Comprehensive Review of Web-Based Manufacturing

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Abstract **- Web based manufacturing enables the implementation of the manufacturing process remotely. This paper explores the different possibilities of web based manufacturing. The integration of new age tools like Additive manufacturing, Simulation analysis, Computer-Aided Design etc. along with the scope of ERP (Enterprise Resource Planning) software in the integration of various stages of product development processes is also explored. All the digital tools that digitize the manufacturing processes have their own limitations. Hence some novel ideas evolved to tackle problems pertaining to accessing design and design platforms to make manufacturing more seamless. Case studies are provided to clearly demonstrate the application of web based manufacturing.**

Index Terms **- Web based manufacturing, ERP, CAM (Computer Aided Manufacturing), CAD (Computer Aided Design), Additive manufacturing.**

1.INTRODUCTION

A lot of companies outsource manufacturing when they themselves don't have the capabilities to manufacture. Also, Outsourcing parts of the production line to a third party in a lower cost location leads to a significant decrease in production costs. Outsourcing production allows companies to focus on what they do best, rather than worry about tasks that are mundane and non-essential. Considering all these advantages it becomes important to optimize the process of lending a manufacturing process at a different place. Along with the many advantages discussed, there are many difficulties associated with manufacturing at a different place like time taken to place an order, monitoring the production process at the outsourcing location, time taken to complete the order etc.

It would be fairly easy and convenient if a customer or a business was able to carry out the entire manufacturing process virtually. This would save a lot of money and time. Over the years, research has been done on how remote manufacturing process should be designed and also how to make it accessible using internet. This is where words like web based manufacturing, digital manufacturing and e-manufacturing come into the picture. Whatever may be the term, but the sole purpose is to digitize the outsourcing process, to improve productivity and customer satisfaction. While some emphasis on the application of additive manufacturing and simulation soft-wares in a production process, others have developed entirely new web-based software to realize the possibilities of remote manufacturing in the name of Web-Based manufacturing.

In Web-Based manufacturing process ERP (Enterprise Resource Planning) software was integrated with CAD, CAPP and CAM, which is called the Web based system [1], to streamline the entire process of remote manufacturing. Since, installing ERP software for placing orders is an arduous process, the Web based system was designed in such a way that a customer can access every feature on the browser using internet. This study provides a comprehensive review of all these developments in a detailed manner to show the capabilities of web based manufacturing.

2. LITERATURE SURVEY

A lot of research went into developing web-based systems and other applications to tackle the process of integrating production processes. Collaborative workflow technology for design and manufacturing coordination [2] developed by Qi Hao,Weiming Shen to streamline the flow of information between engineering and manufacturing departments. The research provides tools to negate the ambiguity that arises due to collaborative design and manufacturing. Taking it a step further, David Latch and Zimring [3] discuss collaborative design and the role of different modes of communication. An asynchronous collaborative system, named the Immersive

Discussion Tool (IDT), was used as a medium to support productive design exchanges. This tool allows the stakeholders to interact with the 3-D model over the internet, making this an invaluable contribution towards web based design tools.

The exiting research area of web based collaborative design tools comes with its own set of challenges and opportunities. The work of Weiming Shen, Lihui Wang on Web-based and agent-based approaches for collaborative product design [4] sheds light on many new challenges that arise from adopting these systems. Another internet based collaborative product design from N.Shyamsundar and Rajit Gadh taked [5] into account the constraints provided by limited bandwidth of internet while transferring CAD based assembly models. This work takes a unique way of utilizing polygonized representations for collaborative design. Here, the AREP and a prototypical system (cPAD) was utilized to perform real-time geometric modification.

A virtual manufacturing system for tool-making companies [6] by Mihael Debevec, Perme T, & Diego Noe focuses on small and medium sized companies for not only reducing production costs but also to efficiently plan the production process. While talking about improving the production process, the role of simulation-based analysis seems very valuable.

Manufacturing process analysis with support of workflow modelling and simulation Huiping Lin, Y Fan, Stephen Newman [7] proposes a compound workflow model (CWM) to provide graphic presentation of the production process which was used directly by simulation to study the impacts of scheduling policy and to analyse the performance of the process and to identify drivers for improvement.

3.DEVELOPMENTS IN WEB BASED MANUFACTURING

3.1 Impact of Digital manufacturing in Sheet Hydro-forming:

Imagine a new sheet metal part order is received. Then immediately the supplied CAD data and material specifications are uploaded into the simulation software. In the next couple of hours the engineers develop the design, simulate and refine the tool design, flat pattern design and forming process variables [8]. Also to address the tendency of wear and tear the tool radius is modified and the pressure required to prevent wrinkles is identified.

