Influence of casting defects on damage evolution and potential failures in hot rolling simulation system

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In this research, a previously developed rolling simulation code, based on a novel meshless collocation method, is upgraded from a deformation theory with ideal material properties to a new mechanical model that considers predefined defects even before the rolling process occurs. Considering homogeneous casted steel free of errors to enter a rolling mill will not produce any reliable predictions of possible failures. Depending on the rolling schedule, failure might occasionally happen during rolling as well, most likely due to high strain rates, shear stress, temperature gradient, friction, etc. However, most simulations that try to foresee those possible failures by only considering the rolling process parameters are incomplete. Even at the macro level, previous defects from the casting play a crucial role in failure that might occur or come very close to during rolling. The damage variable is initially defined as the density of micro-voids in the material. Instead of fracture mechanics, continuum damage mechanics is considered here to analyse the mechanical behaviour of the rolled steel in parallel with the damage evolution. As a result, a damage tensor is calculated during the hot rolling simulation based on the current deformation state. In each deformation step, the effective stress tensor is redefined with the inclusion of the damage tensor. For simplicity, a two-dimensional [redacted] model is co[redacted] in the simulations. These slices are aligned parallel to each oth[redacted] direction. S[redacted] main advan[redacted] defects of t[redacted] where and [redacted] on experim[redacted] different le[redacted] been create[redacted]

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INTRODU[redacted]

In this rese[redacted] novel mesh[redacted] a damage [redacted] hot rolling [redacted] properties [redacted] displaceme[redacted] placed righ[redacted] billets are h[redacted] is rolled, it [redacted] in a certain [redacted] considered [redacted]

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already contains defects. All those unwanted contents/ errors may be assumed as damage. In each representative volume element, the amount of damage over the volume gives us the local damage value to be used in simulations.

The first idea of including damage variables in the equations of material deformation is given by Kachanov and Rabotnov [2-3]. They introduced a scalar damage variable. Later, Lemaitre [4] and Chaboche [5-6] used laws of thermodynamics to describe damage behaviour. Lemaitre [7], Chow and Wei [8] also came up with multi-

A numerical simulation is carried out with the initial damage d[redacted]mation based on the accumulated deformation h[redacted]ory, which is much lower than the ideal material w[redacted]ithout damage. Second, the initial damage values are read and included in the damage evolution model to observe a more realistic damage evolution.

The damage value in damage evolution models tends to increase with deformation. However, in rolling, compressive stresses are dominant. Based on observations, most porosities might be eliminated with proper rolling schedules. In the future, we need to experimentally investigate damage evolution in compression and develop a more appropriate damage model for rolling simulations.

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