Abstract-- Previously, the OEMs used to design parts and ask the suppliers to produce it. Now-a-days, they ask the suppliers to conceive, design and manufacture the part. Thus, OEMs are becoming more of assemblers and suppliers are becoming more of designers. In this new era of competitive environment, a tier-1 supplier of an automotive OEM must deliver in time; rather much earlier than the deadline to get an extra edge over the competitor. In the designing and manufacturing a certain part, lots of documents are produced in different formats. Also to be a supplier to an automotive company, Advanced Product Quality Planning (APQP) has to be followed to get TS16949. This leads to complexity and paperwork. Without integration and collaboration, same product may be authored repeatedly in different systems. Also the security of this Intellectual Property (IP) is important. To overcome these problems, many companies are implementing product lifecycle management (PLM) solutions. PLM provide a single platform for all product data of different formats and a virtual vault to keep this data secure. This paper covers a research work carried out in an automotive tier-1 company to figure out the changes occurred after the usage of PLM software ENOVIA V6 for the project management purpose and the results were analysed.

Keywords-- PLM, APQP, OEM, ENOVIA V6, Product Development, Automotive.

I. INTRODUCTION

PLM is the business activity of managing, in the most effective way, a company’s products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of. PLM manages products from the beginning of their life, including development, through growth and maturity, to the end of life. The objective of PLM is to increase product revenues, reduce product-related costs, maximize the value of the product portfolio, and maximize the value of current and future products for both customers and shareholders.

If the company loses control during product development, the product may be late to market and exceed the targeted cost. Companies don’t want to have such problems with their products. If a problem does occur, a company will do everything it can to understand the source and to prevent the problem happening again. It’s also useful to identify and understand potential problems with a view to preventing them occurring. PLM has main role in supporting the automotive industry’s Advanced Product Quality Planning (APQP) process framework. APQP is generally described as a set of procedures and techniques used to develop products in the automotive industry. Advanced Product Quality Planning (APQP) serves as a guide in the product development process as well as a standard way to share product related information among suppliers and their OEM customers. For TS 16949 Certification, an automotive company needs to follow APQP.

II. LITERATURE REVIEW

1. Gunther Schuh et al.[2008] concluded that because of its potential benefits to shorten innovation lead-times and to reduce costs, PLM has attracted a lot of attention at industry and at research. However, the current PLM implementation stage at most organizations still does not apply the lifecycle management concepts thoroughly. In order to close the existing realization gap, this article presents a process oriented framework to support effective PLM implementation. The framework central point consists of a set of lifecycle oriented business process reference models which links the necessary fundamental concepts, enterprise knowledge and software solutions to effectively deploy PLM.

2. Jaykumar Yoga Mule [2012] stated how in today’s world, PLM is becoming more important as companies compete in the worldwide market because of growing product complexity, large number of product variants and collaborative product development for automotive industries, aerospace industries and manufacturing industries.

3. Valery M. et al. [2012] aimed at understanding how the use of Product Lifecycle Management Technology (PLM) contributes to knowledge sharing in an international New Product Development (NPD) environment. The research is based on a longitudinal case study of a consumer goods industry group and involved development teams in Europe and local suppliers in China. Knowledge transfer and translation were observed through the reduction of communication glitches among members and increased NPD work with Chinese suppliers.

4. D. Rambabu et al. [2013] dealt with the utilization of SAP integrated with PLM in a pump industry for designing and manufacturing of a water pump with validated results and give details about the process to select, implementation of focus and successful launch of PLM, to manage their design and development process, prototype manufacturing, APQP and supplier quality assurance process. They finally concluded that The Product design and development of pumps are effectively implemented by APQP methodologies through SAP PLM functionalities.

III. OBJECTIVES OF RESEARCH

1. To understand the current usage of PLM system confined to limited number of processes.
2. To optimize the usage of PLM system for:
   1. Bringing all the projects online.
   2. Scheduling the projects for their on-time completion.
   3. Reducing the complexity.
3. To make all other departments, other than Research & Development (R&D), aware about the optimized use of the PLM.
To reduce paperwork and files created due to APQP.
To help the users to focus more on innovation rather than on data management.

IV. RESEARCH METHODOLOGY

A. Introduction

This research work was carried out in a brakes manufacturing company. The company is a Tier-1 supplier to leading two, three and four wheeler automotive OEMs. The company designs the components of both disc brakes and drum brakes as per the requirements of OEMs, sets all the processes required for manufacturing and finally manufactures the product. In doing so, it also outsources some components from Tier-2 suppliers.

Every year, ISO conducts TS16949 audit in the company which is mandatory for the Tier-1 supplier companies of automotive OEMs. This is done to check whether the company follows rules and regulations set as per APQP while designing and developing a particular product.

