



COST 526

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

Half-Yearly Report

To be sent to V.Tesch@access.rwth-aachen.de until **February 28, 2004**

1. Reporting Period	1.1.2004 – 30.06.2004
Project title	Optimization of cooling parameters in continuous casting process
Project leader	Dr Erkki Laitinen
Organization	University of Oulu, dept. of mathematical sciences P.O. Box 3000 90014 UNIVERSITY OF OULU
Main collaborators involved	Helsinki Univ. of Technology, lab. of metallurgy, Finland Lab. for multiphase processes, Nova Gorica Polytechnic, Slovenia Josef Stefan Institute, dept. of Intelligent Systems, Slovenia Banki Donat Polytechnic, Dept. of Material sci. and Tech., Hungary Rautaruukki steel company, Finland Outokumpu steel company, Finland

2. Funding Situation	
Amount of money received specifically for COST	0 kEuros
Other resources partially used for the project	50 kEuros

3. International Collaboration (mention group and type of work done in collaboration during the reporting period)
Participation in the Working Group Meeting in Angers+ project progress report
NO
<i>The bilateral Finland-Slovenia research project: "Numerical optimization of continuous casting of steel"</i> approved (23.2.04) by Academy of Finland and ministry of Slovenia. Within the project co-operation between FIN1 (Laitinen) and SI1 (Filipic) started in order to compare the solution methods and the optimisation methods used for continuous casting of steel.

4. Industry participation (mention name of companies and work done in collaboration during the whole project)
Rautaruukki steel, Finland: Industrial verification of the 3D dynamic secondary cooling software for controlling cooling water flow rates at Rautaruukki steel works.

5. Meetings, visits, exchange of scientists, short-term scientific missions	Location, date

6. Progress within the reporting period

(Not exceeding 3 pages, including tables and figures)

During the last half year we have worked for verifying the new 3D software at Rautaruukki steel works.

The main progress of 3D simulation model

The 3D simulation model is tested on-line at Rautaruukki steel works. The calculated surface temperature was compared with pyrometer measured surface temperature on CC5. The first one was placed on the centerline of the wide face and the other one was placed on the corner of the narrow face of the slab (see Fig. 1).

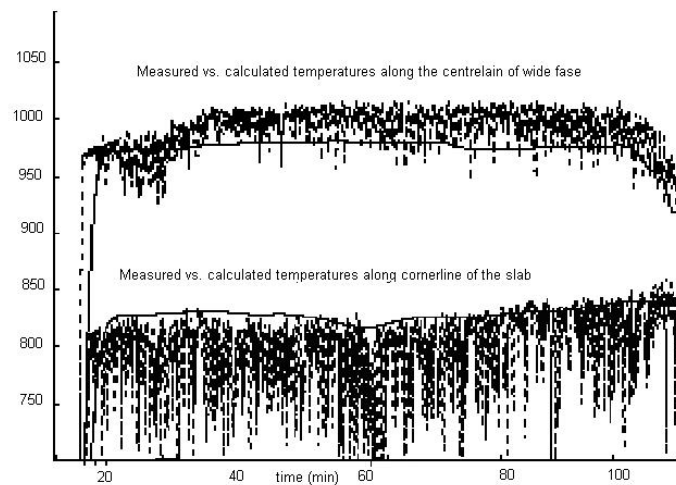


Figure 1. Comparison of measured and calculated temperatures

Shell thickness measurements using the wedge technique were conducted on CC6. The measuring positions were 13.10 m, 16.15 m, 17.85 m and 19.30 m from meniscus.

