Proceedings in MANUFACTURING SYSTEMS
Proceedings in Manufacturing Systems, Vol. 5 (2010), No. 3 ISSN 2067-9238

ASPECTS REGARDING PRODUCT LIFECYCLE MANAGEMENT OF CUTTING TOOLS

Gabriel Vasile ONIȚĂ[1], Paul Dan BRÎNDAȘU[2], Livia Dana BEJU[3]

Abstract: *In this paper we present the concept of product lifecycle management (PLM) with its main stages presented in a sequential workflow. We propose a model for analyzing functional requirements of cutting tools, applied for helical drills and selecting the optimum variant for their design based on network design and QFD method. The rest of PLM stages such as modeling, simulation, optimization, designing manufacturing process, manufacturing preparation, production, delivery, use, disposal and recycling are presented suggesting the important role that an integrated design software has upon the entire lifecycle of the product.*

Key words: *lifecycle, PLM, helical drill, function, needs, QFD analysis.*

1. INTRODUCTION

Product Lifecycle Management (PLM) is a very broad concept with implications on the entire life cycle of products. It is a long term vision of development directions of the organization in product development activities [1].

Also, the concept can be defined as a coherent set of solutions that support the creation, management, dissemination and use of product information, an approach that allows integration of all product information, its production processes and all production resources necessary for the product to be created.

At the base of the PLM concept is the integration of data and process models through a database (CAX models, documents, etc.).

By applying PLM in the field of cutting tools, we reduce of time between determining the need for the product and the appearance of that product on the market. Beside this, we also obtain reduced costs involved in the production, improved flow of information and a detailed record of the use and impact of product on the environment [2].

PLM is a general concept first appeared in the aircraft and automotive industry. Due to the positive effects that it had, it was implemented in all other industries. Cutting tools have an important role due to their worldwide spread in material processing and thus they need to be improved regularly, which requires a detailed analysis of their whole life cycle.

In this paper we propose to establish in broad terms the life cycle of cutting tools, exemplifying it on helical drills and a detailed analysis of their functional characteristics based on network design and use of QFD (Quality function deployment) software.

[1] Eng., PhD. Student, *E-mail: gabriel.onita@ulbsibiu.ro*
[2] PhD, Professor, *E-mail: dan.brindasu@ulbsibiu.ro*
[3] PhD, Professor, *E-mail: livia.beju@ulbsibiu.ro*
University "Lucian Blaga" from Sibiu, Faculty of Engineering, Machine and Manufacturing Systems Department, Emil Cioran street, No.4, Sibiu, Romania, Tel/Fax: 0269217928/ 0269212716

2. PRESENTING THE LIFE CYCLE OF CUTTING TOOLS

2.1. Steps in PLM

PLM requires a sequence of steps which are presented in Fig. 1.

Although at first glance this concept seems relatively simple, it is in reality much more complex. At its basis are the entire staff and departments, whose tasks can not be achieved in isolation but in a total interdependence [3]. PLM can be applied in all three stages of manufacturing process as we can see in Fig. 2.

Integrated Engineering is based on the support of the organization and it is very much facilitated by each member who must be aware of the role it has in the entire process.

Production planning activity consists in a sequence of stages presented in Fig. 3.

To illustrate this system better, we present the life cycle model of helical drills, emphasizing the stage of functional analysis of the product.

Fig. 1. Product lifecycle management.

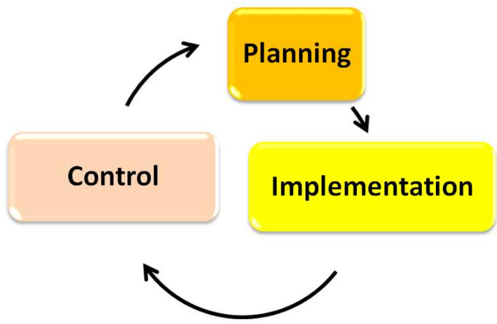

Fig. 2. Manufacturing process stages.

