FE GID BASED SOLUTIONS FOR CASTING AND SHEET METAL FORMING PROCESS

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Abstract. *This document presents two FE softwares based on GiD, Vulcan and Stampack. Vulcan is a Finite Element simulation software designed as a defect-prediction tool for the foundry engineer, in order to correct and improve the casting process, even before prototype trials are produced. The user can simulate the filling, thermal and thermomechanical process of the casted parts.*
Stampack is an advanced, multipurpose and multistage simulation software into single software suite. Sectors covered are automotive, aeronautics/aerospace, transport, metal packaging, home appliance, electronic instruments and other sectors. Several forming process can be validated and checked, starting from a flat or shaped blank or a tube or a profile and reproducing the different forming stages, including forming, ironing, cutting, flanging, stretching, rolling, as well as computation of spring-back or spring-forward for tooling compensation.

1 INTRODUCTION

QUANTECH provides the industry with state-of-the-art CAE simulation software applications to solve engineering problems in the fields of metal forming, optimization of casting processes, virtual testing, damage evolution of composites parts, and others, by using intensive computer-based simulation techniques.

Our simulation software range of products includes **Stampack**[i] and **Vulcan**[ii] packages, which are built on an user-friendly implementation of the FEA (finite element analysis) technology, developed in collaboration with CIMNE, the internationally renowned technological center dedicated to promoting and fostering advances in the using of numerical methods and computational techniques.

Vulcan is a FEM software designed as a defect-prediction tool for the foundry engineer, in order to correct and/or improve his/her casting process, even before prototype trials are

produced. **Vulcan** has been designed to carry casting process simulations in order to help foundries to improve their manufacturing process and avoid casting defects.

Stampack is an award-winning simulation software for multi-stage process in the metal forming industry, helping customers to deliver the products first, in demanding markets as automotive, aeronautics/aerospace, transport, metal packaging, home appliance, electronic instruments, etc. **Stampack** produces the best results in simulating ironing, forming of thick sheets, hydroforming, stretchforming and other specific operations.

2 VULCAN GENERAL FEATURES

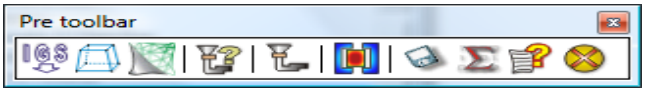
Vulcan helps the foundry engineer to enter a minimum requirement of information, and to analyze the results in a simple and effective manner, allowing the complete simulation of the following processes: (a) Gravity sand casting, (b) Gravity die casting, (c) Gravity tilt pouring, (d) Low pressure die casting, (e) High pressure die casting.

The **Vulcan** system includes two software simulation modules: CFD (computational fluid dynamics) for the mould filling and CTM (coupled thermal-mechanical) for the solidification and cooling analyses.

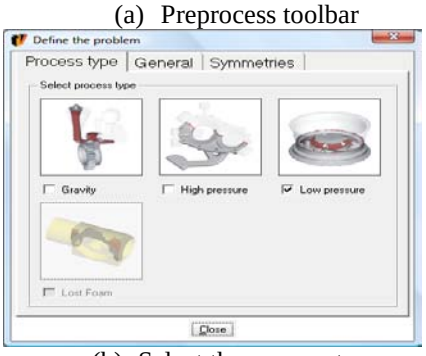
2.1 Vulcan GUI

Vulcan use **GiD** framework for pre and post processing to create an economical, powerful, specialized and user-friendly tool that quickly and accurately optimizes the casting processes to improve the productivity and reduce cost.

