Automating the Design for Manufacturing Cold Forged Parts

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There is continuous pressure on Cold Forging companies to be cost effective for smaller lot parts and reduce print-to-part time. The total time to manufacture a cold-formed part consists of many different tasks including entering the order in part management system, creating forming sequence design, design tooling, manufacture tooling, produce sample parts for approval, inspection and final debug of the manufacturing process to start producing the parts. Any nonconformity to part specifications can add further time to resolve the issues.

This paper discusses automating the design and development tasks including forming sequence design, design of tooling and debugging the process and tooling design. Automation of these tasks can significantly reduce the part to production lead time.

Design and development include the following steps

- Progression Design – Design of sequence to progressively form the part
- Tooling Design – Design of tooling for high production
- Design Validation – Ensure desired part would be produced cost effectively.

MFSI provides its customers with software and training that support this development process

- NAGFORM – Progression Design Software
- NAGTOOL – Tooling Automation Software for NAGFORM users
- DIE PRESS – To calculate the stresses in the inserts from interference and forming
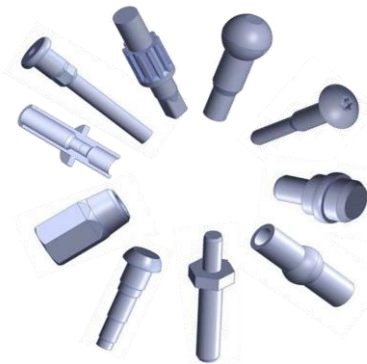- NAGSIM – Simulation software to validate the progression design and tools.

Automating Progression Design using Virtual Designer - NAGFORM

The sequence design can be automated using a virtual designer software such as **'NAGFORM'**. 'NAGFORM' is a unique program for determining forming sequence for cold forged parts in minutes. In this software, the user inputs the final shape of the part as collection of simple shape primitives. Using the forming rules and design logic of expert designers, the software creates alternative ways of forming a part.

Using NAGFORM, the designer can accomplish the following in short period of time:

1. Get alternative progression designs for any part.
2. Use design template to get standardized design for any part of a family in minutes.
3. Get design concepts that the designer may not have thought of.
4. Investigate design options with different wire sizes for best or available wire size to use.
5. Estimate forging loads. The designer can use load as criterion to select the design that requires the minimum forging load.
6. Provides an outline of the default tooling for simulation purposes.
7. Selection of the machine out of available machines that may be suitable to a selected progression design.
8. Output in DXF and SolidWorks part files.

Typical parts designed using NAGFORM

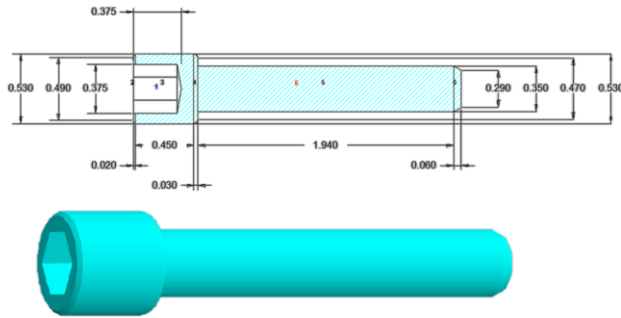Almost all cold forged parts can be designed. The pictures show some typical parts that can be designed using NAGFORM.
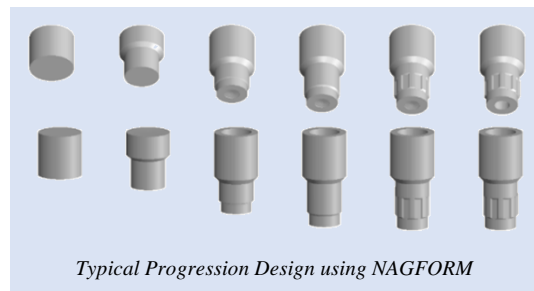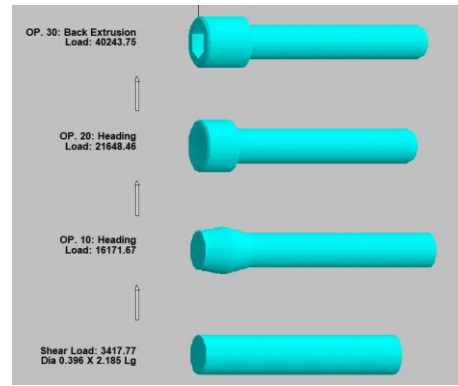

Typical Progression Design using NAGFORM

The picture below shows a standard progression from NAGFORM for a Cap-screw. This part is used as an example in this paper.

