THERMAL COMFORT AT THE TURBINE ROOM IN THE POWER STATION: A REVIEW

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ABSTRACT: Environmental ergonomics deals with the effect of environmental factors on human health, comfort and performance. This day-to-day interaction of humans and their environment affects performance and productivity of workers in various industries. Indoor temperature is one of the fundamental characteristics of the indoor environment. The objective of the study was to investigate the effect of temperature in the turbine room and equipment on the workers performance. This paper presented a systematic review of the literature that relate to thermal comfort of the turbine room in the power stations. The results of this paper identified the factors that affect the performance of workers through the proposed conceptual framework that has dependent and independent variables and a moderator namely temperature in the turbine room.

KEYWORDS: *SPSS, Environmental, Turbine, Thermal Comfort, Performance.*

1.0 INTRODUCTION

Many developing countries and companies begin to think about sustainable solutions to face problems in the power stations using appropriate techniques to raise the efficiency of the production of electrical power, including problems of high air temperature inside the turbine rooms (thermal comfort) [1].

Hensen defines the thermal comfort as a state in which there is no driving impulses to correct the environment by behavior [2]. The (ASHRAE) American Society of Heating, Refrigerating and Air-Conditioning. Engineers define the concept of the thermal comfort as a satisfaction of body and mind for employees [3].

According to these definitions, the thermal comfort is a state of mind and it is the type of satisfaction that leads to environmental comfort in the workplaces. The environmental comfort is affected by physical, physiological, psychological, and other factors [4].

Many studies prove the physical environment for any workplace can lead to positive influence in all work areas [5]. The objective of the study was to investigate the effect of temperature in the turbine room and equipment on the workers performance. The study of thermal comfort in the production of electric power plants will contribute to enhance and improve the performance in difficult thermal conditions.

Various researchers confirm that openness, noise, lighting, relative humidity, airflow, and temperature can affect the performance of workers [6].

2.0 TEMPERATURE OF THE TURBINE ROOM

Gas turbines are used in many countries for power generation. These countries have various changing climatic conditions that affect the performance of gas turbine Gas turbine operates in accordance to the set of design standards (ISO) 3977 with a set of operating conditions, for example, Air temperature 15°C, Relative humidity 60%, Absolute pressure 101.325 kP [7]. Brayton cycle is a theory which is used for the operation of gas turbines because the Brayton cycle describes the path of air inside the gas turbine and interprets the relationship between the volume and the pressure [8].

The increase of air temperature in the work area has a negative impact on performance. Hence, the relationship between the air temperature and the performance is an inverse relationship, whenever to increase the temperature in work area whenever to decrease the performance of workers. The high temperature of the air inside the turbine rooms resulting from the combustion process inside the turbine will reduce the thermal comfort and decrease the performance.

According to several studies, the normal level of thermal comfort in any workplace is within 21-25°C range. The performance will negatively affect beyond that level of temperature [9].

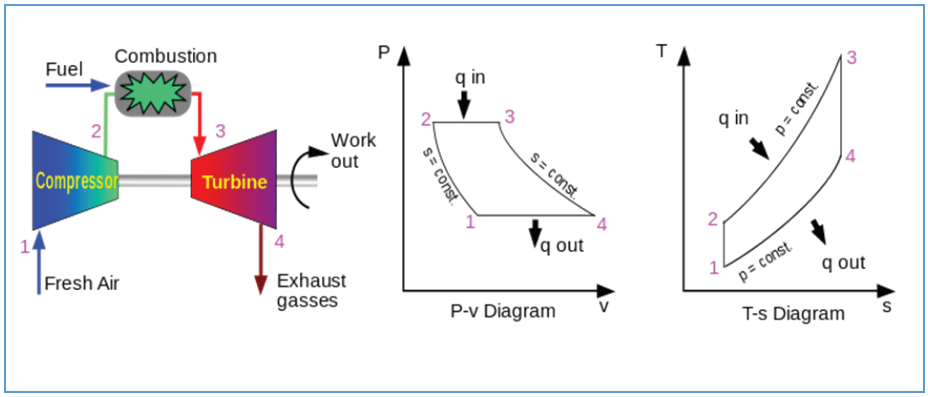

Figure 1: Brayton cycle [8]

2.1 The relationship between the performance of workers and thermal comfort

The workers, operators, and engineers in power stations especially in turbine rooms are exposed to different temperature levels that affect performance, increase air temperature which increase errors in mental performance, and increase errors. Working in heat is also uncomfortable. Heat can be particularly problematic when workers work in confined spaces with little airflow. As with other environmental conditions, human errors due to exposure to excess heat may affect plant safety to the extent that plant safety depends on reliable human performance [10]. The worker's body is always trying to adjust to its environment so as to maintain a state of thermal equilibrium, many physical adjustments are made by the body when it changes from one thermal environment to another such as from an optimum environment to a cold one and from a cold to a hot one, etc. The relationship between the thermal comfort and the performance is a positive correlation (The higher the thermal comfort, the higher is the performance) [11]. The performance will decrease 2% for each increase of 1°C and there is no effect on the performance within 21-25°C range.

