

PLM IMPLEMENTATION EFFECTS IN HEAVY ENGINEERING INDUSTRY: A CASE STUDY

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ABSTRACT

Product Life Cycle Management (PLM) has been a proven approach for industries to increase their productivity, improve their product quality, speed up delivery, and increase their profit and to become more efficient. Hence, some heavy engineering industries adopted a PLM in their firm. This paper discusses benefits achieved due to PLM in four departments of heavy engineering industry. The research paper study analyses marketing department, design department, quality department and project management group of heavy engineering division (HED). According to implementation, working of PLM the benefits differ by a department which are highlighted in this paper. This study highlights the benefits experienced by HED such as increase in response time, improved collaboration, communication across enterprise, cost reduction in project, project rework etc. These observations may be further useful for other industries to realize effects of PLM.

KEYWORDS: Product lifecycle management (PLM), Heavy Engineering division (HED), PLM benefits.

I. INTRODUCTION

As a new generation of lean thinking, a philosophy to remove waste and inefficiency across all aspects of product life, PLM move out as a newest strategic approach to increase the productivity of an organization [1]. In industry, product lifecycle management (PLM) is the process of managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products. PLM concept is defined as “cradle to grave” to “cradle to cradle”. Valuable learning contents on PLM can be referred in various books [1], [2], [3] and research publications [4], [5], [6]. PLM has been a proven approach for many multinational companies to increase in productivity, increases in product quality, reduces time for delivery, and improve the profit and to become more efficient. However, major industries like heavy engineering industry, still face problems like co-ordination in employees, data redundancy etc. To overcome these problems, PLM can be used as very useful strategy. This research highlights the benefits of PLM in HED. PLM implementation effect in four departments of HED viz. are marketing, quality, design, project management groups (PMG) are discussed.

II. PRODUCT LIFECYCLE MANAGEMENT (PLM)

Product lifecycle management (PLM) helps organization to integrate people, data, processes and business systems and manage product related information across the extended enterprise throughout the entire product lifecycle [1]. This vision is enabled by recent advances on information and communication technologies. PLM is needed to support current industry needs for faster innovation cycles combined with effective time. It reduces costs by taking advantage of the efficiencies and effectiveness that come from improved market intelligence and business collaboration [2]. PLM has recently attracted both industry and research because of its potential benefits with current manufacturing challenges [3]. PLM is a strategic business approach that enable organization achieve its business goals of reducing costs, improving quality, decreased scrap and rework during production and shortening time to market, while innovating its products, services, and business operations. Direct

savings include reductions in the time and cost to design products, reduced inventory, and better reuse of components, establishes a more comprehensive and collaborative relationship with customers, and suppliers. It also helps to deliver more innovative products and services in a shorter time within departments [2]. Collaboration results in the full integration of information, goals, performances and the integration of actions in terms of operations as well. These technologies are widely spread in industries and have high cost so it is important to understand real benefits that are derived from PLM implementation. The use of PLM can vary among employees, depending on the advantages they experience with respect to the previous working condition.

III. HEAVY ENGINEERING INDUSTRY PROFILE

Heavy engineering industry involves one or more characteristics such as large and heavy products, large and heavy equipment. The Heavy Engineering industry which is taken for study manufactures and supplies custom designed equipment to critical process industries such as fertilizer, chemical, refinery, petrochemical, and oil & gas, as well as to sectors such as nuclear power, aerospace and defence. HED manufacture equipment's like regenerators, reactors, heat exchanger etc. A HED in Mumbai (India) which provides equipment to process plant industries, nuclear power, defence and aerospace sector was chosen for the case study.

IV. CASE STUDY

This heavy engineering division has 9 strategic business unit located at four different locations in India. Hence firm faces great difficulty to maintain information about project. There was no control on data access etc. To overcome these difficulties firm decided to implement PLM.

