



COST 526

**“Automatic Process Optimization in Materials Technology”  
(APOMAT)**

**Half-Yearly Report**

To be sent to [V.Tesch@access.rwth-aachen.de](mailto:V.Tesch@access.rwth-aachen.de) until **August 31, 2002**

<b>1. Reporting Period</b>	<b>1.1.2002 – 30.6.2002</b>
Project title	Numerical Calculation of the Process Parameters, which Optimise the Gas Turbine Blade Coating Process by Ther. Spraying, for given Spray Paths
Project leader	F. Lavers
Organization	ALSTOM (Switzerland) Ltd Dept. GFH, H4/3 1 CH-5242 Birr
Main collaborators involved	Dr. M. Balliel, C. Pedretti, G. Guidati

**2. Funding Situation**

Amount of money received specifically for COST

159 kCHF committed by Swiss BBW 2002-06-17 with official project start 2002-07-01

Other resources partially used for the project

kEuros

**3. International Collaboration**

(mention group and type of work done in collaboration during the reporting period)

Participation in the Working Group Meeting in Saint-Dié des Vosges + project progress report

YES

NO

Yes, participated in WG Meeting St.-Dié des Vosges.

Project progress report is part of this 1<sup>st</sup> half-year report, section 6.

**4. Industry participation**

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

ALSTOM (Switzerland) Ltd = PL

<b>5. Meetings, visits, exchange of scientists, short-term scientific missions</b>	<b>Location, date</b>
COST526 Swiss group meeting	Prof. Dr. N. Hofmann/FH Aargau, CH-5210 Windisch, September, 9 <sup>th</sup> 2002



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**6. Progress within the reporting period**

(Not exceeding 3 pages, including tables and figures)

**See attachment.**

**7. List of publications**

a) Published

-

b) Submitted for publications

-

c) In preparation

-

## **6. Progress within the reporting period**

The Swiss ministry for education and research (BBW) committed its funding with a project start of 2002-07-01. Before this date mainly preparatory work was executed. Furthermore, it was decided that the ALSTOM Power Technology Center (APTC) will be responsible for the optimization program and the coupling of the optimizer with the coating process simulation tool.

### ***Objectives***

The blading of a gas turbine has to be protected from the hot gas stream. This can be achieved by different techniques, such as cooling air, metallic coating or thermal barrier coating (TBC). The present project is concerned with the process of applying TBC on a turbine blade. Specifically, the project targets the following points:

- § The development of criteria and strategies for the optimization of the coating process, which include the coating thickness, porosity distribution and the total coating time as parameters of the objective function.
- § The development of methods for the optimization of a spray path for complex 3D shapes by taking into account equipment, process and tooling limitations.

### ***Offline simulation tool***

An offline simulation tool for the coating process is available. It models the complete set-up consisting of a robot, a plasma spray gun and a blade. All degrees of freedom and limitations (maximum speed etc.) of the robot are considered. The user can define paths of the spray gun and analyze the resulting coating thickness and porosity on the blade surface. The latter is computed using a predictive software, which was previously developed at ALSTOM.

