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INDUCTIVE APPROACH FOR THE SPECIFICATION OF A GENERIC PLM SYSTEM IN AN EXTENDED ENTERPRISE CONTEXT

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ABSTRACT

For several years, digital engineering has increasingly taken an important place in the strategic issues of mechanical engineering companies. Our proposition is an inductive approach that enables the specification of a PLM system dedicated to small and medium-sized enterprises (SME) in the field of mechanical engineering. This approach aims to provide assistance for costing, development and industrialization of products. It is based on the capitalization, reuse and extension of experts' knowledge. Our research starts with an immersion in SMEs to extract the main needs in terms of collaborative work, technical processes and technical data management. Based on each specific solution proposal, a generic solution is built at the conceptual level. In this paper we will present and justify the inductive process based on three case studies and the synthesis for the specification of a generic PLM system in the framework of an extended enterprise in the mechanical engineering field.

KEYWORDS

Product Life cycle Management, Meta-Model, Extended Enterprise

1. INTRODUCTION

In the present industrial context, French mechanical engineering industries are faced with growing challenges. After having refocused on their core business in order to increase efficiency, they are now encouraged to acquire more diversified skills. Market globalisation and an increase of customer demand have forced companies to produce more complex and customized products in a shorter lead time. To solve this paradox (refocus on the core business and need of multiple specific skills), companies have setup networks in order to pool and share their mutual skills. These networks are built for a specific project which is called 'virtual enterprise', or 'extended enterprise' when it is done over a longer period.

One of the key points of the success of such a structure is the ability to communicate on the target product. Products that generate a large amount of information, the classical communication system (phone/fax/email used by 90% of companies) is not structured enough to enable efficient cooperation. For many years, software has been developed to pool all this information. From the EDM (Electronic Document Management) in the 80's to the PDM (Product Data Management) and the PLM (Product Life cycle Management) nowadays, the companies and particularly the contractors understand the benefit of such approaches and software.

Within this context Cetim (an industrial technical centre that represents 7800 French mechanical industry companies) has performed a survey on digital and collaborative engineering for the mechanical engineering companies (Cetim, 2007a).

This survey showed that only 5% of SMEs of fewer than 100 people use a PLM system to manage their technical data. However, more than 70% of these same SMEs consider as important the reuse of knowledge, the share of information within the company and outside, the security of information access and storage and the follow-up of modifications (Cetim, 2007b). And these are the exact functionalities offered by the PLM software tools.

After many visits to SMEs, the contractors see the main obstacles to a PLM deployment as being not only the cost but also the complex nature of the setting, use, and maintenance. It seems, however, that the SMEs in the mechanical engineering industry have very specific needs in terms of PLM. 70% of these companies have customers in various business fields (mainly in the automobile and aeronautic sectors). As a consequence, they have a lot of technical skills to manage at the same time because the contractors use different CAD and PLM systems.

There is a true need for PLM in SMEs in the mechanical industry, but there are some obstacles that stand in the way of this development. Based on this premise, Cetim launched a project aiming to help the emergence of digital and collaborative engineering in those SMEs. This project links up with the strategy of the IVGI (Virtual engineering for industrial engineering) project in the IRCCyN laboratory that optimizes the integration of technical knowledge in virtual environments based on the enterprise processes. These activities need the implementation of specific methods and information system models for the mechanical engineering companies. First of all, we will introduce the scientific studies that will enable us to establish the starting point of our approach. Then we will present our work method, an inductive "research/action" approach, based on a spiral cycle structured on successive phases of analysis, development, experimentation, and then linking up with the methods and models enriched by experience feedback. We will describe our immersion in three different companies chosen with respect to a new typology of the mechanical engineering SMEs. This immersion phase will be concluded by the specifications of a generic meta-model and deployment method for a PLM system mainly dedicated to product data integration and management.

In addition, we will focus on the remaining scientific locks of the specified approach and how we expect to unlock them.

