Recent Development and Future Research of Manufacturing Excellence: A Literature Review

Moses Laksono Singgih[1], Dessy Ahadian[2], Winda Puspitasari[3], Firdausy Anindita Ayudinda[4], Aida Aidil[5], Arventa Lukas Pranastya[6], Paulino Gamboa[7], Afrigh Fajar Rosyidiin[8], Hari Prasetyo[9]

Department of Industrial and Systems Engineering
Institut Teknologi Sepuluh Nopember
ITS Campus, Keputih-Sukolilo, Surabaya-INDONESIA
moseslsinggih@ie.its.ac.id[1], dessy.ahadian01@gmail.com[2], windaapuspitas@gmail.com[3], dindafrdsy27@gmail.com[4], aidaaidil08@gmail.com[5], arventalp@gmail.com[6], paulinogamboa27@gmail.com[7], afrighfajar7@gmail.com[8], hariprasetyo808@gmail.com[9]

Abstract

The development of manufacturing in the current conditions is increasingly advanced, especially in improving manufacturing excellence. To achieve manufacturing excellence, manufacturers need to manage based on real-time performance information. Performance is the measure of manufacturing excellence. Excellent performance can react quickly to changing marketplace conditions, dynamically reflect these changing production targets, and efficiently and reliably achieve these targets. It also requires ongoing cost reductions and quality improvement. This study aims to identify and determine the management of the system by analyzing the implementation, increasing profits, and improving service efficiency. The approach in this research is a literature review of the latest journals related to manufacturing excellence. It found that the size and improvement of manufacturing excellence is something that researchers are continually making improvements to, especially in the manufacturing sector. This paper aims to review the latest development and future research of manufacturing excellence through Product service systems, Manufacturing Safety, Manufacturing Quality, and Overall Equipment Effectiveness, as well as improvement steps to achieve manufacturing excellence through Design for Manufacturing and Assembly (DFMA), Lean Manufacturing, and the Internet of Things.

Keywords:
Manufacturing Excellence, Safety, OEE, Quality, Product Service System

1. Introduction

Manufacturing excellence is a broad term. Some manufacturers measure by production, which is a set of world-class manufacturing standards. Other manufacturing companies define manufacturing excellence as part of a total commitment to meeting safety and exceeding internal goals, including plant capacity, employee satisfaction, customer service, and organizational change. In today's era of global competition, the industrial world, including the manufacturing industry, is mutually enhancing competitiveness in producing products and services of good quality and meeting customer expectations. Each manufacturing industry made various changes to achieve the best manufacturing excellence. Manufacturing advantage relates to competition between firms. In comparing manufacturing advantages, most studies define excellence in terms of several indicators such as waste reduction, operating efficiency, good delivery quality, employee work, and customer satisfaction.

The organization or company must make a significant effort to attain excellence or superiority through various means. Manufacturing excellence is the goal of every manufacturing industry, so that it becomes an essential aspect, especially how to reach that point. So, getting manufacturing excellence is not easy considering a long process, a long time, maximum effort, and sacrifice. Reduced inefficient processes and unproductive employees and replaced them with more professional ones. Direct all activities to achieve manufacturing excellence.

Barletta et al. (2020) stated that building sustainable manufacturing capabilities requires an organization's success. The development of the current manufacturing system is significant so that companies can take advantage of it as one of the potential factors needed. Over time, much research developed a manufacturing system to achieve manufacturing excellence and challenge the future with assessing a manufacturing system. The assessment is needed to measure manufacturing performance with target-oriented and optimal achievement. Performance measurement methods are a common problem that must be solved. Specific studies regarding the current manufacturing system, development, and future research are needed to find benchmarks for achieving manufacturing excellence.

1.1 Objectives

This research aims to identify the characteristics and implications of the management system by analyzing implementation, increasing profits, and improving service efficiency. Manufacturing must consider product service, quality of operational standards, increase manufacturing performance, and implementation removes barriers in making manufacturing excellence designs. This research concerns the latest developments and future research related to the criteria for evaluating manufacturing excellence and how to improve measures. Figure 1 shows that product-service systems, manufacturing quality, and safety are essential factors in assessing manufacturing excellence and Overall Equipment Effectiveness, robust design, design for manufacturing and assembly (DFMA), and lean manufacturing are improvement steps.

Figure 1. Improvement steps and essential factors of manufacturing excellence

2. Literature Review

A manufacturing system integrates equipment and human resources to perform processing and assembly operations on initial raw materials, spare parts, or spare parts sets. Human resources are needed to keep the system running so that the safety factor is also essential in ensuring the continuity of an exemplary manufacturing system. Figure 2 shows the position of the manufacturing system with various aspects that support and have interrelationships. Quality control and manufacturing support systems such as product design, process and production planning, and lean directly impact the manufacturing system. Manufacturing operations which consist of systems, equipment, and resources, are derived aspects of the manufacturing system. All these aspects are an essential part of forming an exemplary manufacturing system and by the company's wishes.