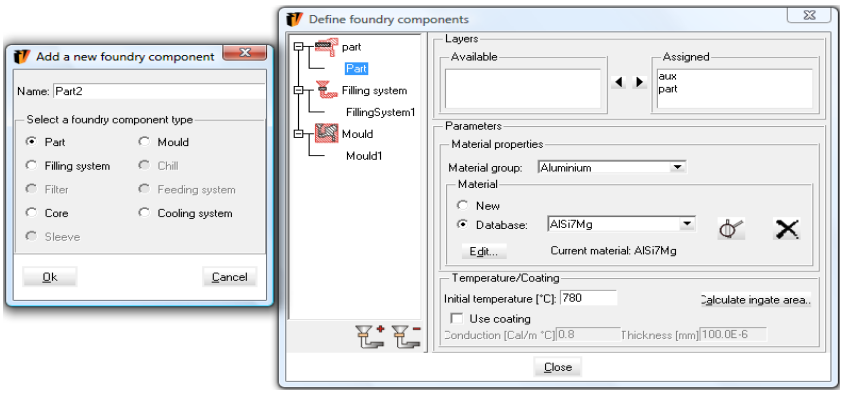
Vulcan has a user friendly GUI with step-by-step menu-driven process definition, default setting of most analysis parameters, fully automatic boundary conditioning and constraining, on-line tutorials and help and customizable software interface. For the material database has an integrated extensive material property data-base, temperature dependent thermo-physical characterization, graphical visualization of the material properties, material parameter optimization through industrial feedback, user defined material property definition, user defined material data-base export,etc., see Figure 1.



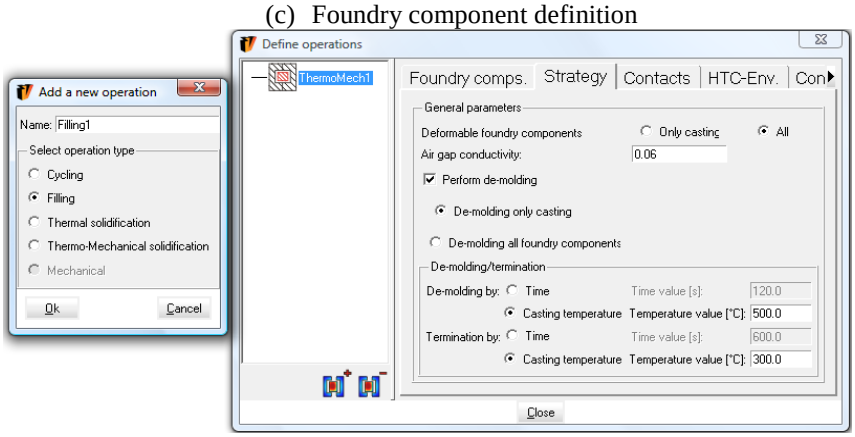
(a) Preprocess toolbar



(b) Select the process type



(c) Foundry component definition



(d) Operation definition

(e) Post-process result toolbar

Figure 1: **Vulcan** GUI.

2.2 Mould filling module

This module performs the numerical simulation of the fluid flow, showing the position of the metal front at different time-steps. The solution of the Navier-Stokes equation for incompressible fluid is coupled together with the energy balance equation[iii] (temperature and early-solidifications) and a sophisticated turbulence model leading to an accurate study of the mould filling process.

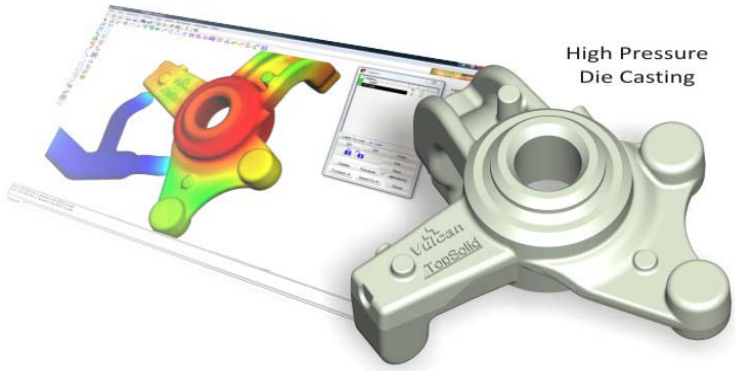


Figure 2: Virtual manufacturing for light alloys casting.

The mould design can be checked and improved allowing for correct decision making at an early stage of the manufacturing process.

By using the simulation the mold developer will be able to optimize the mold design, vents position, filling channels, ingate, cooling channels, filters, etc, to avoid defect in the parts such as: (a) Air entrapments, (b) Surface quality, (c) Non filled areas, (d) Bubble generation, (e) Mold erosion, (f) Particle inclusions.

