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Decision Support System for Designing with Polymer Materials – Current Challenges and Future Expectations

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1. Introduction

Product development process is rather precisely defined and reasonably well supported with modern computer tools. Numerous commercial computer aids or specially developed computer tools are relying mostly on graphic presentation, simulations, engineering analysis and animations of future product performance in virtual environment. In the embodiment phase, the designer has to take decisions, influenced by various parameters, according to the available data. One of crucial decisions is material selection, conditioned by several criteria, among which the focus is on function, technical features and shape of developing product. Other criteria, like serviceability, technical feasibility and economic justification are considered accordingly. Despite the potential of already mentioned computer tools, a designer has to evaluate the information gathered from these aids, seek interdependences and finally choose the optimum from the broad list of materials. Wide spectrum of various polymers or plastics should be outlined here, as they are frequently used in technical praxis. On the other hand, there is a leak of relevant data and knowledge for successful selection among them. Consequentially, the designer has to master all influential parameters, their overlapping or contradictions, and above all, he or she has to be acknowledged with materials available on the market. Designer's right/wrong decision severely influences product's applicability in praxis, its technical feasibility, life time, economic justification and recycling possibilities along with environment impact. Thus, numerous experts from various fields usually need to contribute their expertise to reach the final decision, which is often quite difficult, as opinions may be contradictive. In Small and Medium-sized Enterprises (SMEs'), the financial status commonly thwart the enterprise to hire an expert or entire team, which frequently leads to unprofessional design decisions. Young and inexperienced designers are also in arduous position at polymer material selection process. Solution to this quandary in product development process is the decision support system model for polymer material selection discussed in this chapter.

2. Product development process

The global market has adopted a continuous need to develop new, cost-effective, high-quality products at a very rapid and accelerating pace. To be able to compete, maximal quality at minimal cost should be enterprises' motto. It has been assessed that 85% of problems with new products not working as they should, taking too long to bring to the market, or costing too much, are the result of a poor design process (Ullman, 2003). Thus, designers are often under pressure as they have to justify management's trust in new product also supported with diverse tools for selecting and evaluating the projects (Palcic & Lalic, 2009).

Product development is complex engineering process. The designer is progressing through the process dealing with many design and manufacturing problems, while envisage the production process (Vidal et al., 2005), product assembly, parts' maintenance, their influence on the environment or some other design aspects. Nevertheless, the designer's focus is on product's function where its form, materials and manufacturing processes are of equal importance beside it. In addition, the engineer has to define the new product features like tolerances, type of surface or material, from which the product will be produced. To solve these dilemmas, he or she has to rely upon own knowledge or experiences as existing Computer Aided Design (CAD) application does not provide any recommendations or guidelines.

Current CAD offers support during a great deal of engineering steps when designing a new product. CAD applications correspond to the designer's work at drafting, drawing, modelling, assembling, analysing and simulating. Its limitations appear, when having to accept certain determinations and decisions about the product. This is very important as the following steps of the process are directly or indirectly dependent on these decisions. In other words, the process is a sequence of interdependent events and one decision at the early design stage would then exert influence on all successive events, and the final design solution.

2.1 Decision-making in product development process

A product development process is above all a decision making process. The engineer has to choose the proper tools when performing the design process, such as selecting the adequate software for the initial problem and, more importantly, he or she has to make several decisions whilst working with these tools, in order to achieve an optimal solution. Human cognition plays the key role in product development, as knowledge domain is decisive during decision making process.

Experiences are an engineer's main advantage. Designers are in uncomfortable position here as at the beginning of their careers their experiences are limited. The possibility of acquiring experts' opinions is desirable, since they possess knowledge of specific design aspects and could contribute to the evaluation of possible design solutions. Moreover SMEs' often have quite such absence of knowledge due to economic capability required for hiring the specialists. This observation leads to the conclusion that adequate computer support is often needed for offering some advice and guidelines to designers during product development process. Such computer support for the decision process can be provided by the intelligent decision support system, presented in this chapter.

2.2 "Design for X" methodology

Within product development process, designers face many dilemmas linked with various aspects of the product, material selection being among them. It is one of its crucial decisions and is associated with many design and manufacturing problems, usually affected by basic demands like application mode, and additional factors like supplier recommendation. The designer has to envisage the production process, semi-product or product assembly, parts' maintenance and evaluating the level of environmental influence, which is becoming increasingly important due to global pollution. Thus, Design for X (DfX) methodology, where X resembles the appropriateness for manufacturing, maintenance, service, etc. (Huang, 1996), has to be considered. The field of plastic products' design is of special interest regarding DfX, as the final product could be optimized for one or more domains of its life-cycle (Kuo et al., 2001). Using DfX, the engineer is able to concentrate on the most important domain within the life-cycle in order to provide an adequate product design solution.

Usage of DfX is rational and rationale as it represents one or the first step in the process of attaining optimal product design. Nevertheless, the designer still cannot expect any adequate support from available computer tools in the form of recommendation or guidelines when a material or technological procedure has to be selected. In order to overcome this bottleneck, Knowledge Base Engineering (KBE) techniques have to be taken into consideration, when developing an intelligent decision support system for polymer products' design. The intelligent system model for polymer products' design represents a new approach in design processing. The preliminary condition for knowledge-based support to polymer products' design process is an adequate knowledge base containing related, well organized DfX domain knowledge and relations.

