B4 Underlying Technology

4.1 Microstructure, magnetic, thermal and electrical properties of Fe-Cr alloys

4.1-1. Experimental description of Fe-Cr alloys

Background and Objectives: In a recently published paper by our Association [Mergia, K. and Boukos, N, "Structural, thermal, electrical and magnetic properties of Eurofer97 steel", Journal of Nuclear Materials **373,** 1 (2008)] the mechanical and magnetic properties of Eurofer have been correlated for the first time. This experimental work is very important in the EU modelling effort of Fe-Cr. Taking into account that there is and there will be a considerable effort within EU in modelling the radiation behaviour of iron and iron-chromium alloys, the microstructure and physical properties of these alloys have to be assessed and correlated with their mechanical properties and their behaviour under high temperature and irradiation. This is one of the main aims of the Materials Topical Group referred as "physical understanding to master the evolution of material properties" and modelling of Eurofer. Thus, purpose of this UT task was to fabricate initially good Fe-Cr alloys and examine their structure and physical properties. In order to understand the behaviour of these systems, samples of good quality have to be fabricated and post fabrication heat treatments to be assessed and qualified. This underlying technology task is part of the EFDA 2007-11 work programme and in collaboration with other Associations within the Materials Topical Group it will be extended in the study of structural changes under temperature and/or mechanical loads. In another activity, irradiation induced structural and physical properties changes will be studied and correlated with modelling.

Work performed in year 2007 (*in co-operation with CEA*): Fe-Cr alloys with concentrations ranging up to 20 at. % Cr have been successfully fabricated with good homogeneity by means of the arc-melting technique. Detailed magnetic measurements have been performed on several samples and the dependence of saturation magnetisation, remanence magnetisation and coercive field on Cr concentration and temperature has been studied (see **Annex XXXI**). Some delays due to equipment breakdown did not allow the investigations to cover also the electric properties, which will be done during the year 2008. Also in year 2008, the effects of different heat treatments on the physical properties of Fe-Cr alloys will be investigated, since the results up to now involved samples in the "as prepared" state.

4.4 MHD flows and turbulences

4.4-1. Use and development of MHD code in relation to liquid metal blanket

Background and Objectives: The reactor blanket and the circulating liquid metal contained within are exposed to the strong magnetic fields used to confine the plasma. When the liquid metal enters or exits the magnetic field, the forces acting upon the liquid metal changes which can change the characteristics of the flow. The goal of this activity is to model the flow of liquid metals in strong magnetic fields, and examine the effects of fringing magnetic fields and electrical conductivity of the blanket material on the flow. The modelling is done using a parallel unstructured Navier-Stokes solver developed in collaboration with ULB.

Work performed in year 2007 (*in co-operation with ULB and FZK*):

1. A FORTRAN 90/95 module for modelling MHD flows was developed. The solver uses the finite volume method with time-splitting to solve the Navier-Stokes equation for velocity, pressure, and electric field over an unstructured collocated grid. The solver was then validated for the different cases listed below.

- The code was validated for flow in a pipe at bulk Reynolds number of approximately 8000 as shown in **Annex XXXII** . This is an important verification of the mesh used to model the flow because it shows that the mesh is fine enough for doing DNS at this Reynolds number. Results show excellent agreement with previously published results.

- The solver was verified for pipe flow with Reynolds number of 8000 and Hartmann numbers up to 400 for both perfectly conducting walls and perfectly insulating walls.

1. An investigation of the application of the immersed boundary method to model obstructions and complex geometries in MHD flows has been initiated. The validation of the method for Hartmann flow in parallel ducts has been successfully completed, while we are currently applying the method in ducts with varying cross section and/or solid obstructions.