

**Application form for research topics  
in the field of engineering and technology  
for candidates to the Doctoral School  
in the academic year 2023/2024**

Proposed subject matter of a doctorate
<b>Study on efficiency of heat transfer devices with PCM fluids addition</b>
Scientific discipline <i>(delete as appropriate)</i>
<del>AUTOMATION, ELECTRONICS, ELECTROTECHNICS AND SPACE TECHNOLOGIES</del> <del>CIVIL ENGINEERING, GEODESY AND TRANSPORT</del> MECHANICAL ENGINEERING
Proposed doctoral thesis supervisor
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Brief description of the research topics with an indication of the scientific issues (max. 350 words)
The need to exchange more and more heat (or to store it in the period of excess supply) requires the search for new solutions in the area of liquid heat carriers. Recently, researchers have been increasingly interested in Phase Change Materials (PCMs). PCM material in the form of fine particles can fill the heat storage or circulate in the installation. To prevent the melted particles from merging, the PCM material is encapsulated in micro- and nanometer sizes. A common PCM material is paraffin. The paraffin circulating with the working liquid is designed to receive heat until it melts, then (in another place of circulation) to give this heat back, solidifying again. As a result, the temperature of the working fluid, despite the supply of significant amounts of heat, may vary slightly, which prevents, among other things, heat loss to the environment. Numerous studies are underway, the purpose of which is to 1) determine the properties (physical, rheological, etc.) of a liquid containing additives of microencapsulated PCM; 2) testing the impact of the new working fluid on heat exchange and flow resistance in installations; 3) testing the impact of additives to the base liquid on the efficiency of heat pumps, solar installations, energy storages obtained from renewable energy sources, etc. The potential area of application of liquids with the addition of microencapsulated PCM is unlimited and results only from the scientist's ingenuity, and expanding knowledge in this matter requires extensive research.

Justification of the purposefulness of taking up the research topics (max. 150 words)
Technological progress has made it possible to obtain solid particles of nanometer size or even single atoms. Adding such small particles to a liquid makes technical problems such as sedimentation no longer exist. Profits from additives to the liquid circulating in heat exchange systems have become very measurable. On the one hand, it is possible to transport larger amounts of heat in systems that require it. On the other hand, it is possible to reduce the dimensions of the installation, where an increase in the transport of thermal energy is not required. The constant emergence of new materials makes the problems of researchers, including in the field of mechanical engineering, still relevant.
Proposed topics of doctoral theses within the proposed research subject matter ( up to 3 topics)
<ol style="list-style-type: none"> <li>1. Study of the influence of microcapsules filled with a material changing the state of aggregation on the thermal efficiency of a liquid solar collector</li> <li>2. Research on the possibility of using paraffin to store heat from a solar installation</li> <li>3. Study of the influence of the material changing the state of aggregation on the operating parameters of the selected element of the solar installation</li> </ol>
The sources of financing of the research topics (the subject matter of currently implemented research grants financed from external sources or as part of subsidies)
Internal funds for research activities - subsidy
Confirmation of the possibility of ensuring access to scientific apparatus and software necessary for the realization of the proposed research topics ( <i>delete as appropriate</i> )
FULLY/ <del>PARTIALLY</del> / NONE
If the answer is PARTIALLY or NONE please indicate a type of missing scientific apparatus and/or software and the sources of financing an access to them
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A list of up to 5 major supervisor's publications related to the proposed research topics, published in journals indexed in the Web of Science or Scopus for the period of the last 3 years (taking into account the IF Impact Factor and the MNI <sub>SW</sub> score)
<ol style="list-style-type: none"> <li>1. Dutkowski K., Kruzel M., Kaczmarek D., Nalepa B., Zajączkowski B., Valíček J., Harničárová M.: Influence of the Physical State of Microencapsulated PCM on the Pressure Drop of Suspension in a Circular Channel, Materials 2022, 15, 6719. <a href="https://doi.org/10.3390/ma15196719">https://doi.org/10.3390/ma15196719</a>, (IF 3,623; 140 pkt.)</li> <li>2. Kruzel M., Bohdal T., Dutkowski K., Radchenko M.: The Effect of Microencapsulated PCM Slurry Coolant on the Efficiency of a Shell and Tube Heat Exchanger, Energies 2022, 15, 5142. <a href="https://doi.org/10.3390/en15145142">https://doi.org/10.3390/en15145142</a> (140 pkt.)</li> <li>3. Bohdal, T.; Dutkowski, K.; Kruzel, M.: Experimental Studies of the Effect of Microencapsulated PCM Slurry on the Efficiency of a Liquid Solar Collector, Materials 2022, 15, 4493. <a href="https://doi.org/10.3390/ma15134493">https://doi.org/10.3390/ma15134493</a> (140 pkt.)</li> <li>4. Dutkowski, K.; Kruzel, M.; Bohdal, T. Experimental studies of the influence of microencapsulated phase change material on thermal parameters of a flat liquid solar collector, Energies, 14, 5135, 2021 (IF: 3.004; 140 pkt MEiN)</li> </ol>

5. Dutkowski K., Kruzel M.: Experimental investigation of the apparent thermal conductivity of microencapsulated phase-change-material slurry at the phase-transition temperature, Materials, 14, 4124, 2021 (IF: 3.004; 140 pkt MEiN)
A list of research grants financed by the National Science Centre, the National Centre of Research and Development and the European Research Council in which the supervisor has participated during the last 5 years
Project of the National Center for Research and Development - Intelligent Development Operational Program 2014-2020, Fast Track 6 / 1.1.1 / 2019: Hot water tank without PCM and with PCM content
A list of research services provided for industry related to the proposed research topics for the period of the last 5 years
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