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INTEGRATION OF QRM AND ERGONOMICS IN THE DESIGN OF A FRAMEWORK IN IDENTIFICATION COMPLAINTS AMONG AUTOMOTIVE ASSEMBLY LINE WORKERS

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Abstract— The assembly line is the most critical area of automotive manufacturing. The smoothness of the production process depends on the situation and conditions of the environment and its workers. The assembly process is done manually by using humans to install all the related components in the production line. Complaints felt by workers during the manufacturing process can hinder the smooth running of production in meeting capacity, thus affecting the company's performance. Therefore, the purpose of this study is to design a framework for identifying workers' complaints by using a combination

QRM	of Quick Response Manufacturing (QRM) and ergonomics. This framework is expected to identify grievances felt by workers from all aspects of the assembly environment that could potentially impact employment grievances. Framework design is created using the main concept of QRM which consists of time is money, tailoring your dynamics, focusing on the target market segment and thinking gold. Each of these concepts contains ergonomic elements such as workload variables and complaints of musculoskeletal disorders related to production schedules, production time, overtime, facility layout and equipment used. It is hoped that this framework can achieve the desired goal of minimizing work risk in optimizing the production process of the assembly line.

I. Introduction

The automotive industry produces automobiles globally with a systematic increase in production capacity [1]. The industry is constantly evolving from year to year and contributes significantly to the economic growth of the country [2, 3]. Automobile productions consist of various variants with affordable prices based on different categories [4]. The assembly line plays a very important role in the automotive manufacturing line [5].

The assembly line itself is an activity that combines all the components required systematically by workers to produce a complete product unit [6, 7]. The car assembly line consists of the body assembly, painting, interior, chassis and finishing [8]. For some companies, the assembly

process is done manually and repeatedly using human power as the main source [9]. Such work processes affect complaints of musculoskeletal disorders (MSD) among employees. MSD itself is pain and soreness felt in the skeletal muscles of the human body [10].

These MSD complaints can be caused by environmental factors in the assembly production area, workload and body posture while working that do not follow ergonomic principles [11]. In this case, a risk assessment is needed to identify and analyze the pre-existing situation and ways to address these causes [12]. A framework, which is an assessment tool, is a set of theoretical ideas and practical proposals that are easy to understand, effective and applicable [13]. In the automotive industry, the framework is essential to sustain the manufacturing development [14].

The process highlights opportunities to reduce the ergonomic issues in the assembly process [15, 16]. The novelty of the study has created a framework concept by combining the Quick Response Manufacturing (QRM) principles with Ergonomics and the Plan Do Check Action (PDCA) in a process of continuous identification and improvement.

QRM is conceptualized to respond to consumer needs for the product quickly and according to need in order to reduce waiting time [17]. Whereas ergonomics is an approach used in analyzing human, machine and environmental interactions [18]. Moreover, the PDCA function in this framework is used in the process of analysis and production control in reducing waste for continuous improvement [19].

The basic manufacturing concept of the PDCA QRM-Ergonomic integration framework is to identify problems that occur in the assembly line area that can hinder the smooth running of the production process. The PDCA in this framework serves to provide an overview of improvements in working hours

in terms of workload, work position, and work environment including the arrangement of facilities and equipment used that can reduce ergonomic problems and overtime.

Thus, the purpose of this research is to produce a framework design to identify complaints felt by employees using the collaboration of QRM and Ergonomics principles and combine them with PDCA in a process of continuous improvement for the long term. It is hoped that the design of this framework will facilitate the identification of complaints felt by employees from all aspects that exist in the assembly environment.

