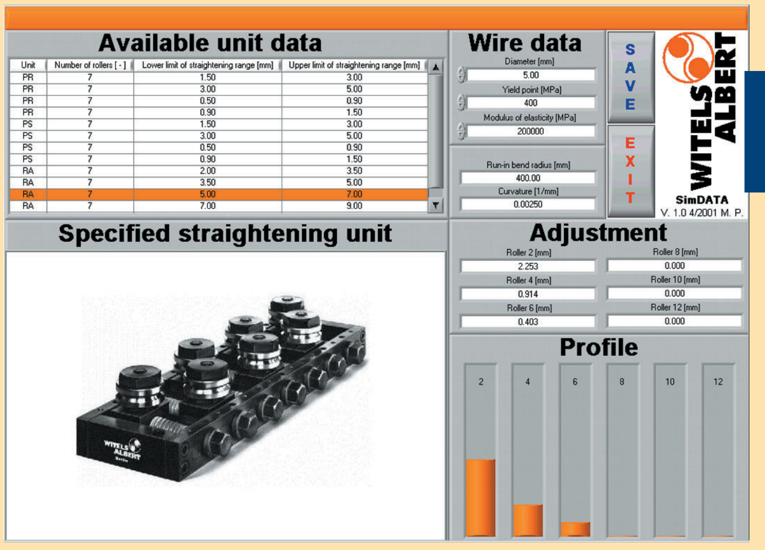


***SimDATA* software user interface**

The positioning of straightening rolls

Roll-type straightening units and systems are increasingly becoming the focus of attention in the manufacture and processing of wire-shaped process materials. Finding the optimal roll position is an expensive process, especially in terms of time, labor and the consumption of process material. With this in mind the software *SimDATA* is designed to help, even the inexperienced operator, with positioning the straightening rolls.

The roll straightening process, which is characterized by an increased level of automation and linking, must meet the challenge of higher process speeds, advanced materials and a stronger awareness of quality and the environment. Advanced straightening technology provides the tools to meet these requirements.

Technical solutions that ensure precise, reproducible positioning of the straightening rolls are particularly significant. Straightening units could be used, for example, which are equipped with mechanical displays to provide information about the position of the straightening rolls when the rolls are adjusted. Semi-automatic straightening technology, which uses modern drive and automation technology, or straightening units that use the *Computerized Tool* to position the rolls, fulfil the expectations placed on them regarding reproducibility and the precise adjustment of the straightening rolls.

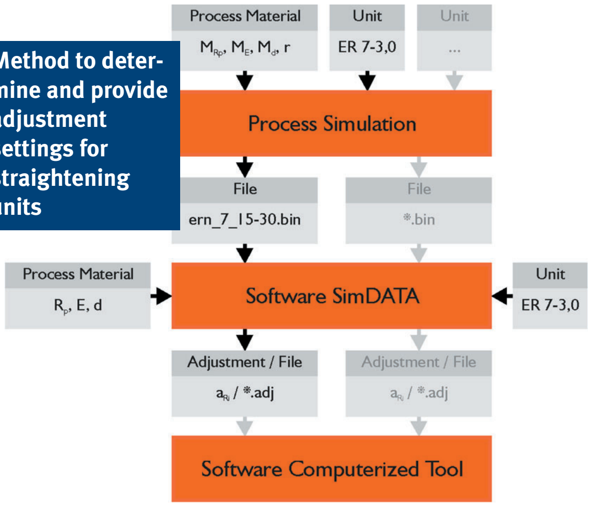
Finding the required roll positions

Any technical solution, however, relies on knowing what the required roll positions are. If this knowledge is not available, it has to be worked out, but this subjective process involves high costs resulting from the time, material, labour and energy involved. From both the economic and technical standpoints, this situation is untenable.

To address the problem, Witels-Albert has set itself the goal of creating a virtual representation of the roll-type straightening process, so that the roll positions can be calculated *a priori*. As has been shown in numerous straightening trials, this goal can be accomplished by simulating the roll straightening process. Simulation is based on a theoretical model of the elastic-plastic alternating deformation of a process material and the link between bending moment and curvature, which can be defined for every bending operation which is performed in the straightening equipment. This allows calculation of the bend characteristic κ(x) in an item to be straightened. The characteristic can then be used to calculate the positions of the rolls $a_{Ri} = y(x)$ by numerical integration of the second-order differential equation, which applies to deformation caused by bending.

$$\kappa(x) = \frac{y''(x)}{\sqrt{\left(1 + y'(x)^2\right)^3}}$$

To create a simulation of the process, knowledge of the process material characteristics and the geometric characteristics of the particular straightening unit is required. Given the large variety of applications for straightening units, the diversity of types and models, and the varying objectives of differentiated straightening processes, it is often desired that the simulation process



Method to determine and provide adjustment settings for straightening units

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can be moved directly into the wire manufacturing or processing environment. The operators themselves should be given the tools to calculate the required positions of the rolls. To address the complexity of process simulation, a method has been developed based on easy-to-use software, which produces results that allow even an inexperienced operator to determine roll positions, so that a defined level of production quality can be achieved.

