

COST 526 - 'Automatic Process Optimization in Materials Technology' – (APOMAT)  
**Final Report – 31 July 2005**  
**Summary sheet**

Project Code	F3
Title	Optimization of Process Parameters in Sheet Metal Forming
Project Leader	Dr. Catherine Knopf-Lenoir
Organization Address	Université de Technologie de Compiègne Laboratoire Roberval, UMR UTC-CNRS BP 20529 – 60205 Compiègne Cedex
Tel	+33 (0)3 44 23 45 48
Fax	+33 (0)3 44 23 46 89
E-Mail	cklv@utc.fr
Main collaborators involved	Prof. Jean-Louis Batoz, Dr Arnaud Delamézière InSIC, 27, Rue d'Hellicourt 88100 Saint-Dié-des-Vosges Dr Hakim Naceur, UTC

**Funding Situation** (for the whole project)

Amount of money received specifically for COST	kEuros
Other resources partially used for the project	
Funding from the french Ministry of Research (OPTIMAT project):	200 kEuros

**International Collaboration** (mention group and type of work done in collaboration during the whole project)

University of Liège : on shell modelling and optimization techniques

**Industry participation** (mention name of companies and work done in collaboration during the whole project)

Mecalog, France : optimization algorithms  
 Quantech, Spain : improvement of the One step code for stamping

**Meetings, visits, exchange of scientists, short term scientific missions** (mention main events during the whole project)

Participation in the 8 APOMAT meetings:

**Location, date**

Brussels, 2-4 December 2001  
 St-Dié-des-Vosges, 21-22 May 2002  
 Budapest, 28-29 November 2002  
 Brussels, 26-27 May 2003  
 Krakow, 27-28 November 2003  
 Angers, 13-14 May 2004  
 Brno, 18-18 November 2004

**Main Outcome of the project** (mention only the major points)

Several strategies of simulation methods and minimization procedures have been implemented to study and solve various optimization problems:

- quality criteria have been defined to take into account the risks of necking, rupture and wrinkling, and the springback effect.
- simplified (inverse approach) and incremental (explicit) simulation methods are used, depending on the nonlinear problem considered,
- adaptive response surface strategy appears as an efficient method when the simulation time is very important and the number of design variables is low ( $\leq 4$ ). Direct minimization with a SQP algorithm has been applied when gradients are available.
- Optimization results are available for the following examples :
  - cylindrical cup (Numisheet'02) : optimization of the blankholder forces during punch displacement
  - square box : optimization of restraining forces, of the material parameters, and design of the initial blank, optimization of the blankholder forces during punch displacement
  - Twingo dashpot cup : optimization of restraining forces, of the material parameters, and design of the initial blank
  - U-bending test (Numisheet'93): minimization of the springback effect
  - Car front door panel (Numisheet'99): optimization of the blankholder force distribution

**Publications, related to this project**

## Published

- DELAMÉZIÈRE A., NACEUR H., BREITKOPF P., KNOPF-LENOIR C., BATOZ J.L., VILLON P.,  
Faisabilité en emboutissage : optimisation du matériau par surface de réponse, Mécanique et Industries, Vol.3, N0 2 (2002), pp93-98.
- NACEUR H., BREITKOPF P., KNOPF-LENOIR C., VILLON P., Méthode de surface de réponse pour l'optimisation de forme des surfaces additionnelles de pièces embouties, 6<sup>ème</sup> Colloque National en Calcul des Structures, 20-23 Mai 2003, Giens (Var), France, CSMA, Actes (Ecole Polytechnique) pp 215-222 et CD-Rom.
- W. GATI, Y.Q. GUO, H. NACEUR, J.L. BATOZ, "Approche Pseudo Inverse pour estimation des contraintes dans les pièces embouties axisymétriques", Revue européenne des éléments finis, Vol. 12, n° 7-8, pp. 863-886, 2003.
- NACEUR H., DELAMÉZIÈRE A., BATOZ J.L. , KNOPF-LENOIR C., Somme improvements on the optimum process design in deep drawing using the Inverse Approach, J. Mater. Process. Technol. V146 (2) pp 250-262 (2004).
- NACEUR, H., GUO, Y.Q., BATOZ, J.L. "Blank optimization in sheet metal forming using an evolutionary algorithm", Journal of Materials Processing Technology, Volume 151, pp. 183–191, 2004.
- H. NACEUR, S. BEN-ELECHI, C. KNOPF-LENOIR, J.L. BATOZ, Response Surface Methodology for the Design of Sheet Metal Forming Parameters to control Springback Effects using the Inverse Approach, NUMIFORM 2004, 13-17 Juin 2004, Columbus, Ohio, US.
- BEN AYED L., DELAMÉZIÈRE A., BATOZ J.L. \*, KNOPF-LENOIR C., "Optimization of the blankholder force with application to the Numisheet'02 deep drawing benchmark test B1", 8<sup>th</sup> International Conference on Numerical Methods in Industrial Forming Processes, NUMIFORM 2004, 13-17 Juin 2004, Columbus, Ohio, US, 6 pages.