The mould filling module results in a powerful engineering tool capable to reproduce the most common pouring technologies such as: (a) Gravity sand casting, (b) Tilt-pouring, (c) Gravity die casting, (d) Low-pressure die-casting, (e) High-pressure die-casting, (f) Centrifugal casting, see Figure 2 and Figure 3.

2.3 Solidification and cooling analysis module

Vulcan offers the most advanced technology for the numerical simulation of coupled thermo-mechanical problems. The solidification and following cooling processes are solved coupling the thermal model (temperature and solidification evolution) with the mechanical analysis (residual stresses and distortions).

The resulting fully coupled thermo-mechanical algorithm is the natural framework to represent the heat flow exchange (by conduction, convection and radiation), the final shape of the casting part, as well as the evolution of the thermal stresses induced by the manufacturing operations.

Figure 3: Virtual manufacturing for low pressure die casting wheel.

The relationship between the heat transfer coefficients and mechanical quantities such as the open air-gap (due to the casting shrinkage) or the contact pressure has been experimentally proved. Hence, the mechanical analysis coupled with the thermal simulation is mandatory to produce a reliable casting numerical model.

The capabilities of this module can be resumed with the following points: (a) Solidification evolution, (b) Riser design and optimization, (c) Die cooling and heating, (d) Residual stresses and distortions, (e) Hot tearing (cracking in the casting), (f) Stress concentration, (g) Stress concentration.

Solidification of the metal within the mould and cooling of the part once the mould is removed, see Figure 4.

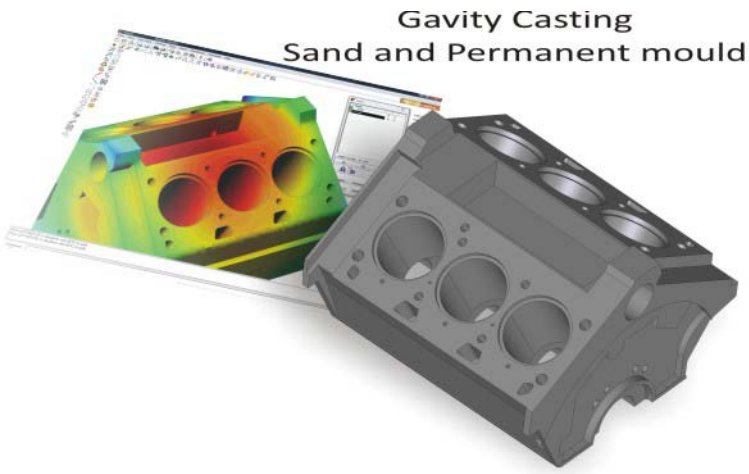


Figure 4. Virtual manufacturing for gravity sand casting.

3 STAMPACK GENERAL FEATURES

Stampack is the metal forming simulation software for many industrial applications such as ironing, stretch-forming, forming of thick sheets, flex-forming, hydro-forming of multi chamber profiles, stretch-bending of profiles, etc., see Figure 5.

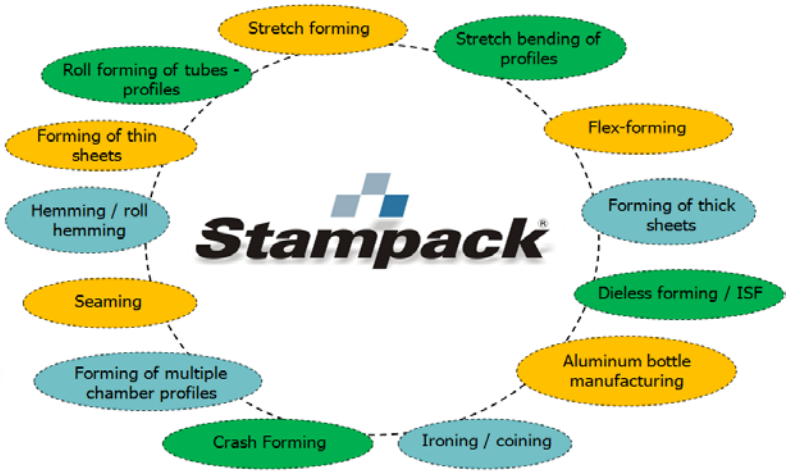


Figure 5. **Stampack** industrial applications.

