Centre for Advanced Manufacturing Technologies

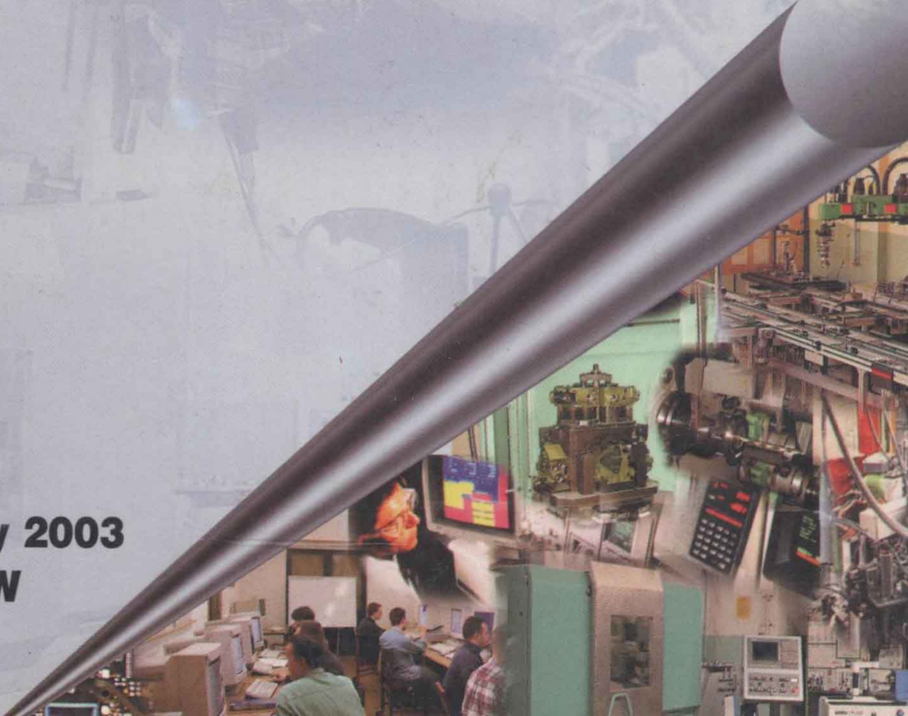
Institute of Production Engineering and Automation

Wroclaw University of Technology

CAMT

Modern Trends in Manufacturing

SECOND INTERNATIONAL CAMT CONFERENCE



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WROCLAW

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SECOND INTERNATIONAL CAMT CONFERENCE

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The conference is co-sponsored by the European Commission within the 5th Framework Programme's activity "Support for Centres of Excellence" (COFEXC)

Conference Programme Committee

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FOREWORD

Centre for Advanced Manufacturing Technologies within the Institute of Production Engineering and Automation at the Wroclaw University of Technology is executing a large three-year project, financially supported by the European Union within the "Support for Centres of Excellence" initiative (COFEXC). In the second year of this activity, CAMT organises the second International Conference "Modern Trends in Manufacturing"; the first one was organised on the 7th and 8th February 2002.

The goal of the conference is to present current trends in science and practice of manufacturing. The contents of the conference will be focused on 6 areas that are the main research fields of the Centre for Advanced Manufacturing Technologies:

- Machine tools, appliances and manufacturing
- Parallel kinematics
- CAx design tools in integrated product development
- Modelling and simulation methods in production engineering
- Automation and control in manufacturing
- Manufacturing and quality systems

During the conference papers of researchers invited from leading research centres from the European Union and Poland, as well as papers on research activities and research results of CAMT will be presented. The participants are both from universities and industry. We hope that the Second CAMT Conference will become a forum during which participants will establish cooperation links leading to projects within the 6th Framework Programme of the European Commission within national and international networks of excellence.

Jan KOCH

SŁOWO WSTĘPNE

Centrum Zaawansowanych Systemów Produkcyjnych CAMT (działające w ramach Instytutu Technologii Maszyn i Automatyzacji Politechniki Wrocławskiej), realizuje 3 letni projekt wspierany finansowo przez Unię Europejską jako „Centre of Exellence" (COFEXC). W drugim roku realizacji tego projektu organizujemy II Konferencję CAMT pod hasłem „Modern Trends in Manufacturing" (pierwsza miała miejsce 7 i 8 lutego 2002).

