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IMPACT OF ERGONOMICS ON PRODUCTIVITY AND COST OF PRODUCTION TO A COMPANY – A CASE STUDY

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ABSTRACT

The quality, quantity, and delivery time of a company's products are critical to its success in any industry. New management concepts such as lean, agile, kitting manufacturing and concurrent engineering among others must be developed and applied by industry. This work focuses on how an ergonomically-based kitting assembly system affects the health and safety of workers in diverse manufacturing businesses. An assembly-oriented industry or one with a large number of repetitive human procedures commonly uses kitting production. Kitting assembly minimizes work space requirements, operator travelling distance and time, and inventory of work in progress. "Improved processes can cut down on considerable amounts of waste and inefficiency in these kinds of businesses. So, in this paper, a thorough investigation was conducted to reduce waste and increase productivity in a manufacturing line. As part of this examination into the consequences of the Kitting assembly system, interviews were performed with managers and supervisors, safety specialists, a safety engineer, and workers. For this purpose, we'll analyses how employees feel about present working conditions and compare them to a new ergonomics-based assembly system and the old one. Because of the improved working conditions, the overall industry productivity increased significantly. Additionally, several significant criteria are grouped into categories for future examination with workers to evaluate the ergonomic level of workers and findings are gathered.

Key Words: Ergonomics, Productivity, Safety, Standard Deviation, Health Problems

1. INTRODUCTION

The term "ergonomics" is derived from the Greek words "ergo" (work) and "nomos" (laws). When it comes to health, human performance, and body activities, ergonomics is a science. To make a product easier to use, ergonomics employs anthropometric data to establish the ideal size, shape, and form of the object. The study of ergonomics is a critical component of product development research. A product's safety, comfort, and performance can all be improved by using this technology. Digitalization, artificial intelligence, Internet of Things, additive manufacturing and cyber-physical systems are all part of Industry 4.0's revolution in automation and robots. Because of its impact on both productivity and human factors, ergonomics is an important consideration for solving manual assembly-related challenges. The repeated nature of the assembly process and the handling of heavy components contribute to the risk of overwork among assembly workers.

Fig.1.1: Ergonomical designed Computer Table and Chair (Image Courtesy: [26])

1.1 The relationship between engineering disciplines and ergonomics scopes

Occupational health and safety and productivity are achieved through the use of ergonomics. Furniture that is safe and user-friendly interfaces for machinery and technology is an important concern in the development of these kinds of products. If correct ergonomic design is not adopted, long-term disability might result from repetitive strain injuries and other musculoskeletal issues. To put it another way, "human factors and ergonomics," or "fitting a work to an individual," is the focus of these disciplines. Considering the user's talents and limitations, it seeks for tasks, functions and information that are tailored to that user's needs and preferences.

Fig.1.2: Ergonomic posture before and after ergonomic intervention on computer chair and table (Image Courtesy: https://physiotherapypedia.com/ergonomics-in-physiotherapy/)

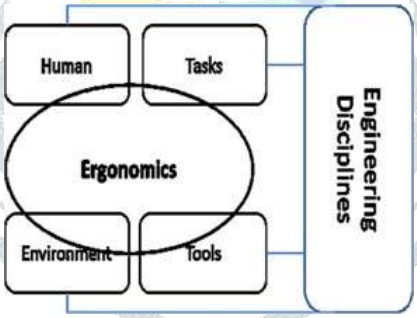

Fig.1.3: Ergonomic relation with Engineering Discipline (Image Courtesy: [27])

Human factors specialists and ergonomists use a variety of factors to determine if a person and a piece of technology are a good match. These factors include the activity being performed, the demands placed on the user, the tools being used (such as their size, shape, and suitability for the task at hand), and the data being used (how it is presented, accessed, and changed). As a field dedicated to the study of people and their interactions with the physical and social environments around them, ergonomics draws on a wide range of fields and disciplines to conduct its research. These range from anthropometry to biomechanics to mechanical engineering to industrial engineering to information design to kinesiology.

