INTERNATIONAL DESIGN CONFERENCE - DESIGN 2010
Dubrovnik - Croatia, May 17 - 20, 2010.

DESIGN SPECIFICATION AND EVALUATION TOOL FOR DESIGN ENGINEERING AND ITS MANAGEMENT

S. Hosnedl, J. Dvorak, Z. Srp and M. Kopecky

Keywords: competitiveness, specification, tool, quality, evaluation, properties, life cycle

1. Introduction

The requirements of customers and society significantly increase the ever higher and higher requirements on quality, cost and delivery time of technical products. This consequently imposes higher and higher demands on quality and truncating of the engineering design process which substantially affects these products' competitive attributes as has been declared and proved many times, e.g. in [Opitz 1971], [Ehrlenspiel 2007] and many others. The outputs of the engineering design process distinctively influence not only ´visible´ functions or shapes of technical products but they also have a fundamental significance on their usable properties, safety, use of materials, manufacturing, maintenance, transport and other life cycle costs, delivery time and many other product properties. Thus without a doubt engineering design is the key stage of the life cycle of technical products, thus it is necessary to streamline it through the use of new and innovated knowledge, methodologies, tools etc. by implementing them from other processes of the life cycle of technical products. Therefore there are also permanently increasing demands on engineering design management.

There are many approaches, methodologies or tools which support the engineering design process with the aim of designing such a technical product/system, which occupies its right place on the market and becomes fully competitive. It is very important for a design engineer to find out/predict as soon as possible, for the designed products their (future) properties and from them the resulting competitive advantages or disadvantages (Strengths and Weaknesses) and to make prompt efforts to their timely improvement or their elimination if necessary. During endeavours towards quality and competitiveness of a designed product, other contentious issues are being revealed and there are hidden risks in product, project and organization. It is two years since we presented our paper [Hosnedl 2008a] at DESIGN 2008 and our approach regarding the developed and used software support tool for product design specification.

Our continuing research in the area of Theory of Technical Systems (TTS) and also fruitful cooperation with industry caused us to change traditional considerations about the role of product design specification. Put simply, we have spread its role to an explicit ('leading') and implicit ('embedded') management tool for a continuously property driven and evaluated engineering design process. This new concept has been utilized and validated in a number of interdisciplinary engineering and industrial design projects which have arisen in cooperation with prominent Czech industrial companies. The presented paper includes the TTS background and a substantially innovated software management and engineering design tool for support of Product Design Specification & Evaluation which has been implemented in MS Excel.

2. Theoretical background

For insight into the depth of the structure of the presented software support tool, the theoretical background of TTS is introduced in short this chapter. The overall concept of this system was introduced e.g. in [Hosnedl 2006]. It stems from close co-operation with Professors V. Hubka and W. E. Eder, and other members of the WDK Society and its successor the Design Society (from 2000). The last comprehensive version of our approach was published in [Eder 2008]. Some of the latest improvements, focusing mostly on the explicit and implicit management of design engineering activities are presented in this paper.

2.1 Technical System

'Technical system (TS) is a category of an artificial deterministic system that performs the necessary effects for transformation of the operands' i.e. of the transformed material, energy, information and/or living beings [Hubka 1988].

Product (technical as well as any other non- technical product) can [CSN EN ISO 9000, art. 3.4.2] after terminological 'harmonization' according to [Hosnedl 2007] take the form of the following generic categories/constituents:

- **Hardware (HW):** tangible formed/solid material (M) constituent (e.g. mechanical parts)
- **Formless-ware (FW):** tangible formless material (M) constituent (e.g. fillings, coatings, etc.)
- **Software (SW):** intangible information (I) constituent (e.g. information of any type)
- **Assistance-ware (AW):** service process (P) constituent (i.e. transformation process TrfP, provided independently of ownership of the transformed object)

Product can be understood and/or specified as an output of a process [CSN EN ISO 9000, art. 3.4.2], which corresponds to the term **Operand of Transformation Process (TrfP) in its Output State** [Hubka 1988, 1996], [Eder 2008]. This is a more general view, because Output of a Process, i.e. Operand, can consist of, in addition to the constituents mentioned above:

- **Energy-ware (EW):** energy (E) constituent (e.g. energy)
- **Living-ware (LW):** living (L) constituent (e.g. 'living beings'; of course the term cannot be generally used for ethical reasons).

Of course, many products comprise elements belonging to different generic constituents. Whether the product is then called hardware, formless-ware (processed material), software, assistance-ware (service), energy-ware (energy), or living beings depends on the dominant constituent.

Technical Product is a product with a dominant engineering content which usually serves as TS Operator (i.e. TS means) for a Transformation Process. Thus **Technical Product** (which stresses 'production view' in the 'practice realm') can be understood as a synonym for **Technical System** (which stresses 'system view' in the 'theory realm').

Here we will be focused for the sake of simplicity only on TS with dominant HW constituent, which however can also comprise HW elements carrying or enabling integration of the remaining FW, SW, EW and AW constituents. To specify, measure, compare and evaluate the designed as well as existing TS, we have developed and implemented the following general hierarchically consistent system for TS attributes and their indicators including the corresponding consistent taxonomy [Hosnedl 2008b].

2.2 TS Property

In this paper a **TS property** is understood as "any attribute or characteristic of a system: performance, form, size, colour, stability, life, manufacturability, transportability, suitability for storage, structure, etc. Every Technical System is a carrier of all properties, and their totality represents the value (comments of authors: i.e. total quality) of the system" [Hubka 1980]. It is obvious that a TS property is a cumulative criterion, i.e. (not elemental) a TS characteristic from a more general, but nevertheless specific "reasonable" viewpoint, which must be further indicated. Further synonyms for the phenomenon TS Property can be and are also being used e.g. attribute, characteristic, (design) parameter, (distinguishing) feature, quality, power, performance, etc. It will be outlined that the consistent use of the term TS property has its advantages in both engineering design theory and practical use including leading and embedded management.