2. PLM: FROM CONCEPT TO META MODEL

In this chapter, we will concentrate on the design of PLM and we will examine the different modelling methods for information structure on which the PLM functionalities are based. Finally we will analyse the different standards that enable the communication and sharing of information and practical technical data between companies that do not have the same data model and the same business processes.

2.1. THE PLM CONCEPT

For many years, the software providers have been extolling the merits of PLM and the return on investment of that software. But PLM is first of all an enterprise strategy (Terzi, 2005). It involves managing all the data concerning a product, throughout its life-cycle, and all the internal and external actors involved in the development of this product. An acceptable definition of PLM is: "A strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination and use of product definition information across the extended enterprise from concept to end of life - integrating people, processes, business systems, and information" (CIMdata, 2003).

Much work has been done in this field, especially in the aeronautic and automobile sectors in order to propose technical data management methods (Bacha, 2002) (N'Guyen Van, 2006). Some others try to address the SME specificities and propose solutions such as Delplace for sand casting foundries (Delplace, 2004).

2.2. THE MODELING OF BUSINESS OBJECTS

PLM relies on a data model being composed of business objects that intervene in the business processes. Several modelling methods and languages have been developed so as to model these objects. Many modelling languages enable these objects and related activities to be represented such as SADT, IDEF3, BPMN (White, 2004) or FBS-PPRE (Labrousse et al., 2004).

The establishments of patterns, based on this modelling language, describe an approach to represent the processes (CIMOSA (Kosanke and Zelm, 1999), ARIS (Sheer, 1998), GERAM (GERAM, 1999), GRAI (Doumeingts et al., 1998), PERA (Williams, 1994)…. These methods contribute to the adjustment of methods and data models required for PLM implementation.

Nevertheless, in an extended enterprise context, it is necessary for these different models to be able to communicate together. Therefore standardized models are required to enable sharing or communication between companies that have not made the same choice of modelling.

2.3. THE STANDARDS OF DATA MODELS

Much work has been done in different sectors to increase the interoperability of data models with the standards, using mainly the STEP norm (STandards for the Exchange of Product model data) (Chambolle, 1999) (El Khalkhali et al., 2002). STEP is an international exchange standard of ISO (ISO 10303), that describes how to represent and exchange product models by covering the whole life-cycle (ISO 10303-1, 1994). STEP uses a formal representation language of data called EXPRESS (ISO 10303-11), and its graphical representation, EXPRESS-G (ISO 10303-11, 1994).

The Application Protocols (AP) are information models of STEP specific for an industry and/or a life-cycle phase. We have focused our attention on the AP214 (ISO 10303-214, 1998), specific to the automobile sector, and the AP239 (ISO 10303-239, 2005) dedicated to the aeronautic sector.

Those models are not fully interoperable, despite having common integrated resources, because the objects and the attributes are different depending on the sector of application. Hence the creation of PDM Schema (PDM Schema, 2001) tried to unify the different information models of STEP APs using their common objects.

It seems that if many methods exist for modelling business objects, their use for the creation and maintenance of a data model that supports PLM is not detailed enough for industrial exploitation. We will keep the FBS-PPRE modelling method (Labrousse & al., 2008) which enables the dynamic representation of objects independently of their roles (the same object can be a product, a resource or a process, depending on the context), which can be useful in an extended enterprise context. Moreover we can notice that in spite of the existence of standards, it is still difficult to get a data model both adapted to the company and interoperable with the standards. So we will develop an approach that uses the maximum of the best appropriate standards for SMEs in the mechanical engineering industry. We will explain how we intend to obtain this result in the following paragraphs.

