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Web Based Direct Digital Manufacturing

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Abstract:- The goal of direct digital manufacturing is to provide the manufacturing and service community with solutions to design, validate, analysis, monitor and control (DVAMC) using web based system by introducing new information and communication technology (ICT) to manufacture the components designed by customers towards build-to-order production. The scope of Digital Manufacturing has evolved recently to include Computer Aided Design (CAD); Computer Aided Engineering (CAE); a Manufacturing Data Base which contains product data, process data, manufacturing resources; Direct Digital Manufacturing is a 2D computer environment. This paper will discuss integration of several stages involved in the design and manufacturing of bioengineering products. The main objective of this paper is to design and manufacture the customized dental implant for permanent tooth in case of tooth loss. The process involves customer as a designer to manufacture his/her own idea for customization of dental implants. The direct digital manufacturing methodology reduces material, less MLT, foster design, shorter time to market and customization. Further the 2D data of design information can be of 3D data for the customized products.

Keywords:- CAD, CAE, digital manufacturing, implant and web based system.

I. INTRODUCTION

The dental implants available in the market are of standard design, which may or may not be suitable for all the patient of tooth loss. There are many variables to be considered for the manufacturing of dental implants viz: jaw size, type of tooth, age factor, sex, etc., presently the doctors are using trail and error method by viewing the x-ray of tooth and matching the implants with patients tooth x-ray and with their clinical experience operate/insert the implant. This may lead to many problems like drilling of more diameter and depth hole than required, oversize implant for small tooth space, Loose Implants Due to Insufficient Bone Mass, Implant Breakage, etc.

By considering the above variables and to avoid the mentioned problems a methodology is developed using direct digital manufacturing for design, validate analysis, monitor and control of dental implants using CAD, CAE and ICT.

Today the design and development of dental implant is carried out with the help of team involving the customer as a designer (Dentist), the experts, engineers, manufactures and all stake holders to share ideas to match the exact requirements with accuracy in turn satisfies the need of customers (digital factory paper ref). Initially the inputs from the dentist as requirements is considered and based on the input the design and analysis is carried out and an opinion is taken from the expert before manufacturing, everything happens off-line. This approach reduces time and cost makes the design and development process more reliable compare to trial and error method. Similarly methods are created by shortening the process to carry out the task simultaneously.

Manufacturing nothing but conversion of raw material into usable products during this conversion various processes, methodology and technology is used. Usually manufacturing means removal of material (Subtractive Process) to get the final finished usable product. In this paper an direct digital manufacturing (Additive Process) is the process of going directly from an electronic, digital representation of a part to the final product via additive manufacturing is one of such methods using ICT. Digital manufacturing has been considered as a highly promising set of technologies for reducing product development times and cost as well as for addressing the need for customization, increased product quality, and faster response to the market.

Dental Implant / Tooth implants are dental devices that have been designed to substitute for individual missing tooth. They function as an artificial tooth root, on top of which some type of dental prosthesis (a dental crown, bridge or denture) can then be placed.

II. CAD,CAE, ICT AND MANUFACTURING

Computer-aided design (CAD) refers to the use of computers in converting the initial idea for a product into an engineering design. The evolution of a design typically involves the creation of geometric models of the product, which can be manipulated, analysed, and refined. In CAD, computer graphics replace the sketches and engineering drawings traditionally used to visualize products and communicate design information.

Computer programs are used to estimate the performance and cost of design prototypes and to calculate the optimal values for design parameters. These programs supplement and extend traditional hand calculations and physical tests. When combined with CAD, these automated analysis and optimization capabilities are called computer-aided engineering (CAE).

Manufacturing is being revolutionised through the application of information and communication technologies. For example, processes can be optimised through advancements in software architectures integrated with novel sensors or devices, knowledge management, visualisation and modelling.

As advanced manufacturing is intelligent, networked and knowledge intensive, any proposal addressing this priority should aim to produce individuals with both a broad awareness of the relevant challenges, and with deep technical knowledge of areas in ICT. This will enable them to recognise where ICT solutions could bring benefit.

ICT applied to manufacturing often requires integration of both hardware and software to create effective solutions or advances. Any proposal addressing this priority should show how it will provide opportunities for individuals to gain the depth of knowledge required to provide whole system improvements.

III. METHODOLOGY

The methodology describes the stages that are design, validate, analysis, monitor and control for manufacturing of dental implant.

Design: design that is optimised for DOC at a configuration level and then investigated for manufacturability at a more detailed level, to include assembly, planning and the provision for all relevant data necessary for subsequent stages in the production.

