

Influence of Environmental Ergonomic Factors on Productivity of Employees in Steel Industry- A Conceptual Model

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ABSTRACT

Ergonomics is the application of engineering technology and human biological sciences in working environment. Better working environment in an organization can positively influence working conditions thereby increasing productivity. Steel manufacturing is undoubtedly one of the competitive industries globally, where efficient companies with minimum human issues can survive. Increasing productivity is one of the ways to address the scientific and technological issues occurring in steel industry. The paper mainly focuses on the influence of ergonomic factors on labour productivity in iron and steel industry located in the state of Kerala, India. Considering the complexity of labour factors and higher literacy, Kerala is one of the important states in India where the study needs to be conducted. An organization performance is closely associated with the organization productivity. The employees of an organization play a major role in the performance and productivity of an organization. Hence, identifying factors affecting the productivity of the employees are the major human issues to be considered for adapting technology. A detailed literature survey is conducted in this paper to discuss about the role of environmental ergonomic factors on productivity. Further, a conceptual model is developed which explains how environmental ergonomic factors can influence the human responses like comfort, performance and health which in turn affects the productivity.

Keywords: Ergonomic factors, productivity, human responses, employee performance, working environment.

1. INTRODUCTION

Steel production and its usage are often regarded as an indicator of the growth of a nation. Iron and steel is a heavy industry because large and bulky raw material and finished goods require high and expensive transport costs. Since 2011, India has a remarkable stand in the role as a leading player. Efficiency of the company is an important aspect and productivity is an important measure of efficiency. One of the important factors that challenge the survival of the steel industry is productivity.

Indian steel industry has got a great potential for the next 10 years as lot of infrastructural expansion plans are going on and at the same time raising per capita steel consumption in our country shows the potential. Indian steel industry has always shown a tremendous growth rate and it will be continued and the contribution of the Indian steel industry towards GDP is remarkable. Also Indian steel industry is such a huge sector that generates many employment opportunities and thus it is a major part of the total industrial production. So an increase in productivity of the steel industry will contribute to the above said factors. Thus measurement of productivity and ways of increasing the productivity in steel industry is very much relevant.

Indian metal industry focuses mainly on the manufacturing of iron, steel and aluminium. Apart from the primary ones several metals like the precious metals are also manufactured (Vilamova et al.2015). The main source of revenue is from the sale of iron and steel products that includes sheets, bars, rods and tubes. Apart from the iron and steel, other metals are also used for manufacturing various products. All these industries contribute a major portion of the revenue and will have a substantial growth in the future years. Expansion of the infrastructures, automobile and heavy machinery will accelerate the metal consumption and will contribute to the steel industry (Saniuk, Witkowski & Saniuk.S., 2013).

Determination and ways of increasing the productivity became an area of interest for the industrial engineers. Industrial engineers have come to a reality that just by increasing the volume of production will not increase the productivity. Efficient utilization of the resources is an important factor for increasing productivity. Resources for an industry are men, material, money and machinery. Thus the efficient utilization of the above said factors will increase the productivity of the organization and make it sustain in the competitive market. In the initial stages of industrialization more focus was on the capital and raw material. Later on studies focussed on the labour productivity and studies showed that it is an equally important factor compared to other two inputs.

Ergonomics is the science that deals with the physical and mental stresses affecting a worker in his working environment. Ergonomics (or Human Engineering) is defined by I.L.O. (International Labour Organisation) as “the application of human biological sciences in conjunction with engineering sciences to the worker and his working environment so as to obtain maximum satisfaction for the worker which, at the same time, enhances productivity”. (M. Helander, 1995).

Productivity is an inevitable factor of every organization because the success of every organization is deeply attached to the productivity of the organization. When high quality work is coupled with greater efficiency it results in productivity (Sibson, 1994). An employee is a vital part of any organization and by improving the employee productivity can improve the organizational productivity which makes the organizations to withstand the competitive market all over. (Altrasi, 2014).

There are several factors affecting the productivity of the employee like technical, production, organizational, personnel and ergonomic factors. Ergonomic factors are

undoubtedly one of the most influencing factors affecting the productivity of an employee. Ergonomics deals with “how well the humans interact with environment”. The objective of this paper is to focus on various environmental ergonomic factors in the working environment and how these factors affect the productivity of the employee.

Productivity depends upon various human responses like health, comfort and performance (Parsons, 2000). These three human responses are strongly correlated with the productivity of an employee which in turn affects the organizational productivity. According to Parsons (2000) the human responses are affected by environmental ergonomic factors like heat, odour, lighting, humidity, smoke, cleanliness and noise.

