Development and Optimization of Cold Roll Formed Profiles

Albert Sedlmaier

Because of their large variety of applications, cold roll formed parts have become increasing important in recent years, and made their way into whole new sectors like the automobile industry. The reasons for this include the introduction of new kinds of materials and improved shaping tool design. Cold roll forming is seen as a highly productive process for manufacturing steel sections through continuous shaping of sheet steel by driven rolls. Particular advantages of this process are the virtually unlimited shape variety of profile cross-sections, and the strain hardening of the material resulting from the shaping process, which can be turned to good advantage if toll design is done properly.

These are the benefits. But there are also drawbacks like, in many instances, the time-consuming design and production of roll tools, installation, startup and try-outs of tool sets, or undesirable internal strain or deformation of the end-product. Which takes us straight to the subject of analysis and optimization software, presenting a whole lot of potential for remedying the situation. To get cold roll forming up and going with all its efficiency, you need to apply methods as early as the profile and tool design phase that can play a major role in improving the quality of the rolled section.

For some time now the company data M Software, based in Bavaria, has been offering a virtual process chain for the design and validation of roll sets in roll forming production. The COPRA® RF (roll forming) software program supports all steps in the development of open or closed profile cross-sections: from design of the final cross-sections to be produced, through definition of the various shaping steps (passes or flower) to generation of technical documentation (production drawings, parts lists, CNC programs, etc), and later quality control of profile cross-sections and roll tools. The latter works with optical instruments specially developed for the application (COPRA® RollScanner and COPRA® LaserCheck).

A multi-stage concept speeds up both the design and the analytical process, allowing for the needs of the designer who wants to create a tool set fast, as well as those of the production manager interested in checking out the later roll forming process as early as possible.

Fast simulation by deformation analysis

Taking the end-user's idea, a profile flower is created by a drafting program. The resulting CAD data go into an analytical program – COPRA® DTM (deformation technology module) – to define the forming stations. Within a matter of seconds, this software program computes the theoretical (elastic and plastic) strain values on the material during forming as a function of influencing variables like profile cross-section geometry, material gauge, roll configuration or diameter. In this way it is able to indicate where the material might be overstressed. This fast simulation program enables you to run through a whole series of different shaping variants, and to correct the drafted flower or number of shaping stations and tool dimensions, as necessary, before starting the actual detailing work or even production of the roll tools. This is very time-saving, and it reduces the risk of having to rework the roll tools later at startup, or even having to make them afresh.
In many cases, the major cause of poor profile quality is residual, local deformation of the sheet metal (internal strain) produced by elongation during roll forming. In addition to the theoretical figures for such elongation on the top and/or under side of the metal, COPRA® DTM predicts how the figures are distributed over the cross-section. Why this is so important is that there is still much talk about so-called strip edge strain, even though the majority of profile cross-sections that are produced are in fact stressed over their entire cross-section during roll forming. You can see this effect very clearly in pre-punched material. The holes punched before the material goes onto the line are deformed by the plastic elongations caused by the roll stations.

Once the design of the flower pattern and details of the roll set are firm, it is possible to generate the complete documentation for making the rolls, i.e. sawing lists, production drawings and CNC data, and to produce the roll tools. After this, the tool is set up on the roll forming line. Without the kind of optimization of the shaping sequence described above, extensive settings and adjustments will usually be necessary on the roll forming mill, sometimes even design modification of the tools, before a new section of the required quality comes off the line. Not so long ago, the only way to create a properly functioning roll set was through practical trials on the machine. Today there is an alternative – a possibility of speeding up this time-consuming and costly running in of a new roll forming tool set, and of avoiding any reworking of the tools altogether – namely simulation by the finite element method (FEM).

FEM simulation of the roll forming process

Once a roll set has been ready designed, the data go into the FEM simulation program. COPRA® FEA RF (finite element analysis for roll forming) simulates the roll forming process by a nonlinear, elasto plastic method of computation. The user can forget questions like definition of the finite element computing model, selection of suitable element types or definition of boundary conditions. The software program fully integrated into the COPRA® process chain automatically considers these factors.

A number of powerful analytical functions predict for the user the expected profile quality or material properties. Both the ready profile and the individual shaping steps are presented in three-dimensional, color images.

