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INTELLIGENT SUPPORT FOR DEFINING AESTHETICAL, ERGONOMICAL AND MATERIAL PROPERTIES OF DESIGNED PRODUCT

Jasmin Kaljun

Original scientific paper

The presented paper gives an insight into a prototype of intelligent advisory system based on the aesthetic and ergonomic factors regarding product design, with emphasis on appurtenant design recommendations. The paper focuses on methodology of determining appropriate combination of ergonomic and aesthetic design actions during product design to achieve pleasant user experience. Along with products' function, ergonomics and aesthetics certainly belong to the most important design factors that affect user experience. In the field of ergonomics not only anthropometrical characteristics of prospective user are important. It is also of significant importance to select appropriate material for contact areas in order to assure comfortable and injury free use. Presented theoretical findings are supported with case study of hand tool handle design using intelligent advisory system Oscar.

Keywords: *aesthetics, ergonomics, intelligent support, material selection, product design*

Inteligentna podrška definiranju estetskih, ergonomskih i materijalnih karakteristika dizajniranog proizvoda

Izvorni znanstveni članak

U radu se daje uvid u prototip inteligentnog savjetodavnog sustava temeljenog na estetskim i ergonomskim faktorima u odnosu na dizajn proizvoda, s naglaskom na pripadajućim preporukama o dizajnu. Rad je usmjeren na metodologiju određivanja odgovarajuće kombinacije ergonomskih i estetskih poteza tijekom dizajna proizvoda u svrhu postizanja ugodne primjene. Osim funkcije proizvoda, ergonomija i estetika su svakako najvažniji faktori koje pri dizajniranju treba uzeti u obzir. U području ergonomije nisu važne samo antropometrijske karakteristike budućeg korisnika. Od velike je također važnosti izabrati odgovarajući materijal za područja dodira kako bi se osiguralo ugodno korištenje, bez mogućnosti povrede. Predstavljena teoretska saznanja potkrijepljena su analizom dizajna drške ručnog alata primjenom inteligentnog savjetodavnog sustava Oscar.

Ključne riječi: *dizajn proizvoda, ergonomija, estetika, inteligentna podrška, izbor materijala*

1 Introduction

Basically every product is developed to satisfy users' needs. To own a specific product, future owner has to find, select and buy the product. With the growth and globalization of the market, the future users of the specific product, (e. g. household appliances, hand tools…), increasingly search, choose and buy desired product in virtual environment e.g. online stores. In such a case, when selecting the product, users rely on: (a) description of the product or technical system, which is usually prepared by the manufacturer; (b) comments of existing users; (c) test reports carried out by the relevant institutions and (d) virtual product presentation. It is a visual perception of the (virtual) product that is crucial, as it must support the aforementioned descriptions [1].

Products' visual appearance has to reflect the correct combination of, for the user, important characteristics such as functionality, ergonomics, practicality, robustness, elegance, material... In the virtual world a visual perception of products' form is a point of contact between the product and the prospective users. On the other hand also in the real world, the prospective user, when selecting a product, among wide range of products of the same category located on the shelf, primarily chooses that or those, whose form most clearly expresses the aforementioned properties, which are important to the user.

1.1 Defining visual appearance

Basic aesthetic characteristics [2] are usually determined through so-called product briefings and from interviewing consumers. In fact, nowadays the importance of involving customers in the product development process by eliciting and integrating customers' needs and feelings into product design is widely recognized [3, 4]. The guidelines for product design are derived as a result of interviewing customers. The basic style properties of a product have to be transformed into aesthetic characteristics which can then be further developed and "perfected" by the designer. It is in the domain of the designer how to translate customers' style properties into aesthetic characteristics and the appurtenant designers' language [2].

Defining basic aesthetic characteristics is crucial during the conceptual design phase of an industrial product, where the product is incompletely defined and the generation of the first model is mainly driven by designers' creativities and high-level constraints. Most of influential design factors [5] will be adapted to the conceptual design during phases yet to come. There is, however, one influential factor, ergonomics, which has to be considered simultaneously with aesthetics. This is needed due to the fact that the parameters regarding ergonomics are derived from anthropometric and biomechanical data of the human body and cannot be changed in order to suit aesthetics. Aesthetic characteristics have to incorporate ergonomic design elements.