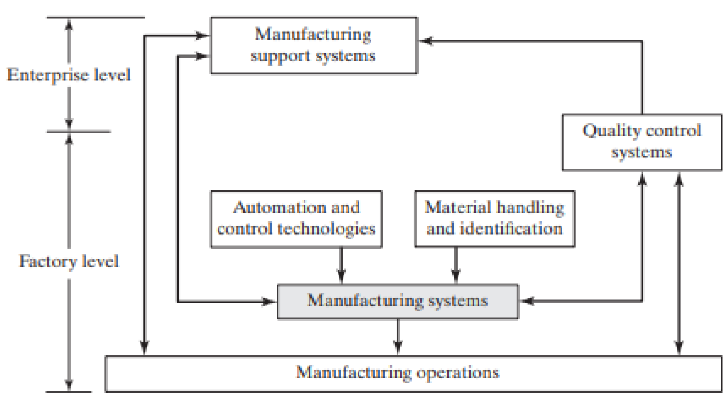

Figure 2. Position of the manufacturing system in the more extensive production system (Source: Groover, 2018)

A sound manufacturing system certainly has done careful planning by paying attention to aspects of excellence since the early stages, namely product design. Manufacturing planning is needed to turn product designs into physical entities. Process planning involves determining the sequence of processing and assembly steps required to make a product. Groover (2018) states that around 70% of the life cycle cost of a product consists of the primary decisions made during product design. These design decisions include material selection, part geometry, tolerances, surface finish, how to organize the parts into sub-assemblies, and the assembly method to be used. After making this decision, the potential for reducing production costs is limited. The term used to describe these efforts to influence the manufacturability of new products is design for manufacturing and assembly (DFMA). DFMA involves systematic consideration of manufacturing and assembly capabilities in the development of new product designs.

Manufacturing excellence in combination with the voice of the customer is the foundation of business performance. The business performance model and its two key elements (manufacturing excellence and customer's voice) are part of its operational strategy to increase profits and provide a structured and proven set of tools that lead to improved excellence. Manufacturing excellence is a broader concept that leads to perfection in manufacturing execution, integrating a Lean-six sigma blending approach to reduce process variability (Alvarez & Perry, 2015). Manufacturing performance consists of direct and indirect inputs and quantitative and qualitative outputs (Leachman et al., 2005). Green manufacturing performance measures involve top management commitment, human resource management, process design, employee empowerment, environmental safety and health, supplier and material management, production planning and control, quality, cost, and company growth (Digalwar et al., 2013). The criteria for manufacturing excellence are consistent with quality, delivery, cost, time, and labor (Amrina & Yusof, 2010). Manufacturing performance indicators consist of organizational achievement, productivity, quality, cost, delivery, safety, and morale (Ahuja & Khamba, 2008). Manufacturing performance indicators are manufacturing suitability and product quality, volume, flexibility, customer service, support, delivery speed, unit production costs, manufacturing lead time, labor productivity, and inventory turnover (Hajirezaie et al., 2010). This study defines manufacturing performance as the effort achieved in manufacturing operations to achieve the expected goals through increased productivity, satisfaction, and innovation.

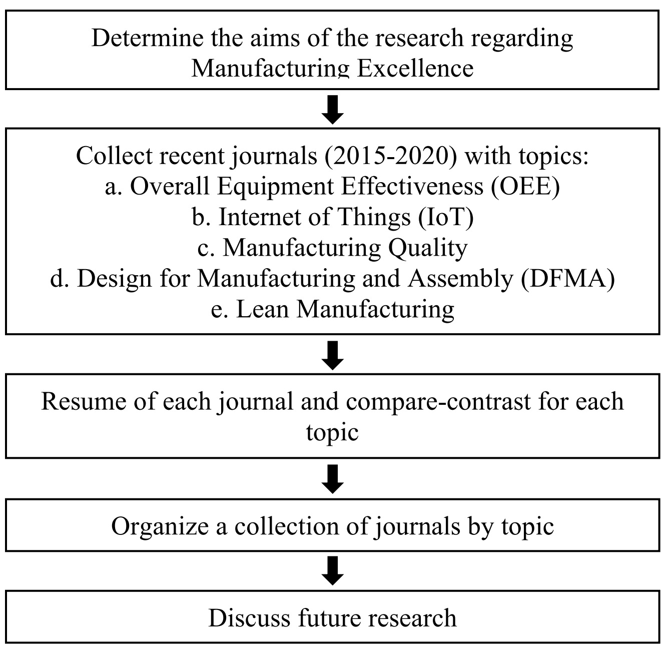

Figure 3. Work flow diagram

3. Methods

In preparing this paper, a workflow diagram describes the methods and steps taken (Figure 3). The initial step in preparing this paper was a literature study based on the latest journals in the last five years, between 2015 – 2020, about manufacturing excellence, especially regarding improvements and essential factors. Therefore, the literature study specifically focused on the topic: Overall Equipment Effectiveness (OEE), Internet of things, Manufacturing Quality, Design for Manufacturing and Assembly, and Lean Manufacturing. All journals are resumed and then compared and contrasted for each topic. An analysis is carried out on various problems in each journal, especially how to build a manufacturing excellence system and make improvements and discuss the implementation and development of manufacturing excellence methods for further research.

