Applying an integrated production system based on social manufacturing to develop a medical device

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Abstract. In the current Covid-19 pandemic, many manufacturing industries have been affected, including the health industry. The need for medical devices during this pandemic was very high, causing scarcity of goods on the market, and high selling prices, because most medical devices had to be imported. The concept of social manufacturing can be one way to revive the health industry in Indonesia. The purpose of this research is to develop an integrated production system through social manufacturing by involving small and medium companies and measuring the competitive level of production results from the quality side. The method used in this research is starting from literature study, field observation, production system design, product and system testing, and analysis of social manufacturing based production system test results. The results of this study are a social manufacturing-based production system for medical device products in the form of a Sanitation Chamber, and also the measurement of product quality in terms of performance (83.20), features (80.40), reliability (79.56), conformance (81.11), durability (84.67), service ability (78.33), aesthetics (81.83) and perceived quality (79.83).

1. Introduction
Conventional manufacturing models are built on supply chain efficiency and concentrate on product development [1]. The role of the product is emphasized more than the role of the customer [2]. However, basing a manufacturing strategy on this conventional manufacturing model can create serious problems for manufacturing companies today [3][4]. For example, because customer needs change rapidly, manufacturers must constantly modify their products [5]. However, this modification resulted in additional production costs and time [6]. Manufacturing companies look for ways to predict their customers’ interests in advance. They seek to avoid additional costs and modification time by following a proactive bid strategy [7]. The technology that is currently developing allows communication relationships between producers to be more intensive [2]. The manufacturing industry can shift from knowing customers to truly embracing or working with customers [8]. The rapid development of internet technology provides an opportunity to connect different industry players in a manufacturing network, which means, for example, that people can use the manufacturing tools they may have at home for a decentralized production process [9][10]. Through this type of crowdsourcing, companies can respond to requests for personalized products [11][12].
A new type of relationship between producers and customers makes it possible to form a manufacturing model that can be referred to as "Social Manufacturing" [8]. At the same time, manufacturing companies have begun to focus on core production tasks and have outsourced their non-core production tasks [13]. This new focus could reduce labour costs, funding and other manufacturing capital expenditures, and it would also increase the market responsiveness of producers. Therefore, the advantages of using a fully distributed social manufacturing model allow manufacturing departments to downsize [14]. The term "Social Manufacturing" has been used in several articles and journals. The Economist magazine first mentioned the idea of social manufacturing in its specificity of manufacturing and innovation reports, "The third industrial revolution" [15]. In addition, Fei-yue Wang explored the new social aspects of manufacturing in his article "From social computation to social manufacturing" [16]. Furthermore, the Institute for the Future (IFTF) has launched an initiative to provide an in-depth vision of the future of social manufacturing and its impact on development worldwide (IFTF, Social manufacturing: Alternative pathways to development). Recently, Gang Xiong introduced a social architecture of a manufacturing system that combines 3D technology, personalized design, business cloud platform and intelligent logistics [8][17]. Then, elaborate on the idea of a social manufacturing system that predicts an ideal social manufacturing system, customers will be able to take care of all production-related processes from machining to assembly, and do not need to invest in expensive manufacturing systems, such as assembly lines [18][19].

Many small and medium enterprises (SMEs) and individual businesses have sprung up with socialized resources and participated in different segments [20]. The SMEs community provides a variety of service-oriented capabilities to meet customer demands [13]. The trend of small and medium industrial communities forming new communities to produce a product has changed the paradigm of manual and automatic manufacturing systems and production modes [21][22].