3. Polymer materials

Conventional materials like metals and ceramics can be often substituted by others, more suitable for certain types of product. Thus, polymers are reasonable alternative as they could offer better characteristics for noticeable lower costs. Some of the advantages such as less weight, lower material costs, cheaper mass production, recyclability, specific electrical, isolative or, corrosive, etc. features, easier part joining (Kim, 2004), higher aesthetic values (e.g. no dyeing is needed) or, easier production of precision products, are of major importance in product development process.

For every scientific discussion it is important to clarify the terminology. Polymer literally means many units so polymers are materials where units consist of chain like macromolecules and are joined together through chemical binding. Furthermore, plastics are materials usually composed of polymers refined with various additives like fillers, glass fibres, and pigments which aggrandize polymers properties (Askeland & Fulay, 2009). Despite of described distinction between polymers and plastics authors usually use both terms interchangeably thus we adopted this idea in this chapter. Common classification of polymers is in three major groups:

- Thermoplastics including commodity and engineering polymers
- Thermosets materials
- Elastomers divided on natural and synthetic

General structure of thermoplastics is flexible linear chains, which could be straight or branched and direct the thermoplastics ductile behaviour. Characteristically for thermoplastics is their ability to melt at heating therefore they are processed in final form by heating at certain temperatures. Consequentially, they could be easily reformed and recycled with the same operation. Thermoplastics are generally distributed into commodity and engineering polymers. First are of light weight with low strength and stiffness as well as not usable for applications at high temperatures and corrosion-resistant. They can be shaped without difficulty in various forms and are among inexpensive polymers. For mechanical engineers the engineering thermoplastics are in focus as they can offer enhanced strength, which in some cases can be greater than the strength of steel. Moreover, their performance at high temperatures sometimes as high as 350˚C is better but engineering thermoplastics' disadvantage is the expensiveness. Thermoplastics overall are present in various engineering applications like wire insulation, bottles, pipes and valves, automobile roofs, carpet fibres, packaging, egg cartons and windshields to mention just a few.

Thermosets have rigid three-dimensional network with linear or branched chains and are commonly stronger although more brittle then thermoplastics and sometimes more than metal or ceramics. As thermoplastics are easily shaped when exposed to temperature high enough, the thermosets to the contrary do not soft under heating but start to decompose. Thus, the recycling is problematic though very important due to the environment pollution. Thermosets are often applied as adhesives, coatings fillers, foams and laminates but are also present in applications like cookware and electrical mouldings.

Group of plastics with enormous elastic deformation are called elastomers generally known as rubbers with structure like thermoplastics or cross-linked thermosets consisting of spring-like molecules, which could be stretched by applying the force. Thermoplastic elastomers are special group of polymers and should be mentioned here as their processing is like thermoplastics' but the behaviour is elastic like elastomers'. Elastomer applications are diverse from tires and golf balls to hoses and seals.

To ensure the proper application of plastics, the designer has to consider three factors that determine the appropriate final use: design, processing and material selection. According to Material Information Society (ASM International, 2003), material selection factor has a great impact on all design aspects. Therefore some major designer's concerns are introduced:

- Designing products that can be built as easily and economically as possible
- Ensuring product reliability
- Simplifying product maintenance and extending product life
- Ensuring timely delivery of materials and components.

For successful product development is crucial to choose appropriate material, process and design matched to the part performance requirements.

4. Approaches to material selection

In contemporary engineering, the material and production process to be selected evolve and change whilst designing simultaneously with form of the developing product. During the process the product evolves from preliminary ideas and sketches and is refined in details, form, material, and production techniques. Being aware of this fact, the designer usually assemble as many information as possible studying the similar devices from the competition in order to understand the product and to set the requirements about the material, manufacturing process, assembly and maintenance. According to Ullman those information has a great impact on the embodiment phase of design at following domains (Ullman, 2003):

- Quantity of the product to be manufactured influences the manufacturing process selection to great extent as for very small series some manufacturing processes like injection moulding are not cost-effective.

- Prior-use knowledge can lead to past and effective solutions and at the same time the better material or manufacturing process solutions could be omitted.
- Knowledge and experiences are the key factors to top-level product contrarily the lack of both could lead in other direction. The invitation to the expert at material or manufacturing process selection is a regular practice in SMEs' to disseminate company's knowledge and experiences.
- Availability of the material is a very important point at material selection as some characteristics of the design could not be implemented with some always available cheaper materials.

4.1 Material selection methods

Material selection is a significant stage of the design process and a complex task, whose execution varies from enterprise to enterprise in accordance with staff and the economic aptitude of the company. In general, material selection methods can be, according to Ashby (Ashby & Johnson, 2005), arranged in four different selection methods called Selection by Analysis, Selection by Synthesis, Selection by Similarity and Selection by Inspiration. All methods require input data in the form of design requirements specific for each method. Selection by Analysis is the most systematic and robust as input requirements are objectives, functions, and constraints, and furthermore, they are precisely defined and unambiguous. Its deficiency derives from this particular distinctiveness, which causes the method to fail in the case of imprecise inputs or imperfectly formulated rules. Previous experience and analogy are key factors in the Selection by Synthesis method, where design requirements appear in the form of intentions, features, and perceptions. This method is used, when knowledge of the solved cases can be exploited and transferred to other product with some features in common. Selection by Similarity is the selection method, where input is already known or potential material solution and its purpose is to find substitutive material for an existing product, often initiated by design requirement changes due to e.g. environment legislation. The less uniformed method is Selection by Inspiration, where input is pure curiosity and the designer's task is to examine and analyse other solutions for a specific feature, in a systematic way. This method is used when no scientific method is helpful. All material selection methods and their variations are implemented in numerous variations as engineering praxis.

