RESEARCH ON INFLUENCE OF CONDITION ELEMENTS THE SUPERCHARGER SYSTEM ON THE PARAMETERS OF THE MARINE DIESEL ENGINE

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Abstract

This paper presents the issues related to the impact of the technical condition elements of the turbocharger system on the parameters of marine diesel engine. Turbocharger system, in addition to the injection system has a significant impact on the quality of the working process, the economics and reliability of the engine.

Contamination of elements of the turbocharger system are the most common faults (24.7% of all damage to marine engines).

Contamination the following relates to elements: air filters, compressor, air cooler, scavenging system elements and turbine. The detailed data follows that the contamination are usually in: flow channels supercharger – 56%, turbine flow channels – 22%, air cooler – 11%, air filter – 6%, scavenging system elements – 4%, other elements – 1%. The technical condition influence of air filter, compressor and air cooler was analyzed.

The analysis was supported by the results of their own research, carried out in the laboratory on the marine diesel engine, four– stroke 3AL25/30 SULZER, supercharged turbocharger VTR160N Brown Boveri. The research was performed in the form of an active experiment to simulate contamination of particular elements of the turbocharging system. Technical condition change of the air filter, the air compressor and the air cooler have been investigated.

Keywords: *ship diesel engine, turbocharger system, active experiment, air filter, compressor, air cooler*

1. Introductions

Marine engines, both main propulsion and auxiliary are turbo-charged. Charging system, in addition to the injection system has a significant impact on the quality of the working process, the economics and reliability of the engine.

A naturally aspirated engine draws air of the same density as the ambient atmosphere. Since this air density determines the maximum weight of fuel that can be effectively burned per working stroke in the cylinder, it also determines the maximum power that can be developed by the engine. Increasing the density of the charge air by applying a suitable compressor between the air intake and the cylinder increases the weight of air induced per working stroke, thereby allowing a greater weight of fuel to be burned with a consequent rise in specific power output.

Application to supercharging turbocharger allows the use of the energy contained in the exhaust gases. Between the engine and turbocharger there are only gas-dynamics connection: from the turbine exhaust gas stream and from the compressor air stream. Of the balance of power the turbine and the power for compressor, result of the amount of energy used to compress the air in the supercharger system.

There are a number of advantages of pressure charging by means of an exhaust gas turbocharger system:

– a substantial increase in engine power output for any stated size and piston speed, or conversely a substantial reduction in engine dimensions and weight for any stated horsepower,
– an appreciable reduction in the specific fuel consumption rate at all engine loads,
– a reduction in initial engine cost,

- increased reliability and reduced maintenance costs, resulting from less exacting conditions in the cylinders,
- cleaner emissions,
- enhanced engine operating flexibility.

The structure of the mechanical-flow turbocharger and its quality is shaped at the design stage. This structure describes a set of design features, including:
- turbocharger connection with engine (the foundation),
- intake manifold,
- compressor,
- the exhaust manifold,
- turbine,
- shaft turbocharger,
- turbocharger shaft bearings.

The deterioration of the technical state of charge is equivalent to the deterioration of the working process engine and affect the parameters of the engine.

The faults of supercharger system are the most common elements of the contamination (24.7% of all damage of the marine engines) [1]. Contamination the following relates to elements:
- air filters,
- compressor,
- air cooler,
- scavenging system elements,
- turbine.

The detailed data follows that the contamination are usually in [1]:
- flow channels supercharger – 56%,
- turbine flow channels –- 22%,
- air cooler – 11%,
- air filter – 6%,
- scavenging system elements – 4%,
- other elements – 1%.

Given the importance of the charge and its impact on the engine, the relationship between the course of the worker and the work of the system should be in operation on an ongoing basis to take care of the state, including turbocharger and air cooler. The course of events in the compressor and air cooler depends on the parameters of the environment and clean the air intake. There is a close relationship and interaction (feedback) between the charge air unit (compressor, air cooler), the process of working, the compressor and turbine driving the compressor.

To emphasize the importance of this problem, consider some typical examples of the impact of the technical condition of the boost to the engine.