PLM include many concepts and technologies woven together to enable the users to access, share, manipulate, reason and update the product data. This PLM projects covers areas such as BOM, Part and change management, document management, integration CAD, ERP, E-mail, Workflow management etc. In a HED there are 28 deliverables in which 22 are processes and 6 are integrations. Deliverables include enquiry process, change management, NCR process QA audit Process etc. Integrations in this project are BOM integration, CAD integration, ERP integration etc. To bridge the gap between the reality and the objectives of the HED, proper strategies are implemented by the management. There are many PLM strategies which can be adopted by the organization. Strategies like increased customer involvement, customization of products, best processes, fastest time to market, and longest life product. The healthy practices introduced in the heavy engineering include timely interaction among users through commercial PLM, in-house computer aided design, structural analysis and casting process simulation, interaction with the customer for the finalization of product and delivery schedule, evaluation of man-hours and its appraisal, online monitoring of resources, and accounting.

In heavy engineering industry PLM was configured with four major departments (design department, project management group & production (Quality) and sales & support (Marketing) as shown in Figure 1.

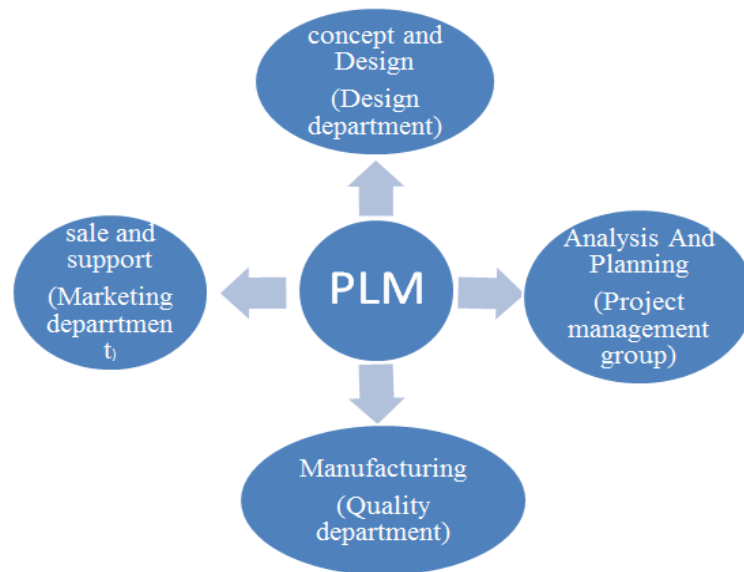


Figure 1. PLM framework towards four departments

The activities take places in these departments such as design a model, make a quote for a product, make engineering change request, Non-conformance report, delivery schedule, Checking quality and serviceability of the product etc. Appropriate system integrations and use of PLM in heavy engineering industry helps company to enhance their co-ordination and increase their efficiency by accurate and prompt usage of information. The benefits to industry can be assured by using PLM technology.

V. PLM EFFECTS ON FOUR DEPARTMENTS

4.1 Marketing department

The heavy engineer industry is engineer to order (ETO) industry. Engineer to order means company designs and manufacturers a product based on very specific customer requirements. In PLM, marketing department mainly deal with enquiry process. In enquiry process marketing team and engineering department work in collaboration in order to create winning proposal. PLM provides information concerning specification, design, and reference to bill of materials to engineering department, where as PLM in marketing department provide BOM inputs for casting and reference to similar proposals. As HED is engineer to order process, in typical engineer to order chain consist of stages in order these are initiate request, pre-order, award order, execute order, complete order, and post order. Each stage in this process may take time from one week to year. The pre order phase is the foundation of HED as this phase has significant impact on top and bottom lines. Common challenges faced by HED while managing enquiry are as follows-

- Very low Bid conversion rate as data such as specifications and design document of project required for bidding not available at time.
- Unique requirements of customer so it was difficult to Manage validated product configuration ensure all customer requirements met.
- Not able to leverage collective intelligence from various group during bidding process.
- Due to improper bid selection in HED, high and costly engineering hours spent in the creation of proposal were wasted.
- Before PLM, the request for proposal held low confidence due to an absence of central repository of the previous bid, engineering information and heterogeneous IT system.
- The manual or ad-hoc process of managing enquiries has longer lead time.

