Integrated CAD customization system for fused deposition models in additive manufacture with 3D printing machine

Achdianto¹, Sally Cahyati¹, Triyono¹ and Saifudin²

¹Department of Mechanical Engineering, Faculty of Industrial Technology, Universitas Trisakti, Jl.Kyai Tapa No.1 Grogol, Jakarta, Indonesia
²Department of Information Technology Engineering, Faculty of Industrial Technology, Universitas Trisakti, Jl.Kyai Tapa No.1 Grogol, Jakarta, Indonesia

E-mail: sally@trisakti.ac.id

Abstract: A computerized additive aided design based on manufacturing system that is digitally integrated, has been modified, built, and designed. The system refers to the smart manufacturing sectoral (smart manufacturing) which to answer the challenges of industrial revolution 4.0, namely the purpose for efficiency of the distance, cost efficiency, time efficiency, quality improvement and increased flexibility. The concept of manufacturing systems with fused deposition modelling 3D printers integrated with the internet or intranet has been modified, for the purpose to connected each other under one platform being namely as category as a Computer Aided Manufacture (CAM) system. A synthesis between the production room and the customer, real-time depiction of 3D CAD users can be presented and connected directly to the manufacturing locations where the desired product is located. Seeing this as an opportunity growing for the industrial society, the author conducted research to modified and collaborate the system. The method used in this study was carried out with rapid application design or better known as Rapid Application Development / RAD aimed at simplifying and accelerating the design of the system for 3D print web application system. CAD drawings can be processed from the user's device to the main webserver and then forwarded into the operator's production system space, resulting in a final product / finished goods, with no restrictions on distance, area and allows low production costs (low production costs). The results of this study represent the manufacturing industrial that is being supported by the application of information technology, where are manufacturing is connected with IoT (Internet of Things). Presenting the benefits of the Industry 4.0 concept. The customization system to be able to add value added for the competitiveness small and medium companies in Indonesia on manufacturing process and can support micro economic growth.

1. Introduction
The development of manufacturing sectoral lines is increasingly showing its latest innovations with each line by continuous improvement, taking various best steps. All improvements in existing processes are according to the kaizen principle has already been made by previous founder and researcher in Mechanical Engineering. An industry concept 4.0 is synonymous with the transformation of manufacturing activities into smart manufacturing, designed to meet and exceed current challenges. The application is carried out with a shorter product manufacturing cycle, an adjustment to the manufacturing of the product through competitive measures, one of the applications being to eliminate borderless and boundaries.
Several previous studies present and discuss the use of the manufacture Industrial area which support by Internet of things (IoT), related topic in this case using 3D Printing connected to the internet will be discuss. Among of them are Z.Bi, L.Da Xu, and C. Wang, discussion presents a strength of the internet in the modern manufacturing world [1] but does not discuss in detail the relationship of the component-components related to the modern manufacture. Other researchers, namely from Barbosa and Aroca, discussed the direct use of a 3D printer with a controlling monitor directly to the device, where the user enters directly into the machine's performance framework, in therefore the author examines and sees that a filter is needed to develop and maintain that users cannot enter directly into the manufacturing system, namely by using a website / world wide website, so that it can be used online, as an interface unit platform or user filtering [2] and Mai, Jingeng in their research discussed the approach to integration of 3D Printing in cloud [3] in the discussion there was not much written detail about the mechanism of performance or configuration of hardware or software and tools that will be used to create a prototype of the synthesis of 3D Printing integration via internet or intranet. All of these studies primary considered the perception and access of traditional machine resources from the perspective of manufacturing capacity, but they did not analyze and discuss solution further for integration for user into manufacture for 3D printers and 3D printing services.

Regarding based on previous researcher before, the author doing some research which related to customization and the configuration of 3D printer. The specification of hardware, local servers, external servers and software being used, that were being connecting between others. Mainly the 3D printer Fused Deposition Model are in different locations, can collaborate as one integrated connectivity as one manufacturing platform area, which can be connected by internet or intranet by entering the main component system framework which is very much needed [4] for the purpose from the user in different area by accessing the website platform. Thus, it is essential to examine how to get the best integrate and apply 3D printing services in web manufacture.[5]

2. Research Objectives
This research work is presented to design a framework for a production system additive manufacture - fused deposition modeling (FDM) - 3D Printer using an online network (website) as a manufacturing service that is integrated with hardware and software online. [6,7] The purpose and benefits of this research are:

a) With modeling and simulations without distance limitation can help synthesize devices and data as alternatives in manufacturing, evaluate the performance of uploaded CAD drawings whether they are in accordance with the user's intentions, can be a fast alternative choice for the industrial world, and can configure designs that are optimal. It is expected to make a manufacturing solution for operators and small manufacturing industries.[5]

b) Can facilitate the user / user in making a dynamic product, and can facilitate the operator to integration of making 3D Printing products FDM (Fused Deposition Modeling) [8,9]

c) Connecting and shortening the distance between Production and Users. In this case cutting the value chain, supply chain in an integrated manner, with the worldwide Web Cloud-Based Design and Manufacturing as the basis for the development of the manufacturing industry in Indonesia.

d) Producing output CAD readings both dimensions, price, material / material and the processing time of the 3D Printing machine.

