DESIGN OF EXPERIMENTS (DOE) STUDY OF THE INDUCTION HARDENING PROCESS

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ABSTRACT

Engineering components rely on good mechanical properties to meet in-service performance requirements. Heat treatment is usually the method utilised to develop the properties required. Induction hardening is a popular and efficient method for rapid heating and cooling of a component surface to achieve desired microstructural and mechanical properties.

The surface hardening of long, slender components such as shafts can be carried out by scanning through an induction hardening unit, comprising of an induction heating coil and a water quench jacket. Tight control of process conditions is important in order that problems such as insufficient case depth do not occur. In addition, the phase transformations involved in the process inevitably mean an increased volume, distortion and residual stress in the component. Balance between the heating and cooling processes can cause the already quenched martensitic surface to become softened from the tempering effect of the still hot core.

In induction heating an alternating current in the induction coil creates a magnetic field which induces an electric current in the component. The workpiece itself is heated by electrical resistance and the heat generation generally corresponds to the depth of the magnetic field and conduction within the workpiece.

The electromagnetic field depends on the coil shape, power, position and frequency, presence of flux concentrators and the electromagnetic properties of the material. The workpiece material properties vary with material type and phase, temperature and magnetic field intensity. As such, developing a new process to achieve the required properties can be challenging.

This paper will present the simulation of steel shaft together with copper induction coil and water quench jacket. The simulation utilises the DEFORM software package combining Boundary Element Method (BEM) to solve the electro-magnetic field coupled with Finite Element Method (FEM) to solve the workpiece thermal, mechanical, microstructural and electrical performance.

Design of Experiments (DOE), which is integrated in the DEFORM system, will be used in the study to assess the key process variables with respect to case hardening depth and residual stress.