In Indonesia, manufacturing industry is one of the largest contributors to Indonesia’s gross domestic product (GDP) in 2019. The contribution of the manufacturing sector to GDP last year was recorded at 19.62%. The Covid-19 pandemic has caused a decline in performance in this sector which is certain to have a significant impact on Indonesia’s overall economic performance. The latest data from the Central Statistics Agency (BPS), during February 2020, the import value of all categories of goods decreased compared to January. In detail, imports of consumer goods fell 39.91% to US $ 881.7 million. Then, imports of raw / auxiliary materials fell 15.89% to US $ 8.89 billion, and capital goods decreased 18.03% to US $ 1.83 billion. The decline in imports of raw materials and capital goods indicates that domestic production activities are sluggish. Changes in supply in China have affected the running of imports to Indonesia, thus validating the shortage of supply conditions in Indonesia. In order to suppress the spread of Covid-19, the government has imposed various restrictions, including through social distancing and Work from Home (WFH). In addition, several regions have also implemented large-scale social restrictions (PSBB). These restrictions have an indirect impact on the continuity of the business world. Many companies have to impose layoffs for their employees because profits have declined. This causes many people to lose their jobs, which reduces their purchasing power. In addition, the implementation of PSBB also hampers distribution channels, thereby reducing production capacity.

In the current Covid-19 pandemic period, many manufacturing industries have been affected, including the health industry. The need for medical devices during this pandemic was very high, causing scarcity of goods on the market, and high selling prices, because most medical devices had to be imported. The national health industry, with the Covid-19 pandemic that has hit the entire world, can be a momentum for Indonesia to awaken and strengthen the national health industry and release from dependence on imported medical devices. The concept of social manufacturing can be one way to revive the health industry in Indonesia.

The rate of increase in the spread of the Covid-19 virus in Indonesia from time to time is very high, between 7-10 times. So it requires the availability of mass prevention facilities that can work quickly, which is currently still lacking. In the New Normal, places where people gather need public sanitation chambers. Because this tool is used for a large number of people, the slow manual recording of measurement results will no longer be effective, so an automatic system is needed.
The social manufacturing system in the medical device industry can be formed by involving a social manufacturing resource (SMR), which consists of groups of SMEs, individuals (workers who have been laid off) and other small companies. Thus the medical device industry continues to grow and develop, and can provide new jobs. In this pandemic era, the need for medical devices in the form of sanitization is urgently needed as an effort to prevent Covid-19 transmission. In addition, as demand increases, production can be carried out quickly and distributed to various public service facilities. Based on this background, this research will develop a medical device (Sanitation Chamber) production system in the form of a social manufacturing-based, which involves SMEs.

2. Methods
This research includes the development of a medical device production system in the form of a social manufacturing-based Covid-19 Sanitation Room that involves SMEs, as well as measuring the quality of the product. The method used in this research is literature review, field observation, integrated production system design, sanitization chamber design, quality product testing, and product testing analysis.

In this research, we involve five SMEs who work together to form an integrated production system based on social manufacturing and produce a product in the form of a sanitization chamber. The companies are 1) PT ATMI, which specializes in making body frames from sanitization chamber, 2) CV Bisri, which specializes in working on sprayers, 3) CV Alfan who works on control systems in sanitization chamber, 4) CV Ekrar who works on android-based applications, so that the results of collecting data in the sanitization chamber can be accessed via internet, 5) Energy Studies Center (PSE) as an integrator, fine tuning and quality control.

2.1 Flow Chart
Research flow chart can be seen in Figure 1, that explains about research process, from literature review, field observation, then make some production system requirement analysis based on the literature and field observation document.

![Figure 1. Research Flow Chart](image_url)
2.2 System Design
The design of integrated production system is shown in Figure 2, which describes the production process, starting from the supplier, then designing and installing by each SME, to the process of integrating each component into a product.

![Figure 2. System Design](image)

PT ATMI makes a body frame for the sanitation chamber, which uses stainless steel, then sends it to PSE to arrange and install the components. Furthermore, CV Bisri designed and installed the sprayer in the sanitation chamber. CV Alfan designed and installed a controller using the Arduino microcontroller, which functions to connect the temperature sensor, temperature display and display the number of users. Then, CV Ekrar designed an Android-based monitoring application, so that data in the sanitation chamber can be accessed via Android and can be accessed anywhere. After all the components are installed in the sanitation chamber, then done fine tuning as well, to check and ensure that all components are running properly. If there are still errors, then fix them immediately.