Celem Konferencji jest przedstawienie współczesnych tendencji w nauce i praktyce wytwarzania maszyn i urządzeń. Tematyka Konferencji skupia się wokół 6 obszarów uprawianych w Centrum Zaawansowanych Systemów Produkcyjnych:

- Obrabiarki, urządzenia i procesy wytwórcze,
- Kinematyki równoległe,
- Narzędzia projektowe CAx w zintegrowanym rozwoju produktu,
- Metody modelowania i symulacji w inżynierii produkcji,
- Automatyzacja i sterowanie w wytwarzaniu,
- Systemy wytwarzania i jakości.

Na Konferencji zostaną zaprezentowane referaty z przodujących ośrodków naukowych krajów Unii Europejskiej i Polski, a także referaty przedstawiające tematykę i wyniki badań w poszczególnych obszarach uprawianych w CAMT. Uczestnikami Konferencji są przedstawiciele zarówno uczelni wyższych jak i przemysłu. Pragniemy, aby II Konferencja CAMT stała się także forum, na którym będzie można nawiązać współpracę w ramach 6 Programu Ramowego Unii Europejskiej i to zarówno w krajowej sieci doskonałości, jak i sieciach międzynarodowych.

Jan KOCH

Centre for Advanced Manufacturing Technologies
Modern Trends in Manufacturing
20-21 February 2003, Wroclaw

Jan KOCH*

INNOVATIONS AND INNOVATION POLICY OF THE EUROPEAN UNION IN 6TH FRAMEWORK PROGRAMME

The report contains the definition and essence of innovation together with the conditions and stimuli leading to innovation. Subsequently, the role of innovation has been briefly presented as it exists in the emerging European research area. Towards the end, the experience of EU countries has been concluded.

1. THE ESSENCE OF INNOVATION

By innovation we mean the act of putting an invention to industrial or commercial use, usually for products and processes. It consists in transforming the invention into manufactured goods, eligible for sale. Similarly, innovation is used for the development and improvement of services. The notion of innovation itself exists in economic context so that one can say: "Innovation is a change that brings about profit". Innovation may also include organisational changes and infrastructure, indispensable for large-scale use of the product.

These numerous aspects of innovation are reflected in the definition designed within the OECD:

"*Scientific and technological innovation can be perceived as the conversion of a concept (thoughts, ideas, knowledge) into a new or improved product applicable for sale, an industrial or commercial process, or a new service. It is thus composed of all the scientific, technological, commercial and financial steps that are necessary for successful development and marketing of new, improved products, commercial appli-*

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cation of new or improved processes and parts of equipment, or a new approach to social services."

Each and every innovation entails a conflict between the old and the new order. Introducing innovation triggers changes that require old models and ways to be renounced, when it is not known yet whether the new solutions are likely to bring expected results. Apart from that, innovation disrupts the existing distribution of power in the company, as it weakens the position of those possessing traditional skills, at the same time enhancing the position of the ones who have mastered new skills. It is no wonder that the implementation of new ideas is always accompanied by defence behaviours.

The obstacles obstructing the path towards innovations are connected not only with human resistance, but they also stem from material resistance, for instance incompatibility of the new product and the existing company offer. Others may originate in the organisation's surrounding, e.g. in legal prohibitions or shortage of specialists.

2. CONDITIONS FAVOURABLE FOR INNOVATIONS

Planning of innovations is possible only to a very limited extent. Doubling the budget for research does not mean that the workers' creativity doubles as well. There is a huge difference between active, conscious and target-oriented development of knowledge resources and emergence of new competences through a stroke of good luck.

The process resulting in new knowledge is hugely spontaneous; nevertheless, the conditions favourable for the development of knowledge ought to be striven for.

The more favourable is the company's atmosphere for organisational learning, the greater is the likelihood that individual workers or units will contribute to the formation of new, useful knowledge resources.

How do ideas come into being, what inspires people and pushes them in the direction of creative thinking?

Everyone of us knows the feeling of revelation, being suddenly struck by an ingenious idea.