2. LITERATURE REVIEW

Westgaard, R.H. and Winkel, J., 2011[1], Overall, this study found that rationalisation has detrimental consequences on physical and mental health, along with risk factors that go along with it. In contrast this gives an empirical basis to conclude that rationalisations have a high potential to cause health problems. As a result, a possible cause for the prevalence of musculoskeletal and mental health issues has been discovered. Findings from studies with moderators show that effective management and equal treatment for all employees have a positive impact on productivity and morale. Battini, D., Faccio, M., Persona, A. and Sgarbossa, F., 2011 [2], Our theoretical exceptions are well-supported by the results of these practical applications. In order to aid in the selection of the optimal assembly layout configuration from the outset of the analysis, professionals should design new and unique qualitative maps that take into account technological and environmental elements. The four maps that the authors have developed are based on a variety of published case studies from the industrial sector. Nadia, H.S. Naeini, S.H. Mosaddad and Naeini, H.S. 2013 [3], More over two-thirds (63%) of students surveyed and interviewed regarding ergonomics definition and scope had no idea what it was; however, this proportion drops to just 20.5 percent if the students of Industrial engineering are omitted. The socio-ecological paradigm's promise in education and innovative therapies to prevent workplace accidents among young workers were brought together by ergonomics. M. Laberge and E. MacEachen and B.

Calvet, 2014 [4], Because of this, it may be necessary to alter the model of work activity regulation in order to better reflect both a healthy and productive work environment and an individual's unique mix of work determinants and resources.

By Ramnath BV; Kumar CS; Mohammed GR; Venkataraman K & Elanchezhian C.; and Sathish S., [5], the researchers did this study; Workers on an assembly line for the automobile industry were the subjects of this study, which looked at the effects of an ergonomic kitting assembly system on worker health and safety. After implementing EKAS, workers can clearly see their better working circumstances, as this study shows. The workers' morale was also boosted by this analysis.
This paper was published in the Journal of the American College of Cardiology (JACC). Working with shoulders and hands at chest level with the back region bent moderately forward is by far the most common position, according to this poll [6]. Other workers said they had to lift loads of less than 5 kilogrammes.
The results of this poll suggested that industrial workers should be more cognizant of their working position in order to avoid harm as a result. In some circumstances, workers are unable to return to work because of back injuries caused by musculoskeletal disorders.
In 2015, Boatca, M.E. and Cirjaliu, B. [7], As the author sought to determine the best model for implementing an ergonomics intervention in the workplace, this research primarily addressed issues related to the organisation. The description of organisational systems from an ergonomics perspective is also critical to understanding the requirements of an ergonomics intervention. Environment and machines [8], are therefore major subsystems of the system. As a result, each system has its own set of ergonomics challenges that must be addressed. A person's working conditions are largely determined by their physical and psychological surroundings. They must meet human requirements and protect public health and safety. Machines, on the other hand, are tools employed in the course of the work. Their design must take into account human preferences as well as the inverse. Design, technology advancement, and occupational health and safety are frequently considered to be the most important areas for ergonomics intervention. Ergonomic interventions are made possible by each of these factors, which play a role in the process.

MARINA CARLOS, BENJAMIN DARIA & ALEXANDRO P. FABIO S. Workplace ergonomics can affect the availability and productivity of labor-intensive industrial systems, according to this article. After conducting several warehouse picking tests, a two-function model of the interaction between human availability, rest allowance and ergonomics level was developed. The impact of ergonomics on the total cost of the system was evaluated using two total cost models (one for a basic system and one for a system with standby units). Standby units, in particular, are preferable and less affected by human availability. In addition, the overall system cost is positively impacted by the global improvement in ergonomics conditions. However, practitioners should do a cost-benefit analysis to determine the economic advantages of ergonomics improvements. In order to reduce the level of ergonomics below a specific threshold, human workers must be replaced by machines.

