



**I3E**  
*South East Europe TCP*

## **Best Practice Report**

# **Vacuum pressure control at the plasma annealing and cleaning machine**

**Document type** : Best practice report  
**Document version** : Final  
**Document Preparation Date** : February 10<sup>th</sup>, 2011  
**Classification** : Internal  
**Contact** : Vladimir.Jovan@ijs.si  
**Project co-ordination** : ISI – Industrial Systems Institute  
**Deliverable Responsible** : JSI – Jozef Stefan Institute

--	--

<b>Rev.</b>	<b>Content</b>	<b>Resp. Partner</b>	<b>Date</b>
0.1	Creation of document	JSI	10.02.2011

Everybody please state revision index and short description of what has been done + partners involved and date.

<b>Final approval</b>	<b>Name</b>	<b>Partner</b>
<b>Reviewer</b>	Gregor Dolanc	JSI
	Vladimir Jovan	JSI

### 1. Best Practice Title

Vacuum pressure control at the plasma annealing and cleaning machine

### 2. Location of Best Practice

*Country, region, town*

Austria, Lebring

### 3. Best Practice Executive Summary

*Describe briefly (max 10 lines) the GP context (partnership, funding, objectives, approach followed, results)*

This best practice report summarizes the 6<sup>th</sup> EU FW project Connect aimed to the research and development of the advanced platform for predictive control. After its development, the platform was evaluated by using it in several case-studies for different control problems at end users from project consortium. Case-studies and resulting prototypes for end users therefore represent further partial results of the project Connect.

One of the case studies was the control system for plasma machine and it was developed by the Jozef Stefan Institute, the Department of Systems and Control for the company PlasmaIt, Austria, which produces the machines. Both partners were members of a consortium of the project Connect, the first one as RTD provider and the second one as end user. The research and laboratory prototype development of the vacuum pressure control system was performed and funded within the project Connect, while the final implementation was funded by PlasmaIt directly.

### 4. Best Practice Classification

#### Best Practice Theme

- Research Transformed to Innovative Product*
- Research Transformed to Innovative Service*
- Research Transformed to Innovative Methodology*
- Research Transformed to Innovative Production Process***
- Financial Mechanism for Transformation of Research to Innovation*
- Support Mechanism for Transformation of Research to Innovation*
- Other (describe)*

#### Best Practice Research / Application Areas

- Industrial / Manufacturing Systems*
  - Industrial Informatics and Communications*
  - Intelligent Devices*
  - Distributed Control Systems*
  - Flexible Manufacturing Systems***
- Embedded Systems*
  - Industrial Embedded Systems*
  - Nomadic Environments*
  - Private Spaces*
  - Public Infrastructures*

## 5. Description of Best Practice

### 5.1 Best Practice Context

*Overall background of the Best Practice. Location, socio-economic, technical & policy background of the BP (max 10 lines)*

This best practice report describes an international project Connect focused to the development of a platform for predictive control and demonstration of the platform in several case-studies. One of the case studies was the research and the development of the system for vacuum pressure control for plasma annealing and cleaning machines. These machines are produced by the company Plasmalt from Austria and they are used in the process of production of wire and related metal products (metal strips, etc.). Machines simultaneously clean, anneal and cover wire surface in one single wire pass by using plasma. Vacuum pressure in plasma reactor is an important process parameter, which must be held within tolerances in order to guarantee stable plasma operation and wire quality. A control system is needed, which keeps pressure in tolerances by controlling the operation of vacuum pump and vacuum valve. The goal is to achieve low pressure deviation from the setpoint and fast response to the various kinds of process disturbances.

#### 5.1.1 Policy Elements

*What are the policy initiatives that have influenced the contextual environment of BP: innovation promotion policies, research funding policies, certification ect as well as relevant tools (max 10 lines)*

The goal of the project Connect was to develop an advanced platform for predictive control. More specifically, the goal was to develop software tools (programming blocks, configuration tools), documentation and case studies which will significantly simplify the implementation of the predictive control to different kinds of closed loop control problems including vacuum pressure control of plasma machines. The importance of this and similar goals was identified within the 6<sup>th</sup> framework program of the European Commission, which made possible to establish the international project consortium, where partners were able to join their expertise and knowledge and share experiences with end users. Without 6<sup>th</sup> framework program the completion of the project would be much more difficult.