2. ENVIRONMENTAL FACTORS AND HUMAN RESPONSES

Brill et al. (1984) made a ranking of several factors according to their significance by considering their influence on productivity. Furniture, Flexibility, Temperature, Air quality, Lighting, Communication and Noise were the several factors considered for his study.

Noise is an important factor affecting the productivity of an employee. Improper levels of noise can affect the comfort and performance of the employee and very high levels of noise can even affect the health seriously. Even though noise is an unavoidable part in a workspace but studies revealed the absence of noise or acoustic disturbance can increase the productivity and reduce the errors.

Noise is considered as an ambient stressor in the working environment while conducting studies on job satisfaction (Osborn and Brill, 1994). Some studies later revealed the importance of acoustical privacy by analyzing the data from Data Management Association. In open public places, studies showed a 40 percent drop in productivity and 27 percent rise in chances of error occurrences when there is a lack of acoustical privacy (McLaughlin, 2000).

Brill et al. (1985), further conducted researches on the improvisation of physical work environment. Office layout, furniture layout, the floor configuration and the lightings were the factors considered. Five to ten percent raise in employee performance can be improvised by the effective design of the workplace (Brill, 1992). Studies in an insurance company showed an increase in their performance from 10 to 15 percent by providing ergonomic furniture. (Springer Inc, 1986).

Lighting and noise can have severe health effects like migraine headaches. American Headache Society sponsored a study on the effect of environmental factors on migraine headaches and the studies revealed factors like noise and lighting were significant. It was estimated around \$13 Billion loss can occur because of the migraine which affect productivity by absenteeism or reduced performance (Friedman, 2009).

Boyce et al., (2003) in his studies showed that there exists a few elements that could affect the physical work environment and lighting of the workplace is an important factor considered. Hedge (1986) in his studies revealed that there are some disturbances in the workplace that could affect the employee productivity and noise was considered as a crucial

element. And there a lot of other factors that could affect the productivity like satisfaction. Employee satisfaction was not a crucial factor in the early stages of industrialization but later industrial engineers found that the productivity is somehow related with the psychological factors like satisfaction (Brill et al. 1985). Increase levels of mental comfort can lead to more commitment towards the work and thereby achieving higher productivity. Mental and physical comfort is a result of the well designed or ergonomic workplace.

Researchers further showed interest in several other factors like the quality of air and the thermal environment with light and noise (Olesen, 1995). Depending upon the task and the environment, the employee productivity varies and having a good environment, they will be fully dedicated to their work and their full energy will be utilized (Visher, 2007). Later researchers considered elements like humidity and air quality along with the above said elements which have vital role in employee productivity (Tarcan et al., 2004; Marshall et al., 2002). Many researchers pointed out that air quality is a crucial factor that affects the human responses like comfort, performance and health. Air quality affects the work quality that has a serious effect on the satisfaction of the employees and the customers (Dorgan, 2006).

Emissions in the steel industry (like smoke and other gases) are a serious threat to those who are working in the steel industry and nearby residents. Studies shows that it affects the comfort and performance of the personnel and at the same time it seriously affects the health even with the usage of personal protective equipments. These emissions affect the cardiovascular physiology (Liu et al. 2014).

According to Amir (2010) physical environment are influenced by certain elements in the working space. Layout plan of the office and also the office comfort were the two major elements in his study. Amir (2010) also stated that in order to achieve the organization's goal; an organization must arrange their physical elements in the working place to make it to a better ergonomic working environment. Housekeeping and cleanliness thus affects the comfort, performance and health. According to McCoy and Evans (2005), physical element has a vital role in developing workplace relations and networking. They further concluded that any factor or element affecting the physical working environment must be properly monitored and controlled, thus physical working stresses can be avoided. Stresses at the workplace will make them do their job slowly and may be without any accuracy.

3. HUMAN RESPONSES AND PRODUCTIVITY

Comfort is an important factor affecting productivity. Environmental factors stated in various literature is well connected with comfort and finally on the productivity. Comfort levels increases the satisfaction of each and every employee and thereby increases the productivity. (Boyce et al. 2003; Hedge, 1986). Studies conducted by Brill et al. (1985) revealed that performance is affected by the workplace environment and the performance is a direct measure of productivity. Higher levels of performance by each and every employee in the industry will increase the overall company productivity.