- BEN AYED L., DELAMÉZIÈRE A., BATOZ J.L., KNOFF-LENOIR C., "Optimization and control of the blankholder force in sheet metal stamping with application to deep drawing" European Congress on Computational Methods in Applied Sciences and Engineering, ECCOMAS 2004, 24-27 Juillet 2004, Jyväskylä, Finlande. 14 pages on CD-ROM.
- L. BEN-AYED, A. DELAMÉZIÈRE, J.L. BATOZ, C. KNOFF-LENOIR, Optimisation des efforts serre-flan en emboutissage pour contrôler la striction et le plissement, CMSM'2005, 23-25 Mars 2005, Hammamet, Tunisie. 12 pages sur CD-ROM.
- L. BEN-AYED, A. DELAMÉZIÈRE, J.L. BATOZ, C. KNOFF-LENOIR, Contrôle de la striction et du plissement en emboutissage, 7ème Colloque National en Calcul des Structures, Giens (Var), 17-20 Mai 2005, Giens, France. 6 pages.
- C. KNOFF-LENOIR, J.L. BATOZ, A. DELAMÉZIÈRE, H. NACEUR, L. BEN-AYED, S. BEN ELECHI, Optimization of process parameters in sheet metal forming, First Invited COST 526 Conference APOMAT, Automatic Process Optimization in Materials Technology, 30-31 May 2005 Morschach, Switzerland, pp 110-119.
- L. BEN-AYED, A. DELAMÉZIÈRE, J.L. BATOZ, C. KNOFF-LENOIR, Optimization of the blankholder force distribution in deep drawing, First Invited COST 526 Conference APOMAT, Automatic Process Optimization in Materials Technology, 30-31 May 2005 Morschach, Switzerland, pp 229-235.
- J.L. BATOZ, C. KNOFF-LENOIR, H. NACEUR, A. DELAMÉZIÈRE, S. BEN ELECHI, L. BEN-AYED, Die Design and Material Identification for Springback Compensation in Sheet Metal Forming, First Invited COST 526 Conference APOMAT, Automatic Process Optimization in Materials Technology, 30-31 May 2005 Morschach, Switzerland, pp 252-261.
- L. BEN-AYED, A. DELAMÉZIÈRE, J.L. BATOZ, C. KNOFF-LENOIR, Optimization Of The Blankholder Force Distribution with application to the stamping of a car front door panel (Numisheet'99), 6th International Conference and Workshop on Numerical Simulation of 3D Sheet Forming Processes, NUMISHEET 2005, 15-19 August 2005, Detroit, Michigan, USA. 6 pages.
- L. BEN-AYED, A. DELAMÉZIÈRE, J.L. BATOZ, C. KNOFF-LENOIR, "Influence des critères de rupture dans le cadre de l'optimisation du procédé d'emboutissage des tôles", XVIIe Congrès français de mécanique, CFM2005, 29 août – 2 septembre 2005, Troyes, France. 6 pages.

Submitted for publication

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In preparation

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The paper from Colloque National en Calcul des Structures has been selected for a special issue of Revue Européenne des Eléments Finis.

Will you continue the actual cooperation with your partners after the end of the action?

Yes

No

Would you participate in a possible "spin-off" action continuing the present one?

Yes

No

Will you continue your present work/collaboration with another European action?

Yes

No