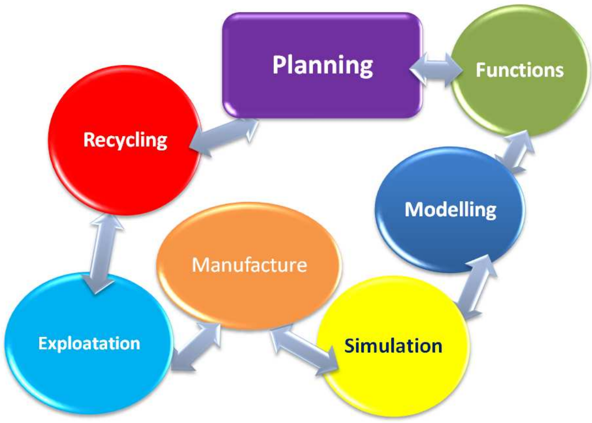

Fig. 3. Production planning stages.

2.2. Defining needs

Assuming that there are two types of orders − drills for general use and special drills − we made a detailed analysis of how implementation of functions can be realized with general use drills. In the other case the client specify its needs and the function analysis is completely based on its requirements and not on a detailed study of the market.

The interaction mode between all the participants in the process of networking is presented in Figs. 4 and 5.

The market study is done based on carefully made surveys so that the design team draws customers needs. N_i needs arise, as we can see in relation (1):

$$N_i = \begin{bmatrix} N_1 \\ N_2 \\ \dots \\ \dots \\ N_n \end{bmatrix}, i = (\overline{1,n}) \rightarrow N_i = \begin{bmatrix} \textit{part dimensions} \\ \textit{tool precision} \\ \textit{type of clamping} \\ \textit{material processed} \\ \textit{surface quality} \\ \textit{productivity} \\ \dots \end{bmatrix} \tag{1}$$

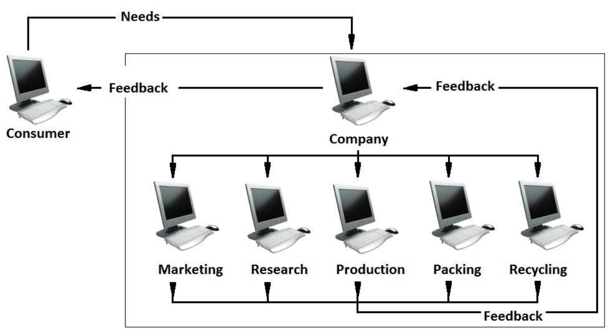

Fig. 4. Networking for special drills.

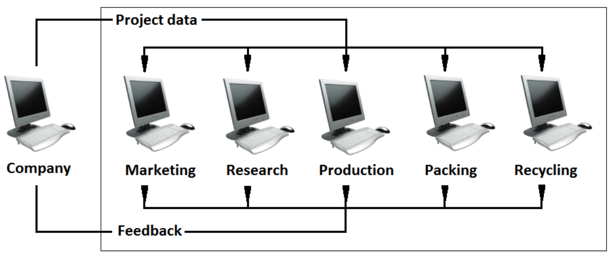

Fig. 5. Networking for general use drills.

From these needs, based on networking, team validates the most important of them and they are filled in the appropriate table fields of the QFD software.

2.3. Determining drills functions

These needs must be satisfied by functions that the product must fulfil. These functions are F_j, shown in relation (2).

$$F_j = \begin{bmatrix} F_1 \\ F_2 \\ \dots \\ \dots \\ F_m \end{bmatrix}, j = (\overline{1,m}) \rightarrow F_j = \begin{bmatrix} \textit{to cut} \\ \textit{remove chips} \\ \textit{appropriate holding} \\ \textit{durability} \\ \dots \end{bmatrix} \tag{2}$$

Because these functions can be implemented in a certain way by different technical features, teams must find these options and determine the importance that they have in the function. These features are C_k, presented in relation (3).

$$C_k = \begin{bmatrix} C_1 \\ C_2 \\ \dots \\ \dots \\ C_p \end{bmatrix}, k = (\overline{1,p}) \rightarrow C_k = \begin{bmatrix} \textit{geometry and dimensions} \\ \textit{tool material} \\ \textit{covering} \\ \textit{thermal treatment} \\ \textit{precision} \\ \textit{surface quality} \\ \textit{spigots for chip removal} \\ \textit{lubrication system} \\ \textit{tool guiding} \\ \textit{tool stiffness} \\ \dots \end{bmatrix} \tag{3}$$

For a better understanding of this analysis we use the case of helical drills.

