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A Modular Product Structure Based Methodology for Seamless Information Flow in PLM System Implementation

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ABSTRACT

Product development process deals with large amount of information generated from market survey, concept design, manufacture, test, limited production, production, service, and obsoleting. The information should be stored systematically so that it is easily traceable and reusable for future product development. This paper presents a methodology for seamless product information flow between the three main enterprise information systems such as Computer Aided Design and Manufacturing (CAD/CAM), Product Data/Lifecycle Management (PDM/PLM) and Enterprise Resource Planning (ERP) used in the process of innovative product development while implementing PLM. PLM implementation deals with various existing product data and information generated over years both from CAD and ERP systems. Data integration is very challenging in multi-national engineering companies and has important impact on future decisions while creating new processes. The aim is to define a modular product structure that can be used to connect the product information throughout the life cycle that can be reused effectively and efficiently for future similar products.

Keywords: Product Life Cycle Management (PLM), Computer Aided Design and Manufacturing (CAD/CAM), Enterprise Resource Planning (ERP), Product structure and information model.

1 INTRODUCTION

The amount of data generated during product development process grows faster than ever. For most of aerospace, automotive and defense companies, to store data for 15-20 years is an absolute requirement and also a big challenge. Sometimes it can go up to 50 years [26]. Extensive regulation development has increased the need to track data about products, suppliers, design, changes and many other issues. If the data is not organized in a systematic and logical manner, there would be different issues in long term data retention. Product modelling is important in the integration of information systems that are applied in global engineering enterprises. To capture the product information within an enterprise and between its partner enterprises, united, robust and flexible data models are required.

Some of the common industrial issues are related to the waste of time and resources in rework, e.g., a lot of time is wasted in implementing engineering changes, handling the differences in product information between engineering, production, global supply; difficulties in re-using the product data for new products; inconsistency in CAD, PDM and ERP data - part numbers in Bills of Materials BoM); communications issues of engineering changes to downstream processes, difficulties in tracking the product information related to customer failures/issues quickly and precisely; inconsistency of product information between service manuals and latest product changes. There are many requirements related to product information that addresses these industrial issues. Most of these can be eliminated if the product information can be organized in a systematic and logical manner so that it is traceable (tractable), accountable and the history is maintained, i.e., when, where, who and how the product has evolved. Information management plays a very important role not only in PLM implementation, but also in the way this will be used in future production. Therefore it is very important to analyze how product information is transferred to PLM systems and also what, when and how the data will flow from and to PLM systems.

To achieve the effective PLM system implementation a study of product information and material flow within or between the business units and outside the organization (suppliers, customers) plays very important role. There is a need for understanding how this information is generated with respect to different stages of product development. Once this is captured, a need to understand the product structure plays vital role in connecting the product information in different levels of the product and also different functions that are generated. In this paper, a modular product structure methodology has been proposed to define the product structure and capture the information generated at different stages of product life cycle and arranged (stored) in a logical manner so that, it can be reused and tracked as and when required. A case study of this methodology has been carried out with Cummins Power Generation's GENSET products.

This paper is structured as follows. In Section 2, a brief overview of PDM and PLM and related research work is presented. Section 3 discusses the relationship between the life cycle and stage gate approach along with systems and functions involved. Product information and material flow for a global product development is discussed in Section 4. Section 5 covers modular product structure methodology and responsible functions and information generated within each function. A case study is presented in Section 6. Conclusions are finally provided in Section 7.

2 OVERVIEW OF PDM/PLM AND RELATED RESEARCH WORK

The term Engineering Data Management (EDM) and then Product Data Management (PDM) emerged in the late 1980s as engineers recognized that there was a need for tracking the growing volumes of design files and documents generated in engineering design and related processes [28]. PDM allowed standardizing the storing and controls of documents, including Bill of Materials (BoMs), revision controls so that the history of information is captured, and most importantly the relationships between parts, assemblies and sub-assemblies can be maintained. PDM is a design-focused technology that increases efficiency within existing product development processes by improving the management of product design data. PDM systems provide extended facilities for the handling of detailed product information, ranging from design to production stage. Nowadays, such systems are routinely applied for the manufacturing of mechanical and electronic devices. They are being succeeded by Product Lifecycle Management (PLM) systems, such as Windchill [21], TeamCenter [30] or CATIA [7]. The aim of these systems is to integrate information on the manufacturing processes (usually in CAM systems) with design data (in CAD systems) on the one hand, and information in Enterprise Resource Planning (ERP) processes on the other hand.