4.2 List of must and want properties in engineering praxis

List of must and want properties method can be characterized mostly as Selection by Analysis however it could be also applied as Selection by Synthesis or Selection by Similarity. Usually this method of material selection involves making a list of properties that you must have for future application and the list of properties that are desired for this particular application. These must and want properties are then matched with the properties of available polymer materials on the market. In engineering praxis, four basic groups of material properties are reviewed:

- Physical (specific heat, coefficient of thermal expansion, thermal conductivity, heat distortion temperature, glass transition temperature)
- Chemical (composition, additives, fillers, crystallinity, environmental degradation, spatial configuration, molecular weight, flammability)

- Mechanical (tensile and compressive properties, heat distortion, pressure-velocity limit, toughness, stress rupture resistance, creep resistance)
- Dimensional considering manufacturing conditions (manufacturing tolerances, stability, available sizes, moldability, surface texture)

In order to illustrate the importance of polymer materials' idiosyncrasies (Budinski & Budinski, 2010), each group of followed properties should be described. Physical properties are material characteristics that pertain to the interaction of these materials with various forms of energy and human senses. Generally they could be measured without destroying the material. Density is a physical property determined with weighting or measuring the volume of the product. Physical properties like feel and colour are even easier to determine while they affect the customer as he or she only looks at it. Nevertheless, they are not marginal material properties and their importance rises in today's consumer oriented society. The designer has to acknowledge that plastic feels different from metal and yellow is happier colour in comparison to brown.

Chemical properties are related to the structure of polymer material, its formation from the elements of which the material is made, its reactivity with chemicals and environments. These properties cannot be visually inspected and are measurable in chemical laboratory.

Mechanical properties are the features of material, which are put on view when it is exposed to a force. They are related to the elastic or plastic behaviour of the polymer and they often require destruction for measurement. Term mechanical is used because they are usually used to indicate the suitability of the material for use in mechanical applications – parts that carry a load, absorb shock, resist wear, etc.

Dimensional properties include as well manufacturing considerations like manufacturing tolerances and moldability. This category concerns also the surface texture and its roughness, which is measurable and essential for many applications. Available size, shape, finish and tolerances of the product are also important polymer material selection factors.

4.3 Material selection program packages

Regardless of the material selection method used in design process the designers and experts all should choose eventually from the broad list of materials in catalogues from several material suppliers or they can use the web or computer programs for easier material selection. Plastic material selection web programs like CAMPUS offer some comparison of plastic materials' properties for one or more suppliers. User can observe the relations between several property types like rheological, mechanical, thermal, processing, etc., where each type has some specific single value technical parameters introduced along with multi-joint graphical data at disposal. Although, the value of such computer tool for the engineer and design process is unequivocal, the plastic material selection support is limited. Firstly, the potential selected polymers – candidates are ranked according to some of basic properties, where maximum and minimum values are defined by the user. Depending on designer's skills to do so, the system offers from zero to hundreds of candidates, which meet the requirements. If the number of candidates is large, he or she has to define the values tightly and vice-versa, if there are no suggestions. Due to unambiguous ranking the user receives systematically acquired candidates. Thus, it could be misleading for the inexperienced designer as he or she could overlook the crucial parameters like time and temperature dependence of properties. In addition,

CAMPUS does not offer the designer the prices of the candidates and as we will be able to notice in this chapter the material cost is important and is checked numerous times during the polymer selection and design process. Another way of finding the most appropriate material is to investigate the polar charts, which allow the comparison of polymers for multiple selection criteria (Elsevier ed., 2010). The properties of each candidate are designated on n-scales, which radiate from a central origin yet the points on scales are joined to form the closed polygon. It is welcomed to define the minimum properties' values of the future product and to create its polygon so the possible candidates are only those, which enclose the product's polygon.
Sometimes during product design the requirements does not meet with existing materials or material production processes irrespective of designer's knowledge, experiences and effort. Consequentially, the project is postponed until new special designed material is developed to satisfy the design. It has to be subjected that this involves additional time and finances to support the project and that it is usually only justifiable for special products at high technology performance.

5. Plastic product design process

Design process is not always alike in all enterprises however the basic phases stay the same. While progressing through the task clarification, conceptual, embodiment and detail design phase engineer has to make numerous decisions not only about product design but also about manufacturing, assembly, maintenance, and its impact to the environment. Plastic product design is very distinguished (Alber et al., 2007) from conventional design with common materials like metal and ceramics as the plastics could offer better characteristics for noticeable lower costs. Some of the advantages mentioned before in Section 3 are of major importance. Therefore, material selection is one of key decisions, especially when the designer has to choose between approx. 120.000 different plastic materials (Ashby, 2005; Ashby & Johnson, 2005). It is of great importance as it influences technical and economical aspect of the product. To support this idea, a diagram of new product development process is described and illustrated in Fig.1. It also indicates where in the described development process, the previously selected material could be modified.
After 3D computer model of potential product is finished, a preliminary plastic material selection is set considering technical parameters, product type (product's purpose, exposure to the high temperatures, etc.), customer's requirements and wishes, fashion trend, special restrictions (product's contact with food, toys, etc.) and material costs. At this stage, first strain/stress analyses and casing simulations could be performed. Some severe material changes could be done according to results and usage of reinforcement fibres is discussed. Production process selection is next engineer's decision directly connected to plastic material selection as he or she has to consider products type, its size and precision, wall thickness, tolerances, surface roughness and even a size of production series. In case the manufacturer wants to use particular production machines or the series is large and the chosen polymer could be produced only with the production process suitable for small series, the need for material change is present again. Next phase is tool design, followed by detail casting simulation. Due to the results, some parameters like strain, elasticity, fibre reinforcement or thermal resistivity may have to be adjusted. Furthermore, additional analyses and simulations are fired to approve or to disprove the last selected plastic. Final step before sealed approval is calculation and costs appraisement.

