Using Software to Design, Validate & Standardize the Cold Forging Process

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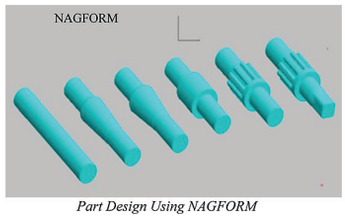
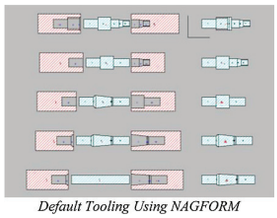
A good design allows the part to be formed in a quick and accurate way with virtually no scrap.

For the design and development of cold forged parts, two types of software are available:

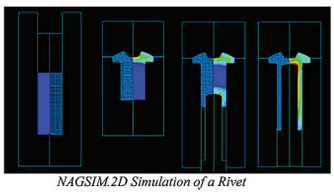
- Sequence Design Software such as 'NAGFORM' determines the forming sequence for cold forged parts. The program utilizes numerous forming rules and design logics to create alternative ways of forming a part. The results can be exported to various CAD programs such as AutoCad, and SolidWorks for creation of tool and part drawings.

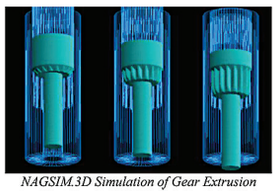


Part Design Using NAGFORM


Default Tooling Using NAGFORM

- Finite Element Method (FEA) based Simulation Software such as NAGSIM.2D and NAGSIM.3d validate the cold, warm and hot forging processes. These programs can predict metal flow and the formation of defects such as laps, nonfill and stresses in tools and the part. Forging sequences determined through software such as NAGFORM or from experience can be tested and validated before building the tooling using these FEA simulation programs. The tool drawings required for simulation can be created through NAGFORM, or a CAD program (AutoCad, Solidworks, Pro-E etc.).


NAGSIM.2D Simulation of a Rivet


NAGSIM.3D Simulation of Gear Extrusion

Part Print to Production

Cold forging is an extremely cost-effective method of manufacturing a part. A good design allows the part to be formed in a quick and accurate way with virtually no scrap. However, bringing a part from concept into production can be a daunting task, even for experienced designers. The designer generally uses his/her experience to define the sequence and often uses the "trial-and-error" method to adjust the process until the right part is created without any defect. Software products as listed above can assist in streamlining, validating and standardizing the print to part process.

The entire sequence of print-to-part is comprised of the following steps:

- Initial Sequence and Tool Design
- Validation of Part Quality and Tool Life
- Production
- Recording Process Know-How

Initial Sequence & Tool Design: Role of Sequence Design Software

Though designing forming sequence remains a skill learned through experience, software programs such as NAGFORM and NAGSIM can make the process efficient and cost-effective, and can reduce the time to develop designs. Traditionally, whenever a designer receives a new part (either for quoting or production), he/she would determine a baseline sequence of forming the part. This sequence is generally based on the following criteria:

- Standard forming rules such as heading limits, extrusion limits, etc.
- Machines available (number of stations, load capacity and maximum wire size).
- Raw material available (wire diameter).

Depending on the complexity of the part, designing the sequence and the related tooling can take one to three days. Sequence Design Software such as NAGFORM can significantly reduce the design time. For similar parts, the design can be created in NAGFORM within a couple of minutes. The following flow chart describes the process of designing a sequence using sequence design software (see **Figure 1**).

Validation of Part Quality & Tool Life: Role of FEA Software

Typically, the design is validated through trial runs on the machine. This process is very slow and expensive, as the designer has to order the tools and wait until they are manufactured. Once the tools are built, then between the trial runs and modifications to the tools, it can take a few more days and an added expense. Using simulation software, the user can significantly reduce the time and expense of trials. Using such software, the designer can determine critical information such as final part shape, part strain/tensile strength, tool stresses, tool deflection and forging loads before building the tooling.

However, the process of performing a simulation is not that simple. The designer has to create the basic tooling for the progression (2D or 3D) and import it into the simulation file. The process of making the tool drawings for each scenario can be a very tedious process. As a result, simulations are generally done when there is a problem with an existing part. Sequence Design Software such as NAGFORM can automatically generate the simulation files with the default tooling already populated. So this significantly shortens and simplifies the task of performing

a simulation.

