Configuration management system for an Alternator manufacturer

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Abstract— **Product configuration is an activity that can be considered as satisfying a customer's demand by creating a product which is composed by a number of previously developed components. The importance of product configuration is currently increasing dramatically as the requirement of managing product varieties. This is due to an increasing demand from customers for separately detailed products and due to better technological opportunities to handle the customization efforts. Therefore, product configuration is a strategic choice for the industry. In order to perform product configuration efficiently and effectively, the product must be specified and is critical for creating product development teams. Configuration involves selecting and arranging parts to fit product and operational constraints. This work deals with developing a product configuration method for an alternator manufacturing industry where managing components and integrating suppliers are important. The methodology adopted is creating a product structure which is basis for the product management. The product structure in the logic tier is supported by a database in the third tier where data are arranged in tables can use in any application related to management. Database is interfaced with user that means a webpage creation. User interface creation is the last stage of project. All the users have specific roles and give access via presentation tier. Database created using MySQL software and database is interfaced with using PHP language. Webpage development using PHP language. User interface creation resulting information flow of order arrival is automated. MySQL and PHP supported database management system reducing human involvement and order details get all departments earlier as compared to present situation. By creation of 3 –tier architecture in this industry reducing time for transferring the order information.**

Index Terms—**Database, Product structure, Webpage interface, MYSQL, PHP.**
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I. INTRODUCTION

Product configuration is an effective activity that can be considered as satisfying a customer's demand by creating a product which is composed by a number of previously developed components. The importance of product configuration is currently increasing dramatically as for a wide range of product variation are to be managed by industries. This is due to an increasing demand from customers for separately detailed products and due to better technological opportunities to handle the customization efforts. Then, product configuration is a strategic choice for the industry. In order to perform product configuration efficiently and effectively, an integrated teams involved in specific activities are to be formed. Currently, products have to be customized and assembled from previously developed components but it is significant also to be able to include some engineering processes in the configuration processes. Configuration involves selecting and arranging parts to fit product and operational constraints. Configuration problems may involve design, manufacturing, sales, installation and maintenance. Selecting and arranging combinations of parts which satisfy given specifications is the core of a configuration task. The configuration rules describes the objects of the application and the relations among them. The specifications for an actual product define the requirements that must be fulfilled by the product and, maybe, optimizing measures that should be used to direct the search for a solution. The solution has to produce the list of selected components as well as the structure and topology of the product. Product configurators are software tools to aid users including customers to develop accepted product configurations fast and precisely with a minimum of effort. These tools reduce engineering effort and improve the improvement process. The proposed solution is built in client-server – database architecture, and implemented PHP and MYSQL tools. The design of the proposed solution is discussed in the next section. Actually main purpose of this work to develop a 3-tier architecture, it separates its tiers from each other based on the difficulty of the users and how they use the data present in the database. It is the most commonly used architecture to design a DBMS.It include Database tier, application tier and user tier. The proposed software solution supports the product data management which is an enabling technology that helps workgroup, departments and enterprise to manage product data throughout the lifecycle of products. There are requirements of efficient configuration management solutions in industries where a complete PDM system is not applicable due to need of investment especially in SME sector. Hence a software solution is developed for computerized management of product varieties enabling reduced lead time, faster information flow and dealing complex products.

II. PRODUCT PROFILE

Project work is done an alternator manufacturing industry, engaged in medium scale manufacturing of brushless alternators on different variations.4.5KW, 12KW.18.5KW, 25KW are on different variations alternators developed in this industry. The industry has a wide range of customers including Indian Railway. Mainly orders are coming to the organization for these four types of alternators.

III. PROBLEM DEFINITION

Selected industry is a government controlled organization, so main reason for the increased lead time of delivery of product is financial problem. Along with financial problem, there are some problems are affecting the process flow. Software supported database management system is needed due to complexity in handling spare parts for the product. But software supported software is not used in this industry. This lead to human interaction is high in this information flow when an order come to organization. Human delay is the main reason for the delay in order processing. There are different types of orders coming to organization .This is another reason for the need of product configuration because Different product varieties are to be managed by the firm. Lot of time needed to arrange the component according to type and quantity of the product. There are four types of orders are mainly come to the organization, so classifying and arranging the components at proper manner. When an order come to the organization whole department do not get the information at the time of arrival of order. Software supported database will reduce this problem. By the application of the computer application in the industry information flow is automated, that is when an order details are arrived at the same time all departments. Current situation in the industry is information is transferring from one department to another take lot of time, because of the involvement of the human interaction.
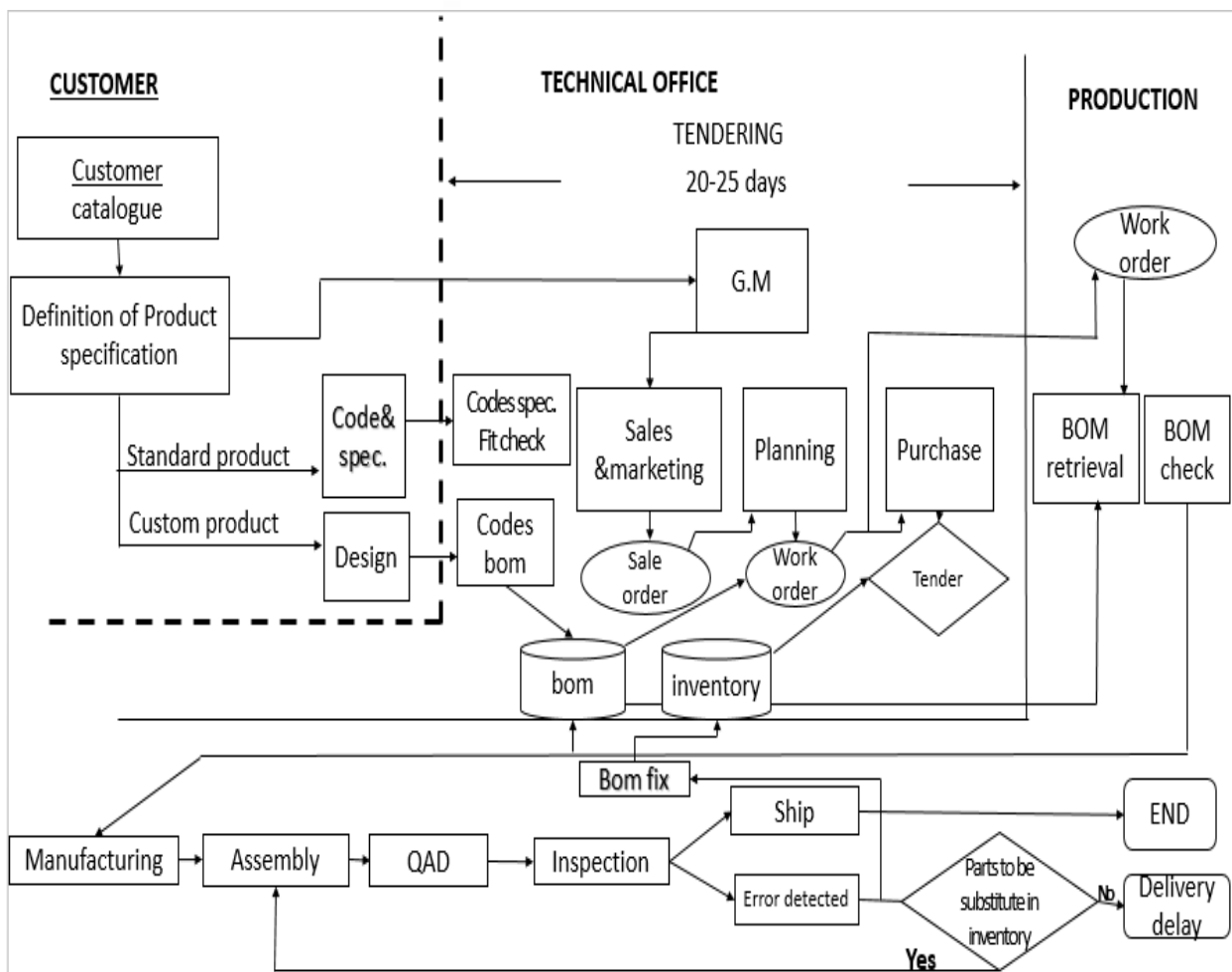