After implementing PLM in HED, marketing team analyses enquiries based on the organizations pre-defined parameter as well as selected enquiries for bidding. PLM as a tool provides document management as common backbone. PLM also gives access to previous similar proposal, reference

BOM and other relevant information. PLM helps R&D in focused innovation and proposal engineering and marketing using previous win-lose analysis for better qualification enquiries.

PLM helps in achieving following benefits to the marketing department

1. PLM captures analysis of win loss and generates a detailed report.
2. Provides facility for tracking opportunity from creation through qualification till its closure.
3. Estimate of BOM can be created and managed for opportunity along with different product configuration.
4. Opportunity is treated and opportunity response plan is automated and standardised for organisation.

Marketing departments achieved following benefits in term of percentage is shown in fig.2

1. As information to create quote is easily available, approval of quote is done within minutes with electronic signature, so time to quote reduced up to 25%.
2. Due to PLM marketing department is connected with departments like design quality, Project management departments, so cross functional co-ordination among individuals increased up to 20%.

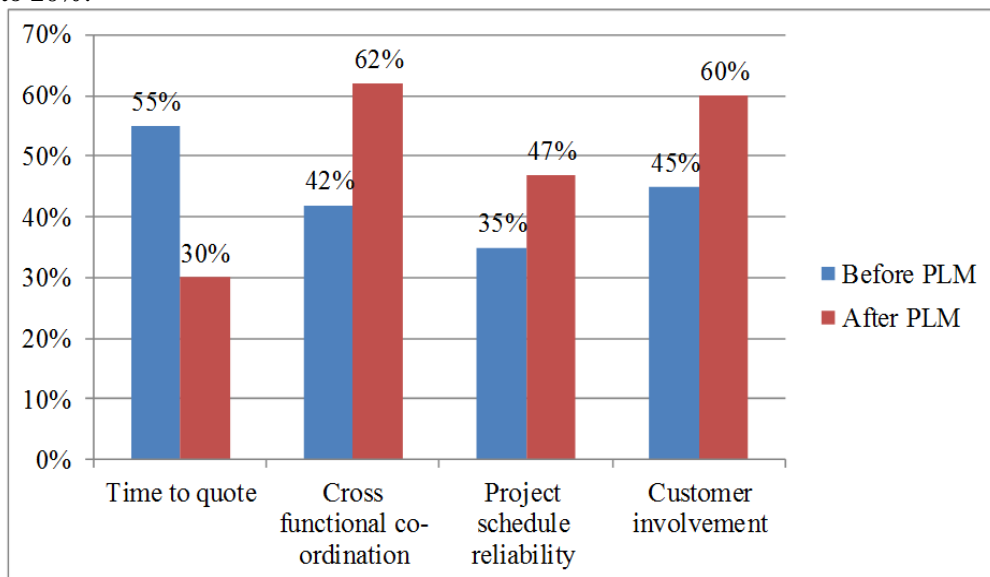


Chart-1: PLM Benefits delivered to Marketing department in Percentage

3. Due to PLM each “Engineer to order process” is completed within time, so project schedule reliability increased up to 12%.
4. As PLM software has functions like Customer feedback action report (CFAR), customer directly involves with companies action. If customer had any problem they directly give opinion on parts or projects, so customer involvement increased up to 15%.

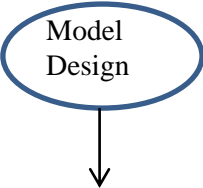


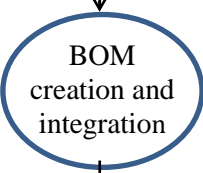
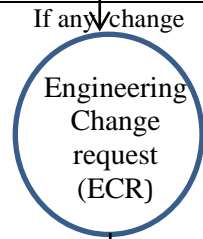
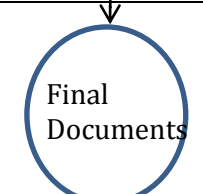
On the basis of discussion with stakeholders of marketing department, approximately trends were plotted and captured.