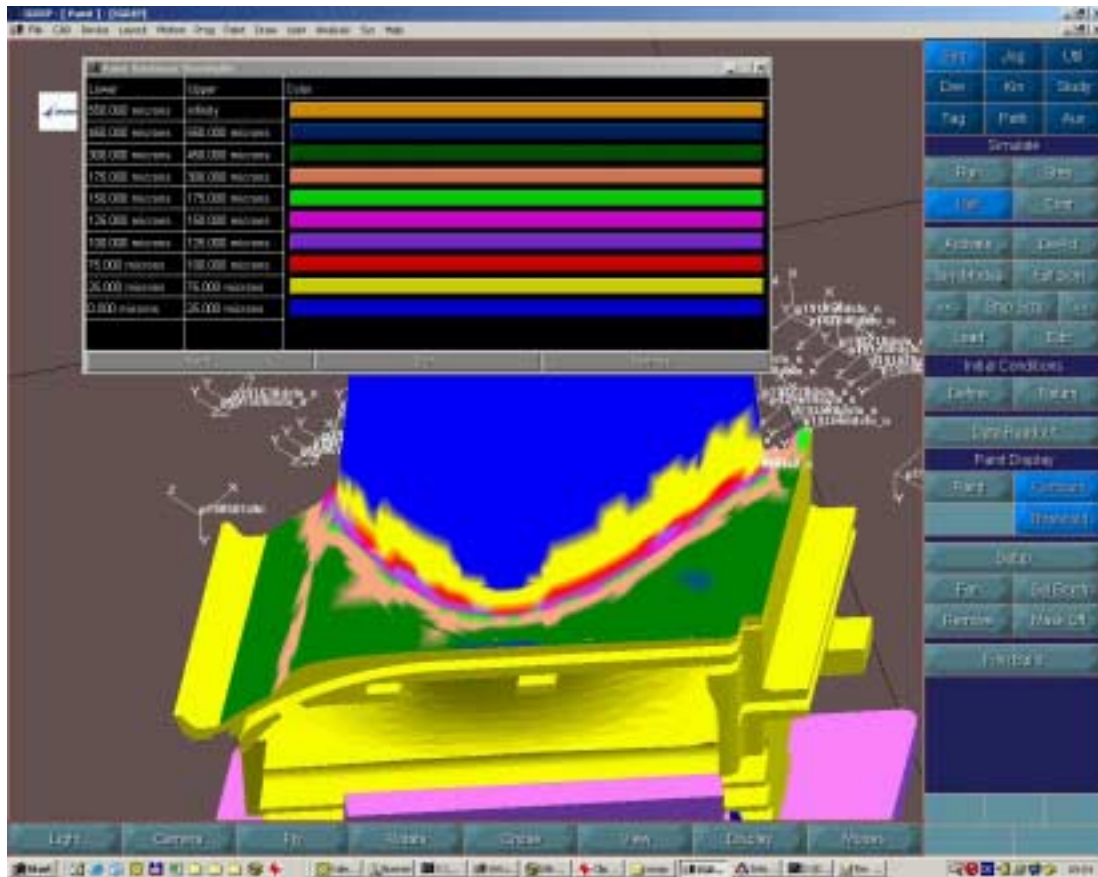
The simulation tool takes into account the spray distance, spray angle, spray time, the limited accuracy in the relative position between gun and component, and the complex component geometry. Figure 1 depicts a screen shot of the simulation tool showing a turbine blade and a color mapping of the coating thickness.

### ***Optimization environment***

An optimization software for the project has been identified. The Java Optimization Environment (JOE) was written at APTC. The programming language is Java. This makes the optimizer especially suited for the application on different platforms.

The program implements several modern optimization algorithms, such as evolutionary strategies. The program was successfully applied in different areas inside and outside ALSTOM, namely for optimizing Francis turbines, gas turbine burners, compressor blades, or wind turbine airfoils.

One of the main strengths of the available optimization software is that it can handle noisy objectives. These can occur when the optimizer is coupled with a predictive software such as the above offline simulation tool. Specific algorithms (response surface techniques) allow to find good solutions with a relatively small amount of evaluations. This is especially useful in the present case where a complete prediction with the offline simulation tool may require a few minutes.



**Figure 1:** Simulation of a blade coating process with manually defined process parameters. Colors of the hot gas surface indicate local coating thickness.

### **Optimization strategies**

To find the best optimization strategy, a three-step approach is employed:

#### § Coating strategy

The first step aims at defining the most appropriate coating strategy. This effort starts with a critical assessment of the strengths and limitations of the current (manual) process. The basic configuration at the moment is a fixed blade with the spray gun mounted on the movable robot arm. Alternative strategies (e.g. fixing the spray gun and moving the blade) will be studied.

Further important questions are e.g. whether the blade platform and a shroud should be treated separately from the airfoil surface, or whether it is possible to define one consistent strategy which covers the whole blade.

#### § Parametrization

After the basic coating strategy was defined, the second step requires a parametrization. This means that the possible spray paths have to be described in a mathematical form with a limited number of free parameters.

#### § Coupling with optimizer

Based on the parametrization of the spray paths, the offline simulation tool is coupled with the optimizer. An objective function has to be defined, which will comprise in particular the predicted coating quality and total process time.