4. Data Collection

Researchers who specifically discuss the manufacturing sector discussed the improvement of manufacturing excellence. Researchers took data by conducting a literature review on the latest journals in the last five years, namely 2015 - 2020 in manufacturing excellence. After reviewing each journal, the differences in each problem also affect the implementation of the improvements. In addition, a review is helpful to determine the implementation and development of methods of manufacturing excellence and future research. The development of knowledge of current and future manufacturing systems always leads to the company's operational strategy to increase profits and provides a structured and proven set of tools that lead to excellence.

5. Results and Discussion

5.1 Results

Based on the review, the development of methods related to the size and improvement of manufacturing excellence. The measurement of manufacturing excellence uses several criteria, including product service system, manufacturing safety, manufacturing quality, and equipment effectiveness indicated by the OEE (Overall Equipment Effectiveness). A Product-service system (PSS) is a value creation concept that combines products (tangible) and services (intangible). Products and services provide added value and meet the specific needs and desires of consumers. The main idea of PSS is how consumers are not faced directly with the product but can fulfill their needs and desires through the services provided. By integrating products and services, consumers can fulfill more desires than just using a product with a specific function. Another measure of manufacturing excellence is the safety aspect, a measure of excellence in the manufacturing industry. Manufacturing Safety aims to prevent accidents in the manufacturing industry work environment from smoothening the production process and increasing productivity.

Manufacturing excellence correlates with many components. A material transformation process, referred to as a unit process, is a method used to transform materials into components and subsystems. It builds or improves many capabilities of the various functions in the system as applied science provides the technical basis for many fields. Computer-based systems provide tools to improve product design, planning, scheduling, control, and sales capabilities and performance. Product and process engineering, unit manufacturing operations, marketing, sales and service, vendors and suppliers, and management and administration benefit from these systems and their ability to describe system performance. Describing the entire enterprise in this way draws attention to the fact that no single operating unit or function can operate independently of all the other system components.

In today's dynamic environment, developing a manufacturing excellence measurement system is a growing challenge and task. A manufacturing system's ideal local and global actions should exhibit a direct cause-and-effect relationship, not correlation. Manufacturing excellence systems must be dynamic and must evolve and adapt to changing internal and external environments. When to change and how much to change required many technical and business skills and technological foresight. Measures for a manufacturing system need to include: key performance indicators in cost, time, quality and flexibility, and productivity considerations. The development of ubiquitous digitization, data mining, and human-machine communication will bring new performance monitoring and control possibilities. The performance measurement system should support alignment with manufacturing strategy and process improvement to drive competition and innovative performance at a higher level. With new technologies, new paradigms of manufacturing systems, there will be a constant demand for new steps to monitor manufacturing excellence intelligently and naturally, starting from progress to performance measurement then performance management.

Several methods can increase manufacturing excellence and apply as improvement steps, including lean manufacturing, a strategy to get fewer inputs to achieve organizational goals better by producing better outputs, where input refers to physical quantities. Resources used and their costs and output refer to the quality and quantity of products sold and customer service accordingly. In addition, the Internet of Things is an extension of internet connectivity that can be connected continuously and provides an approach to managing a company's production system to integrate production systems with internet-based equipment and DFMA (Design for Manufacturing Assembly) guidelines to ensure a product efficiently manufactured and assembled. All aspects mentioned will then be discussed in greater depth based on a review of research to see how the development of methods has existed so far and may emerge in the future.

5.2 Discussion

Several measures of manufacturing excellence found as a result of the literature review will be discussed based on a review of research to see how the development of methods has existed to date and may emerge in the future. Conducting an assessment, of course, requires a measure as a reference and improvement steps to achieve the expected goals. In carrying out manufacturing excellence, it must meet the specifications set for the final product and be cost-effective. The challenges faced in implementing manufacturing excellence are improving product quality, drastically shortening the product development cycle, increasing productivity growth, stimulating product and process innovation, and responding quickly to changing customer demands.

