CHAPTER 5

ERP AND CAD INTEGRATION

5.1 Introduction

Introduction of information technologies in production companies had long ago ceased to be a trend and became essential for company survival in unsparing market conditions. Many computer programs had been written for respective production areas. Abbreviations like CAD, CAM, CAE, PDM, PLM etc. sounds no longer so strange as in early 90's and become more regular.

An increased quantity and quality of production data raised up a need for a better and larger data sharing as between different business software as so between companies. Engineers who use CAD programs stand at the beginning of production cycle and give basic data about product, while information systems like ERP system try to consort all data about products, resources and markets, and to help in an overall company business.

At this point it is interesting to emphasize one engineer's view: "If you ask design engineers what an ERP system means to them, you are likely to hear something like "nothing" or "more work" [1]. Cutler in his paper considers that to most design engineers, an ERP system is either irrelevant or it is perceived as something that requires additional time and effort, often providing little or no value. He also states that one reason for this perception is that most ERP systems are not integrated with the design engineer's drawing tool. But, particular production company must be able to promptly respond on customer's demand for product changes, therefore smooth data flow between engineering and production is substantive. Such company must integrate CAD and ERP.

From a financial lookout, the market of the Enterprise Resource Planning (ERP) systems is very strong with a high profit. Major ERP vendors are on the top of the chart for 100 major software vendors [2]. Such high profit enables and strong market competition propels ERP vendors to extend the functionality of their ERP systems.

Since there is clear need for ERP and CAD integration, issues important for ERP and CAD integration will be discussed in more detail in this book chapter. At the beginning, different types of CAD software involved in product development process will be reviewed and categorized. Then an open issue on integration versus data sharing between CAD and ERP software will be discussed. Afterwards, PDM/PLM concept will be considered as a framework for the integration. Sample integration developed for particular ERP and CAD software will be presented. In conclusion, final thoughts about possible direction of integration will be exposed.

5.2 CAD Software

First issue that should be clarified is: "What is CAD?" CAD is an abbreviation of a term "Computer Aided Design". Term Computer Aided Design designates the use of computer technology in the product design process, thereby considering primarily geometric and solid modeling technologies available through CAD software [3][4][5].

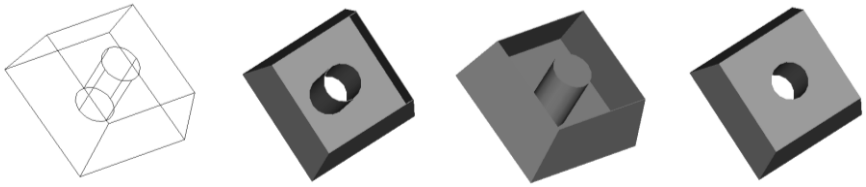

Figure 1 Ambiguous wireframe model

In the very beginning of CAD software in 1960's it covered only drafting and it was mainly considered as Computer Aided Drafting. Further CAD development was oriented towards spatial i.e. 3-dimensional (3D) functionality. 3D CAD models evolved from simple and ambiguous wireframe models (Figure 1), over more complex surface models to solid models. Today, most of 3D CAD software has functionality to create all three types of spatial models, although solid modeling is mostly dominant. Only solid models can be used for all engineering purposes like mass property computation, tool path generation or finite element analysis (FEA).

In last two decades, strong growth of computer market has also reflected on CAD software. Market growth and increased revenues gave power to many of CAD software vendors to develop specialized software packages for specific engineering areas like mechanical, marine, civil or architectural engineering. Since in this chapter focus will be more on ERP systems for

production companies in metal industries, in further review of CAD software special emphasis will be on mechanical CAD software. Mechanical CAD software is recently more often noted with acronym MCAD.

Modern MCAD software packages are primarily parametric and feature-based. Parametric models are also often referred as dimension-driven models [5]. Parameters assigned to model dimensions enable relation between dimensions and quick change of the model with minimum effort (Figure 2). Feature-based approach considers design features as geometric primitives used as building blocks of model. Such approach enables designers to reuse once defined feature in other models. Model features are usually presented in model tree inside MCAD software (Figure 2).