F_1 = *to cut* is influenced by: geometry and precision, tool material, covering, thermal treatment, channels for chip removal, lubrication system, tool guiding.

F_2 = *remove chips* is influenced by: geometry and dimensions, surface quality, channels for chip removal, lubrication system.

F_3 = *appropriate holding* is influenced by: geometry and dimensions, tool material, surface quality, tool stiffness.

F_4 = *durability* is influenced by: tool material, covering, thermal treatment, surface quality, geometry and precision, lubrication system, etc.

For a general view we present these influences in Fig. 6, in which we can see how technical features determine certain functions which concur in designing of a product.

The cost of these technical features directly influences the cost of implementing that function. Based on the work done in the company's internal network, the team determines the costs of each feature and by summing them gets the final cost of implementing that function. Values obtained are written in the table. The team performs an analysis of the interdependence between the needs and functions (Fig. 7) and between functions and technical features of the drill (Fig. 8).

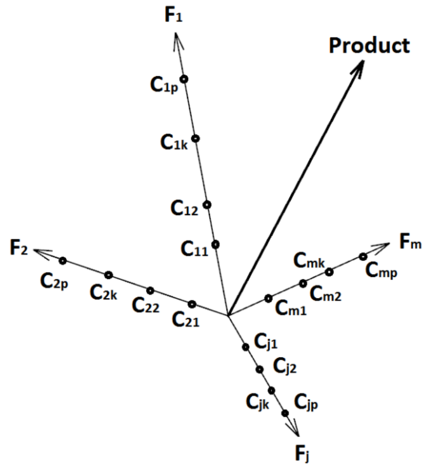

Fig. 6. Functions influences on a product.