4.2 Design Department

Design department is the most important department of case study as most of the processes of design department are carried out in PLM. In PLM, design department mainly deals with the processes such as create drawing, design review, part creation, engineering change request (ECR), Non-conformance report (NCR) etc. Before PLM these processes carried out manually by department while doing this department faces a lot of challenges these are as follows

- Difficult to share & maintain the paper-based drawings.
- Non-Availability of latest version drawing at the working levels.
- Data was isolated in different local workgroup.
- Difficulty in tracking changes of design.
- Duplication of data leading to errors and incorrect reports.
- Absence of design related documents across HED.

Table -1: Design department before and after PLM implementation

Sr. No.	Work flow	Design department before PLM	Design department after PLM
1		Prepared manually and it takes 1 day for single drawing.	Drawings are prepared in software's such as Auto CAD, CATIA and it takes 2-3 hours for drawing.
2		Manual calculation and analysis of design takes 1day.	Analysis is done by software such as ANSYS takes 2-3 hours.
3		Multiple hard copies of drawings are distributed so design review is a long process.	Design is always online so design review is short process.
4		BOM were created manually means hand written sheets of BOM, if any mistake is in the BOM this can lead to waste of time and money on part.	Designer team creates design items and part, planning team creates parts these are synchronized in PLM forms BOM. This BOM has high accuracy. So time and money on rework and changes are saved.
5	<p>If any change</p> 	ECR is created manually and to resolve this issue individuals need to track down to resolve problems. For any issue resolution, respective department needs to wait for board meeting to connect with other approvers.	ECR created in PLM are in the form of electronic workflow, so issues are resolved on respected department comment and view. Board meeting and approvers are connected online so time for approval ECR is drastically reduced.
6		Documents like drawing, BOM are printed on the paper and stored on the different locations so it is a tedious and labour intensive work to find out the information.	Documentation is in the form electronic workflow so it is environment friendly. Information can be easily find out as all documents are stored in central repository system.

Heavy engineering division uses AutoCAD to create 2D assembly and detail drawings for proposals and manufacturing. In the HED it took on average 15 days for two people to generate and check a set of six manufacturing drawings. The limitation of the 2D process was that the design flaws were detected after detailed drafting was done. HED undertook an extensive and thorough evaluation process to adopt suitable software for automating its engineering processes which is integrated to PLM. By automating the process of creating assembly drawings, the cycle time has been reduced from few weeks to few hours. This translates in savings of four man-days on every project. For the HED this adds up to a savings of approximately 120 man days in a year. In HED AutoCAD integrated to PLM which contribute in generation of automatic BOM which is another time saver helps in reduce cycle time. Table shows the workflow of design department before PLM and after PLM

Due to PLM, benefits achieved to design department are

1. The amount of overlapping work decreased.
2. Fewer corrections to information are needed.
3. Parts and drawings can be retrieved quickly and with minimum efforts.
4. The availability of planning information is facilitated, information related to products, parts of the product, assemblies, and such like will be found easily and quickly.