The words we use to describe those situations suggest their spontaneous character. Most probably, the reason lies in the functioning of the human brain. As a result of inner and outer, old and new data interaction within its neuron network, information sequences arise. Those sequences, interconnected, carry new meanings that lead to new ideas. This capacity for forming new ideas and solutions is referred to as creativity. It is a vital characteristic not granted to everyone, that has immense impact on budding new, useful knowledge and innovation in the company.

Thus, promoting the process of knowledge development through creating and shaping of appropriate conditions is a better way of stimulating creativity than direct control and pressure exerted on the company's staff.

Surely, no universal method of forming new ideas exists, but one should indeed consider certain conditions that seem to affect this process.

One of the most important conditions of innovativeness is to allow the workers to freely present their ideas. Good ideas are frequently smothered by corporate culture that does not allow for changes. ("Because it has always been so, we have already tried a similar solution but it did not work out.") The consequence is simple: It is much easier to discard an innovatory idea than to take the trouble of implementing it. There are companies, however, that pay attention to this problem and, firstly, protect innovations, and secondly, implement them either by their own means or means acquired from wealthy sponsors.

Another vital element favourable for innovation is „the time to think". In everyday work we are often short of time even for basic duties, and in such climate it is hard to speak of innovativeness and inventiveness. Therefore it is crucial that workers slow down at times, leave their routine activities aside and jointly consider long-term projects.

Equally important as the time to insure the physical space favourable for thinking, is to build a certain creativity sphere separated from the regular work place. In some organisations the research department's staff devote a considerable portion of their working time to the implementation of their own projects.

A factor to favour innovations is the existence of a community of interests between one's own project and the general tendency of the company. A project chosen personally by an individual is usually implemented with more commitment than the one imposed from above. It happens that such personal projects, which are no longer financed, but are still secretly continued by the workers, result in a major breakthrough. If the organisation is able to reconcile its own objectives in the field of knowledge development with those of its workers, then it ensures proper conditions for the development of their personal commitment.

The atmosphere that accompanies creativity is also affected by the manner in which the management reacts to workers' mistakes. Those corporate cultures that avoid mistakes at every cost do not favour innovation. Faltering is namely inseparable from the process of searching for a new way. If mistakes are not treated as failures, but as the price paid for the discovery of a better solution, workers will be more willing to make searches. Tolerance towards mistakes favours innovativeness, but only on condition that it is a long-term and overtly promoted practice.

The knowledge necessary for innovatory actions does not spring out of thin air. Owing to research in the field of innovativeness and creativity, we can point out to various methods of boosting such actions.

To follow is a series of statements on how to boost creativity:

- Knowledge supplied in small, easily assimilated portions boosts initiative.

- Huge action dynamism within the company's structure stimulates creativity.
- Community spirit is a source of motivation to act.
- Determining concrete aims is a condition of creativity.
- Tolerating mistakes favours creativity.
- Setting a long-term perspective gives freedom of action.
- Fair and honest discussion stimulates innovation.

3. STIMULI FOR INNOVATION

However precise is the source of the stimulus, large technical innovations are introduced and managed as components of a top-down process. It particularly applies to the cases when introducing new technology entails great risk, considerable investments and long time of the new product preparation.

The bottom-up process is characterised by a free flow of ideas from the company's personnel of all levels. In most cases, valuable ideas lead to simple, inexpensive innovations that can be implemented relatively quickly. The cumulative effect of such ideas can surely influence the company's competitiveness a great deal. The majority of such ideas require technical supervisors whose aim would be to support and develop the idea, once it has been positively evaluated.

Apart from home personnel, the major stimuli sources are:

- customers,
- competition,
- suppliers,
- research and educational institutions,
- the government.

Complaints, faulty products and application problems make an inconvenient source of stimuli. They create, however, educational possibilities, warn the company of unexpected faults in products and inspire research work.

Information on the company's main competitors, collected by home marketing but also obtained from catalogues and exhibitions, is both a source and a stimulus for innovation. Patent descriptions are equally important stimuli.

In most cases the suppliers are small companies acting on orders from large manufacturers, but their products make a source of valuable information. Inappreciable information is supplied by data on purchase structure and the directions of service activity.

Precious innovation possibilities open to the company in collaboration with a university.

This facilitates access to laboratories, libraries and periodicals. What is more, many research institutes issue bulletins, bibliography abstracts etc. Co-operation with a university also affords possibilities for training in the form of short courses or seminars.