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Typical parts designed using NAGFORM

Automating Tooling Design - NAGTOOL

Once the forging sequence design is available, it is possible to automate the tooling design based on the sequence design. Metal Forming Systems, Inc. has recently released a development version of its Tooling Design software called 'NAGTOOL'. This program creates 'Tooling Design' for any progression generated by the NAGFORM program. The progression design can be the automatic design from NAGFORM or a manually drawn progression in NAGFORM by the designer.

'NAGTOOL' uses tool design layouts for the 'Header' machine with tooling layouts for basic processes such as extrusion, heading and trimming. The tooling design for any operation can be created in minutes using NAGTOOL. Some examples of tool design layouts are shown below.
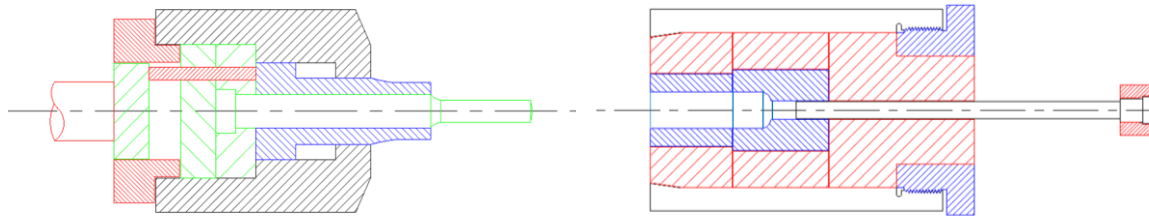

Typical tooling layouts used in NAGTOOL

Advantages of Tool Design software such as 'NAGTOOL' are
1. The tool design can be completed in much less time
2. Tooling Design templates help to standardize the design
3. Skill requirements are reduced as design is based on templates and manual calculations are minimal.
4. Software can search for previously used tools
5. DXF and SolidWorks output reducing burden on the designer to draw tools manually

For the Cap-screw, the tool design created in NAGTOOL is shown below.
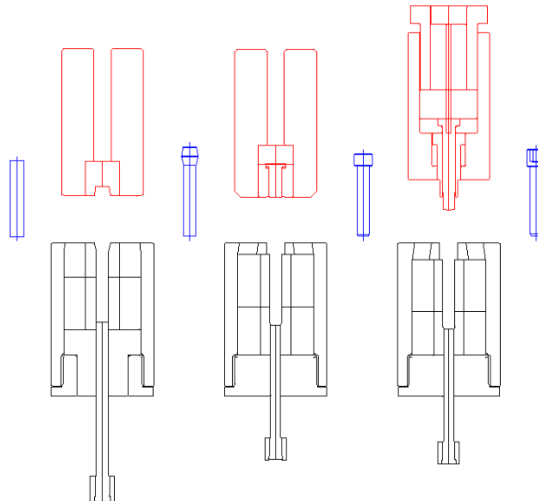

Cap-Screw Tooling generated using NAGTOOL

Design Validation – NAGSIM, DIE PRESS

When accurate prediction of load, strains in the part and stresses in tools is required, FEA simulation program is the only software that can meet the needs. So, to validate and debug the tooling design, simulation program (such as NAGSIM) is almost an essential tool. It can help reduce costly shop floor trials and breakage of tools. However, there is an effort and therefore a cost to perform FEA simulation. Accurate input of material property data, tooling geometry and process details is needed to get accurate results from simulation software.