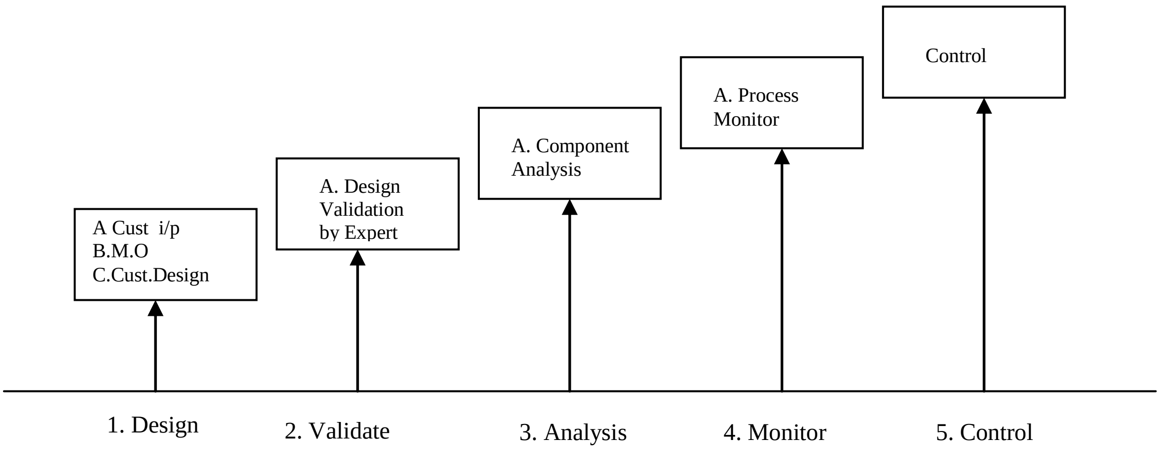

Fig. 1: Step by step procedure in direct digital manufacturing

A. Design

1) Customer Input: Customer initially enters into the website, immediately he will observe the different component display then he will pick his requirement (particular component as customer input) say dental implant retaining bolt, after making selection he will enter into super role mode there he suppose to register himself by entering different details like login name, password, Name of the customer, Email_id, city, country and contact number and post the details that completes the registration of the customer, this detail will go to company database, then he can enter into super role environment by submitting username and password, thereafter he can start interacting with the manufacturing company.

once the registration is done he can enter into the super role environment there he will get the display of different dimensional fields along with 2D model of retaining bolt, there he suppose to enter all fields (Customer Inputs) search for available components, after selecting the required component through web portal and the required component is sent to manufacturer for confirmation.

2) Manufacturer Opinion: Manufacturer will receive the request from customer and check for the feasibility of manufacturing the component by discussing with the experts in the department, and then inform the opinion as the component can be manufactured, i.e., confirming order acceptance to the customer.

3) Customer Design: Once he receives the opinion from the manufacturer he starts designing the component according to his own requirements i.e., by entering the dimensions in the template designed using algorithm. In turn generates 2D part to be manufactured which is to the scale ratio of 1:1 and submitted. The data can be viewed simultaneously by all the stalk holders of the manufacturing and further it is sent to design validation.

B. Validate

Design Validation by Design and CAD Experts: Manufacturer receives the component design from the customer then the same detail is sent to design expert to check the design feasibility and to validate the same. Expert will check the component for design feasibility, if everything is correct then the component is validated for further process. If not he will go back to customer with some remarks for customer clarification, this process will continue till the component is correct, simultaneously or after the opinion of design expert the component is validated by CAD expert regarding CAD feasibility like checking the facility of importing and exporting of data from one platform to another to carry out the manufacturing activity so on then he gives his opinion.

C. Analysis

Component Analysis: Analysis is carried out on the designed component to check its behaviour under different working conditions. For example to determine bite force and its effect on the component and so on based on the practical conditions.

D. Monitor

Process Monitor: Customer and all stalk holders in the team will have liberty and facility to watch all the activities taking place in the manufacturing process and they can monitor the entire process continuously. The process is carried out in different phases; all the stalk holders can keep track of the different phases of the process. The concept of different phases that are taking place in the entire process is as given in the (Process flow chart) figure 2; here colour coding is done to help the stalk holders to keep track of different phases of manufacturing process. The colour codes used in the process are RED, YELLOW and GREEN.

RED: Indicates the phase in the process is not yet begun. (No activity taking place)
YELLOW: Indicates the particular phase is under progress.
GREEN: Indicates the phase is completed.

Initially the entire flow chart will be in RED colour which indicates no activity is taking place in the process, as the process proceeds each phase will turn into YELLOW and GREEN colour respectively at the end of the process the complete chart will be in GREEN colour, the stalk holders will keep track of each phase by looking at the flow chart and monitor the entire process. The phases involved in the manufacturing process are Start phase, Order phase, Expert advice phase, Manufacturing phase, Assembly phase and Dispatch phase.