Then came the Product Lifecycle Management (PLM). While PDM focuses on managing design and product associated data and information especially CAD data, PLM centers on re-engineering product development and manufacturing processes related to the whole product lifecycle. PLM is a strategic, process-centered approach that leverages PDM and other technologies, along with consulting services, in order to manage product lifecycle activities and issues, remake processes, and increase throughput. As a result, PLM improves productivity across the connected enterprise rather than in a single department or a specific process. PDM can be regarded as a subset of PLM which includes the management of intellectual asset information and their relationships. PDM is an important basic requirement that supports PLM, and most of the data comes from PDM to PLM. PLM includes asset creation through CAD, engineering analysis, digital manufacturing, documentation, images, and software issues. There are usually few collaboration capabilities within PDM. However, a strong foundation for PLM starts with a comprehensive and strong PDM solution.

PLM involves management of product information along its complete lifecycle. Several aspects of product models have been researched, including handling of evolution of documents in a Product Data Management system [9], a product data framework for logistics planning activities [2], and an ontology based on the Core Product Model (CPM) of the National Institute of Standards and Technology (NIST) [28,10]. Rachuri et al [22] evaluated the information flows and the relevant existing standards within PLM, highlighting current issues regarding interoperability and information exchange. Model driven approaches for achieving interoperability have also been proposed [11]. This kind of interoperability, called ‘‘product oriented interoperability’’, is based on a meta-model of the product representation, and a mechanism for making a mapping between it and specific models. Recently, ontologies have been extensively used to address interoperability issues in PLM systems. Fenves et al [10] proposed the use of ontologies for Product Data and Knowledge Management, and presented an ontology focused on closed-loop PLM.

Traditionally, PDM/PLM systems are concentrated mainly on CAD data and some Engineering data like part specification, drawing data, change management and part classification. There is much other information generated in the life cycle of the product. The product information model has turned into a fundamental asset, because the most important bottleneck found in concurrent engineering environments within virtual enterprises is the difficulty in capturing, sharing and maintaining product information in a distributed way over time. Most product information is generated while the product is being developed, so study of product structure will give a very good idea of how, where and when the information is generated. If this information is known, it can be connected to the product that will give connectivity between them. The PDM/PLM systems available today adequately support information exchange between developers, especially in the later phases of the engineering lifecycle which are characterized by more deterministic and well-known processes. Nowadays, they also provide improved possibilities to integrate a company’s legacy systems, provided that the company is willing to tackle the required integration effort [15]. However, they lack essential capabilities for the management and reuse of design knowledge [3] and are less suited for the conceptual design stage [11]. Current PLM systems have got most of these functionalities, but proper planning is needed to setup and connect the information so that it can be retrievable, reusable and make correct decisions in the product development. In the next step we will see how product structure is connect to PLM system and stage gate approach and systems involved.

“Translating a market opportunity into a new product requires perhaps 15% invention. The remaining 85% of the work involves previously learned processes that often are undocumented and undisciplined’’ [20]. Therefore it is very important to manage the information (data) in a logical manner so that the existing product information in new product development can be reused which will reduce lead times, resources which in turn reduces the overall product cost. This will give confidence in releasing the product to market quickly with Right First Time (RFT). Integration of product information, project management, processes and procedures has been addressed through a product digital mock-up by Danesi et [6]. Collaborative frameworks and technological requirements for their implementation have also been discussed by Osrio and Camarinha-Matos [17]. In this context, usefulness of enterprise modeling and reference models to achieve enterprise interoperability and collaboration has been highlighted [19]. Collaboration processes during design activities were studied in [18] through a collaboration ontology with different points of view and conflict management, focusing on capturing the knowledge about the collaborative design processes rather than the product knowledge.

Previous research works have focused on information models, business processes integration and interoperability issues. Only recently, the need for putting more intelligence on products making them proactive [16, 12] during their own development and management, to better support business processes, has been recognized. Additionally, there is lack of a holistic and generic (i.e., Independent of the industry/activity) treatment of PLM aspects, including business processes definition, product information models and information exploitation approaches [24]. PDM/PLM systems suffer from the lack of formalized representation of products: they handle data but not knowledge. The information is usually buried within various documents and being processed by different software tools that have no common ‘language’ [4]. In this paper, a product structure methodology approach has been proposed in Section 5 that will be used to capture the product information all along the lifecycle. This methodology has been analyzed through the stage gate product development process, the functions involved and systems used. When the first PLM system is brought into use in a company, it does not replace any specific old systems, but brings new surplus [23]. PLM implementation not only deals with new product development data, it also has to take care of existing data. This paper also studies the relationships between CAD/CDM, PLM and ERP systems, and how the data flow in these systems. One of the gaps in the previous researches work is how to handle legacy data generated in many years, and companies' important intellectual property.

3 AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN INDUSTRIAL SYSTEMS INVOLVED

An industrial investigation is carried out to understand the various relationships between the product life cycle activities along the Stage-Gate product development processes with systems involved. This gives very good understand of the whole process and product information for any PLM implementation. Before starting PLM implementation, the relationships should be understood between different life cycle stages (Stage Gates) and existing systems used in product development. Fig. 1 shows the different stages of the product development process of the collaborating company, general systems used and functions involved at different stages. Product life cycle starts with gathering the market requirements and analyzing them. This is done by program and product management teams. Once all the requirements are analyzed, this will be documented and shared with management. This is also called the contract. This will be analyzed with cross-functional teams and any changes are made if needed and signed off for new product development. This will be the starting point of the project. This is referred as ***Stage Gate 0***.