Fig 3.1 Product configuration-related activities before the introduction of the product configuration system and web interface

When a customer placed an order to this organization named as purchased order. Before placed an order customer contact with organization through phone call. Purchase order contains specification of alternator needed, no of quantities of product etc. When a purchase order from a customer come to the organization, first activity is to place a sale order from sales department. From the collected details are reveals that sale order produced take8-10 days. Normally it takes 2-4 days after getting the sales order. Delay in placing sales order is due to official reasons.Absentism of works for transferring from this department to next be the other reason. After sales order placed to planning department. Work order producing is the major task because assigning work to each machine shops and no of items produced and no of workers assigning each work on each work stations. Relevant data reveals that gives 15-20 days for a work order preparation. Normally it is reduced to 10-15 days, time lag to produce the work order is mainly due to lack of product configuration according to flexible orders and difficulty to handle different types components of different in different varieties of alternators. Printed documents are recorded on paper. Another important problem is financial problem of

the industry to purchase the components to meet the demands. Another minor issue is to absenteeism of workers for transferring from one department to next department. Next is purchase department tender issued according to the quantities required by the customer. Product configuration is more useful for this task. Currently take 20-25days to complete the process up to order tender process. In this project concentrate to reduce the no of days to take complete tendering process. Once the order is placed, the responsibility for producing and shipping the product belong to the production area. In this industry the production manager first retrieves and check the perfection of the BOM. Certainly, due to the many tasks competing for the production manager's time, only hardly he is able to check for the perfection of the BOM.it may lead to some errors as he also has to take care of CNC machines programming (whenever manufacturing activities are needed) and shop floor activities scheduling. Based on the BOM and inventories, he get work order and purchase order from previous departments and releases the work order on the shop floor. Due to the missing BOM check, errors are often detected only through the assembly processes by the workers. In case the wrong parts are present in stock there are not serious consequences on delivery time of product, as it is possible to directly pick them from inventory, perform the required operations and assemble them with the other components. Instead, when the wrong parts need to be substituted by parts that have to be machined or purchased, then a delivery delay is very likely. Another issue is error occur because of misunderstanding the details in the work orders so there is an additional time required to check and correct the errors with planning departments .According with the company's procedures, whenever an error is detected in the assembly process, the BOM should be corrected. However, this feedback always fails, even though for unimportant reasons. For example, the workers could not have time to make the correction because they are working on the final assembly in order to meet the carrier pick up the deadline. In other cases, the personnel in the technical office might not notice the correction may increase the error rate in the BOM.

Table 3.1: Sale Order and Work order

ORDER NO	ORDER DATE	PRODUCT	SALE ORDER DATE	WORK ORDER DATE
150/14-15	07.01.15	4.5KW	13.01.15	04.02.15
01/15-16	25.03.15	25 KW	06.04.15	20.04.15
139/15-16	12.01.16	4.5KW	18.01.16	30.01.15
11/15-16	08.04.15	4.5 KW	02.05.15	22.04.15
47/14-15	03.07.15	18.5 KW	11.07.15	01.08.15
74/15-16	21.08.15	4.5 KW	31.08.15	20.09.15

Table shows the details of sales order and work order produced according to various orders came to the organization. From this table reveals that 20-25 days are required up to tendering process. Main purpose of the work is to reduce the number of days and reduce the lead-time of the product.

