Metal Forming

A news letter dedicated to Forging Industry

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Dear Fellow Engineers,

Demand for steel in India is growing steadily and so also in Gulf countries ,who are looked to day as driving forces for growth. Consumption in India is showing growth trend with make in India and new start up mission of the Government. Growth in Gulf countries has been steadily increasing in the infrastructure projects as they are still net spenders. War between Russia and Ukraine have led to the increased production of steel in the other European countries, like Italy, Spain and Turkey. With recent earthquakes in Turkey we are yet know exact happenings. Electric vehicles are steadily moving ahead in numbers and number of manufacturers. EV three wheelers are progressively increasing in the northern part of India and so also Four wheelers in Western India. Researchers for better batteries for Evs are having relentless efforts for newer solutions. Still no worries for Forging Industry as India is becoming hub for Global procurement of finished forged components.

Hope you will enjoy reading article on Forging simulation by Mr. Durga Prasad. I am sure your companies must have budgeted for booking stall and participation in the mega event being organized by FFTC I December 1st to third at Trade Centre Chennai, details for which will be available to you shortly.

With Best Regards,

Dr. V. V. Kanetkar - Editor

FOR YOU

?

What conditions in the quenching operation lead to formation of Lath, acicular or fine martensitic structure in Steel ?

Simulation technology for forging process optimization

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TRANSVALOR S. A.

Continue in November issue...

After the product is designed the real work for the forging engineer begins: the process design is the most time-consuming part in this chain and demanding the greatest know-how and skill. It is supported by FEA, in case of Parsan and Omtas with two FORGE®-clusters that are used for all processes that are designed for production. Only when the simulation is showing a satisfying result the CAD-files will be released for tool production.

The variety of results that can be taken out of such a simulation are shown in Fig. 2. In addition to the most important results like form-filling and detection of folds there are many others that are helpful to design a cost-effective and robust forging process:

- Press load
- Grain Flow
- Die stresses
- Consumed Energy and number of blows on hammers
- Die Deflection and Die wear
- Strain rate
- Marking grids for shear edges and piping/vacuuming effects
- Grain size and phase change (heat treatment)
- Temperature of billet (e. g. inductive heating)
- Temperature of dies (thermal steady state)

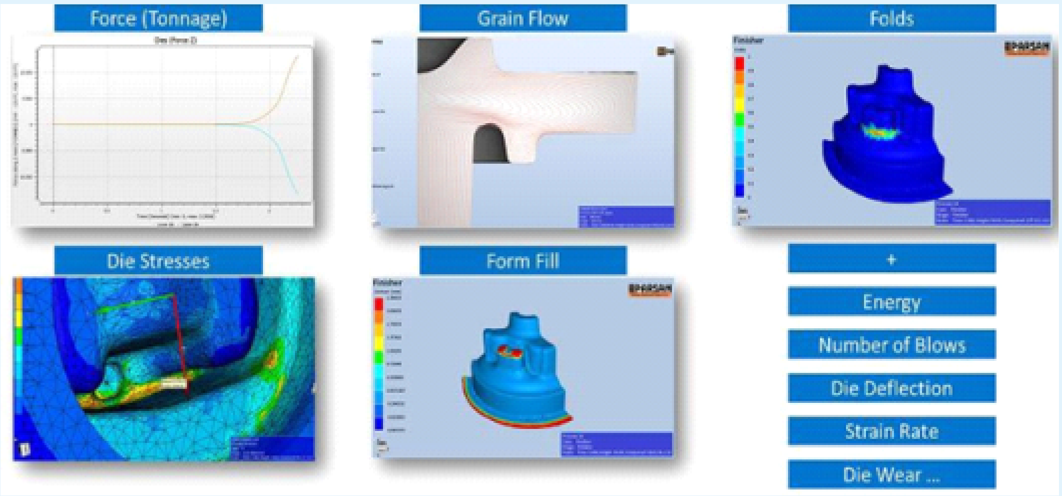

Fig. 2: Typical usage of forging simulation

Virtual Forging Processes

Typical forging process simulations are done with nominal values, practically with ideal conditions. The billet is warmed up homogenously, the dies are rigid, the friction is constant on the whole die surface and through the entire forging process. When comparing the numerical forging result with reality, which is a necessary step in the entire process, we can notice that a 100%-result is never possible because several assumptions are considered (Fig. 3). For example, the initial billet temperature is non-homogenous due to an induction heating or a cooling during the transfer, the dies are not rigid, and the friction is not constant.