3. Results and Discussion
The results of this research are Sanitation Chamber products made of stainless steel, and equipped with components such as a sprayer, controller, temperature sensor, temperature display and modem for connection to the internet.

3.1 Sanitation Chamber Product
In Figure 3, a display form of the Sanitation Chamber product is shown, that have a dimensions 1m x 1m x 2.5m. The way this sanitation chamber works is first, before entering the chamber, the user will take his temperature, then the body temperature will appear on the display. The normal body temperature that has been set is 38 degrees Celsius, if the temperature is more than that, it is not allowed to enter the chamber. So, if the body temperature shows a temperature below 38, a notification will appear, a sign that the user can enter the chamber. After entering the chamber, the user will be sprayed using a sprayer in each corner of the chamber, which will work automatically when a user enters, within 5 seconds. After that process, the user can exit the chamber. There are 3 data on the display, namely on the left side a green person picture will appear, in the middle is the body temperature measurement and the number of chamber users will appear, and on the left side, there is a measure of degrees Celsius.
3.2 Product Quality Measurement

Measuring the quality of the sanitation chamber product uses the Garvin principle [23] which consists of 8 dimensions, namely: Performance, Features, Reliability, Conformance, Durability, Serviceability, Aesthetics and Perceived Quality. Measurements were made through direct sanitation chamber tests by 30 respondents, as well as filling out questionnaires related to product quality.

In this research, product performance is measured by temperature measurement using temperature sensor, temperature sensor works well, accurate temperature readings, easy access to the chamber, and the sprayer works well. The product performance test results are presented in Figure 4. The minimum value of product performance is 72.00, the maximum value is 100.00, and the average of performance is 83.20.

![Figure 3. Display of Sanitation Chamber](image1)

![Figure 4. Performance Measurement](image2)

Product features is measured by temperature display, number of users display, android based monitoring system, data can be accessed anywhere, sprayer is on every corner. The product features test results are presented in Figure 5. The minimum value of product features is 56.00, the maximum value is 100.00, and the average is 80.40.
Figure 5. Features Measurement

Product reliability is measured by temperature sensors are affected by ambient temperature conditions, body temperature is read in real time, sprayers at all points work properly. The product reliability test results are presented in Figure 6. The minimum value of product reliability is 66.67, the maximum value is 100.00, and the average is 79.56.

Figure 6. Reliability Measurement

Product conformance is measured from the room works well in all weathers, easy to use, there are user temperature measurement applications. The product conformance test results are presented in Figure 7. The minimum value of product conformance is 60.00, the maximum value is 100.00, and the average is 81.11.

Figure 7. Conformance Measurement
Product durability is measured from the sanitation chamber is made of stainless steel, strong body frame, sprayer works for a long time. The product durability test results are presented in Figure 8. The minimum value of product durability is 60.00, the maximum value is 100.00, and the average is 84.67.

![Figure 8. Durability Measurement](image)

Product serviceability is measured from components are easy to find, components can be set as needed, users can use the chamber without manual information, the chamber is easy to move. The product serviceability test results are presented in Figure 9. The minimum value of product serviceability is 55.00, the maximum value is 100.00, and the average value is 78.33.

![Figure 9. Service Ability Measurement](image)

Product aesthetics is measured from the chamber is easy to move, easy to move, the chamber is easy to move. The product aesthetics test results are presented in Figure 10. The minimum value of product aesthetics is 70.00, the maximum value is 100.00, and the average value is 84.67.

![Figure 10. Aesthetics Measurement](image)
Product aesthetics is measured from nice and strong room shape, sensor placement is appropriate, curtain placement is appropriate, there is a sanitation chamber name display (BICO). The product aesthetics test results are presented in Figure 10. The minimum value of product aesthetics is 65.00, the maximum value is 100.00, and the average value is 81.83.