#### 5.1.2 Socio-economic & Other factors

*Other contextual factors such as customer / target market addressed, international validity, customer density, economic conditions, customer values, research area addressed (max 10 lines)*

The effect of the project Connect is twofold. Firstly, the developed predictive control platform represent a benefit in a very wide sense not only for existing project partners but also for numerous present and future end-users, which will be able to the benefits of predictive control platform and thus optimize their processes. The predictive control platform will accelerate the implementation of the predictive control (which is proven to be more effective than standard closed loop control schemes) by providing the system integrators with the necessary knowledge (theory + case studies), prefabricated program blocks and configuration tool. Secondly, particular end-users from the project Connect will gain immediately from the optimization of their technological processes.

### 5.2 Objectives

*Aim of the project, specific objectives & strategies to achieve these objectives (max 10 lines)*

The goal of the project Connect is to provide platform, which will accelerate the use of predictive control technique in practice. The predictive control technique is proven to enhance control performance of the closed loops but, on the other hand, it requires a lot of effort for implementation and adaption to the particular technological process. Once implemented it requires relatively high computational power to execute optimization algorithms. All this makes it difficult and expensive to implement and maintain. The project Connect provided a platform (programming blocks, configuration tool, more effective optimization algorithms, documentation, case studies) which should tackle with all mentioned problems of predictive control and accelerate its use and promote it by several well documented case studies.

## 6. Process

*Describe the project including key concepts and the overall approach followed. Indicate project end users, target market, main project phases, problems encountered and solutions, problem resolution (max 10 lines)*

The main goal of the project Connect, i.e. the development of predictive control platform was completed by combining different kinds of expertise: theoretical background of predictive control, optimization algorithms, programming, industrial software and understanding the characteristics and requirements of particular technological processes. Project consortium was carefully selected to fulfill all required fields of expertise. Once developed, the platform was demonstrated through several case studies, one of them was the control system for plasma machine was developed by the Jozef Stefan Institute, the Department of Systems and Control for the company PlasmaIt, which produces the plasma machines. Both partners were members of a consortium of the project Connect, the first one as RTD provider and the second one as end user. The research and laboratory prototype development of the vacuum pressure control system was performed and funded within the project Connect, while the final implementation was funded by PlasmaIt directly.

### 6.1 Project Design

*Project design based on targeted market complete understanding, project structure, policies and procedures, management and implementation actions (max 10 lines)*

Project Connect was designed according to the following factors:

- Predictive control is theoretically well known and proved to be more effective than standard closed loop techniques. In spite of this it is relatively rarely used in practice due to its demanding nature, as described above. There was a wish to provide step forward in implementation of predictive control in practical cases.
- At the time of project start-up the 6<sup>th</sup> framework program of the European Commission recognized this need and identified it in a call for projects. 6<sup>th</sup> framework program provided not only the financial framework to complete the project but also raised the motivation of project partners by confirming the relevance of the subject.
- Particular project partners were coping with the technological control-oriented needs of their industrial partners who then became project end-users. The technological needs of end users represented the motivation for the development of predictive control platform on one hand and on the other hand they prevented the development would go into wrong direction.

### 6.2 Project Management

*Activities relevant to project coordination and management, project documentation and reporting, quality control,*

*validation and verification (max 10 lines)*

The project was managed by the standard procedures, which were required by the 6<sup>th</sup> framework program. This means that complete project was subdivided in to several work-packages, which were performed in logical chronological and content order. Management activities were addressed within the dedicated work-package by identifying responsible institutions and persons for each of the work-packages. Progress was monitored by the work-package reports, which were presented at regular project meetings. The overall progress was closely monitored by the officers from European commission.

### **6.3 Project Implementation**

*Main elements associated with the project implementation. Realization of new idea, or new technological realization or improvement / novelty to known technology and means to achieve this. Innovation associated with the project realization in terms of new products, services, methodologies. Marketing, advertising and customer service. (max 10 lines)*

Project Connect was completed by the members of project consortium. In the development of the predictive control platform all consortium members were involved and their different areas of expertise were combined. The key points were: providing the theoretical background, implementing the algorithms within selected programming environment (Matlab, programmable controllers), testing the algorithms numerically and on experimentally on test cases, providing the documentation and completion of several case studies. End users, which were also a part of the consortium, provided the description of their technological processes and helped at the definition of technological demands and specifications. They provided their processes for experimentation activities.

