

COST 526 – Final Report

Foreword from the Chairman

The main objective of the COST 526 action „Automatic Process Optimization in Material Technologies” (APOMAT) was to develop and to apply numerical optimization methodologies to automatic process design in material technologies, i.e. casting, injection moulding, forging, sheet metal forming, heat treatment, welding, coating, and chemical processes. The approach is based on quantified product qualities and related to process targets and constraints, including economic aspects.

In response to the market-driven pressure for reducing time-to-manufacture, numerical analysis has become state-of-the-art in materials science and processing. Over the past two decades, a large range of different virtual processing models have been developed world-wide and software codes partially commercialized. The common platform is the integration of material laws, including appropriate numerical schemes, e.g. the finite element method, for solving generic equations for heat transfer, fluid flow, and concentration or stress/strain evolution on both macroscopic and microscopic length scales. For a large number of process steps (and also complete manufacturing procedures), these numerical tools have proven to be successful in terms of quality improvement and process design. The main feature of virtual process models (simulation models or simulators) is the numerical analysis of a process step, providing insight into the status quo of a process at each stage. At the same time, such models enable the execution of virtual experiments, and therefore facilitate systematic process optimization by trial-and-error methods (“manual optimization”). Oriented accordingly, the concerted R&D activities of the COST 512 action remained ongoing from 1993 until 1998, successfully chaired by Prof. Michel Rappaz, EPFL-Lausanne (Switzerland).

A substantial upgrade of this procedure is to combine virtual models with numerical optimization techniques. The logical connection is the so-called quality, cost or objective function, including its constraints, which allows for automatic quantitative quality assessment of the simulation results. Typically, the quality function relates a set of process parameters to a number of quantitative material laws describing the specific material properties emerging from a specific process step. Achieving this task requires high-level interdisciplinary development work among material scientists, process engineers and computer scientists. It has been the intention of COST 526 to promote this topic at a European level and the action, which got underway 29 March 2000 will end 28 September 2005. Eleven countries signed up to the action and approximately thirty proposals were evaluated (24 being approved by the Management Committee). Finally, 22 projects took up their work, each assigned to one of the three working groups “Thin-Walled Product Processing”, “Liquid/Solid Processing” or “Bulk Product Processing”. The fourth working group “Optimization Methodologies” was created as a discussion forum (Fig. 1). During the course of the action, due to severe funding problems four projects have been withdrawn.

For presentation and coordination of project activities seven joint working group meetings each followed by an MC meeting have been arranged and a final joint meeting is planned for November 2005 in Besancon, France. A comprehensive website, www.cost526.de, was designed and maintained for communication and information. One of the key outcomes of the action is the close cooperation established between some of the material scientists, simulation engineers and computer scientists involved in this action for

- formulating quantitative material qualities based on appropriate material laws for quality function design, taking account of inherent constraints
- providing accurate and high-performance process simulation software
- dealing with high-dimensional, nonlinear optimization problems.

In May 2005, the “First Invited COST 526 Conference” was held in Morschach, Switzerland, organized by the Institute of Informatics, University of Applied Sciences Aargau, Switzerland. The objective was to give a comprehensive demonstration of the COST 526 topic, including presentations of all participating COST projects and contributions from industry and academia. The conference provided an open platform both for strengthening ongoing collaborative work and for initiating new relationships, while also disseminating state-of-the-art automatic process optimization techniques. The conference proceedings are available at the COST 526 website.

One important criterion for project evaluation was that each project was to start from a well-defined technical process, including an appropriate numerical simulation model. The intention was to draw maximum effort to the design of the quality function, including a dedicated optimization scheme and – last but not least - to the overall checking process (calibration, verification and validation). However, in the course of this action in a number of projects the performance of the simulator used for numerical process optimization proved to be insufficient: either the underlying physical models were too simple for the calculation of relevant process quantities or the software was not accurate enough and often too slow with respect to computing time.

Resolving these challenges could be the goal of a follow-up action aimed at a more product-driven approach for automatic process optimization.

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Chairman of the Management Committee Cost 526

Cost 526 (APOMAT)		
Chairman: F. Hediger Scientific secretary: P. Swiatek		
WG 1 Thin Walled Product Processing WG leader: J.-P. Ponthot deputy: J.-L. Batoz participating projects: B 1, CH 1, F 1, F 4, G 1	WG 2 Liquid-Solid Processing WG leader: J.-C. Gelin deputy: N. Hofmann participating projects: CH 2, CH 4, CZ 1, CZ 5, D 4, F 2, FIN 1, SI 1, SI 4	WG 3 Bulk Product Processing WG leader: L. Fourment deputy: T. Rodic participating projects: CH 3, CZ 2, CZ 4, F 5, PL 1, SI 2, SI 3
WG 4 Optimization Methodologies WG leader: B. Filipic deputy: C. Knopf-Lenoir		

Figure 1: Working group structure