Method

If a configured straightening unit is taken as the starting point, a straightening process and the achievable straightening quality are defined primarily by the diameter *d* of the round wire and the properties of the process material. Theoretical and experimental studies have demonstrated that the yield point R_p as well as the modulus of elasticity *E* of the process material are among the elementary parameters of the material properties. The reason for this lies in the regularity of alternating deformation, without which a straightening effect cannot be achieved using a straightening unit. So in addition to the diameter of the round wire, the yield point and the modulus of elasticity are also defined as process parameters.

The radius of curvature of the input process material is a secondary factor for the straightening process and straightening quality, if depending on the straightening range of the straightening unit a minimal curvature radius r_{min} is assumed and roll positions are taken into consideration in the prebend zone, which ensure a sufficiently large elastic-plastic deformation. This allows a fixed value for the curvature radius $r = r_{min}$ to be assigned as a further parameter for the straightening range of the straightening unit. Consequently, there is a direct relationship between the size of the straightening unit and the radius of curvature of the wire.

Using this method, process simulation for round wire can be used successively on all Witels-Albert straightening units. For a specific straightening unit, one element from each of the following sets is selected: process material elastic limit M_{RP}, modulus of elasticity M_E and wire diameter M_d. The simulation is then performed, and the results are stored in a file. Repeated execution of process simulation produces a calculus of variation, which provides all the information needed to make settings on the straightening equipment relating to the primary parameters yield point R_p, modulus of elasticity *E* and wire diameter *d* as well as the secondary parameter curvature radius *r* of the process material.

The table documents the sets and their elements for a straightening unit ER 7-3.0, which is assigned a fixed curvature radius *r* = 250mm. Given the number of elements in the various sets, there are a total of 392 possible combinations in the model example.

The software program *SimDATA* uses the information contained in the results file, which is created following a calculus of variation and which provides an exact description of the number of roll-type straightening processes for a straightening unit (hence the term unit library), to derive the required roll positions while taking operator input into account. The figure documents in schematic form a unit library (ern_7-15-30.bin) as well as the use of process material parameters (R_p, *E* and *d*) and straightening unit type (ER 7-3.0) parameters. The software calculates the positions of the rolls or the adjustments (a_{Ri}) based on the parameters, visualizes them and saves them to a file if required.

Sets and elements in a calculus of variation for the ER 7-3.0 straightening unit

Set	Elements
M_{Rp}	{400; 600; 800; 1000; 1200; 1400; 1600; 1800; 2000; 2200; 2400; 2600; 2800; 3000}
M_E	{180 000; 190 000; 200 000; 210 000}
M_d	{1.50; 1.75; 2.00; 2.25; 2.50; 2.75; 3.00}

Saving the roll positions to a file with a specific extension (*.adj) creates an interface to the *Computerized Tool*. The program, which is needed to use this modern tool, is able to read this type of file and to use the files for determining defined settings for straightening rolls. It is also conceivable that the information relating to adjustments could be transferred to semi-automatic straightening devices or machines, where the straightening process is an essential factor.

SimDATA Software

SimDATA enables personnel who operate straightening units to plan roll-type straightening processes with minimal effort. Now operators can objectively determine the required positions of the straightening rolls based on mathematical-physical laws.

SimDATA is a simple program, which uses binary coded unit libraries containing information about the roll positions to produce a defined finished-product quality level. The program has the advantage that it can be used without change to create new libraries or improve existing ones. Different straightening process objectives can also be addressed. You could have libraries, for example, that contain roll positions for production of straight process material or material that has a defined curvature. Up-to-date distribution channels can be used to send these libraries to users of Witels-Albert straightening units around the world.

After *SimDATA* is installed and started, the roll adjustments for a straightening unit are calculated, visualized or saved automatically once the operators have input the process material properties and the type of unit being used. The user interface provides appropriate input fields and buttons for this purpose. It is normally quite straightforward to determine or look up the properties of the process material.

All adjustments, which have been calculated and documented on the user interface, should be made on the straightening unit using the process material zero line as a starting point. Whether conventional or semi-automatic straightening equipment is used is irrelevant. The term wire-specific zero line means that the straightening rolls are positioned in relation to defined geometric conditions on the unit in such a way that a process material of a specific dimension is only touched, but no deformation takes place in the area influenced by the rolls. ■

Basic literature: E. Albert; M. Schilling; M. Paech: “We do it straight” – Wire Straightening. Witels Apparate-Maschinen Albert GmbH, Malteserstrasse 151-159, D-12277 Berlin/Germany