IV. LITERATURE REVIEW

Product configuration

Philipp Holtewert et al (2016) 'Optimal configuration of manufacturing cells for high flexibility and cost reduction by component substitution'. This paper discusses a novel method for an optimal configuration of manufacturing cells is defined which allows the increase of flexibility as well as the reduction of costs by component substitution. C. Forza et al (2002)' Product configuration and inter-firm co-ordination: an innovative solution from a small manufacturing enterprise'. This paper discusses case study of the implementation of a product configuration software in a small manufacturing enterprise. The paper highlight that the company enjoyed important benefits from the implementation of the software especially in terms of delivery time of product and customer relationships. Aravind chandrashekaran et al (2014) 'Product configuration, ambidexterity and firm performance in the background of industrial equipment manufacturing '.This paper discusses about to handle the different types of orders of organization. That means product configuring for individual customer and others. In this work mentioning product configuration effectiveness (PCE) and product configuration intelligence (PCI). Hypothesize mention in this paper revels that the simultaneous presence of PCE and PCI—that is, product configuration ambidexterity (PCA) drives superior organization responsiveness and, indirectly firm sales and operating margin. Zhaoxun Chen et al (2010) 'Personalized product configuration rules with dual

formulations: A method to proactively leverage mass confusion'. This research discusses to propagate the effort of personalization from front-end roles to back-end configuration knowledge by proposing a kind of personalized configuration rules (PCRs).

Database

S.D Rajan et al (1984)' On designing a database management system for a computer-aided engineering software system'.in this paper discusses development of DBMS. The different data models are explained and their usage in CAD/CAM settings is illustrated. The importance of data independence, modularity, efficiency, and portability is emphasized. Mainly this paper explain the steps required to configure an engineering DBMS. Faizul huq et al (1993)' The use of relational database management Systems (dbms) for information retrieval in a group technology (GT) environment '.This paper discusses about the use of the tools available for a relational DBMS for the purpose of developing a Group Technology (GT) application Specifically, we will concentrate on Structured Query Language (SQL) but the possibilities of using other structures such as Host Language programming and Report Generators will also be examined the paper demonstrates the use of Relational DBMS technology as a tool for implementing a GT project m an advanced manufacturing environment. Database is created using SQLlanguages.Data model are developed and relationships are represented with Bachman diagram notation. Sahithi Tummalapalli et al (2016) 'Managing MySQL Cluster Data sing Cloudera Impala'. This paper discusses MySQL cluster is a widely used clustered database used to store and operate data which has a shared nothing clustering for the MySQL database management system providing high availability and high throughput with low latency.

Webpage interface

Dimas Gilang Saputra et al (2013) 'A Metadata Approach for Building Web Application User Interface'. This paper discusses metadata as an approach to store the elements of user interfaces, so that the elements can be managed dynamically without having to go through the codes. In this provide a preliminary metadata model of user interface elements of web applications in an entity-relationship model. Venkidachalam Senthilkumar (2010) 'A web-based system for design interface management of construction projects'. This paper discusses the design and the development of the tool. It contains the design of class structure, relational database system and communication engine using object oriented concepts. In addition, the design of user interface which contains of a set of dynamic web pages is also described. The paper also explains the usage of the tool for the design of a glass factory and discusses the utility of the tool in supporting design interface management. Jung Rong Chen (2006) 'Component-based Web page management environment '.This paper discusses a component based web page management environment, which are (1) enables high-level modelling capability of web pages through components, (2) improves the maintenance of web applications, and (3) facilitates the reuse of Web page components. Hai Wang et al (2016) 'Application of ontology modularization to human-web interface design for knowledge sharing'. This paper discusses an approach of ontology modularization to navigating and searching web portals for the purposes of knowledge sharing.

V. METHODOLOGY

Identify the problem is the first step, collection of data, product structure creation according to collected data, database creation using product structure, database is interact with user ,and the web page creation is the final stage of project work. Webpage using the database information by using the PHP language. MYSQL and PHP are open software any one can download and install directly with no expenses.
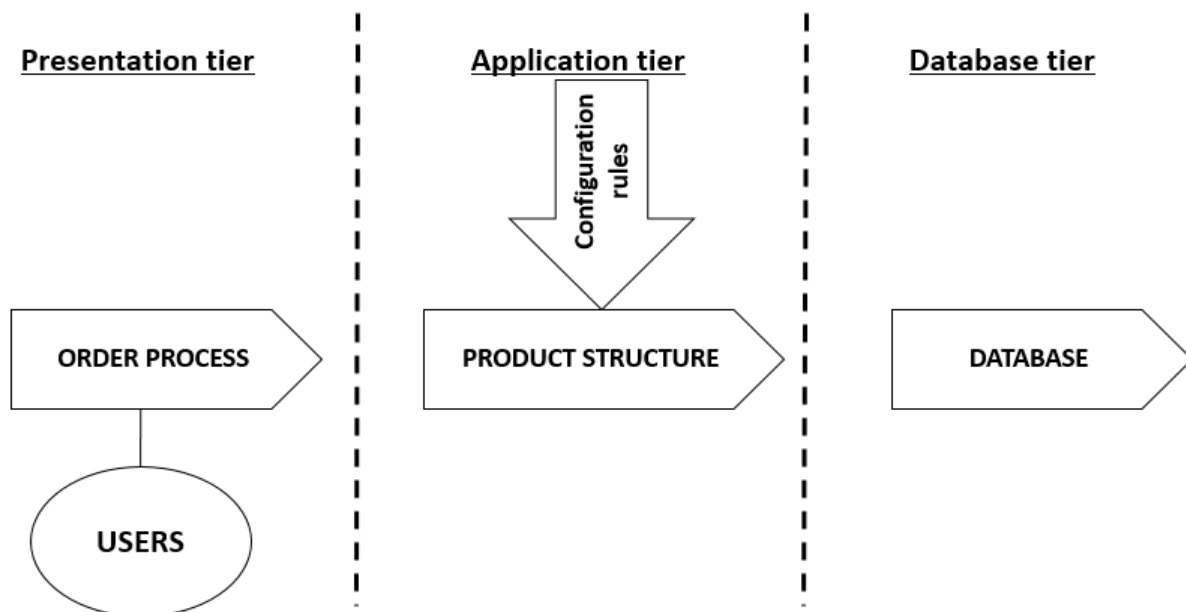

