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REVERSE ENGINEERING FOR DRILLS RECONDITIONING DEVICE

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Abstract: *The reverse engineering is considered as a discovery process and, at the same time, a creative process. Essentially, the reverse engineering supposes the detailed analysis of an existing equipment, in order to subsequently develop another new or improved equipment. The reverse engineering could be applied both in information technology and in the design of the mechanical equipments. Along the time, the researchers highlighted the conditions in which the reverse engineering could be applied. Taking into consideration the existence of a device for grinding valves, the problem of design a device for sharpening small diameter drills was formulated. Initially, certain machining schemas valid in the case of sharpening drills were examined. Some of the principles specific to the reverse engineering were discussed and applied in the case of the device for sharpening small diameter drills. Graphical representations were elaborated, in order to highlight the characteristics of applying reverse engineering. In this way, some solutions for changing the structure of the initial device were identified and a device able to ensure the conditions for sharpening small diameter drills was designed. The solving of the problem was possible by means of a cam which could facilitate the achieving of the necessary rectilinear alternative motion in the frontal plane of the grinding wheel.*

Key words: *drill, sharpening schemas, grinding process, reverse engineering, sharpening device.*

1. INTRODUCTION

The high performance tools need an attentive maintenance, and the activity of products designers was directed to an intensive search concerning the methods of knowledge acquisition and finding creative ideas in order to increase the efficiency of using such tools. If this problem is formulated, one can apply, for example, the so-called *reverse engineering techniques* in reconditioning/ re-sharpening the worn tools (Fig. 1), to ensure to them high operating performances; in particular, this could mean to find a simple and performance device able to contribute to the tools reconditioning. Production of high-quality products with lower cost and in a shorter time of manufacturing process is an important challenge in a competitive industry.

The reverse engineering formerly meant making a copy of a product belonging to the competing company or a product similar to that of the competing company, but nowadays the reverse engineering is looked as a creative process, able to generate realistic and efficient ideas. It is used in order to understand how a certain product/process was designed or how this product/process operates during its utilizing [2, 4, 8, and 14].

Even the reverse engineering method was usually used especially in information technology field, it could be also applied in mechanical domain. From the point of view of information technology, the reverse engineering could consist in the decompilation of any application concerning the programming language that was used to create it, so that one can acquire its source code or any part of it. Anyone can subsequently re-use any information technology code in his own programs or modify an existing (already compiled) program to perform in other ways [5, 12].

One can use the knowledge gained from reverse engineering in order to correct application programs, also known as bugs. But the most important aspect is that one can get extremely useful ideas, by observing how other

Fig. 1. Tool sharpening [11].

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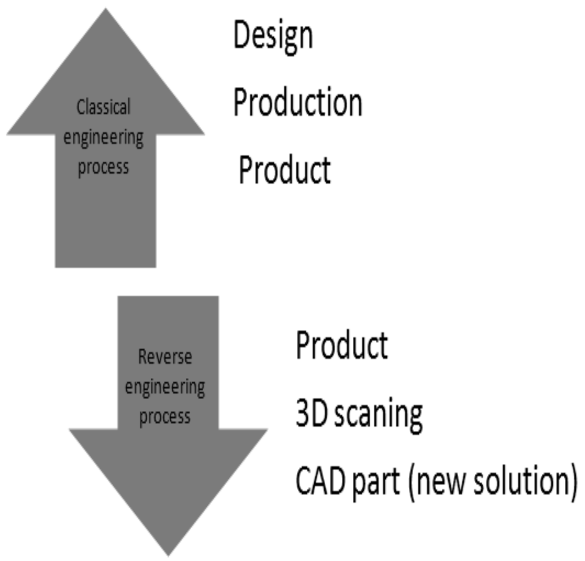

Fig. 2. Reverse engineering versus traditional engineering.

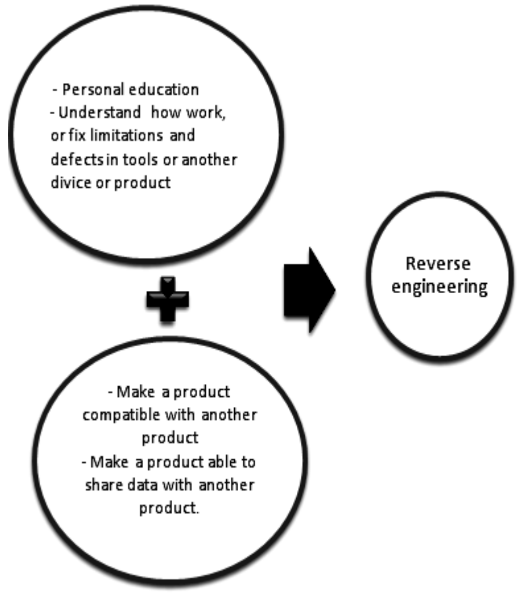

Fig. 3. Advantages of reverse engineering.

programmers work and think; thus could improve the proper skills and knowledge [15]. Such ideas could be extrapolated in the mechanical field, too.