The Azadeh and Sheikhalishahi research teams TaguchieDEAePCA is proposed for rating GENCOs using HSEE indicators in this paper. The combination of DEA, PCA, and Taguchi is an effective way to rank this industry for all GENCOs. The GENCO's performance is evaluated using all of these methodologies' beneficial and influential aspects. A thorough investigation is required to identify all economic and technological markers. To rate GENCOs in the suggested case study, Taguchi was selected. A sensitivity analysis also confirms the proposed approach's outcomes. A deeper understanding of the strengths and weaknesses of a system's performance may be gained through such studies, which can also help experts and researchers identify the acceptable levels of performance in terms of HSEEfactors. This study's findings could also be utilised to monitor and enhance GENCO's energy supply performance in relation to HSEE parameters on a regular basis. A comparison is made between this study's recommended approach and that of other comparable research to demonstrate the advantages it has over earlier ones.
Nunes, I.L., The DMAIC cycle-based paradigm for integrating Ergonomics and LSS was provided. To add to the DMAIC cycle's ergonomic perspective, the suggested framework links ergonomic tools and approaches to each of the LSS operations. A DSS model was used to merge Ergonomics and LSS continuous improvement processes. DSS helps professionals in continuous improvement and SME managers who are well-informed but lack the resources to implement critical procedures for continuous improvement in their companies.

Sgarbossa et al. mentioned in this paper by Battini D.; Calzavara M.; Otto a.; and Sgarbossa et al; Calzavara, M.; Otto, A. Based on SALBP1, this joint problem is extended to include physical ergonomics considerations in this study. in ergonomics, the necessity for longer job processing times In addition, an assembly line-synchronized feeding system for lean components is taken into account in this study.

This paper was co-authored by three experts: The strategy used in this study, which is practical, could assist all levels of an industry. The lack of a major stakeholder group that has industry support and is well-equipped to engage in the study is one limitation. When it comes to industry-level difficulties that require a lot of cooperation and effort from all parties, such as MSDs, there is still a disagreement about how well this technique works over time in any event, first results from this work are encouraging. It appears that MIHSF has a degree of ownership of MSD interventions and is ready for industry-level change after the study was completed and the intervention document was disseminated. For future MIHSF publications, the intervention document's material will be utilised.

It's not just M. Mengoni, M. Matteucci, and D. Raponi, As a result of this study, an evaluation technique for ergonomics and safety in seed company manuals has been developed. A list of potential risk factors can be used to establish all the features essential for measuring and assessing ergonomics-related elements using this methodology.. A technological set-up that works in both an industrial plant and a laboratory can be defined after this step is completed. Because of this methodology's emphasis on practical and cost-effective ergonomics solutions, acceptable solutions are as efficient as feasible.

Both Berger-Douce as well as Sgarbossa are co-authors of a work by Abdous that was published earlier this year. MILP model for SALBP-1 with employees weariness proposed in this study. There was a linear progression of experiments on laboratory ergonomic norms. Using a -constraint method to design assembly systems, workstation numbers and fatigue were demonstrated in the Pareto frontier.

Viviani C; Arezes P; Braganca; Molenbroek; J; Dianat I; and Castellucci, H.I. were among the researchers. Finding out whether current ergonomics studies of working adult populations take into account precision, reliability, or accuracy challenges was our primary goal. More than half of the 79 publications only discuss or analyse one phrase, and none of the studies looked into every term. A wide range of measurement equipment can have an impact on the reliability and correctness of the papers being examined. In addition, nothing is known about the methods and procedures used to gather anthropometric data. A closer look should also be made at the methods used to collect anthropometric data for ergonomics. The techniques indicated in the applicable standards or technical reports should be taken into consideration when testing for and reporting measurement inaccuracy.

2.1 OBJECTIVE OF THE PRESENT WORK:

- To perform the quantitative research through questionnaires in different industries and perform qualitative analysis.
- To study the productivity improvement with ergonomic interventions.
- To study the effect of ergonomics on reducing production cost, after implementation of ergonomic principles.

3. METHODOLOGY

In the present work while performing the research the following methodology is adopted as shown in the fig.3.1.