Team leaders for the execution of project from all functions like engineering, manufacturing, global supply, program management, lab operations, global data management, IT, after sales, parts and services, safety will then be appointed. This cross-functional team will meet on regular basis to discuss the status of corresponding tasks for their function. Engineering starts working on concept designs to meet the market requirements and specifications. These concepts will be shared and discussed with other functions as part of design reviews. Large amount of product information is generated in the concept generation stage. This information is also very important. One of the gaps at this stage is how and where to capture this information since the decisions are made with this data in the process of developing the product. This is ***Stage Gate 1***.

In the past, drawing boards with paper were used to generate the designs. Later 2D drawing tools were developed which made easy to produce different concepts. Currently most SME's (Small and Medium Enterprises) uses 3D CAD tools to generate designs in 3D which enables engineers to visualize virtual products even before they are made as prototypes. This facilitates to review the designs with cross-functions, cross-sites located globally within the company, or with other units or even with suppliers. There are many 3D CAD tools available in market. This is also called digital product creation. Some of the designs are validated using Finite Element Analysis methods. There are many software systems in the market that facilitate to do this work. Using these tools the designs can be validated theoretically. This is very important information of the product that needs to be captured which will be used to compare the physical testing. At this stage, the sales of the product are not yet started. Next step is to create manufacturing detail and assembly drawings and release them into the system for approval. PDM/PLM systems are useful in storing this information along with accountability. This is ***Stage Gate 2***. For every stage gate completion there will be Management review meeting where in a decision will be made the corresponding gate is passed or passed with minor corrections or failed to rework.

In the next stage, the drawings are shared with the global supply and manufacturing to start their activities. Since these two functions are involved in design reviews, they are aware of the designs and might have preliminary plan for their functions. The global supply team will plan sourcing the materials from different suppliers - setup new suppliers if required for this. They will make 'Make' or 'Buy' decision on the parts/assemblies that are required for the product. Manufacturing starts planning for prototype build depending upon the global supply plan for procuring all material. Engineering will work with global supply in helping them in manufacturing or purchasing long lead items to suit the manufacturing plan. Engineering will also start working on product structure design, working on various options/variant designs and planning for design verification analysis process for testing the product. This product

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information gives proof of validation of the product that needs to be stored for future reference. While building the prototype, all the manufacturing, assembly and supply issues are captured and recorded. This is done using the change management process in PDM/PLM. When these are addressed and resolved, ***Stage Gate 3*** is completed. At this stage the product structure will be designed in configurator with all its options/variants for configurable products. This set up can be done in standalone Configurator or it can be part of ERP systems. Recent new PLM systems providers are having this function incorporated within PLM function which makes it easy to write rules for variable product creation.