All this occurs before manufacturing a single tool or single flat pattern. So within couple of hours the engineers are ready to make the tool and cut the engineered blanks. Engineers export the tool design generated within the simulation software to an in-house 3D printer.

The printer goes to work, building up the tooling layer-by-layer with high-performance material designed to withstand the intense forming pressures associated with sheet hydroforming. The print job continues through the night via lights out manufacturing, and is ready for work by the time the operator returns to the plant the next morning.

Time to load the tool and blank and then, program the forming procedure: You cycle the press with confidence; since the tool and blank designs were optimized during simulation perform as planned.

After a fast 8-sec press cycle the fully formed part can be removed. By morning the part is ready to be shipped to the customer. All this is possible in short span due to Digital Manufacturing [8]. Here, the integration of simulation to design the tool and additive manufacturing makes the process an example of digital manufacturing as shown in figure 1.

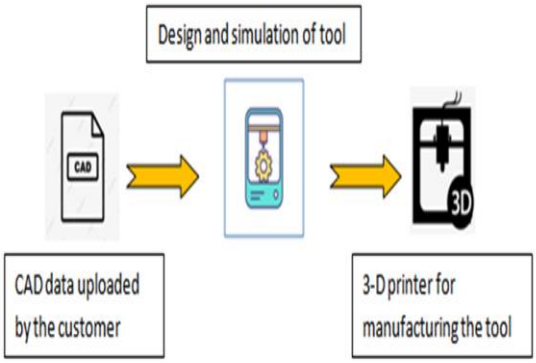

Fig 1: Digital manufacturing

3.1. 1 Simulation tools

Forming-simulation software has fundamentally altered the engineering process, allowing users to predict a host of real-world scenarios that in turn influence and improve part and die design. The ability to simulate the forming process virtually, with confidence that the simulated result will closely mirror the actual forming result, has become an indispensable tool for many. Fig 2 shows the simulation software in action.

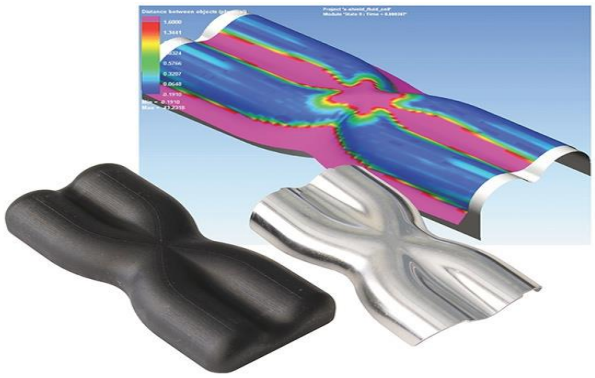

Fig 2: Analysis of design using Forming-simulation software

Users input into the software standard CAD data, properties of the material being formed and the forming strategy, including drawing, stamping, bending, sheet hydroforming and others.

In addition to lowering costs by eliminating immature form blocks and flat patterns from the scrap bin, forming-simulation software also can aid the part-quoting process.

3.1.2 Additive manufacturing:

Facilities with access to forming-simulation software and 3D-printing technology can leverage the tool geometry, refined during the simulation process, for use in their 3D printer. The CAD data transfers wirelessly to the 3D printer, which converts the digital data into a three-dimensional object—layer-by-layer as shown in figure 3. Specific to additive-manufactured tooling for use in sheet-hydroforming operations, recent advances in print materials and processes have resulted in durable tooling able to withstand high forming pressures.

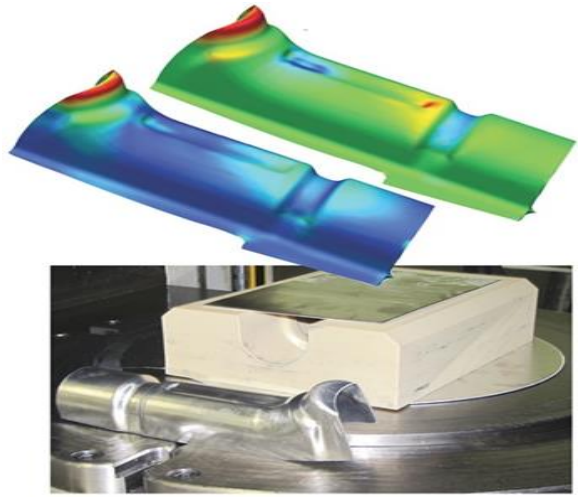

Fig 3: Manufacturing of tool using 3-D printer

While tool life hinges on several factors, including the 3D-printing medium, forming material and forming pressure, tools commonly last for hundreds of cycles before showing signs of wear. Dimensional accuracy reaches ±0.005 in. The advantages associated with 3D-printed tooling revolve primarily around savings in cost and time. Additional benefits include lighter, more ergonomic tools that improve operator safety.Companies with 3D-printing capabilities can bypass their machining departments and send the tool geometry direct to the printerAnd, with virtually no limit to the geometries that can be produced, 3D printing allows for on-the-fly implementation of design improvements. Secondary tooling, such as drill and trim tools, as well as check fixtures also can be eliminated.

