



A Novel Low-Cost Product Data Management System

L. Xie, H. Ching and R. Du

The Chinese University of Hong Kong, lhxie@mae.cuhk.edu.hk

ABSTRACT

Many small and medium size companies have multiple products with a complex supply chain. To these companies, managing their product data is vital and yet may be headache because of the complexity of the product, the manufacturing processes and the supply chain. There exist some commercial Product Data Management (PDM) software systems. However, these PDM systems are expensive. Moreover, they are difficult to use. This paper presents a novel low cost product data management system. This system is developed based on Microsoft Foxpro® but can simply run in the MS Windows® environment. It integrates the design (CAD files), the supply chain (MS Excel® files), the production schedule (MS Project® files), and the database (MS Foxpro®). Moreover, it can be expanded to include other information, such as manufacturing simulation. Its Graphic User Interface (GUI) makes the system easy to use and to maintain. A practical demonstration example on mechanical watch movement is included.

Keywords: product data management, engineering documents management, mechanical watch.

DOI: 10.3722/cadaps.2008.30-38

1. INTRODUCTION

Many small and medium size companies usually have multiple products with a complex supply chain. To these companies, managing their product data is vital and yet may be headache because of the complexity of the products, the manufacturing processes and the supply chain. With the development of information technology, Product Data Management (PDM) systems are being developed to keep track of the massy information related to the design, the manufacturing and the suppliers. It can effectively integrate the data from design, to manufacturing and supply chain and manages the information^[3, 8].

A lot of people have researched on the product data management and proposed many methods towards the PDM, such as structured methodology^[2], the integration of PDM and production process^[6], PDM on web technology^[14], SETP-based PDM^[1], and etc. Presently, there are a number of commercial PDM software systems available, such as Enovia MatrixOne^[5] by Dassault Sytemes, TeamCenter^[11] by UGS Corp., Windchill^[13] by PTC, and etc. These powerful PDM systems are able to manage the product data and the production processes, such as design geometry, engineering drawings, production plans, assembly diagrams, material specifications, CNC programs, and much other information. However, these PDM software and similar tools have been known as tools difficult to acquire, use, update, or replace^[4]. They have also had problems with scalability and compatibility. And what's more, these software systems are rather expensive, both in software price and in hardware requirement. As for small and medium size companies, implementing such a high-cost PDM may become a burden. Therefore a low-cost easy-use PDM system is highly desirable.

In this paper, we presented a novel low cost PDM system, especially designed for small and medium size companies who focus on mechanical engineering. As a demonstration example, the system is being used to manage our mechanical watch movement project.

The mechanical watch is one of the most complicated mechanical devices that have ever invented, which contains more than 100 precision mechanical parts within a small space (typically, $\phi 40$ mm \times 15 mm)^[10,12]. During the

development of mechanical watch movements, data management is a key concern. We use this as a practical demonstration example to illustrate the development of our PDM system.

The rest of this paper is organized as follows. Section 2 presents the configuration of our PDM system. Section 3 defines the data structure of the PDM. Section 4 describes the access and version control mechanism. Section 5 discusses the implementation issues, with the mechanical watch movements as an example. Finally, Section 6 contains the conclusions.

2. SYSTEM CONFIGURATION

For small and medium size companies, data management mainly concentrates on design, manufacturing, material and purchasing. Therefore, the database will mainly manage the data from these four sections. It is also necessary to control the schedule and status of the whole project, so the system should contain the function for project planning. Version control and access control are also two key functions in data management. As shown in Fig.1, the product management system is made up from six modules: design, manufacturing, material, purchasing, administration and project plan. Tab. 1 shows the detail functions requested from each section.

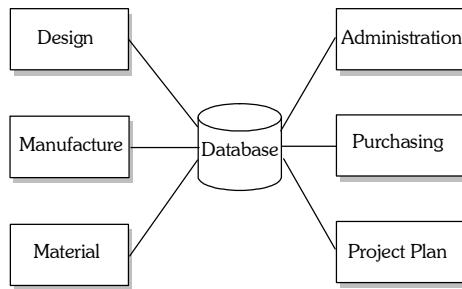


Fig. 1: Main modules of the database.