If one take into consideration the specific literature point of view, one can notice that some authors appreciate that *conventional engineering* creates a computer aided model based on the functional specifications of a new product and *the reverse engineering* is the method that reconstructs computer aided models by considering physical models [2, 7].

A principle comparison of the reverse engineering process with the classical engineering process could be seen in Fig. 2; one can notice that if in the classical engineering process there is a product or a production process design, in the case of the reverse engineering one must scan the existing product or examine the production process, in order to find a similar or a new solution.

Engineering [15] is described as "the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems". This type of engineering is more commonly known as *a forward engineering*. An *emerging engineering* concept uses the forward engineering in a reverse way [9].

Thus, the reverse engineering could be considered as the opposite of forward engineering. It takes an existing product, and creates a computer aided model, by modification or reproduction of the design aspect of the product [10].

As a design method, the reverse engineering is no limited to a particular purpose, but it is appreciated frequently as an important part of the scientific method and even of the technological development.

One can learn many things by breaking something down, in order to understand its structure, to built a copy or improve the initial product. From our particular point of view, we propose to use reverse engineering in order to build an improved copy of a certain product.

The reasons for using reverse engineering are many; some of these reasons are presented in Fig. 3. So that one can notice that each year, the researchers find new reasons for applying the reverse engineering either for personal education in order to understand how work another product or to create a new product starting to another one.

The purpose of this paper is to highlight that reverse engineering allowed to designers to truly understand what the initial product was doing and mostly that one can make a new/improved product without the risks that this new product can or cannot be considered "legal".

According to Chikofsky [3], there are many fields that use the reverse engineering:

- "Redocumentation"; this implies the intention to develop a documentation to see if a certain product existed or should have existed;
- "Design recovery"; this supposes the observation of the product by using general knowledge of the problem, personal experience, external information, deduction and reasoning, with a view to the recovery of the design intent [1, 3].

To the above mentioned aspects, one can add another stage, concerning *the "new product" development*.

In 2 000, Houny and Tai considered that an ideal reverse engineering system should not only be able to reconstruct a complete geometric model [13, 3].

The recent developments in the field of design methods gave another perspective to the possibilities of using the reverse engineering, especially in generating new ideas of product or production process.

2. METHODS OF SHARPENING

The objective of tools sharpening processes is to obtain appropriate functional angles from the outside to the core drill. Convenient drill geometry of the chisel edge and a better quality of the cutting face (Fig. 4) are other objectives to be followed by applying a sharpening process.

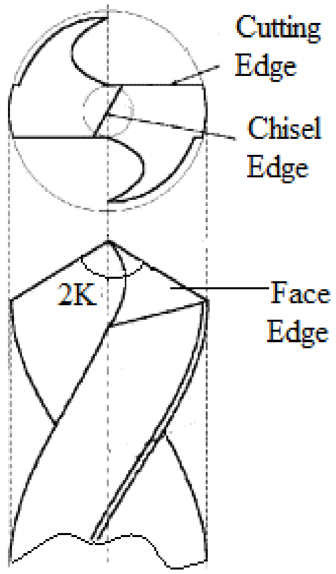

Fig. 4. Geometry of the drill active zone.

The specialty literature from the technical field describes some sharpening base methods (Fig. 5); there is the opinion that this group of methods includes the main possibilities applicable in order to sharpen the drills [4].

Of course, there are yet other methods [11, 10], but the content of this paper was focused only on some of the sharpening methods presented in Fig. 5, considering that these methods could be applied in the case of the available device.

Some details concerning the most known sharpening methods applied to drills are presented in Figs. 6, 7 and 8.

