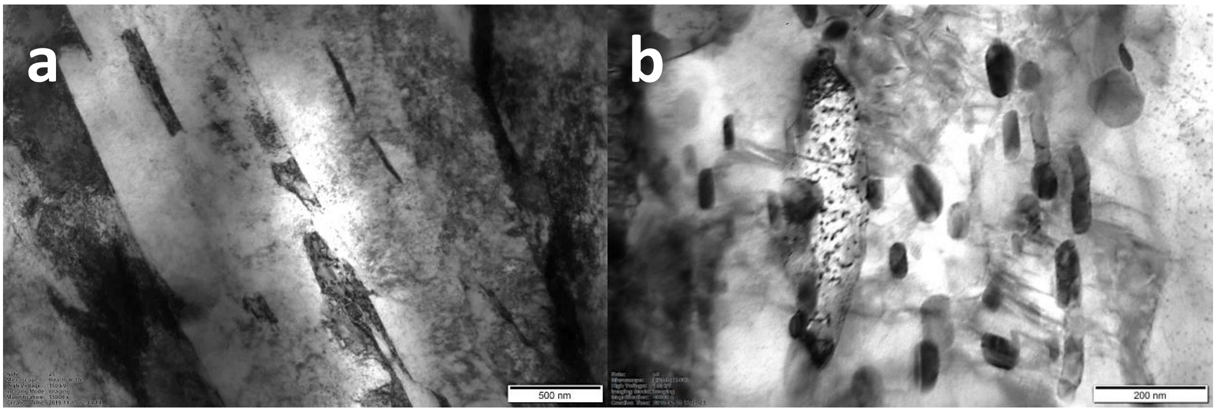
The contemporary problems of mechanical engineering and materials engineering in terms of steel research and applications relate to the improvement of mechanical and functional properties. Due to the ultra-high mechanical properties, nanostructured bainitic steels have been the subject of intensive research for over two decades. This project is focused on enhancing the thermal stability of nanostructured bainitic steels, which plays a key role in the context of welding processes, galvanizing processes, and exploitation in an elevated temperature range. Besides two novel steel alloys will be designed, which will be also characterized by sufficiently high hardenability. This factor is critical in the context of the welding process with the regeneration technique (thus increasing the weldability). The main motivation for this research in the scope of designing the chemical composition of two nanobainitic steels is a little number of research on the impact (Mo + B) and methods of microstructure stabilization by increasing the content of nickel (for nanobainitic steels this method was proposed in articles published 1 ÷ 3 years ago). The subject of this research is primarily innovative and based on recent research and publications in prestigious journals. Besides, advanced techniques for testing the structure of materials (high-resolution electron microscopy and dynamic electron microscopy) were included in the scope of this project. The research results and their interpretation will significantly increase the current state of knowledge on the mechanisms of bainitic microstructure degradation and kinetics of bainitic transformation. Investigations will be carried out on samples after designed heat treatment aimed at obtaining a high-strength nanobainitic structure as well as samples subjected to the influence of increased temperature (during tempering, continuous heating, and in the Heat-Affected Zone of the welded joint). It should be highlighted that the implementation of dynamic electron microscopy (*in-situ* TEM) will allow real-time observation of microstructure decomposition mechanisms as a function of temperature. Such investigations are unique and complex in the context of research methodology (require extensive operator experience), and their results will significantly complement the considerations on the decomposition mechanisms, which until now create some controversy. Observations during heating, combined with hardness measurements, will allow determining the thermal stability of the materials and critical temperature for the microstructure decomposition. Exemplary bainitic microstructure and microstructure obtained after the exposure of elevated temperature is presented below on micrographs (commercial-grade steel). In addition to detailed microstructure analysis, strength tests, physical simulations (dilatometric tests) and numerical simulations (phase transitions, welding processes) will be planned.

As a result of this project, several publications indexed in the Web of Science and JCR database were planned. It should be highlighted that the research results of this project can be a significant step towards boarding the application possibilities of this steel grade, which in the future may be a fundamental base for designing steels with both high mechanical and functional properties



(a) Exemplary bainitic microstructure consisting of bainitic ferrite laths and austenite with film-like morphology.

(b) Degradation of the bainitic microstructure in a welded joint (Heat-Affected Zone). Visible carbide precipitations resulting from the decomposition of austenite.
Bainitic rail, Own research, Bright field image, Transmission electron microscopy, 150 kV.