1.2 Defining physical perception

As already mentioned before, prospective user will eventually observe and interact with desired product in vivo. In this situation overall perception will be important. According to the pyramid of comfort (Fig. 1) visual appearance is not the only factor of consideration. Since most of consumer appliances are manipulated with upper extremities, user will also simulate usage of the product observed. This leads to comparison of visual perception to real physical perception. In order to satisfy prospective user the observed product has to "feel" exactly as it "looks".

The "feeling" of the product is in the domain of ergonomics. Designer has to assure appropriate size and shape of contact areas (usually called grips) taking into account anthropometric data of expected user. Designer also has to minimize static load on users' extremities (e.g. hands). Usually reduction of the static load can be achieved by moving centre of gravity towards grip, using less or lighter components or using "lighter" material.

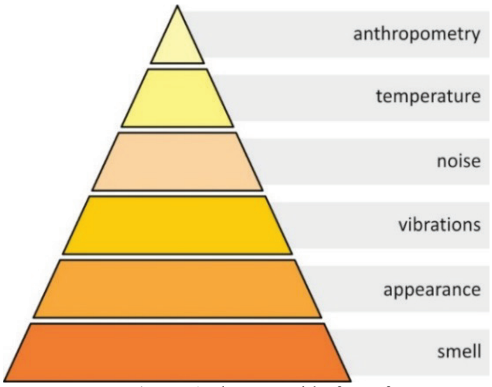

Figure 1 The pyramid of comfort

Appropriate material selection has an important role in the definition of products' perception. Material on one side defines "the elegance" of the product, and on the other side determines the subconscious perception of the product (e.g. weight). Designer has to shape the product according to material technological properties, which are a matter of intense research [6]. The shape of the product also has to prevent possibilities of fatigue damage of the material. Thus it is necessary that designer understands the mechanical properties of the material [7].

Introducing new materials into design process is common practice. Among wide range of various plastic materials, porous metals are gaining attention due to their unconventional mechanical and technological characteristics [8]. When selecting material for grips, these unconventional properties are welcomed, as shown in Section 4.2.2.

1.3 The way to intelligent support

According to already presented facts, designer has to find "optimal" combination of presented factors. The success of the "balancing" depends mainly on the designer's experience. Less-experienced designers have less chance of delivering an optimal design, and any success of the product on the market is consequently smaller. These designers and also other engineers (for example: mechanical engineers) involved in development processes need a way of obtaining some know-how knowledge. One way leads to domain experts, or better still a team of experts, who are, on the one hand hardly attainable and, on the other hand very expensive.

The alternative can be found in computer-aided advisory tools. It is becoming increasingly evident that adding the intelligence to the existing computer aids, such as CAD systems, leads to significant improvements of the effectiveness and reliability at performing various engineering tasks, including design. Actually, Artificial Intelligence (AI) applications to design are reality and subject of intensive development and implementations [9, 10].

1.4 The aim of the paper

In continuation of this paper ergonomic and aesthetic design will be presented from »intelligent design« point of view. Design parameters will be formalised, so they could be used to develop the knowledge base of intelligent advisory system. Special attention will be given to form definition (aesthetics) and contact area design with contact area material selection (ergonomics).

Research results are intended for designers of new products that will be using the proposed model of intelligent support to establish the design of the product with emphasis on both, the physiological characteristics of the user, as well as his/her emotional preference. After the theoretical part of research that resulted in accumulated and recorded knowledge in problem areas, the paper contributes to the systematization, formalization and structuring of domain knowledge. Based on the accumulated knowledge, the paper in its heart presents a model of intelligent support for ergonomic and aesthetic development of products, whose usefulness is confirmed by practical test.

In conclusion, the purpose and importance of research work is summarized, while awaking new questions, suggesting further research work in this area and promise to improve already achieved results.

2 Ergonomics

Ergonomics encompasses the entire knowledge regarding the compliance of humans' physical and mental abilities within a working and living environment. As an interdisciplinary activity, ergonomics represents the syntheses of mathematical, biological, social and engineering sciences (Fig. 2). Based on this knowledge ergonomics experimentally develops comfortable living conditions at home, at work, and during recreation [11].

