Multi-physics and multi-objective design of a benchmark device: a problem of inverse induction heating

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ABSTRACT

Induction heating is used in thermal processes to heat at a prescribed temperature the workpiece with high efficiency and accurate temperature control. In this field the solution of coupled electromagnetic and thermal fields is mandatory, as well as the use of optimization algorithms to identify the best device [1]–[4].

In the paper, a benchmark model to approach a multiphysics bi-objective optimal design is presented [5]-[6]. A finite-element analysis (FEA) is used to solve the inverse problem, whereas the optimization is performed by means of a modified NSGA algorithm. The direct problem solves a time-harmonic magnetic problem to evaluate the power density in the graphite disk coupled to a steady-state thermal problem to evaluate the temperature profile. The optimization algorithm includes a new migration step in order to vary and improve the population characteristics during evolution as it occurs in natural populations when groups of individuals with different characteristics migrate in a given population (e.g. from a different continent).

The benchmark model represents an industrial equipment for the epitaxial processing of silicon wafer [7]. The designed device includes a graphite disk, a pancake inductor and a ferrite yoke. In fact a pancake inductor does not induce power on the axis of the load and temperature close to the disk axis can be significantly lower. The magnetic concentrator is used to increase the temperature in the centre of the disk. The design variables are the vertical positions of the inductor turns and the size of the magnetic yoke. The optimized objective functions are the device efficiency and the temperature uniformity in the workpiece [2], both objective are maximized. In particular the industrial process requires a temperature of 1050-1100 °C in the graphite disk at steady state.

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