To fully evaluate these industrial applications **Stampack** provides information and tools to automatically visualize the simulation results at any point in time during any of the forming stages.

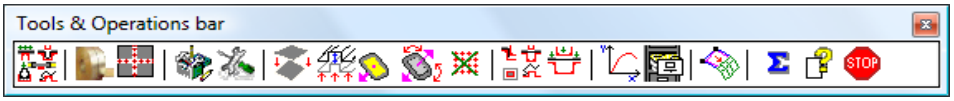
3.1 Stampack GUI

Stampack simulation software offers a huge number of advantages for tool-making on general multistage mechanical forming processes. The built-in technology allows engineers to calculate and analyze any process steps they wish, changing parameters as they wish, evaluating the forming results of any step they wish at any stage from the very beginning to the very end of the process within the same simulation.

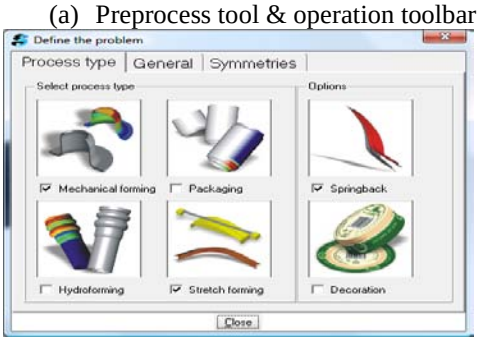
Stampack use **GiD** framework for pre and post processing to create an economical, powerful, specialized and user-friendly tool that quickly and accurately optimizes your metal forming

processes to improve the productivity and reduce cost.

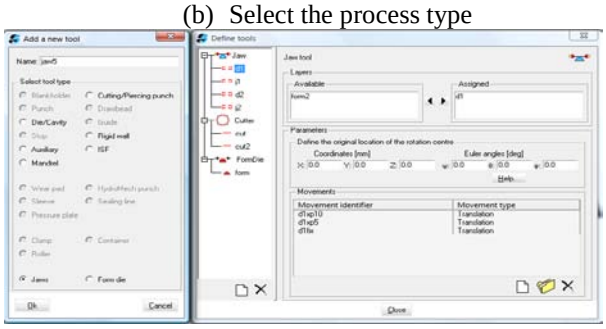
Extremely easy to use walk-down wizards, can be used by non FEM specialists. Industrial user interface specialized for different sectors, speaks customer's language, see Figure 6.



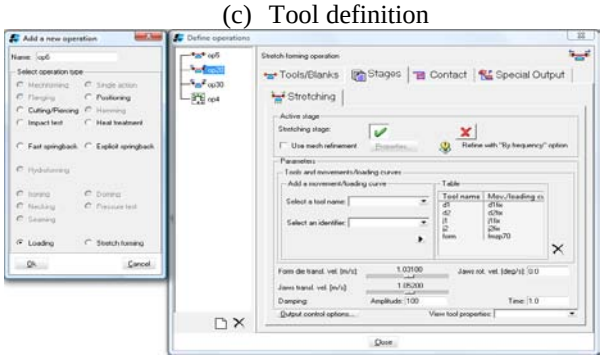
(a) Preprocess tool & operation toolbar



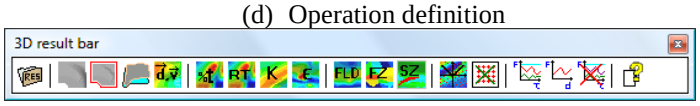
(b) Select the process type



(c) Tool definition



(d) Operation definition



(e) Post-process result toolbar

Figure 6. **Stampack** GUI.

The GUI of **Stampack** provides an advanced and multipurpose simulation tool for all metal forming industries into single software suite. More processes and more flexibility.

