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POSIBILITIES OF IMPROVING STREAMING CHARACTERISTICS OF VARIABLE TURBOCHARGER

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ABSTRACT
With the aim of increasing work efficiency of a turbocharger at lower numbers of engine speed, turbine with stator paddles of changeable geometry have been used. Recently, some manufacturers have started installing 'insert' into a stator construction of a turbine. These additional components in a stator part increase stream losses because of friction, blows and whirlpools. Therefore, it is necessary to find a way to reduce those losses, or in another words to improve streaming characteristics of variable turbocharger.
Keywords: turbocharger, blades, streaming, modeling.

1. INTRODUCTION
Turbocharger is a device which is used for increasing engine power, or in another words for improving working characteristics of an internal combustion engine and reducing fuel consumption in comparison with the same engine with a normal intake stroke. Engine at low number of revolutions stays without getting enough air. To avoid this disadvantage and to achieve more effective work of the turbocharger at low number of engine speed, turbochargers with variable geometry of transporting channels have been used. By turning stator blades, direction of entry of gases into a turbine rotor is changed, a change in the circumferential speed of the rotor is reduced and satisfactory streaming angle of exhaust gases in the entire working area is achieved.
Recently, additional part of the stator is built in the stator construction, which has a function to direct streams of exhaust gases towards the rotor wings (Fig. 1).

Figure 1. Illustration of the directing part of the stator (insert)

Stator blades and a directing device of the exhaust gases stream, because of its position in the stream of the exhaust gases stream, increases stream losses. Losses are made because of fluid friction against touching surfaces, because of stroke of the stream of exhaust gases in parts of the rotor, because of change in the direction of the exhaust gases streaming as well as because of whirlpool of the exhaust gases stream. Listed losses reduce the level of the effectiveness of the turbocharger and decrease transformation of exhaust gases energy into rotation moment of the turbine rotor. Therefore, if we succeed in reducing those losses, it can lead to increase in turbine effectiveness.

2. PREVIOUS RESEARCHES

To get a clear picture of gas flow between directing blades, as well as of an influence of the directing part of the stator on exhaust gases flow in the stator part of the turbine, a CFD (Computational fluid dynamics) analysis has been done. It has been confirmed that the feet of the directing part of the stator create disturbances in the streaming field of the exhaust gases, which has been shown in Figure 2. It should be noted here that in order to show results a characteristic cross section is used, in which profiles of blades and the feet of the directing parts of the stator have been shown. Results have been illustrated by distribution of speeds and pressure in the characteristic cross section.
While calculating, following data have been used as initial:

- pressure on turbine entrance	$p = 4{,}5 \cdot 10^5$	[Pa],
- flow of exhaust gases	$Q = 358$	[kg/h],
- temperature of exhaust gases	$T = 900$	[°C].

In Figure 2, areas where disruptions of the streaming happen have been marked, and they are the exact places around feet of the directing part of the stator. It can be seen that areas with speeds of small intensity are appearing, and that because of small intensity of speed there is a possibility of depositing of solid particles from exhaust gases on the surfaces of the stator parts, which would reduce working function of the directing blades and decrease lifetime of the turbocharger.

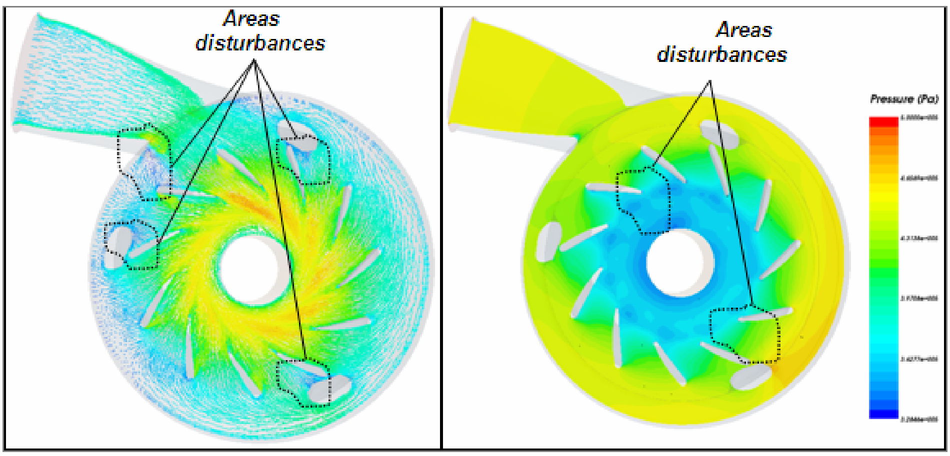

Figure 2. Illustration of the distribution of speed and pressure in a characteristic cross section of the model without hole on the feet of the directing part

3. MODEL FOR IMPROVING STREAMING CHARACTERISTICS

For the purpose of improving streaming characteristics of the turbocharger on the CAD model of the directing part of the stator, openings have been made on the feet of the directing part of the stator, as shown here in Figure 3. The opening has a task to lead a part of the flow of the exhaust gases through the hole and, in this way, to reduce hydraulic pressure which the foot of the directing part of the stator generates by exhaust gases streaming and to enable balanced fulfillment of the transporting channels between the blades. To determine the impact of these openings, the entire procedure is repeated with the same boundary and initial conditions as for the model without openings on the feet of the directing part.