<i>Module</i>	<i>Functions</i>	<i>Data contents</i>
Design	Input design data Edit design data Search and sort data info Browse data in other fields	3D model in solidworks 2D drawing in solidworks Assembly diagram in solidworks Design record in Word FEA result in avi format
Manufacture	Input mfg. data Edit mfg. data Access design data Browse data in other fields	Mfg. method in txt format CNC codes in txt format Fixture model in solidworks Workpiece model in solidworks Mfg. tool info in Excel Mfg. simulation in avi format Quality control spec in Excel
Material	Input and edit material data	Spec of material in Word Physical parameters in Word Testing result in Excel
Purchasing module	Input and edit supplier info Browse data in other fields	Company info in Excel Product codes in Excel Quality Assurance in Excel Schedule and status in Project
Project Plan	Link the file to database	Parts information, Manpower Work schedule, Current status
Administration	Access control	

Tab. 1: Functions in the database.

The design section will be in charge of all details of the design, which may include 3D model, 2D engineering drawing, assembly diagram, design record, and etc. As a user from design section, he needs input the design data to the database; edit these data in the database. He also needs to browse other data owned by other field, such as material parameters by material section, but he can only read the data. For the easy access, design files can be sorted in a number of ways including:

- Assembly – it shows the geometrical relationship of the components in graphics;
- Type – the components can be divided into different types, such as rotational parts, prismatic parts, and etc.;
- Material – the components can also be divided by materials, such as steel, copper, and etc.
- Code – the components are usually coded based on the Group Technology (GT), so they can be sorted by GT codes.

Therefore the database should provide the multiple kinds of searching and sorting functions to easily access the design data.

Manufacture section is in charge of the production. There are many complex manufacturing processes, such as machining, stamping or other forms of metal forming, injection molding or other forms in plastic manufacturing, casting, welding and etc. For small and medium companies, usually only a portion of the manufacturing (often the most critical components) is done in house, while other parts are outsourced. To the self-made parts, the manufacturing section must consider manufacturing methods, machining tools and fixtures, as well as part quality measurement gages. In our PDM system, the manufacturing data are organized as follows:

- Manufacturing methods – for example, machining;
- Manufacturing simulations – for example, cutter path simulation;
- Tools – for example, drills, reamers, mills and etc. A link to related website is also included;
- Fixtures – fixtures are often custom-made, and hence, the fixture design files and application notes shall be attached;
- Measurement gage – for example, go and no-go gage design file and application notes.

Material section is in charge of the material testing, such as mechanical parameters, chemical parameters, physical parameters, and etc, to be the design basis of other section. For this section, their main request for this database is to input and edit the material parameters.

Purchasing section will take charge of buying the outsourced parts, bulk workpieces, tools, and etc. Our PDM system requires the purchasing unit to provide supplier information, delivery schedule, and part QA data. The database should provide the users in this section the privilege of browsing the data from other sections as well. They also need to upload the related information to the dataset and edit these data.

3. DATA STRUCTURE

The PDM system is like a hub, which manages all the data related to the entire project. These data can be classified into two types: embedded data and files stored in some format. The PDM system can store some information using some two dimensional tables, such as simple texts and relations between items, which we call embedded data. However, most of data in our project are complex documents or multimedia files, which can not be simply embedded into the PDM system and should be stored in the files of some format. As for the files in other format, some kind of program should be used to open the files. Therefore, the PDM system is required to provide the function to connect these necessary software programs. Fig. 2 shows the data archives of the PDM system.

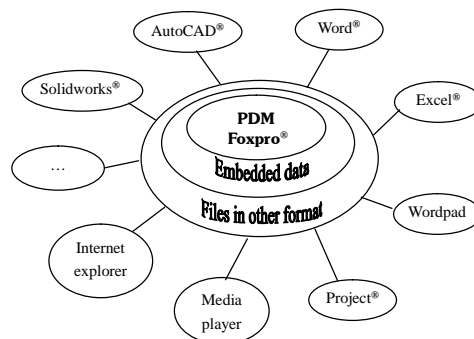


Fig. 2: Data archives of the PDM system.

Embedded data can be accessed in a high speed, so some data in high priority are built into the PDM system. As for MS Foxpro®, it can store text data and relations between these data using a two-dimensional table. Hence, the PDM system builds some table to store some simple text information, such as access level control information, parts list and their relations, and etc.

Files stored outside the PDM system are of all kind of format. For example, three-dimensional model is built in Solidworks® format; engineering drawing is built in AutoCAD® format or others; machining simulation is animation, which can be played in media player. Therefore, the PDM system provides the function to employ other software to load these miscellaneous files.

