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Application Supporting Knowledge Storing and Reusing - Implementation and Concepts of Implementation of Knowledge Management Mechanisms at Conceptual Designing Stage

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Abstract

The article presents progress in the authors' research work, since the last publication, on the prototype software system supporting the process of designing at conceptual stages. The main focus is on the implementation concepts and the implementation of mechanisms managing the collecting, storage and reuse of design knowledge in the mentioned application. The introduction briefly presents the current stage of work on such issues on the basis of an analysis of publications of other authors dealing with similar issues, with particular emphasis on the most, in the authors opinion, interesting solutions and approaches together with an assessment of their usefulness in application supporting the designing of mechanical devices.

The next part of the article is an extensive description of the concept of the proposed process of designing using the functionalities and functionalities' concepts in the prototype supporting application. The application consists of a relational database, a file system and management algorithms managing the stored knowledge. It is also integrated with the CAD system. Additionally it is possible to integrate it with other systems supporting the design (FEM analyses, simulations, etc.). In this part we base on a real example from the industry.

The presented device has been manufactured for several years. During this period, modifications in mechanical structure, electrical system, hydraulic and pneumatic systems were introduced repeatedly. The latest version of the device has been created in accordance with the approach proposed in this paper.

At the stage of conceptual design, it helps to identify essential problems, create operating function structures, select the suitable working principles, and also supports the selection and evaluation of solutions. The functionality of the designing process support was achieved through the use of specially designed mechanisms. On the basis of the knowledge stored in the knowledge base, collected during previous experience in designing, but also in producing and operating the previous versions of the device, the mechanisms provide the designer with tips relevant to current needs.

The utilization of the accumulated knowledge analysis can be also carried out to support the designer in the detailed design phase. The mechanisms responsible for this process operate in an analogical manner. At this stage, the designer is supported when creating design and manufacturing documentation. In addition, the application allows to store detailed

knowledge that mean a documenting individual knowledge development with the description of the premises of taken decisions.
The article is completed with a conclusion with the emphasis on the advantages of the proposed approach. The planned direction of developing the design support system is also described.
Keywords: conceptual design, design rationale, knowledge storage.

1. Introduction

Storage, re-use and share of design knowledge in the environment of designers are presently a serious problem in many companies dealing with mechanical devices designing. Traditional sources of knowledge such as personal knowledge, knowledge acquired in the progress of previous projects, standards, publications, books or knowledge of other members of a designing team is usually difficult to be explored and reused. Recently, the issues in question have become more and more significant because of projects' complexity degree, geographical dispersion of the same team of designers, statistically shorter and shorter time of a designer's work in a team as well as the fact that a large part of new designs is a re-designing job. This paper is focused on knowledge regarding motives for decisions on designs as well as knowledge on functionality of designed devices and sub-assemblies. We do not deal with geometrical features of designs since presently commercially available CAD software copes with storing and re-using of such models. The paper presents the authors' research works on their application designed to support the designing process at the conceptual and detailed stages. Pressure was put on concepts of implementation and implementation of mechanism managing collecting, storing and re-using of designing knowledge at the conceptual stage at the afore-mentioned application.
Issue of non relevant tools supporting storing and reusing of designing knowledge is commonly observed and widely explored in scientific papers dealing support for designing processes [Pokojski J., Cichocki P., 2007, Pokojski J., et al., 2010a, Pokojski J., et al., 2010b, Pokojski J., et al., 2011, Bracewell R., et al., 2009, Ding L., at al., 2009, Lee C. At al., 2006, Aoyama K., Koga T 2006, Keraron Y., et al., 2009, Hisarcikliar O., Boujut J-F., 2009, Lenne D., et al., 2009, Fruchter R., Damian P., 2009]. On the grounds of analysis of the afore-mentioned papers as well as experiences acquired during the development of our own designing process support application the authors declare the application should support the following activities:

- Capture Design Knowledge
- Save Design Knowledge
- Store Design Knowledge
- Retrieve Design Knowledge
- Reuse Design Knowledge
- Evaluate Design Knowledge
- Share Design Knowledge

The activities mentioned above are supported by functionalities implemented into the applications. In turn, use of the functionalities is supported by use of knowledge management mechanism based on gathered knowledge and use of graphic metaphors [Keraron Y., et al., 2009, Hisarcikliar O., Boujut J-F., 2009, Lenne D., et al., 2009, Fruchter R., Damian P., 2009]. Forms of the graphic metaphors are very varied, starting from simple labels with text and ending with graphs with many types of symbols and marks. Knowledge stored in this type of applications is recorded with use of existing models, languages or in specific models enabling representation of it. A crucial attribute is also a possibility to cooperate with the CAD system.