II. Method and Material

A. Quick Response Manufacturing

QRM is a strategy that can be used by the industry to reduce waiting time, improve quality, minimize costs and provide a faster response to consumers [4, 17]. QRM also can be implemented in high and low-volume mixed companies [13]. QRM itself is a complement to lean manufacturing by using four concepts consisting of [17]:

1. Time is money
   The power of time: this section is an activity that learns how to use time, improve quality and get rid of hidden costs in the hopes of minimizing lead time.
2. Tailor your dynamics
   System Dynamics: Look closely at human, machine, product and user interactions that affect wait times.
3. Focused Target Market Segment
   Organizational structure: the process of improvement in the restructuring of the company structure involved in minimizing the waiting time from every angle of the company.
4. Think Global
   The company's overall strategy: the activity of applying the principles inherent in the company's operating processes in minimizing key time spent globally. QRM applications in all existing supply chain activities consisting of

suppliers, office sales operations, procurement, design, engineering and product development.

B. Ergonomics

One of the most important resources in a company is the human to perform physical tasks of assembly and handling of materials [20]. Ergonomics itself is about the relationship between human beings and their tasks and occupations and the design of objects used [21]. The standard approach that can be used for job analysis processes related to human, machine and environmental interactions is ergonomic purposes [18]. MSD is a disorder often encountered by workers on the assembly line that comes from an inappropriate work environment [22]. Ergonomics is much needed by the industry in improving the work performance of employees [12].

Quality and productivity are influenced by the work environment and work methods that are part of employee performance appraisal [11]. In considering the ergonomic risks of workers in the assembly line section, it is necessary to create performance procedures taking into account ergonomic risk factors [23]. Where ergonomic factors play an important role in employee welfare [24]. Occupational therapists and physical therapists with treatment programs on the stretching exercise line have long-term efficacy against musculoskeletal complaints rather than relying on ergonomic modifications alone [25].

In assessing and preventing the risk of biomechanical excess in the workplace, it is influenced by the interaction of work posture with elements of the workstation and the work environment [26]. There are two methods commonly used in postural risk assessment in the workplace, namely RULA (Rapid Upper Limb Assessment) and Reba (Rapid Whole-Body Assessment). From year to year, many companies try to use external support devices such as exoskeletons which are introduced as a new technique to improve employee condition

and reduce the risk of musculoskeletal injury [27].

C. Plan-Do-Check-Action

PDCA is the most widely used method in continuous improvement processes in the service and manufacturing industries [28]. Several studies have been conducted using PDCA in collaboration with other methods, such as the application of PDCA with lean manufacturing [1]. PDCA is mostly used in repairing defective products produced by the manufacturing industry [29]. In addition, PDCA is used in an ergonomic framework that can streamline the assembly process [16], and design the workforce for sustainable processes in all criteria that can improve product quality [19].

In addition, PDCA is also used to create a lean ergonomic concept framework for assembly process [16], sustainable workforce design in the process of analysing various criteria [19] and still uses PDCA mainly improve the quality products all existing sectors. In the investigation, the concept of PDCA is also used in the analysis and process of continuous improvement.

III. Methodology

There are several stages undertaken in achieving the intended goals in this research. The stage consists of:

1. Conduct direct observations and employee interviews.
   This process is done directly by using the help of a camera to take pictures and record the activities of workers at work that show their posture and working methods. Workers work manually and only use simple tools such as hand drills in the process of assembling car components. This kind of work process has an impact on MSD complaints for workers so that an ergonomic assessment of workers is required [30]. This observation process is complemented by the activity of interviewing assembly workers to find out the complaints that are felt [31]. The interview is expected to provide clearer

information about the production process on the assembly line [32].

2. Review the literature on the methods to be used in dealing with problems that occur in the assembly line.
   The literature are based on the scholar articles for appropriate discussion namely QRM, Ergonomic and PDCA. The goal is to establish the integration of these three methods into the conceptual framework. The ergonomic literature review conducted on the problem of a work environment that should be efficient, safe and provide ergonomic awareness in improving the quality and quantity of production [33].
3. Test the validation of ergonomic variables that will be used in integrating them into the four key concepts of QRM.
   The validation test of this ergonomics variable was conducted using an assessment given by 30 respondents.
4. Design a QRM-Ergonomic-PDCA integrated framework concept.
   The framework design is an integration of three methods used to minimize work complaints felt by employees. It is hoped that this framework can be used and function well to facilitate the process of identification and improvements that will be provided in minimizing time that affects employee complaints.