At the quoting and feasibility stage, when the tooling drawings are not available, usually FEA simulation is not done due to the effort required to perform a simulation, unless there are serious questions regarding the design. However, in selection of a new machine, the cost of performing a simulation is justified.

The picture below shows the simulation performed in NAGSIM using the simulation file created in NAGTOOL.
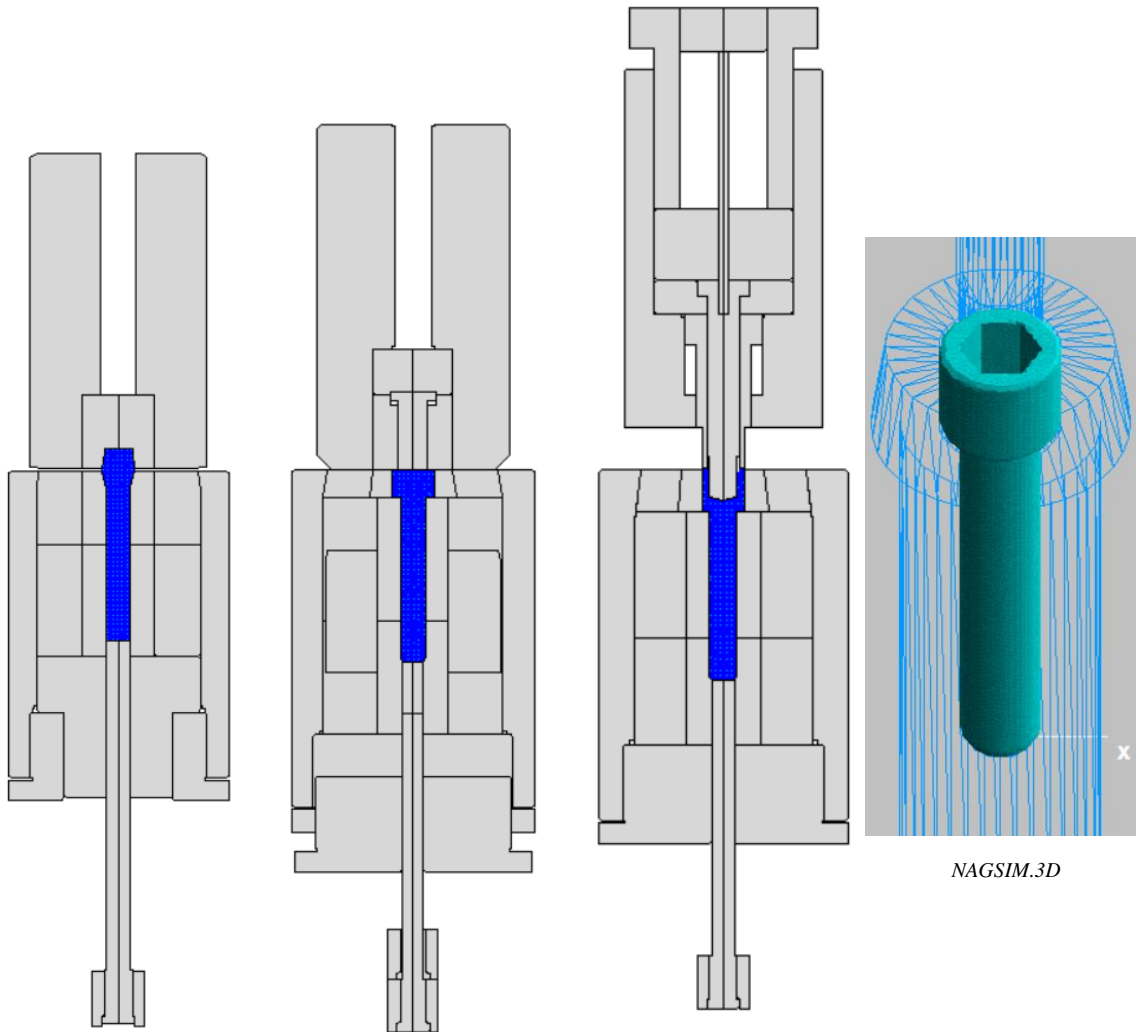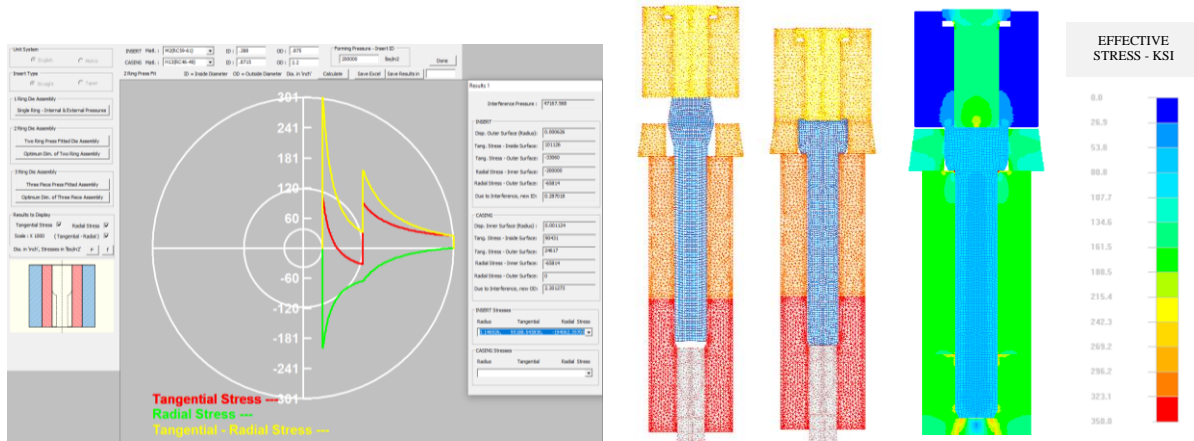