Along with technology development, the Product Service System gives rise to a new type, namely the Smart Product-Service System (SPSS). Lee et al. (2019) argue that SPSS collaborates between users and product service providers connected in systems and machines using innovative technology. In their research, Bu et al. (2021) developed a Smart Virtual Reality platform (V.R.) Rowing Machine based on hybrid intelligence, and Li et al. (2021) designed a blockchain and IoT-based Prefabricated Housing Construction (PHC) platform. The two studies show that intelligent technology used in product design in a platform can add value to the product, lighten work, and increase user experience. With the SPSS concept, many product and service innovations can satisfy consumers by placing user needs at the center of a system development process (user-centric). Research based on user-centric conducted by Chang et al. (2019) regarding designing a treatment platform for the elderly and Yang et al. (2021) regarding the Smart Bed design showed that the designed platform could provide attractiveness and satisfaction. Another study conducted by Lee et al. (2019) regarding the design of the Smart Beauty Service platform in drug and cosmetic stores, providing consumer satisfaction reaching 90% and increased sales by 5.5%. The five reviewed papers concluded that software development also applies several manufacturing excellence factors described above. The platform makes it very easy for users to access the required information to reduce lead time flexibility and lead time. However, designing a platform requires high costs and is adapted to the market. Designing the platform requires careful planning and, at the same time, a good process. It does not stop there; its development also requires management and coordination to achieve the resulting product by its objectives.

In addition to the customer satisfaction aspect, the safety aspect is also a measure of excellence in the manufacturing industry. Most small and medium-sized companies often consider manufacturing safety unimportant because it is unrelated to core business functions. Therefore, Manufacturing Safety is often a burden and does not help in running a business. The causes of manufacturing safety problems can identify, and from these causes, we can find solutions to improve workforce performance. Gunaseelan & Gerald (2017) suggest implementing a safety management system with three safety concepts: Organizational Safety Culture, Behavioral Safety, and Safety excellence. In addition, to truly advance safety in the manufacturing industry requires a paradigm shift or "out of the box" thinking (Reniers, 2017).

After looking at the human aspect, namely the customer and worker safety, from the product side, it is also a significant concern both from the finished product and the effectiveness of the processes and equipment used during the production process. Quality is a measure to assess whether a product functions or has a use-value as desired. Several studies discuss related to quality in various types of manufacturing systems. Colledani and Angius (2020) conducted an in-line product inspection and identification, which is a new technology that supports the observability and traceability of the evolution of product status in a multi-stage manufacturing system where this technology is in charge of evaluating the production quality of a manufacturing system that operates under product observation that is possible by inspection. In-line products identified renewable technologies and rework. This method is proper for application in several fields where product the system evolution of product status is affected by specific in-line compensation and investigation of product improvements to control the production quality directly. Lu & Zhou (2019) stated that product quality and machine reliability are two essential indicators in manufacturing that are prone to deterioration due to machine breakdowns. A Condition Based Maintenance (CBM) policy is helpful towards the quality and reliability of mass production. Gomez & Gharbi (2017) stated that there are times when the manufacturing system deteriorates, which results in not being able to produce suitable spare parts to meet product demand. Improvement of production inventory control and preventive maintenance on inadequate manufacturing systems, using preventive maintenance policies based on machine age to reduce the rate of shifting to out-of-control conditions. By proposing control policies that aim simultaneously to determine excessive production and overhaul rates and the level of subcontractor demand that can minimize total costs. So it can be concluded that the importance of process quality in manufacturing excellence business. How the company carries out an improvement effort dramatically affects the company's excellence. The better in carrying out quality control, the better the manufacturing excellence will be. Some papers aim to reduce costs and focus on finished goods. However, not all manufacturing companies can adequately run the same manufacturing system due to various manufacturing problems.

Overall Equipment Effectiveness (OEE) is a measurement method that determines the effectiveness of using and utilizing machines, equipment, time, and materials to improve production. OEE consists of 3 components, namely Availability, which is an indicator that shows the reliability of the machine, excellence, which is an indicator that shows the effectiveness of the machine and quality, which is the ability of the machine to produce products with good quality, resulting in a series of relationships OEE = Availability x Performance x Quality. Today, OEE is one of the most important metrics used by manufacturing companies as an indicator to achieve the title of Manufacturing excellence. There are many studies related to the development or improvement of OEE. Suryaprakash et al. (2020) explained that Total Productive Maintenance (TPM) could increase the OEE value by ensuring machine availability, and its implementation involves continuous improvement. In addition, lean tools Single Minutes Exchange of Die (SMED) can increase machine availability. The result of the application of TPM and SMED is an increase in OEE by 6%. Research conducted by Chandra, A, et al. (2018) also describes the value of OEE before and after the application of TPM is carried out in the form of autonomous maintenance. The results of the OEE calculation after the implementation of TPM showed an increase of 11%. In terms of developing the OEE method, Oliveira, R et al. (2019) conducted many studies to assess the effectiveness and efficiency of production processes, such as Overall Equipment Effectiveness (OEE). However, no analysis has been able to describe the results in terms of accuracy with the plan. Global Process Effectiveness (GPE) created a new formulation in production, namely GPE = Availability x Performance x Quality x Schedule Adherence. The results show that the more a production process deviates from the planned production plan regarding product quantity and variety, the less effective the process is by customer expectations. In addition, Puvanasvaran A et al. (2017) modified the standard OEE calculation still containing waste so that it was to OEE modification = Availability x Usability x Human factor x Performance x Quality. The results show that the traditional OEE and modified OEE values are the same, but the modified OEE is better able to provide detailed visualization of waste to indicate the scope of improvement. Each company has provisions in maintaining their respective machines to produce an output of good quality. To make improvements, indirectly improve the company's manufacturing performance.