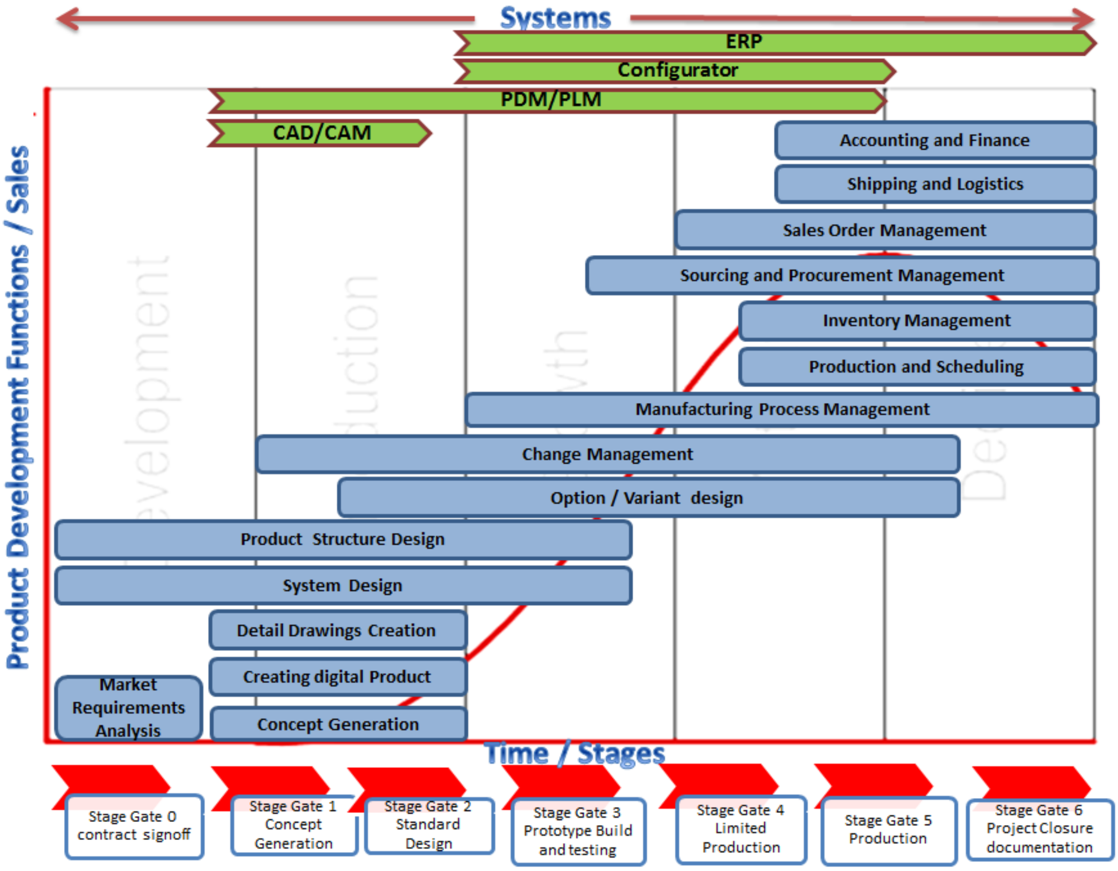

Fig. 1: Stage Gate approach in product development process along with systems used and functions involved

From the configurator the product data will be integrated to the ERP system. The integration between the systems plays very important role. The manufacturing process management team will create routings in the ERP system that facilitates the production and scheduling process running without any issues. Once the setup is done, test run is carried out to check whether the correct Bill of Materials is generated for all different variant products. This will complete ***Stage Gate 4***. Then limited production will be planned depending upon the number of variants in the product. Various products are manufactured and tested as part of the limited production. All the test reports as per design verifications plan will be generated and recorded. Once all the tests are satisfied the product is submitted (handover) to production. This will complete ***Stage Gate 5***. Other functions such as Inventory management, material supply, Sales, order management, shipping, logistics, finance and accounting complete their tasks in ERP system to facilitate smooth production run. In product life cycle, this is the stage where the product sales can go to the maximum. The ERP system handles all the functions listed above for production. The final stage is documenting the project information and lesson learned while executing the project. This completes ***Stage Gate 6.***

In the life cycle of a typical product development process in an international engineering company, it can be seen that a lot of information is generated using many systems and many processes involved. In the whole process, there are systems, people and processes involved. If it is not planned properly, the information may be lost, may not be traceable or not accountable.

4 PRODUCT INFORMATION FLOW IN A GLOBAL PRODUCT DEVELOPMENT PROCESS

To achieve the effective use of PLM, it is essential to share information gathered over the entire product lifecycle in multiple departments. Fig. 2 shows the product information and material flow in the process of a typical product development process. Product information starts from the marketing personnel gathering requirements from consumers, and these requirements are analyzed by the product management team and prioritized for implementation. Most of these requirements are segregated into two types, one is to upgrade or modify the existing product, and another is to make new products. In the first method, the current product support team will be involved to analyze the requirements and plan the changes that will meet the requirements. The second method will follow through the project management process. Product management or programmer management (in some industries) will create project charter for new product development with all requirements that are captured from marketing. Cross-functional teams will be formed from all functions that will be involved in executing the project. This will be led by the project management team. Project charter will be created and reviewed by the management and by cross-functional teams. In an ideal global companies the cross functional departments involved are project management, product design, manufacturing, maintenance, development testing, global supply, production/process design, production planning, order management, customer services, logistics, production, production testing, inventory, shipping, customer services and distribution.