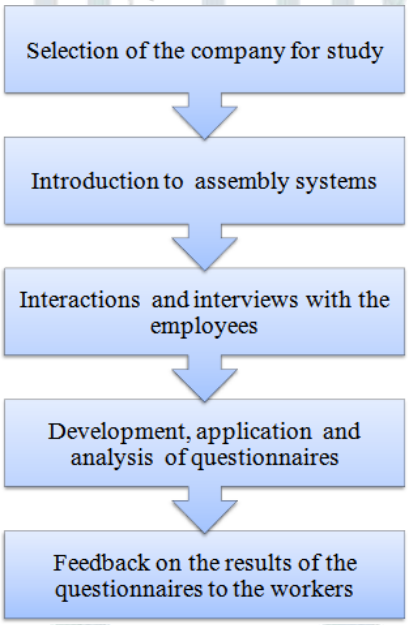

Fig.3.1: Flowchart of present problem

3.1 Selecting on a business to research

An ergonomic-based kitting assembly can be easily implemented by virtue of (a) the company's involvement in the automotive sector and (b) the fact that they have been using the ergonomic concept in their production system for some time already.
Audits of the health and working conditions requirements of the workers were undertaken on a regular basis, based on interviews and questionnaires. Our online profile is for Caltech Engineering Company, Private Limited.

3.2 Results of questionnaires are given to staff as feedback.

A meeting was held, and the workers talked about the results of the surveys. People who worked on the project had a talk about how to make things better when the results were clear. With the help of the survey's results, the organization's top people talked about them.

Table 3 .1: represent name of the company, number of employees, and number of questionnairesdistributed to each employee

S.no	Name of the Company	Number of Employees	Number of questionnaires
1.	Caltech Engineering Company Pvt.Ltd	496	10

3.3 Work content factor

- The findings of the questionnaires are shown in the table below, both before and after ergonomics were implemented.
- The work content element was evaluated and based on factors such as health and safety, assembly easiness, repetitiveness, stress and motivation are all factors that contribute to pain and discomfort.

3.3.1 Formula

- Mean
  $\bar{x} = \sum xi/N$
- Standard deviation
  $\sigma = \sqrt{(\sum(xi - \bar{x})2/N)}$
- Coefficient of Variation
  $C.V = (\sigma/\bar{x}) \times 100$

Questionnaire - Role of Ergonomics in improving safety and Productivity

Name of the Surveyor :
Qualification :
Under the Guidance :
College :

Name of the Company	:		
Name of the Employee	:		
Job title	:	Phone Number	:
Job address	:	Height	:
Gender	:	Weight	:
Supervisor	:	Years in Current position	:
Department	:	Hours worked per week	:

❖ Have you at any time had trouble such as headache, discomfort, pain, numbness etc.

During last 6 to 12 months				During last 7 to 15 days			
S.no	Parts	Yes	No	S.no	Parts	Yes	No
1	Neck			1	Neck		
2	Shoulders			2	Shoulders		
3	Elbows			3	Elbows		
4	Wrists			4	Wrists		
5	Upper back			5	Upper back		
6	Lower back			6	Lower back		
7	Knees			7	Knees		
8	Ankles/Feet			8	Ankles/Feet		

❖ The medical condition listed below may predispose individuals to repetitive strain injury. If you have any of the listed condition and are comfortable disclosing them, please do so.

S.no	Condition	Yes	No	S.no	Condition	Yes	No
1	Lung disease			6	Overweight		
2	Diabetes			7	Mental strain		
3	Cancer			8	Smoking		
4	Heart disease			9	Eyesight problem		
5	Skin disease			10	Hearing problem		

❖ Work related questions

S.no	Condition	Yes	No
1	Carrying and lifting heavy loads		
2	Frequent work lifting		
3	Poor working posture		
4	Work under extensive pressure		
5	Have too many job tasks		
6	Frequent work near workstation		
7	Any musculoskeletal disorder		
8	The work flow goes smoothly		
9	Ease of Assembly		
10	Self interests in work		

To the best of my knowledge, the above information is accurate and complete.

Sign: Date:

Fig. 3.2: Questionnaire format is given in company

4. RESULTS AND DISCUSSIONS

After analyzing the data collected from questionnaires from the employees of the company regarding various parameters which affect the productivity of the employee before and after ergonomic interventions.

Table 4.1: Consolidated Questionnaire of Caltech Engg. Company before and after ergonomics intervention.