Several methods increase manufacturing performance, such as lean manufacturing, the internet of things, and design for manufacturing and assembly. Lean manufacturing is a strategy to obtain fewer inputs to better achieve organizational goals through producing better outputs, where "input" refers to the physical quantity of resources used and their cost, and "output" refers to quality—furthermore, the number of products sold and appropriate customer service (Wahab et al., 2013). Many studies proved that lean manufacturing helps reduce waste and increase economic profits for the company. Nallusamy (2020) conducted a study to minimize overall product lead time by finding bottlenecks and eliminating them in the pump industry in Chennai, India and the result was an increase in assembly-line efficiency of 97%. Sutharsan et al. (2020) conducted another study to understand the current state of the pump manufacturing process and the opportunities by developing a "future state vision" of each process, increasing productivity, and developing action plans for higher production and reduced waiting time with lean. After making improvements, it shows a reduction in the production waiting time from 26.3 days to 24.9 days and the lean rate increases from 16.66% to 25%. Production per month increased, and the damage rate reduced from 3% to 1%. Mulugeta (2020) researched to increase productivity by minimizing or eliminating problems and waste found in companies and increasing market competence by using various lean manufacturing tools such as; motion study, standardization of work through time study, and line balancing. The results obtained successfully reduce cycle time by 32.73%, production lead time decreases by 11.8%, and productivity increases by 16.66%.

Internet of Things (IoT) is an extension of internet connectivity that can be connected continuously. The application of IoT provides an approach to managing a company's production system, which aims to integrate the production system with internet-based equipment. The Internet of Things is influential in various industries such as manufacturing, logistics, health, urban planning, homes, agriculture, and even the automotive industry. Kurniadi & Ryu (2017) revealed that the Reconfigurable Manufacturing System (RMS) emerged as a solution for high variations in customer demand that allowed manufacturers to meet different amounts of demand in each period. IoT-based RMS will undoubtedly have advantages over existing RMS and Reconfigurable Machine Tools (RMT). The factual information of spare parts and RMT can be collected through many sensors; so that RMS can reconfigure its structure more efficiently. Chen et al. (2020) The evolution of semiconductor manufacturing between IoT and equipment has an increasingly complex relationship in the track-in or track-out process mechanism. In this case, propose a Computer-Integrated Manufacturing (CIM) system based on the Internet of Things (IoT). Where companies can gain greater asset visibility, reduce labor costs, and connect with world trends. Xu, Li, & Zhang (2021) revealed that fully automated manufacturing systems have received widespread attention and adopted in the manufacturing industry to adopt the Internet of Things. In this case, consider the optimal control problem that arises in a fully automated manufacturing system based on the Internet of Things and formulate it as a scheduling problem for a new parallel machine with multiple servers. With the rapid development of automated IoT manufacturing systems, there is increasing attention to system performance. They applied some of these engineering adjustments to the permutation flow or even some machine settings. Almost every aspect of business will be affected by digital transformation and IoT: business efficiency and product quality will increase, as will innovation. In this era of Industry 4.0, the most significant impact of IoT for the industry is its role as a new method to collect and analyze big data accurately. Even though IoT offers many conveniences, IoT is still often faced with different problems depending on the company starting from the sophistication of the IoT where not all practitioners understand the features offered to the complexity of IoT itself how to integrate it with traditional systems.

In addition to lean manufacturing and the internet of things that can help improve the production process, a method can improve from the initial stage, namely DFMA. Design for Manufacturing and Assembly (DFMA) is a combination of Design for Manufacturing (DFM) and Design for Assembly (DFA). DFM facilitates all components' manufacturing process and material selection to be assembled, then converted into unit costs. DFA for easy assembly will measure the design efficiency or DFA index and the total assembly time. DFMA is a guide to ensuring a designed product to be efficiently manufactured and assembled. Naiju et al. (2017), in their research, redesigned the pedestal fan product by modifying the shape and reducing the number of components according to the DFMA principle. The total product cost reduction was obtained by 6.8% and cut product assembly time by 15.17%. By applying DFMA, Xin et al. (2019) also proved that DFMA successfully increased the design efficiency or DFA index. The number of components reduced by 25%, and assembly time decreased by 24.92%, increasing product design efficiency to 6.65%. Focusing on reducing the number of components, Volotinen & Lohtander (2017) changed the fastening design so that assembly is faster, which is also an alternative in increasing design efficiency. DFMA's ability to create new, better designs was also developed by combining DFMA with other methods. Azri et al. (2018) conducted a preliminary study of the combination of DFMA with a sustainable concept. By knowing the type and amount of material to be used, Azri can determine how much impact the product has on the environment, such as carbon footprint, water eutrophication, and water acidification. Butt & Jedi (2020) also succeeded in combining the DFMA method with the Pugh Control Convergence (PCC) method to help select new design concepts and deflection and stress analysis to test the load limits that the product can accept. In the literature review carried out in these five journals, it can conclude that DFMA can design the components of an assembly so that they are easy to handle and assemble into a final product while still paying attention to the realization of the component manufacturing process. DFMA has also succeeded in shortening the prototyping stages of a product and reducing production costs. However, DFMA requires careful planning using the assembly method designed to re-evaluate whether the assembly method is feasible to apply based on its strengths and weaknesses.

