"Numerical offline rolling process simulations with special emphasis on profile, flatness and roughness transfer"

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Abstract:

Hot and cold rolling processes of flat metal sheet can be considered to be key steps within the production chain of steel and aluminium products. Therefore, the development of highly sophisticated mathematical offline and online models is a vital precondition for manufacturing high quality products satisfying even the most challenging tolerance demands. Although the analysis of transient and steady state elasto-viscoplastic forming processes is not new, the higher and higher demands from customers concerning product quality are the reason, why it is of utmost importance to attain a better understanding of the underlying process details by utilising highly sophisticated formalisms and optimised numerical simulation concepts.

For a great variety of challenging transient dynamic 3D-offline problems, such as the thermo-mechanically coupled simulation of the “true-shape” formation of steel blocks in plate rolling and of billets in groove rolling, commercial finite element packages such as Abaqus Standard and Explicit or Deform-3D are well suited in the meantime. However, the requirements concerning storage capacities and calculation time are often extremely high, especially when different length scale values appear in the simulation model. Therefore, the simulation of the deformation of edge crack defects in hot rolling and the investigation of the transfer of surface roughness structures from the work roll onto the uncoated or hot dip galvanized strip surface in temper rolling are extremely challenging from this point of view.

One of the most important objectives of rolling simulations is the accurate and reliable prediction of lateral flow and strip spread, which enables the precalculation of relative strip crown changes and profile transfer functions. In rolling of wide thin strip, the transverse distribution of the residual stresses is essential for practical reasons. As is well known, residual stresses are not included by purely rigid-viscoplastic constitutive laws, but can be obtained by taking into account elasto-viscoplastic material laws. As the computation of elasto-plastic flow problems is more costly, the development of efficient steady state algorithms for the elasto-viscoplastic material flow is an essential task. Moreover, especially for thin wide strips, the aspect ratio width over thickness is extremely unfavourable for finite element calculations, leading to calculation time values of several days with commercial FE-programs like Abaqus, Ansys or LS-Dyna. Therefore, the development of reliable, tailor-made and efficient numerical codes for the prediction of strip flatness, where the non-linear coupling with the elastic roll stack deflection models is of utmost importance, is really a challenging task.

Keywords:

Flat hot rolling, profile, flatness, profile transfer, elastic roll stack, elasto-plastic constitutive laws, residual stresses, buckling, A.L.E., edge-cracks, true-shape, groove rolling, temper rolling, roughness transfer.