ANNALS of Faculty Engineering Hunedoara
International Journal of Engineering
ISSN: 1584 - 2665

PRODUCT LIFECYCLE MANAGEMENT WITH KNOWLEDGE MANAGEMENT AS A STRATEGIC APPROACH FOR INNOVATIVE ENTERPRISE ENVIRONMENT

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ABSTRACT
Process planning knowledge (PPK) is one of the most important knowledge in production manufacturing enterprise. This paper analyzes the PPK and the concept of process planning information model (PPIM) implemented in production enterprise. In second part of the paper, there is done the basic information about PLM concept as a business strategy for product development where are included PPK and PPIM approaches, strategy which offer possibilities for innovation. Product Lifecycle Management (PLM) is the process of managing the whole life cycle of a product starting from generating an idea, concept description, business analyzes, product design, solution architecture and technical implementation, to the successful entrance to the market, service, maintenance and innovative product improvement.
Keywords: Process Planning, Knowledge Management, Product Lifecycle Management

1. INTRODUCTION

With the development of knowledge economic, knowledge resource becomes the most important resource in mechanical manufacturing enterprise. The competition superiority of enterprises comes from the effectively development and management on knowledge resource. Nowadays, with the rapid application of enterprise information software [1], the location of knowledge resource is changing from employee's brain and papery document to digital databases in mechanical manufacturing enterprise. These databases are the foundation and sources of knowledge management. How to change these data into knowledge is the work of knowledge discovery. Knowledge management in production enterprise can be divided into three parts; they are creating knowledge, finding knowledge and spreading knowledge.

Process planning knowledge (PPK) is one of the most important knowledge in production enterprise. It includes foundation data, process planning specification, experience of expert etc. for process planning. For the complexity of PPK, the PPK acquisition in process planning instances of papery documents needs human knowledge engineers to accomplish. With the in-depth application of Computer Aided Process Planning (CAPP) system, digital process planning data is accumulated rapidly in databases. How to accomplish knowledge discovery of technique, experience, data, principle, and specification in industry practice has been the key problem in production enterprise.

How to discover new knowledge and enrich PPK based on the accumulated product process planning database (PPDB) is concerned by engineers significantly. It is a new technology as it is called process planning knowledge discovery (PPKD). Nowadays, knowledge discovery technology has been widely used in finance industry, communication industry, retail industry etc., but for production industry, especially on process planning knowledge discovery in CAPP application system, it has less report and research. But, it is on contemporary way to develop innovative product or process in the company. In fact, process planning discovery technology covers the theoretical issues related to data mining, learning-by-examples, knowledge acquisition, knowledge discovery, database, and information mapping. The PPKD is certainly not for humans entirely; actually, most analysis work needs to be automated [2]. A goal for PPKD is to build a foundation for the application of knowledge discovery based on CAPP database from an interdisciplinary perspective including artificial intelligence, database, software technology, statistics and management. Recent research achievement in expert system (ES), artificial intelligence (AI), knowledge management (KM), data mining (DM), database (DB) etc. have established abundant foundation for PPKD.

2. ENTERPRISE SYSTEM ACTIVITIES

The product development and production involves several production management activities with a series of individual tasks that are to be completed in order to design and produce a product of a required quality. These tasks are usually carried out in a linear sequence, but very often the feedback is necessary from the subsequent task to the previous one. Many of these feedback loops are requests to modify the previous task's solution in order to generate a better solution in the subsequent one. This interlinking is what has become known as concurrent or simultaneous engineering.

2.1. Product development cycle

Product development cycle may be seen as a set of answers to a series of simple questions [3,4]: Why to produce? What to produce? How to produce? Where to produce? Who to produce? When to produce? The answers of these questions will identify what functions a necessary in the cycle from developing an idea to the realization of the final product.

Answers to these questions may be given by connecting them with particular manufacturing functions: marketing function, design function, process planning function, resource planning function, production control function (shown of Figure 1). The product development cycle is not a linear path without obstacles. Usually, the product development follows some zigzag pattern between functions with frequent needs to feedback information from a function to previous one. There are numerous feedback loops and overlapping between functions. Therefore, there are process planning tasks that can not easily be classified into particular functions and these tasks lead toward integration between these functions.