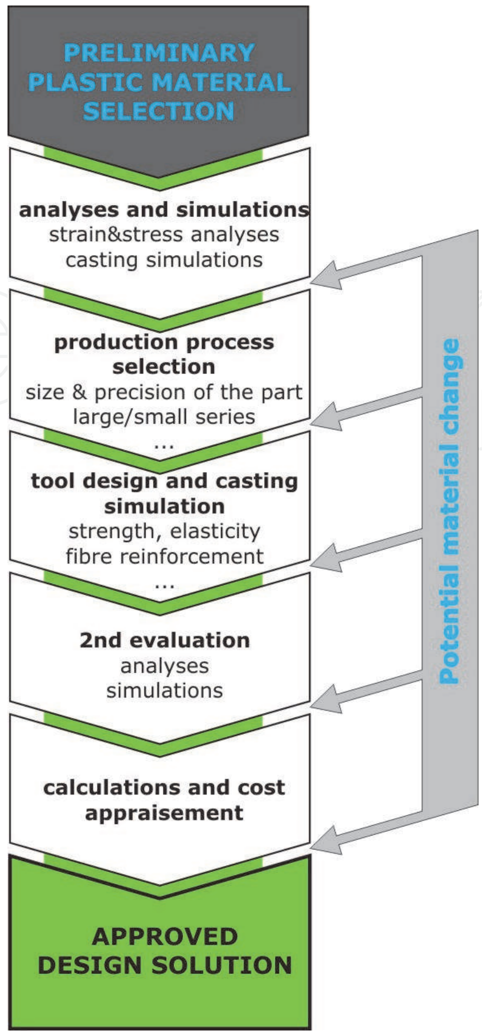

Fig. 1. New product development process

Evidentially from the Fig.1, the plastic material could be modified up to five times after preliminary polymer selection. In every phase, the designer has to make the best possible decision considering all relevant parameters, sometimes also contradictive. In order to surmount this obstacle and to make product development process less experience dependent, the decision support system for plastic products' design is proposed.

5.1 Material characteristics comparison – case-study

In general, there are diverse plastic materials on the market with similar technical features as widely used Actrylometril-butadiene-styrene (ABS). Designers are often used to design with it and do not consider any other material as potential material choice. High density Polyethylene (PE), Polypropylene, and Polyamide (also called Nylon) are some of the polymers, accurately thermoplastic polymers resembling overall characteristics but to a larger extent at certain parameters (Ashby & Johnson, 2005). Let's study one of the key parameters, the fracture toughness of these three materials in comparison to ABS (Fig.2). We can observe from the chart that Polyamide has the greatest extent of fracture toughness values, while Polypropylene has the smallest. Some versions of Polyamide and high density Polyethylene have lower fracture toughness than ABS but, simultaneously, these also have varieties with higher values of fracture toughness in regard to ABS. Moreover, Polypropylene can also be tougher than ABS. To sum up, the toughest version of ABS still does not reach the value of the toughest versions of the other three materials (Sancin et al., 2010).

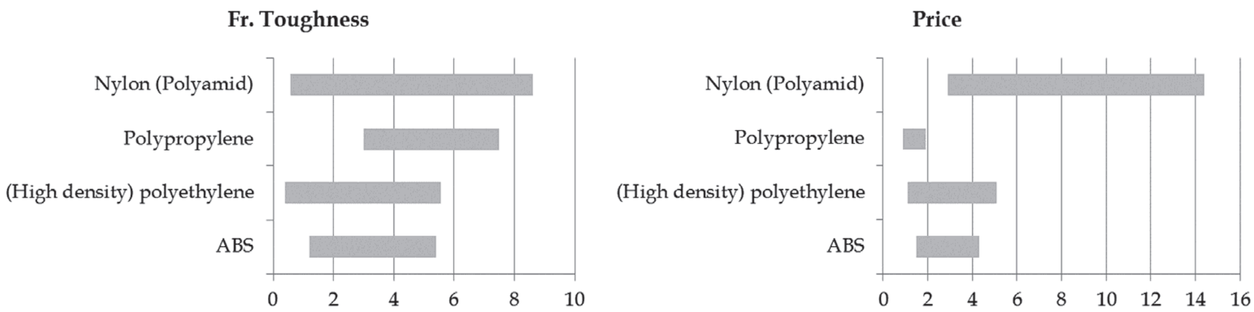

Fig. 2. Comparison of selected thermoplastics for fracture toughness and material price

In addition, the material price is an increasingly important parameter of the design process and the diagram on Fig.2 shows that Polypropylene and high density Polyethylene could have a lower price than ABS. It is necessary to explain that a higher price is sometimes justified due to the acquisition of other design components of the product, such as the possibility of smaller wall thickness, which leads to a reduction of the material needed for production of the manufactured goods. On the other hand, the designer has to evaluate numerous, and for the final product design crucial parameters within the development process by considering all the materials available on the market, with the aim of achieving optimal results, which can sometimes be an almost mission impossible. Younger inexperienced design engineers have major difficulties regarding material selection, thus, in order to overcome this barrier, the decision support advisory system for plastic product design is proposed. This computer aid will offer recommendations and guidelines according to the required parameters, shape or/and function of the product and could also be helpful for experienced designers using the system as a verification tool.

