NetCastPL4.0 Seminars Series

Online event, **January 20**, 2026, 02:00-03:15 pm CET

View on Ni-based superalloys and ADI reinforced with titanium carbides for thin-walled castings

02:00 pm – Rafał Cygan (20-25 minutes)	02:30 pm – Jan Marosz (20-25 minutes)
Thin-walled Ni-based superalloy castings for aerospace applications – Microstructure, stability and mechanical properties	**Analysis of Austempered Ductile Iron Castings Reinforced with Titanium Carbides**
Thin-walled Ni-based superalloy castings are key structural materials for modern aerospace engines, where they operate in extreme environments characterized by high temperatures, aggressive atmospheres, and complex thermomechanical loads. The continuous drive toward higher turbine inlet temperatures and improved engine efficiency requires alloys that simultaneously exhibit superior mechanical performance, excellent microstructural stability, and high corrosion resistance. This work presents a comprehensive overview of recent experimental results on the processing, microstructural evolution, and mechanical and environmental behaviour of thin-walled castings produced from several advanced Ni-based superalloys, including René 125, René 77, MAR-M247, C101, and IN713C. Particular emphasis will be placed on vacuum investment casting and directional solidification technologies, which are central to manufacturing turbine blades and vanes with controlled grain structure. The influence of processing parameters, including shell reinforcement, mold preheating temperature, melt-pouring temperature, and withdrawal rate, on the primary microstructure and defect formation will be discussed. Overall, the collected studies demonstrate that optimized casting routes, careful control of solidification and heat-treatment parameters, and understanding of precipitation and segregation phenomena are crucial for achieving the required balance between microstructural stability and mechanical performance in thin-walled components. The seminar will conclude by outlining current research directions, including automation of investment casting, advanced process monitoring, and design of next-generation superalloys for higher operating temperatures and longer service lifetimes in aerospace propulsion systems.	The aim of the presented research was to produce a new cast composite material based on the attractive engineering material i.e. ADI (Austempered Ductile Iron). The transformation of ADI cast iron into a composite material was based on SHSB (Self-Propagating High-Temperature Synthesis in Bath) reaction. This was a "solid Ti" – "solid C", which ensures that TiC particles are obtained in the microstructure of the alloy. The titanium carbides are thermodynamically stable as a result of their covalent bonding nature, so they do not undergo transformation during the heat treatment process. In the present work castings with different wall thicknesses ranging from thin-walled, i.e. 3 mm, up to 25 mm were attained. The study showed that it is possible to produce a ADI using the SHSB reaction in which titanium carbides of up to 5µm in size are evenly distributed in metallic matrix. Heat treatment was carried out to attain upper and lower ausferrite, reinforced with titanium carbides. The characterization of novel ADI material in terms of mechanical and performance properties was carried out using XRD (synchrotron radiation), light microscopy, scanning microscopy and mechanical properties. Finally, it was shown that ADI strengthened with TiC using SHSB synthesis makes it possible to obtain an attractive material that can be used in demanding areas such as defence, railroad or automotive.

Rafał Cygan	Jan Marosz
Ph.D. D.Sc. Eng. Rafal Cygan is Associate Professor and Senior Research & Development Specialist. The focus of industrial activities is on investment casting technologies. From 2005 to 2016, he worked at Pratt & Whitney Rzeszów. Since 2016, he has been employed at Consolidated Precision Products Poland. Both Pratt & Whitney and CPP are involved in the development of investment casting technology and new industrial technologies, including direct and single-crystal solidification. He has documented experience in executing and coordinating research and implementation projects related to investment casting technology for aviation turbine components made from Ni- and Co-based superalloys. Since 2024, he has held the position of Associate Professor at AGH University of Kraków in the Faculty of Foundry Engineering. Research activities are concentrated on the following areas: microstructure of superalloys, investment casting technology, ceramic moulds, solidification and heat treatment, and additive manufacturing processes. He has participated in over 40 industrial and scientific projects, developing technologies for several universities. He is the author or co-author of more than 100 research articles. Member of: Polish Materials Society, Aviation Valley, The Minerals, Metals & Materials Society (TMS), European Investment Casters' Federation and European Partnership for Clean Steel - Low Carbon Steelmaking.	MSc Jan Marosz, after defending his Bachelor's and Master's theses, continued his scientific activity at the Faculty of Foundry Engineering and undertook doctoral studies. During this period, he obtained a position as a research and teaching assistant at the Department of Alloy and Composite Engineering. At that time, he published eight articles in specialist journals and participated in twelve scientific conferences, including two national and ten international conferences related to Materials Engineering. His papers and presentations were awarded first and second prizes for innovative subject matter and a clear, well-structured manner of presentation. In his research work, Jan Marosz focuses on casting materials transformed into metal matrix composites (MMCs) using in situ synthesis methods. The materials within his main area of interest include primarily high-quality spheroidal graphite cast iron, vermicular cast iron, alloyed cast iron, and ADI cast iron, in the form of both conventional and thin-walled castings. He is also involved in the crystallization of metals and their alloys, both from a theoretical and practical perspective. He has mastered numerous laboratory methods for sample preparation, including specimens and metallographic mounts for specialized mechanical testing (strength and tribological tests), classical microscopic observations in reflected light, as well as research in the field of electron microscopy and scanning observations. He is also proficient in the interpretation of electron and X-ray diffraction results, as well as in the analysis and interpretation of X-ray fluorescence spectra, both on a macroscopic scale and within micro-areas.

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