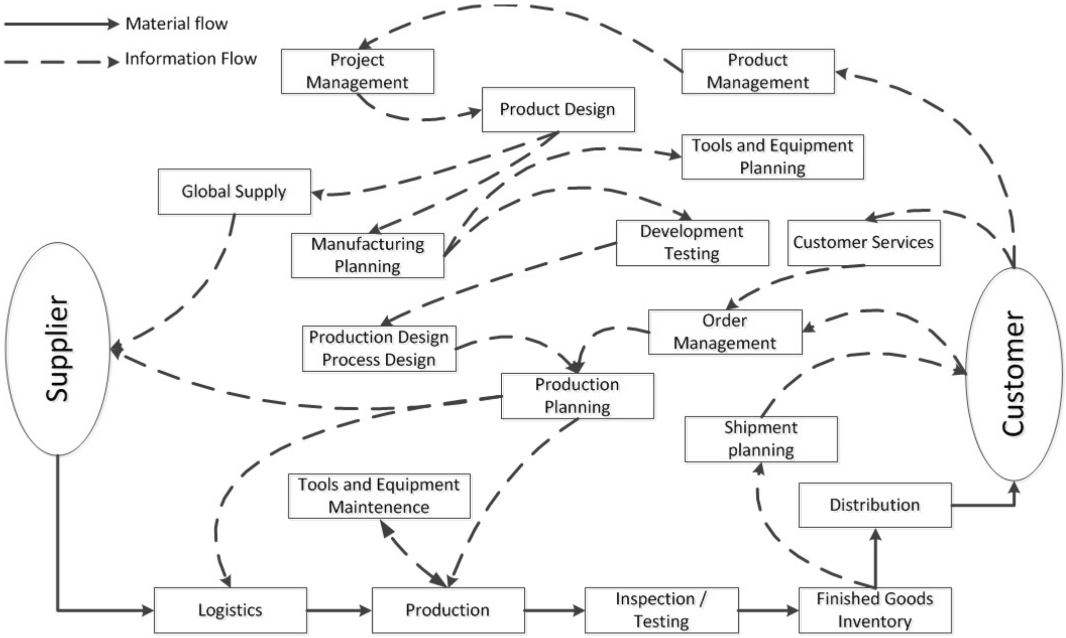

Fig. 2: Product lifecycle information and material flow

Engineering takes the lead in developing the product as per the requirements. Product design information is shared with manufacturing and global suppliers for planning the prototype manufacturing. For this, one or two products are manufactured for testing the overall performance of the product. The manufacturing team plans tools and equipment in producing the product. Global supply plans with suppliers in procuring the parts that are planned as purchasing items, Manufacturing in coordination with global supply and lab testing together plan for prototype product testing. All issues that are occurred in manufacturing, assembling and testing are captured and resolved. Once the product performance reaches or exceeds functions as planned, the production design/process design team plans for production. In many times, some of the tasks are done in parallel, for example, while the testing is going on, production planning is also being done.

There is a large amount of information gathered, starting from marketing till shipping the product to customers. Tab. 1 shows some of the product information generated in different functions. To achieve effective use of PLM, all these information should be gathered over the entire product lifecycle in multiple departments. There are different BoMs generated at different levels of product development. Engineering generates Engineering Bill of Material (E-BOM), also called overloaded BoM. This BoM will be converted into manufacturing bill of material (M-BoM), and configuration bill of material (C-BoM). In the process planning process, information on the process planning that is based on the production plan and is stored in the process BOM. In the task of design process, the task is designed, and information on the processing procedure and the workstation layout is stored in the W-BoM [14].

Function	Information
Engineering	CAD data, Engineering Drawings, Assembly drawings, Engineering Bill of Materials, Part specificatios, Assembly specifications, Design Specification sheets, Change management data, Design reviews information, Resource and project planning information, version management data.
Theoretical Validation	Finite element analysis data, Areo dynamic analysis, Simulation details.
Configuation	General BOM, Product specifications, module specifications, configuration Bill of Material, parts classifications.
Manufacturing / Maintenance	Manufacturing planning data, Tools and equipment information, Manufacturing work instructions, Manufacturing BOM, Manufacturing routing information, NC programs, flow charts, Machine libraries, Maintenance information, process plans, shop floor instructions, tools and fixtures.
Global Supply	Suppliers information, cost information, supply stratagy data, purchasing information.
Testing	Product test planning information, Testing tools information, test reports information, equipment designs.
Order Management	Order details, customer information, pricing data, costing data, as orderd BoM.
Inventory Management	Raw material data, finished goods data.
Logistics and Shipping	Goods in / out information, shipping information.
Finance and accounting	product pricing, invoices, slaes order, profit/losses etc
Miscellaneous	Patent information,regulatory information, service description, service manuals, quality assurence data, spare parts information, standard costs and times, technical publications, test data files, user manuals,

Tab. 1: Functions vs product information

5 THE PROPOSED MODULAR PRODUCT STRUCTURE METHODOLOGY

In a typical company with large numbers of people involved in the product life cycle, there are many low – level problems in particular regarding product data. People often waste a lot of time looking for it. Sometimes they are unable to find the information they need. Even they can find it, it may not correspond to the actual state of the product. For example, a facility drawing may not correspond to the physical facility layout [26]. In section 3 and 4, we have seen how a large amount of product information is gathered in the process of product development. The purpose of this paper is to investigate how the product information is arranged or stored in PLM systems that are easily traceable, accountable and re-usable. This can be achieved if the product information is stored and connected to product structure itself. A modular product structure provides good opportunity for arranging the information structurally which can facilitate user for searching the information easily.

