

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

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| Project Code                | F5   |
| Title                       | Forging Process Optimization   |
| Project Leader              | Lionel FOURMENT  |
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| Main collaborators involved | Tien Tho Do, Abderamane Habbal   |

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

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|--|---------------|
| Amount of money received specifically for COST | 0.7306 kEuros |
| Other resources partially used for the project | kEuros        |

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

- French funded project "OPTIMAT" gathering all French partners of APOMAT (MECALOG, LMA, UTC, ENSAM, CEMEF) and TRANSVALOR (software house) and Amis (forging company) following same objectives as APOMAT, the optimization of metal (sheet, bulk, powder) forming processes.
- University of Dortmund, Germany, Chair of System Analysis, collaborative work on Optimization Algorithms based on Evolutionary Algorithms
- University of Twente, Netherlands, Faculty of Engineering Technology, collaborative work on Optimization Algorithms based on Meta modelling

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

Setforge, Sifcor, Forge de Bologne, Snecma (French forging companies) and Cetim (Technical Center of Mechanic Industry) have participated to the project by providing industrial problems for testing and validating Optimization Algorithms and Methodology.

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

- Short term scientific mission of Michael Emmerich from the Chair of System Analysis of the Dortmund University
- Research Stay of Martjin Bonte from the Faculty of Engineering Technology of the Twente University

**Location, date**

Cemef, Ecole des Mines de Paris, Sophia Antipolis, France, 18-23 November 2003

Cemef, Ecole des Mines de Paris, Sophia Antipolis, France, 9 May – 8 August 2005

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

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During this project, we have extended the adjoint state method for the calculations of sensitivities to tool shapes in 3D metal forming processes, so allowing comparing gradient, non gradient and hybrid algorithms on complex 3D forging problems. Non gradient algorithm, Evolution Strategy using Meta-modelling, has been provided through the collaborative work with the Dortmund University within Apomat, while we have internally developed hybrid algorithms based on Genetic Algorithms and Meta-modelling using the Gradient information. Extensive applications to actual 3D forging problems have both shown the feasibility of such complex optimizations and the efficiency of the studied algorithms, and the robustness of the evolutionary ones (with or without gradient).

## **Publications, related to this project**

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M. LAROUSSE, L. FOURMENT « The adjoint state method for sensitivity analysis of non-steady problems. application to 3d forging » Int. J. of Forming Processes, vol. 7/1-2, 35-64 (2004)

### Published

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P.-O. BOUCHARD, N. CAILLET, Y. CHASTEL, L. FOURMENT, T.T. DO, "A numerical tool for optimization of grain flow orientation, in forged parts submitted to multiaxial fatigue loading", Fatigue Design, Conférence internationale sur la part respective de la simulation numérique et de l'expérimentation dans la conception vis-à-vis de la fatigue, 16-18 Novembre 2005, Senlis, France

L. FOURMENT, T.T. DO, A. HABBAL, M. BOUZAIANE, "Optimization of forging sequences using gradient, non-gradient and hybrid algorithms", First Invited COST 526 Conf. APOMAT, 30-31 May 2005, Morschach, Switzerland

L. FOURMENT, T.T. DO, A. HABBAL, M. BOUZAIANE, "Gradient, non-gradient and hybrid algorithms for optimizing 2D and 3D forging sequences", 8<sup>th</sup> International ESAFORM Conference on Material Forming, Cluj-Napoca, Romania, 26-29 April 2005

M. LAROUSSE, L. FOURMENT « Sensitivity Analysis of 3D Forging using the Adjoint State Method : Extension to folds detection and die filling », VII International Conference on Computational Plasticity, COMPLAS, Barcelonna, April 7-10 2003

L. FOURMENT & M. WARD « Shape optimization for preform tool design in reverse Superplastic Forming », VII International Conference on Computational Plasticity, COMPLAS, Barcelonna, April 7-10 2003

### Published in Conference Proceedings

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### Submitted for publication

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A. HABBAL, L. FOURMENT, T.T. DO "Gradient, non-gradient and hybrid algorithms: application to the optimisation of 3D forging"

B.

### In preparation

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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