5. Certificates, records and test results can be connected to a product so design review process increases.

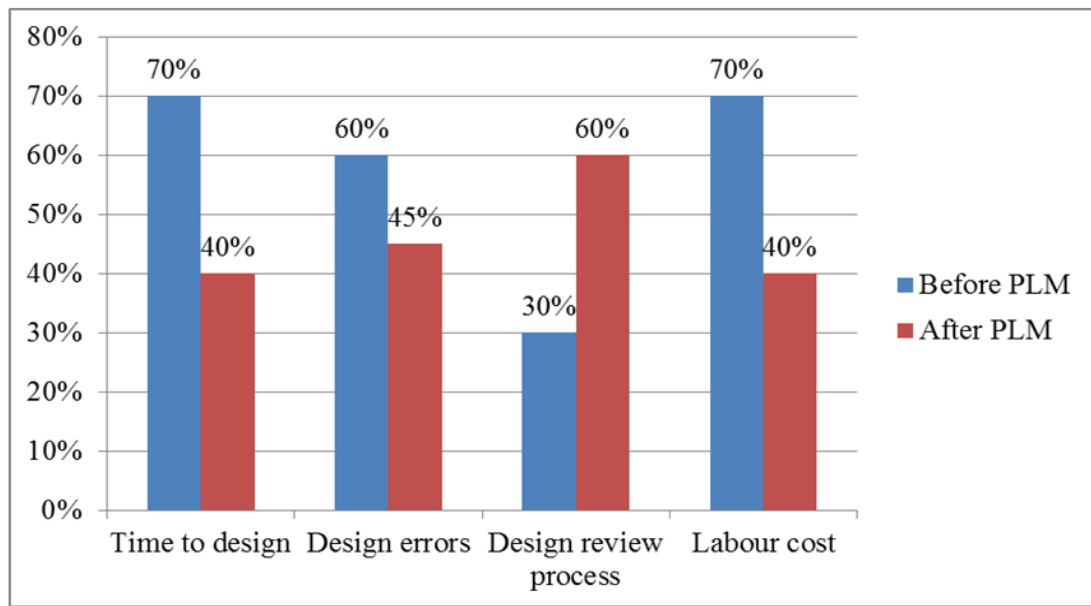


Chart -2: PLM Benefits delivered to Design department in Percentage

Chart-2: shows Design departments achieved following benefits in terms of percentage

1. For sheet drawing software's used were Auto CAD, CATIA etc. and these software's were integrated with PLM, so time to design was reduced up to 30%.
2. In PLM software there are processes such as engineering change request (ECR), Non-conformance report (NCR), due to these processes design errors are reduced up to 15%.
3. In PLM software design and documents were reviewed by electronic signature, so design review process improved up to 30%.
4. Due to PLM, sheet drawings of 3-4 days' work were completed within 3-4 hours, so Labour cost reduced up to 30%.

On the basis of discussion with stakeholders of design department, approximately trends were plotted and captured.

4.3 Project management group department (PMG)

In HED, project management group department has responsibilities such as project planning, project execution, give sequence of operations, give estimated hours, Prepare tool requisition, Check materials requisition (MR), prepare engineering change order, heat treatment request, make critical path method etc. Documents handled PMG in HED are purchase request, heat treatment request, non-conformance report. Functions of PMG are carried out in Concerto software .This concerto software is integrated with PLM software.

Challenges faced by Project management group before PLM

- Documents such as drawings, specifications, procedures required for project planning were discrete to different locations, so it was difficult to get right information at the right time.
- Processes like heat treatment request, engineering change order were hand written so there were many mistakes in these documents and single mistake causes reworks, delay etc. to project.
- Project data was insecure as there was no restriction on access to information; stakeholders were in the confusion while sharing the information.
- Work tasks, schedules of processes were analysed manually by stakeholders, so it was very time consuming process. It causes delay in projects.

After implementing PLM, projects were connected by single source of data base. PMG department creates workflow of processes like engineering change request, Non-conformance report etc. Due to these workflow processes information reaches at right time to right person. PMG has capability to

assign person for a process and gives access only to this persons, due to this data security increases. PLM manages schedules, work tasks, baselines and constraints of projects. With the help of PLM, PMG support for planning resources, material and expenses of project. PLM analyses capital investment and company performance.

PLM helps in achieving following benefits to the PMG department

1. Increased in individual productivity due to reduction in time for simulation and analysis of project data.
2. Increased in data security.
3. Improved business decision to select and manage future program.
4. Enhances co-ordination between employees.
5. Has Reduced cost with less manual efforts to execute process.