3. RESEARCH APPROACH

Our approach aims to propose a methodology in order to structure and manage the technical data of companies in the mechanical industry in an extended enterprise context. We will propose methods to structure and manage technical data and the data models needed by those methods, using the existing standards. To define these methods and to reach a common data model for the different companies, we have implemented a three-step research approach, an inductive research/action type, based on a spiral cycle approach, typically consistent in terms of scientific experimentation:

- Immersion within the company and proposal of models and methods, development of the experiment,
- The experiment itself and results,
- Analysis of these results and identification of the limitations of the method and the proposed models,
- Proposition of modifications, implementation of these modifications and definition of the next experiment scenario, and so on until the desired results are obtained.

3.1. IMMERSION: NEEDS ANALYSIS AND INTEGRATION OF SPECIFIC METHODS

The first phase of our work is to interview companies to extract the present practices in terms of digital and collaborative engineering, and the best practices to implement. Benchmarking has also been done on existing software tools to list the functionalities and their ability to meet SME needs.

Then we created a typology (LeDuigou & al., 2008) to choose pilot companies representative of the mechanical industry. We selected different companies to cover the whole mechanical industry.

Finally we went into the different companies so as to directly and inductively integrate the technical data structuring and managing methods. This phase is coupled with the implementation of the methods with real data in the companies to verify the gap between our proposal and the objectives. From the initial situation of the company, we act by inductive research/action to arrive at the final state that we defined during the audit phase.

3.2. GENERALIZATION: CREATION OF A GENERIC APPROACH

In this phase, based on the analysis of the different pilot companies, we will generalize the method of managing technical data, and create a meta-model. This approach has to be compatible with the standards and applicable to all the types of companies in the mechanical industry so that it may be used in an extended enterprise context.

One of the main points of the generalization phase is the interoperability of the applications. Chen (Chen and Doumeingts, 2003) distinguishes three different approaches for interoperability: the “integrated approach” (Figure 1), using a common model for the whole enterprise, the “unified model”, where the users’ models are unchanged but a neutral formalism expresses the concepts and their relations and finally the 'federated approach', coupling the individual models with a common ontology.

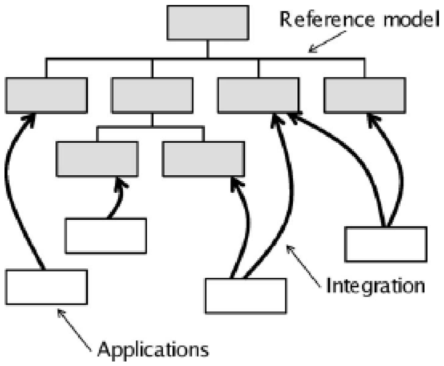

Figure 1 – Integrated approach (Bigand et al., 2007)

As we try to create a generic meta-model, we will focus on the integrated approach, that Bigand (Bigand et al., 2007) considers as consistent and very interesting, but not easy to be adopted by users who want to preserve their own models or tools. We will try to unlock this problem in an innovative way with a new approach that we will outline in our conclusion.

3.3. VALIDATION: EXPERIMENT OF THE APPROACH, BACK TO AN EXTENDED ENTERPRISE

Finally the experiment feedback will test, improve and validate our generic approach. We will test our approach on an extended enterprise to verify the method and its suitability to the product data management needs of this extended enterprise.

4. IMMERSION IN COMPANIES

In this paragraph we first propose a typology to choose our pilot companies. Then we explain the initial situation and our proposal in one company of each SME of our typology. Finally we assess those immersions.

4.1. TYPOLOGY OF MECHANICAL ENGINEERING SME

We have now to choose some pilot companies for our research. To obtain results that allow us to generalize the whole extended enterprise we need a typology of the different companies that could be integrated into this kind of enterprise.

We took as differentiation axes the number of parts in the product (produced by the SME) and the fact that the product is standard or specific. We obtained four zones (Figure 2).