The results of this study are highly expected and can be a reference for the world of industrial production design and other similar research. The main contribution of this research relates to the following two aspects:

1. Integrating and building a service or platform from CAD (Computer aided design) users to a 3D cloud web printer which then translates the CAD image to be able to support more efficient production and can reach in a variety of different locations / regions. By using online tools and integrated with 3D CAD drawing model construction in purpose to be integrated as computerize aided manufacture.
2. Development and design of a manufacturing system for 3D Printer machine production services, including a dynamic 3D Product evaluation facility with monitoring and assembly via the web and cloud and a combination of production services, as well as scheduling the work of the 3D Printer machine.

Figure 1. Manufacture world wide web computerize aided manufacture integration connected to operational area with monitoring system.
3. Significance of Implemented Techniques

RAD (Rapid Application Development) is an object-oriented approach to system development which includes a development method and software. RAD aims to shorten the time that is usually required in the life cycle of traditional system development between the design and implementation of a system. In the end, RAD also tried to meet the conditions of development that were changing rapidly [10].

Figure 2. The basic phase of making a system

The methodology used in this study is the RAD prototype method carried out in Figure 2 which consists of several stages, namely:

1. Planning: in this phase, the user and the analyst meet with each other by identifying the objectives of the application or system, and to identify the information requirements arising from those objectives. The orientation in this phase is to solve the problems that will exist or exist, the focus will always remain on the efforts to achieve the goal of making the system [10]. Without perfect planning, counting the strengths and weaknesses of the system, software development is meaningless without a plan. Planning starts the project perfectly and can positively influence its progress.

2. Analysis: This step is about analysing the system performance of both software and hardware at various stages and making notes about additional requirements. Analysis is a very important step to go further into the next step.

3. Design: After the analysis is complete, the design step is to take over, which basically is to build and develop architectural projects with various development innovations. This step helps eliminate the possibility of weaknesses by setting some standards and trying to track them.

4. Implementation: In this implementation phase, the analyst works intensively with users during the workshop and designs the business and non-technical aspects of the company. As soon as these aspects are agreed upon and systems are built and filtered, new systems or parts of the system are tested and then introduced to the organization [10].

Figure 3. The analogy process implementation making the system
Manufacturing via website [11] which provides services for users with various objectives framework are surely needed for the flexibility and reducing the cost for small manufacture. Which can be modified to the needs of users themselves, it can be directly print in user demand exactly location. Web manufacturing production technology using CAD (Computerize aided design) to a 3D Printer can provide an adjustment for a production system, especially when 3D printer technology can be shared (sharing) through networks in online manufacturing [12]. Compared to traditional manufacturing methods, 3D printers can significantly reduce some of the dependencies at very complex stages of the manufacturing process.

Framework purpose are to combine the software to make it easier for users, to create an application for a website or a system in which there are various functions related to them, including using a plugin, and is a concept for forming a particular system to be more structured and neatly structured.[10]

The framework contains following functions are being needed to construct and modified the system (1) webserver for user interface, (2) cpanel access to controlling the system of worldwide web manufacture (2) advance wordpress within integrated with customized wp3dprint and others plug in into the system, (3) customized repetier server within integrated with (4) repetier host as local network area between operator computer and 3D Print fused deposition model.

Table 1. Description for actor use case diagram

| No | Actor            | Description                                                                                                                                 |
|----|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Admin/Administrator | Admin or administrator website is the main actor who performs documentation data, delete documentation data, edit documentation data, add admin, delete admin, and edit admin. Admin communicates with the user, as well as the operator to be addressed, adds and configures the user's wishes (user) in accordance with user expectations. Forward the image in the form of format stl (stereolithography) and obj (Object) to the operator, and can configure the 3d printing machine (Fused deposition model) to be addressed for the production process. Can see the web virtual machine condition fused deposition model (3D Printing) with the help of API (Application programmable Interchange) connection from the repetier server installed by the destination operator. |
| 2  | Operator         | Receiving orders from the Admin as the main actor to carry out execution of the 3D Printing -Fused deposition machine The operator also monitors the machining periodically and maintains the machine's performance. The operator also checks the availability of materials that will be used periodically and is informed to the Admin. |
| 3  | User             | The user is an actor who can see the documentation data that will be uploaded in the obj / stl format. The user (user) performs work instructions (standing instruction) through the web filtered by the main actor (Admin). Users (users) can edit the profile (personal data) and include the wishes of the material to be used, as well as the desired destination location. |
Figure 4. Flow chart of making rapid prototype 3D printing manufacture web system
4. Processes in the System Design

Figure 3 describes a process design will be made in this research and customized implementation. The user will be directed to open a site, where the user (user) can upload a model / image that you want to print on the expected 3D Printing, the image is in the format stl / obj (stereolithographic / Object file), the user completes the order data and provides notes regarding images that are expected to become a finished goods process. After the order is confirmed, the admin takes action on the approval confirmation process. In the next process the admin forwards the order confirmation of the goods to the intended operator according to the user's wishes, after the data is received by the operator then the operator executes execution to the 3D printer machine to do the work so as to produce the finished product.