IV. Results and Discussions

A. Observation of the Assembly Process and Interviews

Figure 1 depicts some of the workers' methods and postures during the assembling process. It works by bending when attaching components to the car body and crouching with one side of the body facing sideways.

During the installation process, the neck rotates, the components are placed into the car body with a small bend, the arms and hands are bent and rotated, and both

feet are used as a force in limb defences.

Figure 1: The way and posture of workers work while working

B. Understanding the Theories of the Concepts of QRM, Ergonomics and PDCA

An understanding of the literature on each concept from QRM, ergonomics and PDCA in conceptualizing the identification framework is essential as they will all be integrated with each other to achieve the desired goals. Ergonomics is a science that is related to risk factors for humans and the nature of the work they do [34]. QRM is a study that focuses on minimizing the time in achieving the goal [35]. While PDCA is a method that is used in continuous improvement activities in considering the minimization of existing waste [36].

The concept of the three methods that are combined into one in producing a framework for the identification of employee complaints on the assembly line.

C. Ergonomic Variable Validation Test

Validation tests were conducted to determine whether the ergonomic variables to be used are valid for inclusion in each QRM concept. Ergonomic variables consist of workload, work position, arrangement of facilities and equipment used. Based on the results of the verification, it is found that the four variables are valid and can be used in the employee complaint identification framework. The results of the verification calculations is tabulated in Table 1.

It can be seen that the verification results obtained in Table 1 for the four ergonomic variables used in creating the framework have a "valid" final result. Pearson correlation evaluation used as a calculation for the validation of each variable. The value of person

correlation (r count) has a value greater than the value of 0.3610 (r table) which means it is valid.

Table 1: Validation Variable Ergonomic

		X1	X2	X3	X4	Total
X1	Pearson Correlation	1	-.040	.061	.131	.525**
	Sig. (2-tailed)		.835	.745	.489	.003
	N	30	30	30	30	30
X2	Pearson Correlation	-.040	1	-.046	-.060	.379*
	Sig. (2-tailed)	.835		.809	.752	.039
	N	30	30	30	30	30
X3	Pearson Correlation	.062	-.046	1	.140	.590**
	Sig. (2-tailed)	.745	.809		.459	.001
	N	30	30	30	30	30
X4	Pearson Correlation	.131	-.060	.140	1	.595**
	Sig. (2-tailed)	.489	.752	.459		.001
	N	30	30	30	30	30
Total	Pearson Correlation	.525**	.379*	.590*	.595**	1
	Sig. (2-tailed)	.003	.039	.001	.001	
	N	30	30	30	30	30

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (1-tailed)

D. Development of the QRM-Ergonomic framework concept of PDCA integration

QRM is a strategy used to reduce lead time and provide a good approach in increasing production speed [35]. QRM can be adapted to environments that produce a large number of products with changing demand for each product. In the design of the QRM work complaint identification framework, it is integrated with ergonomics because the object of study is human beings as employees which greatly affects the smoothness of the assembly process.

The stages in making the QRM-Ergonomic framework concept consist of four QRM concepts in collaboration with PDCA principles. Figure 2 shows the results of the automotive product assembly worker complaint identification framework based on the integration of the three methods namely QRM, Ergonomics and PDCA.