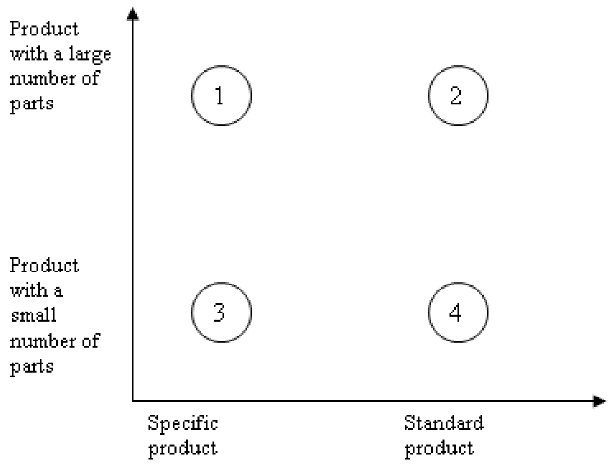

Figure 2 - Typology of SME in mechanical engineering industry.

Thereby we deduced that there were four types of SME:

Type1: SME that produces specific products with numerous parts, for example the special machine producers.

Type2: SME that produces standard products with numerous parts, for example the system or equipment integrators.

Type3: SME that produces specific products with few parts, for example the mould and tool makers.

Type4: SME that produces standard products with few parts, for example the elementary part producers.

This typology classifies the different companies present in an extended enterprise, from the tool maker to the integrator, through all the intermediaries. Then we chose companies covering the different zones of our typology for our pilot companies. By analysing the needs of these different companies, we will be able to extract the generic needs (the needs that are not specific to the activity of the company) and to link them to obtain the specifications of our generic model for the extended enterprise.

The next case studies must enable us to put into practice methods of technical data structuring and management, adapting to those specific companies. In order to do this, we will begin to analyse the needs of the company in terms of PLM. Then we will propose an approach to improve the initial situation. And finally, we will validate this method by integrating our solution in the company.

4.2. AN EQUIPMENT MANUFACTURER – PRODUCT DIVERSITY: PSL CONCEPT

4.2.1. Description of the company and initial situation

The PSL CONCEPT company produces and sells equipment for ships. Among these products, there are reserve rudders, pulleys and tackles, sheaves, jam cleats and various accessories.

This company organizes the main part of its products into families. In fact, as many system integrators and equipment manufacturers, its products are made from standard products, to which options and modifications are added to meet customer needs.

After the audit, it seems that the main needs in this company are as follows:

Knowledge capitalisation: An improvement of design, resulting from customer feedback, a set of tests or the optimization of the designer, are not reproduced on the other products of the family without the involvement of the designer on each product. This process is lengthy and is a source of error.

BOM management: The BOM are manual and have to be updated when there is a major modification of the product design.

Reference management: Due to the diversity of existing products (1200 references only for pulleys), the product references are hard to manage efficiently.

Quote: Giving a precise quote of a new product is complex because it is difficult to know the quantities of raw materials that will be consumed and the manufacturing time before the detailed design of the product.

Archive management: When a client comes back with a product, it is not always easy to find the original drawings of the product that has been sold with the references of the different parts.

Thus the audit phase underlines the main PLM needs of this company. Now we will propose an approach to give a global solution to these needs.

4.2.2. Proposed approach

First of all we aimed at organizing the technical data of a family of products. The families in PSL CONCEPT could be organized by main functions of the products.

We applied the axiomatic design principle (Suh, 1990), (Harutunian, 1996), (Suh and Do, 2000) to link the functional parameters to the design parameters in order to decline it into the technical data structuring and management of a product family (Bernard, 2008). We broke down the different functions of the family, and then we created a set of functional dimensioning parameters for the products in order to link those parameters to the different functions.

Thus, if a function is not required by the customer, and if this function is only linked to a single sub-product, then this sub-product will not be present in the final product. Moreover the modification of a functional parameter leads to the modification of the design parameters which are linked to it.

Now we will give an example for a specific function of the creation process. We will focus on the function “to keep the contact between the fag end and the sheave” when the parameter “angle of traction” is greater than 90°. If the maximum angle of traction is greater than 90°, we should add guides to the flanges and a screw between the two flanges. The fag end passes between the sheave and the screw and it is then forced to stay in contact with the sheave. In the CAD model, the feature “guide extrusion” switches automatically from a suppressed state to a resolved state. The construction parameters of the guide are then downloaded and filled in accordance with the function requirements (Figure 3).