2.3 TS Property Indicators

TS property of any kind is indicated (or characterized) by a set of measurable (not necessarily according to a numerical scale) elemental criteria (from 1 to n) which enable any TS Property to be specified, measured, compared and evaluated. The authors of the paper call these criteria **TS 'Property Indicators'** (which replaces originally proposed term '**Property Characteristics**') and have very good experience with its use in many theoretical and practical fields of design engineering, some of them were also introduced at the DESIGN 2008 Conference two years ago [Hosnedl 2008a]. These TS Property Indicators can be either assigned (established according to experience, intuition, availability, etc., e.g. TS appearance according to the ratio of main dimensions, compatibility of the colours used, etc., or normatively set (defined by laws, standards, etc., e.g. TS (car) safety according to strictly defined crash deformation, deceleration, space, etc. indicators).

2.4 TS Property Indicator Values

TS Property Indicators of any kind can be specified, "measured" and thus compared and evaluated by their one (direct) or more (indirect) 'Dimensions' (in its wider viewpoint, i.e. measurable not only numerically). 'Dimensions' of a TS Property Indicator, can be classified in terms of their measurement scales as follows:

- **Quantitative** Scales (and corresponding Dimensions):
  - Ratio (numerical): e.g. length, weight, duration, absolute temperature
  - Interval (numerical): e.g. relative temperature, relative time
- **Qualitative Ordinal** Scales (and corresponding Dimensions):
  - Ordinal numerical: e.g. Mohs scale of mineral hardness)
  - Ordinal (or weak order) textual: e.g. "hot, warm", "grades for academic performance"
- **Qualitative Nominal** Scales (and corresponding Dimensions)**:**
  - Nominal numerical: e.g. parts numbers on a drawing, sports player numbers,
  - Nominal textual: e.g. hammer, pincers, screwdriver

However, the problem arises of how to generally name concrete 'magnitudes' of dimensions corresponding to these miscellaneous scales. Except for the simplification of statements related to all the mentioned types of TS Property Indicators, the reason is that it is often impossible to predict/specify a concrete type of scale for many dimensions. Considering the fact that scales for any type of dimension can be expressed both textually (linguistically) and numerically (i.e. at least by relevant numerical codes, but very often also by physically reasoned numbers, e.g. by wavelengths of light for colours) or perhaps graphically, it is possible to generalize the term 'Value' for all types of the 'magnitudes' of dimensions (similarly, e.g. the term 'dimension' is frequently generally used both for numerical and non-numerical magnitudes in real life and even in mathematics).

Then any dimension of any TS 'Property Indicators' can be specified, measured, compared and evaluated by corresponding (either quantitative or qualitative) values using the established (assigned or normative) scales. Consequently a Value of a TS Property Indicators state can be specified/measured (directly or indirectly using other TS Property Indicators) by comparison using an appropriate scale. Of course more scales may be available for a particular TS property Indicator. 'Value of a TS Property' can then be thus specified, measured, compared and evaluated, etc. by the corresponding set of values of the corresponding TS 'Property Indicators', i.e. by values of their dimensions.

3. TS Behaviour

TS Behaviour is a **response of a TS Constructional Structure** to (an external or internal) stimulus. TS behaviour (i.e. response of a TS Constructional Structure) is thus specified by **changes of values** (of dimensions of characteristics) of **TS Elemental Engineering Design Properties** evoked by an

affecting (external and/or internal) **stimulus** (i.e. excitement). **TS Behaviour** (response) can be classified according to the changeability of the response and duration of the observation:

- **"Direct" static TS 'behaviour'** (response), e.g. value of a TS static strength, deformation shifts from static (constant in time) load (e.g. bending deformation shifts of a loaded beam, plastic deformation shifts caused by Brinell/Vickers/Rockwell hardness tests). This immediate static response is not usually called TS behaviour but only a '**TS static response**',
- **"Direct" dynamic (**both periodical and un-periodical) **TS behaviour** (response), e.g. changeable values of a TS dynamic strength, deformation shifts from dynamic (changeable in time) load (e.g. dynamic strength of a car loaded by dynamic forces, crash shifts of a car loaded by shock forces). This immediate dynamic response is usually understood as **TS behaviour** in its narrower sense.
- **"**(**Existence) life cycle" TS behaviour** (response), e.g. changeable values of TS dimensions, reliability, appearance, etc. on its static and dynamic "loads" (in its wider sense) during the "existence and liquidation phases" of the TS life cycle. This life cycle response is not usually called TS behaviour but only **changes/ageing of TS (properties) in its life cycle.**
- **"Historical (generalized 'class or family') TS behaviour"** (response), e.g. changeable values of TS dimensions, reliability, appearance, etc. on all "loads" (in its wider sense) during historical development of a TS class or family in time (e.g. a historical series of SKODA cars). This historical long-term generalized response (to "historical, technical, social, economic, laws, etc. loads") is not usually called TS behaviour but only **historical development of a TS class/family** (generalized properties/property characteristics).

TS Behaviour (response) can be either (more or less precisely) ascertained/predicted using relevant simple or sophisticated computer "Predictions/Simulations of X" PoX/SoX methods or it can be experimentally measured on models of the designed TS, or on an existing TS to determine the behaviour and/or check it. To summarize, we can conclude that TS behaviour also belongs under the "umbrella" of TS reactive (see Section 4) properties, but the corresponding (immediate, short, or long-term course of) load (in its general sense) has to be simultaneously specified (by its magnitudes within the active space and time). Load magnitudes can be specified in a similar way to TS Properties by values of the set of the respective Load Property Indicators. TS Reactive Properties are understood in this wider sense in the following sections.

