A case study on implementing lean ergonomic manufacturing systems (LEMS) in an automobile industry

Srinivasa Rao P¹, Malay Niraj²

¹Department of Mechanical Engineering, NIT Jamshedpur, Jamshedpur, India
²Department of Mechanical Engineering, NIT Jamshedpur, Jamshedpur, India
E-mail: 2013rsme015@nitjsr.ac.in

Abstract: Lean manufacturing is a business strategy developed in Japan. In the present scenario, the global market is developing new techniques for getting more and more production rate with a good quality under low cost. In this context, human factors have to be given importance to their working conditions. The study demonstrates the adoption of ergonomic conditions in lean manufacturing for the improvement of organizational performance of the industry. The aim of ergonomics is to adapt the new techniques to their work in efficient and safe ways in order to optimize the human health conditions and increasing the production rate. By conducting survey on various disciplines and showed how the production rate and human ergonomic conditions is affected.

Keywords: lean manufacturing systems, ergonomics, ergonomic risk factors, LEMS, organizational performance.

1. Introduction

A widely used tool some time since the 1940 season in order to get a (Lean Production) for a production system Lean Manufacturing is a model that serves to facilitate competitiveness in several segments, aiming to eliminate waste (not Value Added) and also in improving working conditions. For the auto companies when the application of Lean Manufacturing is to be improving production processes from the supplier of raw materials and consumption to its final production of their products. Enabling with some tools to help in this application to a set of activities encompassed with better resources and lower costs.

The Lean Manufacturing opens up a range to insert other tools that aid, such as: (Kaizen, 5 Senses, Poka-Yoke, Takt-Time, Balancing stations or workstations, supply flow of parts and products, Flow Mapping Value, Safety, Ergonomics, etc.). In the application of Lean Manufacturing should be made a direct correlation between vision of working conditions with a support tool mentioned the (Ergonomics). Each continuous improvement held in any work environment, this correlation can be carried out in order to adapt the improvements to the executor of activities[1]. The common 8 wastes of lean manufacturing are shown in below figure 1.
The aim of ergonomics is to develop and adapt the human comfortable techniques to their work for performing the given task in a safe and efficient way by increasing the productivity. The ergonomics concept applies to the quality of comforts of the machine to its operator, by providing an effective handling, avoiding the ergonomic risk to its operator while operating the task. The repetitive stress injuries (RSI) are the most common physical problems that can cause limitations or inability to work. Using ergonomic solutions in the workplace is an initiative that can significantly increase the levels of satisfaction, efficiency and worker efficiency.

The ergonomics concept was defined in different ways by various researchers in their research. Below table 1. shows the definitions of ergonomics by previous authors [2].

**Table 1. Denotations of Ergonomics**

| Authors            | Definition of ergonomics                                                                                                                                                                                                 |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Te-Hsin & Kleiner  | Ergonomics is a combination of the words ergo, a Greek word meaning "work" and nomics, meaning "study" - the study of work Science which deals with the Synchronization of human physical working conditions with the design structure of different equipments and their capacities and requirements. |
| Tayyari & Smith    | A branch of science that is agitated with the success of optimal relationships between workers and their work environment                                                                                                                                               |
| Lee                | Stimulating similarity between humans and devices                                                                                                                                                                          |
| Fernandez         | While Considering the human’s physical, physiological, biomechanical and psychological capabilities for designing the workplace, equipment, machine, tool, product, environment and system for optimizing the effectiveness and productivity of work systems by assuring the safety, health and wellbeing of the workers. In general, the aim in ergonomics is to fit the task to the individual, not the individual for the task. |
| Brooks            | A system of connecting elements which combines the worker, the work environment both physical and organizational, the task and the workspace                                                                                                                                  |
From the above definitions, the well saying philosophy of ergonomics is mainly about the relationship between humans, machine equipments, job nature and the work environment. Below figure 2, shows the injury type claim counts in an industry, where the ergonomic conditions are not given importance. This is why the author tries to improve and implement the human well being conditions in an industry to decrease the injuries, accidents to the employees [8].

![Injury type claim counts](image)

**Figure 2.** Injury type claim counts

According to the study of Yelin et al. [9], 90% of disabled older workers had musculoskeletal disorders (MSDs). Praemer et al. [10] study states that the treatment for the MSDs problems will cost about tens of billions of dollars. These statements spectacles the studies on ergonomics as an important to develop the best prevention methods of the MSDs which can benefit the employer and also their workers.

