Quick response manufacturing and ergonomic consequences in manufacturing environment

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Quick response manufacturing and ergonomic consequences in manufacturing environment

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Abstract. Many methods can be used in manufacturing industries to minimize the wastage. Waste occurred when the output was below the production target and the high rejection rate of the products due to quality issues. One of the reasons is because of the wrong way of working set-up. Inappropriate working environment can cause workers to feel grievances on their limbs with the frequent complaints are fatigue and musculoskeletal. With this complaint, it has an impact on the smooth production process. Many Methods can be used to minimize waste in the manufacturing industry. One of the methods that can be used is Quick Response Manufacturing (QRM) embedded with ergonomics for the work process. Implementation of the QRM and ergonomic methods in manufacturing companies in different countries is still experiencing some constraints. Therefore, this article contains an analysis to identify and evaluate the application of QRM and ergonomics in the Manufacturing industry based on published articles. The approach can be used to assist in formulating the right model in evaluating the strategies for QRM and ergonomic application in the manufacturing sectors.

Keywords. Industry; Manufacturing; Quick Response Manufacturing (QRM); Ergonomics; Work processes.

1. Introduction

Rapid advancement in the manufacturing technology and processes help companies to grow faster by producing good products [1]. Computer Added Design (CAD) and Computer Aided Manufacturing (CAM) technology are very popular among the manufacturing sector in producing customized products with reasonable costs. [2]. Increasing demands for products by consumers force the manufacturers to fulfill the orders by all means. The manufacturers tend to meet the quantity rather than controlling the quality of the products during the manufacturing process [3]. Thus, many rejected parts were produced which increase the waste and lower the performance of the companies [3] [4] [5] [6]. One of the methods that can be used in minimizing waste and improving performance in the manufacturing industry is Quick Response Manufacturing (QRM) [6].

2. Background

QRM mainly focuses on minimizing lead time in the manufacturing environment [6-7]. QRM framework has been successfully implemented in Brazil, Europe and United States of America [7]. Many researchers conducted study on the companies' understanding of the principles of QRM which is a complement of lean manufacturing principles [5] [8] [9]. Among the studies, are to compare the QRM method with Time-Based Competition (TBC) to identify the similarities and differences of the two methods [10]. There are also researchers who combine QRM with TBC where QRM is a follow-up process carried out after TB in reducing Lead Time [11]. Moreover, there is also a combination of the application of QRM and Generic Paired-cell Overlapping Loops of Cards with Authorization (GPOLCA) to get better performance [4]. Whereas Paired-cell Overlapping Loops of Cards with Authorization (POLCA) research used in QRM to support and control material [2].

One of the factors causing lead time is the work process. When the workers feel uncomfortable and stressed at work due to poor work process, they will affect the performance of the manufacturing companies [12]. The perceived discomfort can trigger a level of fatigue in work and impact on productivity [13]. Health and comfort factors of workers are the most important factor in work activities [13]. So it is necessary to improve the work system improvement by re-structuring the facilities in the factory [14]. For instance, modifying equipment used to minimize fatigue and changing work posture that occurs in the manufacturing process in order to reduce waste and increase productivity [15-17]. In identifying and analyzing work processes, ergonomics methods can be used, where ergonomics itself discusses physiology, biomechanics, psychology, anthropometry, industrial success and kinesiology [18].

Incorrect work processes often provide musculoskeletal disorders (MSD) in workers [19]. In the construction industry, the most influential risk factor for the worker is the posture in handling work tasks, strengths and repetition of movements. [20]. Many ergonomic tools are available in identifying complaints experienced by the workers. Among popular tools are Body Nordic Map, Ovako Working Posture Assessment System (OWAS), Rapid Entire Body Assessment (REBA), and Rapid Upper Limb Assessment (RULA) [17-19, 21]. Based on the complaints and studies, many researchers used the ergonomic tools to design the standard framework for the application at different industries depending on the nature of work [22-25]. Many methods can be used to minimize waste. One of the methods used is QRM. Where QRM is a paradigm that can be used in changing and improving the quality of the manufacturing industry [25]. QRM is known to provide effective enterprise-wide strategies for minimizing lead time [2]. As of now, no one has done any research that combines the QRM method with ergonomics in minimizing waste that occurs in manufacturing companies. Therefore, the review of the current research on QRM and ergonomic in the areas of manufacturing should be done to identify the gap and possibility of embedding the methods. Hence the objective of the study is to study the relationship of the QRM and ergonomic consequences in manufacturing environment

3. Roles of QRM and ergonomic

In this study, articles on QRM and ergonomic application in manufacturing were reviewed to identify the problems, methods, tools and techniques in various industries throughout the world.