Friedman (2009) conducted studies on the effects of health affecting the productivity. His studies proved that improper workplace design affects the employee's health and estimated

around 13\$ billion loss due to the employee absenteeism. Studies showed there is a high correlation between the environmental attributes and the performance. (Shikdar et al. 2003). Major problems faced in the company are performance related problems like low productivity and absenteeism and the employees are unable to perform their job assignments with discomfort in the workplace. (Leaman.A, 1995)

4. MODEL

From the study (Parsons, 2000), the physical elements of the environment like light, vibration, noise, heat and cold were considered and a how it affects the health, performance and comfort was the research problem. The study clearly pointed out the significance of environmental ergonomics as a discipline of ergonomics and suggested to look this with a more practical approach. Worker’s response towards the working environment will not be in a monotonic way while investigating on the direct measures. Human responses and sensitivities vary according to their human characteristics.

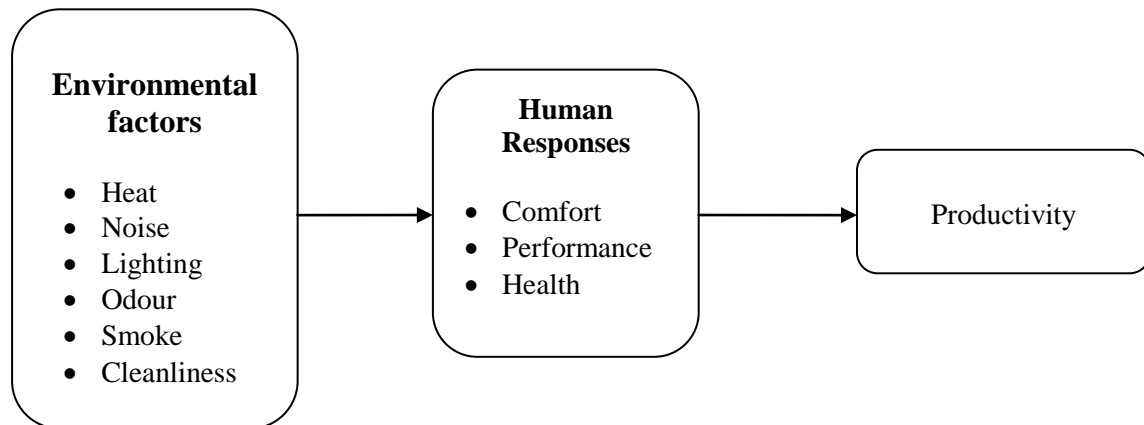


Figure.1 Conceptual Model

A conceptual model has been developed in order to find out how each of the environmental factors affects the human responses which in turn affect the productivity. Model contains six environmental factors (heat, noise, lighting, odour, smoke and cleanliness) and three human responses (comfort, performance and health). Factors and responses were finalized and conceptual model is developed based on the literature review and the expert’s advice.

5. Reliability Study

The variables used in this research are obtained from extensive literature review. Further, discussions were done with the employees and the experts in this field. One of the most common methods of testing reliability is by conducting the reliability analysis based on the Cronbach’s alpha value (Keith S. Taber, 2018). Cronbach (1951) suggested focusing rather on the interpretation of the alpha value while checking the reliability of the questionnaire rather than looking for higher values of alpha which is only ‘desirable’. Questionnaire was developed for measuring the identified variables such as heat, noise, lighting, odour, smoke, cleanliness, comfort, performance, health and productivity from literature review. In the

study, 34 items were used to measure the reliability of 10 identified variables. In the first phase, pilot study was conducted successfully and in the second phase 210 employees' responses were recorded from various industries in Kerala. The responses were analyzed using SPSS version 26 which is shown in Table I.

Cronbach's alpha coefficient (α) is one of the most commonly used indicator of internal consistency (Pallant, 2010), which ideally is above a 0.7 scale. Cronbach's alpha value of 3 variables namely odour, performance and health are below 0.7. However, Griethuijsen et al. (2014) in his studies clearly explained the possibilities of having a value of Cronbach alpha less than 0.7 or 0.6, which is still acceptable.

Table I. Reliability Study

Variables(Constructs)	Cronbach's Alpha	Number of Items
Heat	.837	3
Noise	.747	4
Lighting	.744	3
Odour	.665	3
Smoke	.812	4
Cleanliness	.879	4
Comfort	.780	3
Performance	.658	4
Health	.641	3
Productivity	.778	3

6. Multicollinearity Analysis

Multicollinearity causes excess data, which implies that what a regressor clarifies about the response is overlapped by what another regressor or a set of other regressors clarify. Hair et al. (1998) mention that as multicollinearity increases, it becomes more troublesome to find out the effect of any single variable that produce biased estimates of coefficients for regressors because of more interrelationships for the variables.