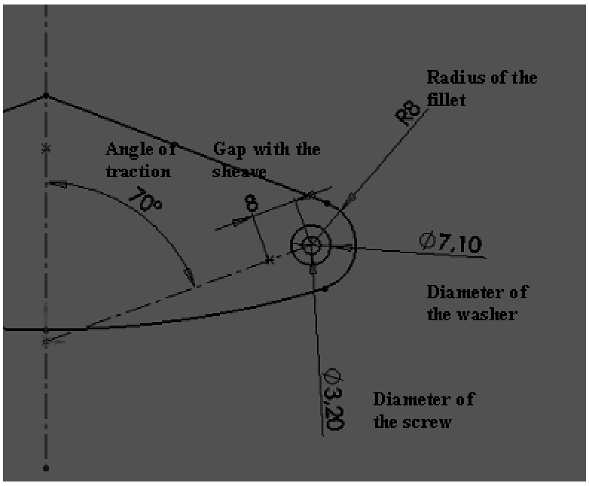

Figure 3 - Sketch of the guide on the flange.

When one of the guide parameters is modified, all the pulleys that have an “angle of traction” functional requirement greater than 90° will be modified. We will no longer change the value of the parameters, but we will directly change their definition. If the fag end is often jammed between the screw of the guide and the sheave (caused by an accumulation of impurities), then we can change the definition of the parameter “gap with the sheave” from “fag end diameter +4mm” to “fag end diameter +5mm”. Then all the new pulleys with a maximum angle of traction greater than 90° will have 1mm more in the gap between the screw and the sheave, so the impurities will no longer jam the end fag.

On this basis we have developed several functionalities to meet the needs in terms of PLM of this company.

Knowledge Capitalisation: When a modification of the design is made, this modification is implemented on all the products of the family that use the function concerned by the modification. There is no longer information loss when a product is improved because if the function or the definition of the design parameter is modified, all the products of the family will be automatically modified and so have the benefit of the improvement.

Reference management: In order not to have to open a large number of references without producing the referenced product, we introduced a system of referencing based on the functions of the product family. This system enables a new product (an unseen combination of functions) to automatically obtain a reference link to the specified functions, without having to open all the possible references beforehand.

Quote: After a study of the price of the product family, we noticed that the price of a product is linked to the functions of this product. So ascertaining empirically the relation between the cost and each function, we were able to obtain a global cost for a product from its functional definition.

Archive management: By registering the modification dates of functional parameters and the former values of these parameters, we are able to find the exact CAD of a past product, by using the parameters at the product sale date.

We have thus defined a global approach of structuring and managing technical data, which enables us to create a software solution to automatically design a family of products and to meet the company needs.

4.2.3. Integration of the approach

We focused on a major and well-known family of products for the company: the pulleys.

A software program was implemented to automatically construct the CAD file of a pulley from the functional requirements.

To create this programme we started by breaking down the functionalities of a pulley. Then we carried out a functional dimensioning of the different sub-parts of the pulley and we set these parameters in the CAD file. Then we brought together the dimensioning parameters in accordance with the functions of the pulley in order to obtain a link between the functions and the parameters in the CAD file. So we obtained a parametric model of the family of pulleys in a single CAD file with a link to the function requirement of each pulley.

The software made using Visual Basic language takes the appropriated parameters in a spreadsheet, then calculates those parameters depending on the chosen option, and finally put those parameters in the 3D model. All the parameters and their definitions are temporarily stored in a spreadsheet. They will then be stored in the PLM data base.

The referencing of the flanges and pulleys is automated in the software. It means that if the part or the assembly is new, the reference is created. If the part is old, the reference is copied. In both cases the references are added to the layouts and the BoM.