4. Taxonomy of TS Properties

A consistent, comprehensive system of the TS Properties classification elaborated on the basis of Professor Hubka's and Professor Eder's fundamental works on the Theory of Technical Systems, within the framework of Engineering Design Science [Hubka 1988, 1996] and using the hierarchical system for TS Properties specification introduced above and generally depicted in Figure 1 and in a simplified example in Figure 4 is briefly characterized in the following subsections.

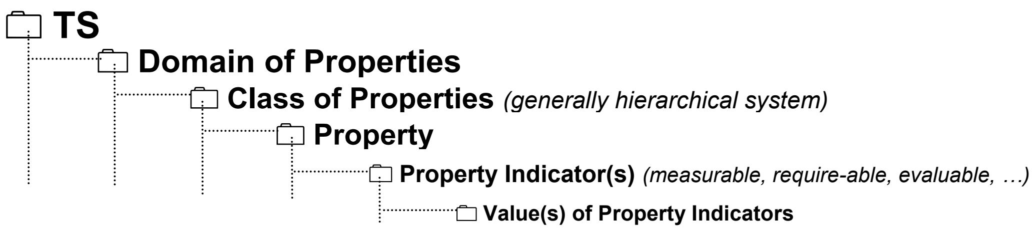

Figure 1. Hierarchical taxonomy system for specification of any TS Property

4.1 Domain and Classes of the Descriptive TS Properties

Domain of TS Properties which characterizes and specifies (i.e. "describes") TS Structure.
This domain can be axiomatically structured into **two classes** [Hubka 1988, 1996], [Eder 2008]:
Elemental Engineering Design Properties of TS:
Class of TS Properties which fully describes/specifies the TS Constructional Structure.

Feature (Intrinsic) Engineering Design Properties (Characteristics) of TS:
Class of TS Properties which describes/specifies the features of TS Constructional Structure and its use in Operation Process.

4.2 Domain and Classes of Reactive TS Properties

Domain of TS Properties covering **General Engineering Design TS Properties** characterizes and specifies topologically internal reactions of the TS Constructional Structure to applied (external and/or internal immediate, short and long term) effects/stimuli. This domain can be split into respective **classes corresponding to the relevant natural science** which studies them [Hosnedl 2008b].

4.3 Domain and Classes of Reflective TS Properties

Domain (of Classes) **of TS Properties,** which characterizes and specifies topologically external active and/or reactive "reflections" of TS on (set of values of characteristics of) Descriptive and Reactive Properties of TS Constructional Structure. TS Reflective Properties thus have to mirror TS in its whole Life Cycle. Separation of the respective TS life cycle stages could be made according to the different standpoints e.g. place of realization, finance provider, etc., however from the viewpoints of design and development of technical products it has been found and proved that it is optimal to structure them according to the dominant life cycle transformations, i.e. transformation processes (TrfP).
By using the General Model of the Transformation System (TrfS) [Hubka and Eder 1988, 1996], [Eder 2008] with its Transformation Process (TrfP) it is possible to depict a transparent **General Model of TS Life Cycle** [Hubka and Eder 1988, 1996]. (Figure 2). Such a model has been found to be an advantageous means of achieving 'total' and effective structuring of **TS Reflective Property Classes** (Figure 3) which are further split into product invariant **TS Reflective Property Sub-Classes**. The introduced concept is still in the process of continuous improvements to be more simple and user friendly for use in education and practice as presented in this paper.

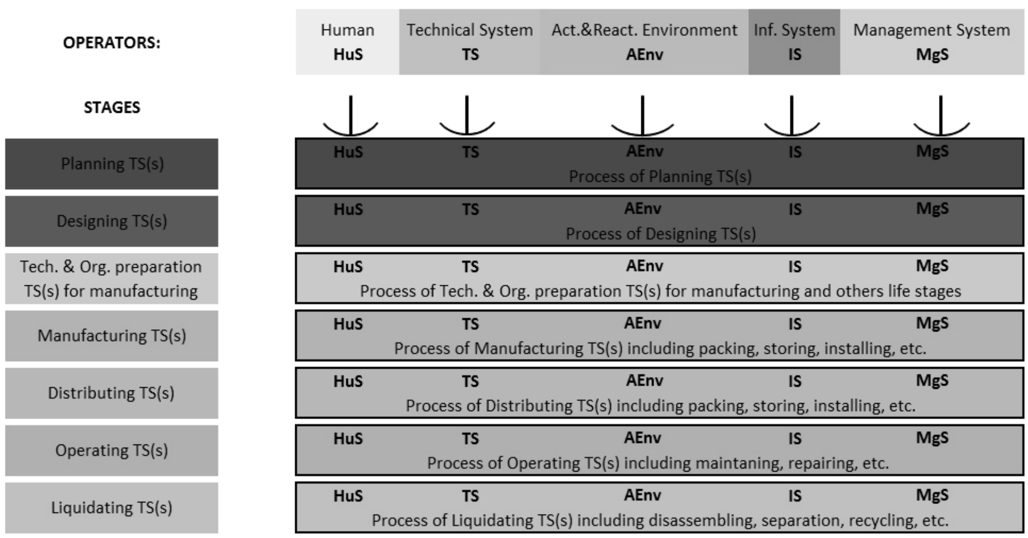

Figure 2. Simplified Model of TS Life Cycle
(TS(s) depicts TS subjected to the shown TS(s) Life Cycle Stages)

5. TS Quality

Quality is defined according to [CSN EN ISO 9000] as a level of fulfilling requirements by a set of inherent characteristics. From it follows that this concept also implicitly comprises a degree of quality. We understand TS Quality more generally in concordance with the philosophical category (in contradiction to Quantity) as a set of required inherent TS properties which represent a view (i.e. criteria for evaluation) of a TS evaluator. Thus TS Quality is defined by posed and judged requirements on inherent TS properties. From it e.g. follows that (TS) Quality is not made by the "highest" technical level of TS (which however represents the "State of the Art" for a considered TS field) or that it is not exclusively specified by a direct user (i.e. 'customer' in a very narrow sense) as very often understood and even stated. Along with a set of considered (specified/required) TS properties we can thus distinguish a number of different kinds of TS quality (and corresponding values of TS Quality), e.g. as follows:

Specified/required properties in TS Life Cycle ⇒ **Sort of TS Quality:**

- "only production" related ⇒ "**Pr**oduction" $\mathbf{Q_{Pr}}$
- "only direct usage/customer" related ⇒ **"**Customer – **small Q"** **q**
- "all" usage, cost and time related ⇒ **"T**otal **L**ife **C**ycle**"** $\mathbf{Q_{LC}} = Q_{TLC}$

- "all" usage related: ⇒ **"L**ife **C**ycle**"** $\mathbf{Q_{LC}}$
- "all" usage related before delivery to a customer ⇒ "**B**efore **D**elivery" $\mathbf{Q_{BD}}$
- "all" usage related after delivery to a customer: ⇒ "**A**fter **D**elivery" $\mathbf{Q_{AD}}$
- "chosen" from all usage related: ⇒ "**J**udged" $\mathbf{Q} = Q_{(J)}$

These "sorts" of quality give a general view of the evaluation of different kinds of TS Quality through its whole life cycle. As far as we know a uniform comprehensive taxonomy regarding these and other sorts of Quality has not yet been established, however some of them are presented or at least implicitly understood as "the only" TS Quality.

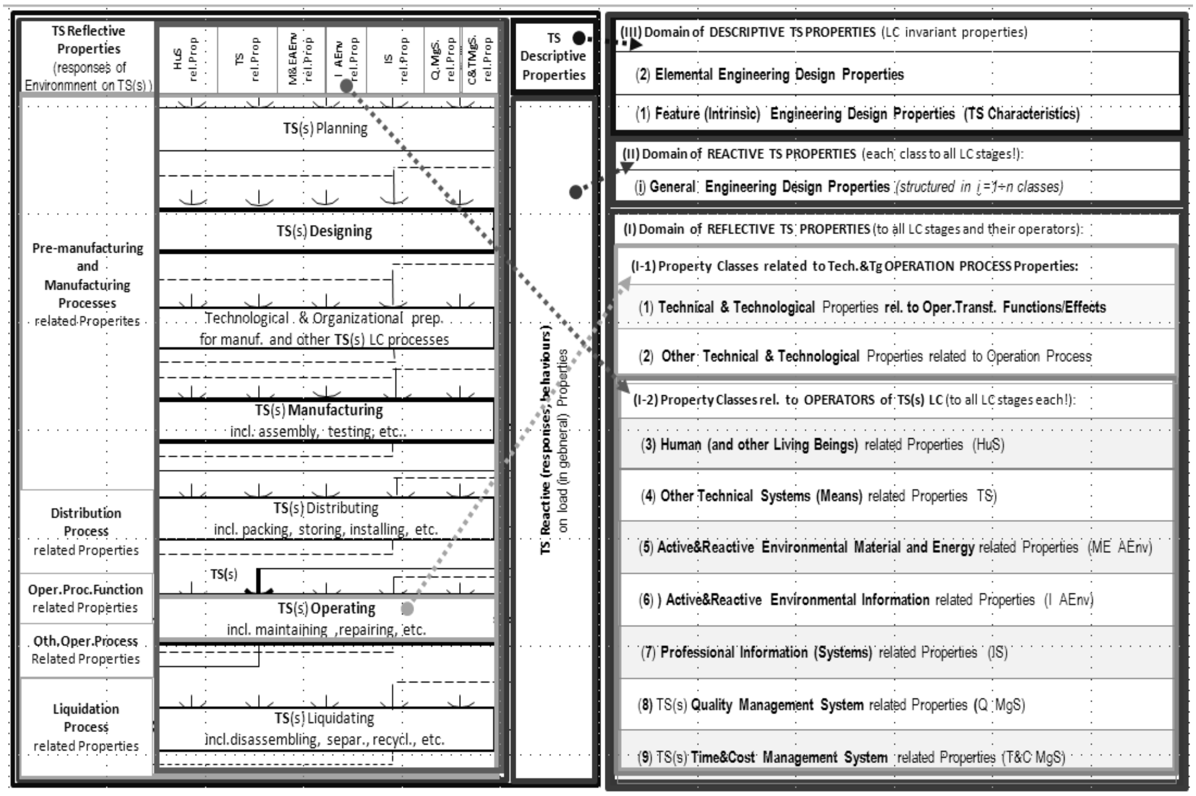

Figure 3. Relationships between TS Life Cycle and TS Property Domains with their Property Classes according to the stated principles

6. Software tool

As introduced above a software programme in MS Excel has been developed to support engineering design specification and continuous evaluation of designed technical products based on the above outlined theory and experience. In the first phase of the engineering designer process it is necessary to carefully specify 'all' requirements which will be imposed on the designed TS during its whole Life Cycle and to predict quality of their fulfilment during the whole engineering design process. As outlined above there are not only customer´s assigned requirements which it is necessary to consider.

As is generally known, any TS has to satisfy not only assigned and other stated requirements, but also a number of other obligatory and generally implied requirements [CSN EN ISO 9000]. A carrier of all TS properties which should primarily fulfil these requirements is a TS constructional (component, anatomic) structure.