1. Sharpening applied in order to obtain a conical surface; this method is known as *Bancroft-Washborne-Stock method* (Fig. 6); it is the most popular method in the field of machine building. One can notice that the face edge is a conical surface. The face edge is obtained by rotation *1* of the grinding wheel and the movement *2*, which is an oscillation feed movement around the axis of the sharpening drill cone. One symbolized by *3* the drill feed motion along its axis and by *4* – a linear motion in the active flat surface of the wheel tool (frontal oscillation of the tool, developed in order to ensure a uniform wear of the sharpening wheel).

Fig. 5. Sharpening methods.

The inclination angle is the result of the misalignment of the tool axis (with the value *K*) to the imaginary axis of the sharpening cone.

2. Sharpening applied in order to obtain a circular cylindrical surface (Fig. 7); it corresponds to the situation when the drill axis is parallel to the front surface of the grinding wheel. In this case, the cutting face or face edge has a circular cylindrical shape, with a constant inclination along the edges. The movements are the same as in the case of the previous method.

3. Sharpening applied in order to obtain a helical surface (Fig. 8); this method could be materialized by the Oliver technique or by Spiropoint-Cincinati technique. This sharpening method is characterized by the fact that the face edge of the drill is the result of applying five work movements:

- Rotation movement no. *1*, which is the main cutting motion, done by the grinding wheel;
- Motion no. *2*, which consist in the feed continuous rotation movement of the drill bit along its axis;
- Motion no. *3*, corresponding to the feed movement in depth;
- Motion no. *4*, materialized by the grinding wheel shaft movement or oscillation, in order to ensure a uniform wear of the wheel;
- Motion no. *5*, feed movement of the grinding wheel (two double strokes on each rotation of the drill are necessary).

In the case of this method, the inclination angle increases towards the drill axis, due to the law of motion of the grinding wheel and to the relative position of the drill in relation with the cutting tool (abrasive disk).

Of course, the easiest sharpening method is that in which a flat surface is considered as acceptable from the point of view of drill behaviour during its use; this machining method needs the rotation movement of the abrasive disk and a single feed motion, along a direction included in the frontal surface face of the grinding wheel. Even this is the simplest sharpening method, usually it does not ensure acceptable conditions for the angles and for the active surfaces shapes of the drill.

One took into consideration that the available sharpening device offers a possible rotation movement of the drill and this was the reason that the last method was not accepted in our analysis.

In accordance with the specialists evaluations, one can say that the drill could be appreciated as the most important, least understood, and most neglected of all cutting tools; this means that generally only standard drills are accepted, based on inflexible precedents, rather than logical deduction and experimentation [8].

Thus, a device able to satisfy in a certain extent the proposed technological requirements for drills sharpening characteristics could be identified; such a device could acceptably solve the request of sharpening productivity and accuracy. The research aim was to improve the

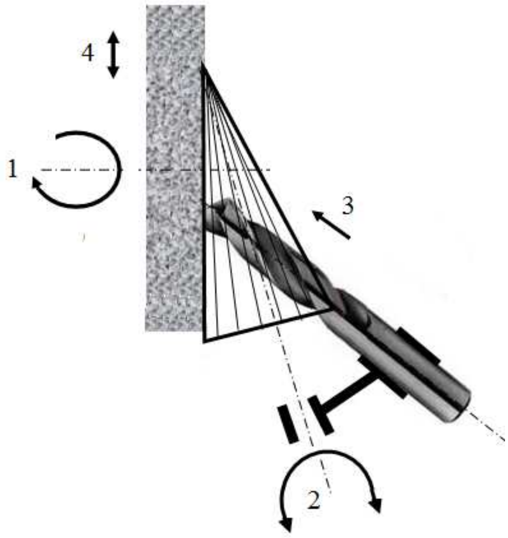

Fig. 6. Sharpening by a conical surface.

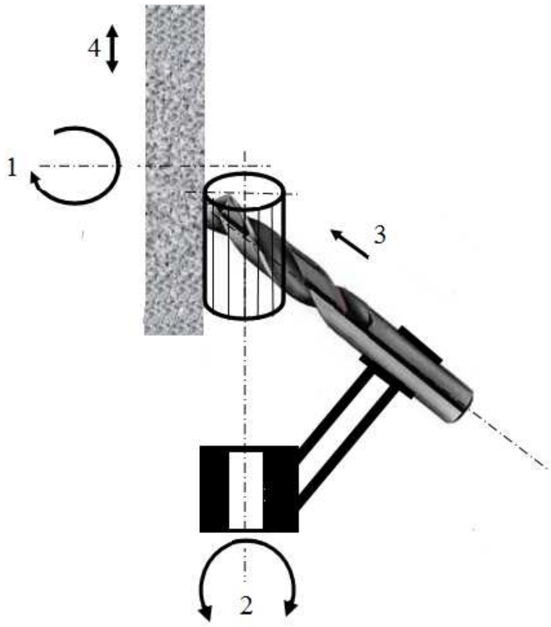

Fig. 7. Cylindrical sharpening method.