When the product is an assembly we add a functionality to automate the creation of the BoM, based on the CAD BoM functionality.

The drawings were created automatically in order to keep a paper record of the pulleys and its parts.

A table for the quotes was also made to calculate the price of a pulley depending on its functionalities. Each function has a price depending on the number of sheaves and the diameter of the fag end. Adding all the costs of the functions required by the customer we obtain the global quote of the pulley.

4.2.4. Conclusions on PSL Concept

We propose a global approach to meet the specific PLM needs of this company. The implementation of the software based on this approach and the results that we have obtained (the design time for a new pulley has gone from hours to minutes) prove that the approach is in phase with the needs of this kind of company, an equipment integrator (type II), in the mechanical industry.

4.3. AN ELEMENTARY PART MANUFACTURER – AUTOMATIC PROCESS PLANNING: CAPRICORN

4.3.1. Description of the enterprise and initial situation

Our second pilot company named CAPRICORN. This company manufactures crankshafts, connecting rods and pistons for the up market automotive industry and racing cars (F1, Nascar, 24H du Mans, Rally…). It is a type IV company in our typology: "elementary parts manufacturer".

This kind of company has problematic manufacturing technical data. The elementary parts manufacturers directly receive their drawings and CAD models from their customers. Then they add their expertise to draw up the plan of procedure of the product and produce it.

The audit phase makes us focus on the following initial situations:

External exchange: The customers directly send the CAD files to the engineering department, mostly in STEP format. When a modification occurs, a new file is sent by the customer. The modification must be done manually on the documentation in the engineering and planning department.

Knowledge capitalisation: The first phase of a route is quite repetitive. CAPRICORN would like to have software to automate this phase in order to be able to launch the supply earlier.

Documentation: The operations of a route need documentations from the production department. They are manually done and it is time consuming and a source of error.

Internal exchange: Once the documentation made it has to be sent to the manufacturing department. If a modification occurs, the right version must be sent to this department.

The following paragraph proposes an approach to respond to those needs.

4.3.2. Proposal

We chose to structure the technical data in three groups. The information from the product, directly extracted from the STEP file, the information from the work centres and the craft rules, both collected during the audit phase.

We suppose that the macro routes are already known. In a chosen route, each operation uses the information of some specific face of the product, the tooling machine information and the craft rules to create the detailed operation.

From these detailed operations, drawings are generated with the intermediary dimensioning, tolerance and a full title block.

Then these drawings are saved and sent to the production department.

4.3.3. Integration of the approach

We focus on the historical product of the company: the crankshaft (Figure 4).

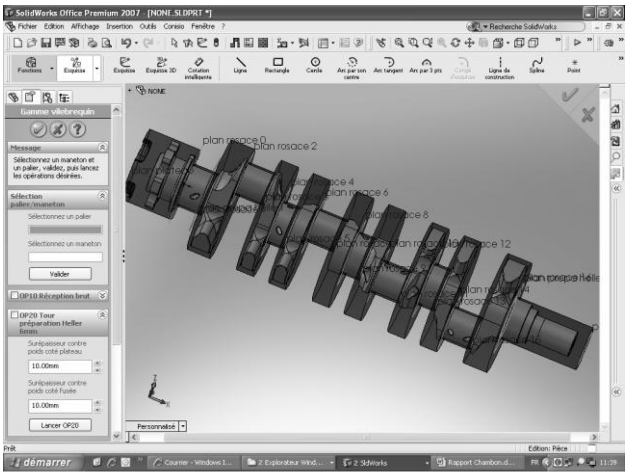

Figure 4 –Interface of the software

When a step file is received from a customer, it is opened with the CAD software.

We let the operator choose the appropriate macro route in a set of patterns. Those patterns contain the list of operations and the work centres usually used for this kind of operation.

With a face recognition based on fundamental knowledge, we are able to find the different entities cut in each operation.