3.2 Transforming management of manufacturing using web based ERP:

ERP brings with it a lot of features:

1. Placing an order.
2. Receiving quotation and production planning.
3. Making payments and receiving invoice (instead of using email).
4. Tracking the production process in real time and viewing status.

The ERP system is developed for the web, thus allowing customers to input its orders of parts anywhere, without having the equipment and software for carrying out the product development cycle. The methodology also allows the company employees to connect remotely to the system and perform activities from any place.

CASE STUDY:

3.2.1 Rapid prototyping (RP) using web based manufacturing (ERP):

Two basic characteristics that make Rapid Prototyping suitable to e-manufacturing:

1) The main input is a solid model part in an STL file format or by reversing engineering techniques.

2) Additive manufacturing which is highly automated without any specific tooling.

Thus, it is possible to model the part or tooling in one location and get the part automatically fabricated in another location by sending the data information of the model through the Internet facility [9].

3.2.1.1 Procedure for Rapid Prototyping using Web based manufacturing:

1. Access the ERP using on browser and send the STL file of the pattern of the model to be manufactured.
2. The STL file is analyzed and errors such as tessellation errors, dangling edges and missing facets if any, are fixed.
3. Generation of quotation depending on the pattern volume.
4. Once the customer confirms the order, process planning is done automatically for the part.
5. The part manufacturing is done using Additive manufacturing, followed by post processing and finally for dispatch.
6. The related invoice and forms are generated automatically and forwarded by e-mail & then further forwarded for dispatch.

This is a simple model of web based manufacturing for Rapid prototyping where basic ERP functions such as accessing the STL file, receiving invoice, confirming order are done using a browser.

3.2.2 Web based manufacturing (A functional model):

This is a step further, where the design of the part to be produced is also integrated into the internet by creating CAD software (CyberCut) using Java [1].

The ERP Manufacturing is a web-based system, written in Java and Java-Server-Pages which enables the management of the entire process. The management is composed by: the control of user accesses through the internet, the integration with CAD/CAPP/CAM modules as shown in figure 4.

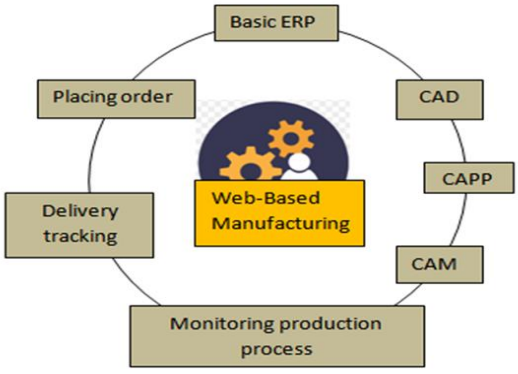

Fig 4: Web-Based Manufacturing system

The proposed methodology integrates engineering and manufacturing management through ERP software. The proposed methodology includes the development of an ERP system and the integration of this ERP system with the engineering module (CAD/ CAPP/ CAM).ERP software was developed in order to carry out manufacturing management, enabling the receipt of customer orders, management functions, CAD/CAPP/CAM integration, and part manufacture [1]. The Web based manufacturing process is carried out as shown in figure 5.

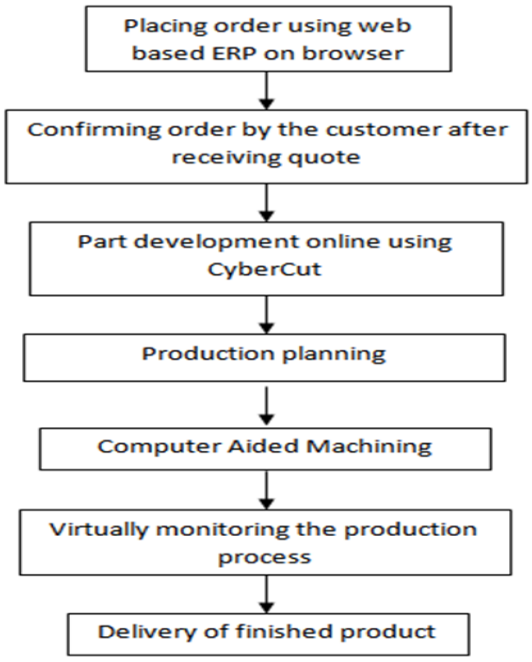

Fig 5: Web based manufacturing process

3.2.2.1 Different modules in the Web-based manufacturing system:

a) Basic module:

This is the part where the employees of the Company perform the administrative and operational activities of the company. The managers are responsible for registering new employees, excluding or modifying a register of an employee, modifying values of the production cost calculation of each shop floor, visualizing monthly profits and expenses.

