Influence of gas over-expansion in the turbine of a gas turbine unit on its efficiency

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Abstract. The effect of gas over-expansion in the power turbine of the gas turbine unit on its efficiency is considered. The research was carried out on the example of a gas turbine unit that uses an air jet ejector to evacuate exhaust gases into the atmosphere. The obtained results were compared with the efficiency of the simple cycle gas turbine unit, which was calculated for similar input parameters.

Keywords: gas turbine unit; air-jet ejector; gas over-expansion; design features; heat drop.

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EFFICIENCY OF THE FLOATING ELECTRICITY POWER GENERATION WITH DUAL FUEL LOW-SPEED ENGINES

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Abstract. The problem of the efficient electricity production increasing on the floating power plants board is significant actual at present. Low-speed dual fuel engines usage for solving this problem is reviewed. Floating power plants have some advantages: less building and tax cost, flexible, decentralized power generation and mobility and do not require a large site. Until present, medium-speed 4-stroke diesel engines are the main one on these floating power plants. Low fuel specific fuel consumption, reliability, acceptable mass and dimensions allow to taken a leading positions on floating power plants. But unfortunately, medium-speed engines power is not over 20,000 kW and all known floating power plants include from 8 up to 20 of engines for reaching power of 300 MW and more. It makes problems in designing and arrangement equipment in engine rooms, servicing and increasing capital cost. Low-speed dual fuel engines of large power, high supercharging, and low-grade heat recovery allow solve this problem. The technically and economically efficiency of this facility is proved. The advantages of the proposed technical solutions are shown.

Keywords: low-speed engine, dual fuel, waste energy recovery, floating power plant.

1. Introduction. At present, energy management and scientists are forcing implementation of the new ways for decreasing of electricity generation cost [1, 2, 3]. Achieving of this goal is possible, due to decreasing electricity energy the cost and taxes due to high efficient engines usage and waste energy recovery. Floating power plants on the base of medium-speed reciprocating engines [4 – 7] are known. These power plants have certain benefits upon stationary located power generation plants. Floating power stations can take advantage of minimal environmental impact and a small coastal land area is required. The floating power plants require minimum investment risk due to the mobility and adaptability.

The most spread are MAN M&W G and Wärtsilä-Sulzer diesel and duel fuel engines. This engine's efficiency is 0.175…0.190 kg/kWh and high enough. At present, energy market requires a power range of 60 MW up to 400 MW. Its require 8…20 medium-speed engine's. Large quantity of multi-cylinder engines creates certain problems in general arrangement and equipment's services. Fix these disadvantages is possible due to using of more power and efficient engines. The efficient high power low-speed engines have specific fuel consumption in a range of 0.156…0.160 kg/kWh. But, unfortunately, waste heat energy is much significant. Their waste heat is not recovery efficient until now and we cannot neglect these resources usage, especially of high fuel costs situation.

Low-speed engines implementation was been limited by the multipole generators absence, but now started production of industrial applications 30-pole SGen-100A/SGen-1000A series up to 370 MVA [8, 9]. It allows generating and supplying electricity of 50/60 Hz.

II. The results of the research

Last years, an increasing demand has been experienced in diesel engine market for large diesel units for reliable and fuel efficient floating power plants up to 400 MW, based on low-cost gas and heavy diesel fuels [10]. This needs is being satisfied by the modern marine medium-speed diesel generators, and for the high power plants, by two-stroke low-speed diesel engines, the latter capable of burning almost any fuel liquid or gas. This situation made it possible to consider the possibility of two-stroke crosshead diesel engines using for high power floating plants. For instance, example one of the possible options for a circuit diagram for a power floating complex based on a low-speed two-stroke crosshead duel-fuel engines Sulzer 14RT-flex-96C with MCR power of 80.0 MW. The simplified diagram of a power facility is shown in Fig. 1. Every engine equipped by 4 ABB TPL type turbochargers with two-stage SAC scavenges air cooling system and auxiliary blowers for air supplying at low load operation. Engine's load is 30-pole electricity generator, which provides current of 50/60 Hz with efficiency 0,975. All blocks and elements in the diagram are shown conditionally and do not claim to be accurate design.

Efficient for this design seems to be the choice of two generator units. Engines are combined with common circulation system, cooling the cylinder block and supercharging air. Exhaust gas from 14RT-flex-96C engine has significant more energy resources then its turbocharger needs that are why gas flow from outlet manifold separated on two ways: one part inlets to turbocharger and rest one inlets to gas-turbo-generator. Further low-grade heat recovery with boiler is inefficient on the floating power station board, and vessel own heat needs is supplying by waste heat from combined cooling system.