2D vs. 3D Simulation—For axis-symmetric parts where the feature of the part can be described by a cross sectional view, the process can be simulated in a two-dimensional (2D) simulation software. For three-dimensional (3D) features such as hex, gears, 12-points, etc., where the user is trying to visualize how the part forms and the features are filled, a 3D-simulation program is required (see **Figure 2**).

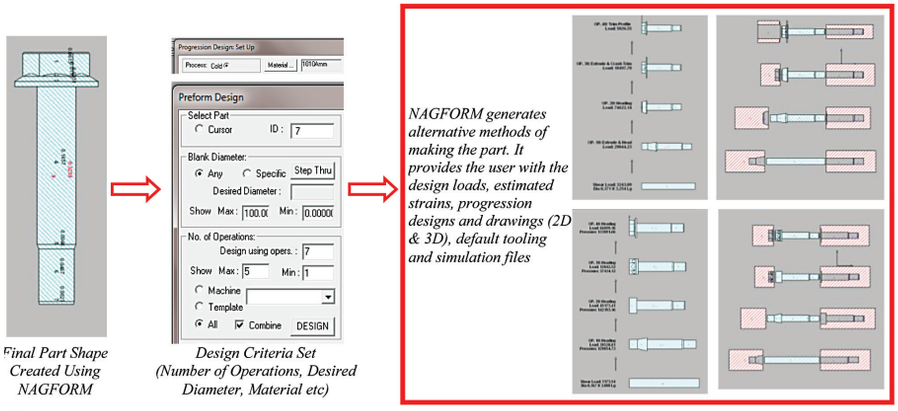


Fig. 1.

Production

Using a scientific approach to determine the best sequence and its tooling makes the part production very efficient. Sequence Design Software makes the initial design process very quick and a FEA (finite element analysis) simulation software validates the tooling before production.

Recording Process Know-How: Standardizing Sequence Design

Once the process design is debugged, keeping design information for future use is critical. The Template System and Design By Command features make the process of retaining knowledge very simple and effective.

Template System: In NAGFORM, any part and its progression design can be stored as an Auto Design Template. Thus over time, a company can build a database of parts and their successful designs. The Template System allows reusing the successful sequence designs for similar parts (see **Figure 3**).

Design By Command: The Auto Design Method does not always include every production detail that the user needs for creating tooling. That's where Design By Command (DCM) comes into play. It allows the user to create his/her own design progression interactively in a few minutes. The interactive session, consisting of questions by the program to determine the design intent and the responses by the user is saved in a Session file, which can be used as a template to create progression design for similar parts or family of parts in minutes. Sequence designs created using DCM have the following advantages over designs created without it:

- Dimensions of the forging preforms are calculated automatically with proper distribution of volumes.

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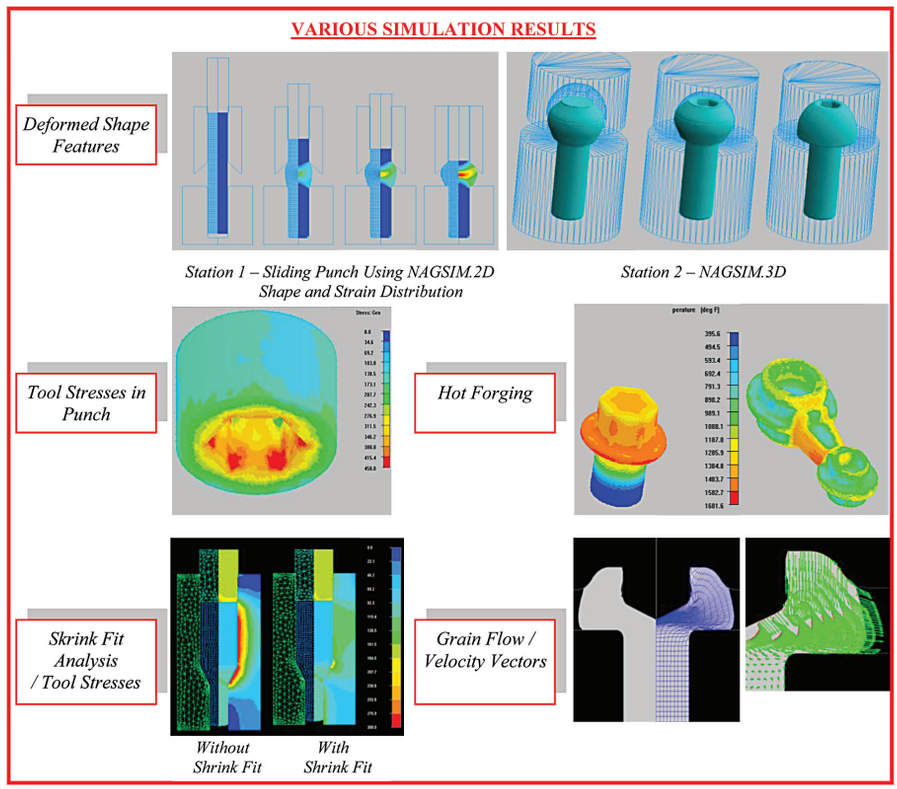