Fig 5.1 methodology

Data collection

Data collection is the initial step of the project work .this data collection is the basis for the product structure. Data collected according the type of order coming to the organization. Mainly four types of alternators are mainly produced in the industry. Brushless alternator is the product produced in this industry. Along with alternator, spare parts orders are come to the organization. ERRU units orders are coming to the industry but handling different type of orders are difficult task so to avoid this collected all component and grouped this data. Important items and its suppliers are collected because when an order are come to the industry organization choose the best supplier. Data collection needed for the creation a product structure. Collected data including specification of alternators (4.5kw, 12kw, 18.5kw, and 25kw), quantity of alternators needed, and delivery details of order. Collected data details are listed below table

Table 5.2: Order dispatching details

ORDER NO	ORDER DATE	PRODUCT	QUANTITY	CUSTOMER	DELIVERY DETAILS
150/14-15	07.01.15	4.5kW	135	ICF	31.03.15 (35) 29.05.15 (40) 31.08.15 (30) 24.12.15 (30)
01/15-16	25.03.15	25kW	18	SR	22.08.15 (12) BALACE -06
95/14-15	13.09.14	4.5KW	129	ICF	15.03.15 (25) 28.05.15 (05) 13.06.15 (30) 30.06.15 (39) 03.09.15 (10) BALANCE 20
11/15-16	08.04.15	4.5KW	60	SWR	08.10.15 (16) 31.10.15 (08) 02.12.15 (25) BALANCE 11
47/15-16	03.07.15	18.5KW	06	SR	01.12.15 (06)
74/15-16	21.08.15	4.5KW	71	ECOR	30.11.15 (25) 31.12.15 (26) BALANCE 26

Product structure

A product structure is a technique of identifying all raw materials, components, and subassemblies in a product. It is recorded as a single level relationship between a main item and component, a product structure determines when and how many component are required. A product structure is also called a bill of material, parts list, or formula. In PDM system product structure has many views namely, design view, manufacturing view, customer view etc. The core of the product structure is explained by the product components and their relationships. Thus, this includes the connecting between items related to the product. The assembly can contain of subassemblies and parts, whereas subassemblies can also consist of other subassemblies or part. This is typically hierarchically ordered. These concepts are generalized into the concept of item. This classification is overlapping because a subassembly could be a part in another assembly configuration. Because of differentiation and variation of items of several concepts must be specified into the product breakdown structure. There are three concepts are involved in this differentiation, namely alternatives, variants and revisions. Another of an item is considered as a substitute for that particular item, whereas a different is another option of an item which the consumer can select. When an error occurs at a part or subassembly, it needs to be revised. This revision specifies the change history of the item. Figure 5.2 is representing the product structure of selected alternator producing industry. Product structure is created according to the type of order coming to the industry. From collected data .mainly orders of four types of alternators are coming from customers 4.5kw, 12kw, 18.5kw, and 25kw are the majority producing alternators. There is difficulty in handling in large no of components of different types of alternators to reduce this difficulty grouping the two types of alternators (4.5&12, 18.5&25) are grouped. Grouped alternators has common sub components, they arranged in one table, other table of alternators contain components of itself only, and it is

not mixed with other. Circle 4.5, 12, 18.5,25 represent only the alternator components of itself only. Circles 4.5&12, 18.5&25 represents only common components of alternator pairs. Circle Supplier representing the important items and its suppliers.
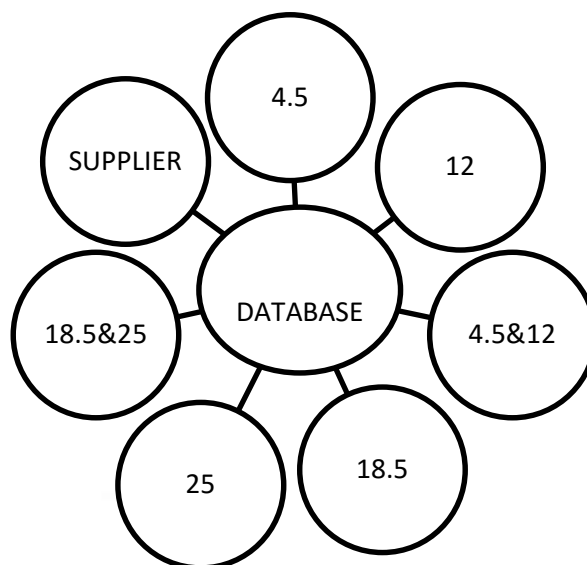

Fig 5.2 Product structure

Database creation

A database is a group of information that is organized so that it can easily be accessed, managed, and updated. In one point of view, databases can be classified according to types of content: bibliographic, full-text, numeric, and images. In calculating, databases are sometimes classified according to their organizational approach. The most prevalent approach is the relational database, a tabular database in which data is defined so that it can be reorganized and accessed in a number of different ways. A database management system (DBMS) is a collective of data, hardware, software, and users that supports an enterprise manage its operational data. The main function of a DBMS is to offer effective and consistent methods of data retrieval to many users. Efficient data retrieval is an essential function of database systems. Most DBMSs deal with numerous users who try simultaneously to access several data items and, frequently, the same data item.

