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Effect of mechanical alloying and compaction parameters on the mechanical properties and microstructure of EUROFER 97 ODS steel (P4-I-275)

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Oxide dispersion strengthened (ODS) ferritic / martensitic (F/M) steels appear to be promising candidates for the future fusion reactor. Their inherent properties, good thermal conductivity, swelling resistance and low radiation damage accumulation, deriving from the base material EUROFER 97, are further enhanced by the presence of the fine dispersion of oxide particles. They would allow in principle for a higher operating temperature of the fusion reactor, which improves its thermal efficiency. In effect, their strength remains higher than the base material with increasing temperature. Their creep properties are also improved relatively to the base material. It is the pinning of dislocations at dispersed oxide particles that helps to improve the high temperature mechanical properties. EUROFER97 is a reduced activation F/M steel, whose chemical composition is 8.9 wt. % Cr, 1.1 wt. % W, 0.47 wt. % Mn, 0.2 wt. % V, 0.14 wt. % Ta and 0.11 wt. % C and Fe for the balance.

A new ODS F/M steel based on EUROFER 97 is developed with the strengthening material as Y2O3 maintained at 0.3wt% based on our past experience. The ODS powder is produced by a different powder metallurgy route. The Eurofer 97 atomized powder with particle sizes around 45µm is ball milled in argon atmosphere in a planetary ball mill together with yttria particles with sizes about 10 to 30 nm. The milled powders are now canned in a steel container. They are degassed at 450°C for 3 hours under a vacuum of 10-5 mbar. The canned sample is sealed in vacuum and finally compacted by hot isostatic pressing (HIP) in argon atmosphere under a pressure of 180 MPa at 1000°C for 1 hour. Electron microscopy and X-ray diffraction observations are done at regular intervals during ball milling to identify changes in the particle and crystallite size and in particular with the solubility of yttria in the matrix. Further, The microstructure and mechanical properties of final compacted material is assessed. The size, shape and spatial distribution of dispersed oxide particles are determined.

The aim is to optimize the processing parameters: 1) Milling time, to reduce contamination while allowing for proper alloying. 2) Compaction temperature to maintain single phase and to achieve highest desnity. Relationship between the mechanical and microstructural properties will be established and compared to EUROFER97. The obtained results are presented here.