E. Control

Generally there will be dimensional and other errors in the component and process due to only manufacturer involvement, where as here dimensional and other errors are very less because the dimensions are decided and entered by customer itself and before manufacturing expert's advice is collected and finalized. The entire process is continuously monitored by all other team members hence there will be very less room for errors.
All the above stages are carried out in different steps are as shown in Figure 2.

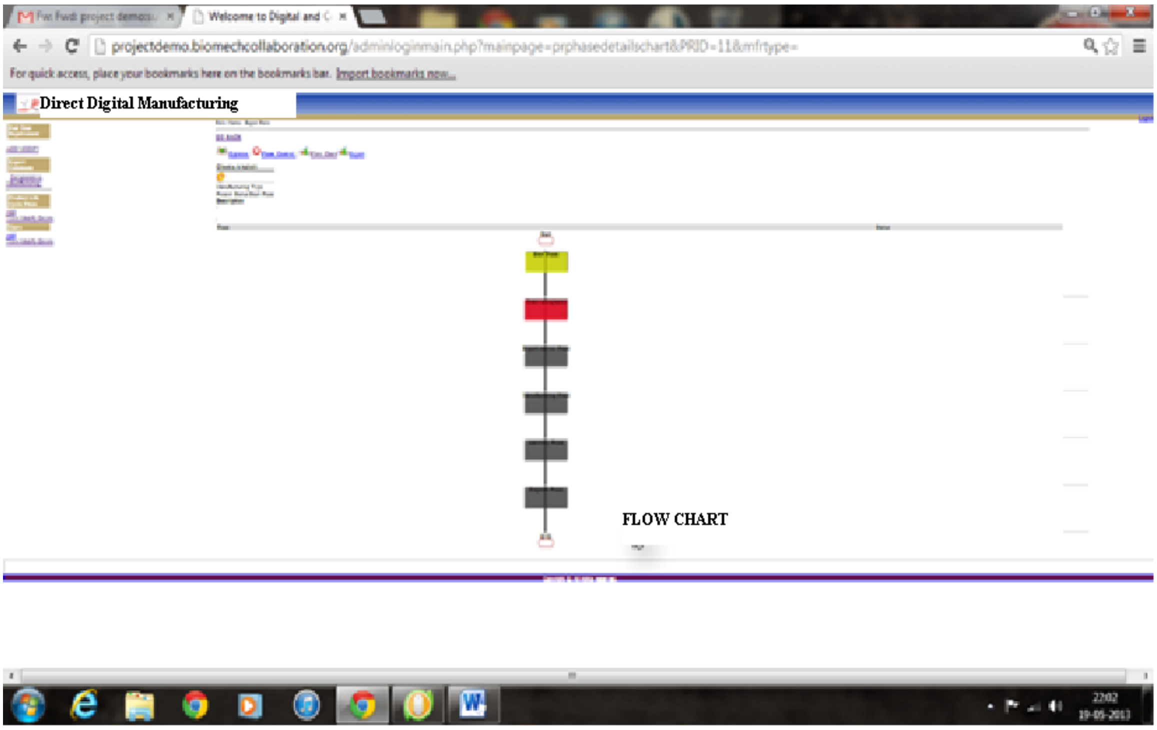

Fig. 2: Flow chart in direct digital manufacturing

The Implant Retaining Bolt for Dental application as shown in figure 3, is the case to build in additive manufacturing using tools and ICT in digital manufacturing

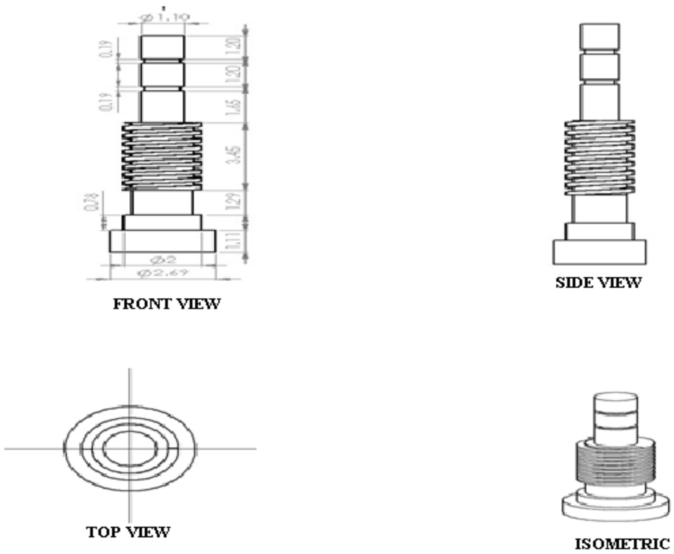

Fig. 3: Component Required to Manufacture

Different Roles in the Manufacturing Process

This Process involves: Super role: Admin of the manufacturing company. General Role: The client/customer.

Expert Role: He is the adviser of the company. Manufacturer Role: Manufacturing the component according to the customer requirement based on expert opinion.

