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INTEGRAL APPROACH FOR THE NUMERICAL MODELING QUENCHING PROCESS OF FORMING ROLLS

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ABSTRACT

When solving mathematical physics problems one often focuses on integral equations due to the significant benefits that have integral equations compared with the differential. Important advantages of integral equations include the ability to assess the errors in their sample, as well as value of the error of the approximate solution to a residual (discrepancy) function. Using numerical integration schemes of high order of accuracy one can also increase the accuracy of the results on the large-scale grid partitions, which is important in modeling the thermal effects on objects with high spatial dimensions.

The developed method - the strings method – has a number of computational advantages over known approaches:
- Can be used for products with complex geometry in two-dimensional and three-dimensional cases and allows to control accuracy of the numerical solutions in each design point, thus avoiding the "nonphysical" oscillations in areas with large temperature gradients;
- For inhomogeneous systems is no need to explicitly distinguish the boundaries of areas to harmonize the conditions of continuity of temperature and heat flow;
- Relatively high efficiency in parallelizing and organization of multithreaded computing.

String method is a generalization of a previously developed method of geometric integrals for the case when the thermal properties of the medium depend on the temperature, as in the case of melting or structural phase transitions. Unlike string method is that in the first method as a function of the unknown quantity favor heat flux density in the relevant areas, and in the method of strings unknowns are already derived from the heat flux density at the corresponding spatial coordinates.

One of the applications to which you can apply thermal calculations are heat treatment of metals and alloys, in which there is a reorganization of the internal structure of the material. For steels the most important characteristic of such processes is the cooling rate, depending on which one can obtain a martensite or pearlite or (bainite) structure, on which depends the performance of the product produced. Thus, the purpose of modeling problems in materials science is to identify changes over time distribution of the temperature field on the thickness of the product, which allows to predict the structure of the hardened layer, and, therefore, to determine such modes of heat treatment, which can provide the required strength and performance.

For surface hardening is often used simultaneous induction heating and cooling via a moving sprayer. The figures show the results of calculations of single-pass quenching when a moving inductor at some distance moving sprayer, pressure fed to the surface of the roll constant flow of water. When cooling with water we take into consideration by setting the corresponding heat transfer coefficient in the selected region impact sprayer.

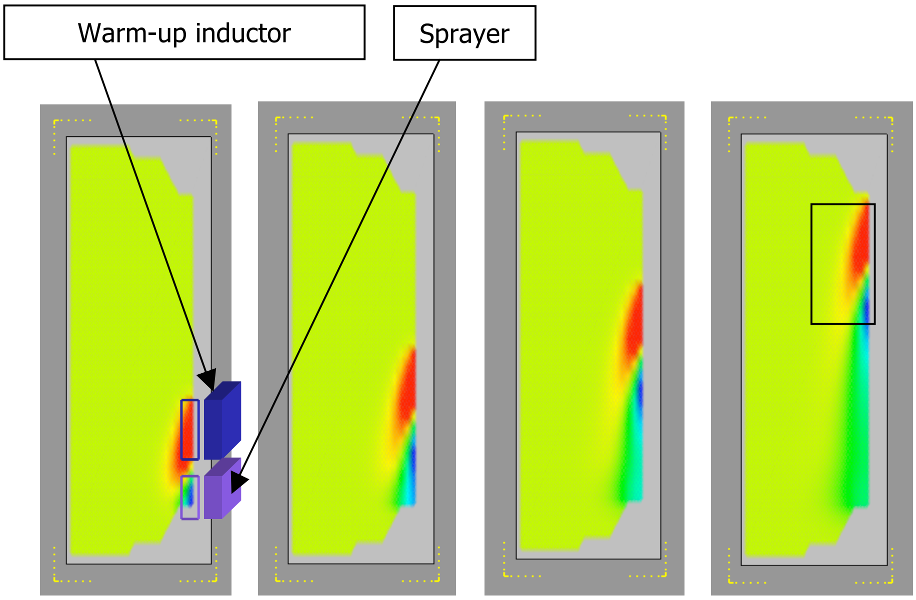

Figure 1. Simulation of single-pass induction warm-up, followed by cooling sprayer.