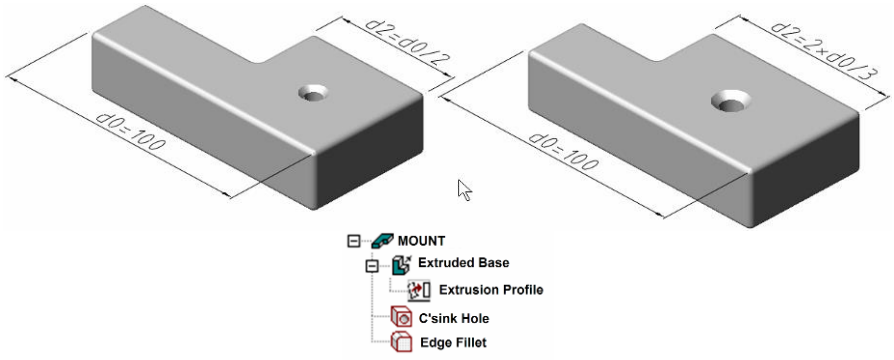

Figure 2 Parametric and feature-based solid model

All modern MCAD software packages include routines for automated drawing generation from solid model. Created drawings have bidirectional association with solid model so any change in the model is automatically reflected in the drawing and vice versa. Furthermore, almost every available package is shipped with some additional modules like: libraries of standard parts and assemblies; sheet metal modeling; photo-realistic model visualization and animation; import and export to other software; piping and routing etc.

MCAD software solutions available at the market are ordinary divided in two categories: midrange and high-end (or high-range) solutions. For high-end solutions are usually considered CAD packages that covers full range of engineering applications like: finite element analysis (FEA) or overall computer aided engineering (CAE); computer aided manufacturing (CAM); product data or lifecycle management (PDM/PLM) and so on. As

representatives of high-end MCAD packages are usually considered (alphabetically): CATIA from Dassault Systems and IBM; Pro/ENGINEER from Parametric Technology Corporation; UGS NX from Siemens PLM Software.

Midrange MCAD packages usually contain parametric and feature-based modeling engine with automated drawing generation. However, in every new version most of midrange MCAD packages includes more and more additional functionality so the distinction between high-end is lower. Many of small and mid-size production companies successfully accomplish all their CAD/CAM/CAE demands with midrange MCAD software. Some representatives of midrange MCAD packages are: Alibre's Alibre Design; Autodesk's Inventor; Solid Edge from Siemens PLM Software and SolidWorks from Dassault Systems.

In a modern process of product development, the new product structure is developed and described in parametric and feature based MCAD software. MCAD software typically uses several files but also several file types to describe product model. The usual file types are: assembly model, assembly representation, assembly drawing, part model and part drawings (Figure 3). Those files often have external file associations, for example a part drawing file usually depends on a corresponding part model file.

An assembly model file contains records of referenced external components i.e. full file path to every component used in the particular assembly. It also stores geometrical relations between components. Ordinary if one product contains more than one component, the product model is stored in one assembly file and each component is in own file. If product or assembly contains subassemblies, every subassembly is stored in its own assembly file. Most of MCAD packages allow storage of components inside assembly file. Such opportunity have negative side-effects: it is hard to reuse a component stored inside one assembly in another assembly.

An assembly presentation file is used in some MCAD solutions like Autodesk's Inventor, and it stores definitions for exploded assemblies and specialized assembly views. Presentation file usually depends on assembly file that presents. One assembly can have more than one presentation file, although it is not often used by designers.

An assembly drawing file contains drawing views or drawing sheets for particular assembly. Drawing sheets could be derived from assembly or its exploded presentation. Drawing file can have more sheets but also one assembly can have more drawing files.