1. Reducing the amount of air supplied to the engine, manifested by a decrease in air pressure loading p_d, causes difficulties in achieving adequate power by the engine and decrease the economy of work and increase in thermal stress elements of the engine combustion chamber and the exhaust valves. Then there is the possibility of the appearance of premature failure of these components, increased wear piston rings and cylinder liner.
2. Loss of air pressure loading makes it possible to return to the area of the exhaust gas flow the space below the piston and scavenging air box. This results in a considerable amount of pollution, carbonization the exhaust ports, and in extreme cases can even cause fires in the space below the piston and scavenging air box
3. Deterioration in operating conditions referred to in points 1 and 2 shall be conducted as a result of interaction, to even greater disruption to the loader, followed by accelerated impurity band, growing resistance to flow, until a turbocharger surging included.

The complexity of today's designs turbochargers and responsibility for the quality of the performed tasks cause the need to provide to the user fast and reliable information about their current technical condition.

The assessment work turbocharger system is usually carried out on the basis of the following parameters:

- temperature and air pressure scavenging air box: t_d, p_d,
- pressure drop across the filter and air cooler: Δp_f, Δp_{ch},
- exhaust gas temperature before and after the turbine: $T_{wyl\,1}$, $T_{wyl\,2}$,
- sea water temperature before and after air cooler: $t_{chł\,1}$, $t_{chł\,2}$,
- turbocharger speed: n_{TS},
- pressure drop on the exhaust gas boiler, Δp_{ku} - exhaust gas counterpressure.

2. Change technical condition of the air filter

A typical technical condition change in the air filter is to reduce the cross-section caused by the deposition of sediment on the filter cartridge. The air intake may be with different types of pollution, including the type of solid (dust), oil and fuel vapors, and even sea spray. The procedure pollution filter structure goes more and more polluted, resistance to flow increase and filtration efficiency decreases. After reaching the limit of the strength of adhesion to the fibers agglomerate filtration ends stable operation range of the filter. Increasing of the aerodynamic forces and agglomerates are detached from the fibers. The increase in pressure drop over the filter revealed distort the intake air flow and deterioration of the work compressor.

The pressure drops at the inlet to the compressor of the value pressure drop on the filter Δp_f. At the same time while maintaining the constant of compressor compression ratio π_S, drop air pressure from the compressor p_k, a reduction in the air mass rate of flow and total air excess ratio λ.

As a consequence, inter alia, the boost pressure p_d will decreases, exhaust temperature T_g and the turbocharger speed n_{ts} increases, and maximum combustion pressure p_{max} decreases. This may also lead to an increase in specific fuel consumption. As with the foregoing, the consequence of the compressor air filter is:

$$Z_f \Rightarrow (\Delta p_f\uparrow;\ p_k\downarrow;\ p_d\downarrow;\ \dot{m}_s\downarrow) \Rightarrow (g_e\uparrow;\ T_g\uparrow;\ \lambda\downarrow;\ p_{max}\downarrow). \tag{1}$$

Studies carried out by the author of the marine diesel engine, four-stroke SULZER 3AL25/30 in the laboratory have shown that the above changes of parameters of engine operation are particularly pronounced, when as a result of the filter contamination, decreases its cross-section for at least 40% a nominal. The graphs in Fig. 1 shows the effect of the air filter contamination on the selected engine operating parameters.

3. Change technical condition of the air compressor

The air compressor flow channels, even though they are protected by filter, contamination build up. It is primarily the oily viscous mass weakly bound to the surface elements. Mainly it consists of hydrocarbon compounds formed during the condensation and oxidation of the fuel and lubricating oil, but also the mineral particles contained in the sucked air. In the turbocharger, which draw air from the engine room to the compressor section of the diffuser about 2000 hours of work can be reduced from 10 to 20%.

Deposits on the walls of the flow channels and the erosive action of the sea spray causes increased friction losses and changing angles leading and trailing blades and aerodynamic flow. As a result, decrease of the efficiency of the compressor η_S occurs and air volume supplied to the engine.

