THE CREATIVE DESIGN OF BORING TOOLS

Gina-Maria MORARU[1] and Paul Dan BRÎNDAŞU[1]

ABSTRACT: The aim of this paper is to present a modern method for creative design of the boring tools, particularly, and of the cutting tools, generally. After studying the ways in which different disciplines use the virtual platforms, we proposed two major directions to be followed in the design of the cutting tools. The first direction consists in adding a database to the platform. Professional users can develop the database, this becoming increasingly wider as time passes by. The second direction is to stimulate design in multicultural teams, taking advantage of the experiences of all the members of the team. We consider that both of these directions increase the use of human creativity in the designing process.

KEY WORDS: creative, design, boring, tool.

1 TRENDS IN THE DESIGN OF TECHNOLOGICAL EQUIPMENTS

In many domains, customers participate to the new product development (Fang, Palmatier & Evans, 2008). Moreover, a viable business is one that payes attention to the consumer education, experiences, and to the feedback sites (Prahalad & Ramaswamy, 2002).

In order to improve the design of cutting tools, we firstly must remember the most important trends registered in the design of technological equipments. These equipments are intended for the industrial market. Usually, the industrial customers are stronger than individual customers, from economic, social, cultural, and legislative perspective, too. Therefore, they form an important group (but not the only one) for outsourcing the design of technological equipments.

There is a single step from outsourcing to crowdsourcing. The crowd-based outsourcing is often a broad-based competition, launched by a producer in order to find solutions to his problems. Crowdsourcing, often used in graphic design, is one option for designing on a platform. The new ideas are obtained from an online community, which includes more specialists than the employees and suppliers. Companies in the automotive industry, like Mercedes Benz, Audi or Toyota are versed in crowdsourcing (www.crowdsourcing.org/, 2014). We appreciate that this method can be used by the producers of cutting tools, too. Another trend in the cutting tools industry is the specialized tool, part of an intelligent manufacturing system. This type of tool is very efficient for mass production.

We must to remember the steps made in the last years in the optimization of cutting tools by increasing the quality of the processed surfaces, the edges strength, or by reducing the vibrations in the process. For example, Sandvik Coromant offers the “Silent Tool” for boring, with a low level of vibrations and noises (Sandvik Coromant, 2014) and other specialists (Mei & others, 2009) suggest the use of the Magnetorheological fluid-controlled boring bars with the same purpose.

So, we consider that it is necessary to analyze in detail the aspects that lead to the quality and competitiveness of the tool.

2 COMPETITIVENESS REQUIREMENTS FOR THE BORING TOOLS

The competitiveness of a cutting tool depends on its functions and on its quality level.

The manufacturer of a cutting tool offers several models of it. The use value of the tool model *“i”* is the level N_i of the tool quality. This level consists of the whole assortment of features that give it the ability to meet specific needs.

The total quality level of the tool model *“i”* can be calculated in two ways (Popa, 2003):

$$N_i = N_{t,i} + N_{se,i} \quad (1)$$

$$N_i = N_{g,i} + N_{e,i} \quad (2)$$

In the first relation (1), the total quality level is the sum of the technical quality level $N_{t,i}$ and the social-economic quality level $N_{se,i}$. $N_{t,i}$ expresses all the technical characteristics of this tool. Similar, $N_{se,i}$ is the sum of economical, aesthetical and social quality characteristics.

[1] “Lucian Blaga” University from Sibiu, 10, Victoriei Bd, Sibiu, 550024, România