Database system software

Database software is the expression used to describe any software that is designed for creating databases and managing the information kept in them. Sometimes it is referred to as database management systems (DBMS), database software tools are primarily used for store, modify, extract and searching for information within a database. Because they have so many uses, there are lot of database software programs available. The options have gone beyond Oracle or Microsoft Access to include FileMaker, Avanquest and Delicious Monster Software for options tailored to a variety of needs. Some of the popular database software applications comprise desktop solutions like Microsoft Access and FileMaker Pro and server solutions like MySQL, Microsoft SQL Server and Oracle. Database is created using MySQL software. MYSQL belongs to a software is known as open source. It makes use of an open source development model, which allows anyone who is interested to participate in the development of the project. MySQL is choose because of the reasons that are cost effective, can install and use it pay nothing in the process. It is quick and powerful and is improving all the time. Using MySQL product structure is converted in to database. Created database can be access and molding for any applications. Database created using CREATE statement. Data are inserted in to the database is using INSERT INTO statement. Data stored in the MYSQL is retrieved using SELECT statement.
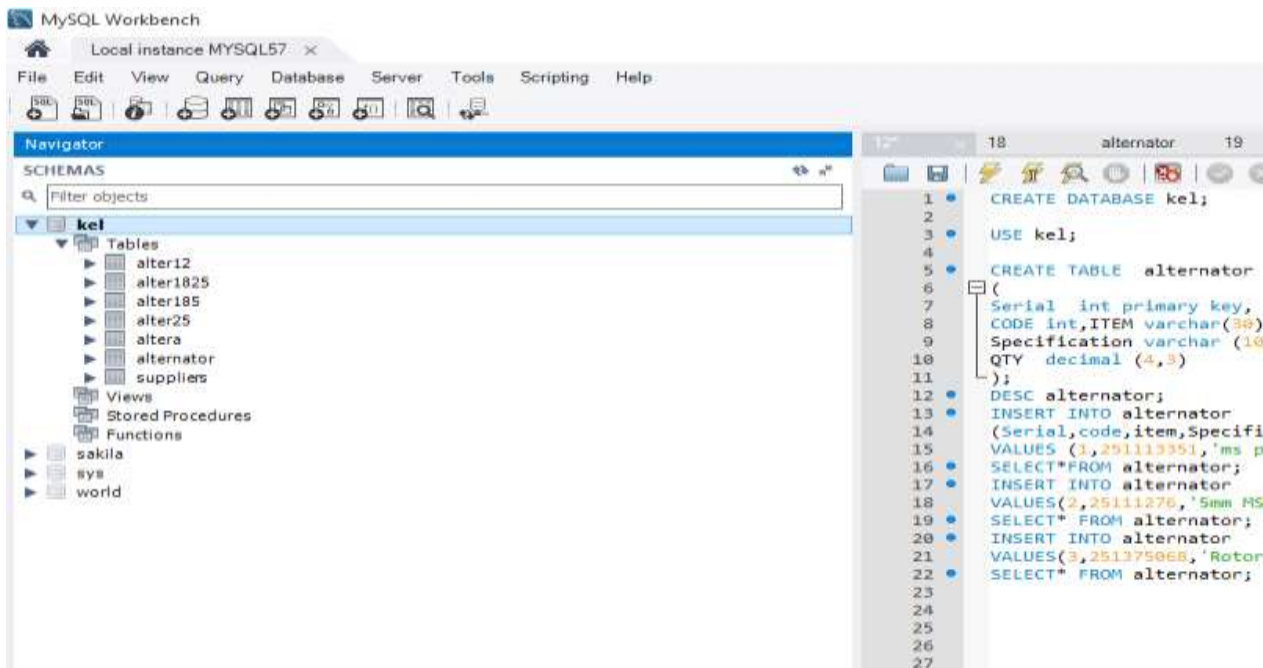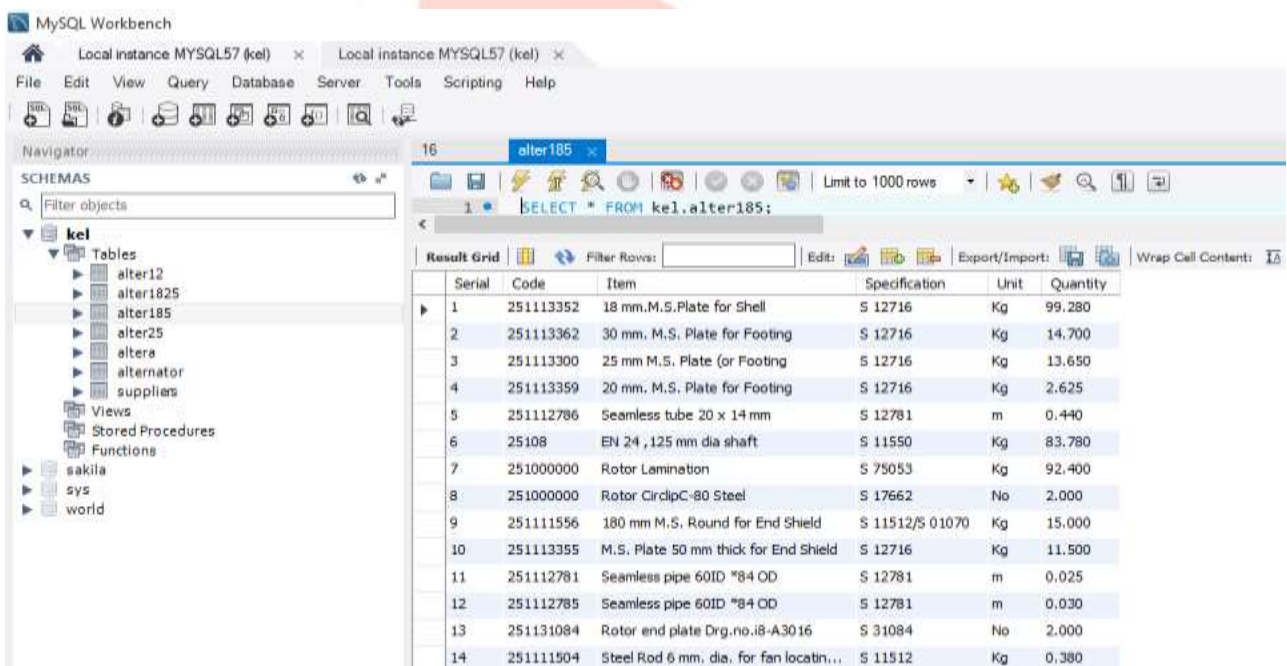
Fig 5.4 Database data in MySQL

Fig 5.5 Components data of alternator 18.5 KW in MySQL

Created a database using MySQL and product structured data are transferred in to the database are showing the above figure5.4and figure 5.5

Web page creation

A user interface webpage creation is the last phase of the project work .User interface means that interactive space between user and organization. According to a 3 tier architecture it is the top most tier because a direct link between a customers is the important task in this industry. A web page including all departments of industry. When an order come to the industry, that means a customer can register to the web page of industry. Customer can view only after approving the Head of industry. After allowing customer can order to the industry. From here flow of information starts.