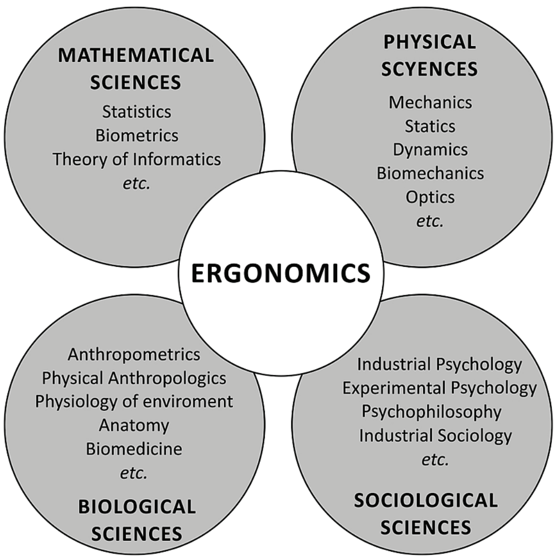

Figure 2 Interdisciplinarity of ergonomics

Of course, ergonomics in itself does not constitute completion of the design process, but only part of the whole, which we present under the name of industrial or product design. Ergonomics is certainly one of the sciences which has, within the emergence of new or redesigned products, a relatively large impact.

When we are talking about ergonomics as integration with design, it can be said that product design, on the one hand, is a cultural discipline, which aims to analyse and create cultural and social relationships that are realized in the form of an object and, on the other hand, ergonomics as a scientific discipline sets the form in dimensional - design normative, which complements a design by acknowledging a human as a biological being. Ergonomics also ensures that the designer actually creates a customer-friendly product and, therefore, enables smoother, more comfortable, and healthier usage [12].

In most cases, a designer needs information about human anatomical, anthropometric, physiological, and biomechanical characteristics and their relation to physical activity, such as working postures, material handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety, and health. Therefore, it is understandable that ergonomic studies form an important phase of the product design process, and make the designer responsible for establishing the ergonomic value of the developed product [13].

Design within its many definitions, essentially reflects the tendency to create products that will meet at least two requirements: the user (in terms of usability), and their function. In order to adapt the product to the user, a designer has to possess information about the characteristics of potential user. Such knowledge can be obtained through an in-depth study of the specific users, which is appropriate for specific products, specifically designed for certain users, or to use previously collected data, such as anthropometrical data on populations or targeted groups.

Such a practice by designers, of course, falls within the scope of ergonomics. Clearly, ergonomic studies are among the most important steps of creating a product, which puts the designer in a creator position of the products' ergonomic value.

Within the increasing demand for reducing the risk of injuries and diseases at work, the designers are faced with rising ergonomic requirements regarding their products. In order to satisfy these requirements, the different recommendations and standards already developed for specific sectors of ergonomic design, should be applied to their designs. Some of these recommendations include various anthropometric data, which the designer can consider when determining the dimensions of the product. Other recommendations, based on dynamic anthropometrics and biomechanics, can be used to develop the ergonomically important parts of the product.

The impact of ergonomics can be detected during the early stages of the product development process. Ergonomic recommendations have to be taken into account when listing the requirements of the product. Of course, the wide area of ergonomic recommendations, standards, and requirements is reduced to those specific parts relevant for the product under consideration. Thus, for each product group, a designer determines the different spheres of influence using certain common elements, such as contact area, noise, mass properties and cognitive consistency.

3 Aesthetics

In the process of designing a product the aesthetic component of the product in most cases is not the main objective, as it would be in an artistic creation, which aims to achieve a high aesthetic value. The aesthetic component is a resultant of design parameters that determine the basic characteristics of the designed product [14]. The designer must develop the aesthetic component of a product included into the basic product concept through the entire creative process. Aesthetic value is formed by the elements (design solutions), which characterize the perception of the product, while challenging the subjective feelings of the user - the observer, which can be called aesthetic. The (appropriate) creation of aesthetic component is influenced by various influential factors, which can basically be divided (combined) into two major groups, (1) subjective and (2) objective factors [15].