2. Concept and scenarios of application supporting process of design knowledge storing and reusing

In this section the architecture and scenarios of use of the author's application supporting the designing process were described in detail. In order to meet requirements described in previous section a decision was made on development of an application integrated with the CAD system comprising relation database, system of files, mechanisms managing processing of gathered knowledge and user's interfaces. Illustrative system architecture and role of its particular elements is presented in the Fig. 1.

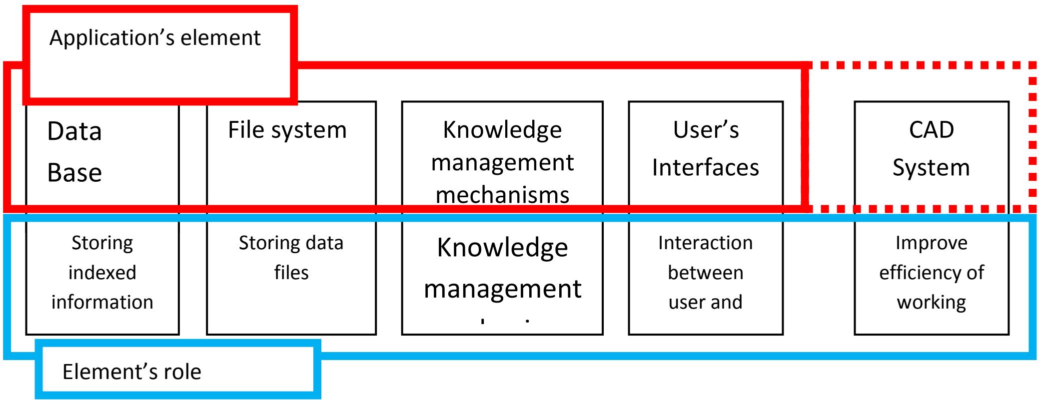

Fig. 1 Application architecture and role of its elements

Gathering and recording of knowledge stored in the system takes place simultaneously with designing in order not to cause increase in time consumed for designing process. At the time of this process a designer may use interfaces specially designed for this purpose. Triggering them a designer obtains possibility to enter information deemed by him/her to be substantial. This information may be in form of a simple note, an appendix in form of a CAD application print screen, a voice note, an appendix with results of calculations or any other appendix. It should be emphasized that the information may take a form of a premise which contains information on a context of made designing decision. At this stage information being entered in a relevant and automatic manner are indexed and recorded by special implemented knowledge managing mechanisms. They are also assigned to a particular design, sub-assembly of a part or any other element which is not necessarily a geometric form (e.g. stresses, deformations, technology of performance etc.). Electronic files are recorded in a system of files which is an integral part of the designing process supporting application. Other data and information are recorded in a relational database.