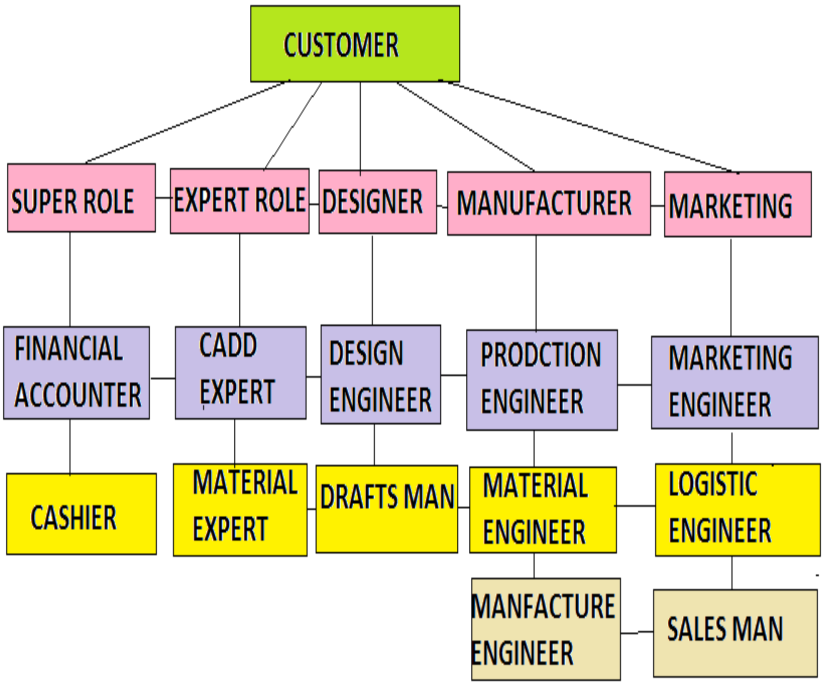

Fig. 4: Process Chart

STAGE I : SUPER ROLE : In super role usually the owner of the company/system administrator will lead the manufacturing and main decision making on-line as show below.

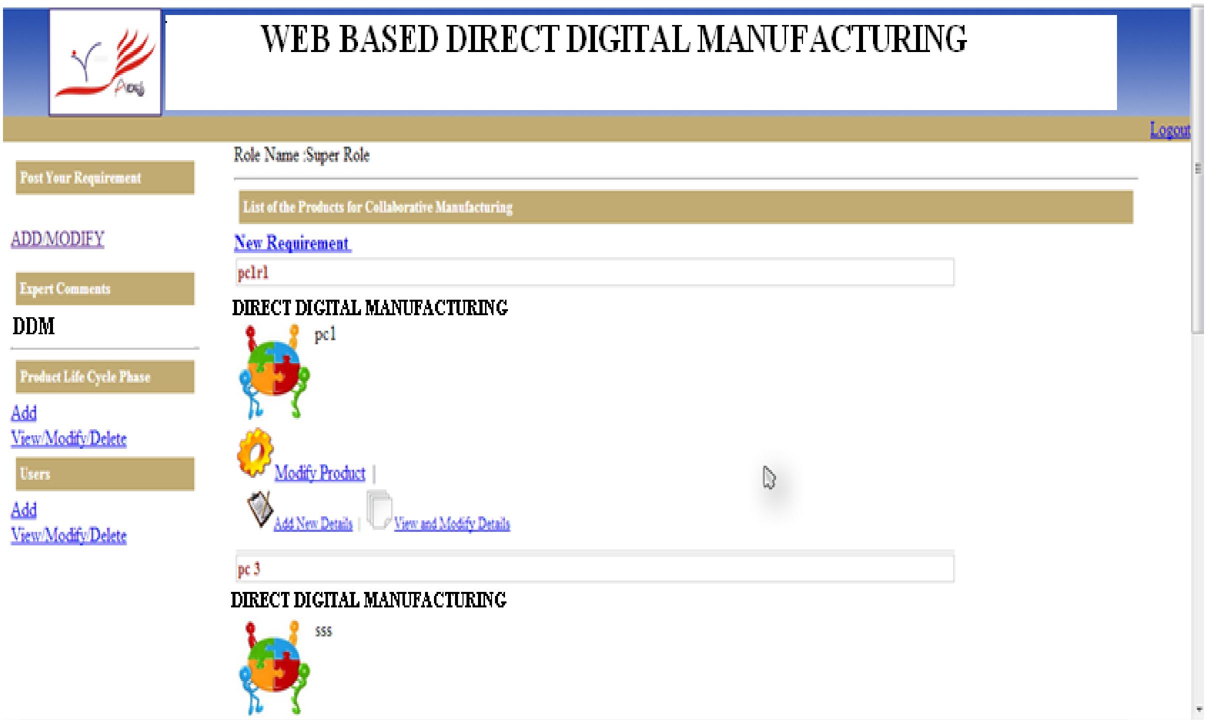

Fig. 5: Home Page of Web site (Here customer can select the component as new user requirement)