6. Intelligent decision support system for designing with plastics

Product design is a major task and a complex process. Its progress does not depend on just solving problems regarding known information like requested technical parameters, standards, conditions and other constraints that could be resolved with one ultimate solution but also on designers' experiences. Thus, the regular computer programs based on a database search do not fulfil the requirements of the designer the decision support system is a reasonable alternative.

Commonly, the decision support system model is executed in five phases, knowledge acquisition, decision support system shell selection, knowledge base construction, reasoning procedure definition, and development of a user interface. First and most time consuming phase is knowledge acquisition as experts' cognition in the field of design and plastics has to be preciously collected, adequately processed, well organized, and properly stored in the knowledge base. Before creating the knowledge base of the system containing human cognition, relations, and experiences, the decision support shell has to be selected. The generally accepted definition is that decision support systems are information systems supporting operational decision-making activities of a human decision maker. The decision support systems shall then help decision makers to compile useful information from raw data that are distributed in a potentially heterogeneous IT infrastructure, personal or educational knowledge, models and strategies. As long as the system can be designed in advance and the focus lays on data, in practice the application of decision support systems is often sufficient. However, according to Yilmaz and Oren (Yilmaz & Oren eds., 2009) the versions of decision support systems are following:

- agent-directed decision support systems, used for rapidly changing environments where the system needs to be able to adapt;
- decision support simulation systems are used to obtain, display and evaluate operationally relevant data in agile contexts by executing models using operational data exploiting the full potential of modelling and simulation and producing numerical insight into the behaviour of complex system;
- agent-directed decision support simulation systems are agent-directed simulations that are applied as a decision support system, whose focus is on processes, so the system can adapt to new requirements and constraints in the environment.

For the decision support system for plastic material selection presented in Section 7 it is expected the agent-directed decision support simulation systems to cover all requirements and wishes the most satisfactory.

6.1 Current decision support systems for material selection

In recent years, many decision support systems where developed and some successfully launched in real applications (Turban et al., 2004). The significance of material selection dilemma within the design process is obvious, as several models were developed to support the engineers at this stage of design. It is essential to study and observe the progress on the field of material selection intelligent support thus, three examples of novel material selection models or methods, all for diverse applications, are going to be briefly discussed. It is significant to get the insight in the background before presentation of the future expectations in plastic material selection with decision support system.

Material selection query occurs at designing various products. Kumar and Singh represented intelligent system for selection of materials for progressive die components, where two knowledge base modules are comprised (Kumar & Singh, 2007). One is designated as selection of materials for active and inactive components of progressive dies. The other module was developed for determination of hardness range of materials for active dies. Acquired knowledge in the knowledge base is analysed and incorporated into a set of production IT rules.

At the present time, we acknowledge several formalised methods to support selection of individual materials. Real design problems often involve materials in combination as sometimes only joint multiple materials can produce the expected performance. Edwards and Dang address this issue and recommend a multiple-mapping strategy and an inter-level behavioural modelling strategy. Structural and materials solution in supporting design decision-making may be considered simultaneously (Edwards & Dang, 2007).

In general, two types of material selection methods were commonly used at past applications: material index based selection method and knowledge based methods. First follows some successive steps to identify the optimal material as the material heaving the largest/smallest material index value. When applying multiple indices the use of optimization method is mandatory to find the optimal result. Knowledge based methods use diverse approaches like IT rules approach, decision-making approach and fuzzy multiattribute decision-making approach. All demand a bunch of human cognition and intelligence just the last one capable of dealing with imprecise data significant for material selection. Ullah and Harib introduce novel material selection method, which does not require derivation of material indices or unpleasant inference calculations. Resembling the material index based selection method it uses always available material property charts as material relevant information in order to become realistic and user-friendly method. The application of presented method is selection of optimal materials for robotic components in early stage of design (Ullah & Harib, 2008).