Software description php

A web page interface is created using PHP language. PHP is Hypertext Pre-processor is a programming language that allows web developers to generate dynamic content that interacts with databases. PHP is basically used for developing web-based software applications PHP scripts reside between reserved PHP tags. This allows the programmer to embed PHP scripts within HTML pages.it is structurally similar to c++.
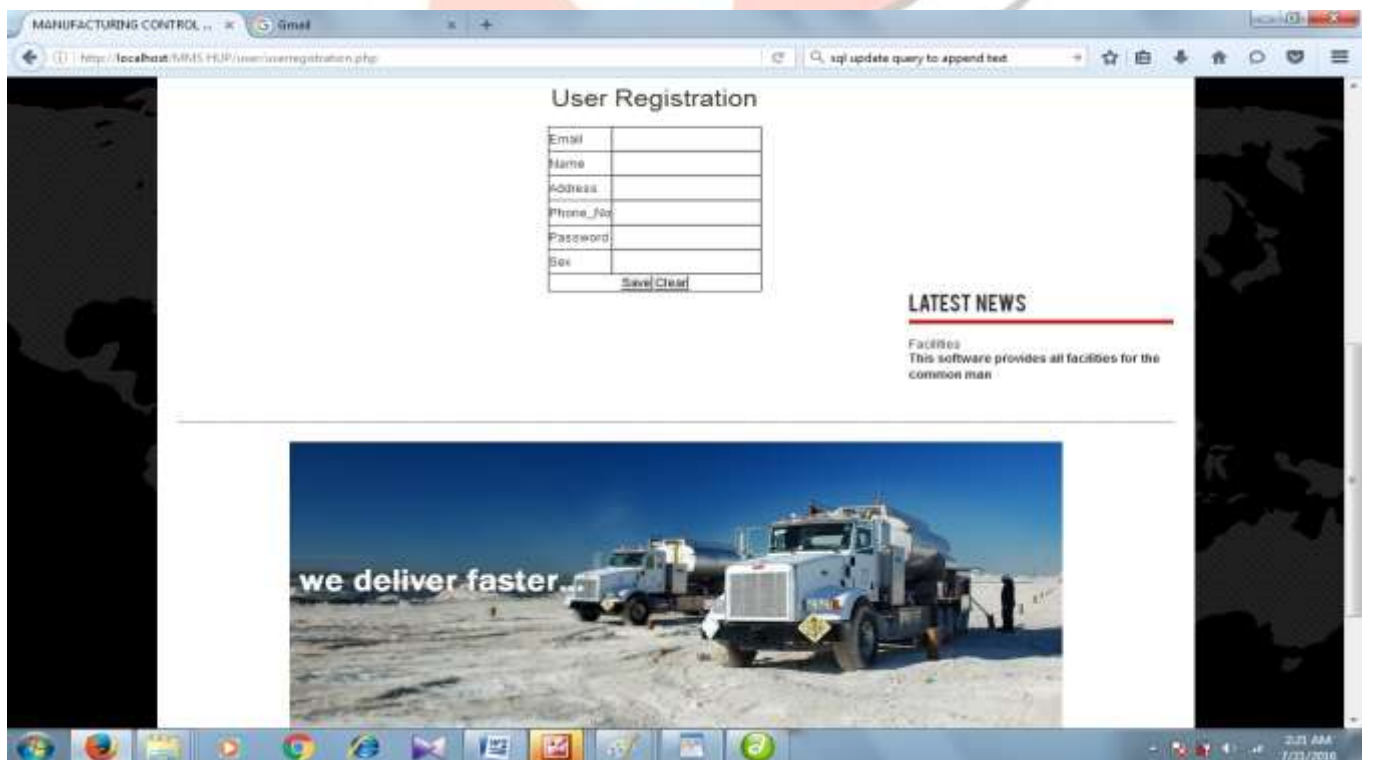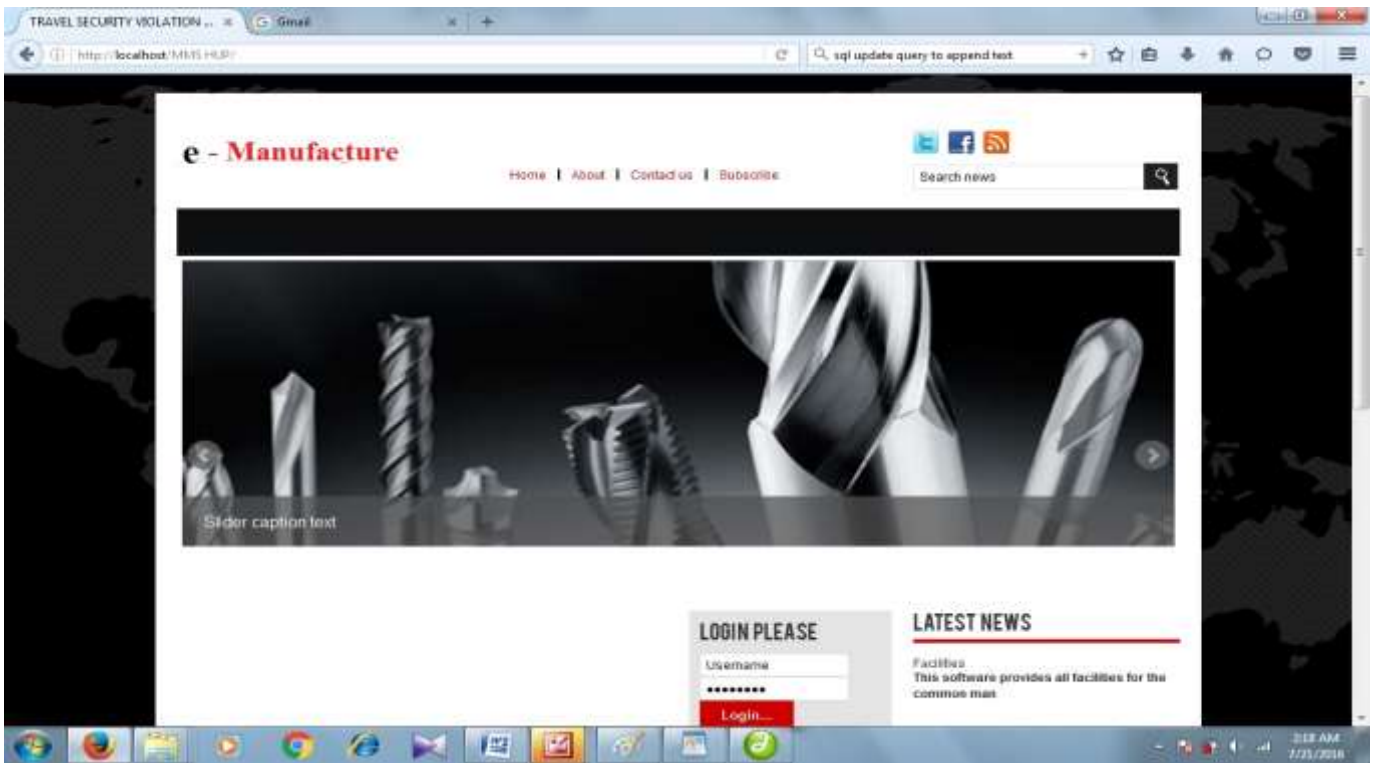