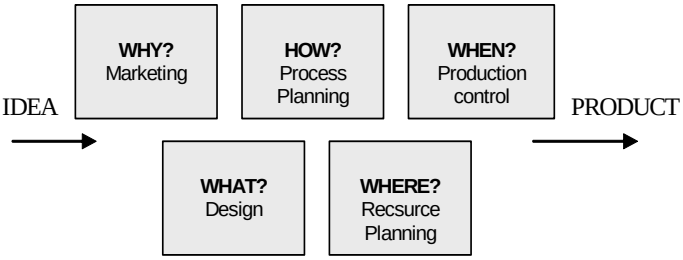

Figure 1. Basic product development cycle

Starting from analyzing set of tasks of process planning and other activities, it is possible to develop the model that shows interactions between process planning and tasks that have to be done in the product development. All of these activities are identified in manufacturing planning literature as activities required during the product development and production. There are numerous tasks that require interactions between two or more activities that represent integration links.

2.2. Process planning

Knowledge discovery in database have been attracting a significant amount of research, industry attention in recent years. Process planning knowledge (PPK) is one of the most important knowledge in mechanical manufacturing enterprise. The traditional method of turning data into knowledge relies on manual analysis and interpretation. On the basis of the widely application of computer aided process planning (CAPP) system in mechanical manufacturing enterprise, the concept of process planning knowledge discovery (PPKD) is proposed based on process planning databases.

Planning of manufacturing processes provides the link between design and production. Its task is to determine a plan of discrete manufacturing operations that, when executed in an actual production environment, will produce the part as required by its design description. Computer-Aided Process Planning (CAPP) may result in better designs, lower production costs, larger flexibility, improved quality and higher productivity and they are develop by the application of artificial intelligence (AI) methods and tools [5]. The reasons of this are two:

- CAPP is a complex problem that includes part analysis, selection of operations and resources, operation sequencing, setup planning, fixture design, and the determination of process parameters. The domain knowledge of a process planner has to cover geometry and tolerances, material properties, manufacturing processes and tools, fixtures, as well as machine tools. Besides generating executable plans, the optimal allocation of resources is the main concern of planning.
- General-purpose AI planning systems provided clear-cut logic-based representation formalisms and more and more efficient solution methods. However, the restricted representation formalisms did not allow to capture all of the relevant domain knowledge and to define planning strategies. Solvers could not handle optimization objectives and support mixed-initiative, interactive problem solving. Hence, they could not fit the real-world problems like the CAPP problem.

3. PROCESS PLANNING KNOWLEDGE MANAGEMENT

3.1. Analysis of Process Planning Knowledge

Process planning knowledge in production manufacturing enterprise includes foundation data, process planning specification, and experience of expert etc. for process planning. All types of PPK are

synthetically used generally, for example, selecting manufacturing method, designing fixture, arranging route etc. In commonly, PPK can be divided into four types:

1. *Handbook knowledge:* It includes data and knowledge in handbook and engineering standard for process planning, for example, tolerance, material, cutting feed and process planning specification etc.
2. *Manufacturing resource knowledge*: It implies data and knowledge that has close relation with manufacturing environment, such as machine, cutter, fixture and process planning database etc.
3. *Decision-making knowledge*: It is compose of experiential rule, procedure algorithm and control knowledge for process planning that commonly exists in engineering expert's brain.
4. *Model knowledge:* It includes process planning data model and process planning knowledge model, for instance, product, part, process planning, operation, step, fixture, machine etc.

The traditional method of turning data into knowledge relies on manual analysis and interpretation. PPKD is the process of mining and formalization domain process planning knowledge in manufacturing enterprise. Nowadays, the main method of PPKD is done by human knowledge engineers assisted by domain expert from literature, document, handbook, process planning file etc. in papery information source. For example, in mechanical manufacturing enterprise, it is common for experts to periodically analyze current trends and documents in enterprise, and on a quarterly or yearly basis. The experts can provide an outline document of the analysis to the engineering department; the effect of this document for decision-making and planning on new product is rather limited [8]. In addition, this form of manual probing of information set is slow, expensive, and highly subjective, and depends on domain experts greatly. In fact, as information volumes grow dramatically, this type of manual information analysis is becoming completely impractical in engineering work, and these problems result in the poor implementation of PPKD.