Each shop floor has operators who have some functions, such as: registering suppliers, updating supply of tools, requesting the purchase of materials, registering monthly expenses, getting the daily production of the manufacturing system.

b) Commercial module:

After having access to the site of the virtual company, the customer enters the commercial module, registers, performs system log-in, and then the page with the customer menu is available. In this page the customer

can input a new work order, see the work order status, modify or cancel a work order and modify its registered data. This is the first stage in the production process of the company, and one of most important. It is in this stage that the customer registers information of the priority, the part type and the batch size.
Details pertaining to Priority, due date, process time, etc are also provided once the order is confirmed by the customer.

c) Cyber Cut module (part development):
In this interface the customer designs the part, which is then sent to the process planning
Module (Web CAPP)
The procedure begins in the collaborative modeling of a part using features in a context of remote manufacturing using tools like Cybercut. CyberCut is a web-based design-to-manufacturing system, developed by Brown and Wright, consisting of the following major components:
Computer-aided design software written in Java and embedded in a web page. This CAD software is based on the concept of destructive solid geometry (DSG); that is, by constraining the user to remove entities from a regularly shaped workpiece, the downstream manufacturing process for the part is inherently incorporated into the design.
This means that instead of building a part incrementally from "nothingness" (constructive geometry or CSG), the user starts out with a prismatic stock and remove primitives or chunks of material. Instead of allowing arbitrary removal, the user is only able to remove certain shapes of material, referred to as features. These features take the form of pockets, blind holes, through holes, and face-off operations. In addition, the user can only place features on one of the stock's original six faces. This design methodology is used to make the problem of process planning a solvable one [10].
With this software a remote user would be able to download a CAD file in some specified universal exchange format to the CyberCut server, which would in turn execute the necessary process planning and generate the appropriate NC code for milling.

d) Production planning module (CAP) and Execution:
The total production time of the work orders is calculated based on times of machining operations, available in the data base, and on the tools setup time. It is assumed that the shop floors are available sixteen hours a day, seven days a week.
The calculation of the minimum production time is made by analyzing the work orders in the data base. All work orders have a completion date, i.e., the date in which the manufacture will be concluded [1]. Every time the system has to preview when the work order will be completed, a search in the database is made to know the next date available to manufacturing the batch. The result of this search is shown to the customer, and he/she decides if it confirms or not the manufacture of the batch. The batch will only be scheduled for production if the customer confirms the production of the work order.
In this case, the parts that have the same tool characteristics are grouped into the same family. This prevents that a new setup of tools is made every time that a new part is processed.
The operators in each shop floor connect via the Internet with the web server and get the information about the work orders to be done in the day. The operators are responsible for controlling the pieces of equipment, and also for the production scheduling in the shop floor.
Each work order has an attribute called "status", which informs the system about the situation of the work order (i.e., "to produce", "in production", and "produced"). A Virtual Monitor provides the virtual monitoring of the workstations in real time.

4. CONCLUSION

While the application of Simulation software and Additive manufacturing in a production process saves a lot of time for both the customer and business, integrating every aspect of making a part from placing an order to delivery of the finished product using ERP is better. Rapid prototyping is an essential aspect of product development. With web based manufacturing using ERP the time taken to produce a finished prototype can be greatly reduced. Also it is important to note that Additive manufacturing is at the core of Rapid prototyping, as the process of manufacturing can be automated with its application.
The web based design to manufacture system named Cybercut is a great way to integrate Computer Aided Design and helps to automatically generate NC coding to carryout machining. But the only limitation here is that it constrains user to remove entities from a

regularly shaped workpiece. This type of downstream manufacturing process wouldn't be applicable for complex shapes. On the other hand, the ability to virtually monitor the manufacturing process enables customer confidence.

It is also observed that the capabilities of web based manufacturing can be greatly improved by overcoming the limitations caused by downstream manufacturing in Cybercut. Additionally, features like live tracking of product delivery in the web based ERP can further improve the experience of remote manufacturing.

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