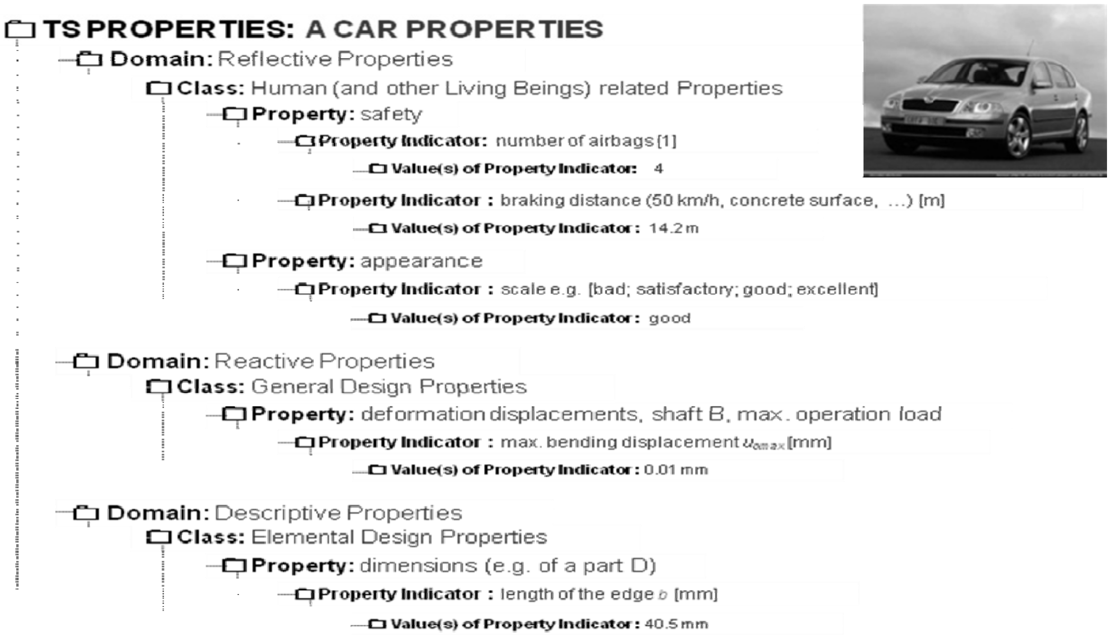

Figure 4. Principle of a general hierarchical system for Specification and Evaluation of all TS Properties and their Indicators – examples for a car

The establishment of a TS structure is obviously under the full responsibility of engineer designers. Of course a close cooperation with other experts or 'at least' use of their knowledge to achieve and evaluate a number of special required TS properties is mostly necessary. However, engineering designers are responsible for converting their own and the experts' knowledge and experience to establish, as far as possible, an optimal final TS constructional structure.

To support the specification of all potential requirements the SW enables requirements to be specified on Values of Indicators of TS Properties transparently structured as outlined in Section 4, which is roughly depicted in Figure 5. The requirements are, for the sake of the following (simplified) evaluations of engineering design competitiveness of the designed TS, split into 'After Delivery'(AD) and 'Before Delivery' (BD) TS Life Cycle fields. For practical reasons the AD field is further divided into the key requirements to the Class of Technical and Technological Properties related to the Operation Process (Figures 2 and 3) which is located on SW Sheet 1 (Figure 5), and into the remaining AD field which is structured into requirements to TS Property Classes related to the respective Operators (Figures 2 and 3) and AD stages (Operating and Liquidating) which is located on SW Sheet 2 (Figure 5).

The complementary BD field is advantageously structured as the previous one into requirements to TS Property Classes related to the respective Operators (Figures 2 and 3) in the BD Stages (Pre-manufacturing, Manufacturing and Distributing) which are also located on SW Sheet 2 (Figure 5). Of course both AD and BD fields also enable relevant requirements to be filled in on Reactive and/or Descriptive TS Properties which generally belong to the designers realm, however it is not generally possible to restrict any stated, obligatory and/or generally implied requirement of this kind to anybody.

In the first phase of designing, a SW user(s) collects and completes all relevant assigned, obligatory, and generally implied requirements on the designed TS belonging to the respective TS Property Classes and obtains a clearly organised product design specification document which is usually called the List of Requirements.

In the next phases he or she can first insert the corresponding stated weightings of the respective of the considered TS property indicators and then fill in their respective required values as well as existing values for an existing former company product marked here TS0 and (default two marked TSA and TSB) competitive products, (if any), and step by step the predicted values for the concretised designed TS (default two marked TS1 and TS2). The resulting both partial, subtotal and total weighted evaluations for the respective criteria are then automatically calculated and represented in a form of diagrams as outlined in the following.

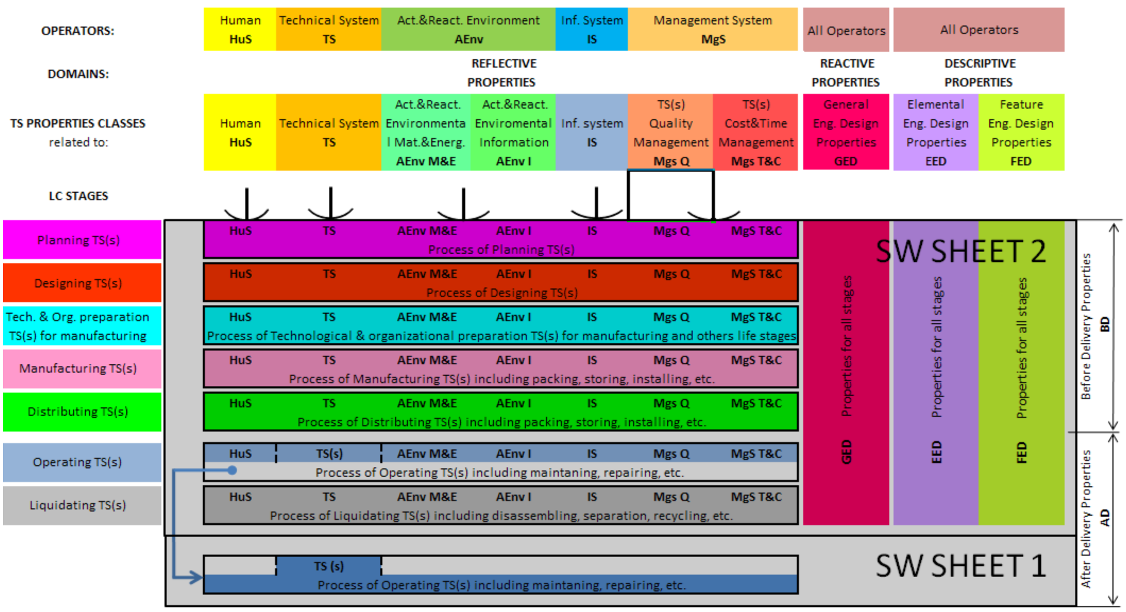

Figure 5. Structuring of TS Properties and corresponding requirements in SW Design Specification and Evaluation tool (TS(s) depicts TS subjected to the shown TS(s) Life Cycle)

At first the SW tool provides user(s) with on-line graphic representation of the resulting weighted evaluations for any mentioned Class of TS Properties and mentioned compared Technical Products as depicted e.g. in Figure 6.

