INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

DESIGN 2004

TRANSFER OF KNOWLEDGE AMONG DIFFERENT BRANCHES WITH USE OF THE THEORY OF TECHNICAL SYSTEMS

J. Formanek and S. Hosnedl

Keywords: engineering design, technical systems, methodology, CA technology

1. Introduction

The objective of knowledge transfer is, among others, transfer of ideas and information about technical products – technical object systems (TS) and their components among different technical branches. At present new possibilities based on Engineering Design Science have arised for knowledge transfer methodology when designing new TS, which has similar or the same required properties including functions as technical systems within the same or different 'source' branch or branches.

2. The objectives and characteristics of the developed methodology of knowledge transfer

The objective of the developed methodology of knowledge transfer is generally a transfer between branch A and branch B, e.g. from the area of production machinery to the area of transport machinery. A broad aim is to support knowledge transfers among "any" technical branches. Its theory [Formanek 2001] comes out from knowledge of Engineering Design Science [Hubka 1996]. The result are applicable both for new and also for innovated technical systems.
This methodology allows to increase the efficiency of design engineering including the enhancement of knowledge of engineering designers. At the same time it brings new knowledge to the respective technical branches, which can be effectively processed by database technology. Several case studies have been performed in order to prove the applicability of this methodology among different product branches. As an example the knowledge transfer from the areas of handling devices of manufacturing machines and the reception devices for signal from TV satellites to the area of health devices was performed. This example has been worked out as real functional model to prove the applicability of the developed methodology [Formanek 2001].

3. Introduction to the theory

The traditional transfer of knowledge related to machine components is a well known concept at present. A wide range of different catalogues, cards, databases etc. have been developed and used for this purpose. These support the selection of an appropriate machine component, e.g. selection of hydraulic or pneumatic components, for the TS to be designed. This selection depends mainly on the abilities of the engineering designer. However, the problem of knowledge transfer among different branches can be aimed not only to select a suitable component from catalogue but also to use and transfer the function of a certain component or to transfer functional principle from one TS to another.

4. General knowledge transfer

The developed methodology of knowledge transfer is based on general knowledge transfer among respective engineering design fields [Hubka 1996]. Model of such transfer with support of the generalised Transfer Box (TrB) interface is based on fundamental structure of the Engineering Design Science knowledge (Fig.1). Generally said the knowledge transfer of the relevant knowledge can be performed from branch X to branch Y or to another branches (including feedbacks to source branch X). Of course the transfer can be vice versa also executed from several branches to a single one.