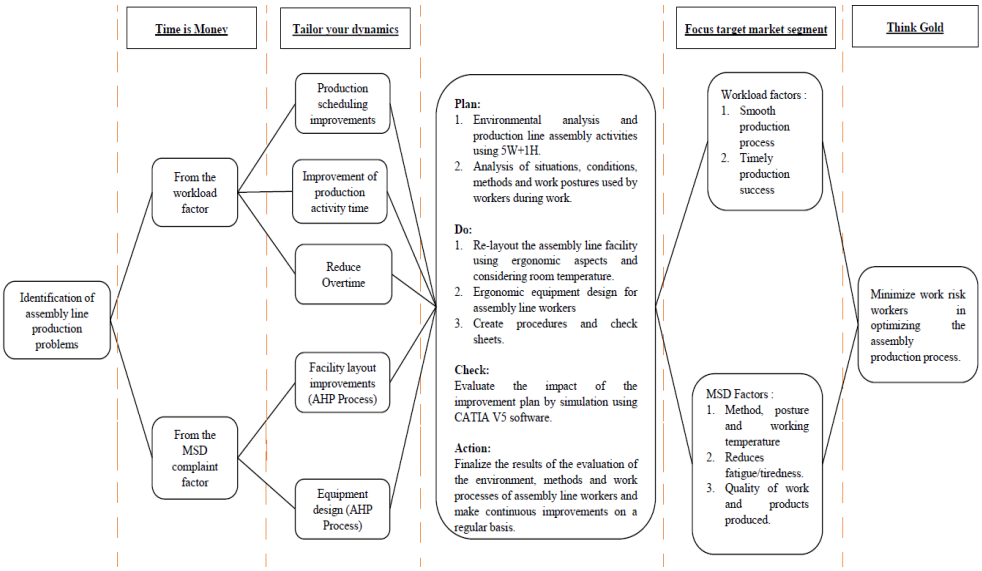

Figure 2: The concept of the QRM Ergonomics PDCA integration framework

Based on Figure 2, it can be seen that the four main concepts of QRM are the main variables used in making the concept of this work complaint identification framework. While ergonomic variables are contained in several QRM concepts that are adapted to the requirements of the QRM concept. While PDCA is a stage of continuity analysis by planning and knowing the results of improvement solutions prepared and implemented. The process carried out in producing the QRM-Ergonomics framework in identifying work complaints felt by assembly workers.

A. Time is Money

This section contains factors that can cause delays in completing production quantities resulting in overtime. In the problems felt by the assembly line workers, the main factors causing discomfort in the workplace that affected the complaints felt were comprised of workload and MSD complaints. Both of these factors greatly influence the smoothness of the assembly process carried out by the workers.

B. Tailor your Dynamics

This element contains with any improvements that can be given from each ergonomic factor used. The workload factors consist of: (1) improvement of production scheduling, (2) Improvement of production activity time (3) Reduce overtime. Meanwhile, from the MSD complaint factors, there are activities: (1) improvement of facility layout (2) equipment design. All stages performed have been adapted to the purpose conveyed from the concept of tailor dynamics.

C. Integration of continuous improvement with the PDCA concept

Before integrating the factors contained in the second concept of QRM, it must first be integrated with the PDCA principle. The PDCA serves to provide better identification of possible causes of complaints than workload factors and MSD. PDCA is one of the methods or techniques used to reduce waste that consists of 4 cycles namely plan, do, check and action [36]. The four cycles of PDCA applied in creating the concept of a framework that is an integration of QRM and ergonomics consist of:

"Plan"

This stage contains an introductory improvement plan carried out in setting goals and processes to achieve the desired outcome [28]. The activities in the "plan" for the creation of the identification framework consist of: (1) Conducting an analysis of the situation and environmental conditions of the assembly line, (2) Conducting an analysis of the worker's activities by looking at body parts, the manner and position of the body during work. The analysis is necessary to find out the factors that cause MSD complaints that employees feel and the improvement solutions that can be given to minimize them.

