“Influence of the strengthening oxide type on structural and mechanical properties of ODS steels”

Oxide Dispersed Strengthened (ODS) steels are considered as one of the most innovative group of materials being intensively investigated in recent decades. Their name is related to the presence of nanometric elements incorporated in their microstructure, which significantly changes their properties. ODS steels exhibit excellent mechanical properties, good weldability, high chemical resistance and durability in harsh environment (high temperature, oxidizing media and radiation conditions) [1–3]. All these properties are almost unobtainable simultaneously for the conventional steels such as 304 or 316L. The outstanding character, ODS steels owes to the presence of nanometric refractory oxides in their structure, which act as defect sinks. Therefore, fundamental research, aiming to understand impact of the nanoparticles on the properties of ODS steel is badly needed. It is expected, that this will help to answer the questions, whether ODS steels can be produced in larger scale?

Due to their favorable properties, and possible use in many industrial applications, ODS steel are being intensively tested worldwide. In particular, processes occurring during production and impact of fabrication steps are still not well understood and need explanation. Moreover, usually ODS steels are manufactured with addition of yttria (Y_2O_3) as a strengthening oxide. Thus, almost no information exist on the use of other refractory oxides, which may have favorable impact on the functional properties of the steels. Finally, long term stability of these materials is very difficult to estimate. This is related to two effects: 1) experimental data (mechanical, structural and chemical properties) is not completed and 2) experiments are very time consuming and require utilization of large, standard samples which make the process very expensive. As a result, ODS steel are still produced in laboratory scale and their properties are investigated by conducting tests separately at high temperatures, and by submitting the material to ion implantation process (which is regarded as a surrogate of fast neutrons). Ion implantation method has been found as very useful, especially due to the fact that amount of microstructural defects introduced to the structure can be controlled. However, the major problem related to this method is thickness of the modified layer which usually does not exceed several micrometers. Therefore, specific experimental methodology must be implemented in order to test such thin layers. Moreover, it seems to be challenging to estimate parameters of bulk material by investigating only a thin layer. Thus, a specific procedure for results validation must be considered.

In the frame of the proposed project, samples of ODS steels strengthened with alumina Al_2O_3 and zirconia ZrO_2 oxides will be fabricated. This is related to the fact that stability of these oxides in about 750^{o}C is almost the same as yttria. Afterwards, full structural and mechanical characterization of the obtained samples will be performed. Planned in the frame of this project studies are continuation of initial work carried out at NCBJ in the past. The goal of the past studies was to investigate: 1) impact of the chromium content and 2) influence of fabrication process on structural and mechanical properties of the steels. Conducted experiments allowed as to generate necessary experimental information’s, verify manufacture methodology and establish validation procedures for testing ion irradiated samples. Therefore, it is expected that experience gained in the past will minimize the risks related to the manufacture process, will help to properly implement all procedures and conduct planned work.

In conclusion, obtained results will enable us to answer the question “if and how different refractory oxides impact” microstructure and mechanical properties of the designed ODS steels. It is expected that implementation of the proposed project will help us to fulfill information gap related to this subject. Therefore, it will help to better understand fundamental processes and phenomena occurring in the material during its manufacturing and will explain impact of the work environment on the structure of ODS steels.

References:

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