Some government ministries can stimulate and inspire innovatory action through their own research and transfer centres.

A similar role is played by conferences and seminars organised by government agencies. Those stimuli are widely available and are not reserved due to authorial rights. The role of government as an important purchaser of numerous appliances can also be treated as an essential source of innovatory stimuli.

4. THE ROLE OF INNOVATION IN THE EUROPEAN RESEARCH REALM

The gap between research spending of the US and the EU is steadily increasing. Eight years ago the US were spending 51 billion euros more than the EU on this purpose. Till the year 2000 this difference reached 124 billion euros, which can only partly be justified by the difference in exchange rates between the euro and the dollar. A crucial reason is low contribution of European companies in the financing of research work. According to the European Committee, the 6th Framework Programme of Research, Technical Development and Presentation of the EU is to be a means to enlarging the private sector's share in the field of research.

The 6th Framework Programme aims at scientific perfection and enhancement of competitiveness and innovativeness mainly through tighter co-operation, complementarity and coordination of activities of all the parties in the research sector. 290 million euros will be devoted to the purpose of improving the relationship between research results and innovation. Further financial backing may be available from the European Investment Fund as well as from regional and social funds. It is to back up technological innovation, to make proper use of research results, to transfer knowledge and to stimulate the formation of new technological companies.

Europe has a rather poor reputation when it comes to transforming research results into commercial success, therefore the means at hand may boost company innovativeness. Moreover, close co-operation of the interested groups of companies and branches of various regions in Europe may help propagate the experience flowing from successful innovation.

In today's global market economy, innovations in regions or countries of the EU depend mainly on entrepreneurs' decisions and much less on politicians. Considerations concerning costs and risk and the decisions of individual entrepreneurs, managers and investors are decisive for innovatory action. However, politics affects innovativeness as well, as it can remove obstacles of formal or legal nature, provide encouragement and improve free flow of information. Most political activity is most effective when put forward on regional or national level by those standing very close to companies' problems.

In the 6^{th} Framework Programme, innovations have taken a new, special position. So far, the problem of innovations was contained in a special programme. Currently, innovations are an inseparable part of research projects. However, if innovations are to be a clear reinforcement to the European economy, there is a need for tighter relationships between companies and universities and other research institutions. The aim is to cause innovation to be an integral part of all potentially economic actions. The whole Programme attaches more importance to innovations, since it is they that can increase competitiveness of the European economy.

The 6^{th} Framework Programme comprises, apart from a special development programme of atomic energy, three main aspects of action:

1. Integration of European research, with seven thematic priorities and special acts;
2. Structuring the European economic area (ERA);
3. Strengthening the foundation of the European research area (ERA).

Pro-innovation activity is contained in all the three realms. A considerable part of the financial means of the 6^{th} Framework Programme will be spent on the integration of research within the European community. Practical application of the new technologies obtained within the research works is to be a fixed component of those programmes. New tools are suggested in order to make this application-aimed action take greater effect than it was in the previous programmes.

With regard to the problem of innovation, six special actions are being established:

1. To back up the connections and networks between key partners in order to incite changes in their way of acting and in culture, and especially to boost the spirit of innovative enterprise;
2. To boost regional innovation policy and regional co-operation;
3. To try out new tools in order to simulate innovatory action;
4. To expand and build innovation-supporting services such as a network of Innovation Centres, information services like Cordis; to renew intellectual property, to extend access to high-risk capital etc.;
5. To extend access to information needed for the analysis of technological and commercial development for researchers and entrepreneurs;
6. To analyse and evaluate innovatory actions in research projects of the EU and to use conclusions originating therein.

Much of these activities already began in the 5th General Outline Programme. However, a common objective of ERA has caused this action to be newly realised. The aim drawn in Lisbon to make the European economy the most dynamic and competitive in the world within 10 years may prove successful only if innovations become the main target of actions. In order to prevent fractionality of actions, that is often encountered in Europe, a new method of open co-ordination is intended, in that an exchange of experience and the use of uniform innovation measures will be headed for. These actions should encourage all member and candidate countries to improve the conditions for the existence of a large number of innovations.