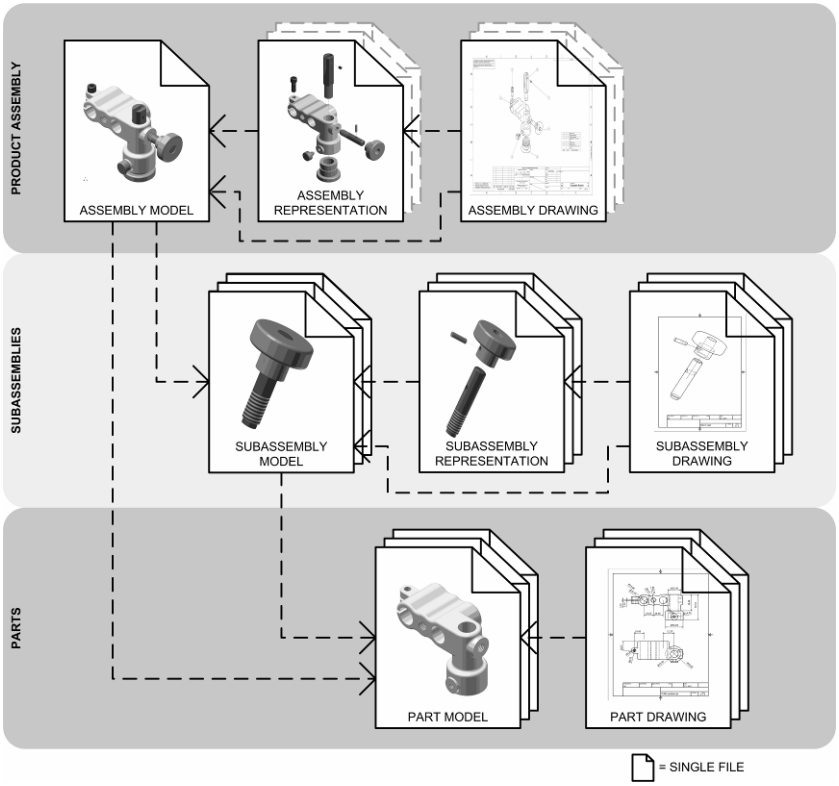

Figure 3 MCAD documents

A part model file stores description of single part. Particular part could have drawing sheets stored in related drawing file.

5.3 System, data and interface integration

If the *system integration* is considered, an important issue must be discussed: Is it really possible to integrate ERP and CAD systems? The system integration means bringing together two or more systems into one system. ERP systems cover more business functions than CAD system. Furthermore, vendors of ERP systems have greater budget than CAD vendors. These circumstances indicate the possible integration of CAD into ERP system, so CAD would be implemented as one of ERP subsystem. However, there are no signs of such activities yet on business software market. It can be

concluded that the system integration of ERP and CAD systems is less probable to happen soon, mainly because complexity of such process and because of significant differences in system architecture of considered systems. However, it can not be excluded in the next decade, because of astonishing power that ERP vendors accumulate every year.

Data integration is the way of integration that is more likely to be achieved then the system integration in a near future. Actually, the data integration between ERP and CAD systems is actually started by many ERP vendors and by many CAD vendors too. From perspectives of both systems, it is performed under the process of managing the entire lifecycle of a product (PLM). Many of ERP systems available today include PLM subsystems[1] and many of CAD systems are shipped or considered as a part of PLM systems[2]. Most of midrange CAD systems are shipped with product data management applications (PDM) and product data management together with CAD are considered as cornerstones of the PLM. Since vendors of both systems are oriented towards PLM it can be concluded that the PLM, or to be more specific, the PDM concept is right choice for data integration between ERP and CAD systems. Therefore, in further it will be nominated as basis of the data integration. For ERP vendors, it means they should enable data integration with CAD based on PDM concept. Several authors also recognized the need but have expressed it as an incoming issue of the Product Data/Lifecycle Management (PDM/PLM) and ERP systems integration, rather than ERP and CAD integration [6][7].

Data integration of ERP and CAD systems can be performed in a similar way as it is performed for PDM and CAD. Oh et al. in their paper made detail analysis of the PDM/CAD data integration [8]. The most suitable type of data integration is through shared database. In such implementation, design engineers access design data and files through ERP system instead through a local file system.

User interface integration should also be implemented for a convenience of design engineers. Main ERP system functions should be available inside particular CAD system. Main purpose of the user interface integration is to simplify access to ERP system for design engineers which spend most of the

[1] Like SAP PLM or Oracle PLM.

[2] For example: UGS NX from Siemens UGS PLM Software; CATIA, DELMIA, and ENOVIA from Dassault Systems; Pro/ENGINEER and Windchill from Parametric Technology Corporation.

time working in CAD systems. It will reduce initial engineers' resistance against ERP implementation and boost the overall performance. Other user interface solutions are also available, but none of them can not be considered as the integration of the user interface.

5.4 PDM concept

To determine integration domain in a sense of functionality, PDM concept and PDM sets of functions are overviewed under this heading. The overview is presented according to several published works, mostly referred to [9], but also to [10][11].

Sets of functions are classified in two levels: core and extended.

Core PDM functions are: controlled secure storage and management of product data in a database - vault; workflow and process management; product structure management; classification of parts; program management.

As one of the primary PDM function, vault in ERP system could be accomplished through common enterprise database. With such implementation, access control is easily addressed through database management system on user level. Under management of design data are considered check-in and check-out functions for tracking design data changes.

