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FLATNESS DEFECTS IN SHEET ROLLING MODELISED BY ARLEQUIN AND ASYMPTOTIC NUMERICAL METHODS

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ABSTRACT

Rolling of thin sheets generally induces flatness defects due to thermo-elastic deformation of rolls. This leads to heterogeneous plastic deformations throughout the strip width and then to manifest out of plane displacements to relax residual stresses [5].

In this work we present a new numerical technique to model the buckling phenomena under residual stresses induced by rolling process. This technique consists in coupling two finite element models: the first one consists in a three dimensional model based on 8-node tri-linear hexahedron which is used to model the three dimensional behaviour of the sheet in the roll bite; the second model is based on a shell formulation well adapted to large displacements and rotations, it will be used to compute buckling of the strip out of the roll bite [1,4]. We propose to couple these two models by using Arlequin method [2].

The originality of the proposed algorithm is that in the context of Arlequin method, the coupling area varies during the rolling process. Furthermore we use the asymptotic numerical method to perform the buckling computations taking into account geometrical nonlinearities in the shell model [3]. This technique allows one to solve nonlinear problems using high order algorithms well adapted to problems in the presence of instabilities. The proposed algorithm is applied to some rolling cases where "edges-waves" and "center-waves" defects of the sheet are observed. The numerical results are compared with experimental data·

Key Words: *Rolling, Residual stresses, Buckling, Arlequin, Asymptotic Numerical Method*

Overview of the model

Flatness defects are among the major problems encountered in strip rolling. Their direct origin is out-of-bite stress gradients resulting in buckling in the compressive stress areas. To model these phenomena of buckling, we based on two finite element models: a three dimensional model based on 8-node tri-linear hexahedron which is used to model the three dimensional behaviour of the sheet in the roll bite but is unable to predict the buckling; the second model is based on a shell formulation which is used to compute buckling of the strip out of the roll bite. So the idea is to combine these two models in the same finite element simulation.

➢ Formulations

We consider small strain elasticity in the three dimensional part and a geometrically nonlinear elastic law in the shell part. This shell model, proposed by Büchter and Ramm [4], avoids locking and uses the unmodified and complete three-dimensional constitutive law.

➢ Arlequin coupling

The central point of the model is the coupling operator C which is selected by analogy with the deformation energy of the shell. Otherwise the coupling area S_c varies during the rolling process.

$$C(\mu,u)=\int_{S_c}\mu.u+\varepsilon(\mu):D:\varepsilon(u)d\Omega \tag{1}$$

Results

To simulate the advance of the sheet in the process, the residual stress field is translated along the sheet. The position of the roll and the coupling area are located by a parameter x_0 which varies along the length of the sheet. The propagation of the edge-waves buckling is presented in the figure 1.

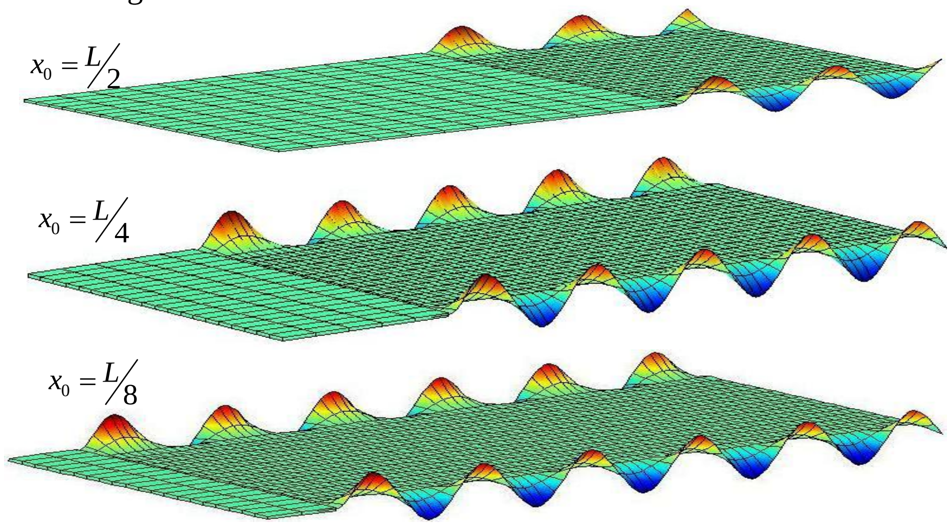

Fig. 1. The sheet buckled under residual stresses

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