3a) Underlying Technology

3a1) Measurement of the structural and magnetic properties of ITER vacuum vessel materials after heat treatments (*Principal Investigator: G. Apostolopoulos*)

The measurements of the magnetic properties of the ferritic steel AISI 430 which are used to correct for the toroidal magnetic field ripple in the ITER vacuum vessel at different temperatures have been carried out. Systematic variations of the magnetic properties with ageing time have been observed. This might have implications on the magnetic performance of this steel after a long period of service especially if the temperature cycling is taken into account. No indication of structural changes was observed. cialis generika viagra soft tabs argaiv1901

Objectives: The ITER vacuum vessel is planned to contain plates of ferritic steel AISI 430 which are used to correct for the toroidal magnetic field ripple. A key property for this material is the saturation magnetic flux density Bs. It is not known if the structure of this material and its magnetic properties will remain the same at the operation temperature. Purpose of this work is to examine if the structural and magnetic properties of AISI30 ferritic steel are modified at higher temperatures.

Task description: Two badges of samples from different producers will be used. The sample will be heated at different temperatures and their structure and magnetic properties will be measured.

Progress report: Samples of AISI 430 steels were obtained from two different suppliers. Two sets of samples were annealed under vacuum at temperatures of 200 and 400°C. The annealing was interrupted at regular time intervals and measurements were conducted. The saturation magnetisation, remanence magnetisation, and coercive field were determined by VSM magnetometry, and resistivity was measured by the four contacts technique. Each sample was subjected to a total annealing time of 1 month. In general the effects of annealing on the steel properties were small and in many cases difficult to resolve. A systematic variation of the saturation magnetisation (Ms) was observed in all samples during the annealing period. Ms decreases by 3 % - 6 % during the first 5 - 10 days and then slowly increases towards its initial value. Details may be found in the **Annex XXVI** .

3a2) Measurement of the structural and magnetic properties of ITER vacuum vessel materials after irradiation

This task has not started as the reactor is not operational.

Note: The magnetic properties of ferritic steels depend strongly on the fabrication conditions and are expected to change after long service conditions. On how critical these issues are have to be assessed by the ITER designers and to be taken into account in the specifications of the material to be procured. When the reactor becomes operational irradiation induced changes in the magnetic properties of the AISI 430 steel will be investigated.

3b) Technology Tasks

3b1) Detailed metallurgical characterisation (including ageing effects) of the EU ODS steel (TW3_TTMS_006-deliverable 2, *Principal Investigators: K. Mergia and N. Boukos*)

The work for this task was delayed because the samples were not delivered. The samples were delivered in December 2005 from FZK Association and work on this task started in January 2006. X-ray diffraction, small angle neutron scattering and electron microscopy measurements have been performed in the as received samples and after some heat treatments. Examination of additional heat treatment is underway and the task is expected to finish in May 2007.

Objectives: Metallurgical characterisation of EU ODS including ageing effects.

Task description: The phase structure of the as received alloy will be assessed. A DSC study will be undertaken in order to understand the precipitation and dissolution sequence of the alloy. Then different heat treatments will be applied in order to obtain a homogeneous as much as possible system (identification of the solution treatment temperature). Then different heat treatments in the temperature range RT-900 °C will be applied (isochronal) to the solution treated material. The microstructure of the system in the above mentioned conditions will be investigated by DSC (phase kinetics), X-ray and neutron diffraction (crystallographic and magnetic structure), SEM with EDX (coarse precipitation), TEM with EDX, EELS. This will permit the identification of the different phases and the phase transformation behaviour. Further the isothermal ageing kinetics will be investigated.

Progress report: X-ray diffraction, Small Angle Neutron scattering, SEM and TEM measurements of the as received and heat treated material have been performed. Electron dispersive X-ray spectroscopy and electron energy loss spectroscopy have been employed for the study of second phase precipitates. Isothermal and isochronal annealing of the samples will start beginning of 2007, while the samples will be examined by SEM and TEM measurements. Details may be found in the **Annex XXVII** .

3b2) Neutron irradiation up to 0.8 dpa at 200-2500 C of EUROFER plates (TW2_TTMS_001b_deliverable 7, *Principal Investigator: S. Messoloras*)

Tests of the irradiation rig with He gas at different pressures were performed. The experimental data in conjunction with MCNP calculations of the gamma heating show that a temperature control up to 350°C under reactor core conditions is feasible.

Objectives: Neutron irradiation up to 0.8 dpa at 200-250°C of EUROFER plates for modelling purposes. The details will be discussed with the group undertaking modelling of the irradiation effects on Fe. Main part of the effort will be devoted in the development of a high temperature rig.

Task description: An irradiation rig capable of reaching 300°C will be designed. The useful volume of the rig will be of diameter 10-15 mm and of height 400 mm (level of 50 % flux reduction) or 300 mm (level of 75 % flux reduction) – 200 mm gives almost constant flux. Samples will be irradiated at different levels up to 0.8 dpa, will be withdrawn and will be despatched for PIE.

Progress report: Experiments with the prototype irradiation rig have been performed in order to assess its temperature control capabilities. A heater placed at the sample position was used in order to simulate the gamma heating which will be present during real irradiation conditions. It was found that the heat transfer from the inner sample compartments to the surrounding constant temperature pool depends strongly on the pressure of the exchange gas (He). Specifically, the heat transfer coefficient may be varied by a factor of 10 when the gas pressure changes from 0.2 to 1000 mbar. Thus, effective control of the irradiation temperature may be achieved by this method. The reactor was shut down during this period and measurements of gamma flux at the irradiation positions were not possible. Therefore we used MCNP calculations to estimate gamma flux and gamma heating of the irradiation rig under normal operating conditions of the reactor. These calculations, in conjunction with the heat transfer coefficients deduced from the experiments, show that temperature control of the irradiation rig in the range of 50 - 350°C should be possible when Al is used for the sample capsule. Details may be found in the **Annex XXVIII** .