Perceived quality is measured from The sanitation chamber needs to be placed in a public place, the time for sprayer spray is appropriate, the sanitation liquid does not make clothes wet, it is necessary to add User Instructions. The perceived quality test results are presented in Figure 11. The minimum value of perceived quality is 50.00, the maximum value 100.00, and the average value is 79.83.

![Figure 11. Perceived Quality Measurement](image_url)

The measurement results are summarized in Table 1, which describes the 8 dimensions of quality measures, with the minimum, maximum, average, and standard deviation values. From the table it can be seen that the lowest minimum value is 50.00 from Perceived Quality and the highest minimum value is 72.00 from Performance, then the maximum value in all dimensions is 100.00.

| Measurement     | Min  | Max  | Average | Std Deviation |
|-----------------|------|------|---------|---------------|
| Performance     | 72.00| 100.00| 83.20   | 1.864         |
| Features        | 56.00| 100.00| 80.40   | 2.631         |
| Reliability     | 66.67| 100.00| 79.56   | 1.172         |
| Conformance     | 60.00| 100.00| 81.11   | 1.392         |
| Durability      | 60.00| 100.00| 84.67   | 1.489         |
| Serviceability  | 55.00| 100.00| 78.33   | 1.826         |
| Aesthetics      | 65.00| 100.00| 81.83   | 1.650         |
| Perceived Quality | 50.00| 100.00| 79.83   | 2.008         |

The lowest average value is 78.33 from Serviceability, and the highest average value is 84.67 from Durability, then for the lowest standard deviation value is 1.172 from Reliability and the highest value is 2.631 from Features. The results of these measurements are also shown in Figure 12.
4. Conclusion

In this research, a study has been carried out related to the design of an integrated production system based on social manufacturing, which can produce a medical device product in the form of a Sanitation Chamber. The results of this research are Sanitation Chamber products made of stainless steel, and equipped with components such as a sprayer, controller, temperature sensor, temperature display and modem for connection to the internet.

In addition, product testing has been carried out, by trying the product directly by 30 respondents. Furthermore, all respondents filled out a questionnaire about the results of product testing to assess the quality of the Sanitation Chamber product. From the results of the questionnaire, it was found that the average value of product performance was 83.20, the average value of product features was 80.40, the average value of product reliability was 79.56, the average value of product conformance was 81.11, the average value of product durability was 84.67. The average value of serviceability was 78.33, the average value of product aesthetics was 81.83 and the average value of perceived quality was 79.83. Thus, from the results of the quality measurement, the lowest average value is product serviceability, which is 78.33 and the highest value is product durability, which is 84.67. For further research, measurements can be made regarding the time required for each process, product prices and measurements for the number of products that can be produced in a certain time.

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References

[1] B. Chen, J. Wan, L. E. I. Shu, and S. Member, “Smart Factory of Industry 4 . 0 : Key Technologies , Application Case , and Challenges,” pp. 6505–6519, 2018.
[2] I. Kauranen, “Paradigm Shift f rom Current Manufacturing to Social Manufacturing Babak Mohajeri,” no. June, 2015.
[3] M. Hamalainen and J. Karjalainen, “Social manufacturing: When the maker movement meets inter fi rm production networks,” Bus. Horiz., vol. 60, no. 6, pp. 795–805, 2017.
[4] M. W. Sari, Herianto, I. G. B. B. Dharma, and A. E. Tontowi, “Design of Product Monitoring System Using Internet of Things Technology for Smart Manufacturing,” IOP Conf. Ser. Mater.
Sci. Eng., vol. 835, pp. 1–7, 2020.

[5] K. Kaneko, Y. Kishita, and Y. Umeda, “Toward Developing a Design Method of Personalization : Proposal of a Personalization Procedure,” Procedia CIRP, vol. 69, no. May, pp. 740–745, 2018.