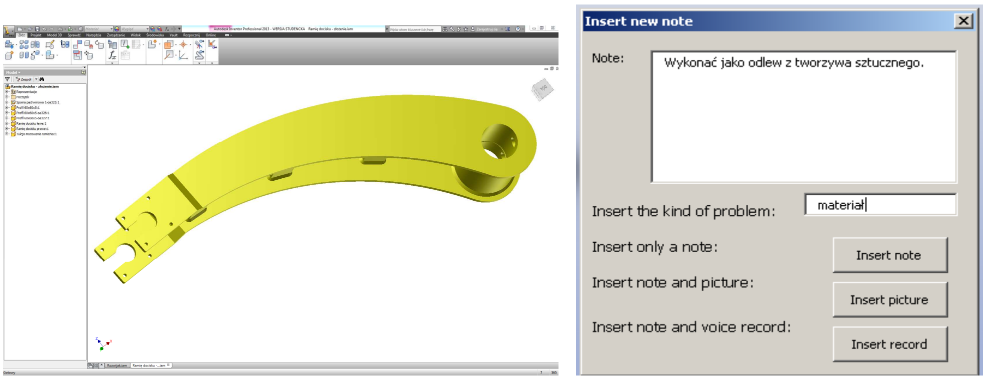

Fig. 2 Interface enabling knowledge/data capturing, saving and storing

Use and re-use of gathered knowledge takes place in similar manner as entering it. In case when a designer meets an issue, which he is not able to solve, he has an insight into the entire knowledge stored in a system. He calls a relevant interface to browse knowledge and he is provided with information on selected issues on the basis of implemented browsing parameters. Obviously, provided that information, which is searched for, has been previously entered into the system. Knowledge stored in the system is classified and linked and due to use of relevant knowledge managing mechanisms, results of browsing respond to current requirements of a designer. A designer is recommended, in order to use the application in accordance with assumptions, after successful solving of a designing problem, to enter information on the issue or in case he has not found any information, to enter information using other sources of information.

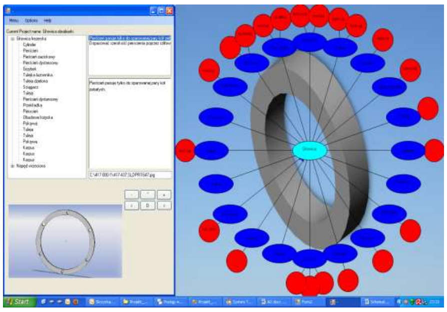

Fig. 3 Interface enabling knowledge/data retrieving and reusing

Assessment of knowledge gathered in the system may take place when using it. Then, a designer has an opportunity to evaluate suggested solutions to assess their suitability for currently existing problem. There also exists a possibility to assess accepted solutions on the grounds of data gathered at further stages of a life-cycle (production, use).

The last of requirements revealed in previous section - share of designing knowledge is also fulfilled. Use of a database and a system of files in the architecture enables storing them at a server. Consequently, members of the designing group have an access to them from their work stations.

3. Design case study - implementation of knowledge management mechanisms at the conceptual design stage

In this section there is presented a detailed process of conceptual designing of certain elements of sheet decoiler based on the designing process supporting application. Described machine has been manufactured for several years. It has been re-designed and customized many times to satisfy requirements of clients. For needs of the design case study database was supplemented by certain quantity of knowledge on the grounds of documents, production data and other information as well as from other sources of knowledge originating from previous versions of the design.

The approach presented in form of the application assumes that the conceptual designing process consists of a few consecutive stages.

- Identification of issues on the grounds of requirements list
- Designing of functions/sub-functions
- Selection of operation principles
- Selection of relevant combinations of structures
- Evaluation of solutions
- Selection of solution

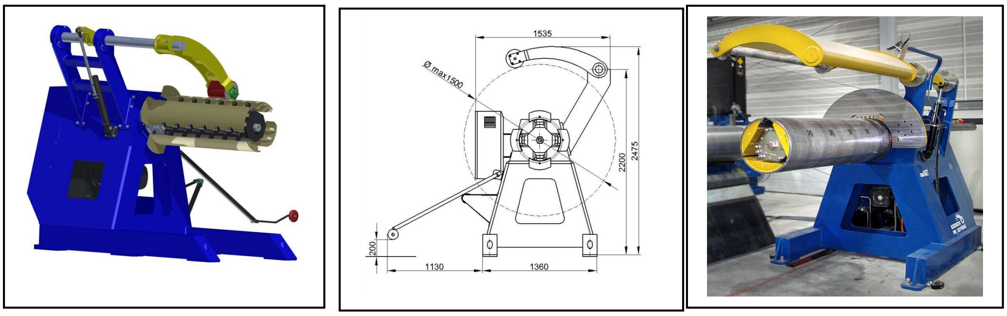

Fig. 4 Steel sheet decoiler 3D/2D CAD model and a picture of the machine

Every stage is supported by a dedicated sub-application, which supports actions at consecutive conceptual designing stage. They shall be described in detail hereunder. Table no. 1 shows manners of provision of designing support at particular stages.

Tab. 1. Conceptual design process stages and methods of support provided by the application.

