CIRP Journal of Manufacturing Science and Technology 1 (2009) 185–190

Contents lists available at ScienceDirect

CIRP Journal of Manufacturing Science and Technology

journal homepage: www.elsevier.com/locate/cirpj

Global approach for technical data management. Application to ship equipment part families

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ARTICLE INFO

Article history:
Available online 30 November 2008

Keywords:
Product life cycle management
Data model
Axiomatic design

ABSTRACT

For several years, digital engineering has increasingly taken a more important place in the strategic issues of mechanical engineering companies. Our proposition is a global approach that enables technical data to be managed and used throughout the product life cycle. This approach aimed to provide assistance for costing, development and the industrialization of the product, and for the capitalization, the reuse and the extension of fundamental knowledge. This approach has been experimented within a company environment that designs and produces families of ship equipment parts. This case study is presented together with the software that has been developed for this company.

1. Introduction

In the present industrial context, French mechanical engineering industries are faced with growing challenges. After having refocused on their primary business in order to increase their production by increasing efficiency, they are now being asked to acquire more diversified skills. Market globalisation and an increase in customer demands has forced companies to produce more complex and individualized products in a shorter lead time. To solve this paradox (refocus on the primary business and need of multiple specific skills), companies have adapted by regrouping in order to pool their mutual skills. When this is done over a short period and on a specific project, it is called ‘virtual enterprise’, and ‘extended enterprise’ when it is done over a longer period.

One of the key points of the success of such an enterprise is the ability to communicate on the target product. Products that generate a large amount of information, i.e. the classical communication system phone/fax/e-mail 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 1980s 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 software.

Within this context Cetim (an industrial technical centre that represents 7000 companies of French mechanical engineering industries) decided to launch a survey on digital and collaborative engineering for the mechanical engineering companies [1]. This survey showed that only 5% of SMEs of fewer than 100 people use a PLM system to manage their technical data. However, a second survey in the same year [2] showed that more than 70% of these same SMEs consider as important the reuse of knowledge, the share of information in the company and with the outside, the security of information access and storage and the follow-up of modifications. These are the exact functionalities offered by the PLM software tools.

After many visits to SMEs, the CEOs see the main obstacles to a PLM installation as being the complex nature of the installation, use, and maintenance. It is also very costly. 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 OEMs use different CAD and PLM systems.

There is a true need for PLM in SMEs in the mechanical engineering industry, but there are some obstacles that stand in the way of this development. Based on this premise, Cetim launched a project aimed 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

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1755-5817/$ – see front matter © 2008 CIRP.
doi:10.1016/j.cirpj.2008.10.005

Engineering) project in the IRCCyN laboratory that optimizes the integration of technical knowledge in the enterprise processes. These activities need the implementation of specific methods and data models for the mechanical engineering companies. First of all, we will work on the scientific studies that will enable us to establish the starting point of our approach. Then we will present our work method, a 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 modified by the experience feedback. We will describe our contribution and an industrial case study. In prospect, we target a generic method and data model to structure and manage the technical data, adapted to the SMEs in the mechanical engineering industry.

2. PLM: from concept to data model

In this chapter, we will first of all concentrate on the design of PLM, then we will examine the different methods of modelling which enable the creation of a data model on which are based the PLM functionalities. Finally we will analyse the different standards that enable the communication and sharing of technical data between companies that do not have the same data model.

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 [3]. 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 system, and information" [4].

This concept enables, for example, planning departments to access information directly from a design department, and to propose modifications, thus shortening the product development cycle and avoiding retro design which is both long and costly. At a more strategic level, PLM enables CEOs to follow critical information on a product line or the exact time to market of new products.

Much work has been done in this field, especially in the aeronautic and automobile sectors in order to propose technical data management methods [5,6], but also in smaller companies, such as sand foundries [7].

2.2. The modelling 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. The modelling languages enable these objects and related activities to be represented (SADT, IDEF3, BPMN [8], FBS-PPRE [9], . . .).

The establishments of patterns, based on this modelling language, describe an approach to represent the processes (CIMOSA [10], ARIS [11], GERAM [12], GRAI [13], PERA [14], . . .). 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) [15,16]. 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 [17]. STEP uses a formal representation language of data called EXPRESS (ISO 10303-11), and its graphical representation, EXPRESS-G [18].

The Application Protocols (AP) are information models of STEP specific for an industry and/or a life cycle phase. What is of interest to us is the AP214 [19], which is specific to the automobile sector, and AP239 [20] which focuses more on 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 [21] that 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 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 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 next chapter.

3. Research approach

Our approach aims to propose a methodology in order to structure and manage the technical data of companies in the mechanical engineering industry in the context of extended enterprise. 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, a research/action type, based on a spiral cycle approach, typically consistent in terms of scientific experimentation: 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. Phase 1: audit of the companies, typology of SMEs in the mechanical engineering industry and choice of pilot companies

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