

Ergonomics As a Lean Manufacturing Tool for Improvements in a Manufacturing Company

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Abstract— Lean practices in manufacturing involve the elimination of wastes. Seven types of waste have been identified in manufacturing systems, one of which is motion. Motion refers to the extra steps taken by employees to accommodate inefficient layout, defects, reprocessing, overproduction or excess inventory and also inadequate equipment design. Ergonomics is a way of designing workstations, work practices and work flow to accommodate the capabilities of workers. Good ergonomic design will reduce awkward postures or excessive effort during work. In this study, ergonomics analysis was carried out in a manufacturing company, focused on the movement and postures of the workers while doing work as part of the lean exercise taken by the company. Non-value added motions were observed and evaluated using questionnaires, motion time study and also assessed using the rapid upper limb assessment (RULA) tool. The modified Nordic questionnaires were distributed and some workers were taken as samples for the RULA assessment. The results showed that the body region affected by work related musculoskeletal disorders are the low back, upper back and also the shoulder. The RULA score also showed that the operators experienced pain in the neck, trunk and leg. Based on these results, ergonomics intervention can be used as tool in reducing motion through identifying the ergonomic risk factors while doing work. The aims of ergonomics and lean are aligned to eliminate or reduce waste especially non value added movements. The ‘waste’ motion of ergonomics such as stretching, bending, awkward postures and extensive reaching can, not only contribute to the safety and health of workers but also productivity and efficiency.

Keywords— *ergonomic, risk factors, WMSD, RULA, lean manufacturing*

I. INTRODUCTION

Wastes generated in production are various and excess motion is one of the wastes. Operator usually use longer route to transfer products from one station to another station. In addition the machine arrangements are one of the factors of the longer route. While transferring the parts or products, operator might hold heavy boxes or push a heavy full loaded trolley. Operator did the transferring job repeatedly for the 12 hour shift. The ergonomics information is not very well known among the manufacturers and the importance of it is not widely spread. The waste reduction improvement activities usually related to the lean manufacturing activities only. Work-related musculoskeletal disorders (WMSDs) are a major concern in industry which can also compromise competitiveness due to costs related to worker compensation, labor turnover, absenteeism, poor quality and reduced productivity. Work related Musculoskeletal Disorders (WMSDs) and in turn reduce worker productivity and product/work quality and increase cost. It would, therefore, be extremely difficult to attain the objectives of the manufacturing industries without giving proper consideration to ergonomics. Many ergonomics problems in Malaysia remain unsolved. The logic behind ergonomics and its benefits is that ergonomics optimizes the interface of human physical and mental aspects with machines and the environment in developing a conducive working environment. Thus, an ergonomically-designed workplace is less error-prone and more productive than otherwise it might be. Better quality products can be produced and workers will have better Occupational Safety and Health (OSH). A low cost ergonomics investment giving many benefits is cost effective. Due to limited education in the field of ergonomics, the level of knowledge and awareness of the discipline among Malaysian engineers and managers is low.

II. LITERATURE REVIEW

6S is about eliminating waste and maximizing value-added work. 6S uses to create and maintain an organized, clean, safe, and efficient setting that enables the highest level of value-added performance. This means eliminating search, travel, transporting materials, inventory, and hazards. It achieves its ends by introducing organization and orderliness, eliminating unneeded materials, and establishing self-discipline [20]. Benefits of adding safety to 5S is to focus on safety, used in areas with more hazardous processes it ca-

Ergonomic is a way of designing workstations, work practices and work flow to accommodate the capabilities of workers. Good ergonomic design will reduce the risk factors which will contribute to the ergonomic illness such as sprains and

strains and cumulative trauma disorders(CTDs). Awkward postures or excessive effort during working will cause a damaged to the ligaments, tendons, nerves and also blood vessel. Ergonomic injuries and illness such as carpal tunnel syndrome, tendinitis and musculoskeletal disorders(MSDs) are across all industries and occupations. The highest illness and injuries are from the manufacturing, retail and service industries. MSDs has associated with cost of the business directly and indirectly. Direct costs includes medical services and compensation while indirect cost are turnover, absenteeism and retraining

Workplace risk factor and ergonomic stressor has been studied in the manufacturing industries in South Africa[Gillian et. al,1993]. Four companies involved and sixteen job associated in the study. The findings reported that pain are associated with jobs components of force and observed unnatural postures. The most common and developing injuries is the low back pain causes by driving motor vehicles, prolonged sitting, whole body vibration and sudden, frequent or heavy lifting.