### **6.4 Project Evaluation**

*Project feedback mechanisms and evaluation mechanisms. (max 10 lines)*

The general part of the project (development of predictive control platform) was controlled and evaluated in the frame of standard management activities, which were required by the 6FP program. Project goals and milestones were clearly defined and they were all completed according to the project plan. Case studies were also evaluated and probably the most important evaluation came from end users, who expressed satisfaction with provided solutions.

### **7. Description of Research team/Institution**

*Short description of R&D team and institution (max. 10 lines)*

Consortium of the project Connect was formed by RTD (research and technology development) providers and end users. RTD providers were in charge for the research and development of the platform of advanced predictive control systems for manufacturing processes. End users provided their industrial and manufacturing processes to be used as case-studies to evaluate the developed advanced predictive control platform. To evaluate the platform generally, demanding control problems in different kinds of industrial processes were required and this was a selection criterion for end users. RTD providers are all experts from the field of advanced control methods. In addition, Jozef Stefan Institute has many experiences also in the transfer of the research results from theory to practice, since this is one of its missions. This made it to be and ideal project partner both for both research and development of the predictive platform and the development of the vacuum pressure control system.

## 8. Applied Financial Mechanism

*Describe financial mechanisms applied in transformation of research into innovation within BP, as well as means of connecting scientific research team and financiers (max. 1000 char.)*

The project Connect was financed by the consortium and the 6<sup>th</sup> framework program of the European commission. Research work, development and prototyping were financed by the grant of European commission. Final implementations at end users were financed from other sources, mainly the sources of end users themselves.

## 9. Impact and benefits

*Describe achieved benefits of R&D team and/or enterprise implemented innovation, as well as impacts on institutional and policy levels. (max. 1000 char.)*

Generally, all RTD providers upgraded their research and technological level by obtaining and mastering a new platform for predictive control, which was the common and main research result of the project Connect. End users gained prototype solutions for their control problems.

More specifically, PlasmaIt, the producer of plasma cleaning and annealing machines was provided with the prototype of the vacuum pressure control system, which was further developed and it is now used in all their machines. The RTD provider (Jozef Stefan Institute, the Department of System and Control) gained access to the new technological field and materialized its research results into practice.

## 10. Sustainability

*Provide information on sustainability of innovation after financial aid within implemented financial mechanisms, and some multiplier effects as replication and extension of the action performed in BP. Expected use of Best Practice and lifecycle considerations. (max. 1000 char.)*

RTD providers, including Jozef Stefan Institute, continue with the development of the predictive control platform and study some possible new areas of application. The company PlasmaIt proceeds with further development of the system and adapts it to the new versions of cleaning and annealing machines.

## 11. Repeatability and transferability

*Lessons learned from the project implementation team. Repeatability and transferability of the project. (max. 1000 char.)*

The direct result of the project Connect is the platform for predictive control. This a transferable result, since the platform is designed to be applied to different kinds of technological processes. The idea was that application of the platform to the versatile closed loop task would require only a reconfiguration and no or little programming. However, characteristics of different processes may require also more extensive modifications of the basic concept. In this manner a library of case studies is very important and has to be continuously updated with new technological cases.

## 12. Evaluation

*Describe reasons and evaluation criteria why the described example is a best practice. (max. 1000 char.)*

The project Connect is successfully completed and provides the platform for predictive control as the main result. Case-studies for end users are successfully completed, as well. More specifically, the vacuum pressure control system, developed for PlasmaIt, meets all the technological demands and it was practically proved in several machines, produced and installed by PlasmaIt worldwide.

<b>13. Contact of research team/institution</b>	<b>14. Contact of financial mechanism facilitator</b>
<p><i>Name, address, tel., fax, e-mail, URL</i></p> <p>Department of Systems and Control Jožef Stefan Institute</p> <p>Dr. Gregor Dolanc Jamova cesta 39, SI-1000 Ljubljana, Slovenia Tel: +386 1 477 37 98 Fax: +386 1 477 39 94 E-mail: <a href="mailto:gregor.dolanc@ijs.si">gregor.dolanc@ijs.si</a> <a href="http://dsc.ijs.si/en/">http://dsc.ijs.si/en/</a></p>	<p><i>Name, address, tel., fax, e-mail, URL</i></p> <p>European Commission, 6th framework program</p>