The above-mentioned innovation indices deserve closer attention, as they enable fairly precise comparison between the accomplishments of particular countries or regions. Those indices, partly ushered in as early as 1997, comprise 4 main sections:

- human resources,
- knowledge creation,
- knowledge application,
- investment financing.

The human resources include the indices like:

- university graduates as the percentage of youth aged 20 - 30,
- the percentage of university degree holders as the percentage of people aged 25 - 64,
- the population's share in the so-called permanent education as the percentage of people aged 25 - 64,
- the percentage of persons employed in high- and medium-technology industries or services, in relation to all employed.

The knowledge creation consists of:

- public means' share in the financing of science as the percentage of GDP,
- industry share in the financing of science as the percentage of GDP,
- the number of patents for 1 million inhabitants.

The knowledge application comprises:

- the percentage of MMP (Material Means of Production) with inner innovation in relation to all MMP in manufacturing industry,
- the percentage of MMP with the so-called cooperative innovation in relation to all MMP in manufacturing industry,
- innovatory products as the percentage of total turnover in the manufacturing industry.

The investment financing includes:

- risk capital within all technologies as the percentage of GDP,
- capital gained by new companies on parallel markets, on most important stock exchanges as the percentage of GDP,
- new market products as the percentage of manufacturing companies' turnover,
- private Internet access as the percentage of all households,
- value-added share in high technology manufacturing companies.

Through regular publishing of the values of those indices for EU and candidate countries, it will be possible not only to compare actions in the sphere of innovation, but also to make use of the experience of those most successful countries and regions.

5. CONCLUSIONS STEMMING FROM THE EXPERIENCE OF EU COUNTRIES

First of all – innovation is an increasingly important element of today's knowledge-based, globalising society.

Competitiveness depends more and more on whether, thanks to new technologies, we manage to direct the manufacturing and service sector towards market needs. The ability to appropriate knowledge in order to increase productivity and create new products depends on the one hand on the spirit of inventiveness and on the other on the spirit of enterprise. Those are for their part decisively affected by the conditions that boost and develop creativity and investment, or break and delimit their development. Companies based on new technologies ascribe their success more to strengths of their human resources than to factors such as the purchase of technology or the ability to attract capital. It is claimed that in the 21st century innovations will be the driving force behind enterprise policy. It is, however, dependent on other actions, such as education, legal solutions and fiscal policy.

Second of all – innovations are omnipresent and manifold.

Innovation has its place in every company, regardless of its size, location or domain. Innovation does not apply exclusively to the so-called high-tech sectors such as biotechnology or information techniques. Those two sectors mentioned above are the important drive of European innovation economy, even though today their participation in the EU educational-innovation policy is relatively scanty. The innovation policy that would regard only those two sectors would run a risk of underestimating the so-called traditional branches or sectors that currently decide about economic strength of EU countries. New knowledge is not created solely through research, but also as a result of investments in manufacturing equipment, machines and the development of human resources. Even in the high-tech sector of electric and electronic equipment research and development expenses amount only to 27 % of the total innovation costs.

Third of all – innovation is omnipresent, but unevenly distributed.

In EU countries innovations are mostly concentrated in larger corporations. Nevertheless, the number of small and medium-size companies (SMC) that build their activity on new technologies is constantly growing. Many of them contribute a lot to technological progress, are placed high on international markets and indicate rapid growth. Despite those positive instances, it is thought that innovation capabilities of most SMCs are still very poor. SMCs are usually short of inner power (capital, people) as well as outer power (domestic and international network connections), and these are a necessary condition for securing access to knowledge, technology and finance that innovation is dependent on.

Forth of all – innovation is a constant and systematic process.

Innovation processes do not have a linear nature, they are multidimensional and their course is not isolated from other activities. Innovations may have a longer time span, involving various participants. Technological transfer from e.g. a research unit to a corporation may trigger successful innovation, but it hardly ever happens in isolation. The pace and success of technology transfer depends almost always on other types of interaction taking place before, in the course of or after transfer. Thus innovation requires the development of overlapping systems acting in a longer time span. Such systems must ensure smooth flow of information between huge corporations, investors, advisors of all sorts, patent representatives, local authorities and other parties. Such systems rely mainly on personal contacts, though. Companies based on new technologies ascribe their success more to strengths of their human resources than to factors such as the purchase of technology or the ability to attract capital.