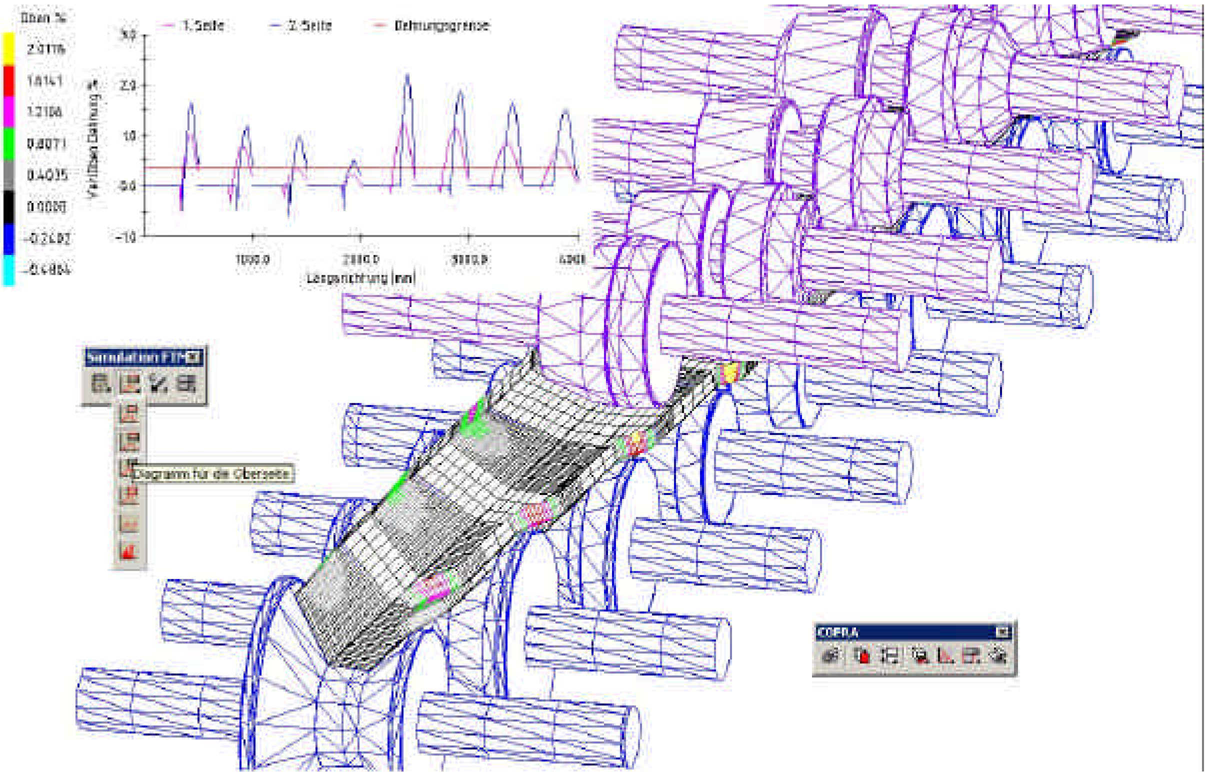
Visualization of defects means that the empirical trials needed to date and adjustments to the forming mill can be dispensed with – a new tool set is ready optimized in the design phase.

An entire finite element computation cannot be performed within a matter of minutes, even on today's high-speed computer systems, so the dual-step solution described here, i.e. advance optimization by a fast computing approach followed by validation of the complete tool set by the FE method, has proven extremely successful in actual practice.

The practical benefits in the roll forming of profiles go beyond reduced setup times for a new tool set and enhanced process control. The producer now derives significant expertise and experience in the roll forming process, putting him in a position to eliminate faults and problems in the leadup phase to new products.

Albert Sedlmaier, Dipl.-Ing., is managing director
of data M Software + Engineering GmbH, 83626 Valley, Germany.
http://www.datam.de

Figures:



Fast drafting and optimization of roll forming to shape by COPRA® DTM (deformation technology module)

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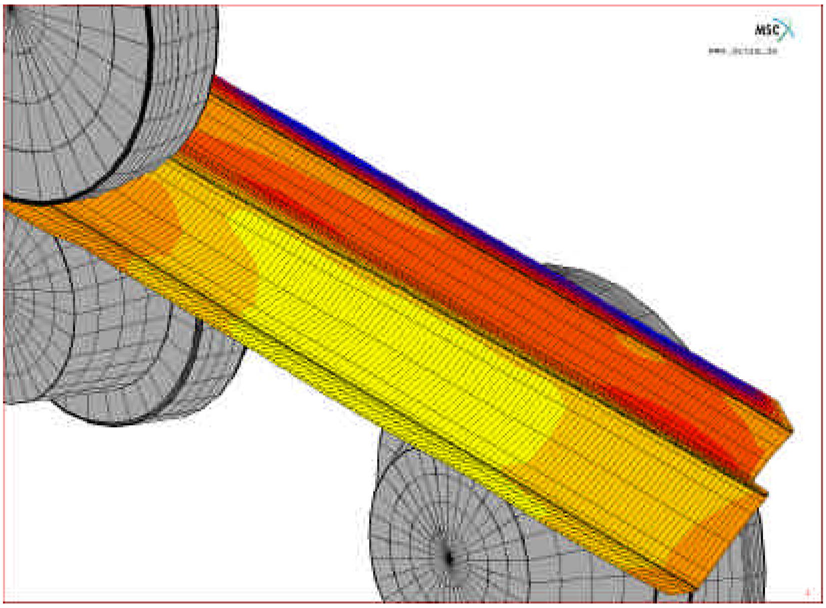