NAGSIM.3D

NAGSIM Simulation for the Cap-screw using NAGTOOL

Tool Validation – NAGSIM, DIE PRESS

The tooling used in cold forging is subjected to very high stresses due to the high strength of the metal when deformed at ambient temperature. To withstand this high pressure exerted by the deforming metal, the tooling is made of multiple components fitted together using interference fit. Design of these tool assemblies is very critical as it determines the life of the tool components. DIE-PRESS calculates the radial and tangential stresses in the inserts and casing in a press-fit die assembly. It determines the optimum interference between the inserts and casing to withstand the required pressure for that application. In this example, the interference fit for the insert-casing was determined using the Die-Press calculator. Based on that, a tool stress analysis was performed. The user can further fine tune the press fit amount during the production to get the longest tool life.

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Die Press and NAGSIM.2D Tool Stress Analysis

Linking of Progression Design, Tooling Design and FEA Simulation Software

To further reduce the time and effort for design and development, MFSI has linked their progression design software (NAGFORM), tooling design software (NAGTOOL) and simulation software (NAGSIM.2D). NAGTOOL can create tooling from NAGFORM file and create simulation file for NAGSIM.2D in a short period of time.

There are many opportunities for a manufacturing company to reduce the time and skills it takes to manufacture a cold formed part. Those within the areas of Sequence Design, Tooling Design and Simulation are presented in this paper. The advantages of automating the design processes are numerous. It saves time, reduces dependence on experience and captures the knowledge that is lost when experienced people retire.
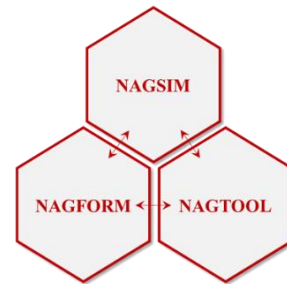
Metal Forming Systems, Inc. develops and supplies process design and finite element analysis (FEA) simulation software for the metal forming industry. The software products include 'DiePress Calculator', 'NAGFORM' for design of forming sequence and 'NAGSIM' for simulation of forging processes by Finite Element Method. MSFI also provides its customers with online and onsite training on the "**Fundamentals of Cold Forging**". For more information on these products and services, please visit www.nagform.com or contact us at (734)658-1716.