Hierarchical product breakdown structure is considered as a basic property of almost any product. It describes how the product is divided into components, which are in turn divided into subcomponents, etc. The STEP standard further distinguishes between the Bills of Material (BOM) structure and the parts list structure of a product as enhanced BOMs, although such distinction is not used generally. But such an aspect is useful to compare this basic PDM function with those usually implemented in ERP systems. ERP systems usually support standard BOM that can be automatically extracted from PDM parts list structure.

Although almost every ERP system have modules for production workflow and production process management, in PDM concept such functions are dedicated to manage processes and workflows used to modify and control the product i.e. to manage Engineering Change Order (ECO) by tracking approvals and authorizations of changes to product data.

Classification of parts provides information on standard components and help in re-use of designs. Integrated in ERP system it provides just-in-time relationship with suppliers of components based on product design demands.

In other manner, integration in ERP system gives to design engineer quantity status of standard component considered to be part of product and possibility to alternate it based on that status.

Program management functions are dedicated to provide work breakdown structures and allow coordination between processes, resource scheduling and project tracking. Although considered as PDM set of functions, it is actually base set in the most of ERP systems.

Extended or utility functions enhance the PDM concept. Among extended PDM functions are considered: communication and notification; data transport; data translation; image services and system administration.

5.5 Sample integration

For a sample integration presented is the integration of ERP system ERPINS-M from Inin Ltd. and CAD system Inventor Professional from Autodesk Inc. Integration is based on PDM concept.

ERPINS-M is ERP system for small and midsize manufacturing companies. It is developed on the Oracle architecture. ERPINS stands as an acronym for the Enterprise Resource Planning ININ Solutions, while M annotates a version of ERP system particularly tailored for the metal industry. The ERPINS system is a result of a twenty year long cooperation between the ININ Company [13] and the Mechanical Engineering Faculty [13], both located in Slavonski Brod, Croatia. The system is aimed at small and medium enterprises, particularly when enterprises have requirements for which ERP system has to be specially attuned.

Inventor Professional is midrange parametric and feature based MCAD system developed by Autodesk.

5.5.1 Product model

In ERPINS-M system, the general concept named as "Production Element" is placed in the very basis of the system. The production element is defined as a basic element of the product definition that could appear in production and according to it enterprise resources are allocated. If the object-oriented approach is used, the production element could be seen as an abstract class from which derived classes inherit basic attributes and methods. Figure 4

shows UML[3] class diagram of the simplified product model suited for the considered ERPINS-M system [14].

The abstract class Compound Production Element is included in the product model with a purpose to simplify the class organization and implementation in the ERPINS-M system. It determines hereditary class members (attributes and methods) that enable derived classes to have subordinated elements. Product and Assembly are classes whose objects could have subordinated elements, i.e. objects could have a structure. The member list SubordinatedElements contains identifiers of subordinated elements in the first level. If a particular subordinated element is also a compound, it has its own list of subordinated elements. To obtain a full structure of compound elements, it is necessary to iteratively read the lists of all subordinated elements.

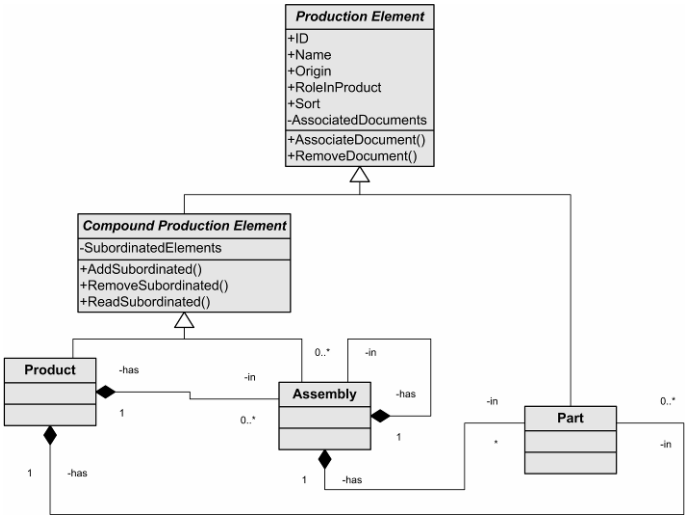

Figure 4 Simplified ERPINS-M product model

Objects from class Part could not have subordinated elements, i.e. they could not have structures. Therefore, the class Part is not derived from class Compound Production Element but directly from the top class Production Element.

