



### Combinations of tools enable smart solutions

A combination of modelling, simulation and facilities for pilot-scale trials gives all the prerequisites for finding solutions to many complicated problems.

We work with a range of commercially available computational tools, but we also develop our own software. In an industrial setting where rapid answers are a priority, simplified computational tools are often much more useful than complex programs. For example, the object of one project was to prolong the service life and improve the performance of drill crowns used in mining. Improved design ensures more secure mine operation with less risk of failure and, thereby, significantly lower cost.

In another project, the performance of rock-reinforcement bolts in underground applications has been evaluated. Combined testing and computer-aided computation ensures better quality in the assessment of all types of rockbolts. A unique test rig for testing rockbolts is now being developed at Swerim.

Swerim also provides third-party services including preparation of requirement specifications and procurement consulting services.

### A SELECTION OF SIMULATION SOFTWARE

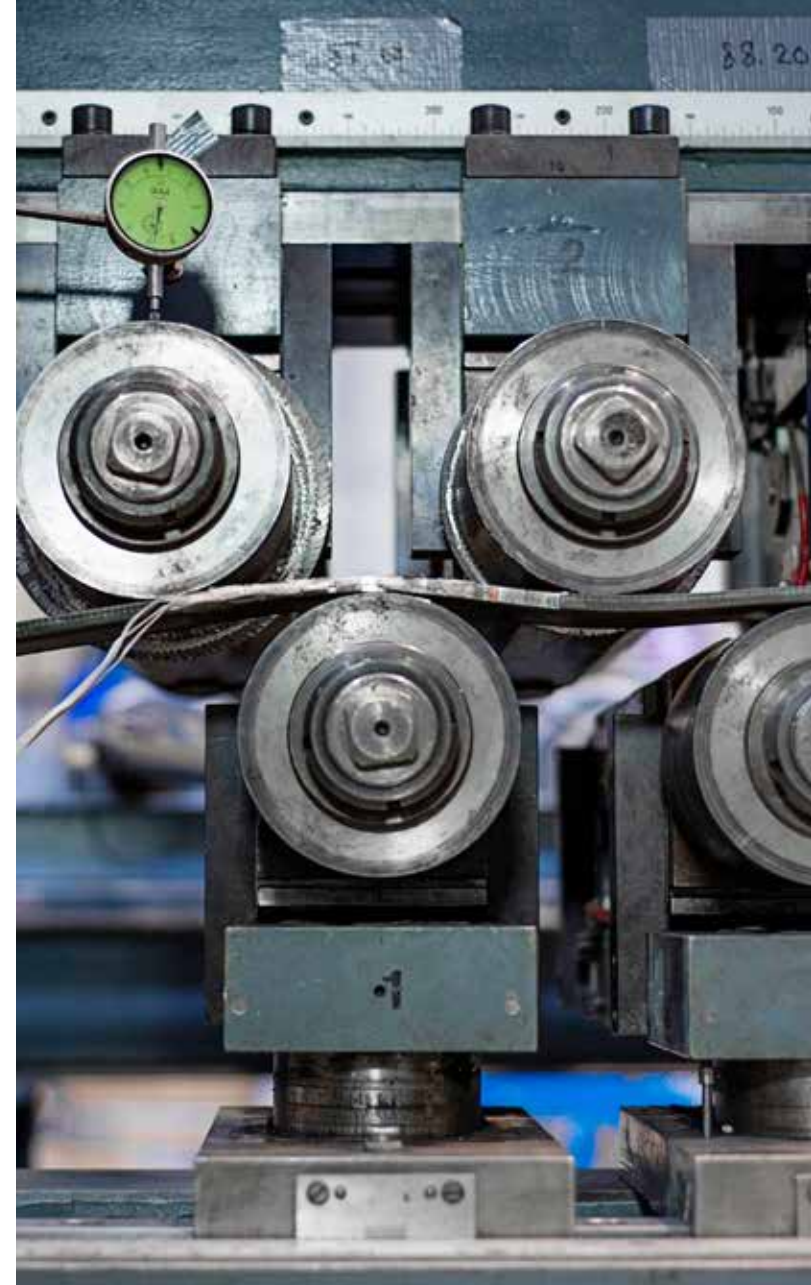
#### Swerim proprietary software:

- STEELTEMP®.
- Diffusion module, compatible with STEELTEMP®, for simulation of hydrogen annealing and decarburization.
- FEBA, for modelling batch annealing, thermal and mechanical modelling, and modelling of product characteristics.
- FEMCoM, for modelling coiling, thermal and mechanical modelling, and modelling of product characteristics.
- ForgeOpt, pass schedule optimization model for forging.
- CROWN, program for profile, flatness, pass schedules and campaign planning for hot and cold rolling.
- CLUSTER for cold rolling in multi-roll mills.