6.1.1 Material selection results provided by decision support systems

As presented in Subsection 6.1, the decision support system for selection of material for progressive die components was developed alternatively to manual material selection with material and die handbooks, heuristics and designer's knowledge and experiences (Kumar & Singh, 2007). The adequate material choice is one of major activities in die components design leading to increased die life and consequential costs reduction of sheet material and costs of production. The proposed system differentiates from existing CAD systems for progressive dies at providing not only the list of materials but also an option to select easily available materials from the advice received from the system. After that the list of materials can be prepared appropriately. According to authors, the discussed system has been designated as powerful and easy to handle due to interactive mode of system-designer communication and extensive knowledge base containing knowledge and experiences of progressive die design. The system was developed to advice the designers at material selection for progressive die components, thus it is oriented mainly in just tool steels, which enables the flexibility of the system.
Edwards and Dang proposed a multiple-mapping strategy and an inter-level behavioural modelling strategy to support design decision-making when applying materials in combination and when they are combined with structural determination or design components (Edwards & Dang, 2007). According to the authors, the objective is to facilitate simultaneous consideration of components and materials at early stage of design and to provide the platform for the designer to work out the couplings among the material properties and corresponding components, in order to determine the respective material properties. Due to the complexity of research area discussed, proposed strategies cannot assure adequate support to the engineering design problems despite of their appropriate implementation and satisfactory validated case studies.
Intelligent materials selection method introduced by Ullah and Harib uses a linguistic description of material selection problems and material property charts relevant to the linguistic description of the problem (Ullah & Harib, 2008). The presented method supports the optimal material selection at early stage of design process and is suitable even for complex machineries, where design requirements and design relevant information are not precisely known. Discussed method could be applied for all groups of materials and is not limited to one.
It is obvious that material selection is interesting engineering domain and advanced decision making process. In recent years, numerous approaches and various methods were developed to create the decision support system for this particular field. Most material selection methods are specific at some points and offer a vast amount of opportunities to build diverse decision support systems. Some are limited to only one group of materials (Edwards & Dang, 2007; Ullah & Harib, 2008) and some are focused on special group of

engineering materials (Kumar & Singh, 2007). Decision support systems, which effectively support the designers at decision making process, are concentrated in knowledge base, specifically in human knowledge and experiences. Well organized and defined knowledge for material selection is of great importance and leads to more than adequate advice to designer and hence is a significant contribution to design process.

7. Intelligent decision support system for plastic product design – future expectation

The decision-making process is a constant for every designer aiming at a successful and efficient performance. Alternatively to experts' acquired domain knowledge, we decided to develop an intelligent decision support system (Đurić & Devedžić, 2002; Edwards & Deng, 2007; Kumar & Singh, 2007; Novak & Dolšak, 2008; Turban et al., 2004; Vitanov & Voutchkov, 2005; Zhu et al., 2008) in order to overcome the bottle neck - plastics material selection (Ullah & Harib, 2008). In the input data are a significant factor for intelligent module performance, the results of which depend on knowledge base content. The main objective of the proposed system is a consultancy with the designer in order to obtain the output, containing the most appropriate material for the product application, product design guidelines, etc.

The development methods included in research are a combination of human cognition in the field of design knowledge (Chen et al., 2007) and special domain knowledge expertise in the field of plastics. The knowledge base will contain human cognition useful for problem solving in the form of rules relating to modern plastic materials' selection and correlated manufacturing processes, assisted by the field of Design for Manufacturing (DfM) (Sevstjanov & Figat, 2007). Different approaches to knowledge acquisition (McMahon et al., 2004) and the appropriate formalisms for the presentation of acquired knowledge (Valls et al., 2009) within the computer program are of special importance. The potential for transparent and modular IF-THEN rules, whose advantage is neutral knowledge representation, uniform structure, separation of knowledge from its processing and possibility of dealing with incomplete and uncertain knowledge, is planned to be compared with more flexible knowledge presentation systems, such as fuzzy logic (Zio et al.,), where fuzzy sets and fuzzy rules will be defined as a part of an iterative process upgraded by evaluating and tuning the system to meet specified requirements. Tuning will be the most delicate job whilst building a fuzzy system as fuzzy sets and rules should frequently be adjusted during the system's construction. The main goal for the system is to apply domain knowledge, including human cognition, relations and experiences in the knowledge base of the system, which will, together with the data base, serviceable for a complex reasoning procedure (Benzmüller et al., 2008) behind the inference engine leading to qualified design recommendations and guidelines for designing plastic products.

The work on user interface development is in progress as research team devote a special attention to this issue, in order to enable transparent and efficient system application. Two different application modes have been anticipated, in regard to the type of input and output data. Guided mode (question and answer) will be used mostly at the beginning, when the first set of parameters has to be presented to the system. During the data processing phase, the system may present additional questions or ask for more parameters. In this case, guided and graphic modes will be used to present the problem to the user. The solution in the final phase will also be presented in graphic mode.

7.1 Graphic environment of decision support system for designing with plastics

Characteristically for the designers is analytical thinking and when solving various engineering dilemmas they are used to study drawings, models, and simulations noticing all significant details. Virtual environment described in this section is one way of presenting plastic product design solutions to them in graphic mode as familiar working environment. Thus, it is expected graphic modes to be a part of future material selection decision support system applications.

Building the decision support system in graphic mode presented here aiming at a successful and efficient performance is a compound assignment. Research should be focused in human knowledge for problem solving formed as rules related to human cognition of modern plastic materials' selection and correlated manufacturing processes considering also DfM domain (Molcho et al., 2008). In addition, polymer material expertise together with human knowledge in the field of design process should fully be acquainted. In order to develop a graphic mode of plastic material selection decision support system, three major groups of polymer materials: thermoplastics, thermosets and elastomers, arranged in basic structure and presented in individual circles are proposed here (Fig.3). Within the framework of each circle several technical features carefully selected to cover all essential material properties, are assigned:

- Mechanical properties (strength, bending strength and working temperature),
- Production process (injection moulding, compression moulding, spin casting and extrusion),
- Chemical properties (resistance to base, acid, gas/oil, hot water),
- Working environment (internal/external use, fire resistance),
- Optical properties (colouring possibilities).