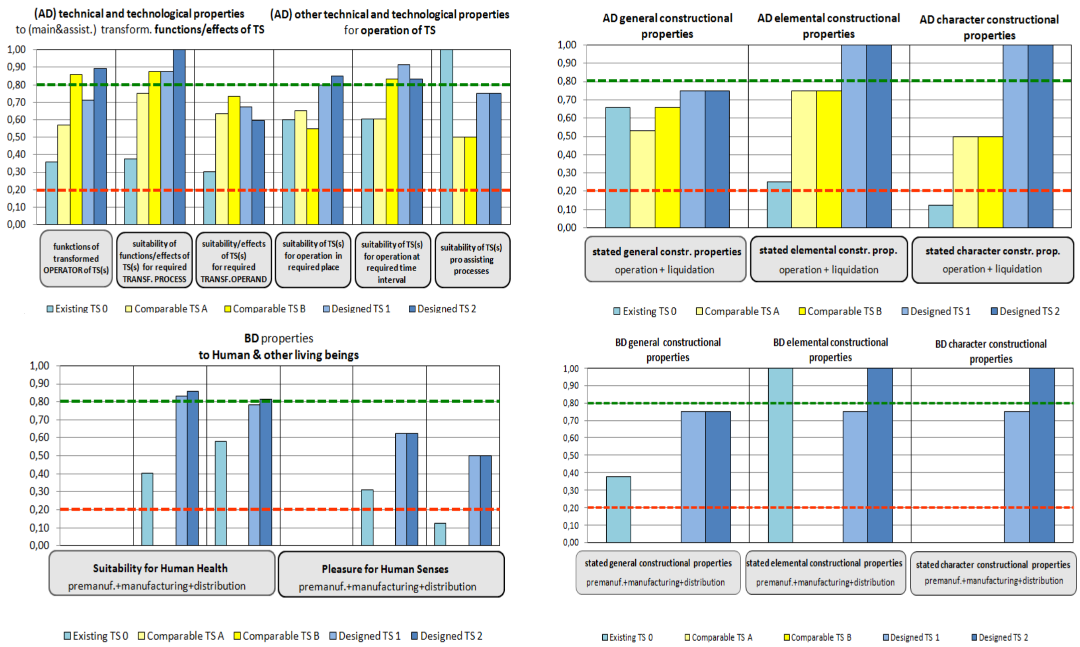

Figure 6. Examples of diagrams of evaluation of fulfilment of the specified requirements on the respective Property Classes by designed and other compared Technical Products

Next, data processing provides SW user(s) with sum values and on-line diagrams showing resulting evaluations of the “Total Life Cycle” constructional quality Q_{TLC} (of the TS constructional structure) for the compared own TS (Figure 7, left), and of the “After Delivery” constructional quality Q_{AD} (of the TS constructional structure) for all the compared TS (Figure 7, right). These results support evaluation of fulfilment of AD and AD&BD requirements by the compared technical products. In general Q_{TLC} can also be evaluated for the competitive products (here TSA and TSB), but only if values of their BD Properties are available, which is not often.

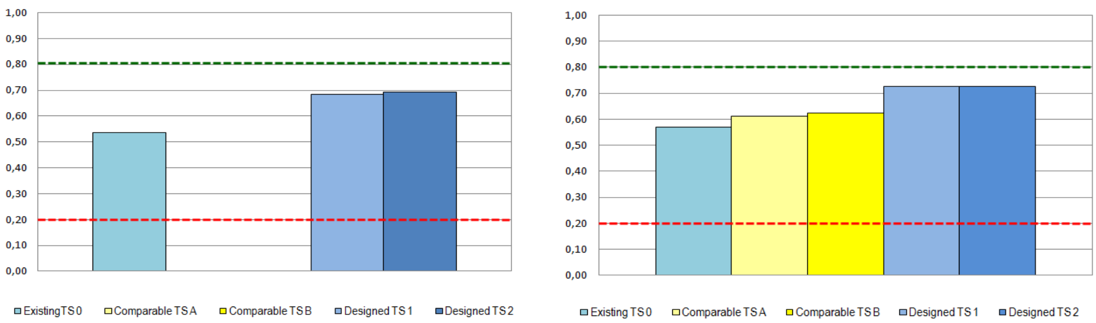

Figure 7. Diagrams of evaluation of the “Total Life Cycle” quality Q_{TLC} (left) and “After Delivery” Quality Q_{AD} (right) of the designed and other compared Tech. Products

After input of some essential business data and weighting relevant to prediction of the delivery Quality (which is considered here for simplicity **Q** = $Q_{(J)} \approx$ **Q_{AD}**), Cost (**C**) and Time (**T**) in the next SW Q-T-C Sheet (Figure 8) the SW provides user(s) with evaluation and in the two dimensional “3D diagrams” supporting analyses of the mutual constructional competitiveness of the compared Technical products (TS) regarding the three previously mentioned criteria (Figure 9). TS constructional competitiveness is understood as a potential competitiveness of the constructional structures of the compared Technical Products (TS) without considering not yet known manufacturing, market, marketing and other factors.