There are four-layer data table in this data management system to define the relations of parts information and out-stored documents, as illustrated in Fig. 3. The data table in the top layer defines the table relations between the function modules in the whole database, where the keys, index, reference, linkage are defined. The data tables in the second layer are for each section module, for example, the data table for design contains all the parts information in the whole project. For each part, the design data will include 3D model, 2D drawing, FEA simulation, and etc., which are depicted in the data table in the third layer. In the data table of the third layer, there also includes hyperlink information of each file, where the file can be opened. For each file, such as 3D model, there is a data table containing all its related information, including designer, revision, and etc. Such data table lies in the fourth layer.

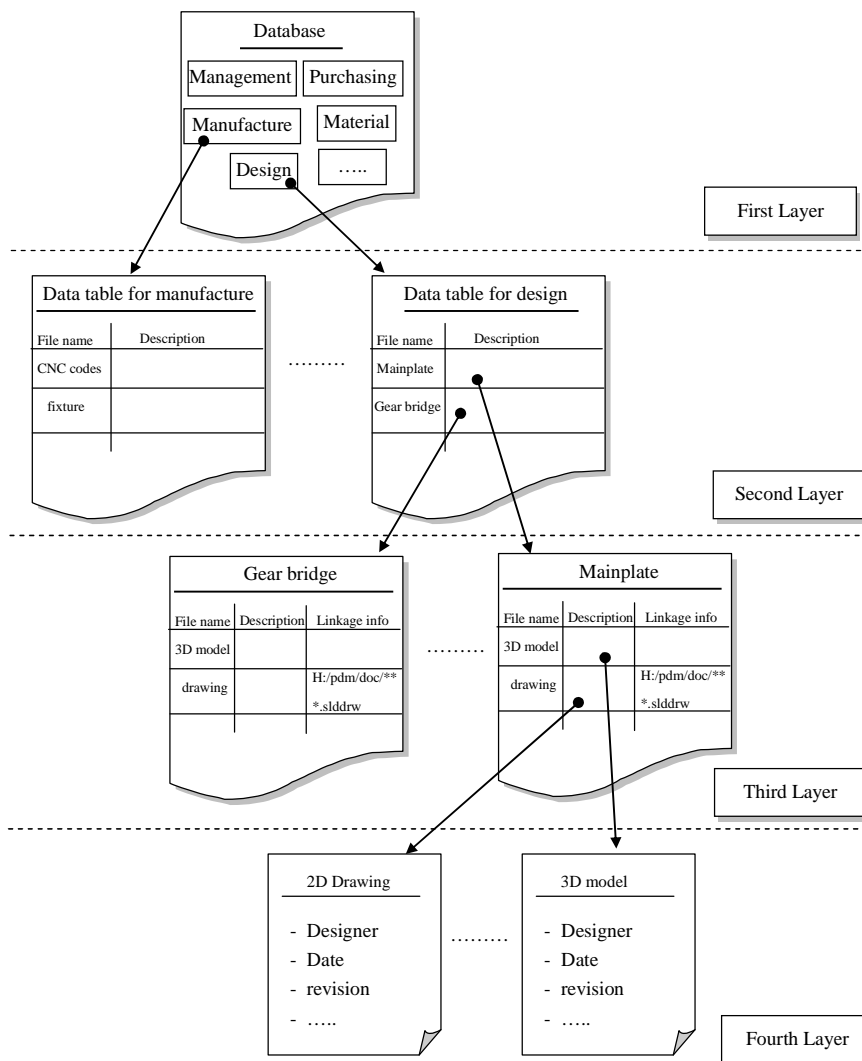


Fig. 3: Four-layer structure of database.

4. ACCESS AND VERSION CONTROL MECHANISM

The PDM system is designed for team usage. In order to keep the safety and consistency, different users will have different privileges to access the system. User needs to input his or her user name and password allocated by the system. Then the system will verify the information with the data in the access control file. If the user name and password are correct, accessible privilege and modules will be allocated according to the access code which presents the user's identity and can be modified by manager. When user leaves the system, he or she should log off and the system goes back to the login page. Meanwhile, when idle time of the PDM system is longer than the defined value, the system will lock the system and jump to the login page. For the manager, he or she can control all the data in the system, including access level assigning, schedule setting and controlling, and data or information related to design, manufacturing and purchasing. As for the design, manufacturing and purchasing user, he or she will be allocated modules related to his or her field. He or she has the privilege of full controlling all the relevant documents, and can only read the other field's information.