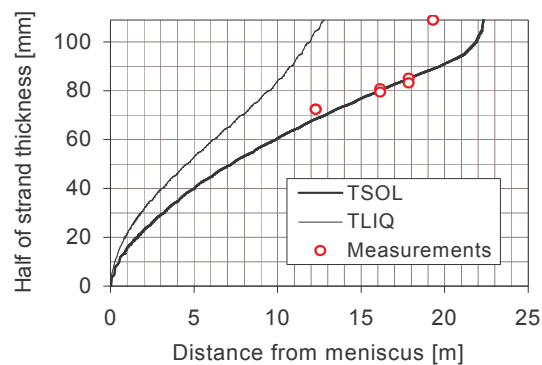


Figure 2. Measured shell thickness vs. calculated shell thickness

The main progress of optimization model

The optimization model has been verified at Rautaruukki steel works with on-line tests. The objective of quality function is to avoid surface and internal cracks of cast. The quality function is defined mathematically as follows:

$$\begin{cases} J(T) = \frac{1}{2} \int_0^{L_z} (T - T^{tar})^2 dz \\ J(T) = \frac{1}{2} \sum_{i=1}^{N_z} h^i_z (T(z_i) - T^{tar}(z_i))^2 \end{cases}$$

The target temperatures are defined along the centerline (green) of the slab and along the corner (red) of the slab as shown in Fig. 3.

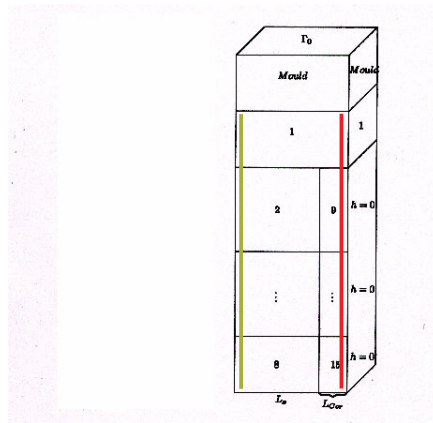


Figure 3. The target lines of the objective function

In the figure 4 is presented the calculated temperatures along the target lines

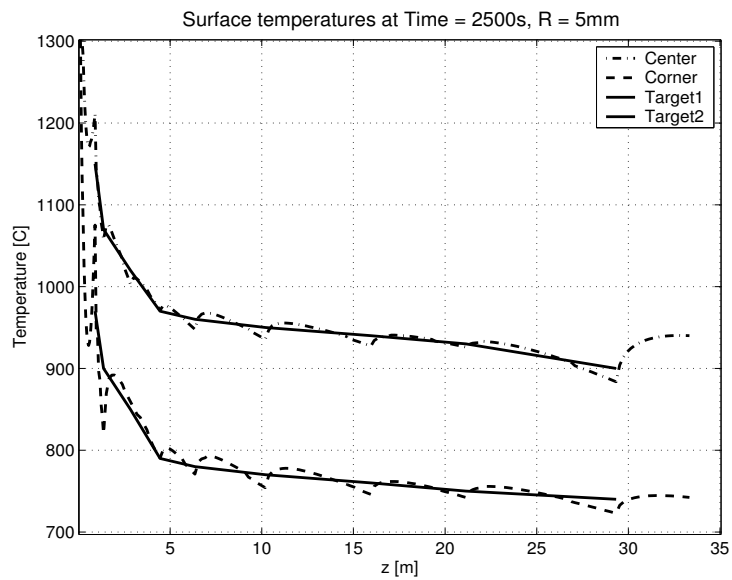


Figure 4. Surface temperatures along the target lines

7. List of publications

a) Published

Laitinen E., Pieskä J., Toivonen V.: "On 3D dynamic control of secondary cooling in continuous slab casting process", Advanced Computational Methods in Heat Transfer VIII (eds. B. Sunden, C.A. Brebbia and A.C. Mendes), WIT Press, Southampton, UK (2004), pp.161-170

b) Submitted for publications

E. Laitinen, J. Pieskä, I. Rentola, V. Toivonen: "Quality optimization of steel products in continuous casting process using numerical optimization and soft reduction", The 10th International Conference METAL FORMING 2004, Poland, september 19-22, 2004

c) In preparation