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CONSIDERATIONS ABOUT IMPROVING ELECTRIC HAND-TOOLS DESIGN IN RESPECT TO ERGONOMIC PRINCIPLES

Abstract: *Electric hand-tools design is a very dynamic domain. Many companies develop their products according to the usual restrictions such as costs, aesthetics, functionality, safety, reliability etc. Ergonomics is another constriction designers should respect. In this paper some usual hand tools are analyzed based on the ergonomic principles. Also, some suggestions regarding the form improvement of the products are formulated in the paper.*
Key words: *design, ergonomics, hand tool.*

1. INTRODUCTION

In systematic respects, designing is the *optimization* of given objective(s) within partly conflicting *constrains* [1]. Usually, requirements change with time, so that a particular solution can be optimized only for a particular set of circumstances.

Constrains involved in the design process are of different nature: functional, economic or aesthetic. Designers should choose the most important restriction and establish the goal(s). Thus, it becomes the objective function of the optimization process and the others remain restrictions of different weight.

It is known [1] that the first activity of the design process is the elaboration of the requirements list. Every item of the requirements list represents a function the product must fulfil.

Obviously, the requirements list should contain items related to ergonomics. These requirements represent in fact specific functions included by the designer into the solution principle in respect to the ergonomic principles.

2. ERGONOMICS DESIGN PRINCIPLES

Ergonomics is a relatively new science, which studies the human characteristics, abilities and necessities and, in particular, may be considered a buffer between human being and technical products. From this point of view, ergonomics has these two main goals:

- to adapt technical products to human beings;
- to adapt human beings to products and/or activities, using education and experience.

In this context, technical products include home appliances, leisure, sports and fun products.

In fact, this science called ergonomics studies the human behaviour during the labour process. Thus, it tries to improve the human adaptation to work and working conditions and, at the same time, to adapt work to human possibilities.

Depending on the phase of the product lifecycle, two directions of study can be distinguished: the *conceptual ergonomics* and the *correction ergonomics* [1].

The conceptual ergonomics is the designing team's job and refers to the application of ergonomic principles while designing the product.

The correction ergonomics is the activity of ergonomists and consists in verifying and analyzing the products at the place where they are used, meaning they are studied in the real working conditions. This activity is more difficult because designers cannot preview all the situations and include them as constrictions during the design process.

For this reason, the products may not be perfectly adapted to all the possible functioning conditions.

Ergonomics is usually in this situation. Because it strictly studies the relation between the product and human during the working activities, if the design team does not include an ergonomist, the ergonomic principles may not be entirely respected.

Thus, the situations when the product may be improved from the ergonomic point of view are quite numerous.

3. ELECTRIC HAND-TOOLS

Electric hand-tools are one category of products that can be analyzed easily because they have a reduced number of functions and therefore a simple structure.

These products' handling or using imposes specific movements and/or positions for the operator. This results due to the space arrangements, the joining of the different shape elements conceived in the embodiment design phase with respect to human body dimensions.

Generally speaking, these products should be easy to handle, adapted to human possibilities as concerning the dimensions and weight. Also, the hand position should be adapted to the principal effort, depending of the main function of the tool.

Fig. 1 Jig-saw – existing solution.

Two hand-tools, a swinging saw (jig saw) and a rotary drill machine will be analyzed as follows.

3.1 Jig-saw

The analyzing of the existing constructive variants of jig-saws reveals the following functions (Figure 1):

- cutting function,
- adjusting the cutting angle function;
- change the cutting blade function;
- adjusting the cutting timing function;
- fast cutting function;
- dust absorbing function;
- power supplying function;
- cooling function;
- human protection against splinters;
- adjusting the handle position function.

In addition, the product should not be very heavy (the weight must be minimized), easy to handle and operate with one hand. The product must be safe for human operator and as safe as possible for the environment.

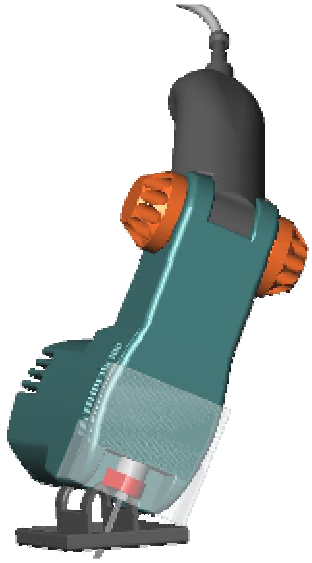

Fig. 2 Jig saw – tool position.