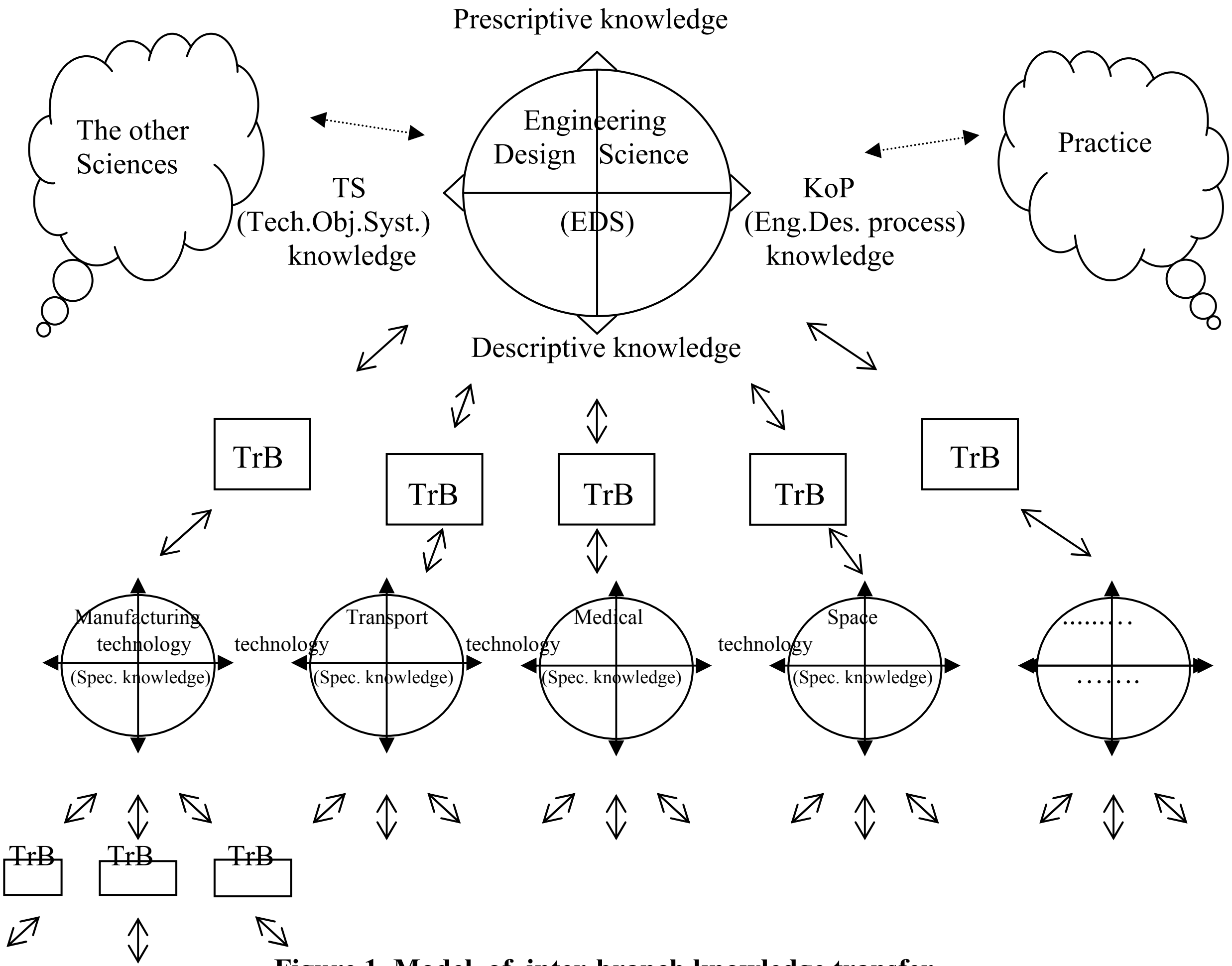


Figure 1. Model of inter-branch knowledge transfer

During the knowledge transfer it is necessary to include also human´s own knowledge and at the same time to enhance these knowledge using feedback or to use SW expert systems, to add new knowledge to these systems. Thus such enlarged knowledge transfer contributes more to the complex upgrading of all its involved elements.

5. Applied knowledge transfer

5.1 Basic structure of knowledge transfer

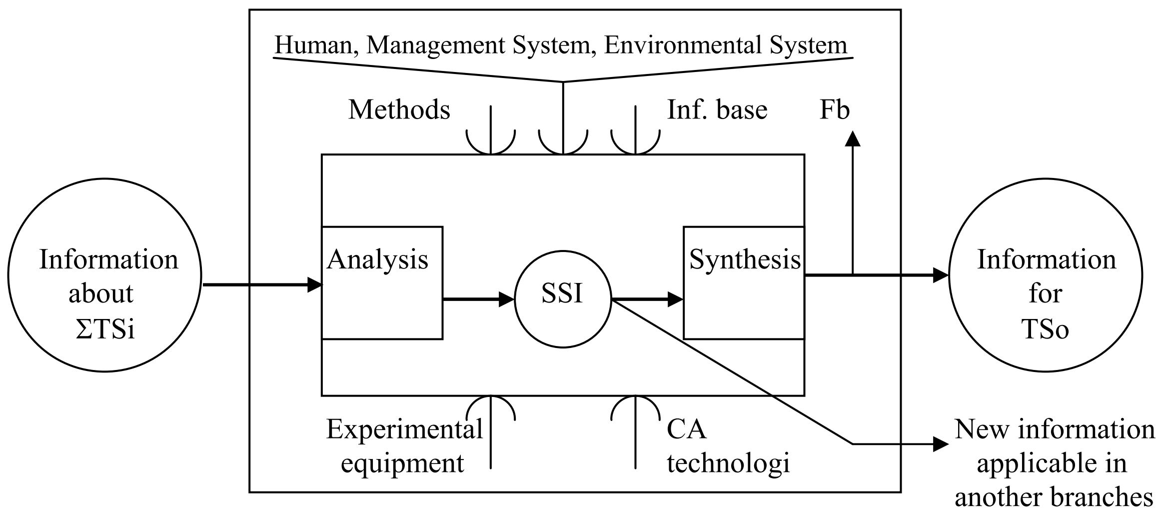
The developed methodology of knowledge transfer is based on the published concepts of transformation processes, technical systems, and other models from the Theory of Technical Systems [Hubka 1996]. In accordance to the general procedural model for design engineering of TS, general model of design engineering with use of knowledge transfer can be expressed as follows:

1. Arise of a need of TS (branch A)
2. Specification of the problem (problem analysis and assignment)

3. Searching for solutions including the knowledge transfer from branches (A...X)
4. Evaluation of properties of the established constructional TS variants and decision making (selection of optimal variant)
5. Elaboration of documentation
    a. Elaboration of documentation about designed TS
    b. Elaboration of the obtained knowledge (to database system)

5.2 Model of transformation system for knowledge transfer

A model of Transfer Box (TrB) for knowledge transfer (based on the model of transformation process) has been introduced for this purpose. This Transfer Box can be understood as an information process interface between knowledge on TS_i and TS_o. This interface can be divided into three steps: *analysis – structured set of information about TS_i (SSI) – synthesis.* The entire model of the transformation system related to the knowledge transfer is depicted in Fig.2.



Information about ΣTS_i	– information about ΣTS_i from a specific branch
Analysis	– analysis of information on the ΣTS_i
SSI	– structured set of information about constructional elements of ΣTS_i
Synthesis	– synthesis of information needed for TS_o
Information about TS_o	– information about designed TS_o
Fb	– feedback information for management of TrB

Figure 2. Model of knowledge transfer as Transformation System

This model consists of the mentioned transformation process – Transfer Box (TrB) and transformation operators – Human, Technical means (both CA and experimental), Information system (both descriptive and prescriptive), Management System and Environmental System. This transformation system enables to obtain in the first step (using analysis of the constructional structures of the source ΣTS_i) the information descriptions of the relevant constructional parts. This information is then stored into the SSI database. The information items are structured here in a form of a morphological matrix according to respective organs (carriers of functions), which serve as addresses to retrieve respective constructional parts again in the following step. This enables to obtain by synthesis with support of the SSI database the required information for design of constructional structure of a new TS_o or for redesign of the constructional structure of the existing TS_o.

5.3 Hierarchical structure of the transfer processes within TrB

However, the knowledge transfer can be performed not only at the level of constructional structure, but also on the level of organ or functional structures as shown in Fig.3.

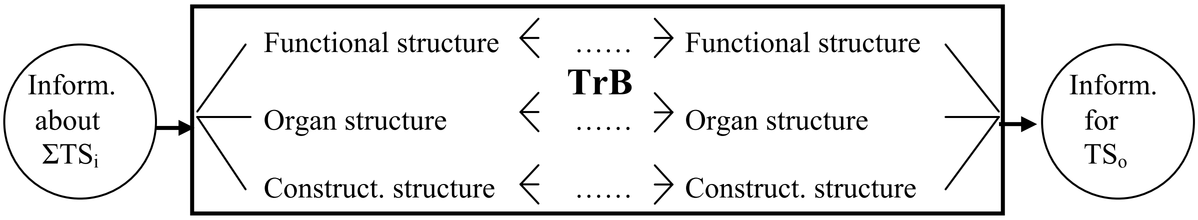


Figure 3. Hierarchical structure of processes within Transformation Box

The analyses of the ΣTS_i can be then executed with use of the mentioned morphological matrix from the level of constructional structures (elements&organs), through the level of organ structures (organs&functions) to the level of their functional structures (functions&effects). The reverse procedure can be applied for synthesis from functional level through the organ level to the constructional level. The system of these morphologic matrices is depicted in Fig.4:

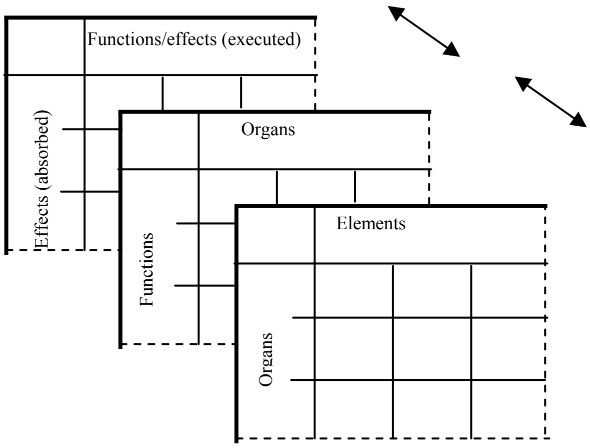


Figure 4. Morphological matrices for different abstract levels of TS structures

After analysis and completion of morphological matrix at all these abstract levels for ΣTS_i available, this matrices can be further improved by the next information items, which result from the following analyses of ΣTS_{i+j} or from experience of designers in the source areas as shown in Fig.5.

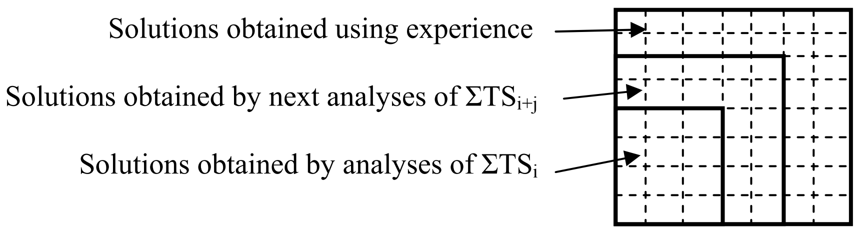


Figure 5. Principle of hypermorphologic matrix growth - adding information about the known solution

Thus multidimensional matrix, called a hypermorphological matrix (Fig.6) can be build in this way. This matrix includes a system of information items about analysed functional, organ and constructional elements. Using this matrix it is possible to retrieve any suitable elements for the TS_o to be designed according to the stated requirements.

This systematic hypermorphological matrix can be effectively processed using CA technology. It is prepared the development of SW system to support creative activities of engineering designers in this way. This SW system could be then connected to internet, to engineering database system or to another SW system to increase further the effectiveness of its use.