STAGE II: GENERAL ROLE (CUSTOMER)

CUSTOMER REGISTRATION: To initiate the digital manufacturing the customer (Doctor) have to login in the web site as shown below

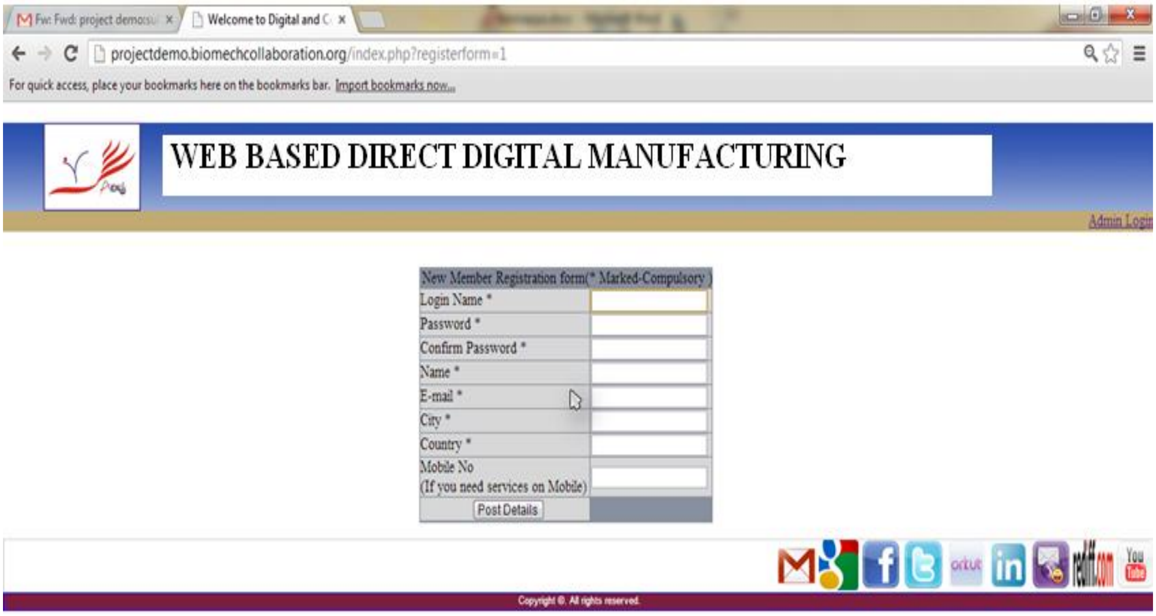

Fig. 6: New Customer Registration Form (After getting opinion from the company he can register

CUSTOMER DESIGN: Once the customer is registered, the customer can give input for manufacturing of implant as show below.