	Before Ergonomics			After Ergonomics			
Questions	**Mean**	**Standard deviation**	**Co-efficient of Variation**	**Mean**	**Standard deviation**	**Co-efficient of Variation**	**Mean difference**
Health and safety	70.4	3.38	4.80	89.2	2.78	3.12	18.8
Difficulty level of the tasks at hand	56.4	5.23	9.28	35	3.03	8.66	21.4
Ease of assembly	66.6	5.49	8.25	85.8	2.99	3.48	19.2
Stress	65.8	4.57	6.95	44.2	2.71	6.13	21.6
Motivation	63.8	2.4	3.76	85.2	2.78	3.26	21.4
Empowerment	61	4.14	6.79	84.2	2.56	3.04	23.2
Mental strain	63.4	2.15	3.39	43.8	2.99	6.83	19.6
Self interest in work	67.2	2.78	4.14	87.4	1.74	1.99	20.2
Avg. mean difference							20.67

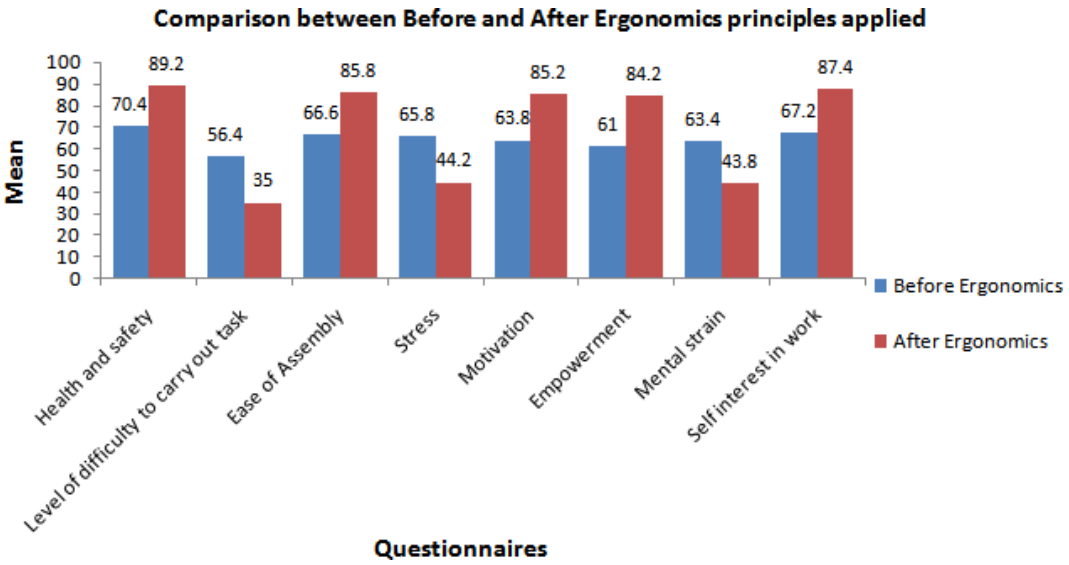

Fig.4.1: Graph representing the questionnaire of Caltech Engg. Company before and after ergonomicsintervention

So by observing the calculated data there is a 20.67% improvement after applying the principles of ergonomics, due to which production cost will drastically come down significantly because of ergonomics intervention in company.

4.1 Improvement after applying Principles of Ergonomics

4.1.1 Productivity Calculation

The quantity of outputs generated in relation to the amount of inputs required in production is how basic productivity is measured.

Productivity = output/Input

Number of components manufactured in one week : C_m
Number of hours worked in one week : T_m
Productivity before Ergonomics : P_B
Productivity after Ergonomics : P_A

Table 4.2: Productivity of a company

S.No	Name of the Company	Before Ergonomics			After Ergonomics			P_a-P_b	% Increase
		C_m	T_w	P_b	C_m	T_w	P_a		
1	Caltech Engg. Company Pvt. Ltd.	1050	36	29.16	1285	36	35.69	6.52	22.38

CONCLUSIONS

Based on the above results and discussions it is observed that the productivity and safety of employees improved by 20.63% to 24.44%. The findings of this study were derived from a variety of sources, including surveys and direct observations in the workplace. This graphic illustrates how ergonomic principles affect assembly-line workers' health and safety at work. After implementing Ergonomic Principles, workers may clearly see how their working circumstances have improved.

The workers' morale was also boosted by this analysis. Increased productivity can be attributed to an improvement in the overall working conditions of the industry.

Because ergonomic concepts are applied to the workplace, safety and productivity can be greatly improved!

The overall productivity and profitability of a company can be achieved with application of Ergonomics! Hence, good ergonomics is great economics!!

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