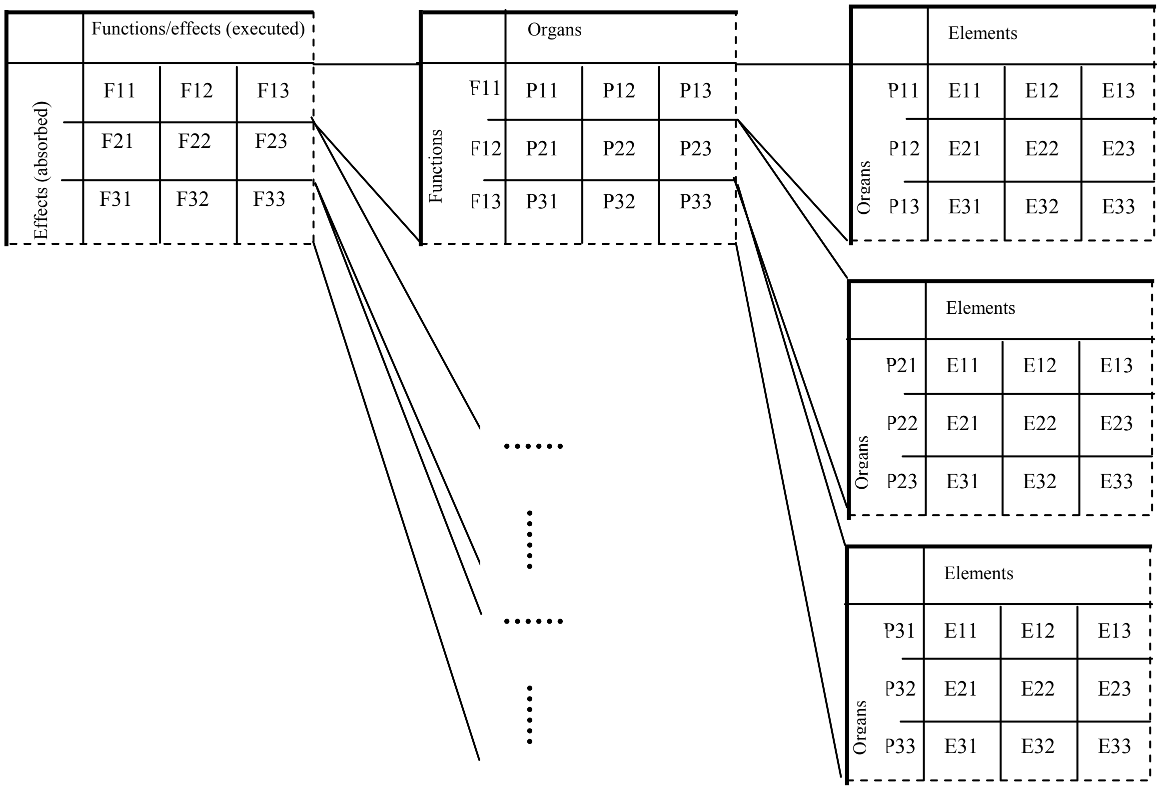


Figure 6. Principle of decomposition of hypermorphological matrix of functions&effects(performed) to the matrix of organs&functions and to the matrix of elements&organs

6. Case study

As mentioned above the developed methodology of knowledge transfer has been piloted on the engineering design of the electronically controlled feeder for disabled people using the area of manufacturing manipulation devices and of satellites TV as a source ones. When the complex analyses of the ΣTS_i available and SSI database have been completed the transfer of the required set of information to the area of health devices as in our case have been performed.

After engineering design of the feeder and subsequent evaluation of its components, an experimental model (Fig.7) has been manufactured and tested (Fig.8). Functional tests, were aimed at keeping and handling lightweight objects such as ballpoint pens, drawing aids, etc. These fully proved the functionality and capability of the feeder to perform all functions, which are required by its disabled user.

Figure 7. Overall view of functional model of feeder

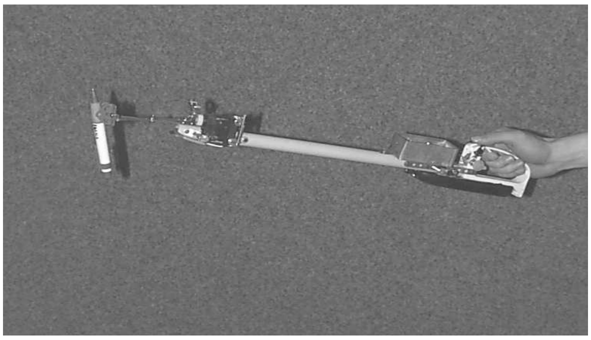


Figure 8. Holding an object by the feeder

7. Conclusion

The objective of this paper was to present the developed methodology for knowledge transfer among different technical branches including those, which are apparently without any relations. Basic concept of the general methodology for transfer of entire engineering design knowledge among different technuical branches has been outlined. The developed applied methodology can improve knowledge transfer in the course of engineering design of technical products. The methodology is suitable for computer and database processing. As an example of the application the functional model of a feeder for disabled people has been designed, realised, and succesfully tested.

Systematic approach based on Engineering Design Science has been used to minimise possible mistakes and errors of designed technical systems (products) because even small matters neglected sometimes using intuitive design engineering can be punished by human health or life losses.

Further development of the methodology is intended in upgrading and more detailed description of the respective steps and in development of active supporting SW and other tools for engineering designers. This should help them more to find out easier new solutions and thus to achieve effectively innovations of the current products, which should have better potential to be successful on the market.

Acknowledgement

This paper includes partial results from the Research Project "Innovations, Engineering Design, Technology and Material Engineering of Industrial Products" MSM 232100006 supported by Czech Ministry of Education.

References

Formanek, J. "Transfer of knowledge from engineering design of manufacturing machines to other industrial branches." Dissertation, Pilsen, University of West Bohemia, 2001

Hosnedl, S., Vanek, V. and BorusikovaA, I. "Design Science for Engineering Design Practice." International Conference on Engineering Design - ICED 01. Glasgow (GB): 2001

Hubka, V. and Eder, W.E. "Design Science." London: Springer-Verlag, 1996.

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

Roth, K. "Basic function structures, their variation of machines, their active and passive branch." Konstruktion 1/2, 2000

Dr.-Ing. Josef Formanek
University of West Bohemia, Department of Machine Design
Univerzitni 8, 30614 Pilsen, Czech Republic
Telephone: +420-37-7638256, Telefax: +420-37-7638202
E-mail: formanek@kks.zcu.cz