SIMULATION-BASED-SOLUTION FOR HOT-STAMPING

Mohamed Mohamed[1], Jean-Luc Babeau[2], Harald Porzner[2], Rajab Said[2*] and Jianguo Lin[1]

[1]Imperial College London

[2]ESI Group,

ABSTRACT

The increasing pressure to produce vehicles with low carbon footprint has left OEMs in the automotive sector with no other option but to consider alternative lightweight materials. The high cost and slow manufacturing processes associated with composites materials have made it as a viable option only for low volume production of luxury and sports cars. Turning into metallic alloys with low density, high ductility and high strength seems to be the preferred option for the mass production of family-cars.

A range of Magnesium, Aluminium and High & Ultra Strength Steel alloys are now been considered. Every one of these alloys has its own advantages and disadvantages based on properties, cost, performance etc and, naturally, a combination of them will probably co-exist in vehicles for years to come. Nevertheless, what is clear that relying on traditional processes such as cold stamping to produce complex shaped parts from such alloys is not feasible. Serious issues with springback and low formability at room temperature have shifted the bottleneck to the forming process itself. Well established forming processes used widely by Aerospace such as Superplastic Forming has also its limitation as it requires forming at very high temperature and is considered to be a very slow process.

A number of techniques of hot stamping have been developed and demonstrated successfully to date particularly using steel-based alloys. Stamping a heated sheet of aluminium alloys does increase its formability and reduce springback, but it can destroy the desirable microstructure and material properties. The subsequent heat treatment to obtain ideal microstructure and strength to the formed panel parts would cause thermal distortion, which affects accuracy of the components and creates high residual stresses. To overcome such problems technologies that combine stamping and heat treatment in one process are being developed where the quenching of formed sheet is done utilising the die itself. A novel process, called ‘solution Heat treatment, cold die Forming and Quenching (HFQ)’, has been developed by researchers at Imperial College London to address the challenges associated with hot forming of aluminium sheets in particular. Such an innovative process that integrates heat treatment and forming in one operation will give aluminium sheets a great potential to produce high strength, high precision, and complex-shaped lightweight components in a cost-effective way.

In order to be able to simulate advanced forming processes such as the HFQ a multidisciplinary approach is inevitable. Aspects related to the complex material behaviour in the heated/cooled sheet, and the need to design dies that can maintain the same outcome of the 'quenching-step', need to be integrated into existing traditional stamping-simulation-tools. The paper will present a comprehensive solution developed by ESI Group to simulate hot-forming processes and elaborate on how such tools are been enhanced to accommodate for variation in process and materials. Unique developments related to the HFQ process and aluminium alloys will be discussed and demonstrated in association with the PAM-STAMP-2G software package.

The paper will address all major aspects in the simulation-based-solution of hot-forming and will present two different examples of hot-formed parts from the automotive sector. Points to be discussed will include:

- optimisation of initial sheet profile and the potential of 'nesting' multi-parts to reduce material waste
- links between forming simulation and efficient manipulation of the die surface geometry if/when needed
- integration of new material models with strain-rate depended behaviour
- new Forming Limit Diagrams for specific aluminium alloys
- thermal and mechanical contact between sheet and die surface
- utilising CFD tools to optimise cooling system in the die
- thermo-mechanical behaviour of the die and effects on its lifespan

SUGGESTED THEMES

Sheet Metal Forming, Hot-Stamping, Simulation Driven Design, Multidisciplinary simulation

ACKNOWLEDGMENT

The authors thank the European Committee for their support on the FP7 project "An industrial system enabling the use of a patented, lab-proven materials processing technology for Low Cost forming of Lightweight structures for transportation industries (LoCoLite), http://www.locolite.net/", Grant No: FP7-NMP-2013-SME-7 (604240-2LoCoLite CPTP).