What some of the literature reviews have shown, however, is that the understanding of separate manufacturing operating units, no matter how complete, is not sufficiently representative of a company that can be said to be good at manufacturing excellence. Manufacturing systems are much larger than the production facilities or transformation processes that companies use. It includes all functions and activities related to the conceptual, design, production, sales, maintenance, and service of products. Manufacturing companies must constantly remind their manufacturing excellence that maintaining this "system view" is essential to understanding the totality of these functions and the interrelationships between manufacturing systems. It is also essential to recognize that while the need for system suppression is urgent in many ways, it must balance with considerations for unit operations. Based on the results of the analysis and discussion related to manufacturing excellence and its criteria, it was found how recent development was, and the priority targets for each of the criteria summarized in Table 1.

Table 1. Recent development of manufacturing excellence

Criteria of Manufacturing Excellence	Recent Development	Target Priority
PSS (Product Service System)	A value creation concept that combines products (tangible) and services (intangible)	Flexibility and lead time
Manufacturing Safety	Prevent accidents in the work environment of the manufacturing industry from smoothening the production process and increasing productivity	Zero Accident
Overall Equipment Effectiveness (OEE)	Accelerating the process and improving quality to improve is an essential indicator	Visualization of waste
Lean Manufacturing	Beneficial for companies in making continuous improvements to achieve company targets	Less waste and better flexibility
Internet of Things (IoT)	An extension of internet connectivity that can be connected continuously	Provide solutions for high variation Reduce of time Associated Cost
Design for Manufacturing Assembly (DFMA)	Reduces the cost and time of product assembly and has the existence and development potential, especially for each product that grows.	Cost and time benefit

The problem that often occurs in implementing manufacturing excellence is not only one of the systematic applications of existing technology. The problem is developing actual manufacturing science. This need is not well understood, perhaps due to a common misconception that the natural progression of everything is from science to engineering to applications or from basic science to applied science to development. A manufacturing system can mean many things, depending on the point of view taken. Manufacturing operations are placed at the company's center, overlapping and interacting with administration and management, product and process engineering activities, applied science, marketing, sales, and service activities.

6. Conclusions

After doing some literature review, it is found that to achieve manufacturing excellence, not all manufacturing systems of every company are the same, and different companies can use different types of manufacturing systems depending on what the company produces, how the company wants to produce it, how much the production is, and other factors. Several criteria for assessing manufacturing excellence, namely service system, quality, safety, and effectiveness of process support equipment, are essential. In addition, improvement steps also need to be carried out and studied more deeply to meet the appropriate product quality aspects, timely delivery, minimum cost, efficient processing time, customer satisfaction with systems and products, and worker safety.

A Product-service system (PSS) is a value creation concept that combines products (tangible) and services (intangible). By integrating products and services, consumers can fulfill more desires than just using a product with a specific function. The studies above show that the development of existing or non-existent products or services is still needed. Therefore, future research can carry out further investigation of PSS problems. Research related to manufacturing quality shows the importance of quality in a Manufacturing excellence business. Manufacturing Safety aims to prevent accidents in the work environment of the manufacturing industry from smoothening the production process and increasing productivity. Zero work accidents streamline not only the production process but also the costs caused by the losses incurred. Overall Equipment Effectiveness (OEE) application by accelerating the process and improving quality is an essential indicator in the Manufacturing Company's efforts to improve manufacturing excellence.

To meet manufacturing excellence, needed improvement steps with various methods. The Lean Manufacturing method is beneficial for companies in making continuous improvements to achieve company targets. With the implementation of Lean Manufacturing, there will be less waste and better flexibility resulting in an equipped business to thrive in the future. Internet of Things (IoT) is an extension of internet connectivity that can be connected continuously. The application of IoT provides an approach to managing a company's production system, which aims to integrate the production system with internet-based equipment. IoT can provide solutions for high variation so that manufacturers can meet different demand quantities in each period and reduce the time and associated costs for each part to be produced. Design for Manufacturing Assembly reduces the cost and time of product assembly and has potential development, especially for each product that grows. The variety of product types and characteristics will also require research on other issues in the future.