The volume of product definition data generated in the lifecycle of products is large and complex. If this data cannot be accessed in the appropriate fashion then it is useless. Users need to work with the latest version of a design, and all the data should be consistently interpreted [9]. Fig. 4 shows the version control mechanism. Assuming that the first 'User A' wants to access 'File A', if he just wants read the 'File A' without any modification, then he is free to copy the file a to his local computer; if he wants to revise the file, he should lock the file so that others can't do revision to the same file by making the file read-only and adding a warning message to the file to remind others. After revising the file, 'User A' should renew the version information and backup the old version file before uploading the file to the server. After that, 'User A' will unlock the 'File A' and add revision record to it. If 'User B' want to access the 'File A' during this period, a warning message will popup to remind him that this file is read-only and can't be revised. If 'User B' just wants to read this file, he can copy it. However, 'User B' can't upload the same file, even if the file is revised.

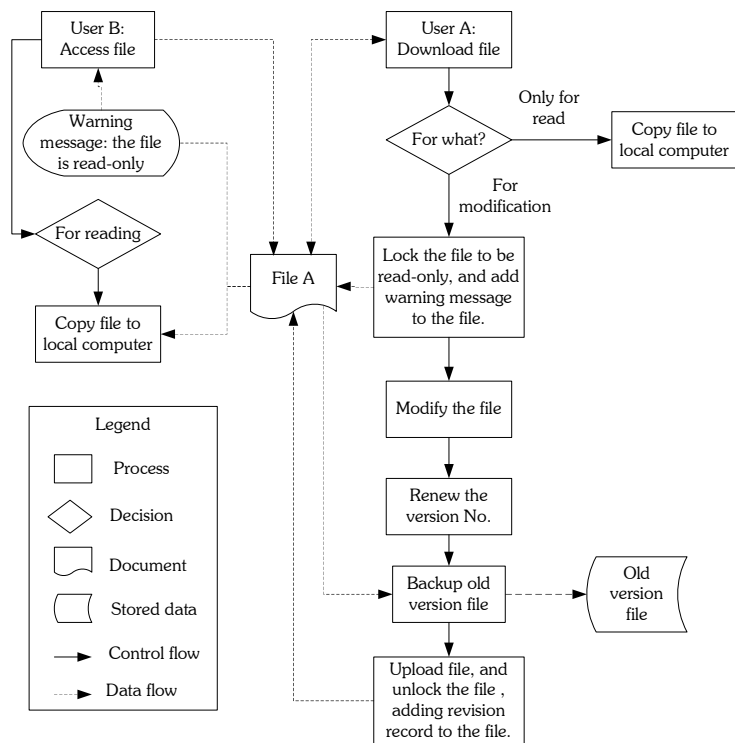


Fig. 4: Version control mechanism.

5. SYSTEM IMPLEMENTATION

In order to keep it low cost, the PDM system was built using MS Foxpro® software, which can be run in any MS Windows®-based computer. It does not need a computer server. Moreover, after the program is compiled, it can run

without the MS Foxpro® software. However, it requires having MS Project® software to open the manpower assignment and schedule files and MS Excel® to open part information files. Furthermore, it requires CAD software (e.g., SolidWorks®) to open the design file.

The following will illustrate the use of our PDM on one of our current projects: design and build mechanical watch movements. Fig. 5 shows the main page of our PDM system, which contains a logon button, turn off button and contact approach. The system requires any user to login the system firstly, and then the system allocates the relevant privilege to the user.



Fig. 5: The main page of the data system.

Fig. 6 shows the function modules accessible for administrator, including assembly, parts info, enquiry, input, schedule and users. Clicking each button will show a relevant function module, which is easy to realize by adding an expression of “DO FORM *** (the name of linking form)”. One of merits of programming using Foxpro® is simplicity. In our PDM database, only a few hundred lines of codes were used. Actually, the major effort is the design of software architecture and interfaces.



Fig. 6: The accessible function modules for administrative user.