Subjective factors are closely linked to potential users and therefore relatively difficult to measure. They are formed by personal and cultural norms that apply in the environment the potential users are originating from. A large part of successful design depends on the designer's knowledge of the environment in which the product is going to be introduced. Different psychological and philosophical studies, which the designers can use in their work, can be very useful.

Objective factors are a kind of "universal" measure of aesthetic value of each product. Objective factors dictate the aesthetic elements and relations between them, which can be called the building blocks of harmony. This group of factors includes, among others, functional factors such as clear shape, which is adapted to the main function of the product, to increase the aesthetic value of it.

The inclusion of appearance, or aesthetics, as a major design metric represents both an augmentation to conventional engineering design and an intersection with artistic endeavour. Aesthetics in the context of product design refers to all visual aspects – the statics and dynamics of form, proportion, colour, patterns, and textures, including reflectivity. Aesthetics affects humans both psychologically and physiologically and proffers opportunities for improving both human efficiency and "attitude" – thereby increasing overall productivity and enjoyment[16].

General aesthetic guidelines in product design include "soft curvatures" and "warm colours", perhaps indicative of a specific evolution-induced predilection for "naturalistic" forms and hues. For some designs these guidelines might actually bring satisfactory solutions. For other more complicated demands, the designer has to know and use certain more-detailed guidelines. In order to understand the extent of aesthetics, we will divide it into three types of elements, as shown in Fig. 3.

The first and foremost element type is the Elements of art, a set of techniques that describe ways of presenting artwork. The elements of art can include many or all of the following artist's concerns: colour, value, line, shape, and texture.

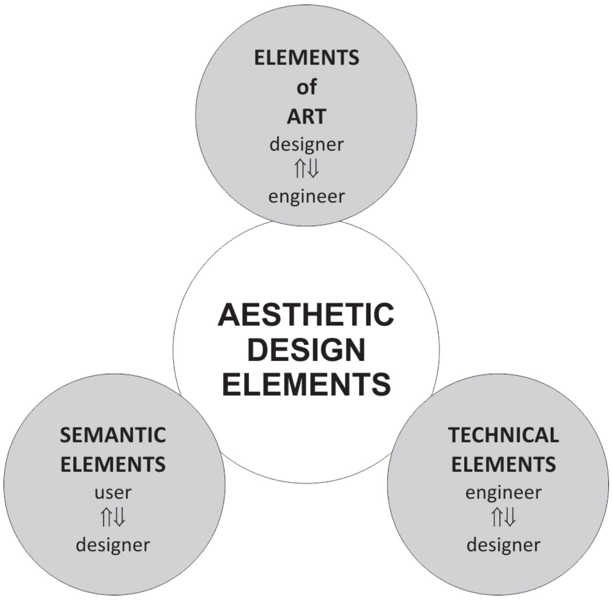

Figure 3 Aesthetic elements

They are combined with the Principles of art (movement, unity, variety, balance, emphasis, contrast, proportion, and pattern) during the production of art.

The composition of elements of art, which form the shape of the product, can be described through Semantic elements, or the elements of form acceptance. The purpose of the semantic elements is to translate the composition or its parts to the user's (observer's) understandable language [17]. Reversely a designer can, on the basis of the known - the desired semantic elements (communication of the product), build an appropriate composition of art elements.

Since an exact description of the art elements and composition is very important in further developing the product, the desired aesthetic value can only be accomplished by maintaining the intended composition. Therefore, it is necessary to transform the elements of art to Technical elements, which represent a form of instruction for the technical execution of each element of art and overall composition, respectively.

4 Intelligent framework

The research work which resulted in the framework of ontologies presented in this paper is only a part of ongoing research oriented in support of design processes using artificial intelligence. Our vision of an aesthetic and ergonomic design-cycle supported by an intelligent system is presented in Fig. 4. It is anticipated that the product development cycle using an intelligent advisory system would be very similar to the present conventional development cycle. The first main difference, however, would be noticed during the concept design phase, where the intelligent advisory system would be used to improve the aesthetic and ergonomic value of the concept design solution.