Based on table 1, within 23 years (1995-2018), QRM research was conducted in USA, India, Brazil, Europe, Portugal, and Malaysia particularly in the manufacturing industry. Due to the magnitude of the manufacturing in these countries are high, therefore QRM is applied to cater for high products demand. While for the less industrial based countries such as Indonesia, QRM is not being applied. It represents only 20% of the total reviewed articles on QRM and ergonomic. However, ergonomic methods are widely used in the world compared to the QRM method (80% of the reviewed articles). It is found that most of the manufacturing industries use similar ergonomic tools such as anthropometry, Nordic Body Map, Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) in their assessment depending on the nature of work. One important finding from the review is that no one has been doing any research on QRM embedded with ergonomics. Therefore, further research for the future is the effort to implement QRM with ergonomics in improving work performance

Table 1. QRM and ergonomics applications in manufacturing environment.

Year	Author	Industry	Tools and Techniques	Country
1995	David[7]	No Indicated	QRM & Capability	USA
2002	Irad &Joseph[1]	Manufacturing	DOE	Israel
2003	Ketut, I Nyoman & IG.G Djestawana [17]	Manufacturing Gamelan	Nordic Body Map & Cardiovascular	Indonesia
2006	Nuno & Silvio [4]	Manufacturing	QRM&GPOLCA&MRP	Portugal
2009	Torik, M.Kholil & Ari[14]	Manufacturing	Anthropometry	Indonesia
2010	Farida[28]	Traffic Control Services	Rula	Indonesia
2011	Yuni [24]	Vulcanized Tire	Anthropometry & Reba & Rula & CATIA	Indonesia
2011	N.Jaffar, A.H.Abdul & F.Mohd[20]	Construction	ERF	Not Mentioned
2011	Agung & Dianasa[15]	Manufacturing	Anthropometry Data	Indonesia
2012	Rajiv[29]	Not Mentioned	Lean Manufacturing & Human Factors	India
2012	Taufiq, Rahmaniyah & Fuad[16]	Printing	Nordic Body Map & Anthropometry	Indonesia
2012	Adhi, Rahmaniyah & Susy[22]	Small Medium Enterprises	Nordic Body map & Design	Indonesia
2013	Siswiyanto [23]	Batik Business	Anthropometry & Body Mass Index	Indonesia
2013	Moacir & Elizangela [11]	Not Mentioned	TBC&QRM	Not Mentioned
2014	Roberta, Rusdi & M.Gasali[30]	Not Mentioned	Nordic Body Map & EFD	Indonesia
2014	N.A.Ansari & M.J.Sheikh [19]	Small Medium Enterprises	Rula & Reba	India
2014	Bong & Chong[3]	Manufacturing	Principle QRM	Malaysia
2014	Ruchi & Ashok[1]	Manufacturing	Flexibility Manufacturing	Not Mentioned
2014	L.Meily, Edy, Nadia & Ike [31]	Hospital	Reba &Nordic Body Map	Indonesia
2015	Zelio, Lenadro & Giles [32]	Automotive Industry	5S & Lean Manufacturing	Brazil
2015	Rio & Ferida [27]	Hospital	CSI & Kano	Indonesia
2016	Bianca & Anca [33]	Not Mentioned	Lean manufacturing & Ergonomic	Not Mentioned
2016	Arminas [34]	Business	Rula	Indonesia

Table 1. Continued.

Year	Author	Industry	Tools and Techniques	Country
2016	Yassierli, Dwina & Inayati[35]	Manufacturing	Reba & QEC (Quick Exposure Checklist)	Indonesia
2016	C.S.Bong & W.C.How[36]	Manufacturing	QRM, POLCA, MCT, TP&WIP	Not Mentioned
2016	Srinivasa & Malay[37]	Manufacturing	Lean manufacturing Techniques & Employee Risk Factors	Not Mentioned
2016	Somnath, Rahul&Sheelratan [26]	Not Mentioned	ERF & Power Loom	Not Mentioned
2016	Ganesh, Gurunath, Sawant & Vahid [38]	Not Mentioned	Reba dan Rula	Not Mentioned
2017	Fabio, Rodolfo & Lara [10]	Companies	Lean Manufacturing & QRM & TBC (Time Based Competition)	Brazil
2017	Moacir, Antonio, Jan, Nico & Gilberto [5]	Manufacturing	QRM & Lean Manufacturing	Brazil, Europe & USA
2017	Fernando & Moacir [9]	Not Mentioned	Lean Manufacturing & QRM	Not Mentioned
2017	Moacir, Antonio, Jan, Nico & Gilberto[5]	Companies ETO/MTO	Lean manufacturing & QRM	Brazil, Europe & USA
2017	Meiza, Ketut & I Made [39]	Business Chips	Nordic Body Map & Design	Indonesia
2017	Kade, Ketut & Nyoman [40]	Farm Chicken Business	Pretest- posttes Control & desain & OWAS	Indonesia
2017	Edgar & Shrawan [41]	Not Mentioned	Working posture & Muskolekeletal	Not Mentioned
2017	In-Ju Kim [42]	Not Mentioned	Lean Manufacturing & Ergonomic Principle	Not Mentioned
2017	Heri [43]	Manufacturing	Ergonomic	Indonesia
2018	Heri [43]	Manufacturing	Antropometrik	Indonesia
2018	IK Widana, Ni Wayan & I Ketut [44]	Not Mentioned	Experimental with the same subject design & Mann-Whitney	Indonesia
2018	Arfian, Susi, I Made & Ida[38]	Manufacturing	SEMG & Nordic Body Map & Uji Wilcoxon & Test T-paired	Indonesia
2018	Farid & Wahyudi [45]	Not Mentioned	Bibliometrik	Not Mentioned

Table 1. Continued.