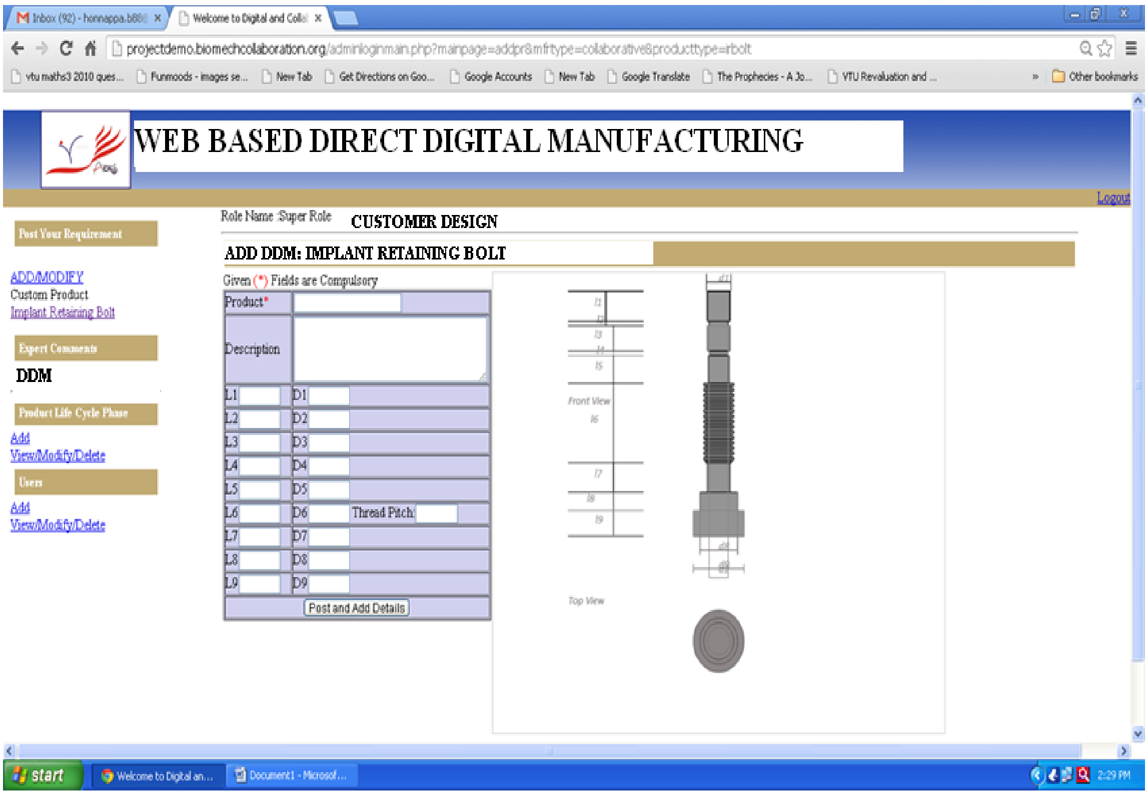

Fig. 7: Customer Design Page

STAGE III: EXPERT ROLE: The technical expert will decide to manufacturing or redesign the product based on the suggestion the CAD engineer / Manufacturer will manufacture the product as shown in the figure 8. The sequence can be view by super role and also the customer and also they can track the product.

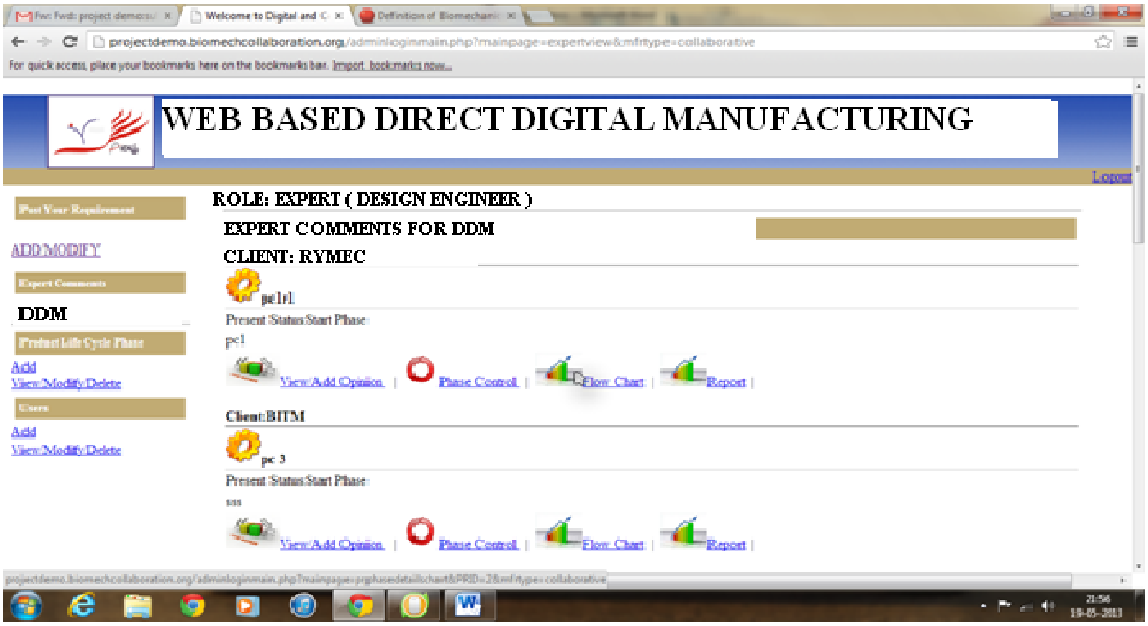

Fig. 8: Expert Opinion (Here design engineer similarly CAD engineer will give their opinion)

STAGE IV: MANUFACTURER: Based on the information and suggestion from the expert the manufacture will manufacture the product and is as shown below.

