice of introducing nuclear installations into ships is analyzed in article [5]. The authors of the article review past and recent work in the field of offshore nuclear power plants, and for the purpose of demonstration, set out technical considerations for developing the concept of a Suezmax tanker operating on a small-module Gen4Energy 70 MW reactor (SMR). The authors focus on understanding the technical risks and consequences of introducing modern nuclear technologies, which are an important first step in the long-term process of improving energy conversion.

In article [3] is described photovoltaic (PV) systems converts the solar energy falling on them directly into electricity. In this paper, a small-scale ship's bus-tied PV system is proposed. Also, the necessary steps and key components needed to design and build an efficient, reliable and low cost photovoltaic system for TW are examined.

However, the experience of using the above energy sources has not been sufficiently developed as the main source of energy in the fleet for various reasons.

3 RESEARCH RESULTS

Currently, specialized vessels use power plants, the source of potential energy on board of which is nuclear fuel. The power plant of such vessels includes, like the power plant of vessels using oil products as a source of potential energy, mechanical, thermal, and electric energy generators and, from the standpoint of assessing the interconnection of energy flows, the concept of energy conversion is presented in Figure 1 both for ships using the potential energy of petroleum products, and for ships on board which the source of potential energy is nuclear fuel.

The use of oil products as a potential source of energy on TW board is widely used in the transport fleet due to the possibility of ensuring safe storage of fuel reserves on TW board, the development of energy conversion technology that allows you to control the process of energy conversion from the position of the required amount of it, maintainability of energy converting equipment, which determines the durability of this equipment.

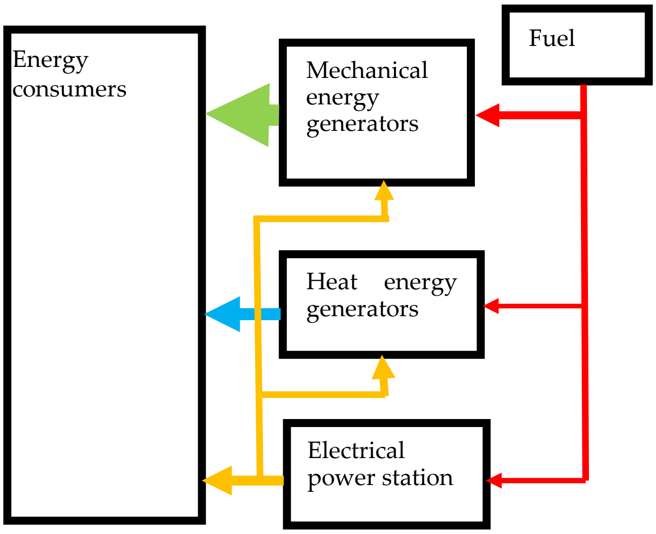

Figure 1. The concept of energy conversion

To ensure the current operation of the TW, it power plant (PP), using the fuel on board and the corresponding energy generators, provides the vessel with (Figure 1):

– mechanical energy generated on board the vessel by the main or several main engines (ME), which ensure the operation of the ship's propulsion and the mechanisms attached to the main engine and auxiliary engines, which ensure the operation of electric energy generators;
– thermal energy generated by special equipment on board the vessel - the main or auxiliary boilers and ME exhaust gases economizer. Thermal energy is necessary to ensure the operation of the TW as a whole and to ensure the life of the crew;
– electrical energy, which provides the operation of mechanical and thermal energy generators, as well as almost all:
– auxiliary equipment of the ship power plant;
– navigational equipment of the vessel;
– devices and household items on board the vehicle.

The issue of obtaining the necessary flow of basic mechanical energy on board has been studied from the very beginning of navigation, and almost the entire marine and propulsion industries continue to deal with this issue. The issues of converting the energy of petroleum products into mechanical energy of rotation of the shaft, internal processes and the design features of the main engines are considered in a number of publication and today in the practice of shipbuilding they have received solutions acceptable enough to ensure the safety of navigation.

In the practice of sailing, the use of thermal energy of steam as the main energy on board the TW was developed when studying the processes of converting the liquid phase of water into gaseous and the development of steam engines that convert thermal energy into mechanical energy used to drive the TW propulsion. Steam, as a workspace of thermal energy, is generated using steam generators by converting fuel into potential thermal energy of steam.

On most modern ships, internal combustion engines are installed as the main engines, due to its universality, and the steam energy during the operation of the TW is used to perform the vessel's production tasks - heating the cargo and fuel, provision the needs of the power plant (PP), generating electricity, and satisfying household crew needs. The practice of equipping a ship's PP with heat-generating equipment shows that on board an unspecialized transport vessel, an autonomous steam generator and a steam generator that uses the energy of exhaust gases exhausted in the main exhaust gas - the "exhaust gas economizer" are usually installed.