Ergonomic analysis and aesthetic evaluation would be performed on the CAD model using more precise geometrical definition. Then, the intelligent system could be used again to advise the user as to which redesign changes are possible to improve the ergonomic and/or aesthetic value of the product, if applicable.

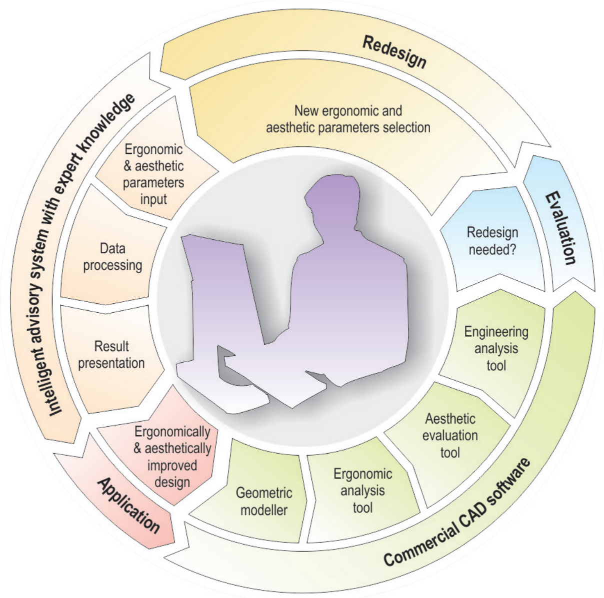

Figure 4 Design cycle using intelligent advisory system

4.1 Oscar – intelligent advisory system prototype

In continuation of this paper an insight is given to knowledge base of prototype of an intelligent advisory system Oscar. Oscar covers a field of hand manipulated power tools. In the proposed frame the aesthetic appearance of the product is not considered as an influential parameter, which however is the case in the presented system. Oscar is namely composed out of two sub-systems that can be applied in two different modes. Sub-systems can be used independently from each other, or simultaneously and interdependent on the same design project.

The intelligent decision support system Oscar is still a research prototype, and as such, a subject of intensive development, especially more subjective part of the system dealing with engineering aesthetics and aesthetic ergonomics.

Basically, the intelligent advisory system Oscar is a computer system that emulates the decision-making ability of a human expert. Such intelligent systems are designed to solve complex problems by reasoning about knowledge, like a human expert, and not by following the procedure of a developer as is the case in conventional programming.

The structure of the intelligent advisory system Oscar is unique, and significantly different from traditional programs. In foundation, the system is divided into three parts. The first part is fixed, independent of the rest of the system, called the inference engine. The second part is variable, called the knowledge base. The third part, which serves as communication module is called user interface. When running Oscar, the inference engine uses the knowledge base like a human expert and communicates with user through user interface.

The knowledge base is expressed with IF-THEN styled production rules that are similar to the natural language expression used by human experts. Representatives of production rules concerning aesthetics are presented in continuation of this section. Case study presented in Section 5 will demonstrate the use of ergonomic sub-system.

The result of systems' inference process is design recommendations and design goals, which are presented to the user (Section 5). Design goals are presented with confidence factors.

This enables the system to propose multiple design goals with differing degrees of confidence to reach a "best fit" in its conclusion. While in some cases it is possible to give a specific design goal with absolute precision, the real world is not often so clear-cut. Often multiple design goals are simultaneously possible and the system ranks them based on relative merit. Applying of "confidence factors" enables the emulation of the real world and gives the type of responses that human experts would give.

4.2 Definition of form

When analysing the market and the anticipated requirements of customers, including estimates of the target groups regarding the developed product, the designer must have clear aims regarding the aesthetic component, and must define the semantic message of the product's visual identity. Defining the semantic forms of communication is very important, if not the key to mass produced consumer products, where the main function also complements the so-called prestigious function. The duty of the designer is to create such a product shape that best reflects the desired message, and follows the requirements of the relevant components regarding the aesthetic quality of the product. Aesthetic recommendations for the designs of products can also be an assistance and support to the designer. Aesthetic recommendations can be collected in the form of those aesthetics objectives in design, which bring together art, technical and even semantic elements. These objectives are: (1) shape is consistent with the function (form follows function); (2) shape has the desired compositional consistency and (3) shape reflects the planned semantic message.