The existing products have similar characteristics and most of the buying options are made on spot. For this reason, another function becomes of great importance, the aesthetics of the product.

In order to improve the tool ergonomics, some modifications are proposed and illustrated in the following figures. Figure 2 presents the possibility of inclination of the tool in respect to the cutting surface. This function may be fulfilled by designing a rolling plate which can be adjusted very simple. The plate has a semi-cylindrical surface in contact with the tool, in which a groove with the same profile has been made.

The plate position may be adjusted and the distance between the plate and the tool permits the exhausting hose fastening for dust absorbing (see Figure 1).

Figure 3 presents an original product variant with a rotating adjustable handle. Usually, this type of tool does not permit this possibility. Analyzing the operations that are performed with this tool, this function appears as necessary. The operator makes cutting operations which should require another position of the hand (in fact, of the tool handle). Consequently, the operator does the operation, but the hand position is not correct from the ergonomic point of view.

Fig. 3 Jig saw – handle position.

The solution proposed is provided with a rotating adjustable handle. The adjustment can be easily done, with free hand, without auxiliary tools, using the two knobs. The two surfaces have radial grooves which permit a sequential relative rotation of the two parts. The joint provides electric contacts for the tool command (the ON/OFF switch), the electric motor supply being done throughout the handle.

Also, the switch that ensures a continuous functioning is placed on the handle. This function is useful when the operation is very long and the finger placed over the switch might be a discomfort for the operator.

This function is also useful when the cutting trajectory is curved needing both hands to control the tool.

The electric contacts may be fulfilled by rotating contacts or by wire. The second variant is also possible because the handle rotating angle is limited to 90^0.

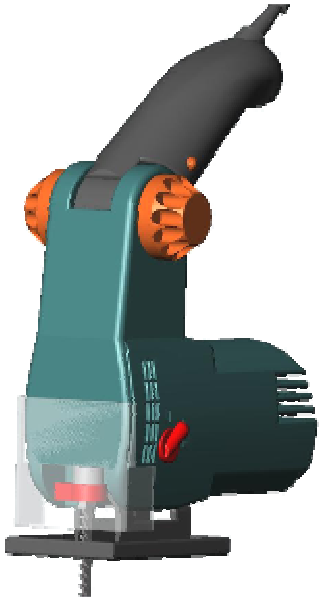

Fig. 4 Jig saw – blade protection.

Figure 3 presents the handle into the extreme position of 0^0, whilst in Figures 2 and 4 the handle is in intermediate positions.

Another studied function is the operator (and tool) safety. The tool should be provided with a protection system in order to be safe for people that operate it. About this complex function many aspects can be discussed. The dust absorbing, the electric wires insulation, the screen that protects the operator from splinters, all these are examples of protective functions.

The new jig-saw design has been provided with a translucent screen meant to stop the splints produced during the cutting process. The screen must be translucent in order to see the blade and to help the operator to follow the cutting trajectory. The screen can be removed in order to change the blade, by simply vertically sliding it (Figure 4).

3.2 Rotary hammer drill

As concern the rotary hammer drill machine, the analyzing reveals the following functions:

- drilling function,
- adjusting the borer speed function;
- change the drilling borer function;
- hammer function;
- power supplying function;
- cooling function;
- auxiliary handle support (second handle);
- human protection against splinters.

Fig. 5 Rotary hammer drill – existing solution.

Like the previous product, this one must also fulfil a number of requirements concerning weight (its minimization), ease of maintenance, safety, reliability and of course, aesthetics.

The existing products have very similar mechanical characteristics. Thus, the aspect of the product and the ergonomics can be decisive in consumer's choice.

A usual drilling machine is presented in figure 5. The information for the existing products, including the pictures is captured from Black &Decker site [4]. The main components are the body including the motor and transmission, the fixed handle with two switches, for starting the motor and holding it up, the auxiliary handle that can be adjusted as needed, and the chuck that supports the drill. Usually, most of the existing products include the hammer function that consists in the possibility of the tool to rotate and to have an axial move simultaneously.

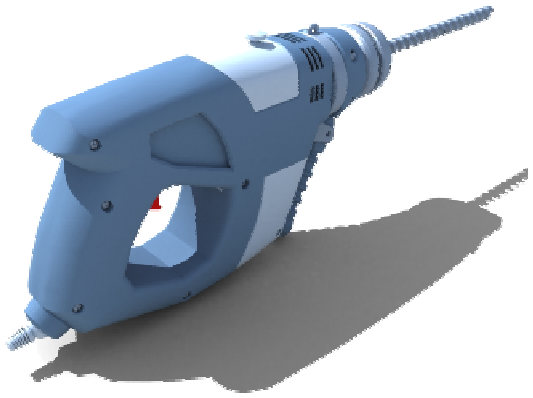

Fig. 6 Rotary hammer drill – colour and texture.