The use of steam energy has been developed from the earliest period of the introduction of mechanical propulsion drives in the fleet. At the end of the 18th century, ships began to use steam piston engines and, somewhat later, steam turbines. At the same time, the theoretical basis and technical design of steam generators, which provide the necessary technical parameters of steam for the main power plant and auxiliary needs of the TW, were developed to ensure the highest possible efficiency of converting fuel energy into heat energy. The perfection of the theoretical basis of the processes of converting fuel energy into thermal energy and the technical performance of equipment that produces and consumes thermal energy is confirmed by the long-term practice of operating the fleet.

Introduction of electric power equipment in the fleet. To meet the needs of the TW for electricity (EE), on-board generators are used that generate EE by converting the mechanical energy of the drive engine. The following equipment are used as drive engines for electric generators:

– internal combustion engines and in the practice of sailing, these engines are called "auxiliary internal combustion engines";
– steam and gas turbines;
– drive from the crankshaft of the main engine or propeller shaft.

An analysis of the processes of energy generation on board a transport vessel allows us to present a schematic diagram of the interaction of energy flows in a ship PP (see Figure 2).

The fuel received from the environment (oil refining products), which is a source of potential energy on board the TW, is supplied via on-board systems to the generators of the main types of energy - mechanical, thermal and electrical.

In the main engine, during the operating cycle, the potential energy of the fuel is converted into thermal energy of rotation of the shaft of this mechanical energy generator. In the TV propulsion system, this mechanical energy is converted into work to move the vehicle through the water.

The generation of mechanical energy by the main engine is accompanied by the formation of thermal energy flows - the thermal energy of the exhaust gases and the thermal energy of the ME cooling water.

The thermal energy of the exhaust gases is used in an exhaust gas economizer - a generator of thermal energy - to convert the energy of exhaust gases into thermal energy of steam on the board.

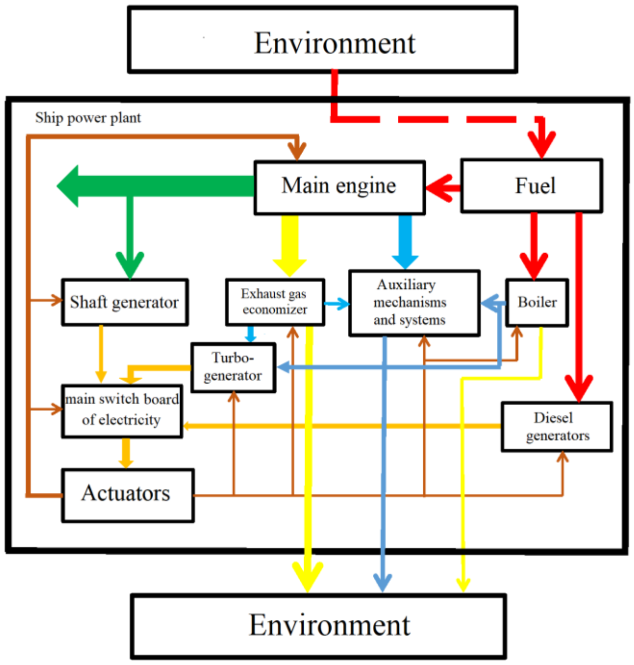

Figure 2. The relationship of mechanical, thermal and electrical energies in a marine power plant

The thermal energy of the cooling water can be used in the ship's fresh water generator and crew life support systems.

The return to the ship's power plant of the thermal energy of the exhaust gases and cooling water allows to increase the overall efficiency of the ship's PP. The magnitude of the increase in efficiency from the utilization of heat energy losses for a ship depends on its characteristics.

The heat flow of energy on board is generated by the boiler (steam generator) and the exhaust gases economizer. The workspace of this flow is steam.

The flow of electrical energy is generated by diesel generators, turbogenerators and a shaft generator and is switched in the main switchboard [7, 10].

There are practically no aggregates and systems on board a modern watercraft whose operation would not be related to electricity consumption.

This is due to the development of power electrical equipment, the use of electric motors as drives, the introduction of power semiconductor electronics, the growth of the introduction of automation of technological processes and computer technology in almost all on-board systems and components.

The introduction of various electrical equipment on board the ship, the total capacity of which reaches tens of thousands of kilowatts, and several megawatts on large ships, necessitated the organization of a shipboard electric power plant (SEPP) on board.

EPP is designed to provide electricity to TW in various modes of operation. The presence of electrical equipment of a different class and power, which ensures the operation of navigation systems, an electronic control system and ensures the safe operation of the vehicle, causes stringent requirements for the quality of electricity produced on board the ship.

4 CONCLUSIONS

Taking into account the peculiarities of the distribution of energy flows in ship power plants can be an effective tool not only to improve the economic performance of it, but also to increase the safety of navigation and navigation in general, due to the reliable provision of uninterrupted and efficient operation of ship power plants.

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