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Using CAD to Develop Precision Roller Tools

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Only experienced forgers have the knowledge for developing reducer roller tools. Now VeraCAD, a software using empirically based forging rules, allows complete reducer roller tool design using 3D CAD. VeraCAD dramatically cuts down the development costs and design cycle time, while increasing the final design precision and process stability.

CAD is excellently qualified for the design and development of roller tools. An integrated solution has to use geometry modules for processing complex free form surfaces as well as powerful technology components. VeraCAD's technology components contain all deformation rules for determining suitable calibration sequences and algorithms that can learn company specific strategies. ERATZ Engineering in cooperation with SMS EUMUCO AG, the leader in industrial roller technology, developed the CAD-System VeraCAD for reducer roll tool design. After being implemented at about 20 forges and practical experience in the last six years, users are playing an important role in the continuous improvement of the software by providing valuable feedback based on specific customer requirements.

VeraCAD is composed of three main modules:

1. Mass distribution
2. Calibration plan
3. Tool calculation and technical drawing generation

The VeraCAD design process starts with importing the forging piece's geometry using a standard interface (IGES, VDA-FS, STL, or EDX). A 3D geometry is cut into many panes, and their volumes distributed over the central axis yield the mass distribution diagram. For bent parts the curved spine line is first entered interactively. If the geometry data set contains no flash area, a filter and offset function adds the necessary flash material amount. Usually the resulting mass distribution is too complex for direct derivation of the final roller piece. Equalizing the local volume balance at all times supports the design of an ideal roller blank. If no 3D geometry exists, an alternate input method based on a sketch of the final roller piece is available.

VeraCAD calculates suitable calibration sequences as well as the size of raw material and number of necessary passes. Therefore a variety of shapes are offered: circle, oval, lens, diamond, square, rhombus and rectangle. Standard rolling algorithms like "linked reduction rates"; "limit reduction", "cross-section spreading" or "priority calibration sequences" are automatically applied. These are based on a SMS EUMUCO database that is continuously improved and updated with the analysis of a wide variety of rolling results. The automatic calculation of motion in advance ranks among the outstanding features of the calibration module.

In addition to the automatic proposal of calibration plans, the practitioner possesses extensive interactive control options. Of course the reduction rate and calibration shape can be altered. If desired, the cross-section can receive a draft angle, leading groove, round edges, or a filling degree correction. Customer feedback has resulted in the continuous refining and increasing of manipulation options. Logically such interactive features require powerful graphic visualisation. The monitor function presents an exact calibration sequence in 2D and continuously updates the image for each change in deformation or geometry parameter.

In 3D the CAD surfaces of roller products help to assess the calibration plan. The shaded image or the wire frame model can quickly reveal possible rolling problems. With the spline surfaces of products also the indispensable volume calculation in each die sections is performed. VeraCAD's name was derived from this important feature (**V**olume **E**xact **R**educer roll **A**nalysis based on **CAD**).

The last step in the design sequence is the conversion of the calibration plan into the final tool surface. After entering the main roller measurements the intermediate product is coiled up to the segment. Phenomena like "relative motion", "true working roll diameter" or "variable roll-off radius" are automatically incorporated during calculations. In addition the software generates a fully dimensioned technical drawing for the die shop. The drawing is part of the project documentation and can be used to note any tool adjustments after the first test run.

Naturally it is possible to incorporate the manual tool adjustments into the original 3D surface representation. Functions therefore range from inputting simple changes to lengths, angles or radii to ones used for "reverse engineering" strategies where scattered data scanned from the surface is input. Updated tool representation is thereby retained as a CAD data set and can be used for manufacturing subsequent tools or tool renewal. This way high repeatability and quality control becomes a given in the manufacturing process.

The 3D geometry of segments and products is exported through one of the four interface formats mentioned above. Basic CNC machining (i.e. the generation of cutter paths) follows in a different CAD system. Due to the simple surface data structure, machining the tools principally is no problem. Currently an IGES interface is available to export technical drawings. After reading the drawing into any 2D system, this is further detailed or completed (e.g. with the company's own title block).