Every organization and individuals have to be aware of MSD injury risk factors and must be skilled in recognizing and categorizing these factors in the future, and finding the solutions to reduce the frequency or duration of exposure to these risk factors. Reducing risk factors in the work make the task smoother and easier resulting more productivity. Reducing risk factor exposure should make task performance less variable.

### 1.1 Ergonomics Risk Factors (ERF)

Industrial work environment is generally designed for the movement of products and to fix machines effectively. As the humans being adjustable to every situation, usage of work place by people draws less attention to all. Because of the ignorance of people in this environment causes more accidents and injuries to them. Due to increase in number of injuries brings more attention towards ergonomic conditions of the humans in the work place. This makes the ergonomics has a critical driving factor in the industry. According to Hagberg et al. [11], ergonomics and human factors are often used interchangeably in workplaces. Both describe the interaction between the worker and the job demands. The difference between them is ergonomics focuses on how work affects workers, and human factors emphasize designs that reduce the potential for human error. Bongers et al [12]
states that aware of traditional and environmental risk factors keeps human free from injuries and accidents.

Repetition of work, long time force, awkward posture, vibration in body, contact stress, static loading and work in extreme temperatures are considered as the major ergonomic risk factors for people. Risk factor revelation is an early warning of increasingly more hazardous, like physical signs and symptoms of humans that can lead to serious injury. Human life is affected by long run exposure of risk factors. Working with the arms abducted away from the body, overextended and shoulders hunched places these joints at the end of their normal range of motion, requires higher muscular force and greatly increases the risk for injury. Strained sitting positions, such as tilting sideways, twisting the vertebral column, bending forward or slumping begin in response to compensation for specific work relationships but can become habit over time.

2. Lean ergonomic manufacturing systems (LEMS)

This study presented was applied in a factory with production of automotive vehicles installed in the state of Jharkhand, India. And with approximately about 1700 direct employees and three production shifts. The kind acts with the lean production system based on the Toyota Production System. The application of Lean Manufacturing is part of the lean process that organization to eliminate waste and reduce production costs and Ergonomics it is part of the concept of tools that same production system in order to provide good working conditions for employees and consequently the welfare of the same. However, when there is a realization of applicability of tool concepts to seek improvements and cost savings for this Organization, the rule has to be followed according to the methodologies and also following your current Production System. In the application of Lean Manufacturing, the correlation was performed with the tools that help this Production System and were also applied some tools with techniques for achieving results [13].

After the advent of the production system called "Toyota Production System", began a new way of thinking, with a lean process and without waste and, consequently, reducing costs, without forgetting the worker welfare, improving conditions of their work environment. Through many studies and the emergence of ergonomics after World War II, entrepreneurs and society observed that the condition of well-being in the workplace is directly proportional to productivity and employee effectiveness in carrying out its tasks [9]. Many companies looking to adopt Lean principles, in many different industry segments, such as aerospace, automotive, consumer products, industrial products and metallurgy, construction, administration [14].

Similarly ergonomics also deals with the human well beings in the working environment of the industry. Similar like the lean manufacturing process, ergonomics also have the various implementation phases in order to be implemented in a right direction. The different phases of the ergonomics are shown in the below figure 3.
The future activity challenge is to provide the space of possible choices to evaluate to what extent the design choices allow the implementation modes compatible for operation with the chosen choices, in terms of health, productive efficiency, personal development, and also about the collective work [6].

A decision support system (DSS) model is defined to help in decision making process in the integration of ergonomics and the lean manufacturing continuous improvement process. This is useful for both the expertises and the upper level managers in the continuous improvement process which is shown in figure 4.

3. Methodology

So far, the author dealt with the lean manufacturing techniques and employee risk factors in the previous sections and he adopted these techniques in this factory. For this, he created a questionnaire which consists of about 20 issues regarding various departments with the qualitative and quantitative responses to identify the view of employees in relation to the post, workstation, ergonomic factors and organization of these production methods and techniques.

These feedback forms consist of 20 questions with answers which are explained to each person by rigorous training method for filling it on 0-5 point scale. These feedback forms were given at random about 50 employees in various expertises like technician, foreman and manger level. Most of the feedback forms given to manufacturing side as the most of the work relays on lean manufacturing, working conditions and ergonomics human
factors only. The distribution was 20 Manufacturing, 5 engineering, 5 Maintenance, 5 Quality, 4 Logistics, 2 RH, 2 Suppliers, 5 Ergonomics, 1 Occupational Safety, 1 Communication. After collecting the data, it is observed that 36 samples nearly 72% have given a positive response towards the adoption of lean manufacturing techniques with continuous improvement process for the progress of ergonomic conditions of the employees and organization performance as shown in below table 2.