4.2.1 Functionality of the product

At the end of the 19th century, the phrase "Form follows function" was mentioned for the first time and became the 20th century leading thought in the field of industrial design. Indeed, it is in the "first plan" when developing industrially manufactured products regarding implementation of the main function, while the shape of the product mostly serves its ergonomic suitability and visual appearance. In practice this means that the coffee grinder is intended primarily for "user friendly" coffee milling, and not decorating kitchen shelves, while expressing its identity and brand affiliation, among other things with their visual image [18].

Design recommendations in the field of aesthetics, in this case are:

- the form indicates how to use the product,
- the form of the product allows easy and safe use,
- the control areas are easily accessible,
- the use of different materials can add further functional highlight.

A representative rule in this group defines basic design goals for a tool for holding and pressing:

```
IF:
    Select the group of tools most suitable for
    tool in consideration:
    tools for holding and squeezing
THEN:
    Important safety issues are predicted -
    consider ergonomic part of the system:
    Confidence = 5
    Shape (form) of the product should be
    consistent to products' function: Confidence
    = 5
```

4.2.2 Compositional consistency

Combined with the known main function of the product, the designer has to compose a visual image of the product in such a way that it generates pleasant feelings and desires when used or merely possessed by the user, as well as the observer. The principles of visual composition are also present, in certain respects, in the designs of industrial products.

Thus, the objective compositional consistency can be archived by:

- the individual elements that contribute to the whole (in the form of a product) yet are mutually dependent so that the established rhythm expresses the desired message (movement, resting ...).
- tendencies derived through individual elements must conform to the overall composition of the product.
- the proportions used should be in accordance with the principal function of the product:
- where possible, usage of pleasant (real) proportions is desirable,
- the use of different proportions on different elements of one product is undesirable.

4.2.3 Semantic consistency

While the first two objectives of aesthetic design care about subconsciously receiving of the product, semantic consistency carries, in concept stage already known, message of the product. Semantic message is reached with applying certain values of selected technical elements to the shape of the product. Some recommendations are presented in Tab. 1.

Table 1 Design recommendations for semantic consistency

Technical element	Communication form
acceleration	aggressive, speed sports
hollow, crown	power, aggression, tension
convex, concave	tense
sharpness	tense, aggressive
tenderness	tense, natural, organic, warm
crispiness	cold, aggressive
tension	tense, wild
lead in	aggressive, threatening

Representative of production rules for semantic consistency is:

```
IF:
    How is the tool being used: professional use
    OR hobby use
AND:
    How to determine appropriate semantic meaning
    for the product? System shall derive semantic
    meaning
AND:
    Select the group of tools most suitable for
    tool in consideration:
    smashing tools
THEN:
    Tool Semantics aggression AND dominance
```

Presented rule recommends semantic message taking into consideration known usage of the product.

Different production rules are defined to translate semantic message to technical elements (Tab. 1). Representative rule can be seen here:

```
IF:
    Tool Semantics aggression
THEN:
    Consider use of adequate technical
    realization of characteristic
    lines.: Confidence = 5
    [Aest_Rec.ADD] Lines/surfaces should express
    acceleration
```

4.3 Contact area design

As argued before (Section 1) when observing household appliances or hand tools, contact areas are usually in the form of grips.

To be able to define appropriate dimensions and configurations to be respected in hand tools design, the anthropometrical data related to human hand are transformed into design recommendations (Tab. 2).

Table 2 Anthropometrical recommendations

Attribute	Value
handle cross - section	round or oval
handle diameter - power grip	min. ⌀25 to 45 mm
handle diameter - precision grip	min. ⌀7 to 15 mm
handle length (palm side)	min. 100 mm
handle length (palm side) - gloves	min. 114 mm
handle length (finger side)	min. 78 mm
handle length (finger side) - gloves	min. 90 mm
pistol grip handle angle	7° to 10°
finger clearness	min. 35 mm

Figure 5 Digitalized virtual model of users' hand [20]

It is important to select correct handle diameter to provide optimal grip span and consequently optimal grip force. Cylindrical shaped handles are usually not applied to the tool where rotation of the hand around the grip is not expected. In such cases handles have oval or rectangular cross – section with grip span between 35 to 50 mm, considering use of protective leather gloves.