For measuring the degree of multi collinearity of the independent variables with another independent variable in the same model, widely used measures are the Variance Inflation Factor (VIF) and tolerance. (O'brien, R.M.Qual Quant, 2007).

Variance inflation factor (VIF) measures what proportion the variance of the estimated regression coefficients are inflated as compared to when the predictor variables are not linearly related. It is utilised to clarify how much amount multicollinearity (correlation between predictors) subsists in a regression analysis. Tolerance is a valuable instrument for diagnosing multicollinearity, when variables are too closely related.

Table II. Multicollinearity Statistics

Variable1	Variable 2	Tolerance	VIF
Noise	Heat	.454	2.200
Lighting		.340	2.941
Odour		.369	2.713
Smoke		.426	2.349
Cleanliness		.333	3.002
Heat	Noise	.517	1.936
Lighting		.328	3.047
Odour		.406	2.464
Smoke		.425	2.351
Cleanliness		.314	3.187
Heat	Lighting	.453	2.205
Noise		.385	2.597
Odour		.545	1.834
Smoke		.425	2.351
Cleanliness		.317	3.152
Heat	Odour	.439	2.276
Noise		.426	2.348
Lighting		.488	2.051
Smoke		.428	2.335
Cleanliness		.309	3.233
Heat	Smoke	.435	2.300
Noise		.382	2.616
Lighting		.326	3.070
Odour		.367	2.726
Cleanliness		.504	1.982
Heat	Cleanliness	.469	2.134
Noise		.388	2.575
Lighting		.335	2.988
Odour		.365	2.741
Smoke		.695	1.439

In the paper heat, noise, lighting, odour, smoke and cleanliness are used as the independent variable. From the tests it is proved that no multicollinearity exists among the independent variables. If the VIF value exceed above 4.0, or by tolerance less than 0.2, then there is a problem with multicollinearity (Hair et al., 2010). The Table II shows that all VIF values are below the value 4.0 and hence there is no multicollinearity among the variables heat, noise, lighting, odour, smoke and cleanliness.

7. LIMITATION AND CONCLUSION

Role of employees in every industry is an inevitable part and thus the ergonomics has a significant impact in the productivity of the employee which in turn affects the organizational productivity. Researches analyzing the effect of environmental factors on human responses and productivity are undoubtedly significant. In this paper we have considered six environmental factors namely heat, noise, lighting, odour, smoke and cleanliness in iron and steel industries in Kerala. We have developed a conceptual model to analyze the effects in this paper. Three human responses namely, comfort, performance and health were taken and the studies correlating the environmental factors and human responses and their effect on productivity.

The major limitations of this paper are,

- This study is circumscribed only to private sector iron and steel industries in Kerala, India, where majority of blue collar employees are males. Therefore it would be inappropriate to make conclusions about female workers based on this result.
- The present study is limited to selected private sector industries in Kerala, and the same factors can be used to analyze the influence of environmental factors on productivity among the employees working in similar units in other states of India.
- The study can be extended to the public sector industries by using the same factors for the analysis of environmental factors on productivity.
- The study in this paper is limited to the data collection and the associated reliability studies and the multicollinearity studies. It can be extended to further works including the model testing and the correlation studies.

However, reliability analysis shows the data recorded is reliable and can be used for further analysis. By analysing the VIF and tolerance the data shows that there is no collinearity among the factors considered for this study.

DECLARATION OF CONFLICTING INTERESTS.

Mr.Soni Kuriakose, Dr.Shajan Kuriakose, Mr.Bibin K Tharian, hereby declare that, the manuscript "**Influence of Environmental Ergonomic factors on Productivity of employees in Steel industry- A Conceptual model**" is the original work done by us for the research. We declare that there is no conflict of interest. The manuscript is original and not

published anywhere except for this Journal. We here by permit you to publish our manuscript in your esteem Journal.

FUNDING INFORMATION

Mr..Soni Kuriakose, Dr.Shajan Kuriakose, Mr.Bibin K Tharian, hereby declare that, we have no affiliations with or involvement in any organization or entity with any financial interest or commitment in the subject matter or materials discussed in this manuscript.

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