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«MIST: Aerospace - 2021: Advanced Technologies in Aerospace, Mechanical and Automation Engineering»

«Study on the Boundary Layer Control System of Ship's Rudder Blade with the Maximum Effective Deflection Angle»

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Problem statement

- The boundary layer control system is designed to accelerate and ensure smooth fluid flow around the rudder due to additional acceleration of the fluid flow. The liquid jets are supplied from flat slit holes (nozzles) along the rudder airfoil at an increased speed, which ensures a smooth flow around.
- The objective of the article is to carry out a study and assess the effectiveness of the use of boundary layer control systems to improve the hydrodynamic characteristics of the rudder blade in order to improve the maneuvering qualities of the ship.

Solution methods

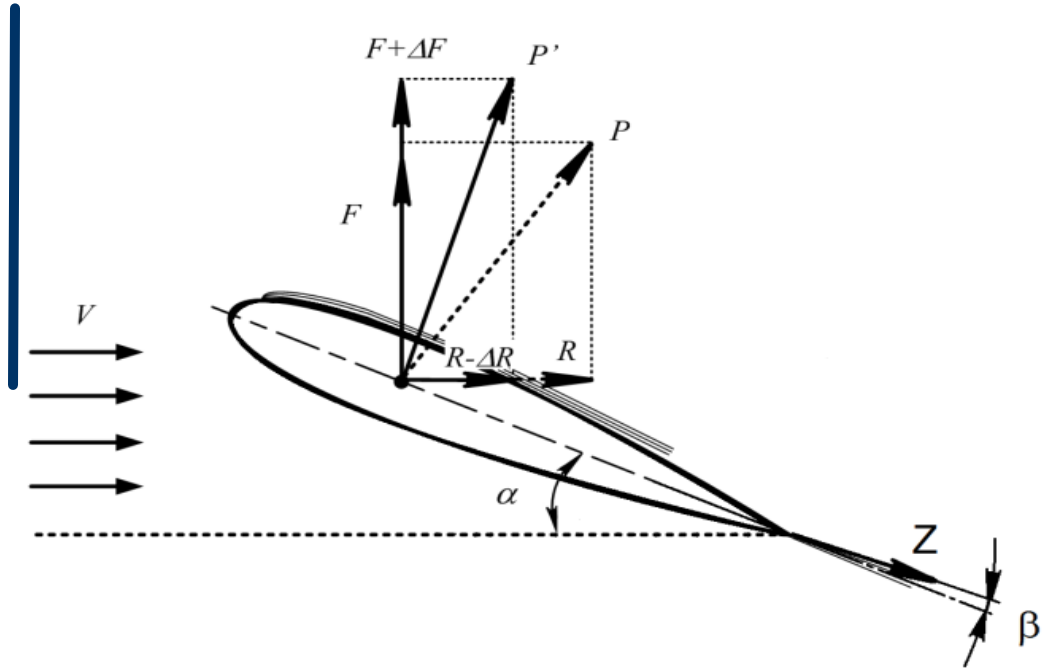

FIGURE 1. Forces acting on the rudder blade when implementing control systems for the boundary layer and flow circulation: P is the transverse hydrodynamic force of the rudder blade airfoil; P 'is the total transverse hydrodynamic force of the airfoil and the jet; F is the lifting force of the airfoil; R is the force of the airfoil resistance; ΔF is the increase in the lifting force of the airfoil due to the additional pressure drop on the jet; ΔR is the relative reduction of the airfoil resistance of the rudder blade; Z is the jet flap velocity vector; V is the speed of the incoming flow; α is the angle of attack of the airfoil; β is the angle of water supply from the jet flap.

Solution methods

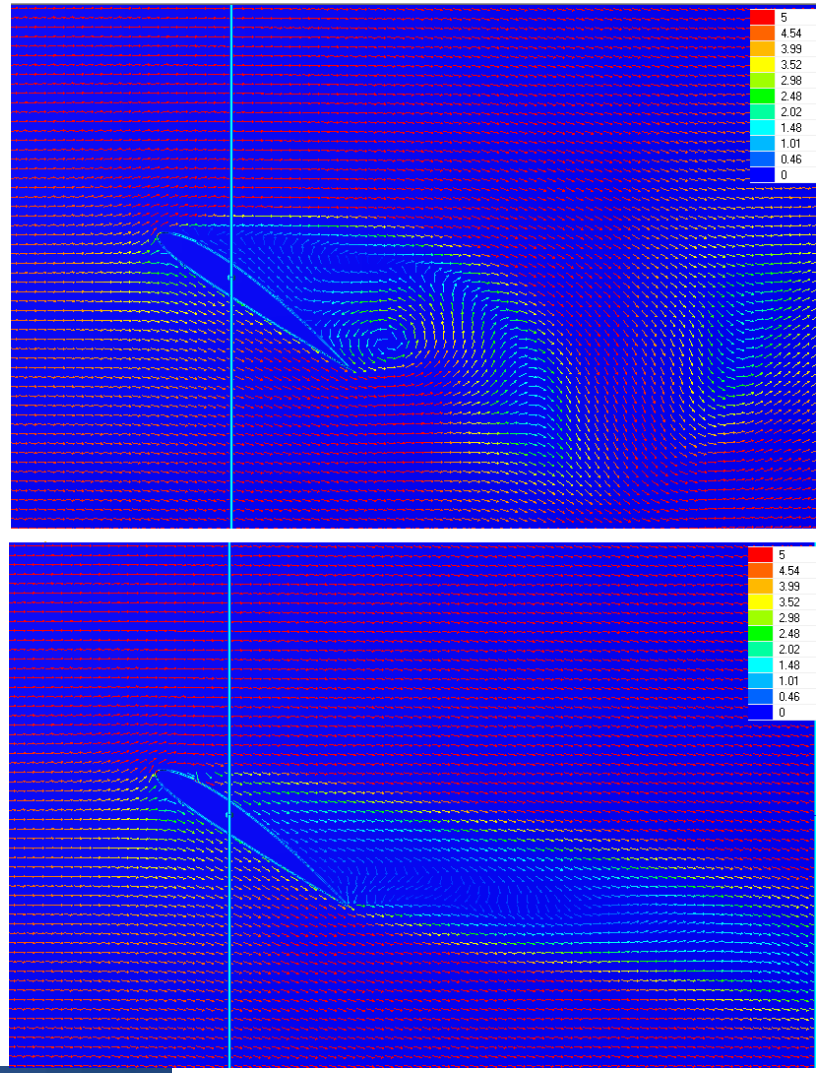

FIGURE 2. The field of absolute velocities (m/s) of the rudder blade airfoil α = 35° with joint control of the boundary layer and flow circulation: up - with zero additional water supply; down - when supplying additional water in the ratio V_j/V_f = 8, β = 65°.

Conclusions

Results, implementation

By combining two methods of supplying additional water to the rudder blade, a 20% increase in the turning moment was obtained for the object of study. This, in turn, may be reducing the steering surface deflection angle from 35° to 25° during maneuvers. Thereby, it prevents a decrease in the ship's speed by 0.8 knots, reducing the power consumption of the 6S60MC main engine by 600 kW.

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