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FTP/4-5Ra: Optimisation of a Nanostructured ODS Ferritic Steel Fabrication towards Improvement of its Plasticity

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In order to increase the operation temperature of the high-chromium reduced activation steels foreseen in applications of fusion reactors, ferritic steels containing 12 to 14% Cr in weight and reinforced with a dispersion of nano-oxides are being under development. The nano-oxides are incorporated into the matrix by adding Y2O3 or Fe-Y intermetallic particles to the initial steel powder, and by performing an intensive ball milling. In order to produce an ODS-steel with better mechanical properties, two specific actions of the production route were considered in this work to minimize the air contamination and porosity. The first one consists in using a higher purity pre-alloyed steel powder instead of mixture of elemental powders. The second one is to perform an additional densification after the hot-isostatic pressing (HIP) by hot cross rolling (HCR) the consolidated HIPed ingot.

The steel powders batches were produced by ball milling of either elemental or pre-alloyed powders with Y2O3 or Fe2Y reinforcement particles in attritor, applying a hydrogen milling atmosphere at a controlled pressure and subsequent hot isostatic pressing. The influence of the type of substrate powders on the mechanical properties was studied for the ODS steels after HIP and after a thermal-mechanical treatment. HCR were applied at a temperature of 800℃.

Optical microscope observations revealed a refinement of the microstructure with smaller porosity. Transmission electron microscope observations of the HCR ODS steel samples microstructures showed mainly recovered grains but also a slight coarsening of the finest oxides particles compared with the steel after HIP. Grains elongation in the rolling plane or in the normal plane was not observed. Hot cross-rolling resulted in an increase of ultimate tensile strength and a significant decrease of the ductile to brittle transition temperature (DBTT). While a lower DBTT has been found for the ODS steels on which HCR was applied, it remains that the upper shelf energy is relatively low in comparison to conventional steel, about twice as low. Thus, more activities are required to produce a material possessing a better balance between the desired high tensile strength, low DBTT and high value of the upper fracture shelf energy. Possible modifications in the fabrication to reach that goal will be discussed.

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