To maximize user comfort, custom made handles are proposed. Using digitalization techniques e. g. magnetic resonance imaging (MRI) or computed tomography (CT), designer can generate virtual model of (exact) user hand (Fig. 5). Based on the model of user hand, custom handle (grip) can be created using computer aided design (CAD) tools (Fig. 6) [19].

Figure 6 Custom handle [19]

Several studies were performed to evaluate user comfort using "conventional" shaped tool handles compared to "customized" tool handles. It has been shown that a certain degree of generalization (e. g. smoothing) of handle shape generates handle which is rated as comfortable for majority of prospective users [21].

4.4 Material selection

Although selection of appropriate material can raise products' semantic value (e. g. elegance), pleasant user experience is lost when user feels discomfort in use of the product. Especially for contact areas, designer has to select and define materials, to prevent tissue compression.

Human skin and subcutaneous tissue are highly complex structures, therefore their material properties are hard to measure and define. The mechanical properties of skin and subcutaneous tissue have been extensively investigated by many researchers [22]. Harih [23] performed series of numerical simulations, analysing the influence of handle material on tissue compression, by computing contact pressure during grasping phase.

Numerical simulations of mechanical behaviour regarding the fingertip grasping of a tool-handle showed that ethylene propylene diene monomer (EPDM) rubber as a tool-handle material produces almost the same contact pressures as rigid steel. Therefore EPDM rubber as tool-handle material does not lower the contact pressure, which in turn does not lower the risk of pressure-dependent acute trauma disorders (ATD) and cumulative trauma disorders (CTD). The best results were obtained using proposed composites of EPDM rubber and EPDM foam as well as EPDM rubber and polyurethane (PU) foam. Based on the mechanical behaviour of the fingertip, the composite of EPDM rubber and PU foam proved to be more suitable, since the material has the greater potential for lowering the contact pressure.

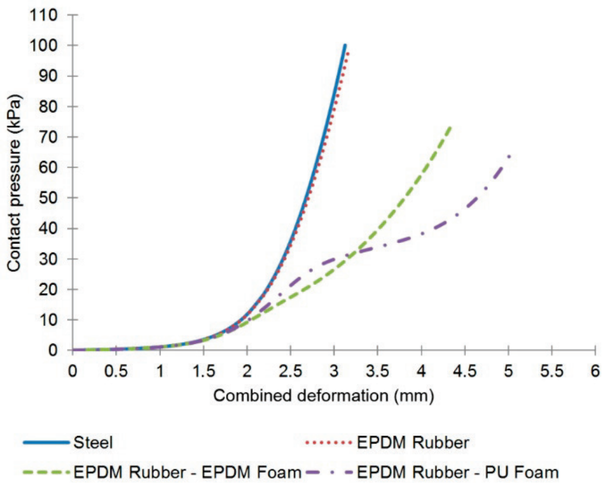

Figure 7 Contact pressure of the fingertip versus the vertical deformation of the fingertip and tool handle material combined [23]

With a clearly evident and higher plateau (Fig. 7), which is typical for porous material [24], this material does not deform at lower strain rates, but begins to deform at higher strain rates in order to provide a higher contact area, which can be observed with broader distribution of the contact pressure and also lower peak contact pressure. This mechanical behaviour and limited tool-handle material thickness can maintain low deformation rate of the tool-handle material for maintaining desired rate of stability of the hand tool in the hands.

5 Case study

A case study dealing with the redesigning a pneumatic hammer's handle was carried out, in order to demonstrate practical application of the ergonomic design knowledge built in the intelligent decision support system Oscar.

The hammer that was chosen for the case study was underdeveloped from both the ergonomic and aesthetic points of view. The manufacturing company was aware of this, and took the opportunity using our innovative technologies to improve the design of their product, in order to increase their competitiveness [25].