MSDs are disorders that affect the musculoskeletal system, resulting from a repetitive exposure to loading. Upper limbs (the hand, wrist, elbow and shoulder), the neck and lower back are particularly vulnerable to MSDs. Lower limbs and the upper back may also be affected. Work related Musculoskeletal Disorders (WMSDs) and in turn reduce worker productivity and product/work quality and increase cost. It would, therefore, be extremely difficult to attain the objectives of the manufacturing industries without giving proper consideration to ergonomics. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can enhance worker productivity; provide worker safety, physical and mental well-being and job satisfaction [21].

One of the well-known analysis tool is RULA (Rapid Upper Limb Assessment) technique. RULA was proposed to provide a quick assessment of the loading on the musculoskeletal system due to postures of the neck, trunk, and upper limbs, muscle function, and the external loads exerted. Based on the grand score of its coding system, four action levels, which indicate the level of intervention required to reduce the risks of injury due to physical loading on the worker, were suggested [16].

TABLE I. COMPARISON BETWEEN RULA, REBA AND OWAS [23]

Method	Metrics	Observation Strategy	Strength	Limitations	Decision rules	Potential user
RULA	Sum score of weighted item	No detailed rules	Easy to use. Computerized registration available in public domain.	Right and left hands. Have to be assessed separately but there is no method available to combine these scores. Does not consider duration of exposures.	Tentative limits indicating level of risk.	Researchers , ergonomist
OWAS	Frequency of item	Time sampling	Widely used and documented.	Does not separate right and left upper extremities. Assessment of neck and elbow/wrist are missing. Posture coding crude for shoulders. Time consuming. Does not include the sequential posture consider repetition or duration.	Decision rules based on frequency distribution arbitrary.	Researchers
REBA	Sum score of weighted item	Most common/ prolonged /loaded postures	Rapid to use. Computerized registration available in public domain.	Right and left have to be assessed separately and there is no method to combine this data. The user has to decide what to observe. Duration and frequency of items not included.	Tentative limits indicating level of risk	Researchers , ergonomist

III. METHODOLOGY

There are three main approaches which are the questionnaires, operator observation and motion study. The questionnaire form will be circulated in this study among the manufacturing workers. This questionnaire form will be used for data collection identify workers risk factors. In addition, RULA Assessment sheet will used to evaluate the movement of body region of the workers while doing their job. This approach is the time study which is a Lean tools to identify non value added of the workers job.

Questionnaire will design to obtain the information about the lean implementation and also about the ergonomics knowledge among the workers at the company. Questionnaires were completed through interviews. Interviews were confidential, undertaken in work time but away from the workplace in a confined office and lasted approximately 15 minutes for each individual. Frequency and descriptive analysis of data from the questionnaire was accomplished using Microsoft Excel 2013

The assessment used to evaluate the body region moved during workers doing their job and scores will be recorded on the movements. Total of the score will identify whether the job need investigation in future or need rapid change to reduce the musculoskeletal disorders among workers.

Motion time study is one of method to identify the non-value added in the workers job such as walking, recording or checking. All the non-value added will be listed and future improvement will be discussed.

IV. RESULT

A. Questionnaire Analysis

Workers were asked few questions about perceived pain/discomfort, which lasted, for at least 24 hrs. Pain was measured at past 12 months, last month and 7 days. Results are presented in order as mentioned above.

During the last 12 months, 20% (5) of the respondents reported pain on low back and 8% (2) on the neck. Of about 32% (8) of the employees complained of upper back problem. And 12% (3) of the employees had shoulder problems. Concerning elbows and ankles/feet pain, 4% (1) of the employees complained. There are 5 operators no complaints were reported.