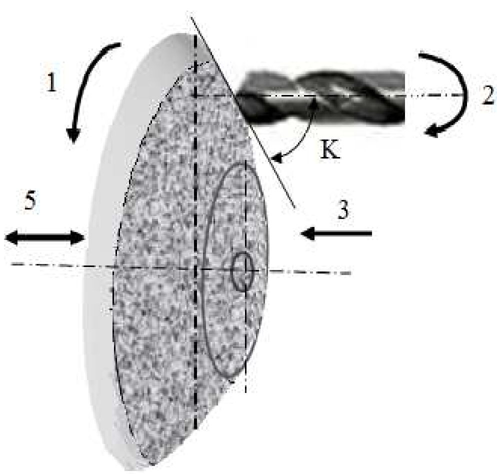

Fig. 8. Helical surface sharpening method.

performances of these cutting tools (drills) widely used in the field of machine manufacturing.

3. EQUIPMENT

In the last years, the machine tools industry showed an increasing need for the remanufacturing of spare parts by applying the method of reverse engineering.

The technology development refers usually to the "forward engineering", when in product development the engineers implement new concepts and abstract methods. An opposite situation corresponds to reverse engineering that begins with final product and analyzes it backward, in order to recreate the engineering concepts by decomposing the design of the product or system and highlighting the correlations among its components.

The reverse engineering involves the applying of four stages:

- Analysis of the old product (data acquisition);
- Generation of an intermediary level product description;
- Analysis of the product description in order to generate certain specifications;
- Generation of a new product.

The last stage supposes the generation of the new product using the previously found specifications.

Our project scope of was to modify an existing product, in the research purpose, to obtain am improved technology, able, in this case, to facilitate the sharpening of small diameter drills.

It is well known that in the reverse engineering process, the geometric shape of a part can be "captured" by mapping the surface with 3D scanning, but there is also a possibility to use less advanced design methods.

A simplified graphical representation of the activities corresponding to the applying reverse engineering could be seen in Fig. 9; the figure offers an overall image concerning the proposed methodology, applied in the case of a device for sharpening the drills.

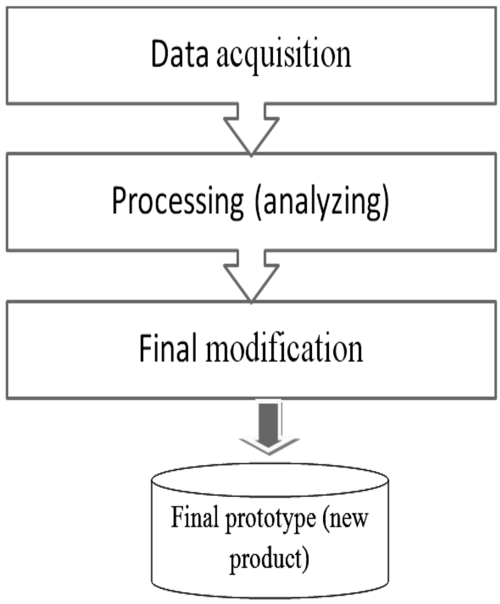

Fig. 9. Flow of reverse engineering for the new device.

Fig. 10. Device for grinding valves.

The initial device, destined to grinding the valves active surfaces, is presented in Fig. 10.

Within the first stage, this device was attentively studied; formally, this supposed a "process of analyzing a subject system, to identify the system's components and their interrelationships and to create representations of the system in another form or at a higher level of abstraction" [3].

The device simplified schema is presented in Fig. 11, where *1* is electromotor and *6* is a subsystem for clamping the valves. The gear transmission is achieved by means of the gears *3* and *2*; the wormgear including the components *4* and *5* achieves a decrease of the rotation sped, that are related to the main movement performed by the cutting tool (in this case, the abrasive disk). In the initial device, the workpiece (the valve) was achieving a rotation movement by means of the gear transmissions.