In fact, with the application of CAPP system in manufacturing enterprises, process planning knowledge is implicated in digital process planning databases. It becomes a main PPK source in manufacturing enterprise. Based on representation of process planning knowledge model, technology and method, discovering knowledge from digital process planning databases can be an effective method to solve the PPKD.

The PPKD refers to the overall process of discovering useful process planning knowledge from CAPP database, and process planning data mining is a particular step in this process. The whole steps in the PPKD include, such as data preparation, data selection, data cleaning, incorporation of appropriate prior knowledge, and proper interpretation of the results of mining, are essential to ensure that useful knowledge is derived from the CAPP database.

3.2. Process planning information model

In order to represent the commonness of PPK in mechanical manufacturing enterprise, process planning information model (PPIM) is founded based on the overall analysis of process planning information in mechanical manufacturing enterprise. PPIM is the foundation of PPKB and PPDB. PPKD is founded on the analysis of PPKB and PPDB based on PPIM in CAPP system.

PPIM includes all fundamentals process planning object (product, part, process planning, manufacturing resource, route etc.). PPIM establishes the protocol on PPKD in CAPP system database by the standard description of concept, item and model for the sharing on PPK. Figure 2 shows the relation of PPKB and PPDB based on PPIM.

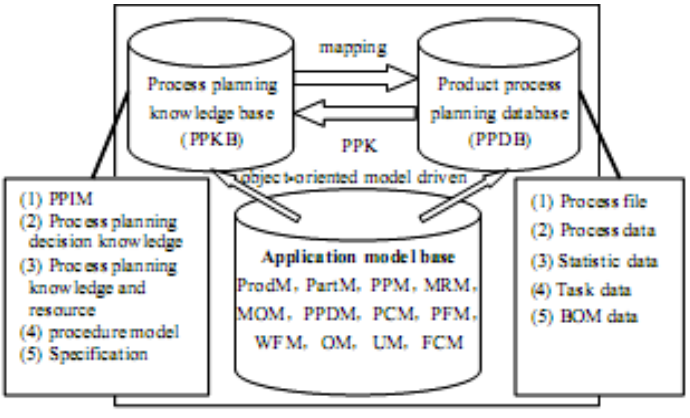

Figure 2. Process planning database and knowledge base based on PPIM

4. CONCEPT OF PRODUCT LIFECYCLE MANAGEMENT

In today's demanding global economy, product success depends on company's ability to beat the competitors to market with products that capture customers' imagination with stylish yet appropriately functional content that performs as required while being delivered at a price the market is willing to pay. In other words, the products must be able to satisfy customer requirements for: timing, function, performance, style and price. Since these variables frequently change during the

course of a product lifecycle, the innovation process must be able to account for change and easily accommodate its demands on a systematic and repeatable basis.

4.1. Definition of PLM

Product Lifecycle Management (PLM) is generally defined as a strategic business approach for the effective management and use of corporate intellectual capital. Today, challenges faced by product development teams include globalisation, outsourcing, mass customisation, fast innovation and product traceability. These challenges enhance the need for collaborating environments and knowledge management along the product lifecycle stages. PLM systems are gaining acceptance for managing all information about the corporation's products throughout their full lifecycle, from conceptualisation to operations and disposal. The PLM philosophy and systems aim at providing support to an even broader range of engineering and business activities [6,10].

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. PLM is an integrated, information-driven strategy that speeds the innovation and launch of successful products, built on a common platform that serves as a single repository of all product-related knowledge, data, and processes. PLM is the process of managing the whole life cycle of a product starting from generating an idea, concept description, business analyzes, product design and solution architecture, technical implementation and product testing, to the successful entrance to the market, service, maintenance and product improvement. PLM gathered and make accessible all the data and information of all stages of this process.