Finite element simulation of roll forming process by COPRA® FEA RF (only one half of profile cross-section shown)

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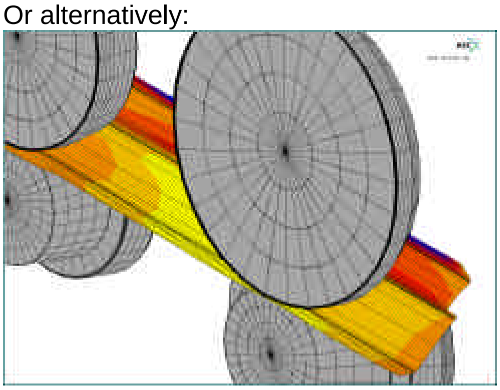
Or alternatively:



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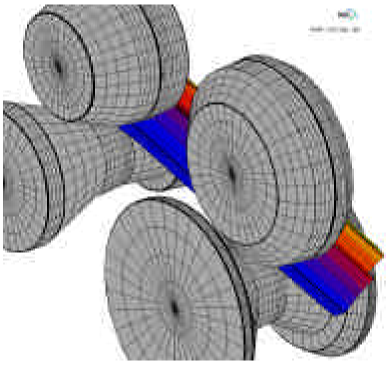

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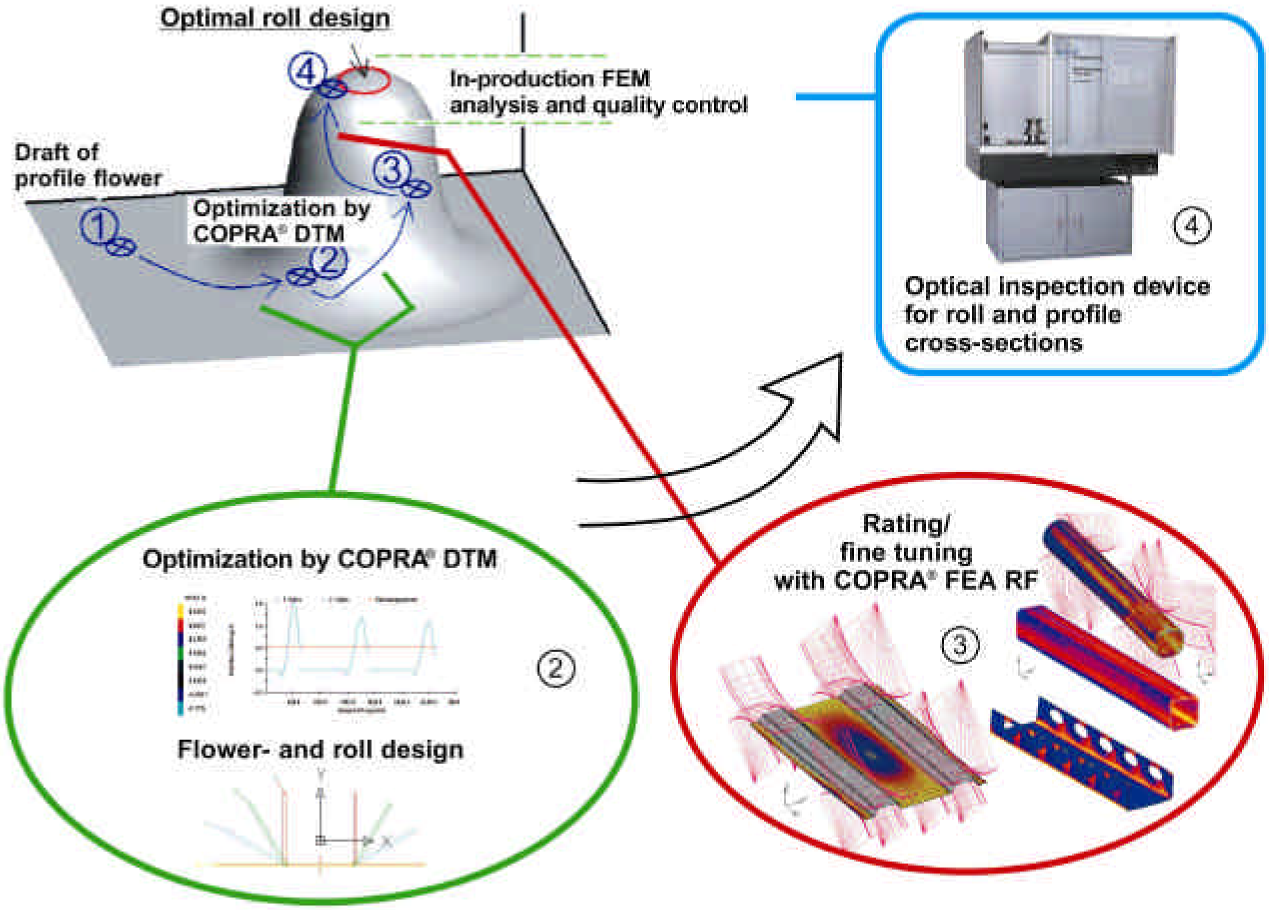