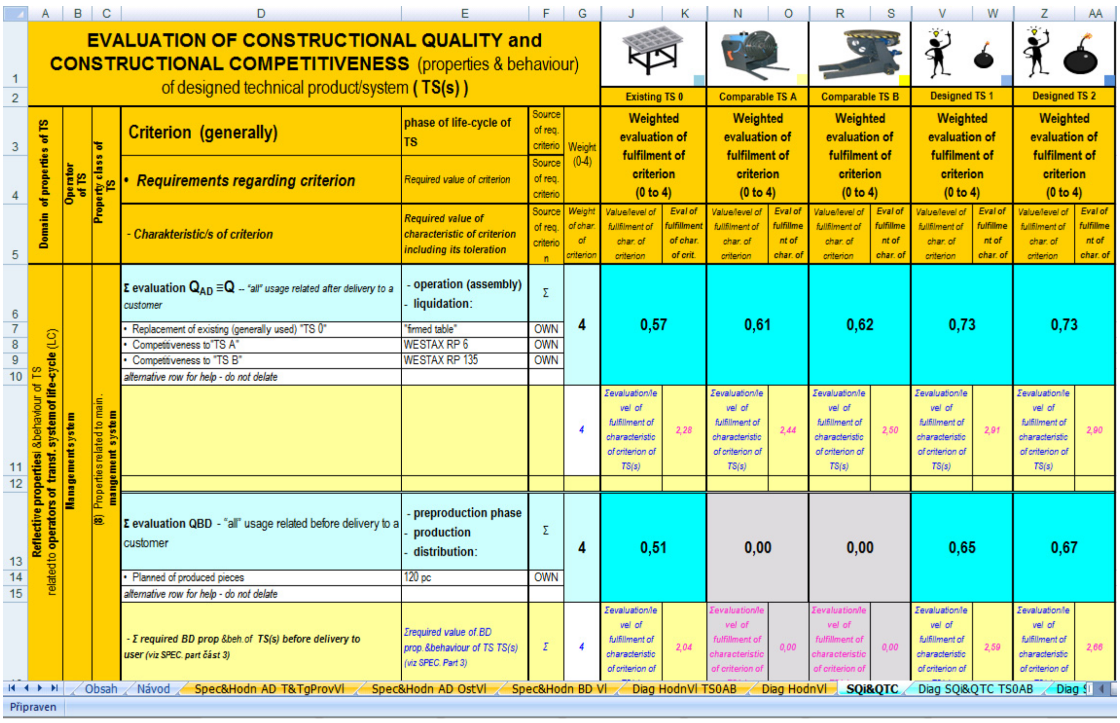

Figure 8. Q-T-C sheet (part) for Business Requirements and Evaluation of the Constructional Quality and Competitiveness of the designed and other compared Technical Products (TS)

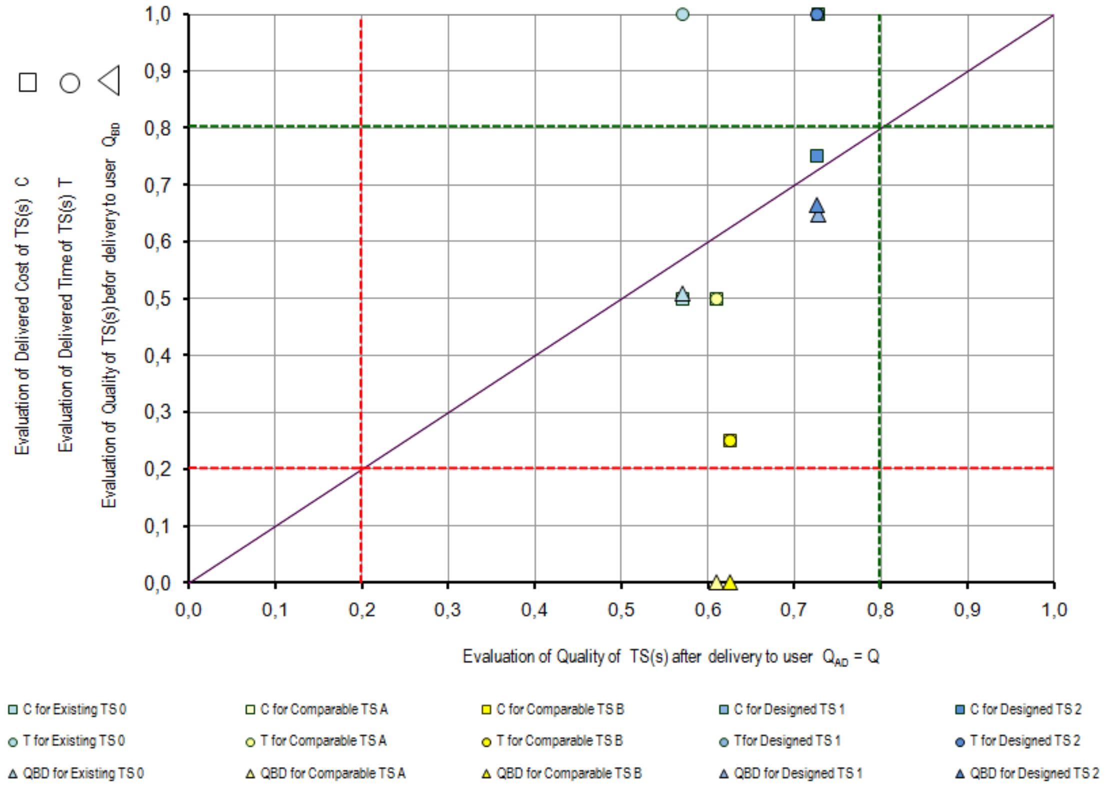

Figure 9. Diagram for evaluation of the constructional competitiveness of the designed Technical Product compared to other existing and compared Technical Products

All evaluation diagrams are split by red and green lines (as depicted on examples in Figures 6, 7 and 9). Values above green lines roughly indicate TS Strengths and vice versa values below red lines indicate TS Weaknesses from the viewpoint of the corresponding criteria (i.e. either corresponding TS Property Class, TS Quality or TS Constructional Competitiveness respectively) and thus creates also a basis for risk analyses. It efficiently supports demanding evaluations and minimises danger of evaluation mistakes.

