RollOilFree II Newsletter No 4

Early 2026 marks a significant milestone for the RollOilFree II consortium: Scuola Superiore Sant'Anna has successfully completed the **Mathematical Model of Cold Rolling (MMCR)**. Serving as a core deliverable for Work Package 4, this model functions as an advanced investigation and support tool for both our pilot and industrial trials.

WP4: The Mathematical Model of Cold Rolling

Within WP4, SSSA has developed and validated a one-dimensional mathematical model of cold rolling (MMCR) featuring mixed lubrication and thermal coupling, which has been implemented in a user-friendly web interface (see Fig. 1) to enable consortium partners to interactively set up, run, and visualize simulations. The MMCR incorporates **modular components** tailored for specific process mechanics, including **lubricant behavior** that implements the Roelands equation for viscosity-pressure dependency paired with the Eyring model for describing shear thinning. For material characterization, the model utilizes **custom flow stress curves** to accurately capture plastic deformation under varying strain rates and temperatures. Furthermore, it addresses **roll flattening** by offering three specialized options: a rigid roll, the classical Bland & Ford model, and Meindl's advanced semi-analytical model, which accounts for general radial and tangential displacements of a cylinder in plane-strain. Finally, the system employs **robust numerical solvers**, utilizing a new Runge-Kutta 4 solver alongside the Forward Euler method, equipped with user-defined tolerances.

The MMCR has been rigorously validated against data from the first pilot trials at Tata Steel, encompassing hard steel, soft steel, and tinplate (packaging) grades.

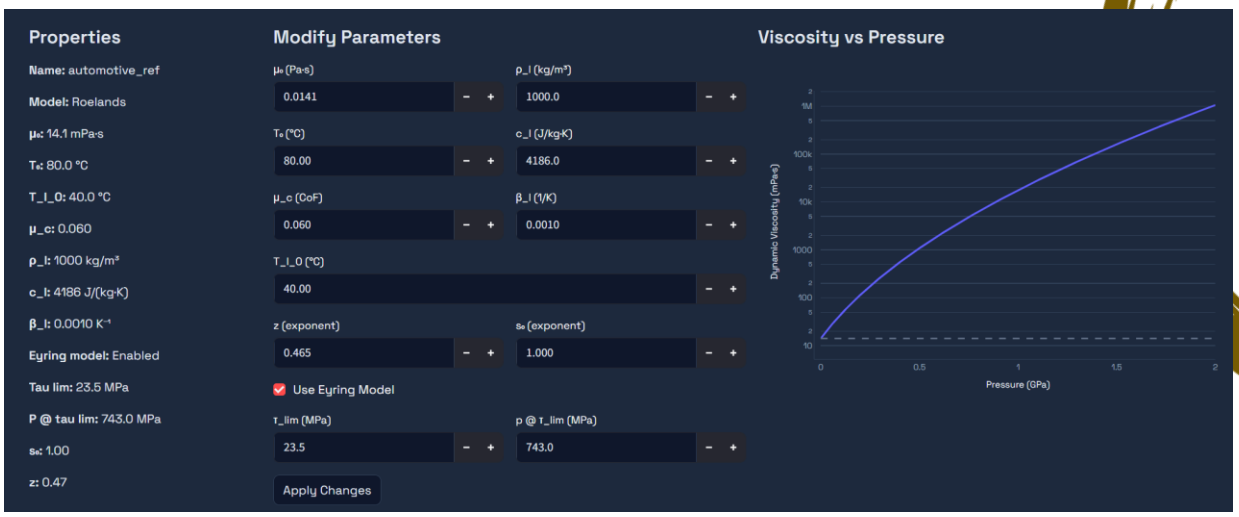

FIGURE 1 – LUBRICANT MODEL INTERFACE FOR FULL CUSTOMIZATION

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Validation and Application

The simulated roll force, torque, and forward slip demonstrated strong agreement with the measured values across multi-pass rolling schedules (see Fig. 2).

Additionally, the model has been preliminarily applied to the second pilot trial data (Stribeck-type tests), showing highly encouraging results for automotive and tinplate steels. The validated model forms a strong basis for the upcoming industrial trials at thyssenkrupp Rasselstein (tkPS), and it will be continuously refined as more experimental data becomes available. The validated model is also being actively used to plan and support the upcoming set of industrial trials.

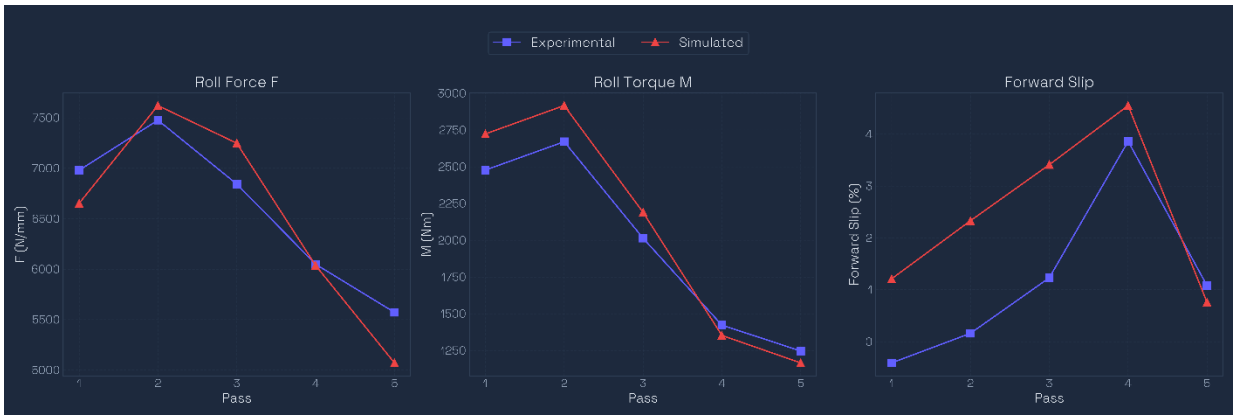

FIGURE 2 – MMCR VALIDATION RESULTS FOR THE TINPLATE STEEL IN THE FIRST PILOT TRIALS USING THE REFERENCE LUBRICANT: COMPARISON BETWEEN EXPERIMENTAL AND SIMULATED VALUES FOR ROLLING FORCE, TORQUE, AND FORWARD SLIP ACROSS FIVE PASSES

Dissemination

A scientific paper on the MMCR, authored by V. Colla, O. Toscanelli, A. Petrucciani, L. Jacobs and T. Grossi, is currently under peer review at ***Ironmaking & Steelmaking International (SAGE) journal***.

A second conference paper has been recently presented at the International Conference of the Association for Iron and Steel Technology ***AISTech 2026*** (Pittsburgh, USA).

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