RESULTS OF THE INFERENCE PROCESS

Basic information regarding tool:

Tool type:	hand tool
Grip style:	pistol
Grip class:	power grip
Grip quantity:	

Important Ergonomic Goals

Static and Dynamic Anthropometric data should be used to determine the dimensions. Conf=15.0
Tissue compression has to be avoided. Conf=15.0
Wrist(s) should maintain neutral straight position. Conf=10.0

Figure 8 Results of the system - degree of accuracy: general ergonomics

For the purpose of this paper a short summary of design process using Oscar is presented. Oscar can work at three different levels of detail: general ergonomics, contact area design and grip design. In this case all three levels were used.

The level of general ergonomics was used during the first step. This level of detail is used to determine basic ergonomic properties of a designed product, in general. Typical users at this level are designers with no ergonomic design experience. A part of the results returned by the system at this stage can be seen in Fig. 8.

Contact areas were used for the level of detail during the second step. Oscar then proposed ergonomic and also one anthropometrical recommendation, using already known basic information, and additional information specific for this level of detail (Fig. 9).

Ergonomic Recommendations

Use adequate design methodology.
Use information for 50-percentile user
Thumb triggers on the grip have to be positioned on the both sides of the grip. Finger supports have to suit both hands.
Heavy tool should not be used above chest line.
Use ellipsoid, oval or rectangular cross section for the grip. Assure fillets on sharp edges.

Anthropometric Recommendations

Consider anthropometric data for male.

Figure 9 Results of the system - degree of accuracy: contact areas

Finally, Oscar was used for the highest degree of detail: grip design. Oscar provided detailed recommendations after considering previous recommendations. The user was advised in text form (Fig. 10) as well as by graphics, for illustrating the proposed recommendation (Fig. 11).

Ergonomic Recommendations

Use adequate design methodology.
Use information for 50-percentile user
Thumb triggers on the grip have to be positioned on the both sides of the grip. Finger supports have to suit both hands.
Use ellipsoid, oval or rectangular cross section for the grip. Assure fillets on sharp edges.

Anthropometric Recommendations

Consider anthropometric data for male.
Consider anthropometric data for "classical" pistol grip.
Inclination of the grip should be between 10° and 20° from vertical. Grafika
If gloves are used, add extra space on the handle.

Figure 10 The results of the system - degree of accuracy: grip design

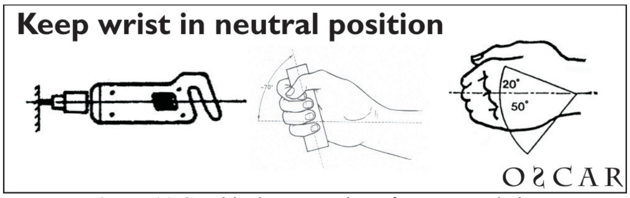

Figure 11 Graphical presentation of recommendation

In the case study presented here, the redesign recommendations proposed by the intelligent system Oscar can be summarized in three groups:

- change the shape and dimensions of the handle,
- change the cross-section of the handle,
- change the position of the handle.

A virtual model of the new pneumatic hammer's handle was modelled (Fig. 12) after considering all the recommendations based on the ergonomic knowledge built in the system.

Figure 12 Virtual model of redesigned handle

6 Conclusions

Some aspects of product design, such as aesthetics and ergonomics with material selection, which were often unduly neglected in the past in comparison with the functional and economic efficiency of a new product, are now becoming increasingly essential. Designers have the obligation to fashion a product to specific guidelines, regulations, standards and other elements, during the early developments stage, so that ultimately, a product will be successful on the market. This is a difficult task for people whose jobs should be oriented into the creative development of new goods rather than constantly studying certain rules.

Presented paper proposes the use of artificial intelligence techniques to support designer in decision making process. Intelligent advisory system Oscar is developed to assist unexperienced users in the first place. Expert knowledge built into Oscars' knowledge bases is constantly being updated.

Case study gives an inside look at work process, showing recommendations proposed by Oscar. Nevertheless it is the designer who has to make a final decision on which recommendation will be taken into account. As discussed in Introduction Oscar can offer expert help to designer, but cannot design "perfect" products, since pleasant experience in use of the product cannot be programmed.

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Author's addresses

Jasmin Kaljun, Ph.D., assistant
University of Maribor, Faculty of Mechanical Engineering
Smetana 17, SI-2000 Maribor, Slovenia
E-mail: jasmin.kaljun@um.si