7. Conclusions

The presented engineering design and management SW tool which stems from the consistent system of the Theory of Technical Systems (TTS) [Hubka 1988] has been proved to help both experienced and novice engineering designers and engineering design project managers to manage and execute their interdisciplinary creative teamwork and continuously evaluate and document results of their work more efficiently. This therefore supports the achievements of the required designed product at a higher quality, lower cost and with a shorter delivery time, which results in an increase in the engineering design competitiveness of the designed product and improves its chances of succeeding in the market place. The approach presented here has been successfully verified in comparison with other published analogous systems [Pahl 1995, Pugh 1991, Roozenburg 1995, etc.] in the world and validated in a number of very different engineering design applications for industrial partners.

The advantage of TTS based engineering design and management tools has been especially proved during a number of interdisciplinary students' projects (e.g. in Figure 10), which have been appreciated not only by the teachers and students involved but especially by the participating industrial and research partners. The tools have been successfully utilised for both external management of these projects and internal team management and executive engineering design activities.

Some of these tools have already been taken over and implemented by our industrial partners. In addition to these benefits, this strategy has also proved to have a high pedagogical value. Students brought into interdisciplinary teams and using the presented tools are able to understand the general

Some of these tools have already been taken over and implemented by our industrial partners. In addition to these benefits, this strategy has also proved to have a high pedagogical value. Students brought into interdisciplinary teams and using the presented tools are able to understand the general approach, priorities and aims of the design work very easily. It has enabled us to validate it and to gain quite a large experience of management of these student projects. Students who used this SW tool also reached a lot of pure new solutions, and some of them have already obtained the certificate of Utility Model published by the Industrial Property Office of the Czech Republic in Prague.

Figure 10. Examples of results of integrated engineering and industrial design projects using the presented SW tool for specification of requirements on designed TS and continuous evaluation of their fulfilment during designing

Acknowledgements

This paper includes results from Project No. 402/08/H051 Optimizing of multidisciplinary designing and modelling of production systems subsidised by the Czech Science Foundation and from Project SGS-2010-049 Complex support of design engineering of technical products to improve their properties and competitiveness subsidised by the Czech Ministry of Education.

References

Autorsky zakon, 121 Sb (Authorial Law, 121 Coll., in Czech.). April 2000 (Praha)

CSN EN ISO 9000 (idt ISO 9000:2005 - Czech version of the European Standard EN ISO 9000:2005 Quality management systems – Fundamentals and vocabulary. 2006 (Czech Institute for Standardization, Prague)

Eder, W. and Hosnedl, S. Design Engineering, A Manual for Enhanced Creativity. 2008 (CRC Press, Taylor & Francis Group Boca Raton, Florida USA)

Ehrlenspiel, K. , Kiewert, A., and Lindemann, U. Cost-Efficient Design. Berlin Heidelberg: Springer-Verlag, 2007. ISBN 10 3-540-34647-3, ISBN 13 978 3-540-34647-3

Hosnedl, S. "Hardware, Software, Processed Materials and Services as Consistent Elements of a Designed Technical Product". Proceedings of the 16th Int. Conf. on Engineering Design - ICED 07, 2007, Ecole Centrale Paris, Paris, 2007, pp 749-750

Hosnedl, S. and Vanek, V. Engineering Design Science based Design Research for Education and Practice. In: Special Issue of the Selected Articles (4 Best Paper Awarded and 10 being come up for the Best Paper Award) of the 1st Conf. on Design Engineering and Science – ICDES2005. Tokio: Japan Society for Design Engineering, 2006, p. 31-36

Hosnedl, S., Srp Z., Dvorak, J. Cooperation of Engineering & Industrial Designers on Industrial Projects. In: Proceedings of the DESIGN 2008 - 10th International Design Conference. Eds.: D. Marjanovic et al. Dubrovnik, Croatia, 19 – 22. 5. 2008, p. 1227 – 1234 [Hosnedl 2008a]

Hosnedl, S., Srp, Z. and Dvorak, J. Technical Products and their Attributes – Theory and Practical Applications. In: Proceedings of the 11th Applied Engineering Design Science Workshop - AEDS 2008. Pilsen, 31.10.-1.11. 2008. p. 109 – 120 [Hosnedl 2008b]

Hubka, V. and Eder, W. E. Design Science. 1996 (Springer-Verlag, London)

Hubka, V. and Eder, W.E. Theory of Technical Systems. 1988 (Springer-Verlag, Berlin Heidelberg)

Hubka, V. Fachbegriffe der wissenschaftlichen Konstruktionslehre in 6 Sprachen (Professional Terminology for Engineering Design Education in 6 languages). Schriftenreihe WDK 3. 1980. (Heurista, Zuerich)

Opitz, H. Moderne Produktionstechnik Stand und Tendenzen, Verlag W.Girardet, Essen 1971, ISBN 3773609981, 565 pp

Pahl, G., Beitz, W. Engineering Design, A Systematic Approach. London: Springer, 1995. ISBN 3-540-19917-9

Pugh S. Total Design. Integrated Methods for Successful Product Engineering, 1991 (Addison-Wesley Pub)

Roozenburg, N. F. M., Eekels, J.: Product Design: Fundamentals and Methods. Chichester, UK: Wiley, 1995, ISBN 0-471-94351-7

Stanislav Hosnedl, Professor, Dr. - Ing.
University of West Bohemia, Faculty of Mechanical Engineering
Department of Machine Design
Univerzitni 8, 306 14 Pilsen
Telephone: +420 377 638 266
Telefax: +420 377 638 202
Email: hosnedl@kks.zcu.cz