Fig. 2.

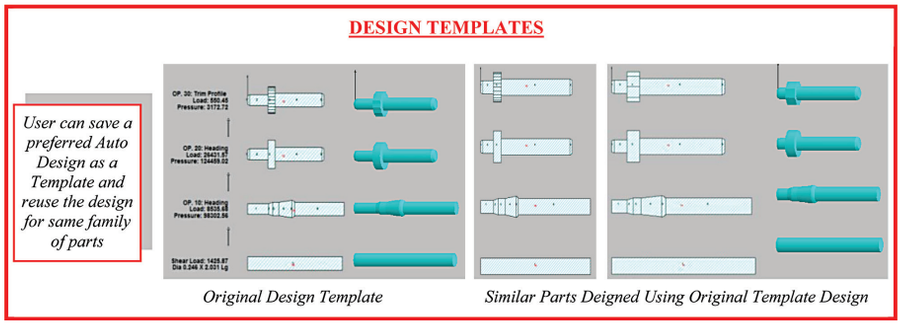

Fig. 3.

- Forging loads are calculated automatically.
- Forging design is checked against "forming rules".
- Session files serve as reusable templates that can be used for designing similar parts within a couple of minutes.
- Retention of knowledge allows users to enter every small detail of the design based on their experience. Design of similar parts include all of these details included in the DCM design (see **Figure 4**).

Program Updates

The software programs for process design (NAGFORM) and simulation (NAGSIM.2D/NAGSIM.3D) are being improved continuously in the following areas.

With the NAGFORM software system:

- More complex cold forged parts can be designed and simulated (off-center/exotic shapes).
- Process designs include designers' preferences
- Process designs for a range of part sizes can be performed to give blank dimensions.

With the NAGSIM software system:

- Simulation run time for NAGSIM.3D is reduced significantly.
- Improvements in graphical display of part deformation and tool stresses.

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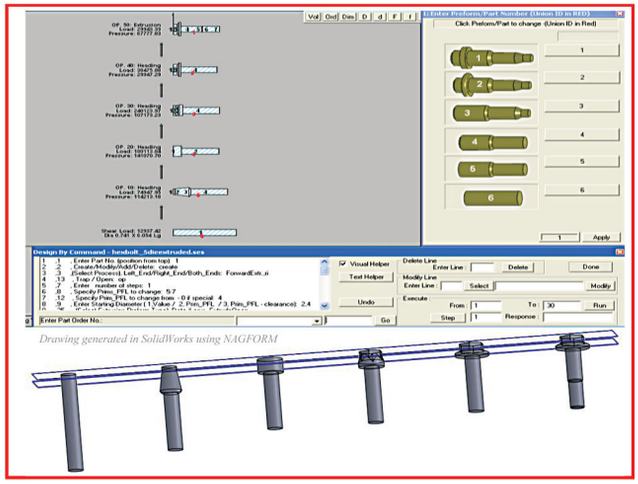

Fig. 4.

Company Profile:
Metal Forming Systems, Inc. *develops and supplies process design software (NAGFORM) and finite element analysis (FEA) simulation software (NAGSIM) for the metal forming industry. To receive additional information, visit the Metal Forming Systems website below.*
www.nagform.com