From the final 3D model product, we reconstruct the blank part. Then we simulate each cutting metal by a feature of cutting. As a result we obtain the 3D model of each intermediary part.

For example, to draw the preform of the arms, we take the machining allowance, the emplacement of the rosettes (faces between the crank pin and the arm) and the diameter of the cylindrical cutter that determines the intermediary form of the arms with a craft rule. All those information, combined to the previous intermediary part, are necessary and sufficient to draw the next intermediary part.

All the parameters of the detail operation are modifiable directly in a specific window of the CAD software.

The generation of documentation is done automatically from the 3D model of the intermediary part (Figure 5). They are saved as PDF files and sent to the production department.

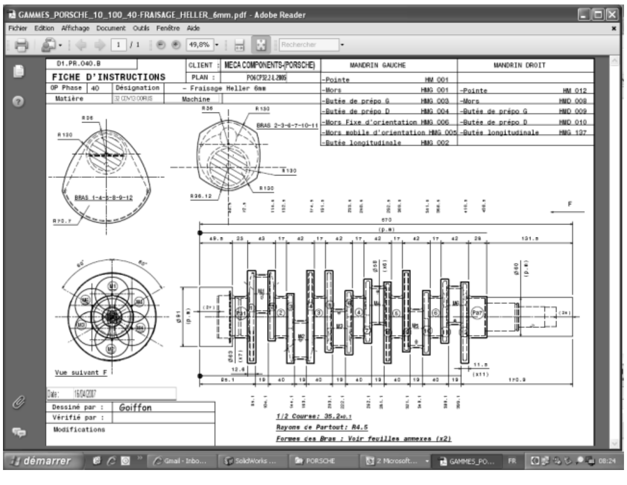

Figure 5 –Drawing of an intermediary crankshaft

4.3.4. Conclusion on CAPRICORN

This case study enables us to identify the different technical data used by the planning department during the industrialisation phase. It also enables us to extract the knowledge to use those data internally as well as externally via the exchange with the customer and the production department.

4.4. A MACHINE PRODUCER – BOM MANAGEMENT: SMP

4.4.1. Description of the enterprise and initial situation

Our third case study is SMP, a grinding machine producer. This company is a type I, "machine producer".

Due to the high number of components of its products and its high customisation, this type of company often encounters bill of material problems.

After the audit phase we select the following initial needs:

BoM creation: At the moment the BoM are done manually from the analysis of the CAD model using a spreadsheet and sent to the manufacturing department.

BoM management: when a modification occurs, in a sub-assembly, the operator has to detect all the impacts. He manually applies and checks the modifications to all the BOM that are impacted.

BoM structuring for the production department: the production department and the engineering department have two different ways to structure the BoM. So the modifications of the engineering BoM are more difficult to impact on the production BoM and vice versa.

BoM integration in the ERP: The integration of the BoM in the ERP of the company is done manually, which is time consuming and source of error.

The next paragraph will explain which approach we integrated to improve the initial situation.

4.4.2. Proposal

The approach proposed here is based on the double view of the bill of material. Using a buffer file without the structuring of the product, we can have a different structuring in each department of the company.

First of all we select the different information needed by the engineering and the production departments. We make a list of attributes for each kind of products, sub assemblies and assemblies.

Then we create a BoM for the engineering department extracting from the list of attributes only those wanted by this department and with the same structure as the 3D model.

A second BoM is created for the production department extracting from the same list of attributes only those wanted by this department and with the same structure as the ERP model.

If a modification occurs in the attributes, both, the engineering and the production BoM will be automatically changed.

If the change is made on a sub-assembly or a part, all the assemblies containing the sub-assembly or the part are updated.

4.4.3. Integration of the approach

The attributes are directly filled in in the CAD software, as attributes of the part or assembly.

The BoM with the engineering view are extracted directly from the CAD model based on CAD functionality.

For the production point of view, a software extracts a specific list of attributes from the CAD software and lists them in an excel file. The operator can structure it as he needs, without breaking the dynamic link with the attribute of the CAD model.