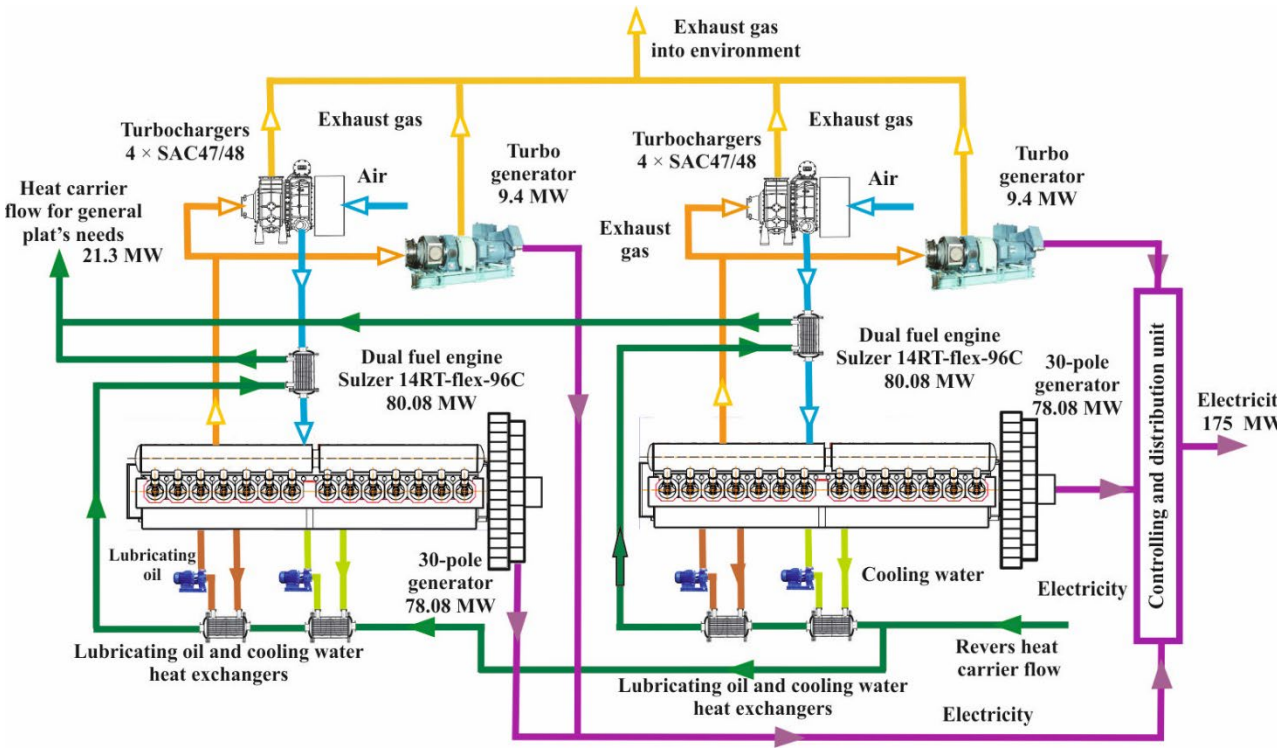

Fig. 1. The simplified diagram of a floating power station equipped with dual-fuel engines

The results of mathematical modeling determined the electricity power of gas-turbo-generator as 9.4 MW and total installation power increasing up to 87.48 MW from one unit, and total electricity power is reaching 174.96 MW. It allows to increased total engine's efficiency up to 0.557, and specific fuel consumption 0.151 kg/kWh at MCR and R1 point, accordantly.

The specific cost of low-speed engines is 350…360 $/kW and some higher compared to medium-speed engines 260…270 $/kW [11], but total energy production efficiency is higher due to higher fuel efficiency and service life. Dual fuel two-stroke low-speed engines can be successful used for floating power plants, for instance, modern X52DF, X62DF series have good basic engine's data, as well [12]. Perhaps, it is possible to apply 12X92DF engine with power up to 63.8 MW [13], but its crankshaft revolution is 80 rpm only and is not enough for 50/60 Hz electricity generation.

Further decreasing electricity production cost is possible due to artificial diesel fuel usage. For instance, diesel fuel of wide fractional content as result of plastic waste processing with properties closed to IFO 180 [14]. Increasing engine's efficiency may be reached due to small hydrogen additives amount to conventional fuels [15]. Efficiency growth up can be achieved due to usage a thermochemical systems with metal-hydrides for low-grade waste heat recovery [16].

III. Conclusions

Floating power plants are efficient facilities for electricity supplying coast and riverside areas. These power plants have advantages instead of stationary generation: less capital expanses, mobility, small position area, friendly to environment and less energy cost. Low-speed dual-fuel engines are effective enough for floating power plants design and creation. Engine's type and total floating plant power are chosen in according with regional electricity needs and different fuel supplying possibility. We certainty presented concept of floating power plant should be effective for electricity generation for coast and riverside regions.

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ПЕРСПЕКТИВИ ТА ПРОБЛЕМИ ВИКОРИСТАННЯ БІОПАЛИВА В ДИЗЕЛЬНИХ ДВИГУНАХ

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Аннотація: Дизельні двигуни визначаються відносно високим рівнем викидів шкідливих речовин. Одним із варіантів використання даного типу двигунів є перевід їх на альтернативні палива з відновлювальних джерел енергії - рослинних олій. До переваг рослинних олій відносять те, що при попаданні на землю вони через пару тижнів розпадаються. Завдяки незначній кількості сірки в рослинних оліях у відпрацьованих газах двигуна практично відсутні оксиди сірки. До позитивних екологічних факторів можна віднести зниження викидів в атмосферу оксидів азоту (NO_x), оксиду вуглецю (CO) та сажі (C). У статті представлені результати експериментальних досліджень щодо визначення ефективних показників при роботі на соєвій олії дизельного двигуна 6ЧН 26/34, що входить до складу стаціонарного дизель-генератора ДГА-900.
Ключові слова: дизельний двигун; дизельне паливо; максимальний тиск; температура відпрацьованих газів; викиди токсичних компонентів.