Figure 5. Administrator and Operator manufacture web login system

Figure 6. Inside monitoring system for administrator website and operator small manufacture
5. Result and Discussion

In our research, there’s are three area include, in production area, the operator run the 3D print machine which integrated with the repetier software [13] which in this sector are the customization repetier firmware and being configured with the repetier host. separate system placement software in the local application and it will be connected to customized system of server repetier to be acknowledge as one each other’s on local area.

The system server will get command from the operator itself or by website administrator to run the process as shown in Figure 4 and 5.

In user area sectors, user can directly upload the 3D data (STL, Obj) to front interface website as fig.6, and also they can exactly choose what material to be used, location for the 3D Print will be process, the dimension for they need, and they can customized the size and also the user can get information for the price regarding to the dimension and material they want to use.

![3D system](image)

**Figure 7.** Manufacture web upload area

With the 3D CAD output with STL or Obj file as input it has a function to describe the dimensions of the box (length, width, height), and can be used to make a decision, to produce or not to produce; to tell which customer which is appropriate to their product.

In the web manufacturing system that we customized and developed based on repetier server and advance php wordpress 3d system, the interaction will be providing directly in front of user (rotating, zooming in, zooming out) the 3D model is used interactively in the decision making process.

6. Conclusion

Regarding to the merge some of the existing system, the aim for 3D CAD data communication as our path research, a useful collaboration among others system can be applied as one synthetic system, repetier advanced server on local server and php wordpress 3D [14] attach it on the server website, and others detail component include, will be an advantage to better realization for the process. The system can collaborate with each other and can meet the shortcomings of each other. The ease of interaction between the user and the operator and administrators will be closer and easier to understand.

Collaboration system can be observed by each other and can be monitored between users, admin and operator. This became the foundation of its scope and the purpose of advance manufacturing which cannot be separated from a flexibility, distance efficiency, costs efficiency, and monitor with ease.

With this system which customize the 3D CAD transfer data, hopefully it can facilitate the controlling on ongoing projects and is desired by 3D Printing users to make virtual goods manufactured without knowing the distance and space restrictions.
Figure 8. The user interface with location and material need

Figure 9. The 3D CAD upload model within price, material and location printer as user demand and friendly use.

References

[1] Z. Bi, L. Da Xu, and C. Wang, “Internet of things for enterprise systems of modern manufacturing,” IEEE Trans. Ind. Informatics, vol. 10, no. 2, pp. 1537–1546, 2014.

[2] B. GF and A. RV, “An IoT-Based Solution for Control and Monitoring of Additive Manufacturing Processes,” J. Powder Metall. Min., 2017.

[3] J. Mai, L. Zhang, F. Tao, and L. Ren, “Customized production based on distributed 3D printing services in cloud manufacturing,” Int. J. Adv. Manuf. Technol., 2016.
[4] P. Nyamsuren, S. H. Lee, H. T. Hwang, and T. J. Kim, “A web-based collaborative framework for facilitating decision making on a 3D design developing process,” J. Comput. Des. Eng., vol. 2, no. 3, pp. 148–156, Jul. 2015.

[5] P. Siltanen and S. Valli, “Web-based 3D mediated communication in manufacturing industry,” in Advanced Concurrent Engineering, 2013, pp. 1181–1192.

[6] F. W. Baumann and D. Roller, “Closed-loop control of 3D printers via web services,” in CEUR Workshop Proceedings, 2017, vol. 1826, pp. 44–50.

[7] I. Gibson, D. Rosen, and B. Stucker, Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing. second edition. 2015.

[8] I. Gibson, D. W. Rosen, and B. Stucker, Additive manufacturing technologies: Rapid prototyping to direct digital manufacturing. 2010.

[9] A. Alafaghani, A. Qattawi, and M. A. Ablat, “Design Consideration for Additive Manufacturing: Fused Deposition Modelling,” Open J. Appl. Sci., 2017.

[10] Kenneth E. Kendall and Julie E. Kendall, Analysis Y Diseño de Sistemas, 2001

[11] P. Nyamsuren, S. H. Lee, H. T. Hwang, and T. J. Kim, “A web-based collaborative framework for facilitating decision making on a 3D design developing process,” J. Comput. Des. Eng., 2015.

[12] M. Livesu, S. Ellero, J. Martinez, S. Lefebvre, and M. Attene, “From 3D models to 3D prints: an overview of the processing pipeline,” Comput. Graph. Forum, 2017.

[13] Hot-World GmbH & Co. KG.2011-2019, “Repetier Server.” [Online]. Available: https://www.repetier-server.com/.

[14] Burkov, Sergey., “Wp3DPrinting,” 2019. [Online].Available: https://www.wp3dprinting.com.