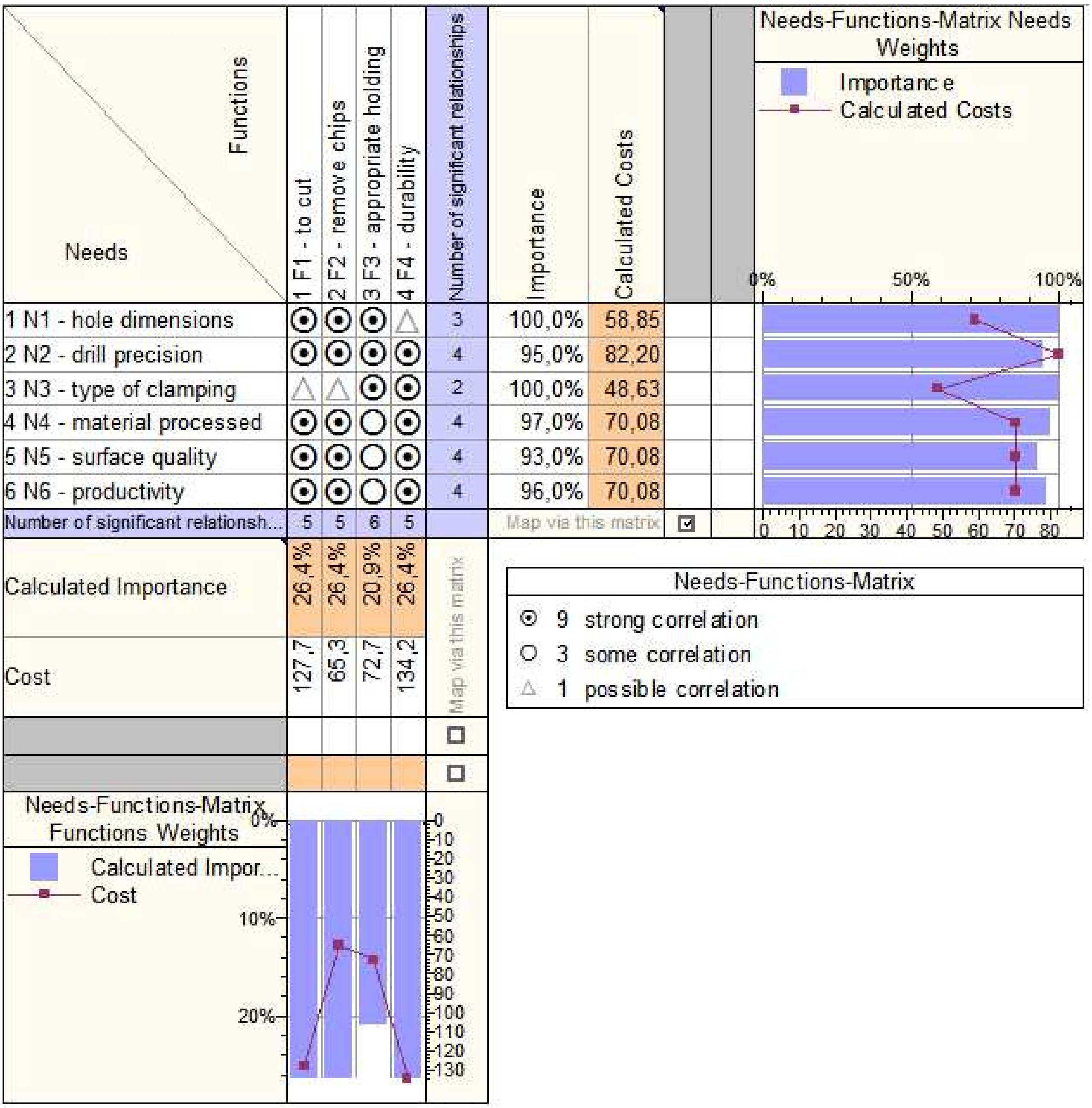

Fig. 7. Functions – Needs analysis.