Year	Author	Industry	Tools and Techniques	Country
2018	Siswiyanti & Rusnoto [25]	Batik Manufacturing	Nordic Body Map & Reba	Indonesia
2018	Jungsun, Yangho & Boyoung [46]	Manufacturing & Construction	Musculoskeletal	Korea
2018	Grooten & Wilhelmus [47]	Not Mentioned	Ergonomic Risk Assessment (ERA) & Musculoskeletal	Sweden, USA & The Netherlands
2018	Bong & Chong[6]	Manufacturing	ETO & QRM	Malaysia
2019	Jordi, Gonzalo & Maria[48]	Airplane Seats	Anthropometry	Not Mentioned

3.1. The development of QRM

QRM is a method that can be used to improve the performance of a company. It can be developed at manufacturing environment including Small and Medium Enterprises (SME) in assessing its effectiveness and success [3]. The principle of QRM focuses on the entire strategy of the company in reducing lead time in the hope of lowering cost, better quality and increasing market share in the face of a growing trend [49]. QRM is very important in many things like the growing number of competitors in the global market, demanding that companies struggle to build a competitive advantage that is very difficult to imitate so that consumers who demand faster product deliveries. Here the QRM roles are highly beneficial for engineer to order (ETO) companies [6]. QRM is used by companies as an effective competitive strategy in planning target markets that focus on reducing lead time across the company, such as POLCA for material system control [2]. In minimizing the lead time which is the main function of QRM, TBC tool can be used to measure lead time performance [11]. So, the core of QRM methodology in the reviewed articles is mainly on how to reduce the lead time. Based on the study that has been done to existing companies (more than 20 companies) in Brazil, Europe and United States with the Make to Order system, QRM has been successfully being used to draw analysis and performance [5]. In the United States, the level of understanding of QRM methodology is higher because their employees are well-trained and aware of the elements of QRM. The barrier for companies in understanding QRM is mainly on productivity planning, timely delivery and low cost mindset.

3.2. The development of ergonomics

Ergonomics is the method used to identify the behaviour, abilities, and limitations of humans [26]. Ergonomics is an effort for workers to have proper occupational safety and health in any work that can put them on risks [27]. Most ergonomics are used to identify factors that cause complaints by the person involved. The usual solution is related to tools design based on anthropometric data. Errors that occur in the work process are part of the waste that must be minimized if not eliminated. According the reviewed journals, ergonomics approach is rising rapidly in the world, including Indonesia, United States, Argentina, Brazil, Chile, Colombia, Mexico, and Peru. These countries place special attention on the welfare and health of the workers by providing designated regulations and enforcement body [45]. The ergonomic research relates to work-based activities either by using tools or performed manually, work processes at each station, material handling techniques and physical environment. Among the examples of the ergonomic studies that have been done at the SMEs in Indonesia are including feeding broiler work [40], adjustable chair [23], portable ice maker machine [22], and coconut scarring machine [30]. The ergonomics methods used to facilitate workers in workplaces have provide comfort and minimize musculoskeletal complaints and increase productivity of the companies. Postural analysis tools used to identify workers' complaints are RULA (Rapid Upper limb assessment), REBA

(Rapid whole body assessment) [13] [14] [19], Anthropometry, OWA, and Nordic Body Map. The main objective of ergonomics research is to reduce and even eliminate the complaints felt by the workers so that they can work comfortably and help to increase the productivity of the products. On the hand, researches use different ergonomics tools depending on the type of work.

4. Conclusions

Many studies have been conducted in identifying and analysing waste, one of which is the lead time in manufacturing companies using the QRM method combined with several other methods. QRM method is the development and complementary of the Lean Manufacturing process. QRM can be combined using TBC, POLCA and GPOLCA methods to minimize lead time. Application of QRM combinations and some of these methods can work well and provide good results. But unfortunately, not all companies understand the process of QRM. So few companies are implementing the QRM process in improving the performance, quality and processes that are available in the company. Among problems of waste or decreased performance is a work process that is not according to the conditions of the workers. So it affects the health of the workers and consequently reduce the production performance, delays of work and increase the waiting time of consumer orders. This research will focus on the manufacturing industry in managing the waste that occurs by the work process factor that is not by the human condition as its employees.

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