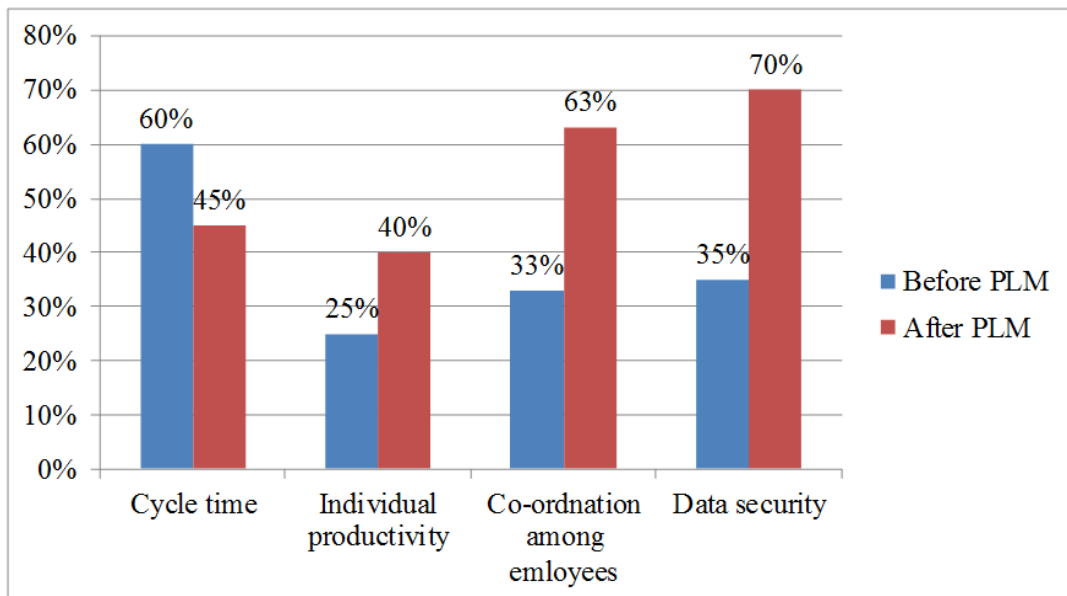


Chart-3: PLM Benefits delivered to PMG department in terms of Percentage

Chart 3 shows Project management group (PMG) departments achieved following benefits in terms of percentage

1. Due to PLM, time for simulation and analysis of project planning, reduced cycle time up to 15%.
2. Due to PLM, redoing the same task due to product data inconsistencies were avoided, so individual spent more time on technical aspects, therefore individual productivity increased up to 15%.
3. PLM software was integrated with CONCERTO project planning software, the daily project data were updated in respective departments, and this data was shared to individual departments, so co-ordination among employees' increased up to 30%.
4. In HED, PMG assign project to employee and give access to only project members so data security increased up to 35%.

On the basis of discussion with stakeholders of PMG department, approximately trends were plotted and captured.

4.3 Quality department

In HED quality department works on quality inspection, quality planning, audit management, create a corrective and preventive action, and identify internal and external issues, find root cause analysis etc. In PLM software, quality departments mainly deals with the processes such as non-conformance report (NCR), corrective and preventive action CAPA, audit, customer feedback action report (CFAR), Non-destructive test reports.

Challenges faced by quality department before PLM

- To solve the root cause of issues HED rely on manual process like emailing documents, obtaining signature it was very time consuming process.

- Before PLM, due to lapses in manual processes, poor documentation and communication between various departments, HED quality department has higher rework rate and more repeat efforts.
- Before PLM, audit was very time consuming process as data were not available at right time at right location.
- Quality department faces issues such as compliance to standards as there were no regulatory certificates test and results available with projects.

So HED decided to implement PLM system for quality department. PLM software gives overall view of processes of the quality department. It helps to analyse and identify trends, and provides knowledge how to resolve issues. So due to this, quality Department gets following benefits due to PLM

1. Changes in documents were electronically accepted and released so time for approval reduced.
2. The distribution of change information was faster so cross co-ordination among employees in department increased.
3. Certificates, test and results are connected to project, so project information can be easily retrieved.
4. Root causes are found out easily, so the CAPA was fast and efficient.
5. Improved in the quality of products.