Fig 5.10 User registration webpage

VI. RESULTS & DISCUSSION

A user webpage is developed and introduced in the selected alternator manufacturing industry. Webpage is developed using PHP and database is created using MYSQL software, both are get freely in the market and install and easy to use. Select industry is a government organization, financial problem is the main reason for delay in delivery of product.so it webpage interface more useful in the area of financial and management. Product configuration is done according to the flexible order coming from the customers. Components of different varieties of alternators are selected and arranged in to different tables and transferred in to a database. This database details are linked with webpage of each departments.
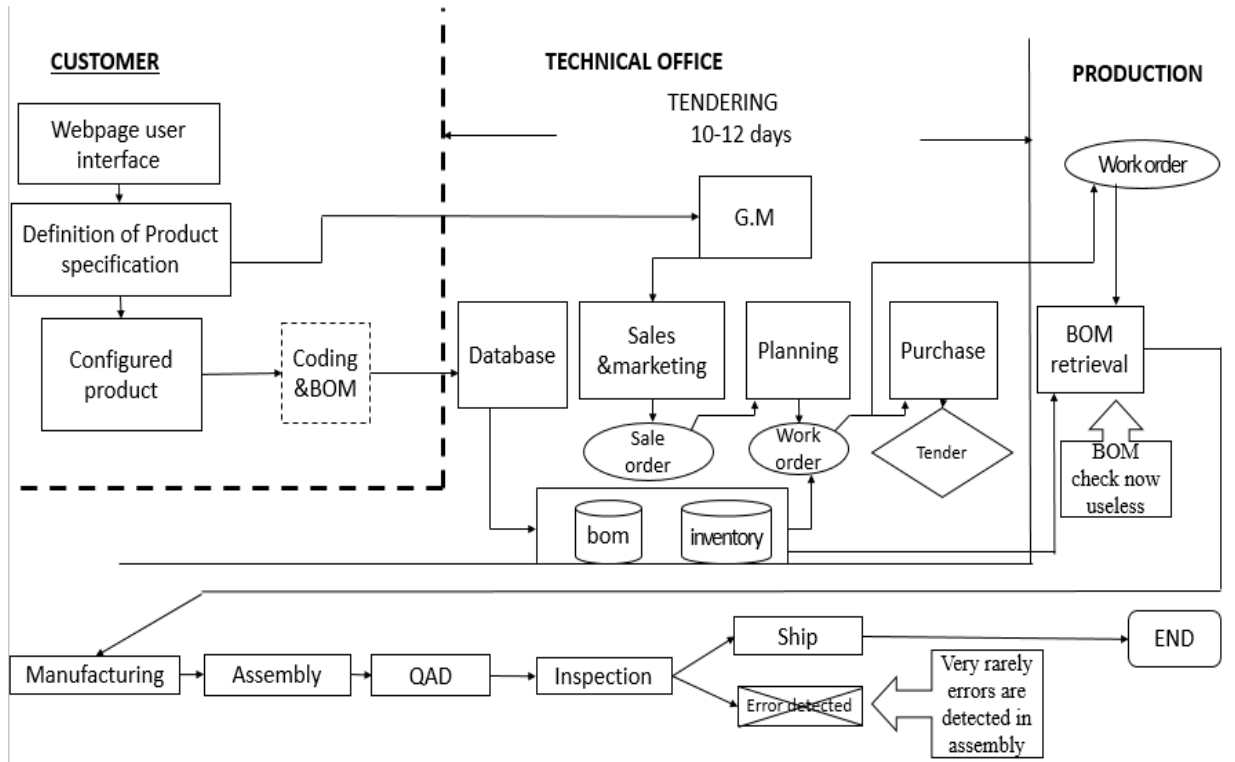

Fig.6.1. Product configuration-related activities after the implementation of product configuration system

By studying the changes in the company's operational processes one the product configuration system was up and running, it emerged that these implications affect both the company and the co-ordination between the company and its customers (Fig. 6.1). As the company internal processes are affected, the implementation of the product configuration software resulted into two different kinds of advantages:

• Reduction of manned activities in the tendering process (tendering lead-time from 20-25 to 10-12 days)
• Increase in the level of correctness of product information (almost 100%).

Concerning the reduction of manned activities in the tendering process this is due to consequence of the presence of product configured models that automatically generate product information like components lists in grouped manner. Especially in the case of custom products, the coding as well as BOM are disappear that means it is replaced by database that including codes and BOM and required quantities. Also the improve level of correctness of product information removes the need to perform certain control activities, such as the product code and product specifications fit check in the tendering process or the BOM check before production starts. In practical situation since these activities were often bypassed because of rush, then the more correct product information results in fewer errors to be detected in the assembly phase and consequently in greater delivery timeliness.