Traditionally, each product development project was carried out offline in the company. This meant that there was no system such as project management and project visibility to all, scheduling and they had to maintain a heavy file of each project inclusive of all the paperwork related to it for the TS16949 Audit purpose.

B. PLM Software

ENOVIA V6 is a PLM system developed by Dassault Systemes and what truly makes this platform different from previous generations is that in this environment, people can work concurrently in real time via a simple Web connection relying upon a single server. The V6 (SOA) enables global deployment while centralizing the metadata in a single master site repository and distributing the file within the different remote locations. This centralized dataset is accessible to all users, regardless of location. The different distant sites use a local file server to load large representation files, eliminating time consuming network transmissions.

The company had ENOVIA V6 installed but they were deriving limited use out of it. So to use this PLM system to its full extent, they required to bring all the projects online. PLM benefitted the company for following purposes till now:

1. To release and freeze the final drawing
2. To create a new part number.
3. To create Engineering Change Requests (ECR), Engineering Change Orders (ECR) and Bill of Materials (BOM).

So, the idea of bringing projects online was new for all working there. To be able to understand the commands and functioning of PLM, an experimental project was uploaded.

C. APQP Template

First of all, a project template was created which includes all the project tasks, their estimated duration and the dependency of each task. When a dependency is added for a task, the task dates for the dependee task determines the dates for the dependent task. Using the template, an APQP project was created.

Figure 1: Sample APQP Template
Overall, APQP specifies the following five main product development phases:

1. Phase 1: Plan & Define Program — this phase focuses on determining and documenting customer needs, requirements, and expectations.
2. Phase 2: Product Design and Development — during this development phase, the inputs are reviewed and the outputs are created (e.g. DFMEA, Design Verification Plan & Report (DVP&R), design reviews, material and engineering specifications).
3. Phase 3: Process Design and Development — this phase focuses on defining the manufacturing systems and related control plans for production of the product being defined.
4. Phase 4: Product and Process Validation — this phase includes the validation of the selected manufacturing process and its control plans.
5. Phase 5: Feedback, Assessment and Corrective Action — this phase focuses on reducing variation and continuous improvement activities.

D. Creating a Project

There are two system servers i.e. Development and Production Server. On development server, people from R&D work and on production server, people from Production Department should work. Once the project is uploaded on production server, it can be deleted or removed by higher admin authority only.

By uploading the .CSV (Comma Delimiter) file on PLM, project template is created. Using this template, a project is created.

Figure 2: Project Initial Dashboard
As seen in Fig. 2, initially all the phases in project are coloured grey as no task has been completed.
E. Work Breakdown Structure (WBS)

A Work Breakdown Structure (WBS) is a hierarchy of tasks and subtasks required to complete a project. A WBS task is work assigned to a project member by a Project Lead. This is where the project structure is created, due dates for tasks are defined and people to complete the tasks are assigned. Tasks are associated with a project, but have their own lifecycle.

WBS task Lifecycle is as follows:
1. Create: The task has just been created and an assignee specified. When a Project Lead is ready for work to begin on a WBS task, the Lead promotes it to Assign.
2. Assign: The system notifies assignees and the tasks appear by default on the assignee's WBS Tasks page.
3. Active: The assignees have begun work on the task. The system automatically promotes a task to Active when the % Complete is changed from 0% to any percentage less than 100. Alternatively, an assignee can promote the task to Active to indicate it is being worked on.
4. Review: Project members are reviewing the task and its deliverables. When 100% is entered for % Complete, the system automatically promotes the task to Review. Alternatively, the task can be promoted to Re view and the system automatically changes the % Complete to 100%. Typically, an assignee creates a route to have route members review the task. The route can be created with the option to automatically complete the task upon completion of the route.
5. Complete: The task is complete. The system automatically promotes a task to Complete when an assignee enters an Actual Finish Date. Alternatively, an assignee can promote the task to Complete and the system enters the current date as the Actual Finish Date.

V. PERFORMANCE ANALYSIS

After understanding all the basic commands of PLM system, an ongoing project was needed to be uploaded on Production Server of PLM system. As per company’s requirement, it had to be a Two Wheeler Project.

In this section, the respective files i.e., deliverables were added in each respective tasks, and then they were promoted to the Complete state.

It is almost impossible to go 100% paperless, as some drawings are easy to review for a Design Engineer on printed paper rather than on PCs. Also, for the approval of some drawings from senior authorities, those need to be signed by them. Hence, whatever these printed files and wherever they may be stored on PCs of CAD Engineer, Design Engineer or anyone other, these files are needed to be stored in one vault.