[3] Unified Modeling Language

5.5.2 Vault model

To support the process of product development, ERP system must provide an electronic vault with a capability to associate documents with production elements but also with routines for tracking internal file dependencies within the same production element. Routines for tracking internal file dependencies are closely dependent on used CAD system in a particular enterprise. Tracking dependencies on different document levels should not be accomplished through internal file records, but through product or assembly structure as it is stored in ERP system.

The basic demand for a successful vault implementation in ERP system is that all documents associated with a product and production, have to be stored and controlled through the vault. Figure 5 shows the vault model implemented in ERPINS-M system.

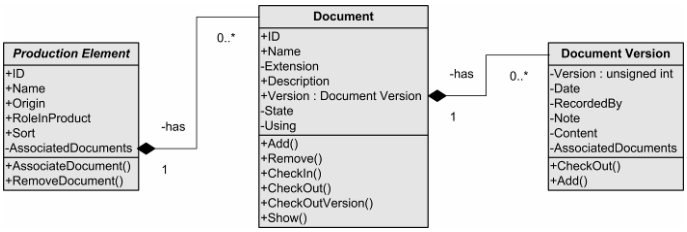

Figure 5 ERPINS-M Vault model

Documents are identified on the very same way as elements with a unique identifier. Such identification enables ERPINS-M to handle documents as production elements. The attribute Name usually has the same name as the associated production element, if there is one. The attribute Extension holds genuine document file extensions, while the attribute Description holds basic data about an application which is primary used to create and modify documents. For the purpose of coherent data storage, it is convenient to determine the attribute value by reading a document header or the file extension at the time of document storage in the vault. For ERPINS-M users the access to values of the attribute Description is available as read only. The attribute Description is presented in the model as a public member of the class Document so it could seem to be in contradiction with the previous statement. But one should distinguish between access rights for system user and access rights inside the system program code in terms of object oriented modelling.

The attributes State and Using are necessary in a multi-user environment to enable document locking. Changes of those attributes happen upon the execution of class Documents methods CheckOut, CheckIn and CheckOutVersion which are used to take out the document from the vault and write changed document back into the vault.

The attribute Version together with a class Document Version are used for tracking of consecutive document changes through the ERPINS-M system. The version annotation is set up with an integer number. Therefore, the first document version stored in the vault starts with number 1, and every subsequent version gets the number incremented by 1. The attribute Date stores the date of a particular version storage. The attribute RecordedBy holds the name of the user who stored a particular document version. Note enables users to store comments with a particular document version. The attribute Content, depending on document storage model either contains an actual binary file or it keeps referenced file addresses. The attribute AssociatedDocuments stores the list of vaulted documents, which are in any way associated with a particular document in a level of the same production element.

5.5.3 Integrated user interface

The proposed data integration demanded also interface upgrades of considered ERP and CAD systems.

User interface upgrade of ERPINS-M system is mostly reflected in subsystem for the definition of products and technologies, named DEPTO. Inside the structure of DEPTO subsystem, prototype implementation is reflected in the upgrade of the modules Production Elements and Product Breakdown Structure (Figure 6).

Text box for search by name and list of production elements serves for easier choice of active production element. Elements with a structure are shown shaded with different colour in the list. The module also enables an assignment of starting raw material for the production of particular element. The starting material is recorded and represented as a subordinated element to the assigned production element. Therefore, it is possible that non-compound production element like part is presented with shaded row, if it has starting material assigned.

The structure presentation frame shows hierarchical structure presentation of the active production element in a table. The numbers in circles in front of table row designate subordination level of particular production element. For

example, element 120 – Pin has subordination level 3 which means it has two superior production elements in the hierarchy. Just before unique identifier (ID) of the particular production element, an icon could be present to mark that production element has associated MCAD documents. If the icon is missing before ID, then the element does not have associated MCAD documents but it still could have associated documents of other types, like manuals or so.