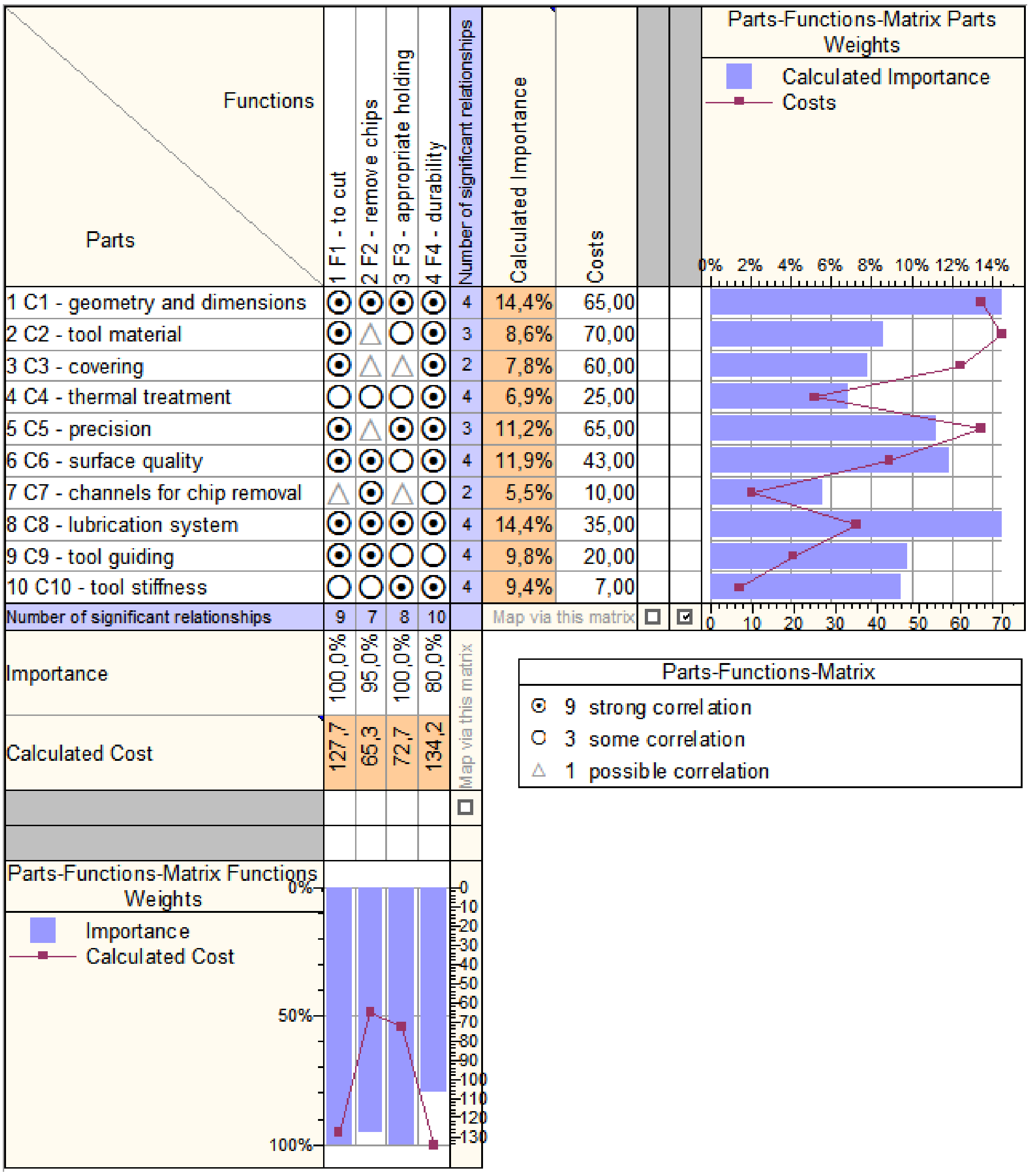

Fig. 8. Functions − Technical features analysis.

Figs. 7 and 8 are given as an example of how work can be simplified using a QFD software. Values written in tables are obtained after careful examination of the team.

Creative design is made based on these features resulting in a number of models which are then ranked using technical and economic conditions in the manufacturing process, use and recycle (ex. Morphological matrix [4]). Following the search phase of ideas and possible variants, the team will find a number of conceptual solutions. Previously obtained conceptual solutions will be combined to create a unitary concept.

To achieve this it is necessary to select the optimal variant so the designers can focus their energy and attention on a feasible safe option.

The logic diagram whose description was made above is found in Fig. 9.

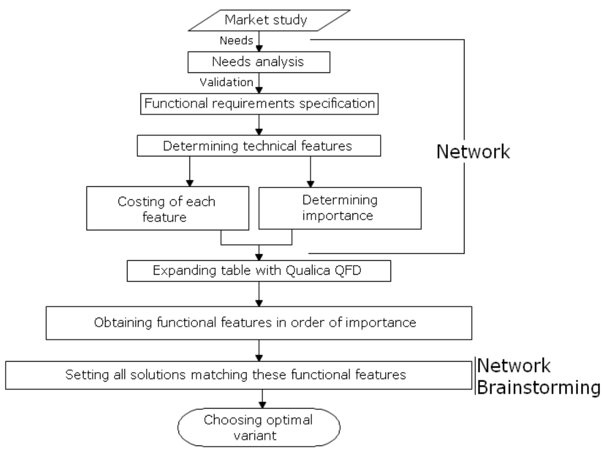

Fig. 9. Process diagram.

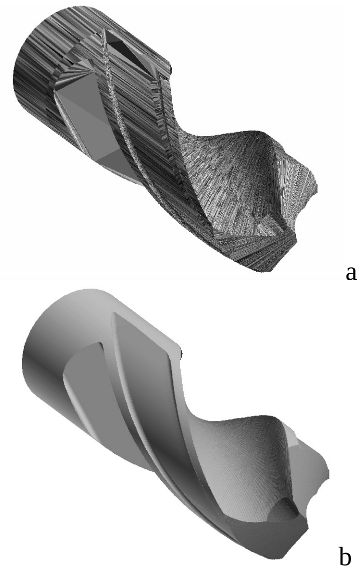

Fig. 10. Triangulated model of helical drills [5].

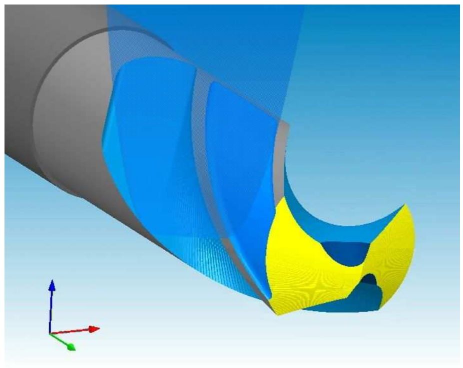

Fig. 11. Helical channels generation using SolidPRO software of System V [5].