E-mail: gina.moraru@ulbsibiu.ro; dan.brindasu@ulbsibiu.ro

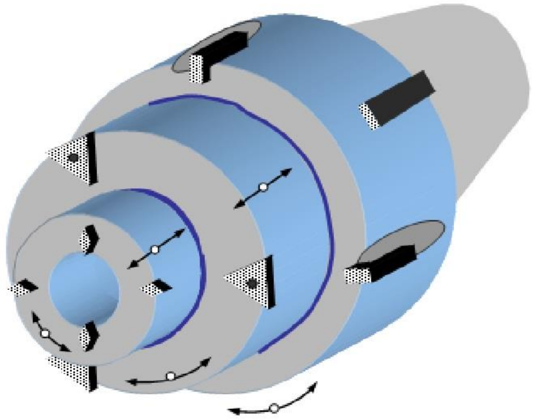

Figure 1. Boring head model *"i"* with *z* tangential and radial inserts

In the second relation (2), the total quality level is the sum of the global quality $N_{g,i}$ and economic quality level $N_{e,i}$ of the tool. The global quality level of the tool $N_{g,i}$ corresponds to its global function F_{gi} and includes the quality characteristics regarding to:

- The availability of the cutting tool;
- The identity of the tool model *"i"*;
- The functional conection with external environmemts;
- The ability to protect the natural environment;
- The ergonomics;
- The aesthetics of the tool;
- Some socio-cultural effects generated by using the tool.

The competitiveness of the tool is usually calculated by relation:

$$K_i = \frac{N_{g,i}(F_{gi})}{N_{e,i}} \rightarrow \max \qquad (3)$$

respectively

$$K_i = \frac{N_{g,i}(F_{gi})}{P_i} \rightarrow \max \qquad (4)$$

P_i is the tool price. Relations (3) and (4) are used for serial and mass production. For unique products, the reports overturn (Popa, 2003).

The global function F_{gi} of the model *"i"* expresses what the tool does or can do. More exactly, it highlights the transformation of inputs into outputs required by the user. Take the example of the telescopic boring tool with radial and tangential inserts from Figure 1. The dimensions of the tool are adjustable axial and radial, too.

The global, function of this tool consists of the following elements:

$$F_{gi} = \sum_j F_{\text{int},ij} + \sum_{k=1}^{t} F_{pik} = = \sum_j F_{\text{int},ij} + \sum_{k=1}^{u} F_{fik} + \sum_{k=1}^{v} F_{cik} \qquad (4)$$

in which:

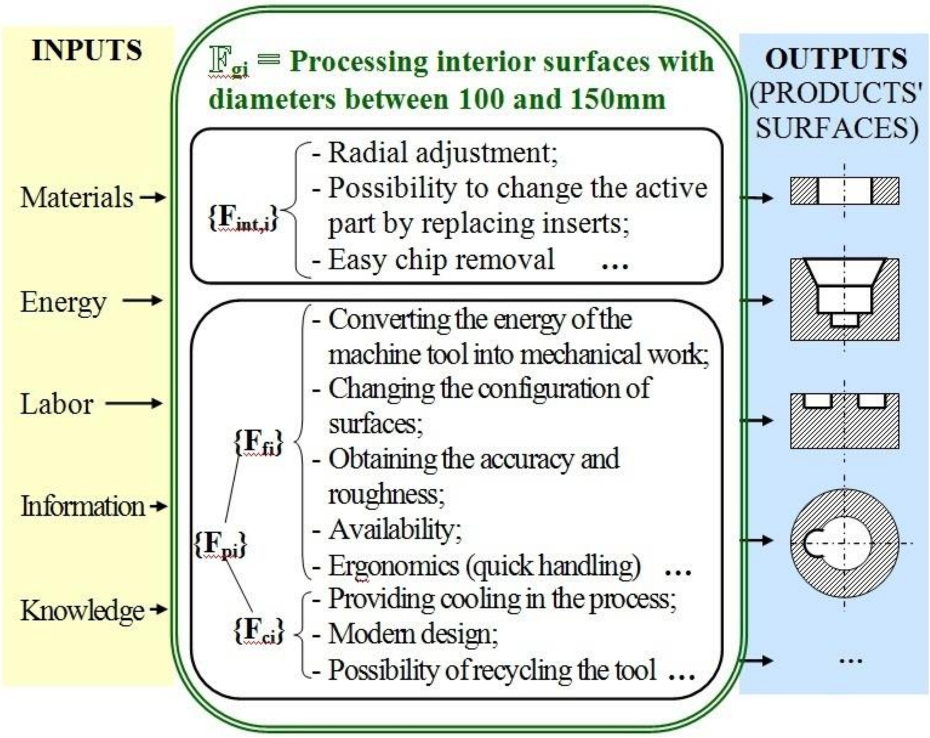

Figure 2. The global function of the boring head model *"i"*

- $F_{int,i}$ are all the intermediate functions of the tool model *"i"*;
- F_{pi} are the performance functions of the tool model *"i"*, in number of t ;
- F_{fi} are the final functions of the tool, in number of u ;
- F_{ci} are the complementary functions of the tool, in number of v ;
- The relation between parameters u, v, and t is:

$$u + v = t \quad (2)$$

To understand the difference between the intermediate, final, and complementary functions of a cutting tool, please see Figure 2. The components of the global function of the boring head model *"i"* with *z* tangential and radial inserts presented in Figure 1 are detailed there.

3 CREATIVE DESIGN OF CUTTING TOOLS USING PLATFORMS

3.1 Using a database in creative design

James Reid and Filippo Gilardi have conducted several Transmedia teaching and learning projects in different countries (Reid & Gilardi, 2013). Working on the Moodle site, they used, in one from their projects, a learning tool called "*Memrise*". The teacher can offer courses between this tool. The users (students) can create their own flashcards, in order to achieve and review new knowledge (www.memrise.com/, 2014).

We want to propose a similar tool – a program – to encourage the creative design on the platform. Engineers, students from technical faculties and industrial customers can be all designers. We called this tool "*Add-create*", because everyone can show her/his creativity and add new parts of a cutting tool in a large database.

When a user starts the design, *Add-create* can offer multiple choices for combining different constructions of the active part, body and holding part of the new tool. The user can accept a construction, but can also improve it with new ideas that will broaden the database (fig. 3).

Of course, the program "*Add-create*" can offer the reasons for one or for another variant of tool construction. For example, there are several reasons why boring tools equipped with interchangeable inserts should be used in the machine building industry, and these are the following:

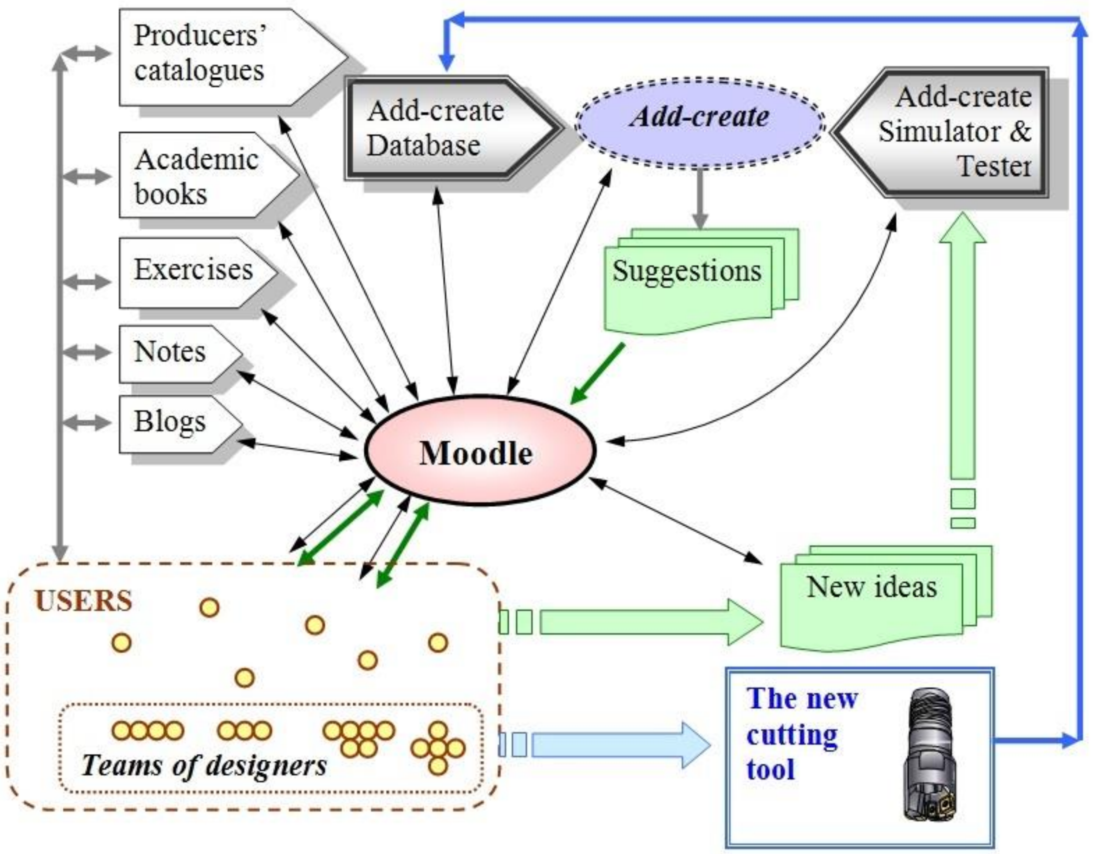

Figure 3. The design of cutting tools on Moodle using *Add-create*

- A high degree of safety in working conditions;
- Good quality and precision of the surfaces processed using these tools;
- A quick and effortless changing of the inserts, slashing auxiliary times;
- A more convenient load of the inserts;
- Saving time and materials;
- A more even distribution of the cutting forces.

Based on these considerations, *Add-create* can offer more variants for the tool design. Of course, these suggestions will include recommendations for the use of the tool. The program *Add-create* must include a virtual *Simulator and Tester* for the users' new ideas (fig. 3). Once validated, the new ideas become projects for new products. Then, the prototype can be built and tested in reality.

