Modelling of a thermo-mechanical response of hot-rolled steel bars on a cooling bed with a meshless numerical approach

Gašper Vuga[1], Boštjan Mavrič[1,2], Božidar Šarler[1,2]

[1]*Faculty of Mechanical Engineering, University of Ljubljana, Slovenia*
[2]*Institute of Metals and Technology, Ljubljana, Slovenia*
E-mail: gasper.vuga@fs.uni-lj.si

Following the continuous hot-rolling process, steel bars are transported to the cooling bed for cooling. Due to high temperatures, the yield strength is low and can be due to cooling exceeded, resulting in residual stress accumulation and bending formation. The study investigates how the spacing between bars and the distance to the heat shield above the cooling bed affect the radiative heat fluxes and, consequently, the thermo-mechanical response. The governing equations are solved in a strong form with a modified version of a local radial basis function collocation method – LRBFCM [1]. The initial bars cross-section geometry is obtained from the existing hot rolling simulation system developed in our research group [2]. The problem is solved in a decoupled way, where the temperature solution represents the driving force for the mechanical model. Temperature solution is obtained with explicit time propagation, where view factors, computed with a Monte-Carlo method, determine the radiative heat fluxes. The mechanical model assumes a generalized plane strain state and accounts for bar bending. Small strain elasto-plasticity with isotropic von Mises temperature-dependent hardening is considered. The global system of nonlinear equations arising from the mechanical model is solved with the Newton-Rhapson method. The return mapping algorithm is used to solve constitutive relations. The cooling process results indicate that the positioning of the heat shield has a minimal impact on temperature and stress distribution. Conversely, the spacing between bars has a more significant influence, which diminishes as the distance between them increases. The modified version of LRBFCM is proven capable of resolving such a complex thermo-mechanical industrial problem.

1. R. Vertnik, B. Šarler, *Int. J. Numer. Methods Heat Fluid Flow*, **2006**, *16*, 617-640.
2. U. Hanoglu, B. Šarler, *Comput. Struct.*, **2018**, *194*, 1-14.