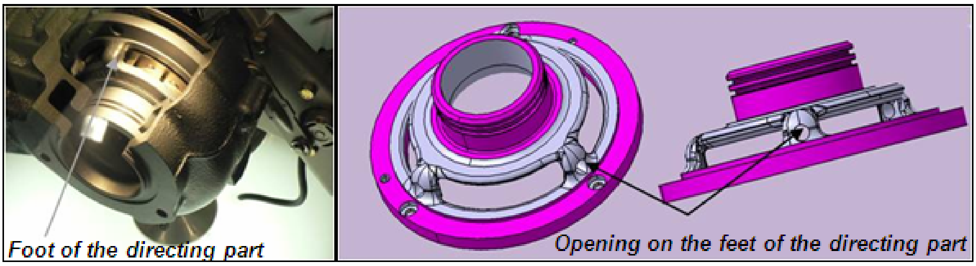

Figure 3. Illustration of the openings on the feet of directing part of the stator

4. RESULTS AND ANALYSIS OF THE RESULTS

After procedure completion and the CFD analysis of the exhaust gases flow through the stator part of the turbine, values that are shown are relevant to the description of exhaust gases flow through characteristic cross-section. It should be noted that the values are displayed in the same typical cross-section as in the previous model.

Figure 4 shows an illustration of the distribution of the speeds and the pressure of exhaust gas flows in the model with the openings in the feet of the directing parts. On the basis of the illustration of the distribution of the speed, by comparing two models, it can be concluded that the openings on the feet of the directing part has a positive impact on homogenization of the distribution of the speeds, because there is no distinctly reduced speed intensity rate in the transporting channels between the blades. Areas where energy dissipation happens are reduced.

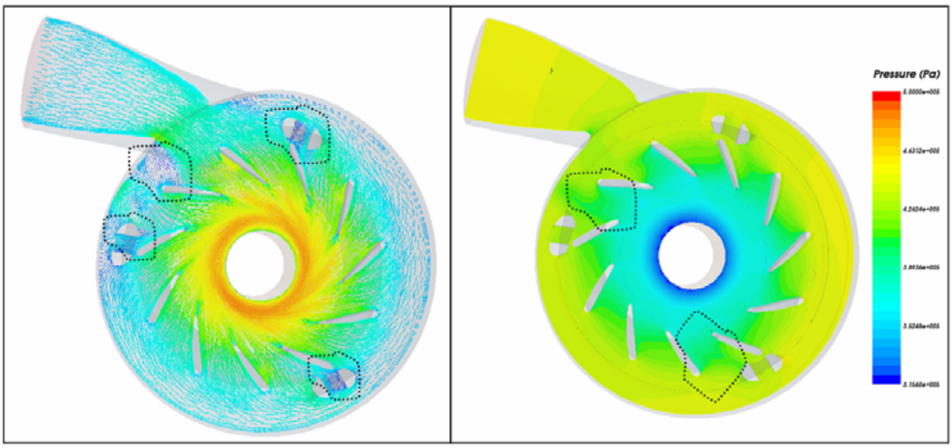

Figure 4. Illustration of the distribution of the speeds and pressure in a characteristic cross-section of the model with the openings on the feet of the directing part

By observing the field of distribution of pressure shown on the right side in Figure 4., it can be noted that some unloading is achieved by making an opening, which is shown in more homogenous distribution of the pressure in the transporting channels between the blades and it results in creating more balanced pressure on the rotor wings. On the scale of the pressure distribution in observed cross-section of the model with openings, the difference between maximum and minimum pressure is written as $\Delta p_{M2} = 1{,}37 \cdot 10^5$ [Pa].

5. CONCLUSION

By comparing distribution of the speed with the model with openings on the feet of the directing stator part and with the model without openings on the feet of the directing stator part, it can be noted that the distribution with model with openings on the feet of the directing stator part has become more homogeneous. By observing distribution of the speeds in the area around the openings on the feet of the directing stator part, it can be seen that in one part of the opening the speed of the exhaust gases is bigger and that in the other part this speed is lower. This happens because of the angle in which exhaust gases flow into the opening, which leads to non-homogenous distribution of the speeds through transversal cross-section of the opening. A consequence of this is possible depositing of the solid particles from the exhaust gases on the surfaces alongside areas of lower speed of the exhaust gases.

By comparing illustrations of the distributions of the pressure of the exhaust gases with the model with the openings on the feet of the directing part of the stator and with the model without openings on the feet of the directing part of the stator in the area of transporting channels between the blades of the stator, a more homogenous distribution of the exhaust gases pressure is noted. These results in a more evenly distributed pressure on the blades of the stator as well as of the rotor of the turbine and therefore it also results in more balanced ballast for those parts. This reduces the uneven ballasting of the rotor and stator blades of the turbine in the model without openings on the feet of the directing part of the stator. By reducing uneven distribution of the ballast, performing of the working function is assured and the lifetime of the turbine under such a pressure is extended.

6. REFERENCES

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