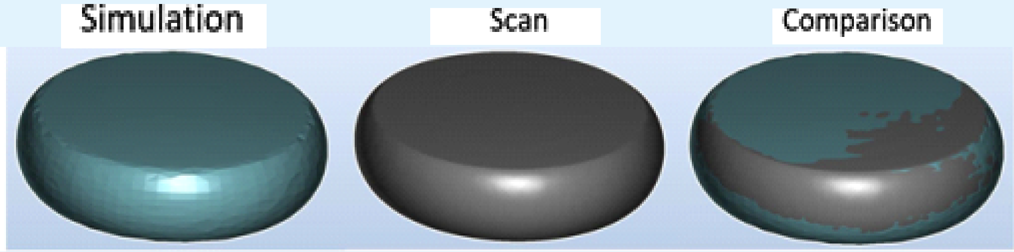

Fig. 3: Comparison of simulation and real part with GOM-Scan

At Parsan and Omtas the forging results are compared with the simulation using optical scanning with GOM, done for each step of the forging sequence. This is the easiest way to find out if the simulation is close enough to the real process. However, even for a simple stage like an upsetting as shown in Fig. 3, a small difference is always visible.

The only way to reduce this difference is to close the gap between assumptions and simplifications in the simulation and the variations that are shown in the real forging results. This has been discussed in many papers already [1, 2 and many more] and includes steps like these:

- Simulation of induction heating rather than considering a homogenous billet temperature
- Thermal steady-state-simulation with deformable dies
- Consideration of press kinematics and punch tilting
- Simulation of real lubrication leading to non-constant friction
- Simulation of trimming with deflection
- Simulation of the cooling and heat treatment process
- Checking variations of process parameters with optimization [4].

Especially for products and processes with tight tolerances it might be useful to check if such a whole chain might be giving a closer result. However, considering these additional steps prolongs the design process. For example, running a coupled analysis with deformable dies can easily put a factor of 10 or more to the time consumption of a blocker or finisher simulation. That is why at Parsan and Omtas a sensitivity analysis of the different processes is realized for all products and at all the manufacturing steps. One of these steps that will be investigated in this paper is the induction heating and the thermal steady-state.

Induction heating

Heating by induction can be analysed with simulation software. In this process a multiphysics couplings take place: between electromagnetism and heat transfer, mechanics and heat transfer, metallurgy and heat transfer, mechanics and metallurgy, electromagnetism and mechanics as shown in Fig. 4.

The optimal process parameters (for example frequency, operation time), as well as the accurate temperature distribution in the initial billet as shown in Fig. 5, the equivalent strain distribution (especially in the head and tail of the billet) due to temperature gradient more can be determined [5].