#### Commercial software:

- All according to specific needs in each assignment; e.g., LS-Dyna, MSC-MARC, Hyperworks, COMSOL Multiphysics and Matlab.

**SWERIM** conducts needs-based industrial research and development concerning metals and their route from raw material to finished product. We wish to strengthen industrial competitiveness by enabling improved product quality, greater resource efficiency and more sustainable manufacturing processes. Our vision is a fossil-free and circular industry.



# Modelling and Materials Science

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**A greater degree of specialization strengthens the competitiveness of steel and metal companies. Product and materials engineering, demands on high and consistent quality, high material yield and energy efficiency place greater demands on processes.**

Swerim has solid, longstanding experience of heating and metalworking processes. We have considerable expertise in modelling and simulation, and we know how these processes work in practice and how they can be optimized. We help to develop faster, more efficient, more stable processes, yielding stronger competitive advantage, reduced environmental impact and increased productivity.

The ability to control every aspect of the process demands accurate, reliable simulations. Swerim has its own computational capacity, a Linux cluster with about 200 cores that enables shorter simulation times for large-scale models. Simulation results can be verified in our pilot-plant facilities.

**Heating processes**

Often, the challenge is to save energy while maintaining precise control over stock temperatures and achieving the right material properties. Swerim has worked with thermal processes for many years and we have particularly good knowledge and experience of:

**Heating in reheating furnaces**

- Continuous furnaces
- Batch furnaces, pit furnaces
- Induction furnaces

**Heat treatment**

- Batch annealing/continuous annealing
- Hydrogen annealing
- Decarburization
- Hardening

Modelling and simulation of the various heating processes are done with both commercially available and proprietary software. STEELTEMP® is a well-known program developed and marketed by Swerim. The program calculates the steel stock temperature during heating, cooling and hardening, as well as in casting, rolling and forging. There are also modules for micro-structure and diffusion. STEELTEMP® is compatible with the furnace control system FOCS. Other proprietary programs are FEBA, for batch annealing and FEMCoM, for coiling.

Simulated results can also be verified in various heating furnaces in Swerim's pilot-plant hall.

**Hot metal forming processes**

Swerim provides research and development services in hot rolling and other thermomechanical processes. Simulations are an aid to solving problems, optimizing processes and improving product properties and quality. Many advanced material models developed by Swerim are used to simulate complex industrial processes.

We use commercial and proprietary software to solve problems across a broad spectrum of hot metalworking processes:

- Hot rolling (flat, profile)
- Forging
- Hot forming of sheet (press hardening, blow forming, etc.)
- Welding
- Manufacturing process chains (sequential simulation)

The mechanical properties of metals and alloys are largely determined by their crystalline structures. To be able to predict and control mechanical properties it is important to understand how voids, dislocations, grain boundaries, inclusions and other crystal defects arise during thermomechanical processing. The developed models can accurately predict microstructural evolution and phase transformations.

**Cold forming**

Profile, flatness and residual stresses are key aspects of development in cold forming processes. For Swedish industry, superior product quality and good work environment are two competitive advantages that Swerim has helped to develop. For joint research and development projects, we provide expertise in:

- Rolling (cold, temper, foil and profile rolling)
- Sheet metal forming (bending, pressing and roll forming)
- Levelling (long products and sheet/coil)
- Punching, shearing and slitting
- Grinding

Both commercial multiphysics programs and proprietary software are used for modelling and simulation of metalworking processes. The proprietary software has been specially designed for shape, flatness and rolling force computations for many types of rolling mills. We can also apply numerical simulations together with advanced optimization software to improve the various processes.

