DOCTORAL RESEARCH TOPIC:

Application of energy-efficient and friction-reducing technologies in maritime transport: numerical and experimental studies

RESEARCH FIELD:

Energetics and Power Engineering (T 006)

BRIEF DESCRIPTION OF RESEARCH TOPIC:

The reduction of frictional resistance for a body moving in a liquid is considered one of the most important tasks in hydrodynamics. Various methods are employed worldwide to reduce frictional resistance, such as the creation of air bubbles, polymer-coated surfaces, specific shape designs, hull vibrations, hydrophobic coatings, elastic coatings, and others. The formation of a lower-density layer (gas/vapor) around a body submerged in a water flow (e.g., a ship model) can be seen as an alternative approach to current friction-reduction methods.

The proposed new method is based on the principle of the Leidenfrost effect, where a gas/vapor layer forms at significantly lower surface temperatures due to surface coating modifications. These modifications may include microtexturing, coating application, or the use of chemical methods to create unusual phenomenological conditions that encourage vapor film formation. Modified coatings can significantly improve the conditions for vapor layer formation and reduce friction, thereby increasing the energy efficiency of bodies moving in a liquid (such as ships or other watercraft).

This method has not yet been sufficiently studied, which makes the selection of coatings, their experimental evaluation, and the exploration of their practical applications a challenge. Students could choose different coating materials and application technologies, such as laser ablation, plasma spraying, or magnetron sputtering, taking into account the coating properties and their suitability for the Leidenfrost effect. During the research, students would evaluate the physical properties of the sample coating, such as conductivity, density, roughness, porosity, microstructure, hydrophobicity, and their influence on the Leidenfrost rise conditions. Investigating the physicochemical properties of these coatings would contribute to the development of more effective methods for reducing friction and increasing energy efficiency for bodies in water flows.

This research would require comprehensive experimental studies and numerical simulations to integrate the findings into marine transport models. It would also aim to assess the potential application of the Leidenfrost effect by including energy consumption calculations and coating efficiency evaluations.

The goal of this study is to extend the limits of the critical heat flux while understanding the conditions that would allow control over heat exchange processes between the coated surface and the liquid. This approach has the potential to enhance energy efficiency by minimizing hydrodynamic resistance. Therefore, one of the most critical tasks is to experimentally determine the coatings that significantly influence the formation of the vapor layer. The results of these experiments could later be applied to numerical modeling, providing an opportunity to analyze the efficiency of these coatings under varying conditions, including flow dynamics, changes in liquid temperature, and other parameters.

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