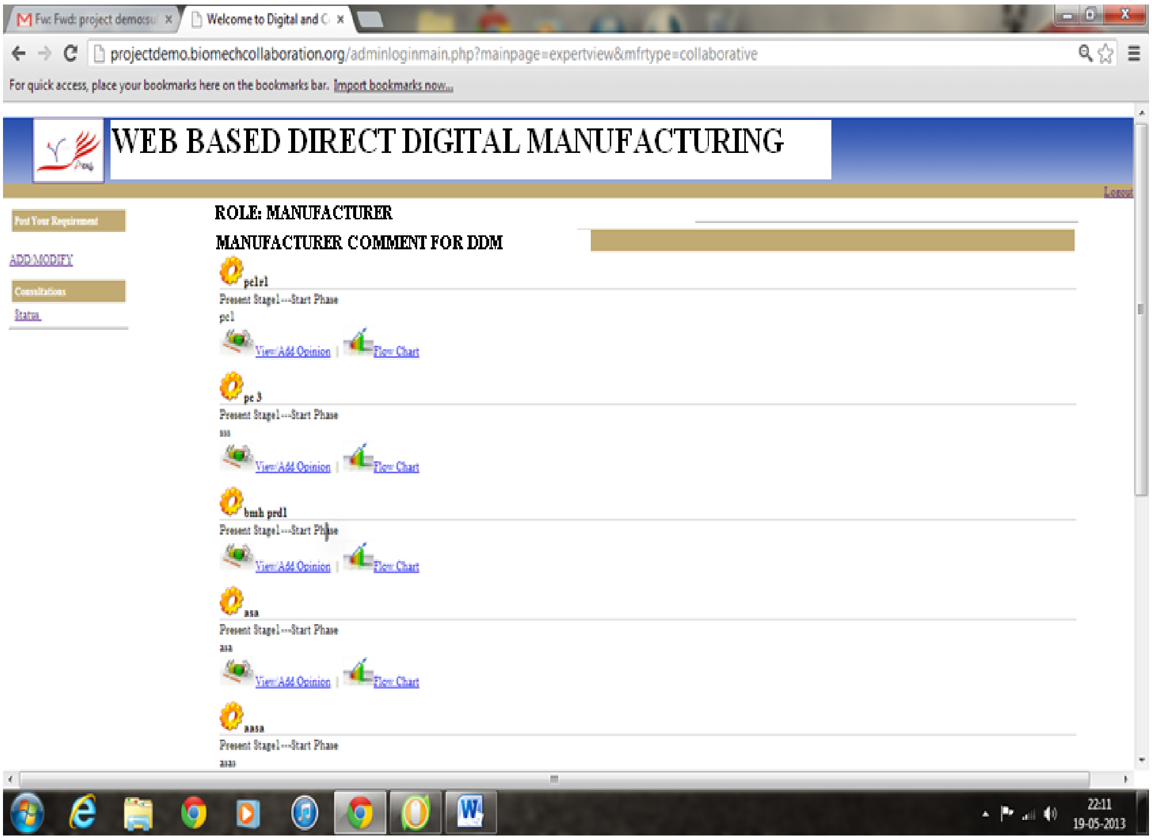

Fig. 9: Manufacture opinion page

TO VIEW USER'S LIST: The super role can also have a check of all the customer and track the product and also can verify the product is in which phase so that to speed up the process or delay as per customer requirement, flexibility is give to customer is as shown below. Finally the customized product is manufactured and dispatched to the customer.