All three circles will have the same framework so the parameters, introduced to the system by the user will reflect through all of them. The system model will provide polymer material suggestions in discussed case, e.g. the designer receives four polymer material results, ABS, high density Polyethylene (PE), Polypropylene, and Polyamide, whose properties are introduced in the outer ring of the circle.

All design problems have a multitude of satisfactory solutions and almost never clear best solution. The significant feature of the system is two level results. The primary solution will be the possible plastic material choice, many of them or none. The database of the polymer materials will play the key role here. Afterwards, the system's knowledge base containing human cognition of plastic material selection and DfM will be of special importance as the system will be able to evaluate the candidates for potential material choices, which were just over the boundaries created by introduced parameters. Thus, some polymers are going to become a secondary solutions presented to the designer in form of notices containing recommendations about the advantages of each suggested solution. Considering the described decision support system with graphic mode, the enterprises will be able to compete at the global market by selecting the optimal material for their product. For the designers, especially for young and/or inexperienced ones, the plastic material selection decision support system is expected to be a helpful and indispensable tool as graphic mode is anticipated to be a familiar and comfortable environment supporting engineering work on large scale in years to come.

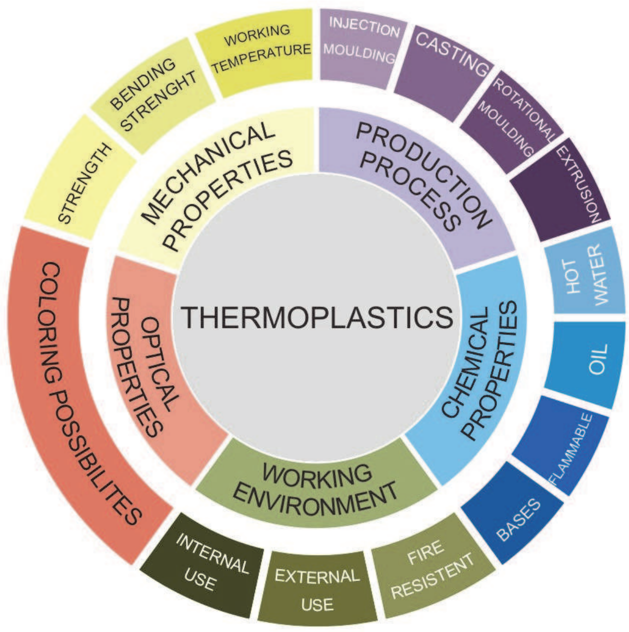

Fig. 3. Example of virtual environment for plastic material selection

8. Conclusion

Modern engineering work is computer dependent. Although computer tools assist the engineer during product development there are still limitations at offering some advice or recommendation at decision-making process. Designer's aim is to have as many optimal solutions as possible, meaning results on diverse queries from designing a product shape, defining its tolerances or choosing adequate material. Plastics are extensively present in everyday life. However it is not a trivial decision when selecting polymer material for a new product. Due to wide spectrum of plastics at disposal, the plastic material selection is about knowledge and experiences, where inexperienced designers are in thwart position at decision-making. SMEs' as well are sometimes kept in the background in case they do not possess the polymer engineer and are forced in hiring an expert. This chapter is an attempt of presenting the engineering dilemma at plastic material selection. Several system models with different applications on material selection are also introduced to enlighten the state-of-the-art in the field discussed. Future expectations from our side at decision support system for plastic products are also explained. This idea is then upgraded with application of graphic mode, which is expected to be added value to the system as designers will have the opportunity to work in reliable, user-friendly environment. Consequentially, the design process is anticipated to be faster, more efficient, and less experience-dependent.

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10. References

Alber, B., Rieg, F. & Hackenschmidt, R. (2007). Product Design with High-tech-polymers – Practical Use of CAE-tools with Cross-linked Simulations and Experimental Verification. *Materialprüfung*, Vol.49, No. 7-8, pp. 402-407, ISSN 0025-5300

Ashby, M. F. (2005). *Materials selection in mechanical design* (3rd ed.), Elsevier, ISBN 0-7506-6168-2

Ashby, M.F., & Johnson, K. (2005). *Materials and design*. Elsevier, ISBN 0-7506-5554-2

Askeland, D.R. & Fulay P.P. (2009). *Essentials of Materials Science & Engineering* (2nd ed.), CL-Engineering, ISBN 0-4952-4446-5

ASM International (2003). Characterization and Failure Analysis of Plastics, ASM International , ISBN 0-87170-789-6

Benzmüller, C., Sorge, V., Jamnik, M., & Kerber, M. (2008). Combined Reasoning by Automated Cooperation. *Journal of Applied Logic*, Vol.6, pp. 318-342, ISSN 1570-8683

Budinski, G.K. & Budinski, M.K. (2010). *Engineering Materials* (9th ed.), Pearson Prentice Hall, ISBN 0-13-610950-0

Chen, R.Y., Sheu, D.D., Liu, C.M. (2007). Vague Knowledge Search in the Design for Outsourcing Using Fuzzy Decision Tree. *Computers & Operations Research*, Vol.34, pp. 3628-3637, ISSN 0305-0548

Đurić, M., & Devedžić, V. (2002). I-Promise—intelligent Protective Material Selection. *Expert Systems with Applications*, Vol.23, pp. 219-227, ISSN 0957-4174