A modular architecture defines the appropriate product structure consisting of a group of modules with distinguishable functions and minimum interaction with the rest of the products [25]. There are many types of modularization that can be done; some of them are (1) bus modularity where all modules are connected to a single common module, (2) sectional modularity where product variants are built from specific combinations of the modules having unified interface, and (3) Scalable modularity where some scalable components are combined with standard components [29]. Product architecture represents the main design of its components layout and their interaction. A modular architecture as shown in Fig. 3 is very useful in designing product variants especially for mass customization. It facilitates customizing variants by removing, adding and switching modules. This also facilitates concurrent design and testing the individual module functions. In the earlier sections, different product information generation at different levels of product life cycle has been described. Product structure plays very important role in organizing its own information in a logical manner so that it can be traceable, accountable while maintaining the history of it. Product components are usually grouped into modules depending on the function of the module assembled using specific design architecture to facilitate future design changes, product variety management, mass customization and manufacturing processes using delayed product differentiation [1]. Product architecture defines the functions of its components and the topology of the interfaces. It also facilitates detailed design, testing and planning of this manufacture and material supply chain of the components [31].

A modular architecture presents a one-to-one correspondence between modules and functions and specifies de-coupled interfaces between components [18]. Product modularity enables the easy generation of product families from a basic-platform design, by simply mixing and matching the various modules. Via this product variation a high degree of customization may be achieved [5]. Moreover, parts or modules carryover and reuse are also possible with modularity. A study has been conducted in Power generation industry analyzing the product structure and thru its life cycle. In the initial product concept design, the product is divided into different modules that satisfy the marketing requirements from product management team. In this case, the end product is the electricity generator called GENSET. Some modules (sub-systems) in this end product are Engine, Chassis, Cooling system, Air-Cleaner and Alternator. Combining all these modules forms the end product.

Each of these modules consists of one or more assemblies or single parts. These assemblies may be standard assembly or optional assemblies. Assemblies consist of BoMs that collectively satisfy the functions of that module and have got many names, such as designed BoM and engineering BoM (E-BoM). Collectively all BoMs under different modules are also called overload BoMs or Generic BoMs (G-BoMs). The G-BoM represents data for three types of products, i.e., Standard products that have got fixed modules, Configurable products that will have BoMs as per options selected by customers, and Engineer to Order which can be formed either by standard products or from configurable BoMs with an extra requirement through request for query (RFQ).

The standard product will be represented as market names, in the above case, it is the node names C250, C275 and C300. Each of these products is made up of combinations of standard and optional assemblies from the overloaded BoMs. The BoM is then called pre-configured BoM which is stored in the configurator and is then converted to manufacturing BoM (M-BoM) also called as-build BoM. The second type of product is configurable product which is generated from customer selections. A predefined questions and answers (rules) are written in the configurator that will select assemblies from modules from the customer selection. The BoM that is generated from this is called configurable BoM (C-BoM). Another type of product is Engineer to Order, which is generated from either standard product or configurable product with specific requirement that is not present in either of them. In this, most of the products are the same, only one or two specific options will be different.

Manufacturing will add information like which parts should be made in-house and which will be purchased from suppliers, also referred to as make/buy decision. They will be responsible for designing tools and equipment, work instructions, and process plans for producing the product. For assembly lines, they will create routings that will give assembly sequence of how the parts need to fit with reference to work instructions and tools to be used at each stage. The parts or assemblies information is then fed to the supply chain's systems which take care of procuring the parts/materials that are required either for manufacturing in-house parts/assemblies or assembling them directly.