Figure 6 presents a redesigned drilling machine having a more compact aspect that confers the impression of increased safety, trust and good looking. The volumes have been reshaped and the result is a more balanced product concerning both its aspect and mass distribution.

The handle has been redesigned and reshaped in a more rigid 'circular' construction. The supplementary inside space situated in front of the handle was designed to include the accumulator for the wireless, portable product variant.

The surfaces with special functions have been pointed out by colour or texture, according to 'Gestalt principles' [2]. For example, the lid for accumulators' compartment was differently coloured, as well as the lid for the motor, brush and ball bearings access.

The volumes being reshaped, the result is a more balanced product concerning both its aspect and mass distribution. In this simple way, the product looks better and its maintenance is easier.

The surfaces of special interest are emphasised not only by colour, but also by texture. For the handle, for example, the contact properties have been taken into account. Considering that the hand might be humid in contact with the tool, the danger of slippery appears and therefore, the surface is made of rubber, not metal or plastics. In addition, the surface should not be smooth, but quite rough.

Fig. 7 Rotary hammer drill – the new design.

Supplementary safety may be fulfilled by designing the main and auxiliary handle in finger catch shape (usually called ergonomic shape – see Figure 7). For this function fulfilment, the mass distribution is essential.The tool should be balanced as concerns the mass distribution. Usually, the medium human operator should be capable to keep the tool in balance and operate it with one hand. The second hand should be kept for guiding the tool and orientate the hand tool towards the working surface.

Figure 8 presents the interior architecture of the rotary drill machine. The lid removing emphasizes the main components of the product: the chuck, the transmission, the electric motor, the battery accumulator, the switch etc.

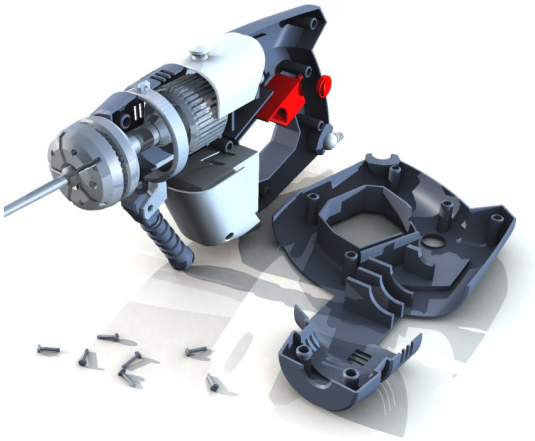

Fig. 8 Rotary hammer drill - section.

Presenting the product in this way is useful both for designer and the client. In addition, the representation in Figure 8 can be included in promotional materials. It presents the simple structure of the product, the accessibility, the ease of maintenance.

The redesigned solution has been improved in accordance to ergonomic principles but also from the aesthetic point of view, the result being a better looking and more ergonomic product.

4. CONCLUSIONS

Ergonomic principles represent an important category of constrictions in the very complex process of design. It is very important that products to be adapted to human dimensions and to their physical and psychical limits. Ergonomics studies these possibilities and helps the designer to make better products.

Hand-tools are one category of products suitable for an ergonomic study. In general, the products on the market have similar characteristics, therefore the consumer chooses the product on spot, between the numerous existing brands. The two examples of hand-tools, the jig-saw and the rotary hammer drill have been analyzed and, based on the conclusions drawn, some design objectives have been formulated. First of all, the analyzing revealed the main functions and then the ways of improving the solutions were identified.

For both products analyzed in the paper, the improvements were based on observation about some hypothetically functions that might improve the products functioning. The detailed observation allowed the designer to develop better solutions not only from the ergonomic point of view, but also from the aesthetic one.

The observations have been made in working places where these tools are used. In some cases, the modifications were suggested by those who handled the tools for a long period of time and experienced both the advantages and the disadvantaged of them.

Obviously, the resulted solutions are also better looking then the existing products. They have more functions and they are more versatile, i.e. better adapted to human needs and to the various tasks during the working process.

It is possible that the started research presented in this paper to be continued and the new solutions to be improved from all points of view, including the safety, the material used and, of course the costs.

The study that was made included a larger number of products all of them belonging to the electric hand tool category. This study included also the angular grinder, the polishing machine and the chain saw and was made with the help of the students for *Master of Science* degree.

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