[6] M. Hamalainen, B. Mohajeri, and T. Nyberg, “Removing barriers to sustainability research on personal fabrication and social manufacturing,” J. Clean. Prod., vol. 180, pp. 666–681, 2018.

[7] G. Xiong, S. Member, F. Wang, T. R. Nyberg, and X. Shang, “From Mind to Products : Towards Social Manufacturing and Service,” IEEE/CAA J. Autom. Sin., vol. 5, no. 1, pp. 47–57, 2018.

[8] Y. Zhou, G. Xiong, T. Nyberg, B. Mohajeri, and S. Bao, “Social Manufacturing Realizing Personalization Production : A state-of-the-art Review,” 2016 IEEE Int. Conf. Serv. Oper. Logist. Informatics, pp. 7–11, 2016.

[9] C. M. Joyner, A. Hirscher, and K. Niinim, “Social manufacturing in the fashion sector : New value creation through alternative design strategies ?,” vol. 172, pp. 4544–4554, 2018.

[10] P. Zawadzki and K. Zywicki, “Smart Product Design and Production Control for Effective Mass Customization in the Industry 4.0 Concept,” vol. 7, no. 3, pp. 105–112, 2016.

[11] X. Shang et al., “Social Manufacturing for High-end Apparel Customization,” IEEE/CAA J. Autom. Sin., vol. 5, no. 2, pp. 489–500, 2018.

[12] D. A. Coelho, F. Nunes, and F. L. Vieira, “The impact of crowdsourcing in product development : an exploratory study of Quirky based on the perspective of participants,” vol. 0349, no. September, 2016.

[13] W. Guo and P. Jiang, “An investigation on establishing small- and medium-sized enterprises communities under the environment of social manufacturing,” 2018.

[14] K. Ding, P. Jiang, J. Leng, and W. Cao, “Modeling and analyzing of an enterprise relationship network in the context of social manufacturing,” 2015.

[15] X. Xiao, W. Shufang, Z. Le-jun, and F. Zhi-yong, “Evaluating of dynamic service matching strategy for social manufacturing in cloud environment,” Futur. Gener. Comput. Syst., vol. 91, pp. 311–326, 2019.

[16] S. Wang, J. Wan, D. Li, and C. Zhang, “Implementing Smart Factory of Industrie 4.0 : An Outlook,” vol. 2016, 2016.

[17] M. A. Abd, E. S. Nasr, and M. H. Geith, “Benefits and challenges of cloud ERP systems e A systematic literature review,” Futur. Computat. Informatics J., vol. 1, no. 1–2, pp. 1–9, 2017.

[18] P. Jiang, K. Ding, and J. Leng, “Towards a cyber-physical-social-connected and service-oriented manufacturing paradigm : Social Manufacturing,” Manuf. Lett., vol. 7, pp. 15–21, 2016.

[19] E. Francalanza, J. Borg, and C. Constantinescu, “A knowledge-based tool for designing cyber physical production systems,” Comput. Ind., vol. 84, pp. 39–58, 2017.

[20] K. Ding, P. Jiang, and S. Su, “RFID-enabled social manufacturing system for inter-enterprise monitoring and dispatching of integrated production and transportation tasks,” Robot. Comput. Integr. Manuf., vol. 49, no. July 2017, pp. 120–133, 2018.

[21] J. Lee, B. Bagheri, and H. Kao, “A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems,” Manuf. Lett., vol. 3, pp. 18–23, 2015.

[22] R. Y. Zhong, P. Stief, J. Dantan, A. Etienne, and A. Siadat, “Smart Manufacturing Execution Systems Enterprises A new methodology to analyze the functional and physical architecture of existing products Sherwin assembly oriented family identification,” Procedia CIRP, vol. 72, pp. 1009–1014, 2018.

[23] D. A. Garvin, “Competing on the Eight Dimensions of Quality”, Harvard Business Review, November-December, 1987.