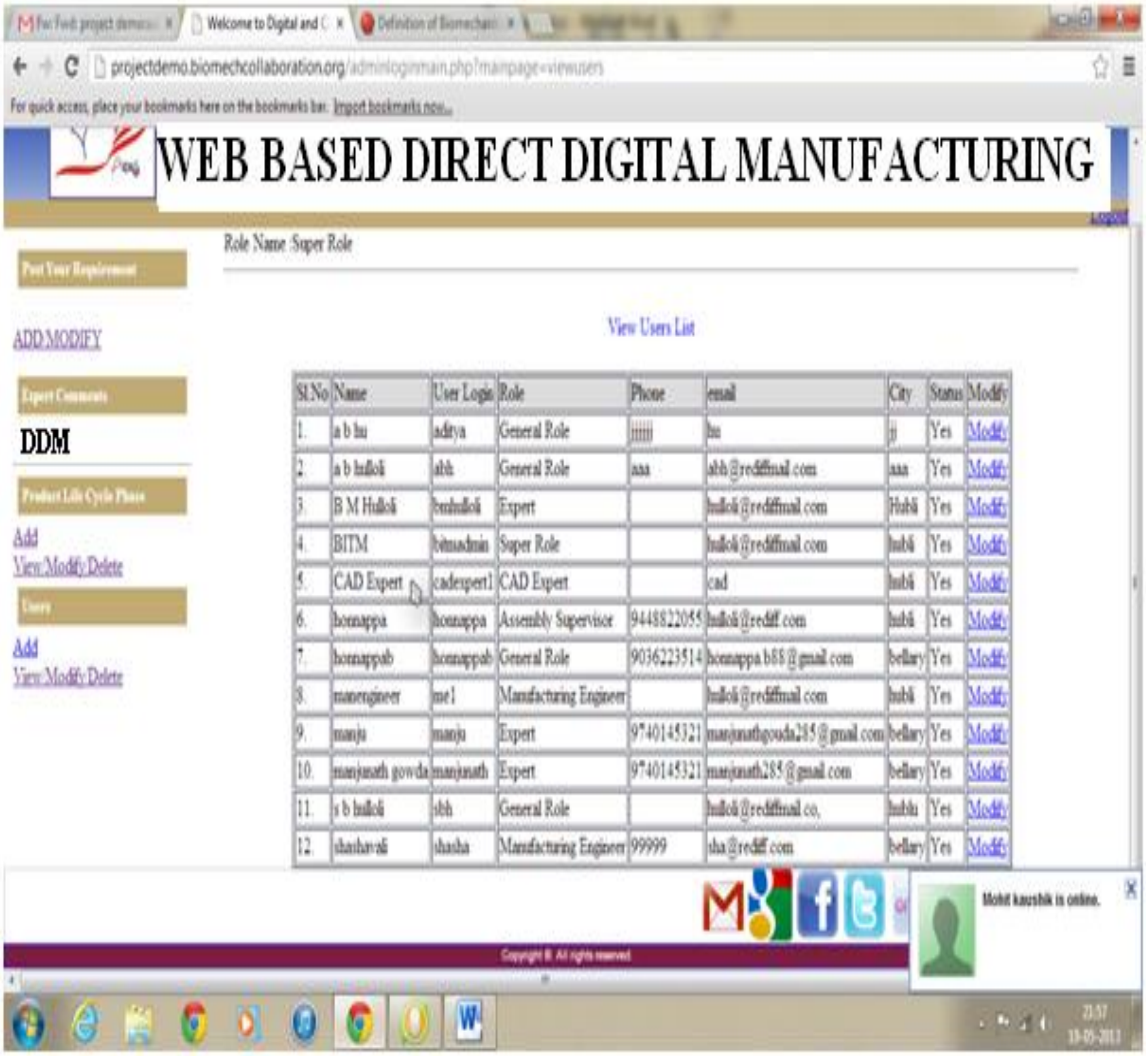

Fig. 10: List of Users (Here we can see list of user's)

IV. RESULTS AND DISCUSSION

There are many advantages of using web based DDM system in any manufacturing industries. This system emphasizes the integration of the software tools and the resources of involved in the manufacturing system to integrate the geographically dispersed manufacturing teams and the customers. This environment will convert the customer into a designer for their products to achieve customization in the design. The distributed environment is highly heterogeneous, where different resources are distributed and not centralized in one location and groups within and outside the company work together with help of web facility. Apart from this the advantages can also include productivity, material can be saved considerably, quick response to the customer, reduced manufacturing lead time and other times also, quality, integration, new product development, reduction of errors, improved flexibility, continuous product tracking, easy cost estimation, design and manufacturing of product according to the customer perspective, easy copy rights and patents because of the proper documentation, this documentation helps new customers and others as a training material.

Based on some of the identified characteristics of web based DDM, Table 1 presents the advantages of web based DDM compared to conventional manufacturing.

Table 1: Advantages of Web Based DDM Compared to Conventional Manufacturing.

Characteristics	Conventional Manufacturing	Web based DDM
Software requirement	Manual Design or some specific design softwares are required to design the product	No specific design software is required because of standard templates are designed using algorithms
Product Design	Expert design engineer has to design the component.	Customer can design the component
Facility	Some of the activities are off-line	All the activities are on-line
Software skills	Designer has to learn design soft wares and procedures.	No need to learn any design software and procedures
Integration of resources	Centralized integration	Dispersed integration.
Scrap rate	High	No scrap
Order time	High	Low
Manufacturing time	High	Low
Response	Delayed	Quick
Correspondence	Limited because of non-availability of complete data and information about physical product	High because of availability of complete data
Process traceability	Risk of wasting time and energy Since no online tracking facility	Easy to trace because of online tracking facility
Security	Less security and difficulty in tracking the activities	Highly secured since each user is provided with login and password
Cost estimation	Complex	Simple
Education and Training	Difficulty in presentation of product data/company portfolio	Product data and information can be retrieved easily at any point of time

V. CONCLUSIONS

The typical case of dentistry with recent tools and strategies with the application of collaborative Digital Manufacturing are discussed in the paper. The paper is an outcome of the real synergy and collaborative research between Engineers and dental Doctors. The work provides the customer (Doctor) in this case is designer to manufacture his/her own idea for customization of dental implants which suits the patient instead of using the standard commercial dental implants available in the market. The digital manufacturing methodology reduces lot of risk and can manufacture customized dental implants. In a nutshell, the paper emphasizes the need of integration of engineers practicing doctors for a much better, long awaiting productive treatments with the proper application of the presently available tools and ICT for manufacturing of dental implants.

Finally the authors conclude that in addition to the usage of tools and ICT, the doctors are designers for patient dental implants and also no need of CAD engineer to develop 2D and 3D models of the dental implants.

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