



PRODUCTION OF NANOCRYSTALLINE STEELS USING PHASE TRANSFORMATIONS



Nanostructured steels exhibit a beneficial set of mechanical properties: high strength, high fracture toughness and wear resistance. Those parameters are much better than mechanical properties of steels after conventional quenching and tempering heat treatment. Moreover the cost of nanocrystalline steels is much lower than the cost of high-alloy maraging steels with comparable mechanical properties.

Nanostructurization technology can be used for heat treatment of machine parts and steel structures as the final stage of the production process, improving the mechanical properties and the quality of steel products and extending their failsafe and long term exploitation.

High strength of nanocrystalline steels allows to reduce cross sections of steel structures and consequently reduces their weight. This is highly important for the production of cars, vehicles for the army, ships, aircrafts, where weight affects the maneuverability and fuel consumption. Nanostructurization process can be used for the hardening of precision components, because the distortion effects are negligible during heat treatment. High fracture toughness, wear resistance and fatigue resistance of nanocrystalline steels allows for long-term safe exploitation of manufactured products and structural components. The use of nanostructurization technology for the previously carburized elements improves theirs' strength and functional properties.

Project description

An innovative technology of nanostructurization of low- and medium-alloy steels has been developed at the Warsaw University of Technology in the frame of the NanoStal Project. The main objective of the Project NanoStal was to develop an innovative technology of nanocrystalline structure formation in low- and medium-alloy steels by controlling the phase transformation processes during heat treatment. The technology of nanocrystalline structure formation is based on the knowledge of phase transformation in iron alloys and on latest results of scientific research on this subject around the world.

The project has shown, that nanostructured steels exhibit a beneficial set of mechanical properties: high hardness and yield strength, high fracture toughness and wear resistance, which are similar to the properties of highly alloyed maraging steels. Unlike the maraging steels, nanocrystalline steels contain relatively low amount of alloying elements, which effectively lowers their price, and thus makes them very suitable for tools production, heavily loaded components, transportation and defense industry applications.

The main objectives of the project have been achieved. A homogeneous nanocrystalline structure was obtained in several commercial steel grades: bearing steels, spring steels, structural steels and tool steels. The technology was successfully applied to heat treatment of carburized structural steels. At present new steels are designed in order to obtain a specific mechanical and service properties.

Project details:

- I. Actual/expected project total value: 720 000,00 €.
- II. Investment amount required: 720 000,00 €, comprising 100 %.
- III. Project development and implementation time: 13 and 32 months.
- IV. Project timeline:

[12.2013 ÷ 12.2014/13 months] Remaining time for project development
Implementation of heat treatment technology for the production of nanostructured steel products
Timeline [1.01.2015 ÷ 31.08.2017/32 months]
[1.2015÷ 4.2015/4 months] Initial phase- Analysis of the product design (steel component), conditions of its exploitation, conditions of manufacturing technology, determination of requirements for steel properties. Cost approx.: 60 000.00€
[5.2015÷ 8.2015/4 months] Phase I: The design of steel chemical composition for the target application in order to obtain the nanostructure and specific properties. Cost approx.: 90 000.00€
[9.2015÷ 4.2016/8 months] Phase II- Research phase: Purchase of commercial steel or the new steel casts with designed chemical composition; investigation of phase transformations occurring in steel; performance of nanostructurization processes in various conditions; determination of the mechanical and functional properties of steels after nanostructurization processes. Selection of the optimal nanostructurization process. Determination of the necessary work implementation-related investment to adjust of the manufacturers' heat treatment equipment or buying new equipment in order to perform nanostructurization process on the steel components. Cost approx.: 190 000.00€
[5.2016÷ 12.2016/8 months] Phase III- Analysis of heat treatment technology and the development of steel products in terms of industrial production. Cost approx.: 190 000.00€
[1.2017÷ 8.2017/8 months] Phase IV - Technological supervision and cooperation in the industrial implementation phase; control of quality and product properties; solving technological problems; possible modification and adaptation of technology. Cost approx.: 190 000.00€

V. Project leadership

Project Manager: Wiesław Świątnicki, D. Sc., PhD. Associate Professor, Faculty of Materials Science and Engineering, Warsaw University of Technology, expert in heat treatment of steels, nanocrystalline steels production, phase transformations and hydrogen embrittlement of steels. His scientific publications include 60 publications in internationally referred journals and 22 publications in conference proceedings. He has been a leader of 6 national (Polish) research projects and 5 international research projects.

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VI. Project ownership

The Warsaw University of Technology (WUT) is the best technical university in Poland. Faculty of Materials Science and Engineering of the Warsaw University of Technology is one of the leading research & development centers in Poland in the area of materials science and materials engineering. According to the parametric assessment conducted by the Ministry of Science & Higher Education, the Faculty is a 1st class unit ranked as the best unit carrying out research in chemistry and materials' mechanics.

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