At the opening of the excel file, a check verifies if the attribute has changed. If a modification occurs, the operator chooses, if he wants, to impact the excel file or the CAD file. Then the modification is applied.

Once the BoM is structured following the production department procedures, the BoM can be imported to the ERP. When the BoM is open in the ERP, the Excel file is open. If a modification is found between the ERP attributes and the excel attributes, the operator chooses, if he wants, to impact the ERP or the excel file and the modification is applied.

To have a better traceability of the modifications, the integration of the excel file in a PDM was envisaged. This method will secured the opening of the excel file, archived the different modifications, the authors and the dates of the modifications. For the moment, the excel file is simply in "track change" mode to have a first level of traceability, but without authentication of the authors.

4.4.4. Conclusion on SMP

This case study enables us to identify the technical data that is transferred between the engineering department and the planning department in this company.

It also allows us to extract the knowledge useful to their transfer and especially concerning the multi view of a product. We applied this multi-view notion using a buffer file that contains all the information of the product, the structuring of the product being specific to each view.

4.5. ASSESSMENT OF IMMERSIONS

During this phase of immersion we integrated a knowledge management approach with first of all an extraction of fundamental knowledge, then a structuring of that knowledge and finally its integration into the software. The validation of this work was done by software tests carried out by the expert. The results of those tests go back to the knowledge extraction phase, then another structuring and integration phase, and so on until we obtain the desired results.

Knowledge extraction: The first phase of each immersion was an extraction of the data used by the expert and the rules used to process them. To obtain that information we use two methods:

- Observation of the expert in the exercise of its function: The observation of the expert allows us to get a first look at the use of technical data in the company. The dialogue with the expert enables us to extract the explicit knowledge inherent in his job.
- The practical aspect of the expert's job: To refine the knowledge about the use of those data, we actually did his job, using his workstation. We extracted the implicit knowledge that was not formalised by the expert.

Structuring: The integration of those methods needs the structuring of the technical data by group (objects and attributes) and the structuring of the craft rules by algorithms.

Integration: The automation of those methods integrates the technical data and the craft rules in software validated by the company.

This phase of immersion defined the needs of those companies in terms of technical data. We will now synthesise those needs to extract the generic needs from the specific needs.

5. SYNTHESIS OF THE NEEDS

Obviously the specific application integrated in our pilot companies are too specialised to be directly integrated into a generic model for the extended enterprise. Some of those data and some processes are really specific to the product manufactured by the company or to its production process (sheave diameter or number of crank pins may not be generic attributes of a product). Nevertheless some other can be processed in a global way in the extended enterprise.

So, two types of needs appeared during this immersion phase: The generic needs and the specific needs. The generic needs are independent of the activity of the company.

We obtained three types of generic needs depending on whether they are linked to the product, the process of production or the resources needed to manufacture the product.

The function of the product seems to be a special need for all the companies.

We also identified the necessity to have a structural view of the product depending of the life cycle step study.

Finally, some craft rules, integrated by algorithms, could also be classified as generic, especially those about exchange and collaborative workflows.

6. DISCUSSIONS, CONCLUSIONS AND PERSPECTIVES

We are, at present developing an innovative approach based on a meta-model to process the development of a product in an extended enterprise. Based on the specification described before and on the state of the art of the domain, we will soon propose a method and a model to support the product development in an extended enterprise.

One of the main scientific locks remaining is that we have done our immersion taking the company as the centre of the system. And this point is one of the main objections of SME for their adhesion to the PDM systems of the contractors: they are not centred on themselves. We will try to respond to this problem in an innovative way using the FBS-PPRE modelling that enables the modification of the role of an object during its life cycle depending on the process that crosses the object. This modelling could allow us to have a company-centred view for each component of the extended enterprise.

This approach will be validated by a second experimentation phase with the integration of the method in an extended enterprise.

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