Optimization in design and production of cold rolled profiles: COPRA® process chain for fast design and optimization by deformation analysis (2); rating/fine tuning of designed roll set by finite element analysis (3); ongoing in-production quality control and finite element analysis of existing tool sets to maintain high product quality (4)

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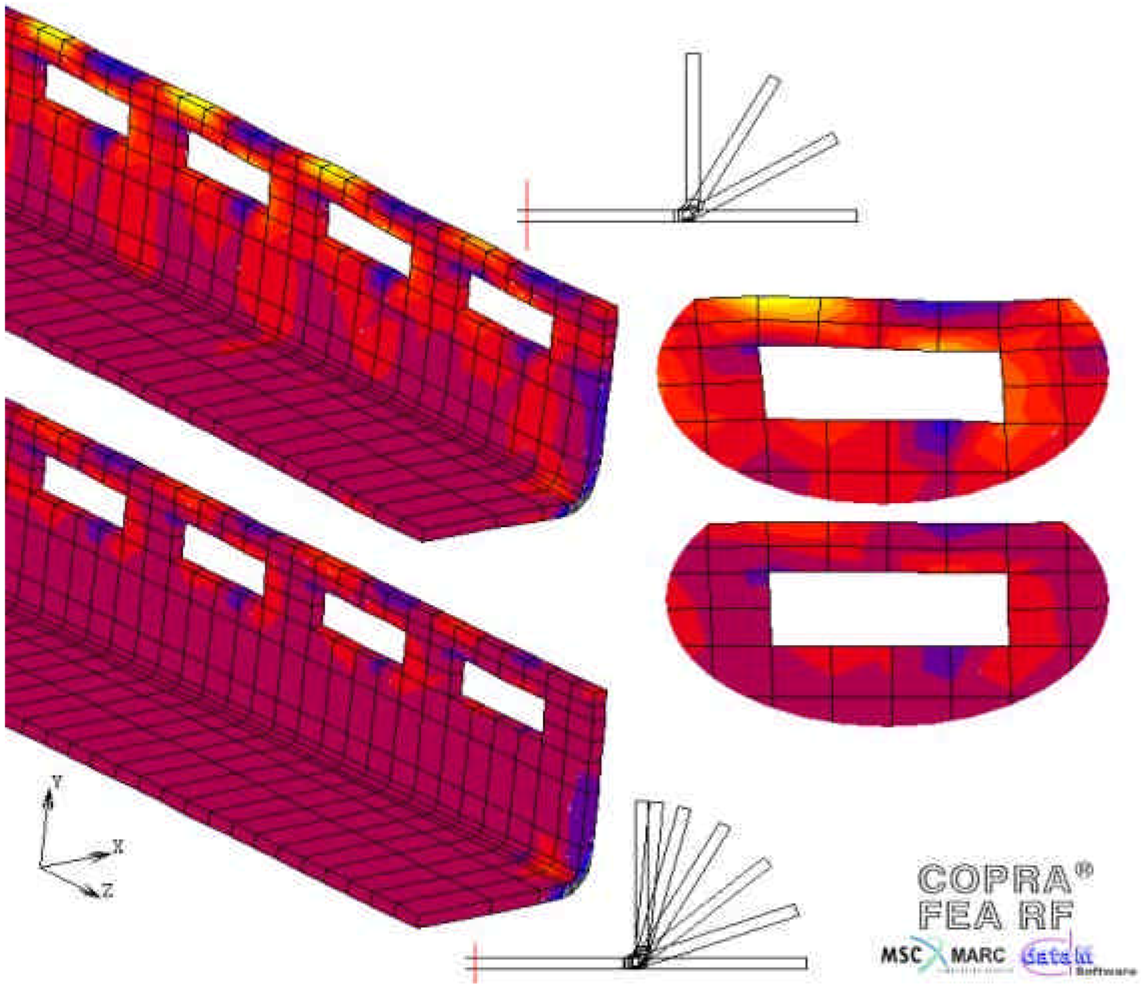

Deformation of rectangular pre-punched patterns in three-step and six-step shaping (COPRA® FEA RF)

File punch.jpg