A Magneto-Thermo-Metallurgical Finite Element Model applied to Induction Hardening Processes

M. Spezzapria, M. Forzan, F. Dughiero

Laboratory of Electroheat (LEP) - Department of Industrial Engineering (DII)
University of Padova
Via Gradeniglo 6/a, 35131 Padova, Italy
e-mail: mattia.spezzapria@dii.unipd.it, web page: http://www.dii.unipd.it

ABSTRACT

Induction hardening has been widely applied for the heat treatment of components mainly in the wind-power and automotive sectors. because of its peculiar advantages like high quality and repeatability of process and its easy automation.

A multi-scale multiphysical finite element (FE) analysis is presented in this paper for the prediction of microstructural evolution during induction hardening processes. An ad hoc external routine has been developed in order to calculate the phase changes during heating and cooling process associated with non-isothermal transformations. This routine has been coupled with commercial FEM codes able to solve the coupled electromagnetic and thermal problem that typically describes the induction heating processes. During the heating, the magnetic field generated by the coil induces currents in the workpiece and as consequence the heating of conductive material by Joule effect.

Material properties depend on the temperature distribution but also on the microstructure since the material could be seen as a mixture of different phases, each one with different physical properties. The effect of latent heat of solid-solid phase transformations has been also considered.

From the solution of the coupled steady-state, at a given frequency, electromagnetic and transient thermal problem, temperature distribution as well as heating and cooling rates are used for the evaluation of the existing metallurgical phases at every time step.

Mattia Spezzapria
Laboratory of Electroheat (LEP) - Department of Industrial Engineering (DII)
University of Padova
Via Gradenigo 6/a
35131 Padova, Italy
Tel. +39 049 8277552
Fax +39 049 8277599
E-mail: mattia.spezzapria@dii.unipd.it

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