As a business strategy [7,8,9], PLM lets distributed organizations innovate, produce, develop, support, and retire products, as they were if they were a single entity. It captures best practices and lessons learned, creating a storehouse of valuable intellectual capital for systematic and repeatable re-use. As an information technology strategy, PLM establishes a coherent data structure that enables real-time collaboration and data sharing among geographically distributed teams. PLM lets companies consolidate multiple application systems while leveraging existing legacy investments during their useful lives. Through adherence to industry standards, PLM minimizes data translation issues while providing users with information access and process visibility at every stage of the product's life.

PLM systems support the management of a portfolio of products, processes and services from initial concept, through design, launch, production and use to final disposal (Figure 3) [8]. They coordinate products, project and process information throughout new product introduction, production, service and retirement among the various players, internal and external, who must collaborate to bring the concept to fruition.

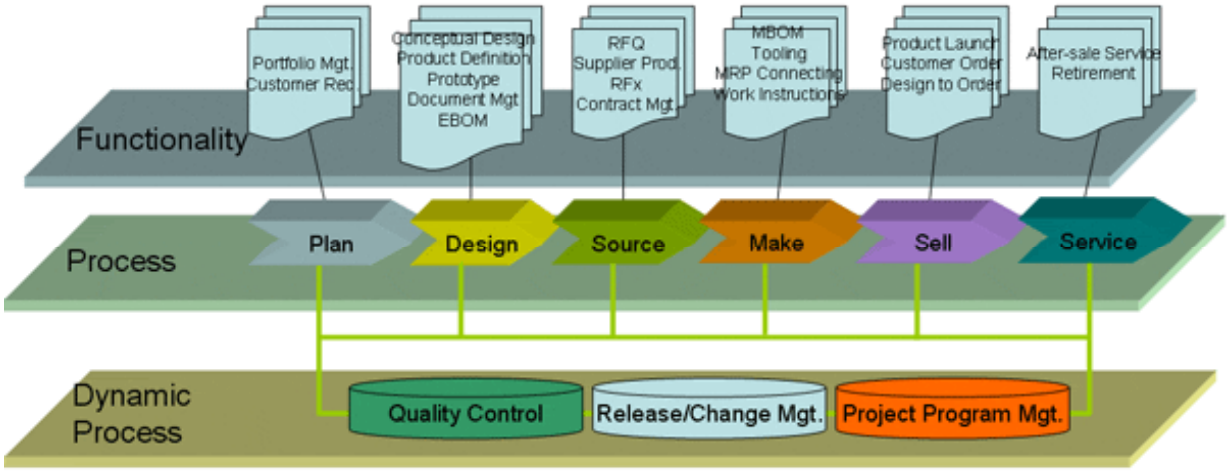

Figure 3. PLM System

The PLM concept gives the strategies to organize and to manage product information the entire life cycle, from concept to re-cycling of the product through:

- Share the updated product information's within the organization to design, manufacturing, marketing and procurement divisions,
- Collaborate internal team with external users, suppliers and customers for iterating new designs,
- Maintain a repository of product information for design reuse and to reduce part redundancy,
- Systematically gather and analyze customer or market product requirements,

- Streamline sourcing team to identify a list of preferred suppliers for purchasing custom and standard parts,
- Streamline resource management and analyze the cost-benefits of allocating resources for specific projects.

Management and distribution of enterprise information by PLM system is realized on different modules or data levels, as: ICT, Processes, Data & Objects, Method & Tools, People & Organization.

4.2. Application of PLM

4.2.1. Medium to large enterprises

In the current economic climate, addressing global business challenges is the top priority of most medium and large enterprises. Whether they want to expand their customer base in new markets, or to leverage more cost competitive resources, conducting their business globally is a necessity [1,7]. To sustain an advantage, they have to overcome the challenges of a dispersed organization, while still empowering individual team members to excel.

PLM concept offers comprehensive solutions to help enterprises address their challenges and create competitive advantage. Five areas where medium and large enterprise should have achieved success include:

- Managing new product introduction, to create a winning product portfolio.
- Achieving concurrent engineering globally, to be faster to market.
- Creating platforms for reuse, to reduce cost and speed product customization.
- Managing product and manufacturing complexity, to avoid program problems.
- Supporting products currently in-service, to ensure they are available for use at minimum cost.