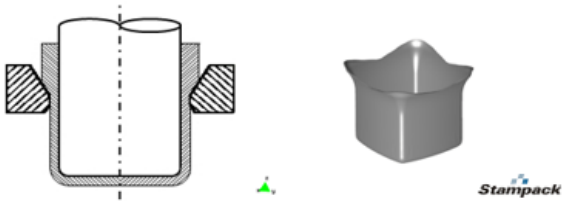
3.2 Mechanical forming process

Stampack helps you to design formed parts so they can be done in the most cost-efficient way using the most economical process and material. **Stampack** also can help you develop a part shape that can be formed easily and that will fit and function properly. Major areas of concern can be identified easily with **Stampack**, such as excessive thinning, fractures, or

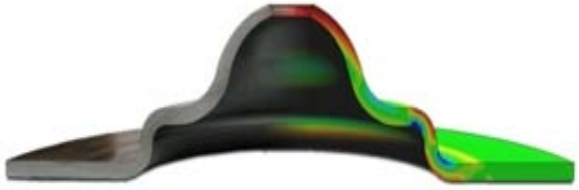
wrinkling.

The mechanical forming process interface includes the ability to define many forming stages: (a) General forming, (b) Ironing, (c) Forming of thick sheets, (d) Roll forming of tubes and profiles, (e) Flowforming and spinning metal forming processes, (f) Hemming and roll hemming process, (g) Post shaping of tubes or profiles, (h) Low and high speed impact. Any of these stages may be combined with trimming, springback, etc., see Figure 7.

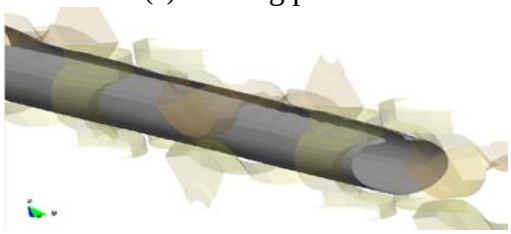
(a) General mechanical forming processes



(b) Ironing processes

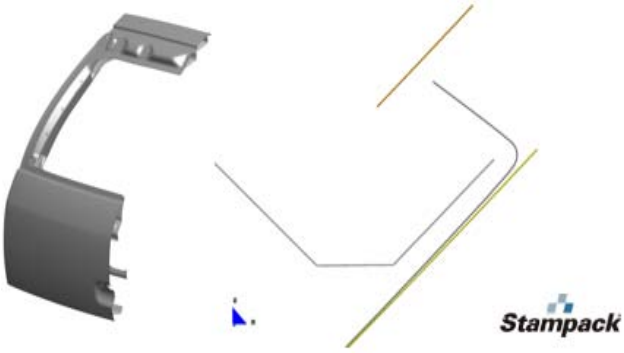


(c) Forming of thick sheet

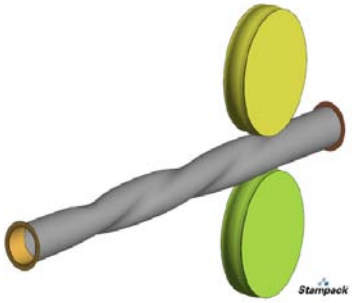


(d) Roll Forming of tubes and profiles

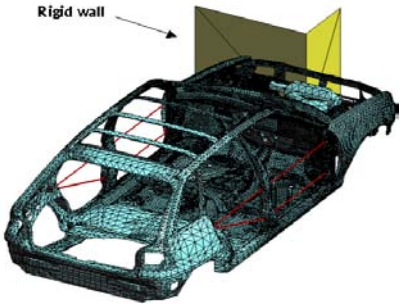
(e) Flowforming and spinning metal forming



(f) Hemming and roll hemming



(g) Post shaping of tubes or profiles



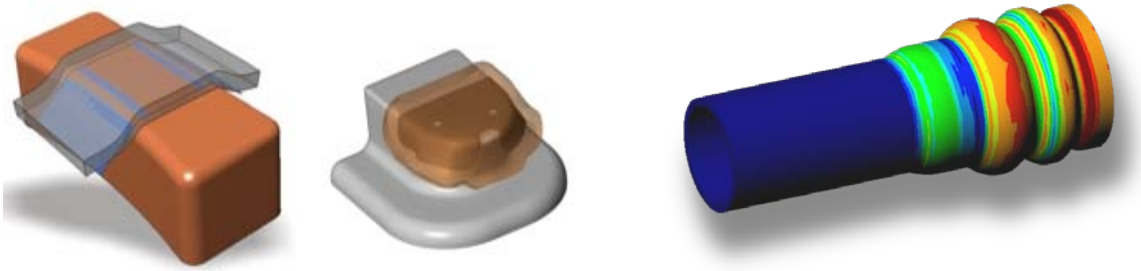
(h) Impacts

Figure 7: Forming process applications.

