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Nonlinear Finite Element Analysis of Rolling Contact between Slab and Roller of Continuous Caster

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Summary

Rolling is the process of reducing the thickness of long work piece by compressive forces applied through a set of rolls. The mechanics of deformation in the roll bite for flat rolling has been a subject of extensive study over the past decades. It takes on an increasingly important role as the automation of the rolling mills advances and the demand on product quality increases. A precise prediction of the roll force is required for accurate set up of the roll gap position, proper selection of roll material and control the product the quality. Therefore the analysis and computation of the roll force within the roll bite region is of the primary interest. Finite element model has been employed to solve many metal rolling processes such as flat rolling, shape rolling, edge rolling and special shape steel tolling. The finite element results are compared with the experimental results which are found to be in good agreement. In this analysis a finite element model of slap/roll rolling is analyzed using the commercial FEA package ABAQUS. The master-slave interfacial algorithm developed for contact modeling in the finite element code ABAQUS is used in this analysis. The SURFACE INTERACTION option with surface to surface contact for contact pairs along with finite sliding contact formulation in ABAQUS is used for this analysis. The FRICTION option with penalty formulation is used to introduce friction at the contact interface. The NLGEOM parameter for geometrical non-linearity is included in each step.

The strip is rolled between two rolls that its thickness is reduced. As the slap under goes deformation, it exerts reaction force to the rolls which leads to roll bending and failure. A simple 2D finite element analysis using a single roll is performed for the slab deformation of 0.5mm. In addition to that a 2D FEM analysis for the slab deformation of 0.5mm, 1mm and 1.5mm is performed where the rolls are placed linearly and the roll centers are moved down vertically according to the required slab deformation. However for the 3D FEM analysis, only two cases of slap deformations 0.5mm and 3mm with single roll are studied. However for simulating the actual experimental set up, a 2D FEM set up using 7 rolls are analysed where the rolls are assembled with the given coordinate system and slap is pulled through the rollers.

As the slap moves further the residual materials at the slap surface tend to raise above the slap surface, which further increases the reaction force. It shows that

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the reason for increase in reaction force not only with the slap thickness reduction but also with the residual material which increases the slap thickness more than the original thickness. The similar behavior is seen in both 2D and 3D finite element analysis.