During the last month, 16% (4) of the employees complained of low back pain, 8% (2) of the employees complained of the neck, 28% (7) of the employees complained of the shoulders and 8% (2) of the employees complained of the wrist/hand problems. About 24% (6) of the employees suffered from upper back pain. About 4% (1) of the employees suffered from elbows and ankle feet.

For the last 7 days, 16 % (4) of the employees had an episode of low back pain. About 36% (9) of the employees suffered from upper back. The employees suffered from shoulders is 24% (6). Of about 8% (2) of the employees had an episode of pain on the neck, 24% (6) shoulders and 4% (1) elbows.

B. RULA

The objectives of the study is to evaluate the workers posture while doing his/her job. Hence, there are four workers which assess using the RULA Assessment Worksheet. The assessment focus on the upper arm, lower arm, wrist, neck, trunk and leg position during workers doing their job. Several number of operator assessed on the working postures which each of them handle a piece of metal that has been stamping and also parts that joints using spot welding process.

TABLE II. SUMMARY OF RULA RESULT

	Table A (Arm & Wrist)	Table B (Neck, Trunk & Leg)	Table C (Final Score)
Opt 1	5	7	7
Opt 2	5	7	7
Opt 3	5	6	7
Opt 4	4	7	6

The RULA assessments shows that most of the operators critical parts contribute to the risk factors is the neck, trunk and leg analysis. They bend their trunk when lifting or transferring the parts from the container or into the container. The bend more than 20 degree from normal line and this produce stress on their body.

TABLE III. POSTURE ANALYSIS OF THE OPERATOR

No	Picture	Description	No	Picture	Description
Opt 1 Posture 1		Arm ranges	Opt 2 Posture 1		Neck ranges >20°
Opt 1 Posture 2		Arm ranges	Opt 2 Posture 2		Arm ranges
Opt 1 Posture 3		Trunk ranges - bend to 90°	Opt 2 Posture 3		Trunk twisted
Opt 1 Posture 4		Arm ranges- straight hand with load	Opt 2 Posture 4		Trunk ranges >60° Leg bending
Opt 3 Posture 1		Neck ranges and shoulder	Opt 4 Posture 1		Arm ranges – full extension

<p>Opt 3 Posture 2</p>		<p>Trunk ranges – low back</p>	<p>Opt 4 Posture 2</p>		<p>Arm ranges – awkward posture</p>
<p>Opt 3 Posture 3</p>		<p>Arm ranges- extension</p>	<p>Opt 4 Posture 3</p>		<p>Neck ranges - extension</p>
<p>Opt 3 Posture 4</p>		<p>Hand and wrist</p>	<p>Opt 4 Posture 4</p>		<p>Trunk ranges</p>

C. Motion Study

The graph shows the average 10 minutes job done by four workers. The first worker is at the stamping section others are working at spot weld section.

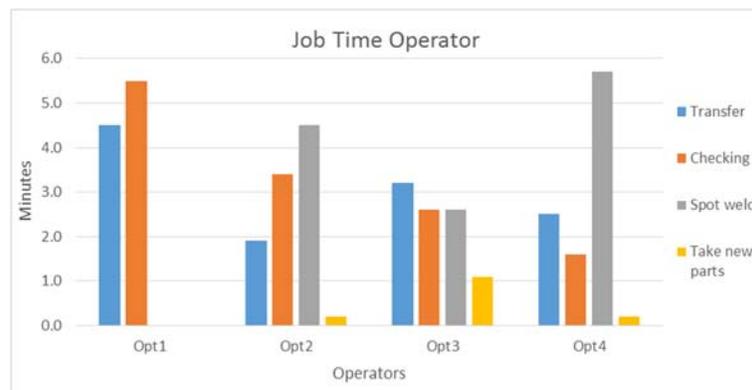


Fig. 1. Job time Operator (minutes)

The graph shows the activity or job by the workers which are transferring, checking, spot welding and also taking new parts. The transferring activity is the most significant job which three workers studied on the working motion. The checking motion also the main activity by the workers and during checking activity, the workers put stress on the shoulder because workers need to nod down their head to check the parts. For Opt 2 and Opt 4, the spot weld process contribute to the risk factors as the weld machine are hanging and they need to use upper bodies to use it. Other workers are using the spot welding machine which attach to the work station

