DEFORM™ Application #114

Rolling Applications

Industrial Rolling:

Many engineering components have been subjected to industrial rolling processes during their manufacture. Numerous process parameters can influence the success of a rolling sequence, including pass reduction, roll diameter, rolling speed, temperature and mill elasticity. In complex shaped rolling, material folding and underfilling can lead to severe problems. In addition, a poor pass design may result in the stock bowing excessively and even colliding with adjacent roll stands.

Process Simulation:

Industrial trials are expensive and interrupting production may be extremely unfavorable. Laboratory trials can be useful but may not provide representative results. 2D rolling simulations have been undertaken for a number of years, usually involving a plane strain assumption. Recently, with advances in finite element formulations and improvements in auto-remeshing techniques, 3D rolling modeling has started to become practical.

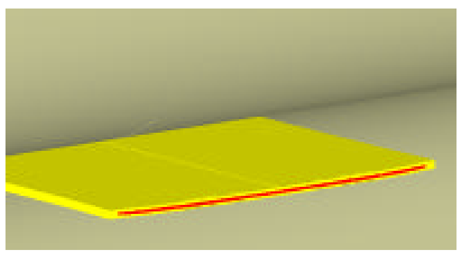

Figure 1: The pack rolled assembly exiting the third roll pass. The aerospace alloy is shown in red, with the mild steel jacket in yellow.

Shape Rolling:

Voestalpine Schienen GmbH carried out this shape rolling analysis using DEFORM™-3D. This tramway rail section is employed in many European cities. Ten passes are involved and the final two passes employ free-wheeling side rolls.

In the next to last pass, the side roll forms the groove in the head of the rail. This side roll was cracking prematurely and DEFORM™-3D predicted uneven pressures acting on it's top and bottom faces. Combining the predictions from DEFORM™ with Voestalpine's experience, the material flow was improved to give more even pressures and thus extend the life of this form roller.

Pack Rolling:

A jacket of mild steel (yellow) surrounds the aerospace alloy (red). The mild steel jacket thermally insulates the aerospace alloy, which would otherwise lose heat too rapidly. In reality, the two materials are rolled as an assembly. This 3D multiple deforming body simulation capability is unique to DEFORM™-3D.

A sophisticated contact algorithm was developed for large deformation of multiple deforming (plastic) bodies. This provides for an accurate representation of material flow of the aerospace alloy and the mild steel. This analysis would be extremely difficult or impossible for most simulation programs.

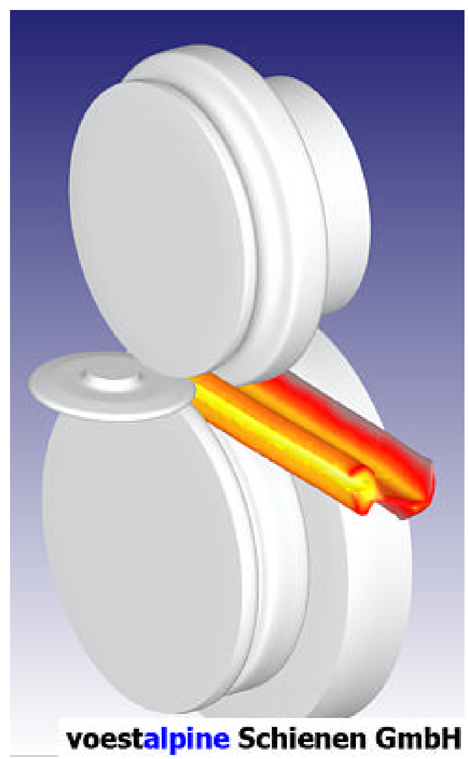

Figure 2: The shape rolled section is shown with a free-wheeling side roll that forms a groove in the head of the rail during this pass.

DEFORM™
Design Environment for FORMing

Tantalum Slab Rolling:

A tantalum slab was reduced from 4" to 2" in eight passes during this industrial rolling simulation. Prior to rolling, this slab had been cogged from round ingot and the predicted deformation history was carried through. Rolling began with the slab at room temperature but a non-isothermal analysis was required to account for adiabatic heating reducing the alloy's flow stress.

The slab was rotated 90 degrees after each pass providing alternating longitudinal and transverse passes. The preliminary simulations in DEFORM™-3D correctly predicted the slight bending of the slab in the 7th pass and the progressive end folding during the schedule.

The predicted load-stroke curve illustrates the greater mill loading from the transverse passes. This is extremely valuable in determining whether greater reductions per pass would be feasible for a given rolling mill capacity. The increased rolling loads in subsequent passes were due to increases in slab length and width, since it was known that any work hardening effects were cancelled by softening from adiabatic heating.

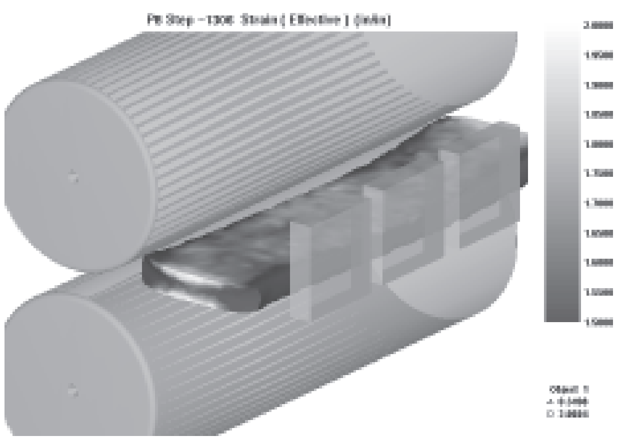

Figure 3: The tantalum slab is shown entering the eighth and final pass. Note the slight bending along the slab length and the folding at its ends.

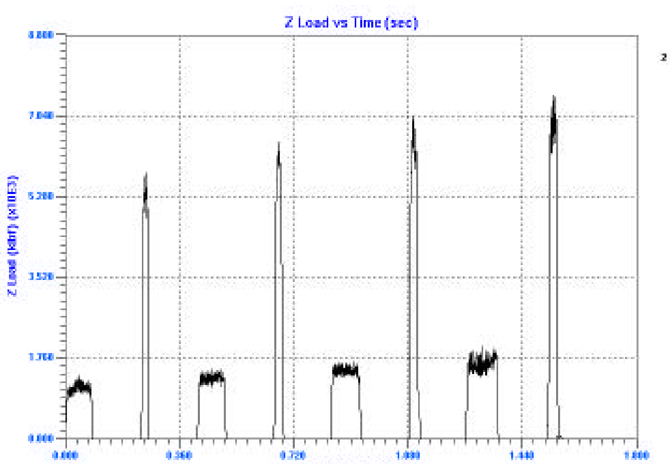

Figure 4: The predicted load stroke curve for the eight-pass schedule. The transverse passes exhibited far greater loads as compared to the longitudinal passes.

On-Going Developments:

A plan to further enhance rolling-specific capabilities within DEFORM™ is in process. Special packaging to streamline input data, recognize rolling specific process conditions and offer solution techniques to provide both transient and steady-state analysis are in development.

Elastic roll bending and flattening capabilities are very significant issues in the rolling of sheet. Capabilities for the crowned rolls and resulting flatness of rolled stock will be included.

Steady state models can be used to predict load, geometry and flashing for single and multiple passes. Enhancements can include the ability to predict the thermal profile, grain size, recrystallization and phase transformation through multiple rolling operations.

Finally, optimization techniques can be used to optimize cross section design, minimize roll stress and predict the number of required passes, as well as avoiding potential defects prior to production trials.

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