Table 2. Results of ergonomic technique implementation

| Point Scale | Description       | No. Of Feedbacks | Percentage(%) |
|-------------|-------------------|------------------|---------------|
| 0           | Poor              | 0                | 0             |
| 1           | Below Average     | 1                | 2             |
| 2           | Average           | 2                | 4             |
| 3           | Good              | 3                | 6             |
| 4           | Very Good         | 8                | 16            |
| 5           | Excellent         | 36               | 72            |

The survey made for this study is a tool concept, which had given a good response for cost reduction and good working conditions of employees within the lean production system. The methodologies adopted and experienced on daily basis has modified the organization and made to run in an improving direction. Adoption of lean manufacturing principles made ergonomic condition factors to the best of the employees. Some of the employees review:

1. I think, when a company gives value to the employees, it will definitely run in an improving direction.
2. I am unfortunate to express my views as i didn’t expect this type of drastic change results a very good overall improvement in my company.
3. I attended to several modifications aimed for improving ergonomic human factors and the expertises came to me for my ideas regarding my department as i did the maximum operations in the department.
4. I felt very happy that the expertises changed the working environment with new principles and also the attitude of the employees in a positive way.

In this context, the author suggests to conduct this type of surveys for the better development of the industry and also to know the present status of the industry. Everyone must know about the preventive targets of their work in order to avoid accidents.

This study draws an attention that the continuous improvement given to the lean manufacturing principles gives the positive improvements in the production rate relating to the better working conditions of their employees. While implementing the continuous improvement process the degree of importance to various fields is given below shown in Figure 5. However the management, employees has known that the ergonomics has correlation with the production rate. Better ergonomic conditions will sustain the productivity.
4. Results

The results had showed the reduction in absenteeism of the employees, as they are interested to work in the better working conditions and to increase their income. Often they are putting their full effort to get the desired output with the best quality and quantity. Now, let us see the impact of these improvements on the product quality.

For getting a product with good quality, there is a need of consideration of the manufacturing process from the starting of the process of the production lines. From the survey, it is observed that the improvements made for the well tool applied with the improvements set gets a good working condition and has a positive and well-significant result for both employees who can perform operations and make quality, and for the organization that relies on the quality of its production carried out by its employees. This shows the improvement in the quality of the products. In the same way, considering the average defects before and after implementation of these techniques gives the positive improvement in product defects and other fields as shown in below Figure 6, 7&8.

![Degree of Importance](image1)

**Figure 5.** Indexing the degree of importance

![Absenteeism](image2)

**Figure 6.** Indexing absenteeism of employees

![Defect rate](image3)

**Figure 7.** Indexing defect rate
Figure 7. Indexing product defects per unit

![annual costs](image)

Figure 8. Indexing annual cost loss

Considering the effective production performance of the company is also important by eliminating the waste to reduce the cost. This means producing more with less. In this study there is a reduction of 27% of waste compared to the years from 2012 to Oct 2015, which means a progress for the organization. In relation to improve the ergonomic conditions of the employees gives the improvement in the performance of the industry and the production performance is shown in Figure 9.

![Production Performance](image)

Figure 9. Indexing the production performance

Ergonomics implemented in the workstations brings better results in the various fields of the industry. On implementation of these principles there is an improvement in the organizational performance also. In the present scenario, it is very important to apply these ergonomics methods to all industries and in all fields of applications like marketing, shopping, constructions etc., in order to be competitive to the global market. These ergonomics training supports the employees in new gestures of postures for the working environment to get a good quality product operated at the first time by eliminating waste.

In the current market scenario the new performance evaluation models are required to, check and report the position on the market and motivate progress and the commitment of employees to the changes or improvement projects that are deployed; and to assist in decision making about the process of implementation and management of the improvements and changes within the organization.

5. Conclusion:
Continuous improvement process is getting adopted by the various companies, due to the increase in the competitiveness in the global marketing. Lean manufacturing is a very powerful tool for the improvements in the industry. The integration of Ergonomics during the lean manufacturing implementation has the potential to obtain substantial gains in productivity and to simultaneously improve the working conditions. The model of a framework regarding the integration of Ergonomics and lean manufacturing systems based on the various tools was presented. The proposed framework associates to the lean manufacturing system procedures used in each phase of the ergonomic tools and methodologies introducing an additional ergonomic perspective.

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