3.3 Hydro-forming process

The Hydro-forming interface includes the ability to define sheet or tube hydro-forming by adding the effects of rubber wear pads, pressure cavities and sleeves in the holding, bulging, forming, heat treatment and calibration process steps. Any of these stages may be combined

with trimming, springback, etc., see Figure 8.

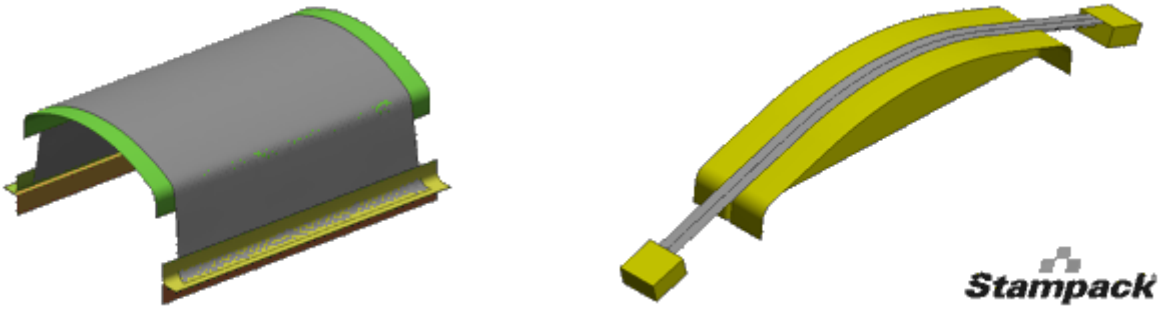


(a) Sheet flex-forming (Rubber pad forming) (b) Hydro-forming of thick tubes

Figure 8: Hydro-forming process applications.

3.4 Stretch-forming process

The Stretch-forming interface includes the ability to define simple or tangential stretch-forming processes by adding the effects of the movements and clamping actions of jaws, clamps and form dies during the loading and forming process steps (these tools and processes are additional to those mentioned above), see Figure 9.



(a) Stretch forming of skin panels (b) Stretch bending of profiles

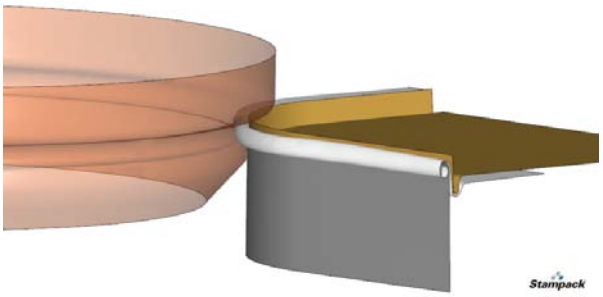
Figure 9: Stretch-forming process applications.

3.4 Metal packaging process

The packaging interface includes the ability to define forming processes relating to the fabrication of food and beverage tins/cans and aerosols by adding the effects of tool actions during the forming, wall-ironing, doming, necking process steps (these tools and processes are additional to those mentioned above). In addition to this, the packaging module enables pressure test evaluations to be carried out on the final tins/cans/aerosols, see Figure 10.

(b) Aluminum bottle manufacturing

(a) Fabrication of beverage tins/cans



(c) Seaming process

(d) Can decoration

Figure 10: Metal packaging process applications.

4 CONCLUSIONS

- The personalization and customization of **GiD** system, allow engineers to simulate and evaluate complex industrial processes in a fast, reliable and easy to use way. The sophisticated approach permits process quality maximization and increases efficiency.
- The simulation is able to completely reproduce the technological process and allows to detect virtual failure.
- The engineer may decide to optimise or to change the technology using virtual information only.
- Simulation applies to all industrial design levels and is an affordable tool for all companies.
- It has been proven that using simulation saves money and reduces time to market.
- The wide capacities of **GiD** for post-processing allow a quick and reliable evaluation of the obtained results.

REFERENCES

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