This affects the working process, decreasing the amount of gases coming to the turbine, and hence a decrease in the rotational speed of the turbocharger. The decrease of air volume supplied to the engine may result in poor scavenging the cylinder, the increase in thermal load of the combustion chamber components and an increase in exhaust gas temperature. As the above shows, the consequence of contamination of the compressor is:

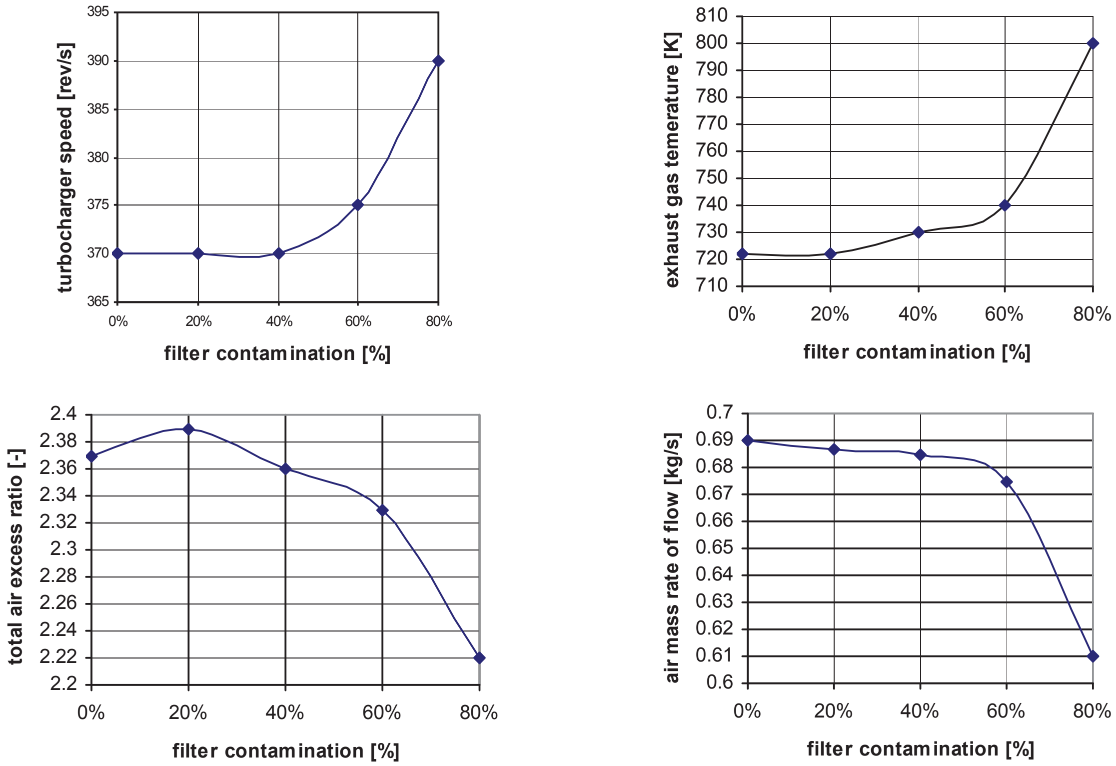

Fig. 1. Changes in selected marine engine parameters depending on the degree of contamination of the air filter

$$Z_S \Rightarrow (\eta_S\downarrow;\ \pi_S\downarrow;\ p_k\downarrow;\ p_d\downarrow;\ \dot{m}_s\downarrow) \Rightarrow (g_e\uparrow;\ T_g\uparrow;\ \lambda\downarrow;\ p_{max}\downarrow). \qquad (2)$$

In Fig. 2 are shown the results of simulation studies the impact of contamination air compressor on the selected operating parameters of the turbocharger system. The study was conducted in the laboratory for marine diesel engine SULZER 3AL25/30. Simulation the compressor progressive contamination was carried out by controlled releasing the air (0 m^3/h, 48 m^3/h and 96 m^3/h) from the compressor to the atmosphere.