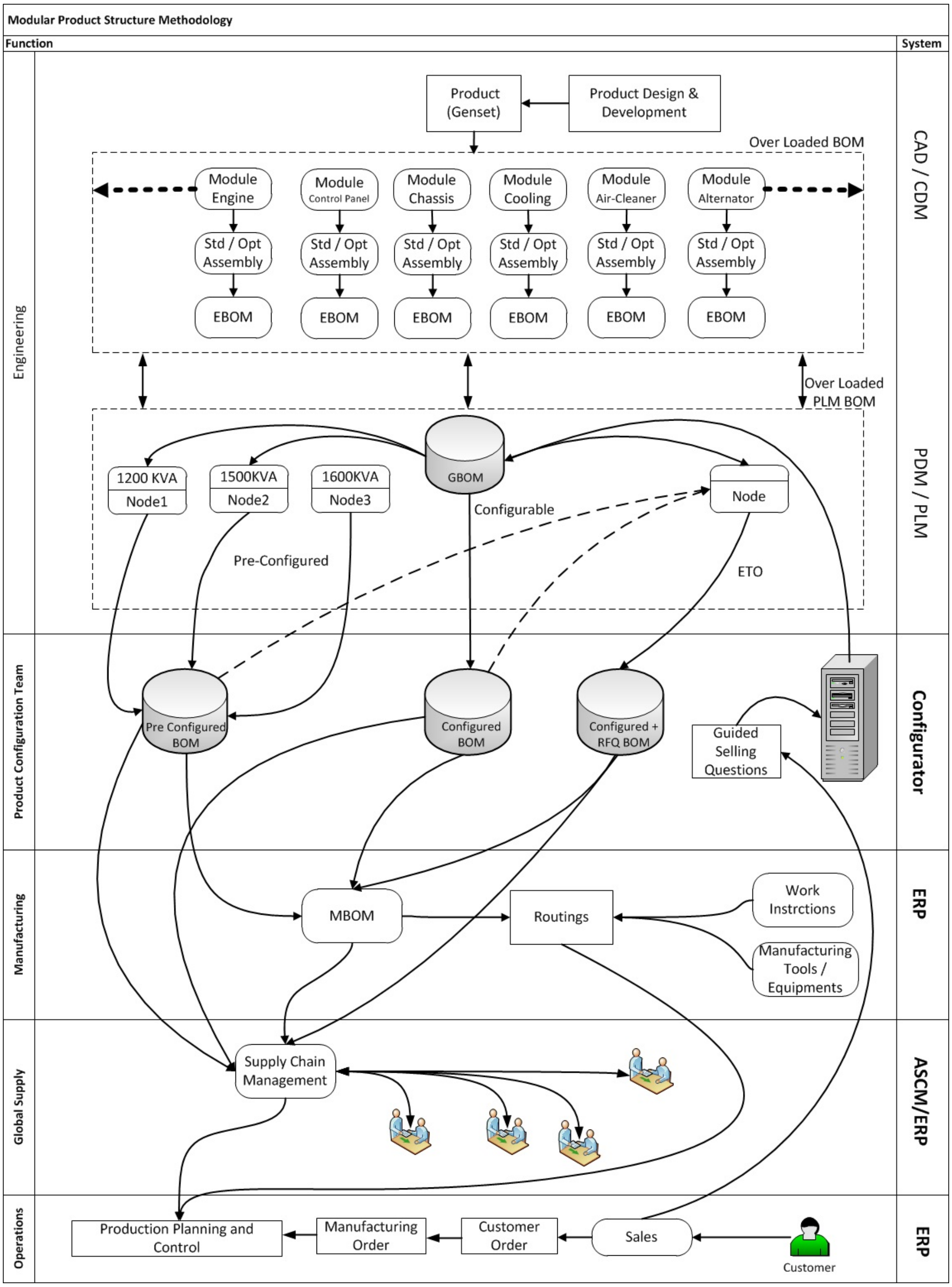

Fig. 3: Modular product structure along with responsible functions and Systems.

To overcome the great complexity that customization potentially creates in the manufacturing systems, modularization is used as a tool to break the product structure into smaller, manageable units.

Modules are defined as physical structures that have a one-to-one correspondence with functional structures. They can be thought of quite simply as building blocks with defined interfaces [8]. Modular products may be defined as machines, assemblies or components that accomplish an overall function through combination of distinctive building blocks or modules [27]. A modular product development is one in which the input and output relationships between Components, that is, the component interfaces, in a product have been fully specified and standardized [13]. Strategic advantages of modular product development include the following: greater product variety; mass customization; product family; reduced cost of development – leverage fixed investments over multiple products; economies of scale; faster technological upgrading; increasing speed to market; decoupling of tasks – concurrent product development, subcontracting / network cooperation; ease of maintenance, repair and recycling; handle uncertainty; and better integration of marketing and technical objectives.

6 CASE STUDY

A case study of a product family has been carried out within Cummins Power Generation. Cummins Inc. is divided into 4 divisions; Engine, Components, Power Generation, and Distribution. Components division is divided into 3 main groups: Turbo Charger, Emissions, and Fuel systems business. Power Generation is one of the Cummins business units and its end product is Power Generator called GENSET for short. This product is categorized from the output of the GENSET which is measured in KW or KVA. The modular product structure within the PLM system architecture along with product information is shown in Fig. 4. The end product (GENSET) is divided into different modules both consisting of standard and optional modules. Each module may have one or more assemblies depending on how many variations that module will offer. For example, the Air-Cleaner module has got options for Heavy, Medium and Low duty air cleaners. One of them is standard and the rest are optional. Each of these assemblies has parts / sub-assemblies that satisfy form, fit and function of that module with interfaces with the rest of product. All these assemblies and optional assemblies are called overloaded BoM.

A standard product is formed with the combination of these modules. C250 is a standard product that is made of certain modules from the Over Loaded BoM. The Over Loaded BoM is maintained in the PLM system and interfaces with configurator and ERP systems. Since there is direct parent-child relationship between modules and assemblies, the BoM under the assembly will have the ability to synchronize with the configurator and ERP system. Similarly there are the same parent-child relationships between parts and assemblies which give the connectivity right from product to part in this modular structure, and some of the advantages of this method have been discussed earlier.