Conceptual design phase	**Support method(s)**
Identifying of essential problems	Relevantly filtered list of problems from previous designs. Possibility to add new ones
Creating of function/sub-function structures	List of functions and sub-functions used in the past,
Working principles combining	Simplified due to decisions made during previous designs + knowledge on development and use
Suitable combinations - selection	Simplified due to decisions made during previous designs + knowledge on development and use
Evaluation of solutions	By access to previously selected solutions and their effects

Main requirement, which the machine was supposed to meet, is weight of coils: 15 tons, coils' width: 1250 mm and decoiling speed not lower than 50 m/min. Identification of basic issues was obvious since the job was to redesign the machine.

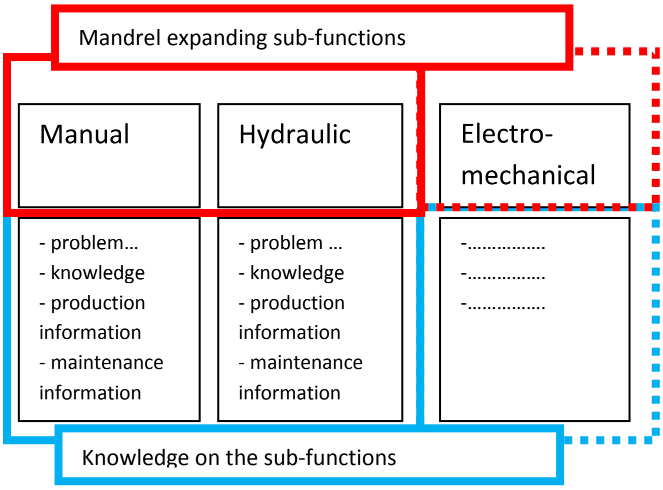

Fig. 5 Steel sheet decoiler - Mandrel expanding sub-functions

Main function of this machine is sheet de-coiling. Sub-functions are (among others): drum expansion, pressing arm drive, rotation of the main shaft and many other. In the further part of the section we will deal with the drum extension sub-function, on which coils are fixed, as well as the pressing arm drive sub-function. In this case in the database the sub-functions of drum extension have already been available (manual and hydraulic). There was entered other sub-function of the extension function that is electro-mechanical extension. For a sub-function of the pressing arm there were created two other operating principles: hydraulic and pneumatic.

At the stage of selection of operation principles a designer could use elements of knowledge and issues related to particular solutions regarding the drum expansion sub-function. On this basis the mechanical extension was rejected. In the database information was available that the manual drum expanding because of weight of the coils, despite the fact it was technically correct, was criticized because of work-consumption rate. Both methods of pressing arm driving were classified as permissible ones.

After selection of solutions classified as permissible ones, the designing supporting application enables also selection of a method to assess solutions. In case in question there was used a method of weight coefficients to select relevant set of principles. There is a possibility to implement any method and providing it with support when performing it. Final step was selection of preferred solution. In this case it was a hydraulic drum extending and a pneumatic drive of the pressing arm.

4. Conclusions

The authors can see a need to provide designers with designing process supporting application in the field of designing knowledge gathering and re-using. In the paper there is described progress of works on application which supports processes of designing knowledge gathering and re-using. The goal is to present an approach to the development and proposed principles governing mechanisms managing the knowledge acquired at the conceptual designing stage. The presented approach was implemented in the course of a real designing example in the field of industry when the latest version of the machine referred to in the section 3 was being designed. On the grounds of the afore-mentioned example it can be concluded there are advantages of use of the designing supporting system. Previously gathered knowledge, due to use of knowledge management mechanisms, which sort it and process it, is easily available and it substantially accelerates and simplifies the designing process. Additional advantage can be access to gathered information on wrong designing decisions due to which quality of the designing process gets better.

Proposed solution has also limits. Main disadvantage, which must be mentioned, is lack of possibility to use it at the beginning stage since the database is empty. It could discourage potential users, who need to make efforts at the very beginning to use gathered resources in the future. Other disadvantage is that gathered knowledge must be limited to a certain field since, in otherwise, it will be too broad and access hampered.

In the nearest future the authors plan to continue works on the application as well as tests on other real industrial examples.

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