Edwards, K.L., & Deng, Y.-M. (2007). Supporting Design Decision-making when Applying Materials in Combination. *Materials & Design*, Vol.28, pp. 1288-1297, ISSN 0261-3069

Elsevier ed. (2010). Design Engineering Manual, Elsevier, ISBN 978-1-85617-838-9

Huang, G.Q. (Ed). (1996). *Design for X - Concurrent Engineering Imperatives*. Chapman & Hall, ISBN 0-4127-8750-4

Kim, I.S., Prasad, Y.K.D.V., & Stoynov, L.A. (2004). A study on an Intelligent System to Predict the Tensile Stress in Welding Using Solar Energy Concentration. *Journal of Materials Processing Technology*, Vol.153-154, pp. 649-653, ISSN 0924-0136

Kuo, T.-C., Huang, S.H., & Zhang, H.-C. (2001). Design for Manufacture and Design for 'X': Concepts, Applications and Perspectives. *Computers & Industrial Engineering*, Vol.41, pp. 241-260, ISSN 0360-8352

Kumar, S., & Singh, R. (2007). A Short Note on an Intelligent System for Selection of Materials for Progressive Die Components. *Journal of Materials Processing Technology*, Vol.182, pp. 456-461, ISSN 0924-0136

McMahon, C., Lowe, A., & Culley, S. (2004). Knowledge Management in Engineering Design: Personalization and Codification. *Journal of Engineering Design*, Vol.15, No. 4, pp. 307-325, ISSN 0954-4828

Molcho, G., Zipori, Y., Schneor, R., Rosen, O., Goldstein, D., & Shpitalni, M. (2008). Computer Aided Manufacturability Analysis: Closing the Knowledge Gap between the Designer and the Manufacturer. *CIRP Annals - Manufacturing Technology*, Vol.57, pp. 153-158, ISSN 0007-8506

Novak, M., & Dolšak, B. (2008). Intelligent FEA-based Design Improvement. *Engineering Applications of Artificial Intelligence*, Vol.21, pp. 1239-1254, ISSN 0952-1976

Palcic, I., & Lalic, B. (2009). Analytical Hierarchy Process as a Tool for Selecting and Evaluating Projects. *International Journal of Simulation Modelling*, Vol.8, pp. 16-26, ISSN 1726-4529

Sancin, U., Dobravc, M. & Dolšak, B. (2010). Human Cognition as an Intelligent Decision Support System for Plastic Products' Design. *Expert Systems with Applications*, Vol.37, No.10, pp. 7227-7233, ISSN 0957-4174

Sevstjanov, P., & Figat, P. (2007). Aggregation of Aggregating Modes in MCDM: Synthesis of Type 2 and Level 2 fuzzy sets. *Omega*, Vol.35, pp. 505-523, ISSN 0305-0483

Turban, E., Aronson, J.E., & Liang, T.P. (2004). *Decision Support Systems and Intelligent Systems*, Prentice Hall, ISBN 0-1304-6106-7

Ullah, S.A.M.M., & Harib, K.H. (2008). An Intelligent Method for Selecting Optimal Materials and its Application. *Advanced Engineering Informatics*, Vol.22, pp. 473-483, ISSN 1474-0346

Ullman, D.G. (2003). The Mechanical Design Process (3rd ed.), McGraw-Hill, ISBN 0-0723-7338-5

Valls, A., Batet, M., & Lopez, E.M. (2009). Using Expert's Rules as Background Knowledge in the ClusDM Methodology. *European Journal of Operational Research*, Vol.195, pp. 864-875, ISSN 0377-2217

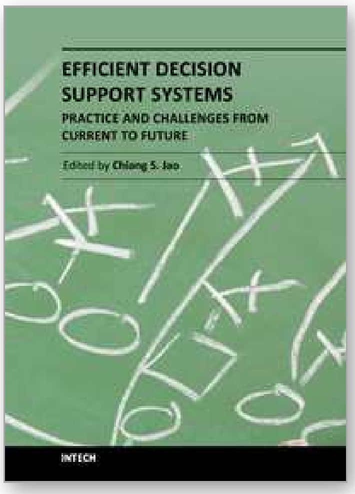
Vidal, A., Alberti, M., Ciurana, J., & Casadesus, M. (2005). A Decision Support System for Optimising the Selection of Parameters when Planning Milling Operations. *International Journal of Machine Tools & Manufacture*, Vol.45, pp. 201-210, ISSN 0890-6955

Vitanov, V.I., & Voutchkov, I.I. (2005). Process Parameters Selection for Friction Surfacing Applications Using Intelligent Decision Support. *Journal of Materials Processing Technology*, Vol.159, pp. 27-32, ISSN 0924-0136

Yilmaz, L. & Oren, T. (Eds.). (2009). *Agent-directed simulation and systems engineering*, John Wiley & Sons, ISBN 3-5274-0781-2

Zhu, F., Lu, G., & Zou, R. (2008). On the Development of a Knowledge-based Design Support System for Energy Absorbers. *Materials & Design*, Vol.29, pp. 484-491, ISSN 0261-3069

Zio, E., Baraldi, P., Librizzi, M., Podofillini, L., & Dang, V.N. (2009). A Fuzzy Set-based Approach for Modeling Dependence among Human Errors. *Fuzzy Sets and Systems*, Vol.160, pp. 1947-1964, ISSN 0165-0114



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