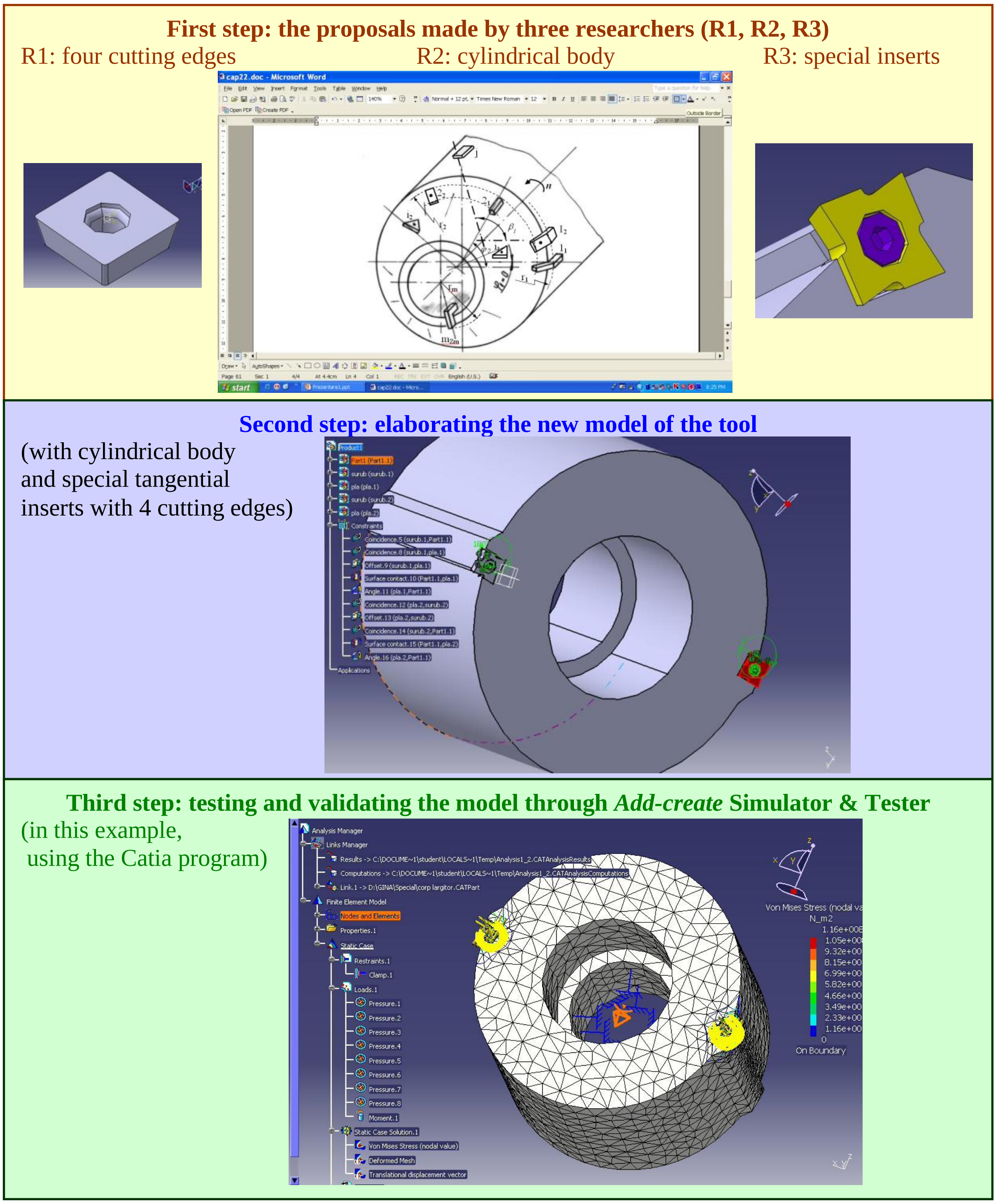

Figure 4. An example for team-design, using a platform and *Add-create*

3.2 Design in multicultural teams

On the other hand, we want to encourage the design in multicultural teams on the platform, taking advantage of the experiences of all team members (Fig. 4). One of the most important advantages of the team-designing is the use of the various knowledge and professional experiences of the participants. Another advantage is the synergic effect of combining their individual creativity in a collective creativity. These factors can lead to unexpected solutions of boring tools, similar to that of Figure 4, which reduce the costs of the boring process.

4 THE CREATIVE OPTIMIZATION OF BORING TOOLS

In order to optimize a cutting tool, we must first regard it as a system. Therefore, a boring tool and the boring process of a piece with this tool will consist of (Fig. 5):

- Inputs (energy, materials, informaitions, dates, knowledges, creativity and others);
- The boring tool design and processing;
- Control factors (technical, organizatoric and human factors);
- Disruptive factors – usually called noises (physic and chemical defects, mechanic or electronic defects or errors at the technological equipment etc.);
- Outputs (dimensions, precision, cutting speed and others characteristics).

The optimization process on Moodle (fig. 5) is open, allowing some new inputs and some new control factors, since the objective function follows the needs of the users. Its main advantage lies in the fact that it allows the designer, respectively the user of a boring tool, to choose between:

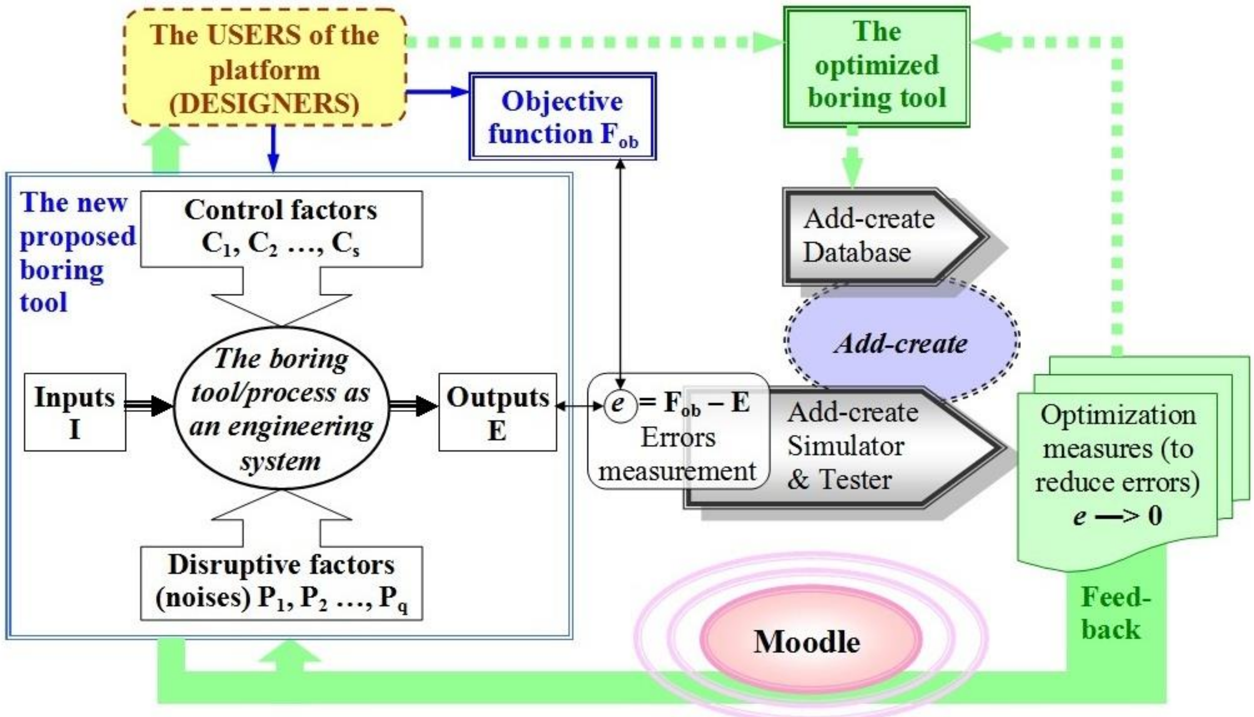

Figure 5. The optimization process of the boring head using *Add-create Simulator & Tester*

- the best methods, techniques and comparing procedures between actual and ideal characteristics, based on a special instrument, the *Add-create Simulator & Tester*;
- the most effective tool quality optimization measures, the most suitable corrective measures towards diminishing perturbing factors, the most effective adaptation of control factors and ensuring the input elements needed during the conception and design of the boring tool;
- increasingly competitive objective function, embedding the most recent requirements, demanded by the client or the technical and economical progress;
- a very efficient use of the designers' knowledges and creativity.

5 CONCLUDING REMARKS

The aim of this paper is to present a modern method for creative design of the boring tools, particularly, and of the cutting tools, generally.

After studying the ways in which different disciplines use the virtual platforms, we proposed two major directions to be followed in the design of the cutting tools.

The first direction consists in adding a database to the platform. Professional users can develop the database, this becoming increasingly wider as time passes by and stimulating the visitors' creativity.

The second direction is to stimulate design in multicultural teams, taking advantage of the experiences of all the members of the team. We consider that both of these directions increase the use of the human creativity in the designing process.

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8 NOTATION

The following symbols are used in this paper:

N_i = the total quality level of the tool model *"i"*;

$N_{t,i}$ = the technical quality level of the cutting tool model *"i"*;

$N_{se,i}$ = the social-economic quality level of the cutting tool model *"i"*;

$N_{g,i}$ = the global quality level of the cutting tool model *"i"*;

$N_{e,i}$ = the economic quality level of the cutting tool model *"i"*;

K_i = the competitiveness of the tool model *"i"*;

P_i = the price of the tool model *"i"*;

F_{gi} = global function of the cutting tool model *"i"*;

$F_{int,i}$ = the intermediate functions of the tool model *"i"*;

F_{pi} = the performance functions of the tool *"i"*;

F_{fi} = the final functions of the tool *"i"*;

F_{ci} = the complementary functions of the tool model *"i"*;

F_{ob} = the objective function of the tool model *"i"*, which can be the global function F_{gi} or some components of it, with the desired value/values.