In order to apply the reverse engineering method to design a new product, one generally can follow the above mentioned four –stage process:

- Identifying the product components which will be reverse engineered. In this case, there is a device for grinding valves;
- Observing or disassembling the original product, to understand how it works;
- Implementing the technical data generated by the reverse engineering in a modified version of the original; in our case, it is necessary to design a device for sharpening the cutting tools, namely cutting tools from the categories of drills.
- Creating a new/improved product. This stage will be reached later on.

When one wants to transform a certain device into another one, the main problem to be solved is to introduce an element able to transform the continuous rotation movement of the drill by means of the gear *3*, in a discontinuous rectilinear movement, so that to ensure a certain correlation between two movements or to find a kinematic chain of interdependence able to correspond to the proposed initial conditions.

One can use reverse engineering to find the functional principles of a mechanical application by means of analysis of its structure, function and operation. Sometimes, this involves the study in detail of the work way of the analyzed structure, usually with the intention to design a new/improved device or program that solves the same problem, but without applying anything from original device.

Applying the reverse engineering rules, someone can place a cam or a tappet to transform the movement, as we can see in Fig. 12.

The main device needs also a subsystem able to ensure a certain position of the drill, and thus, to respect the values prescribed for the cutting angle.

As one can see, in our design, we kept the majority of the original device components, but we tried to give them a different utility and functionality.

Thus, we had the occasion to notice that the reverse engineering techniques are much more than taking a certain product and examining its internal components. It

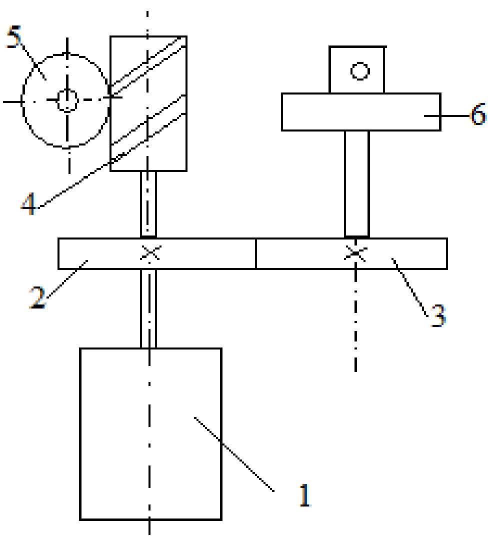

Fig. 11. Grinding valves device schema.

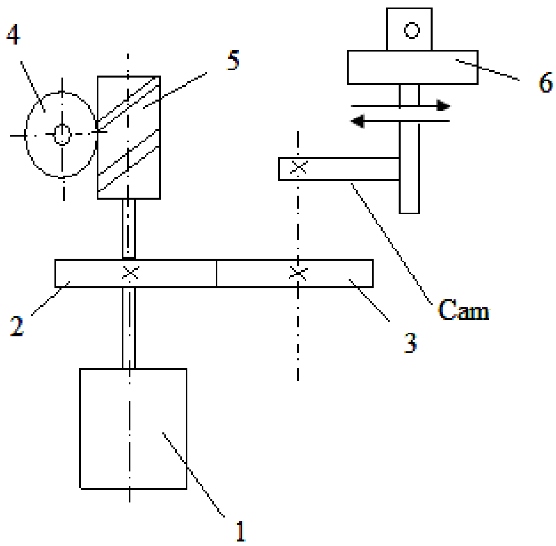

Fig. 12. Device modified in order to allow grinding of small diameter drills.

was also important to understand why the components were include in the analyzed structure, where they were placed, how they were made, how they correspond to the proposed aims etc.

4. CONCLUSIONS

The reverse engineering is an important tool by means of which one can generate CAD models or, in other cases, new/improved products. One can use a suitable computer aided design program or a systematic approach, in order to efficiently use the reverse engineering.

The objective followed by the research activity was to transform a device for grinding valves in a device able to ensure conditions for sharpening the small dimensional drills.

Of course, applying reverse engineering principles we can find other solution for the relative movement between the abrasive tool and twisted drill.

The paper highlights the possibilities to the reconsider a device structure in order to obtain new equipment. The applied methodology had as an objective to improve a device and to transform it in something else. This approach was based on the reverse engineering method principles, applied to the particular case of a mechanical device, in order to modify the destination and the work way of the original device.

The general principle stages of the reverse engineering were applied to the particular case of a device for grinding valves; one can appreciate that the methodology is simple and the convergence of ideas could be rapidly achieved, as only one new approximation was needed.

The reverse engineering method develops a systematic approach of thinking about the engineering design of devices and systems.

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