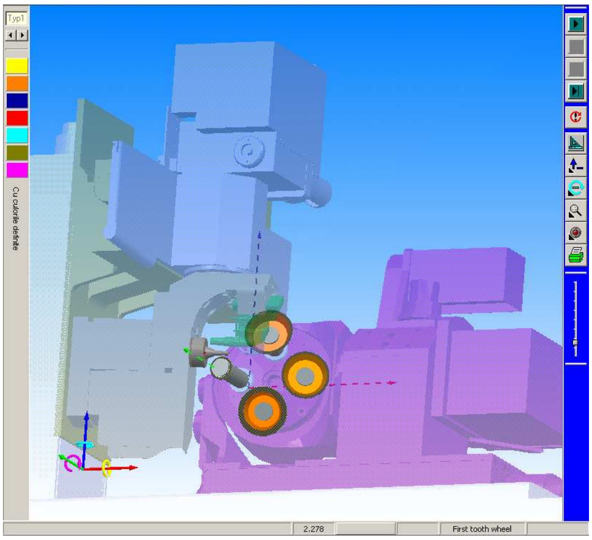

Fig. 12. Machine tool - complete assembly simulation [5].

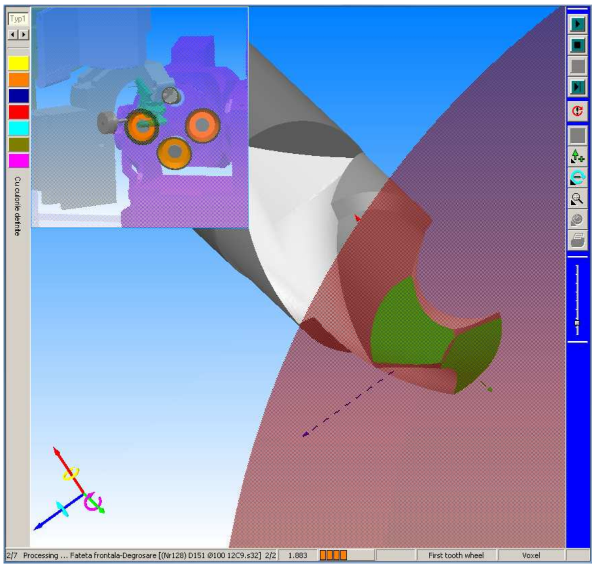

Fig. 13. Virtual surface generation using SolidPRO software of System V [5].

2.4. Modelling, simulation, optimization

Drill modelling involves the detailed modelling of its shape, dimensional design, cutting geometry determination, establishment of dimensions and types of clamping systems, etc. Modelling, as shown in figure 10, can be done in various software. For exemplification we use SolidPRO software of System V [5].

Following this modelling, the design team can perform a finite element analysis of the digital model. This analysis is necessary to identify whether or not the drill resists operating conditions and can be useful to make some improvements to this end. They perform a simulation to avoid overlaps or clashes during surface generation. Also the entire manufacturing process is virtually simulated (Figs. 11, 12 and 13).

2.5. Designing manufacturing process

Starting the production requires previously obtained product file and production specifications, which include production schedule (production volume, manufacturing time, production rate, maximum manufacturing cost) and the means of production (machinery, equipment, measuring and control devices and human resources available).

The study of various phases in process development reveals two types of activities:

- creative activities: selection procedures, technological solutions, structuring and ordering the production process;
- routine activities: cutting regimes, determining the time, preparing documentation for launching and tracking performance.

2.6. Manufacturing preparation

Sintered pre-finished cutting tools manufacturers, such as Gühring, Sandvik, realize these pre-finished products with helical channels for lubrication thus saving material and money in subsequent processing. These drills will undergo only corrections and sharpening of the cutting edges, resulting in significant reduction of production time and also a lower end price.

Here takes place the purchase of all raw and auxiliary materials, tools, devices, measuring and control devices required in the manufacturing process.

It is a significant economic activity in which the acquisition costs, delivery times, size of lots ordered, inventory management, collaboration with suppliers, are crucial elements for economic efficiency and continuity of the manufacturing process.