4.2.2. Small to medium enterprises

Small and medium enterprises have special needs and limited resources. PLM concept brings a complete solutions designed specifically for them; solutions that help them respond better to their customer's needs.

Small businesses need a product lifecycle management solution designed from the ground-up – one that is pre-configured with the industry's best practices, and offers fast and affordable deployment. Fully integrated PLM solutions are designed to provide what small and medium enterprises need to maximize their innovation strategy, and easily scale to meet their needs tomorrow.

One significant PLM software solutions is Siemens PLM software [11]. It helps mid-sized manufacturing companies to transform their process of innovation by applying preconfigured best practices to everyday engineering tasks and processes. Companies using PLM software benefit from:

- Securing their corporate design data while facilitating access by authorized personnel
- A more successful move from 2D to 3D
- Increasing their design reuse, facilitated by a powerful and flexible search capability
- Streamlining their engineering process with simple design review and release workflows and effective change management
- Error reduction through more effective collaboration between their departments and the elimination of mistake manual handoffs to manufacturing
- Rapid deployment of a full-featured product data management (PDM) solution
- Low total cost of ownership.

4.3. PLM Business Value

When the enterprise implements the PLM concept in work, than it can move forward strategically while achieving near-term results and can establish a platform for innovation. As the enterprise address specific business issues and builds a solid foundation for future success through PLM platform [11], it will be able to realize measurable innovation benefits both immediately and over the long term, shown on the Figure 4.

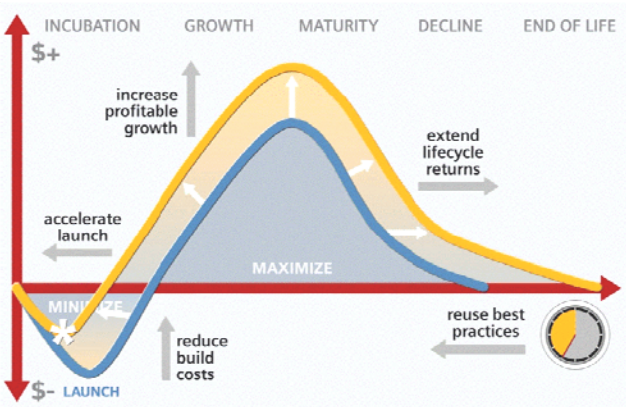

Figure 4. PLM business value

Traditionally, companies brought their products to market in time-consuming serial processes that delayed the participation of downstream contributors, such as suppliers, manufacturing experts and service/maintenance providers. By allowing to the enterprise to execute as many lifecycle tasks as possible in parallel processes, PLM enables to the enterprise to streamline and collapse critical stages in the product lifecycle. PLM delivers aligned, accurate, and

highly synchronized product knowledge to multiple disciplines early in product lifecycle – thereby avoiding the cost and scheduling impact that comes when late suggestions and unexpected concerns arise from downstream players. PLM enables to the enterprise to beat the competition to market with innovative product content that carries first to-market advantages and drives early product sales.

5. CONCLUSIONS

Although a quite new method with short history PLM has proven itself to be useful for all management levels within the company in both vertical and horizontal organization. By making relevant historical information structured and available PLM is used both for those who are doing execution and decision makers within the organization answering to the rapid changes in the business environment. A business approach for coordinating design process through the implementation of PLM systems is proposed for improving design coordination in company. Firstly, this business approach is based on a method for analysing informal collaborative practices and modelling detailed design processes. Secondly, these processes are implemented by using PLM technologies. Multi-level workflows are implemented to control progress of design schedule from project management level to document lifecycle management level.

PPKD and PPKM as the strategic approaches implemented in the PLM modules are important foundation part of work in the production enterprises. By the industry practice of using PPKD technology and PPKM developed and based on CAPP platform, PPKD can be executed automatically in PPDB and PPKB. It can help the standardization and specification of process planning data effectively.

Acknowledgment

This paper is part of the work developed in frame of the TEMPUS project No. 144959-2009-JPCR, titled: Master studies and Continuing Education Network in Product Lifecycle Management with Sustainable Development, financed by the European Commission for the period 2009-2012.

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