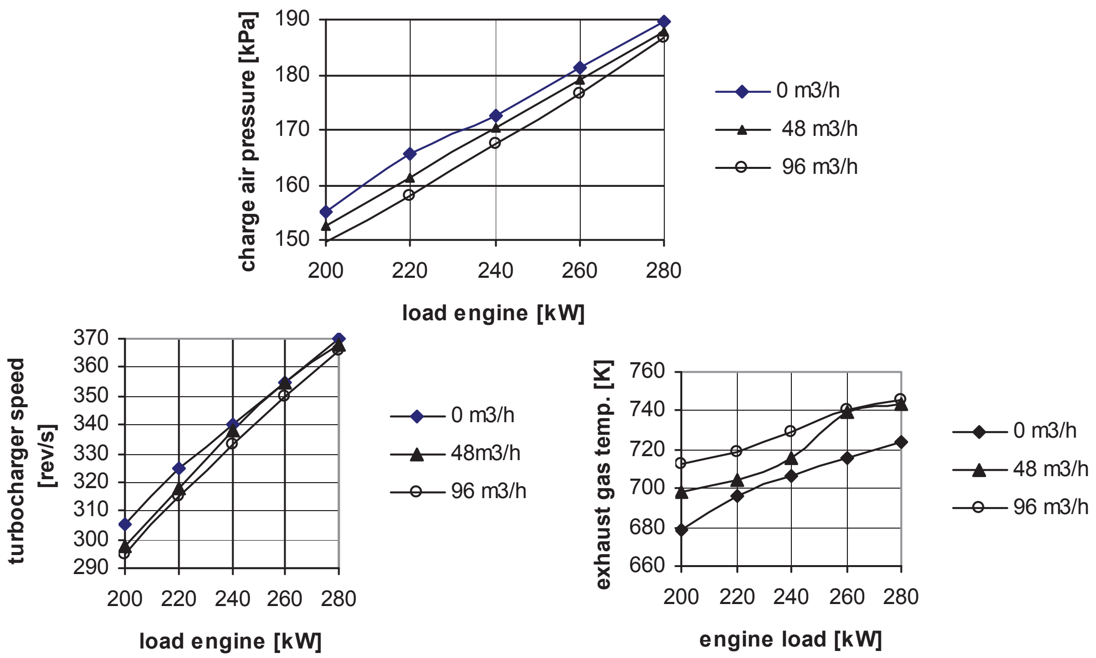

Fig. 2. Influence simulation of contamination the compressor on charging on selected parameters, the engine load range of 200 to 280 kW

4. Change technical condition of the air cooler

Technical condition of the air cooler may deteriorate as a result of contamination from the air or water and as a result of loss of containment, the water leaks into the air. The consequence of contamination of the cooler would be cooling performance degradation, an increase in charge air temperature and thus the cycle of operation. As a consequence of these phenomena will increase the thermal load of the combustion chamber components and exhaust valves. Projected changes in engine operating parameters as a result of cooler air pollution are as follows:

$$Z_{CH} \Rightarrow (\Delta p_{CH}\uparrow;\ p_d\uparrow;\ \dot{m}_s\downarrow;\ T_d\uparrow) \Rightarrow (g_e\uparrow;\ T_g\uparrow;\ \lambda\downarrow). \qquad (3)$$

Nominal, recommended by the manufacturer, the air temperature is between 35^{0}C boost to 45^{0}C. In order to determine the impact increasing contamination of the air cooler on the selected engine performance simulation tests were carried out on the marine diesel engine 3AL 25/30 Sulzer. Simulation air cooler contamination carried out by raising the temperature from the nominal value 45°C to 60°C and 65°C. Selected results are shown in the graphs in Fig. 3.