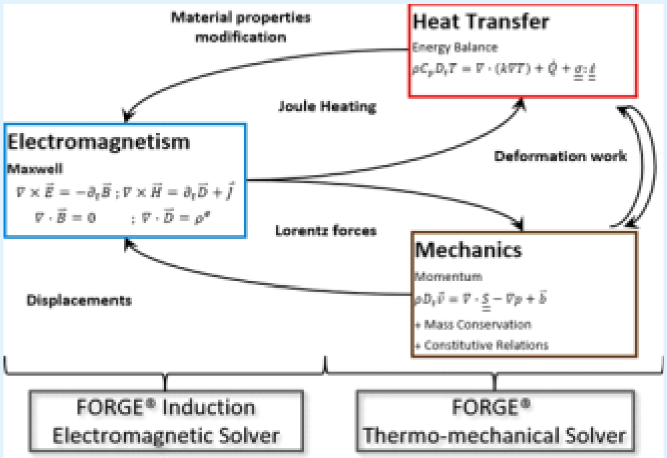

Fig. 4: Multiphysics couplings

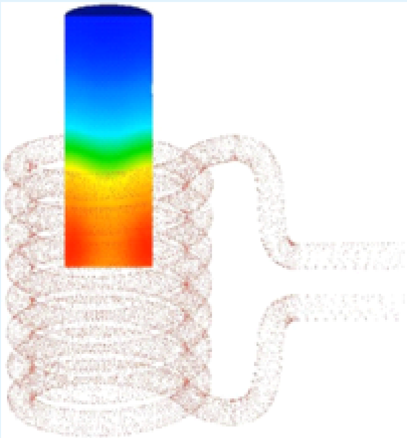

Fig. 5: Temperature evolution after induction heating

Thermal Steady State

FEM-Simulations are good tools to increase the die life and reduce the wear, plastic deformation, and mechanical fatigue [6].

To make an accurate thermal steady-state-simulation several steps are modelled as shown in Fig.6. The process starts with a waiting time, followed by the forging process, performed on deformable dies. A deformable die is a die where the mesh is generated on the surface and in the volume. Mesh constructions in FORGE® use the Delaunay triangulation which produces fast meshes with a good quality. They are based on mathematical foundations that guarantee a minimum value. Surface and volume meshes generated by Transvalor software are unstructured composed of 2D triangles and 3D tetrahedra. They

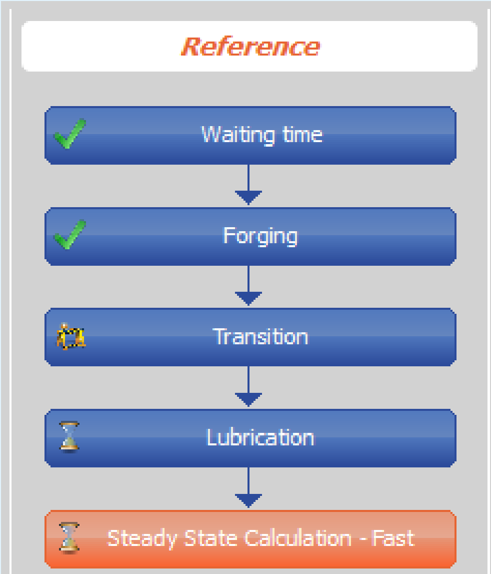

Fig. 6: Thermal Steady State Simulation [3]

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The 3rd step transition is only used to take out the billet to make the dies lubrication, The last step is the steady state simulation. Making a thermal steady state computation, the dies temperature distribution after a number of forging cycles can be predicted or the user can determine the number of forging cycles needed to get a uniform temperature.

The following figure illustrates a complete die cycle sequence: cooling / forging/ transfer / lubrication stages until the final steady state operation. During the complete die cycle the thermal equation is solved on the dies.

Fig. 7 shows the temperature evolution after a number of forging cycles. Here we can see that the temperature rises to a certain level. After 14 cycles the die reaches a thermal equilibrium in a given tolerance and the thermal steady is reached.

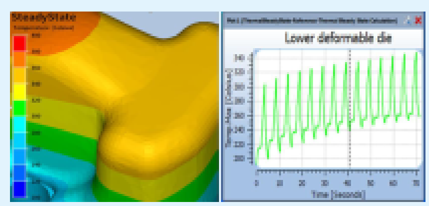

Fig. 7: Distribution of the temperature after the thermal equilibrium (right) and Variation of the max temperature during the thermal steady state calculation (left)

Conclusions and perspectives

The development of the software must follow the market needs.

- An oxide scale growth and spalling model
- An auto radiation model
- A new crack insertion algorithm
- A friction and heat transfer models function of the oxide scale influence

Numerical simulation allows the capture of the defects occurred in existing forging process. The benefits of the numerical simulation use are reduction in cost, increase in productivity without any forging defects. Results of the simulation shows a correlation with the reality. An excellent correlation is a necessity to ensure the process design at Parsan and Omtas.

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