8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

NON LINEAR, THERMO-MECHANICAL ANALYSIS OF Nb_3Sn STRANDS

***L. Reccia[1], A. della Corte[2] , D. Boso[3] and E. Salpietro [4]**

ENEA C.R. Frascati, Italy
[1]luigi.reccia@frascati.enea.it
[2]dellacorte@frascati.enea.it
http://www.fusione.enea.it/

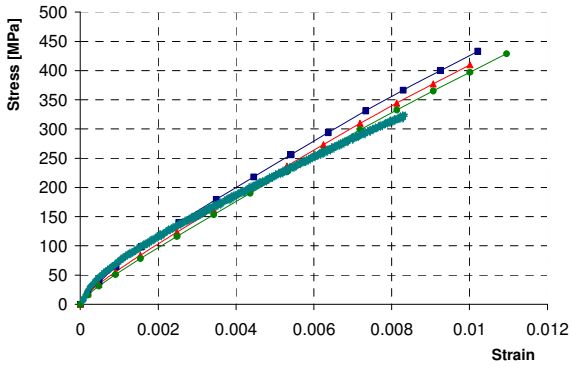
[3] University of Padua, Italy
boso@dic.unipd.it

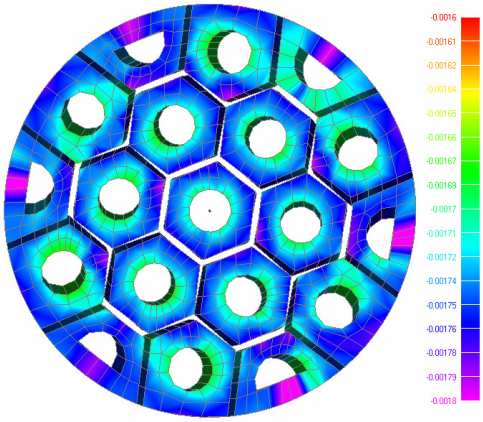
[4] EFDA, CSU Garching, Germany
ettore.Salpietro@tech.efda.org

Key Words: *Superconductors, strand, magnets, fusion, Nb_3Sn, FEM.*

ABSTRACT

Nb_3Sn strands are widely used for Cable in Conduit Conductor technology, but their electric performances strongly depend upon the mechanical behaviour. In particular the value of the critical current is limited by the strain field due to the cool down and to the bending caused by Lorenz forces. In this paper the problem of the strain evaluation has been addressed by means of the finite element method. Starting from a Scanning Electron Microscope (SEM) image of the OST (Oxford Superconducting Technology) strand, a detailed discretization of the cross section has been developed, respecting the real area values for copper, bronze, tantalum and Nb3Sn. Performing a non-linear, 3D thermo-mechanical analysis, taking into account the elastic-plastic behaviour and temperature dependent material characteristics, stress and strain fields have been computed for the strand.
Firstly the axial behaviour has been investigated, simulating a tensile load after the cool-down also using the experimental data to trim some material characteristic.
Secondly the bending behaviour has been analyzed respecting the actual load constraint condition and comparing the numerical results to the experimental tests. This analysis is the first necessary step to allow the assessment of the strand behaviour, which is a key point to study higher order cabling stages.





REFERENCES

[1] W.A.J. Wessel, A. Nijhuis, Yu. Ilyin, W. Abbas, B. ten Haken, and H.H.J. ten Kate, **A novel "test arrangement for strain influence on strands" (TARSIS): mechanical and electrical testing of iter Nb_3Sn strands**, Adv. Cryog. Eng. (Materials) 50 (2004) 466-473

[2] Najib Cheggour and Damian P. Hampshire, **A probe for investigating the effects of temperature, strain, and magnetic field on transport critical currents in superconducting wires and tapes,** Review Of Scientific Instruments Volume 71, Number 12 December 2000

[3] P. Bauer, H. Rajainmaki, E. Sampietro**, EFDA Material Data Compilation for Superconductor Simulation** EFDA CSU, Garching, 04/18/07

[4] D.P. Boso, M. Lefik, B.A. Schrefler. **Multiscale Analysis of the Influence of the Triplet Helicoidal Geometry on the Strain State of a Nb3Sn Based Strand for ITER Coils**. Cryogenics; 45(9), 589–605, 2005.

[5] J. A. Parrell, M. B. Field, Y. Zhang, and S. Hong, **Advances in Nb_3Sn Strand for Fusion and Particle Accelerator Applications**, *IEEE Trans. Appl. Supercond. 15 (2)*, 1200-1204, 2005.

[6] D.P. Boso, M. Lefik, B.A. Schrefler**. Thermo-mechanics of the Hierarchical Structure of ITER Superconducting Coils**. *IEEE Transactions on Applied Superconductivity,* 17(2), 1362-1365, 2007.

[7] A. Vostner and E. Salpietro, **Enhanced Critical Current Densities in Nb_3Sn Superconductors for Large Magnets**, *Sup. Sci. Technol. 19*, S90-S95, 2006.

[8] **http://www.iter.org**