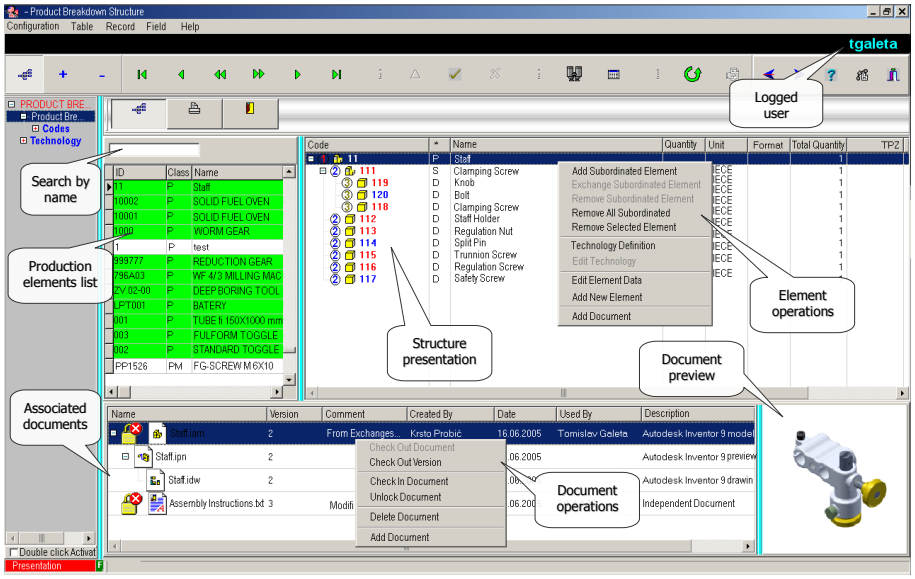

Figure 6 Upgraded ERPINS-M interface

Operation "Add Document" associates structured MCAD documents and documents of other type to the active production element. It is also available in the context menu inside the associated documents frame. The associated documents frame contains all documents associated with the active production element. Therefore, MCAD documents are presented hierarchically with the model of part or assembly on the top, regarding the sort of the production element. Implementation allows association of only one part or assembly model document with the production element, what is in conformity with common development procedure for parts and assemblies. Subordinated documents like representation or drawing file types are listed bellow the row of the main associated document. For an easier distinction, appropriate icons conformed to those of considered MCAD system are depicted just before the document name. If there are other

types of documents associated with the active production element than structured MCAD documents, it will be listed in additional row bellow MCAD documents.

User interface upgrade of CAD system is performed in Autodesk Inventor Professional. Upgraded functions are available through the drop-down menu ERPINS-M (Figure 7). All functions are available only after the user login into ERPINS-M system with valid user name and password.

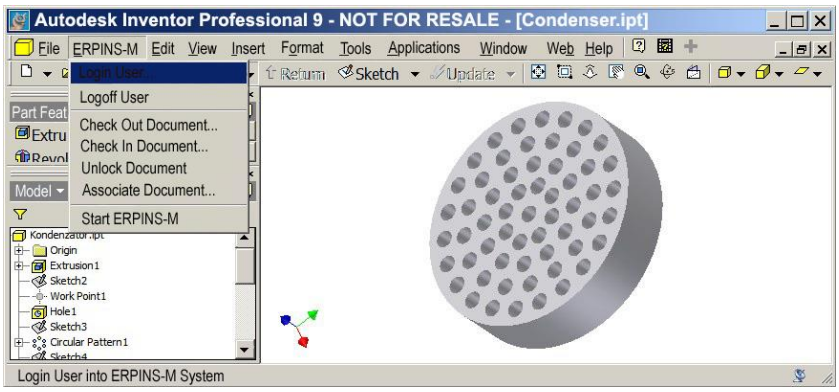

Figure 7 Upgraded CAD interface

Command Check Out Document enables selection and opening of selected document from the ERPINS-M. It is available immediately after successful user login. After finding all related subordinated or superior documents, the routine remove documents locked by other users and shows available documents in appropriate list for document check-out procedure. After check-out activation, the selected documents are written to selected user folder and locked in the ERPINS-M system for other users. Custom attributes are added to document written in user folder to make easier further document handling regarding ERPINS-M system. Routine will then try to open selected document in Inventor. Document opening does not necessary have to be successful if some of related files were locked by other users.

The basic command for association of an Inventor document with an ERPINS-M production element is executing for active Inventor document but also for related documents whether related documents are opened or closed. If active document is compound (model, representation or assembly drawing), routine executes recursive synchronization for production element structure with structure of subordinated part or assembly documents.

Document check-in is available only if at least one document is opened in Inventor and if active Inventor document has appropriate attribute values which describes document as previously checked-out from ERPINS-M system. Not only the active document, all related documents are also analysed and checked-in if necessary. Likewise, if active document is compound, eventual structural changes are examined and synchronized with associated production element in the ERPINS-M.

5.6 References

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