Fig. 7 shows the layout of the form structures in MS Foxpro to provide users to access all the parts in the mechanical watch movement. There are three steps to build such form structure: firstly adding buttons, tables and other control elements to the form, then connecting these elements to the data table, finally adding some expression to control button to realize some function. Fig. 8 shows the compiled form with some data. Selecting one item in the parts list,

the function buttons at the bottom are available. Actually, a few line codes are needed to realize all the functions. For example, sorting and linking between subassembly diagram and its parts is done using “SET FILTER TO ALLTRIM(sub)=***(the name of subassembly)” function; enquiry and searching are done by using the “SELECT” function.

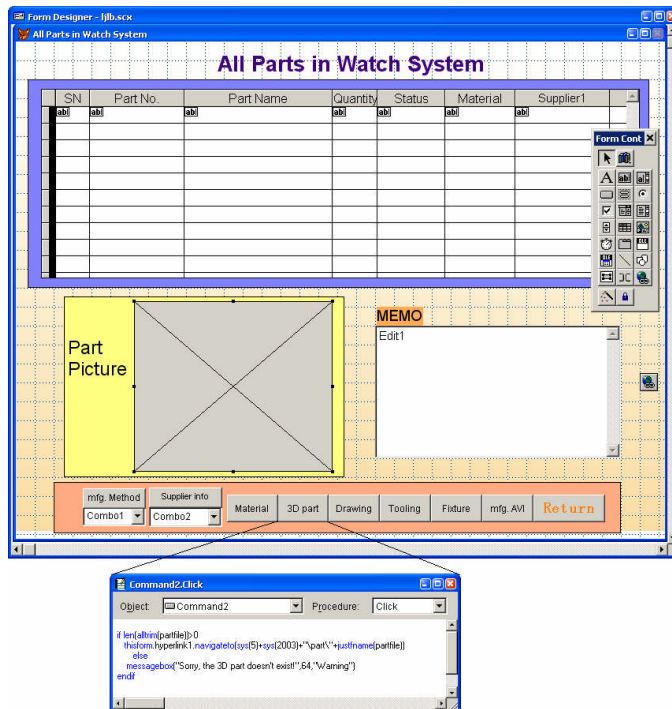


Fig. 7: layout of form structure in Foxpro.

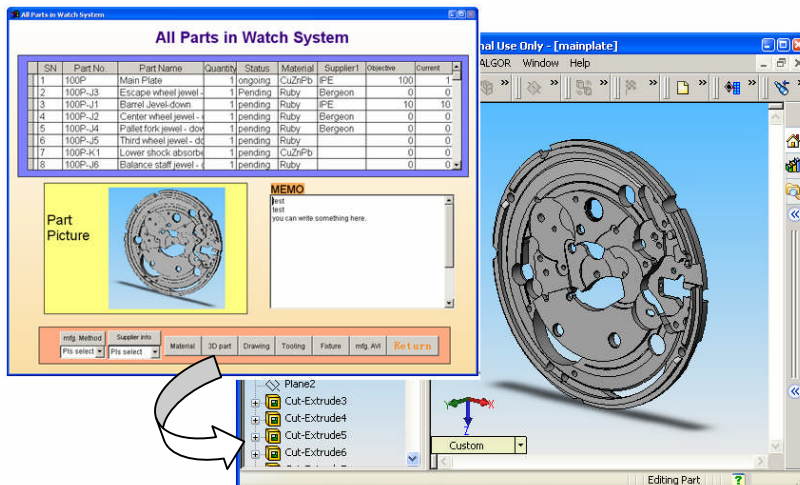


Fig. 8: Compiled function page.

Project schedule is necessary. As a low cost database, we didn't build up the schedule function by ourselves, but used a MS Project® to act as a schedule platform. We only need to add a button on the database interface with some simple

codes to drive the project software. Fig. 9 is our project schedule used in the watch project, where contains all the items related to the project, including part information, manpower, starting date, finishing date, duration, current solution, future potential work, etc. Administrator can modify information in this file, but operator can only read the information.

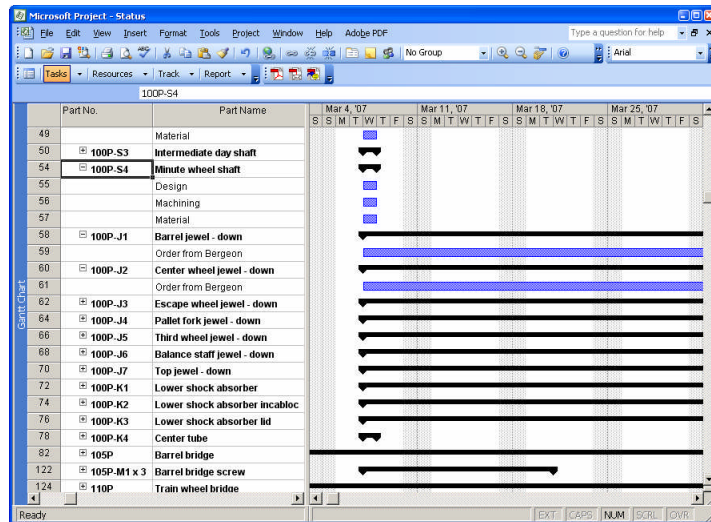


Fig. 9: The project plan.