References

Ahuja, I.P.S., and Khamba, J.S., An Evaluation of TPM Initiatives in Indian Industry for Enhanced Manufacturing Performance, *International Journal of Quality & Reliability Management*, vol. 25, pp. 147-172, 2008.

Alvarez, J.C., and Perry, C.M., Manufacturing excellence Approach to Business Performance Model, *European Journal of Business and Economics*, vol. 10, pp. 13-14, 2015.

Amrina, E., and Yusof, S.M., Manufacturing Performance Evaluation Tool for Malaysian Automotive Small and Medium-Sized Enterprises, *International Journal of Business and Management Science*, vol. 3., pp. 195-213, 2010.

Azri, N. M., Effendi, M. M., and Rosli, M. F., Preliminary Studies on DFMA and Sustainable Design Approach: A Case Study on a Cordless Drill, Green Design, and Manufacture: Advanced and Emerging Applications, *AIP Conference Proceedings*, 2018.

Barletta, I., Hoffenson, S., and Johansson, B., Organisational sustainability readiness: A model and assessment tool for manufacturing companies, *International Journal of cleaner production,* vol. 284, 2020.

Butt, J., and Jedi, S., Redesign of an In-Market Conveyor System for Manufacturing Cost Reduction and Design Efficiency Using DFMA Methodology, *Multidisciplinary Digital Publishing Institute*, vol. 4 Design, 2020.

Bu, L., Chen, C. H., Ng, K. K. H., Zheng, P., Dong, G., and Liu, H., A user-centric design approach for smart product-service systems using virtual reality: A case study, *Journal of Cleaner Production*, 280, 2021.

Chandra, A., Chaturvedi, Y and Kumar, A., OEE Enhancement Using TPM in Light Machine Shop: A Case Study, *International Journal of Applied Engineering Research*, pg. 202-208, 2018.

Chang, D., Gu, Z., Li, F., and Jiang, R., A user-centric smart product-service system development approach: A case study on medication management for the elderly, *Advanced Engineering Informatics*, vol. 42, 2019.

Chen, Y. Q., Zhou, B., Zhang, M., and Chen, C. M., Using IoT technology for computer-integrated manufacturing systems in the semiconductor industry, *Applied Soft Computing*, vol. 89, 2020.

Colledani, M., and Angius, A., Production Quality Performance of Manufacturing Systems With In-Line Product Traceability And Rework*, International journal of CIRP Annals-Manufacturing Technology*, vol. 69, pp. 365-368, 2020.

Digalwar, A.K., Tagalpallewar, A.R., and Sunnapwar, V.K., Green Manufacturing Performance Measures: An Empirical Investigation from Indian Manufacturing Industries, *Measuring Business Excellence*, vol. 17, pp. 59-75, 2013.

Gomez, H. R., Gharbi, A., Kenne, J. P., Arango., O. M., and Gress, E. S.H., Production Control Problem Integrating Overhaul and Subcontracting Strategies for A Quality Deteriorating Manufacturing System, *International Journal of Production Economics*, vol. 171, pp. 134-150, 2016.

Groover, M. P., Automation Production Systems and Computer-Integrated Manufacturing, Pearson, 5th edition, 2018.

Gunaseelan, V., and Gerald, L. A., Study on Safety Management System of Manufacturing Industry, *International Research Journal of Engineering and Technology (IRJET)*, pp. 788–790, 2017.

Kurniadi, K. A., and Ryu, K., Development of IoT-based reconfigurable manufacturing system to solve reconfiguration planning problem, *Procedia manufacturing*, vol. 11, pp. 965-972, 2017.

Leachman, C., Pehels, C.C., and Shin, S.K., Manufacturing Performance: Evaluation and Determinants, *International Journal of Operations & Production Management*, vol 25, pp. 851-874, 2005.

Lee, C. H., Chen, C. H., and Trappey, A. J. C., A structural service innovation approach for designing smart product service systems: Case study of smart beauty service, *Advanced Engineering Informatics*, vol. 40, pp. 154–167, 2019.

Li, C. Z., Chen, Z., Xue, F., Kong, X. T. R., Xiao, B., Lai, X., and Zhao, Y., A blockchain- and IoT-based smart product-service system for the sustainability of prefabricated housing construction. *Journal of Cleaner Production*, 286, 2021.

Lu, B., and Zhou, X., Quality and Reliability Oriented Maintenance for Multistage Manufacturing Systems Subject to Condition Monitoring, *Journal of Manufacturing Systems*, vol. 52, pp. 76-85, 2019.

Mulugeta, L., Productivity improvement through lean manufacturing tools in Ethiopian garment manufacturing company, *Materials Today: Proceedings*, vol. 37, pp. 1432–1436, 2020.

Naiju, C. D., Jayakrishnan, V., and Warrier, V., DFMA for Early Cost Estimation of Pedestal Fan*, Journal of Industrial and Intelligent Information*, vol. 5, pp. 1-4, 2017.

