EUROPEAN COOPERATION IN THE FIELD OF SCIENTIFIC AND TECHNICAL RESEARCH - COST

COST 526
Automatic Process Optimization in Materials Technology
(APOMAT)

Title:

Hydroforming – Aquadraw Process Optimization

Keywords: hydroforming, aquadraw, finite element analysis, explicit non linear dynamics, smooth particle hydrodynamics, optimization, sensitivity analysis, automotive industry

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1. Duration / run time of the project

- 1/1/2002 – 31/8/2004, under the restriction of getting initial public funding

2. Overall cost

- 220 kEuros

3. Funding situation

- Public funding to be defined by introducing national and international research projects (PREDIT OR RNTL projects)

4. Project partners indicated to participate

- Several Automotive Industries (Ford, PSA-CITROËN, RENAULT)
- Research Laboratory (ENSAM/ESEM LMSP, UTC LG2mS)
- Industrial test problems / experimental results provided by the car manufacturers
- Development of methodologies / software tools at MECALOG
- Research activities supported by the ENSAM/ESEM LMSP and UTC LG2mS Laboratories

5. Project partners to be found

- Automotive suppliers of hydroformed parts

6. Short description of the material process to be optimized

In the field of material forming, many car manufacturers consider an increasingly broad use of the hydroforming process for the manufacture of elements of the body or mechanical components of the vehicle. Because they have many advantages with respect to rigidity, security, flexibility, weight and cost, many manufacturers consider for future the use of structures known as " space frames ". Hydroforming process will be used there for the realization of steel or aluminium profiled which, after welding or assembly, will constitute the skeleton on which the sheets of the body will be brought back.

For mechanical parts, hydroforming process could be used to manufacture mechanical components such as suspension connecting rods, etc.

Thanks to the use of fluid instead of mechanical tools, hydroforming is known to allow a better formability of blanks at a lower cost. This feature is enhanced by the hydroforming process called AQUADRAW. Actually, the particularity of AQUADRAW is not only to replace a mechanical tool by a fluid but also to generate a fluid flow between the die and the blank. Thus, the effects of fluid onto the formability are extended as follows :

- higher formability coefficients
- better quality of surface
- better distribution of strains
- decrease of spring back effects.

7. Material(s) involved:

- Steel and Alluminium alloys

8. Optimization potential of the process or process step

The definition of the process requires the combination of various mechanisms of deformation: expansion and contraction primarily. These mechanisms are difficult to define without the use of numerical procedures of optimization.

The potential benefits of optimization techniques are :

- Reduction in design time of the process (sequence, tools, etc.)
- Improvement/control of the quality of the manufactured parts (thickness distributions, plastic strain, residual stresses, final shape)
- Improvement/control of metallurgical properties (anisotropy of the formed material parts)
- Reduction in manufacturing variabilities (robust design)

Quantitave value are difficult to define at this stage but an overall reduction of 50% in the design time and associated costs is expected.

The optimization of the hydroforming process can build on the past experience in deep drawing optimization.

9. Specified material properties to be achieved

- As regular as possible thickness and plastic strains distributions
- Minimization of the residual stresses and permanent deformations due to the elastic springback
- As few as possible (no) tears, wrinkles, surface defects
- Solution of inverse optimization problem with assumed final shape, material properties and damage distributions (after elastic springback)

10. Process parameters to be optimized

- Time evolution of the pressure curves and blank holder forces
- Counter-pressure value
- Initial thickness of the blank
- Die shape to account for the elastic spring back

11. Material laws including material dependent coefficients

- Material laws specific to the simulation of processes will be integrated so as to take into account the anisotropy of plastic behaviour during stamping and to describe the possible appearance of a tearing by constriction.
- Quadratic criteria (for steels) or not-quadratic ones (for aluminium alloys) make it possible to describe with accuracy the plastic anisotropy related to the manufacturing processes of sheets by rolling. Damage models will be integrated to describe the appearance of ruptures. Propagation models of microcavities like the Gurson type and damage models like the Chaboche type will be integrated and compared for concerned applications.

12. Simulator

The RADIOSS® FE System will be used for the numerical simulation of hydroforming processes. World reference among the “explicit” finite elements software for nonlinear analysis, RADIOSS makes possible the solution of problems of strongly nonlinear dynamics including the solution of generalized contact problems. In particular, RADIOSS is routinely used for crash studies of vehicles as well as for the simulation of deep drawing processes by the explicit approach. For many car manufacturers - a vehicle on two in the world is computed using RADIOSS -, RADIOSS has become an essential element of the design of vehicles and passive safety devices. The use of RADIOSS is however not limited to the automotive domain as RADIOSS can also be found in the aeronautical, defense and the equipment goods fields.

The modelling of hydroforming/aquadraw processes will need to have a particular coupling between structure and fluid. Using an explicit dynamic software, we can use not only an ALE (Arbitrary Lagrangian Eulerian) formulation but also a SPH (Smooth Particles Hydrodynamic) method which is specially suitable for the creation of the fluid flow between the die and the blank.

13. Optimizer

Off-the-shelf design exploration platforms surch as the iSIGHT® of BOSS-QUATTRO software will be used as a software platform for design exporation and robustness assessement. These platforms make possible to integrate in a same software environment modelling and simulation tools to automate and systematize repetitive computational phases. To help in the design process, they associate the know-how of the engineer with a whole of numerical tools for decision-making aid. Those include/understand tools for experimental designs, optimization methods, tools for construction of response surfaces, knowledge rules, as well as techniques for " Quality Engineering " making it possible to take into account the non-deterministic aspects of the design.

14. Competence / activities of proposer

The core activity of MECALOG is the development, the maintenance and the marketing of the RADIOSS software and of its environments.

The second pole of activity of MECALOG is in the development of Custom Modeling Simulation and Design Environments (CMSDE). The CSMDE developed by MECALOG contributes to the capitalization of companies’ know-how by formalizing the modelling and design practices, and by systematizing them. They contribute to the reduction of the simulation and design cycles and costs and at a more rational use of simulation hardware and software. By giving to the designers the possibility to explore a broader choice of alternatives, and to reach optimal solution quickly, they takes part in the innovation and to the performance, the quality and the reliability of products.

15. International state of the art and references

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