The contribution in this paper is connecting the product information generated in different stages of product life cycle to the corresponding object and storing them in a systematic way which can make the information easily traceable as and when required thus reducing engineer searching time. One more advantage is that, since all the product data is stored in a logical manner, it can be reusable. Modular structure facilitates in mass customization, since modules can be made compatible across products with minor changes. As shown in Fig. 4, the program information which is related to the program management team is connected to product and can be stored in program management space (folder). This way engineers can setup controls at different levels if required. All the CAD engineers may have access to Engineering folders where all CAD files are stored. Similarly all manufacturing information is stored in different spaces that are controlled by the manufacturing team. However, since the information is connected directly to objects in the product structure, there will be always connection to products. For example, with this set up, it is easy to create report for all change requests done for a product since all these are connected to the product and stored in the product data itself. The PLM system records each and every activity information about who, when and what has been done in the system. This will give the accountability factor.

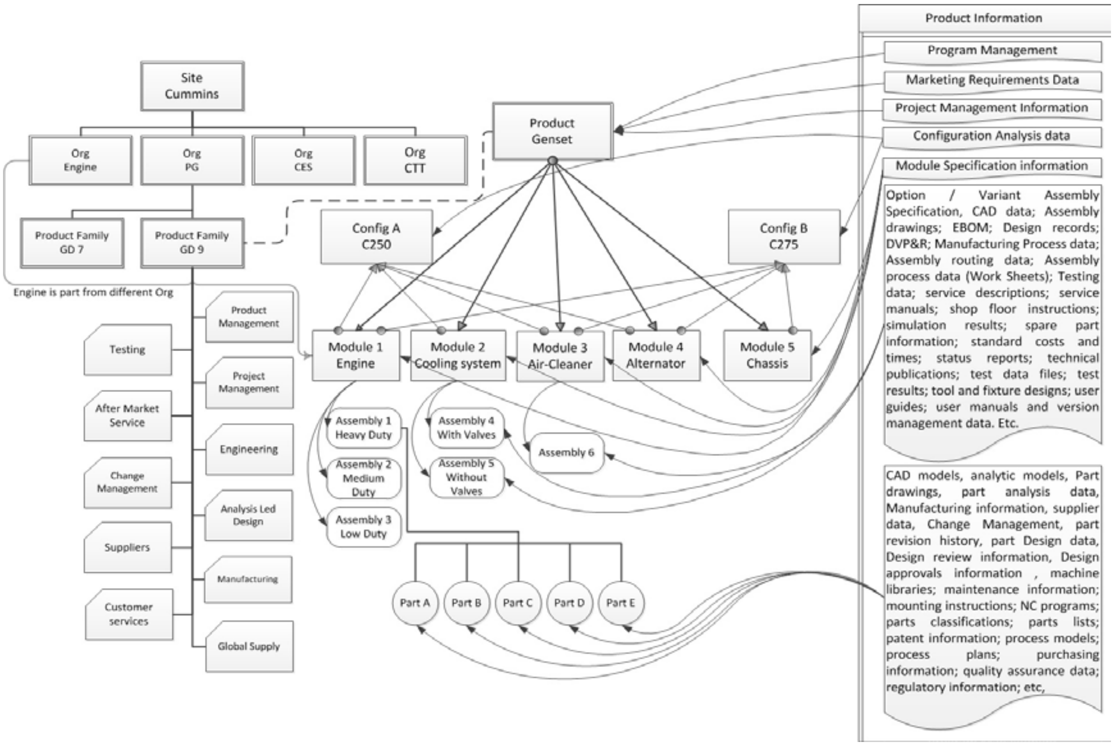

Fig. 4: Product information connectivity to modular product structure in a PLM system

Another contribution from this paper is that, since the CAD objects and product information are connected to product structure, there is seamless connection between CAD data, part information, assembly information (BoM) and its modules. Few PLM systems offer CAD and PLM functionality within one system which eliminate interface issues. The data from PLM system is shared with the configurator and ERP system for manufacturing, production and other functions. These systems add more information in their process. In case of manufacturing, information like tooling will be added to the object. In most cases the assembly E-BoM is interfaced to these systems. In configurator depending upon the customer selection, the assemblies will collectively form the product. These assemblies have got backward connection to the main product structure. This gives good relationship between the three systems to make the flow of the Product information easy and makes information traceable.

7 CONCLUSION

Relationship of product life cycle with Stage gate methodology and functions/systems involved in this process has been investigated, and issues in managing large amount of product information flow across all functions in a global company including material flow have been analyzed. A modular product structure methodology and its types and its advantages have been proposed based on the investigation. The proposed methodology has been implemented in a PLM system to give guarantee for manageability, integrity, consistency, security, and traceability of product data in the whole lifecycle, and various and dynamic data information can be shared in the product evolution chain. The mapping process of product data between CAD, PLM and ERP systems is a feasible approach that gives seamless flow of information between them. This can be achieved with the modular product structure methodology. Industries are evolved for many years and there is large amount of product information already exists. One area not covered in depth in this paper is how to manage the legacy data that already exists in the company. Future work of this project is to develop the mechanism/methodology to migrate and manage the legacy data into the proposed methodology.

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