Analysis of degradation processes and stability analysis of heat-resistant nickel superalloy under operating conditions

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Abstract

Statement of the Problem:

This study aims to present the results of the author's work on the analysis of degradation processes with the analysis of the stability of the Incoloy 800HT alloy in high-temperature operation conditions. The paper presents the test results for a given alloy in the delivery condition and after 70,000 hours of operation in creep conditions. Incoloy 800HT alloy belongs to the group of heat-resistant superalloys based on iron-based 800 series with a nominal composition of Fe-32.5Ni-21Cr. This alloy has very good high-temperature strength properties, oxidation resistance and corrosion resistance.

These alloys were introduced into use in the 1950s as materials characterized by high heat strength and heat resistance with a relatively low nickel content.

INCONEL 800HT alloy is used to produce elements of industrial boilers, pipes in cracking furnaces used in the petrochemical industry and covers of electrical heating elements.

Knowledge of the degradation processes of the Inconel 800HT alloy during operation is necessary to assess the technical condition of the installations, determine the possibility of further operation and ensure their safe use.

Advanced material tests were carried out on the tested material, both in the delivery condition and after operation for 70,000 h at a temperature of 875oC, using scanning and transmission electron microscopy, testing of the chemical composition of pipe material and internal deposits, X-ray phase analysis of isolates, testing of strength properties at room temperature and elevated close to the operating temperature. Additionally, the influence of chemical composition and temperature on the thermodynamic stability of the phases in the INCONEL 800HT alloy and on the kinetics of precipitation processes was also examined using numerical modeling using the CALPHAD method.

Conlusion & significance

Currently, there is little literature data on these issues, therefore the project results contribute to the development of materials engineering, including the development of nickel superalloys recommended for applications in the petrochemical and energy industries. Comparative analysis of the test results, shown in the form of comprehensive material characteristics of the Inconel 800HT superalloy, allows determining the safe operation time of elements made of it. This provides a practical database of reference materials for the actual loss of service life of nickel superalloys.

Image

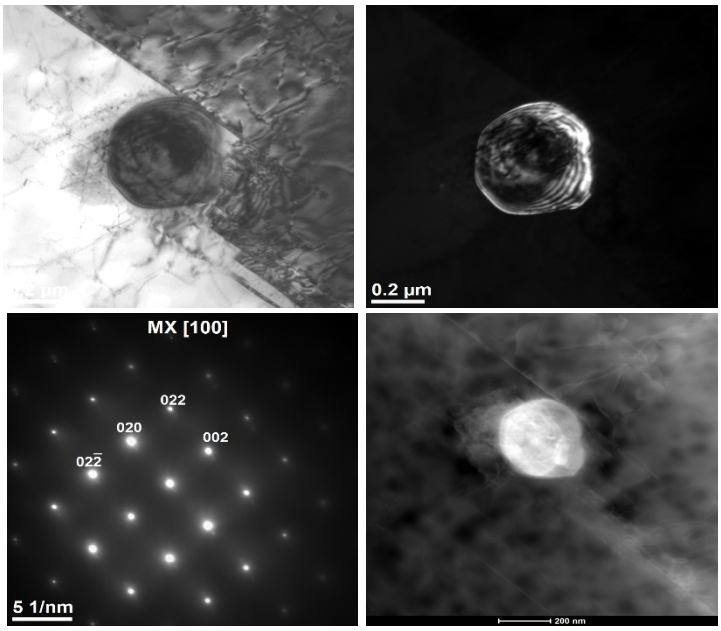

Figure 1. Images of structural elements (thin foil) made of a section of an unused compensation pipe made of INCOLOY 800HT alloy

Recent Publications:

1. A. Zieliński, R. Wersta, M. Sroka; Analysis of the precipitation process of secondary phases after long-term ageing of 304H steel, Bulletin of the Polish Academy of Sciences, Vol. 69(5), 2021.
2.H. Purzyńska, G. Golański; Incoloy 800HT iron-based superalloy – preliminary characterisation, Journal of Metallic Materials 2022, 74 (3-4), p. 42–46.
3. G Golański, H Purzyńska Influence of ageing on microstructure and mechanical properties of TP347HFG austenitic stainless steel, Bulletin of the Polish Academy of Sciences. Technical Sciences 71 (2)
4. H Purzyńska, R Kuziak, G Golański Numerical Modeling of Precipitation Processes in Heat Resistant HR3C Austenitic Steel Using CALPHAD Method, Acta Physica Polonica A 142 (1), 145-148

Photograph

Biography

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As part of her scientific and research activities, she mainly deals with the issues of heat resistance of steel and alloys, issues of assessing operational durability and material degradation processes.
She is the author of many research methods and methodologies used in assessing the condition and forecasting further safe operations of energy devices, and creates material databases necessary for these purposes.
The developed methodologies for diagnosing damage to critical elements of pressure installations are practically used in industry, also in assessing the causes of their failure.
She cooperates with the electricity and heat generation industry, the Office of Technical Inspection, companies producing pressure equipment and repair and diagnostic plants.
Her scientific achievements include the authorship and co-authorship of over 50 publications in renowned domestic and foreign scientific and technical journals and conference materials..

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