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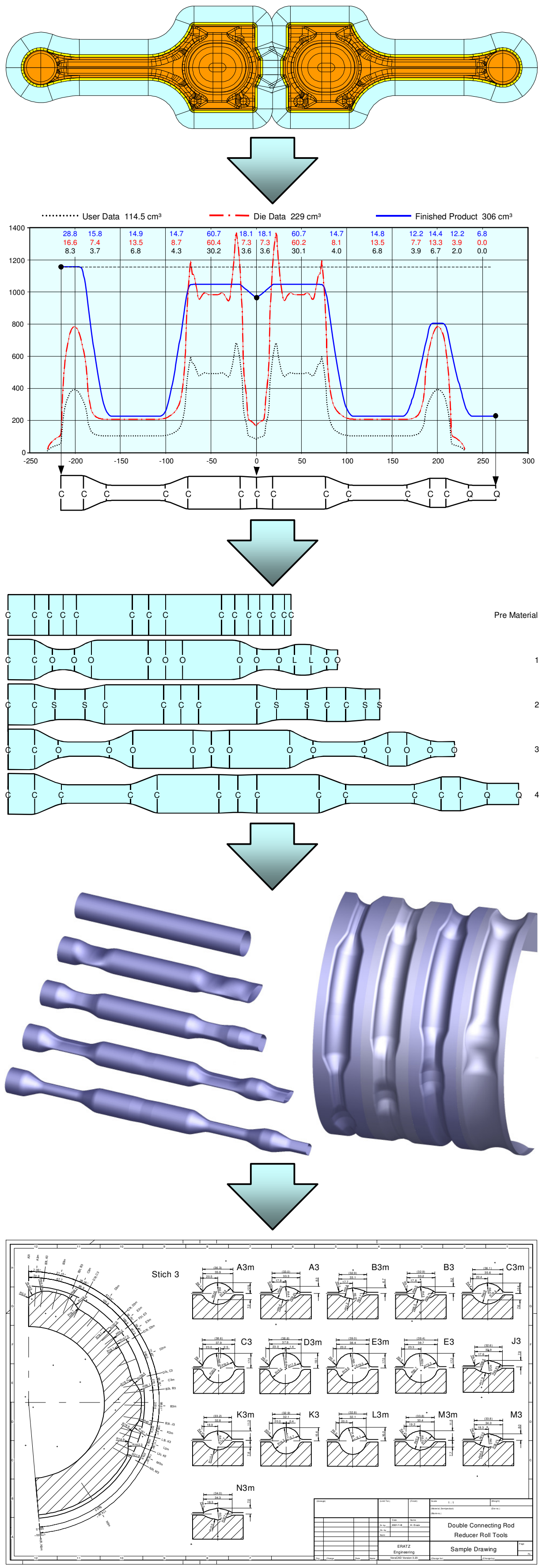
Working Steps in VeraCAD



The close connection between program modules could only be realised as a "stand alone" solution. Therefore VeraCAD does not make use of other CAD packages. Versions are currently available in English, French and German and run on MS Windows™ XP, 2000 and 2003. A detailed user manual is available, and 10 video summaries on CD provide an introduction to roll forging technology and the user interface.

VeraCAD closely models the traditional roller tool design process and uses the same empirically based rules-of-thumb used by the experts. In addition VeraCAD's powerful geometry component provides an exact graphic of the current calibration plan and the 3D geometry during all design phases. This allows input errors or illogical calibration sequences to be recognised immediately. Only through the constant visualisation the full optimisation potential is revealed to the designer.

While the traditional design process requires laborious calculations and extensive drawing work to develop one single set of rolling equipment, VeraCAD can tremendously shorten the development cycle. Engineering resources now can be utilised for more complex decisions such as comparison and assessment of different designs, checking borderline cases, like whether a roll operation is meaningful with 2 or 4 passes. This way tool costs can be set against process stability. The optimisation leads to a final roller product that just can meet all manufacturing requirements with the least amount of material inputs.

VeraCAD is installed at large forging plants and automotive manufacturers worldwide. Initial results have led to improvements in the database, but roller parts produced during the last three years exceed all our expectations. In most cases the VeraCAD designed roller tools have worked perfectly from the beginning with either no, or only minimal, reworking necessary. Consequently the tool development process has rationalized, and the reliability of the manufacturing process has increased. In addition users, not trained in traditional design methods, have gone on to successfully develop reliable roller tools after 2-3 days of technology training.

Even with VeraCAD's comprehensive solution for reducer roll design and the numerous outstanding results, a broad potential exists to further expanding features and functionality. From adapting to future operating systems, the addition of new interface formats, improved user comfort, an essential point is to come closer to the manufacturing process limits. By means of forecasting local material flow and exact observance of deformation rules, VeraCAD will avoid rolling defects and can reach the process limits. The goals to be achieved are higher reduction rates, fewer roll segments or steeper mass ascents. These finally will result in lower tool, material and energy costs.