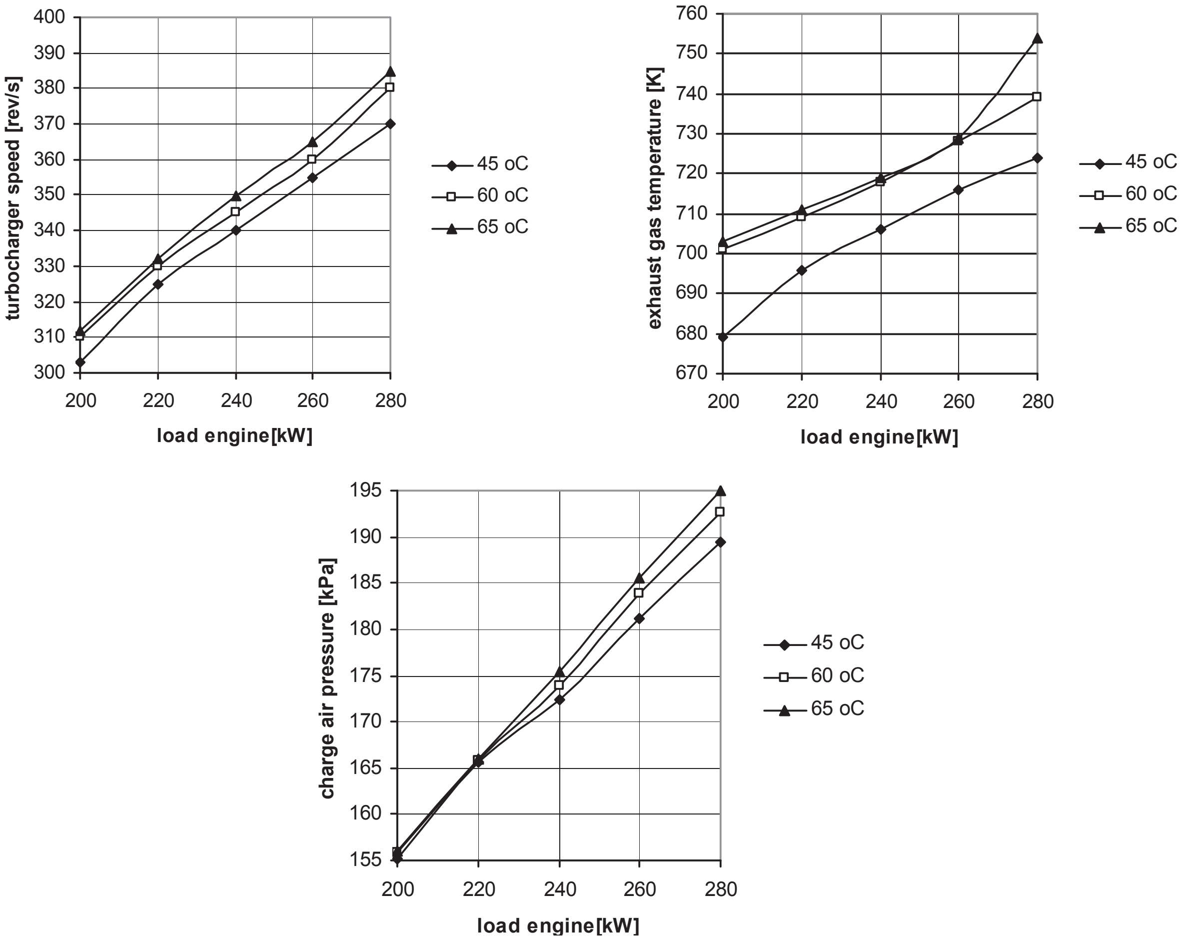

Fig. 3. Influence simulation of contamination the air cooler on charging on selected parameters, the engine load range of 200 to 280 kW

5. Summary

Cleanness the air filter has a significant impact on the value of charge air pressure, total air excess ratio and exhaust temperature. In engine operating do not allow excessive filter contamination, because as shown by tests, more than contamination 40% the filter area a causes distinct changes in these parameters. The condition of the air filter, particular attention should be paid to ships carrying bulk cargo such as grain, cement, coal, where the dustiness when loading a large extent contributes to the rapid contamination of the filter.

Contamination of the compressor causes a decrease in quantities of air supplied to the engine. This affects the working process, decreasing the amount of gases flowing into the turbine, and hence a decrease in the rotational speed of the turbocharger. Decrease quantities of air supplied to the engine may result in poor scavenging the cylinder, the increase in thermal load of the combustion chamber components and an increase in exhaust gas temperature. In order to reduce the negative effects of pollution of the compressor, you should periodically wash the compressor during the operation, on average, every 250 hours of operation.

The consequence of cooler air pollution will decrease the effectiveness of air cooling, increased air temperature charger, drop excess air ratio and exhaust gas temperature increases. It is therefore necessary to periodically clean the cooler, both from the air and from the cooling water. At the time of the assessment of the state cooler air pollution also check its leak tightness. Water leaks, especially seawater, pose a potential threat to the engine. Seawater and air charging can get into the cylinder.

References

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