"Do"

Do is the stage of implementing an improvement plan that has been made in a previous process. The "Do" stage carried out in creating the concept of the introductory framework consists of: (1) Rearranging the assembly

line facility using ergonomic aspects and taking into account room temperature. (2) Design of ergonomic equipment for assembly line workers. (3) Create procedures and check sheets. All three of these improvement activities can be selected as an activity that is closer to the process of reducing complaints felt by priority employees. All of these improvements take into account ergonomic principles to provide comfort to employees and improve performance.

"Check"

This stage is a process of reviewing the results of the improvements applied. In this case, comparison has been done on the conditions before and after to find out the achievement of the goal. The improvement process is done by means of simulation using CATIA V5 software for Ergonomic Complaint Analysis and Evidence for the improvement results from the facility layout design so that the quantity that has been produce is identified.

"Action"

The action stage is the final stage of each improvement given based on the results of the "check" that has been done before. The purpose is to obtain standardization of improvements that can improve quality and quantity. Within this framework, the action stage is in the form of analysing the results of environmental assessments, work methods and processes for assembly line workers and making continuous improvements on a regular basis.

D. Focused Target market Segment

After the PDCA stage which is the integration of the process carried out on the second concept of QRM, the next step is to repair all the parts on the assembly line so that it can have an impact that reduces the time wastage caused by the work complaints. As for the target focus in improving work complaints that assembly line workers feel consists of: (1) smooth process, it is hoped that the assembly activities can run smoothly according to normal

time and even faster with better performance. (2) The success of timely production. This means that all production targets can be achieved according to the set time without the need for more time. Punctuality greatly influences the evaluation of a company's performance by users. Therefore, employees need to be given attention so that they stay away from perceived complaints. (3) The quality of work and products produced. In addition to achievable timeliness, the quality of the product produced also needs to be considered. Timely work processes with high quality products are expected from this activity. This is because of both have a good impact on the overall performance evaluation of the assembly line.

Meanwhile, the expected targets for improving employee MSD complaints consist of: (1) Work method, posture and temperature. Posture and way of working according to the principles of ergonomics and comfortable room temperature have a good impact on employees. Workers will no longer complain of pain in the limbs so that production runs smoothly. (2) Reduce fatigue or tiredness. From the improvements given by taking into account for the ergonomic aspect, it can make employees work well, comfortably and efficiently so as not to feel tired and fatigue while working.

E. Think Global

Based on each improvement activity provided from each QRM concept that takes into account for the ergonomic elements which integrated with PDCA. Thus, the final goal expected to implement the complaint identification framework concept can be achieved. The main goal of this identification process is to minimize work risk in optimizing the assembly line production process. All activities in the assembly line can run smoothly which improves the quality and quantity produced by the workers.

F. Final Analysis

The concept of the resulting complaint identification framework by applying the integration of the principles of QRM, Ergonomics and PDCA methods is expected to provide ease for workers in identifying the causal factors and solutions that can be provided. Everything is inseparable from the ergonomic aspects for the comfort of workers, QRM from the time side and PDCA for the continuous improvement process. So, it is expected to be effective and easy to use.

V. Conclusion

This study produces the concept of QRM-Ergonomics framework with PDCA as an integration process in the process of continuous improvement of the problems experienced by employees in the work environment. PDCA serves as a process, analysis and corrective action that takes into account ergonomic factors. This framework was created based on complaints by employees such as MSD. It affects production which is not smooth so it requires more time in achieving production targets. The function of the QRM concept is to minimize time in the assembly process due to perceived work complaints.

There are four main concepts of QRM which consist of time is money, customize your dynamics, focus on target market segment and think gold. Meanwhile, Ergonomics serves to identify and provide solutions to reduce complaints felt by employees from all aspects such as work position, workload, arrangement of facilities and equipment used. The PDCA in this framework serves to analyze and conduct tests to find out changes in the solutions provided on an ongoing basis. It is hoped that this framework will assist the relevant parties in identifying and resolving the problems felt by employees in the assembly environment. The final goal expected in the implementation of this identification framework is to reduce work complaints in optimizing the production process of automotive product assembly.

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