Customer entering the order details to the organization through web interface. Purchase order is the scanned copy that from the officials of the customer, it is not avoided. But in the use of webpage interface system product order details are get earlier than the present situation.sales&marketing department and planning department are get time for preparation time for developing the sale order and work order details. When official scanned copy of purchase order are getting, sale order are prepared normally in 2-3 days. And click summit to planning departments works are starts earlier than the present situation. Product configuration is help to prepare the work order much easier than the present condition it take 5-10 days with the use of interface because manned activities are reduced for transferring the data .after click to submit to next department ,information regarding the orders are transferred. Purchase department check overall inventory status and reply to management and submit to the next section.it is the most time consuming section of the organization. Product configuration more useful in this section .purchasing process much easy with the help of product configuration. Work orders are transfer to production department. There may occur some issues regarding the work order details with technical offices. Product configuration with BOM and codes of components are helpful to reduce the issues. Overall management process up to order tendering process to reduce to 10-12 days without including the manned activities. Effective database is reducing the error in the assembly phase. Fault components are avoided with the help of efficient database data because it can modify, delete and improve data.Also inter-organizational processes connecting the

company with its customers are affected by the implementation of product configuration systems. In fact, customers accept the product configuration software established by the firm through the MYSQL, then product coding, specification description and product details are all expressed using the conventions set out by the company. This in turn would reduce the final distortions in the company and customer communication channel reducing the chance of delivering a product that does not conform to the customer wants. At the same time through the help of product configuration software the company drives the customer to order objects that fall into its normalized product range. In fact the software tells the customer when he/she is defining specifications that fall out of the normalized product range and that, therefore, are likely to require longer lead-times and/or increased costs. Reducing the incidence of products out of the normalized range allows for greater efficiency in production.

However, this project work proposes that the effects of product configuration software implementation help to propagate to parts of the company not directly involved in this implementation, such as the production department. Moreover, this case study reveals that the changes in the workflow affected by the implementation of a product configurator are not essentially confined within the company boundaries, as they can affect also the customer's organizations. The product configurator therefore can be seen as an instrument that does not just increase internal working practices, but that increases inter-firm co-ordination by aligning working practices between the firms involved in the bidding–tendering process. Finally, product configurators may present to customers a configuration discussion that drives them, as far as possible, towards the specification of product variants that tend to require a low content of really custom product features, improving the company's operational efficiency.Ovreall about 50-55%decresre in no of days up to tendering process.

VII. CONCLUSION

Product configuration is effective task to handle the customer needs in the industry having wide variety of demand. Customer demand are flexible so that production system and product are flexible to meet the flexibility in demand. Product configuration is done based on the customer demand coming to this alternator manufacturing company .common components of various types of alternators are grouped and remaining components are separately grouped. Database is created with the basis of this product structure .database is created using MySQL software. This database is interfaced with user using PHP language. PHP and MySQL are open free software for data base management sytem.by creating a webpage interface for user, can interact and organization after the approval of the organization. All department get data of order of the product in a line after get the approval from the previous section. Database created based on the components of various types of alternators are linked with all departments. Currently transfer of order information from one department to next by workers that means any delay due to involvement by human is because delay in transferring information consequently delay in all process in the industry. This is the main imitation for the development of webpage interface, so that order details are get all departments before getting printed data record. Product configuration flexible for individual and bulk orders. This information is get earlier in all department especially in purchase departments .they can check the inventory levels are sufficient or not for an individual or bulk orders. If the inventory levels are sufficient for small quantities it is proceed at first and required quantities of components are listed for purchasing .production department get the approval through the web interface they can set the machines for production. That means the information flow is automated thereby reducing the human interaction .by introducing the software supported webpage for, individual as well as other companies directly interact with the company. Customer can't order the items directly. Firstly register and waiting for the approval of from organization. Customer can check the status of their orders directly. Computer controlled interface is very webpage very useful to present situation of the industry through automating the information flow and data are recorded on the computer. Flexible orders can handle with flexible database.

REFERENCES

1. Philipp Holtewert, Thomas Bauernhansla," Optimal configuration of manufacturing cells for high flexibility and cost reduction by component substitution", 48th CIRP Conference on manufacturing systems - CIRP CMS 2015, Vol. 41,pp .111-116,2016.
2. C.Forza, F. Salvador," Product configuration and inter-firm co-ordination: an innovative solution from a small manufacturing enterprise", Computers in Industry, Vol.49, pp.39-46, 2002.
3. Fabrizio Salvador, Aravind chandrashekaran, Tashfeen Sohail,"Product configuration, ambidexterity and firm performance in the context of industrial equipment manufacturing", Journal of Operations Management,Vol.32,pp.138-153,2012.
4. Zhaoxun Chen, Liya Wang," Personalized product configuration rules with dual formulations: A method to proactively leverage mass confusion", Expert Systems with Applications, Vol.37, pp.383-392, 2010,
5. S. D. Rajan, M. A. Bhatti," On designing a database management system for a computer-aided engineering software system", Computers & Structures, Vol.21 (5), pp.1047-1057, 1984.
6. Faizul Huq, Mahesh Kurpad, M.K.Raja," The use of relational database management Systems (DBMS) for information retrieval in a group technology (GT) environment",Computers&Industrial Engineering,Vol.26(2),pp.253-266,1993.
7. Sahithi Tummalapalli,Venkata rao Machavarapu," Managing MySQL Cluster Data using Cloudera Impala", International Conference on Computational Modelling and Security (CMS 2016),Vol.85,pp.463-474,2016.
8. Dimas Gilang Saputra, Fazat Nur Azizah,"A Metadata Approach for Building Web Application User Interface", The 4th International Conference on Electrical Engineering and Informatics (ICEEI 2013),Vol.11.pp.903-911,2013.
9. Venkatachalam Senthilkumar, Koshy Varghese, Ajai Chandran," A web-based system for design interface management of construction projects", Automation in Construction, Vol.19, pp.197-212, 2010.
10. Jun-Rong Chen, Yong-Feng Lin, Jason Jen-Yen Chen," Component-based Web page management environment", Information Sciences, Vol.176, pp.628-639,2006.