ENOVIA PLM provides this storage vault and project management facility. So, these printed on paper files are needed to be scanned and uploaded in respective tasks in WBS.

As seen in Fig. 4, as all the deliverables i.e. respected files were added in tasks and promoted to complete stage, all phases are green in colour.

A. Deliverables Report

During the TS16949 Audit which is conducted usually in Dec/Jan of every year, auditors ask for some files and check whether the product development process is being carried out according to APQP format or not.

All the deliverables uploaded in a particular project can be viewed and downloaded if required with one option only.

B. Mathematical Analysis

As per the APQP template created by Design Engineer for the development of any APQP project, all the phases are run parallel to distribute work in the project members and reduce the overall product development time. The estimated duration for each phase is as below:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 Plan and Define Programme</td>
<td>31</td>
</tr>
<tr>
<td>Phase 2 Product Design and Development</td>
<td>49</td>
</tr>
<tr>
<td>Proto-1 Timeline</td>
<td>101</td>
</tr>
<tr>
<td>Proto-2 Timeline</td>
<td>55</td>
</tr>
<tr>
<td>Phase 3 Process Design &amp; Development</td>
<td>34</td>
</tr>
<tr>
<td>Phase 4 Product &amp; Process Validation On</td>
<td>171</td>
</tr>
</tbody>
</table>
The total time estimated to develop any product according to APQP manual is 246 days. When the project was routed through PLM system, the reduction in Proto-1 development was 101 days. After routing the project through PLM, the lead development time for Proto-1 came to nearly three months.

VI. RESULTS

Due to effective utilization of PLM to its full extent, increased awareness about responsibility and improved communication between project members and customer, ‘First Time Correct’ strategy is achieved and the expected results are coming in the first attempt only and any errors that may occur in future are reduced. The estimated time by the Design Engineer for the Proto-1 Development was 101 days.

The differences occurred between the working environment before and after the PLM for project management can be justified using table 2:

<table>
<thead>
<tr>
<th>No.</th>
<th>Attribute</th>
<th>Before</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TS16949 Audit</td>
<td>Files had to be maintained manually</td>
<td>Direct display of files on PLM platform</td>
</tr>
<tr>
<td>2</td>
<td>Paperwork</td>
<td>Abundant</td>
<td>Less</td>
</tr>
<tr>
<td>3</td>
<td>Product Data</td>
<td>Scattered over all PCs of project members</td>
<td>Collected on one central PLM storage vault</td>
</tr>
<tr>
<td>4</td>
<td>Communication</td>
<td>Lack of communication or chances of</td>
<td>Transparency in vendor-consumer relation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>miscommunication</td>
<td>due to effective communication</td>
</tr>
<tr>
<td>5</td>
<td>Traceability</td>
<td>Don’t had the idea about file already</td>
<td>Avoid already created file and can be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>created or not</td>
<td>recovered</td>
</tr>
<tr>
<td>6</td>
<td>Backup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Time to Market</td>
<td>More</td>
<td>Less due to reduced errors</td>
</tr>
<tr>
<td>8</td>
<td>Errors</td>
<td>No. of errors</td>
<td>Almost no errors</td>
</tr>
<tr>
<td>9</td>
<td>Customer satisfaction</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Environment</td>
<td>No</td>
<td>Collaborative</td>
</tr>
<tr>
<td>11</td>
<td>Innovation</td>
<td>More time spent on data management</td>
<td>More time spent on innovation</td>
</tr>
<tr>
<td>12</td>
<td>Responsibility</td>
<td>Lack of awareness</td>
<td>Increased</td>
</tr>
<tr>
<td>13</td>
<td>Schedule</td>
<td>Hardly met</td>
<td>Hardly missed</td>
</tr>
</tbody>
</table>

CONCLUSION

By accessing the benefits after embedding program management in PLM and the current working environment in Endurance, following changes are proposed in the future for innovative and collaborative environment:

1. Other than R&D, all other departments should start using PLM.
   i. Manufacturing Department to see any changes in the previous design.
   ii. Production Planning & Control (PPC) to view newly released drawings and plan accordingly.
   iii. Vendor Communication Department (VCD) and Costing Department to determine the cost of tools and equipments to be purchased and determine the cost of new product.
   iv. And overall, to avoid the carriage of drawing manually in the plant.
2. To avoid last minute rush, start to feed the data as soon as the completion of phase, for the TS16949 Audit.
3. Make more people trained and aware about the usage and scope of PLM.
4. Use Budget Management in PLM to fund the right budgets and for making the decisions on continuing the project or not.

It is always the best business strategy of making the continued full utilization of the resources available within the context of any industry. So, the full utilization of PLM is to be encouraged for the overwhelming results.

References