Fifth of all – in most innovatory systems the key word is proximity.

Politicians should consequently display projects directed at creating local and regional innovation teams. They can be e.g. technology parks in the vicinity of universities. Vertical connections are essential here as well, such as the ones between business advocates, banks, high risk capital or stock market. Finally, also interregional and international contacts make an important link in the exchange of knowledge, people or effective practices. This approach is favoured by e.g. such actions on the part of the EU as transfer strategies of technology, innovation and infrastructure (RITTS projects) and the network of innovation centres (IRC).

Innovations are thus a source of new, improved products, services and processes. They can create new sale markets and new economic and social action areas. The public authorities play a key role here, as they must provide conditions in which the economic and social benefits of innovations can be utilised entirely.

INNOWACJE I POLITYKA INNOWANYJNA UNII EUROPEJSKIEJ W 6 PROGRAMIE RAMOWYM

W referacie przytoczono definicję oraz omówiono istotę innowacji a także warunki i bodźce powstawania innowacji. Następnie przedstawiono zwięźle rolę innowacji w tworzącej się europejskiej przestrzeni badawczej. W końcowej części sformułowano wnioski płynące z doświadczeń krajów Unii Europejskiej.

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design of experiments, quality,
optimization, response surface methodology

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METHODS OF IMPROVING QUALITY PRODUCT AND PROCESS USING EXPERIMENTAL TECHNIQUES

This paper presents an experimental approach to optimization of technological process. The performed researches were based on designed experiments such as: the 2^{n-p} fractional and composite design as well as the method of steepest descent. There were five independent and one response variable involved in optimization process. Results of the particularly experimental stages were discussed. An attention was paid to practical aspects of research.

1. INTRODUCTION

In articles and works concerning quality, there is a lot place devoted to methods of DOE (design of experiments) [1, 2, 3, 4]. These procedures are mainly used at the beginning stages of product or technological process development. Usually, there are many factors that can affect on the process quality. The role of quality engineers is to settle which factors are important to process improvement and which ones can be neglected. But without any prior knowledge, it is hard to determine the importance of the particularly factors. In such cases only one way to get the information about the process is to take an advantage of experimental techniques. If an initial problem will be settled – another one occurs. Although, one can choose the proper set of factors that are critical from the quality point of view, one cannot say anything about the optimal conditions of the process it ought to be run. In this case another technique of DOE should be applied to search for conditions in which quality of product will be considered as satisfactory.

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This paper discusses the Response Surface Methodology (RSM) that deals with the problems described above. As an example the results of injection molding process optimization are considered.

2. THE RESPONSE SURFACE METHODOLOGY

The Response surface methodology (RSM) [1, 3, 5] is a collection of statistical and mathematical techniques useful for developing, improving, and optimization of processes. Most applications of response surface methodology are sequential in nature. This is, at first some ideas are generated concerning which factors or variables are likely to be important in the response surface study. This usually leads to an experiment designed to investigate these factors. This type of experiment is usually called as screening experiment or phase zero of a response surface study.

Once the important independent variables are identified, phase one of the response surface begins. In this phase, the experimenter's objective is to determine if the current levels or setting of the independent variables result in a value of the response that is near the optimum. If the current setting or levels of the independent variables are not consistent with the optimum performance an additional action has to be taken in order to move the process toward the optimum. During this phase of RSM the method of steepest descent can be applied. This optimization technique makes considerable use of the two-factorial experimental design to get first order polynomial that determinate the tendency of changes in a function response.

If the process is near the optimum - phase two of response surface method is made. In this stage, the main aim of researcher is to get more elaborate model of process. The region of experimentation around the optimum's vicinity must be relative smaller in order to approximate the true response function. Since the experimental procedure reached the optimum, the effect of curvature is expected. In most cases, the second-order polynomial is an appropriate approximation of the function response. Once the accuracy model has been obtained, it is possible to estimate the optimum condition for the process.

Table 1. Ranges of independent variables

Independent variables	Alias	Acceptable range		Units
		Min	Max	
Mould temperature	T_f	26	64	^oC
Injection temperature	T_t	240	265	^oC
Injection time	t_w	1,25	1,75	s
Cooling time	t_{ch}	36	60	s
Holding pressure	p_d	8	12	MPa