Building up such PDM system is straightforward, which needs neither complex data structure nor intricate program. What needs to be done is to analyze the requirements from the users and to lay out the interface using the MS Foxpro[®] software. We estimate that the implementing is less than 200 man hours and the implementation cost is minimal. As a small data management system, it doesn't provide customization and upgrade function. However, the system can be revised in Foxpro platform, then rebuild the file. Therefore, user can customize and upgrade the system. To compare with other commercial PDMs, this low cost system doesn't provide some functions, such as release management to package software in a form suitable for distribution and generating documentation to inform users and developers and changes included in the product release, change management to provide support for the process of entering and implementing changes in the product.

6. CONCLUSIONS

Based on the discussions above, following conclusions can be drawn:

- A low cost Product Data Management (PDM) software system can be built using a combination of simple software systems, such as MS Foxpro[®], MS Excel[®], MS Project[®], and SolidWorks[®].
- In building such as PDM system, the key is to design the software architecture (similar to Fig. 3) and the user interface (similar to Fig.e 6). Accordingly, the PDM system can be implemented using MS Foxpro[®] with simple commands.
- We built a PDM system for our mechanical watch project. It consists of six modules: Assembly, Part Info, Enquiry, Schedule, Input, and Users. Different users may have different privilege in assessing the software. It is very easy to use and to manage.
- The presented PDM software system is easy to develop and can be used for many small and medium size mechanical engineering companies.

7. ACKNOWLEDGEMENT

The presented research is partially supported by a grant from Hong Kong Innovation and Technology Fund (Grant No.: ITS/001/05). The authors wish to thank for Dr. H. Ching and Dr. J. Mao for their support.

8. REFERENCES

- Chao, P. Y.; Yeh, S. C.: Representation of standard mechanical components in a STEP-based product data management system, International Journal of Computer Applications in Technology, 12(1), 1999, 16-26.

- [2] Chen, Y. M.; Tsao, T. H.: A structured methodology for implementing engineering data management, *Robotics and Computer-Integrated Manufacturing*, 14,1998, 275-296.
- [3] Chu, X. J; Fan, Y. Q.: Product data management based on web technology, *Integrated manufacturing systems*, 10/2, 1999, 84-88.
- [4] Crnkvic, I.; Asklund, U.; Dahlqvist, A.: Implementing and integrating product data management and software configuration management, Artech House, 2003.
- [5] Enovia, <http://www.3ds.com/products-solutions/plm-solutions/enovia>, 2008.
- [6] Kovacs, Z.; Goff, J. L.; McClatchey, R.: Support for product data from design to production, *Computer Integrated Manufacturing Systems*, 11(4), 1998, 285-290.
- [7] Liu, D. T.; Xu, X. W.: A review of web-based product data management systems, *Computers in Industry*, 44, 2001, 251-262.
- [8] Philpotts, M.: An introduction to the concepts, benefits and terminology of product data management, *Industrial Management & Data Systems*, 96/4, 1996, 11-17.
- [9] Sackett, P.: Framework for the development of a product data management strategy, *International Journal of Operations & Production Management*, 18, 1998, 168-179.
- [10] Tam, L. C; Du, R.: Virtual Library of Mechanical Watch Movements, *Computer-Aided Design & Applications*, 4(1-4), 2007, 127-136.
- [11] Teamcenter, http://www.plm.automation.siemens.com/en_us/products/teamcenter/index.shtml, 2008.
- [12] The Swiss Federation of Technical College: *The Theory of Horology*, Switzerland, 2003.
- [13] Windchill, <http://www.ptc.com>, 2008.
- [14] Yoo, S.; Kim, Y.: Web based knowledge management for sharing product data in virtual enterprises, *International Journal of Production Economics*, 75(1-2), 2002, 173-183.