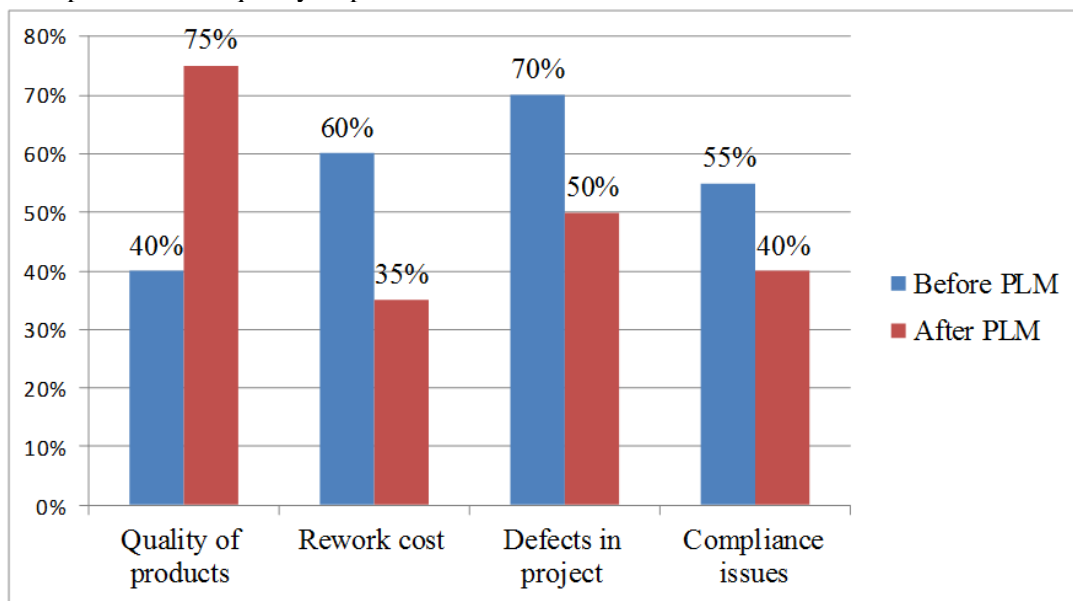


Chart-4: PLM Benefits delivered to quality department in Percentage

Chart-4: shows quality departments achieved following benefits in term of percentage

1. PLM has visibility of pending or future changes, and these changes were made by processes like engineering change request (ECR), therefore quality of products increased up to 35%.
2. Instant access to any drawing or information is available, so there was no chance of error of data which leads to rework, therefore rework cost reduced up to 25%.
3. PLM has capability non-conformance report (NCR), in which root causes are find out and these are available as history for future projects so number of defects reduced in project 20%.
4. PLM track, manage and comply with environmental, safety and process and standards and regulations, so compliance issues reduced up to 15%.

On the basis of discussion with stakeholders of quality department, approximately trends were plotted and captured.

VI. RESULTS AND DISCUSSIONS

There are many benefits of using PLM in heavy engineering division. Due to PLM they get benefits such as increase in productivity, quality, collaboration and new product development, the reduction of

human errors, improve more effective project coordination and control, increases knowledge integration and reuse etc. By understanding the activities and discussion with PLM end users of four departments of HED some of these advantages were identified. Table 2 Shows advantages of PLM Before implementation and after implementation.

Table -2: PLM implementation effect in HED

Problems	HED Before PLM	HED after PLM
Data redundancy	Multiple versions of data for individual products, so difficult to identify and control data	Unique identification for each product, so easy to identify and control product data even after revisions
Correspondence	Limited because of non-availability of complete data and information about physical product	High because of availability of complete data and information about the physical product
Traceability	Risk of wasting time and energy since product data is not recorded digitally	Easy to track the product data and information and its updates because of digital storage
Data availability	Product and process data not available at time leading to wastage of time	Right product data available at right time even without any search
Complexity	Difficulty due to incomplete representations and insufficient information	Easy to modify product data and information to include any complexity leading to mass customization
Security	Less security and difficulty in tracking the activities	Highly secured since each user is provided with login and password
Ownership	Difficulty in presentation of product data/ portfolio of company	Product data and information can be retrieved easily at any time to train a new comer/ next generation employee

VII. CONCLUSION

The Heavy engineering Industry which followed the traditional and old fashioned way of project management and data management affected duration, cost, rework etc. for the project. To overcome the drawbacks and minimize pains during project implementation, HED implemented PLM into various departments of the organization. PLM resulted into seamless integration between different departments, which led to easy and instant access to information at the single click of a button Study was conducted in four departments of HED. Based on the study, it was found that many processes were standardized; response time was increased, improvement in collaboration and communication across enterprise, cost reduction in project, and reduction in rework on project etc. An attempt was made to understand the benefits of using PLM in heavy engineering industry. These observations may be further useful for other industries to realize effects of PLM.

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