2.7. Production

Production consists in corrections of the pre-finished surfaces of carbide drills using grinding wheels. These discs are mounted in packages, so by using a single package we obtain a finished product. To ensure the mechanical characteristics during use, it is necessary to apply a coating.

Having the finished product, the next step is tagging and its packaging.

2.8. Delivery

Delivery of the product is preceded by specific preparation activities in order to withstand any shocks during transport, protecting against environmental factors, etc.

2.9. Use

The product is supplied to the user, whose expectations must be met during use. The client will use the product by following its instructions. During use, the product is subjected to maintenance operations. The existence of a consistent database for all cutting tools, relative to a period of time, which documented all interventions, regular maintenance or accidents, brings a significant contribute to an effective maintenance.

Reconditioning is performed on drills in order to restore their cutting capacity. Steps taken are presented in Fig. 14.

2.10. Disposal and recycling

Used product is withdrawn at the end of its life. Wasted drills that can no longer be refurbished are grouped by type of material in order for them to be sent back to the tool factories. Here they are grinded and the powder obtained is sorted and sintered, minimizing waste and reducing the environmental impact.

3. CONCLUSIONS

The present paper has proposed conducting an analysis that will lead to a hierarchy of needs and functions that effectively enable the design and implementation of a helical drill in terms of price performance ratio. Because there is a small number of functions that a drill must fulfil we need to take the analysis at a deeper level, considering the technical features which influence these functions in various proportions. Using

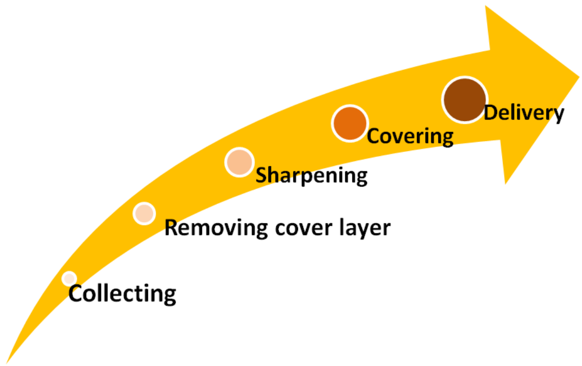

Fig. 14. Helical drills reconditioning.

QFD software is very useful because the analysis is much easier.

The previously presented sequence of steps in terms of PLM concept help us to make a comparative analysis between this method and classic design of drills.

We can draw several conclusions:

1. Time to launch the product is significantly reduced compared to classic design of drills because of virtual modelling and simulation of the entire process.

2. We have an overview about the entire life cycle, highlighting the factors that influence it and we can make improvements more effectively.

3. Environmental impact is significantly reduced by implementing since the concept stage of the criteria based on environmental protection.

4. It makes a superior meeting of customer requirements through the active role that he has in the cycle.

5. The company manifests enhanced competitiveness on the market and produces superior quality products.

REFERENCES

[1] K. Munenori, Y. Tetsuo, W. Ichie, *PLM education in production design and engineering by e-Learning*,International Journal of Production Economics, Vol.122, Issue 1, November 2009, pp. 479−484.

[2] P.D. Brîndaşu, L. Beju, *E-learning regarding knowledge and projects for the cutting tool*, 4th Balkan Region Conference on Engineering Education, pp. 33−38, Sibiu, Romania, 12−14 July, 2007, ISSN 1843-6730.

[3] S. Gunther, R. Henrique, A. Dirk, Z. Eduardo, *Process orientated framework to support PLM implementation*. Computers in industry, Vol. 59, Issue 2−3, March, 2008, pp. 210−218.

[4] S. Borza, P.D. Brîndaşu, L. Beju, *E-research centre and E-creative design − New trends for E-activities platform*, Transactions Journal on computers, Vol. 7, Issue 4, April 2008, ISSN:1109-2750, pp. 273−280.

[5] C. Muţiu, P.D. Brîndaşu, L. Beju, *Mathematical model for determination of the abrasive wheel profile for helical drills manufacturing*, Proceedings of the 10th WSEAS International conference on mathematical and computational methods in science and engineering, Bucharest, November 2008, ISI web of Knowledge, pp. 194−199.