V. DISCUSSION

A. *Lean 6S Ergonomic*

There is a strong correlation between Lean and safety. The new version of the 5S is called 6S in which “safety” is added that aims at creating a safe workplace for the employees. Many Lean improvement studies in manufacturing environments have been conducted and focused on different Lean aspects. However, a limited number of studies were conducted to improve the safety in the workplace to support the lean implementation process, some examples are given in. The current study focuses on the assessment of ergonomic risks in a manufacturing workplace to eliminate/reduce the risks and improve the performance of the operators.

B. *Tools and Equipment Design*

The main equipment used in the manufacturing process is the container where it holds the parts before transferred to the next process. The container are the basic one where there is not even a wheel to help the operators to move the container at the working area. The company should invest on the new design of container which has the wheel and also the lifter where the position of the container will not force operators to bend too much to gather the parts or to arrange the parts in it. The other option for new equipment design is table with turn or tilt features. The tilting features makes the parts gather more easily and workers do not have to bend their trunk too much.

C. *Checklist for Ergonomics Improvement*

There are several risk factors that make manual handling tasks hazardous and therefore increase the risk of injury. The risk factors for MSDs are: length of the MHL, posture of the body, exerted force during the manual handling and frequency of movements. The checklist includes questions related to all aspects of manual handling and offers examples of preventive measures that can help to improve handling and therefore reduce risks. A checklist can help identify hazards and potential prevention measures and, used in the right way, forms part of a risk assessment.

D. *Design a Better Workspace for Workers*

The observation shows that the workspace area of the workers are not well designed which forces the workers to do awkward posture and extensive hand reach. When the workers are using their hand out of the comfortable zone, the performance of workers will decreased as they have to reach the components which far away or do some extra motion to reach the components. Hence, workspace design must fit to the workers condition. The power zone is the lifting region that is considered optimal by ergonomists area extends from approximately standing elbow height to standing knuckle height and as close to the body as possible

VI. CONCLUSION

As a conclusion, the study was successfully conducted. All the tools that planned to use in the study was used and the result are as expected. The objectives of the study have been achieved by identifying the risk factors among the workers of the company. The result obtained help to determine the control measure that should be taken by the company. All tools indicate earlier used to achieve the objectives. The questionnaire designated and distributed has collected the data on the risk factors of WMSDs among workers. The scores of RULA assessment showed that the most of operators showed in the neck, trunk and leg having scores 3, 4 and 1 consecutively. The scores are in line with the survey feedback from the operators.

The company can choose whether to apply the recommendations proposed or not. In future, the ergonomics factors has to be highlighted as important aspect to the company in order to produce safety working environment and also can protect the workers from any disorders. Currently, most companies only implementing lean tools and not consider the safety aspects to the workers. Hence, by conducting the study, the company can provide safety and healthy environment and working condition to the workers. In addition, the performance of the company can be excelled as the health of the workers are secured and it is one of the advantages to the company.

The study showed that ergonomics can act as a lean manufacturing tools as it can be used to identify hazard and also ergonomic tools reduce the risk factors associated with the risk. Align with the lean purposes which is eliminate or reducing

waste, ergonomic also aims the same and the main concern on the safety aspect where the risk factors reduce or eliminated and less injuries, disorders or accidents occurs. Waste motion of ergonomics that can be reduced are stretching, bending, awkward postures and also extensive reaching.

VII. RECOMMENDATION

In order to further study of the ergonomics factor and lean tools in manufacturing company, there are some recommendation and suggestion. It is recommended to the company to give the employee training about ergonomics so that in future the company can achieve more safety environment.

Besides, the company can construct the questionnaires to evaluate how the opinion of the workers on ergonomic workplace in the working areas from the employee point of view. The better working environment will give the better satisfaction to the employees to do their jobs in the company.

In the study, the questionnaires and RULA method has been used. In the other hand, several others method can be used to evaluate the risk factors in the company. Some examples are REBA and OWAS which this two tools act similar to RULA method.

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BIOGRAPHY

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