Nallusamy, S., Execution of lean and industrial techniques for productivity enhancement in a manufacturing industry., *Materials Today: Proceedings*, vol. 37, pp. 568–575, 2020.

Oliveira, R., Taki, S. A., Sousa, S and Salimi, M. A., Global Process Effectiveness: When Overall Equipment Effectiveness Meets Adherence to Schedule*, International Conference on Flexible Automation and Intelligent Manufactu*ring, pp. 1615–1622, 2019.

Puvanasvaran, A., Yoong, S., and Tay, C., Effect of Hidden Wastes in Overall Equipment Effectiveness Calculation, *Journal of Engineering and Applied Sciences*, 2017.

Reniers, G., On the future of safety in the manufacturing industry, *Procedia Manufacturing*, vol. 13, pp. 1292–1296, 2017.

Suryaprakash, M., Prabha, M. G., Yuvaraja, M and Revanth, R. V., Improvement of Overall Equipment Effectiveness of Machining Centre Using TPM, 2020.

Sutharsan, S. M., Mohan Prasad, M., and Vijay, S., Productivity enhancement and waste management through lean philosophy in Indian manufacturing industry, *Materials Today: Proceedings*, vol.33, pp. 2981–2985, 2020.

Volotinen, J., and Lohtander, M., The Redesign of The Ventilation Unit with DFMA aspects: Case Study in Finnish Industry, *Procedia Manufacturing*, vol. 25, pp. 557-564, 2018.

Wahab, A. N. A., Mukhtar, M., and Sulaiman, R., A Conceptual Model of Lean Manufacturing Dimensions, *Procedia Technology*, vol. 11, pp. 1292–1298, 2013.

Xin, T. J., Farizuan, R. M., Radhwan, H., Shayfull, Z., and Fathullah, M., Redesign of Drone Remote Control using Design for Manufacturing and Assembly (DFMA) Method, 5th International Conference on Green Design and Manufacture, *AIP Conference Proceedings*, 2019.

Xu, D., Li, G., and Zhang, F., Scheduling an automatic IoT manufacturing system with multiple servers, *Computers & Industrial Engineering*, 2021.

Yang, X., Wang, R., Tang, C., Luo, L., and Mo, X., Emotional design for smart product-service system: A case study on smart beds, *Journal of Cleaner Production*, 298, 2021.

Biographies

Moses Laksono Singgih is a Professor in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. Currently, he supervises postgraduate students with topics: a design for manufacturing and assembly (DFMA); quality management; lean six sigma; internet of things; sharing economy; circular economy and product-service systems. He is a Professional Member of the IEOM Society. Please find my publications at www.moseslsinggih.org/publications**.**

Dessy Ahadian is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. She received her Bachelor's degree from the Industrial Technology Department, Institut Teknologi Adhi Tama (ITATS) Surabaya, Indonesia. Her work experience is more than 16 years at one of the biggest international branded footwear manufacturers and worldwide. She has completed the following industrial engineering courses as a work measurement practitioner, lean method developer, and MTM-UAS practitioner in Xiamen.

Winda Puspitasari is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. She received her Bachelor's degree from Safety and

Health Engineering Department, Politeknik Perkapalan Negeri Surabaya (PPNS). Her job experience was almost three years in the areas of quality, health, and environment department. Her research interests are quality, productivity, and industrial management.

Firdausy Anindita Ayudinda is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. She received her Bachelor's degree from the Department of Industrial Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur Surabaya. She works in Dinas Sosial Provinsi Jawa Timur as a staff. Her research interests are of quality, productivity and industrial management.

Aida Aidil is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. She received her Bachelor's degree from Industrial Engineering Department, Universitas Muslim Indonesia (UMI), Makassar. Her research interests are in the areas of productivity and quality.

Arventa Lukas Pranastya is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. He received his Bachelor's degree from Industrial Engineering Department, Institut Teknologi Sepuluh Nopember (ITS). Currently, research with topic design for manufacturing and assembly (DFMA).

Paulino Gamboa is a postgraduate student through the 2019 KNB scholarship program in the Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. He received his Bachelor's degree from the Industrial Engineering Department, Universidade Dili (UNDIL) Timor Leste. His research interests are in the area of productivity and quality.

Afrigh Fajar Rosyidiin is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. He received his Bachelor's degree from Safety and Health Engineering Department, Politeknik Perkapalan Negeri Surabaya (PPNS). His research interests are risk analysis, quality, manufacturing safety, and productivity.

Hari Prasetyo is a postgraduate student in the Industrial and Systems Engineering Department, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. He received his Bachelor's degree from the Industrial Engineering Department, Universitas Trunojoyo Madura (UTM). His work experience is 2 years in a steel construction company and 3 years as an instructor in an official college. His research interest is manufacturing systems. Currently, he is an operator of PDDIKTI at the official university and still active as an instructor with topics: Basic Workshop Theory and Technical Drawing.