Any increase in the air temperature inside the turbine room will leave a negative impact in addition to the many health risks of the workers and operators in the power plants. The thermal conditions could result in negative impact on the body of the workers if exceeding 35°C [12].

3.0 PREVIOUS STUDIES

Further investigations of the previous relevant studies are conducted to demonstrate the impact of increase in air temperature in indoor areas and effect on the thermal comfort of workers:-

- A variety of studies has shown the impact of the increase in air temperature at 29°C on the performance and then assesses the effect on predictable performance as well as thermal comfort in the workplace. The methodology of this study is based on the measurement of the performance in six different tasks that reflect different stages of performance. The study is based on the exposure of each person for 3.5 hours in each heat condition. The findings of this investigation show that temperature has an effect on performance as well as it causes concentration difficulties [13].

- The impact of heat stress on the workers has been studied. The authors use an analytical study to include 41 acclimatized and healthy males who participate in the study. Environmental climatic parameters are measured and then heat stress is evaluated according to HSI index, WBGT index, and core body temperature. All data are analyzed by the SPSS version 16 and in order to establish a relationship between measured parameters and the core body temperature and the heat stress indices, Poisson correlation coefficient is used. The results of this study prove the heat stress is one of the occupational hazards in the workplace and severely affects the health and productivity. Heat stress can decrease efficiency, increase accidents and reduce safety levels. The results show the mean of WBGT index is 40.02 and mean of HSI index is 489.97.Thus, all workers are exposed to high heat stress. Whilst mean of core body temperature is 37.19°c, the maximum of core body temperature is 38.5°c. In terms of estimating heat stress, it is better to use the biological monitoring method such as core body temperature which may have been closer to real heat stress in exposed workers. Pearson correlation coefficient between the core body temperatures has less correlation with globe temperature (r= 0.648), relative humidity (r= 0.307) and with natural wet bulb temperature (r= 0.469) than HSI and WBGT. WBGT has a high correlation with globe temperature (r= 0.956) and natural wet bulb temperature (r= 0.877),

thus, affirming that WBGT index shows higher heat stress than core body temperatures. the Pearson correlation coefficient between HSI with relative humidity is r=0.619 and HSI has more correlation with relative humidity than core body temperature (r= 0.307) and WBGT(r= 0.494) the HSI index does not have a statistical significant relation with air velocity (p=0.058) and HSI index has limitations for assessing heat stress in environments with high relative humidity and low air movement [14].

- A study investigates the effect of thermal comfort in warm, cold and moderate weather and the effect of all these factors on the comfort thermal and health of a body. The effects of heat and cold on human performance are very significant. It has been found that task performance is affected by the thermal environment and mental performance is found to decrease with prolonged exposure to the warm environment. Vigilance is also found to decrease at low temperature and people show signs of mental confusion at reduced temperature. Hand tool manipulation becomes very difficult when a person's hands are cold [15].

- The thermal comfort can be achieved by the active means to become one of the largest energy intensive activities in factory environments, which directly influence the manufacturing cost. The findings of this study show the thermal comfort for the workers is very important to increase efficiency and improve the adaptive opportunities as a potential passive technique that can be used to minimize the energy requirement [16].

- Heat Stress has largely affected working as well as mental errors by workers in ambient temperature higher than 35° C which are caused by the inability of the body to release internal heat energy and the eventual overheating and dehydration of the body. These two factors are responsible for a cascading series of events that cause a person to be both physically uncomfortable and fatigued, along with diminished thinking skills [17].

- The indoor room temperature and light are the most vital basic elements that influence the productivity of office laborers, as well as the warm discomfort brought on by raised air temperature, which influence the employees [18].

- Another study affirms that 80% of the samples agree that the influence of physical work environment (comfort level, temperature) has a great influence on the productivity. This study has been conducted among the workers in the Malaysian automotive industry. The results show that environment comfort level has a great influence on the productivity of the employees [19].

- The impact of labor policies on the workers in electric power plants has been studied. The authors affirm that the Labor Policies and the Performance of workers have the critical role in the operation of

- power plants and present anecdotal and empirical evidence that operators can have a significant impact on the efficiency of plant operations [20].

- The thermal comfort depends on the type of tasks and the workers can keep thermal comfort but for a short time. However, the thermal comfort affects the performance of workers in a workplace [21].

- A study on the thermal environmental to factory workers with the high temperature in a workplace is conducted, The findings of this study yield that the turnover tension is very high among the workers [22].

- Another study analyzes the risks that relate to the increased temperature for indoor room. The results of this study show the workers who are exposed to high temperature in their work are more likely to suffer serious illnesses and permanent disabilities [23].

3.1 Summary of the previous studies

This paper has studied much literature on the effect of temperature on the performance of workers and operators and engineers. The literature focuses on improving work condition because the performance is becoming more essential and all organization struggles to achieve it. The benefits of increasing the performance have been highlighted in many types of research which indicate the necessity of studying and investigating this issue and its dimensions.

A lot of studies have been conducted toward understanding the effect of air temperature on the performance in many aspects. However, literature on the influence of air temperature in power stations, especially inside turbine rooms is scarce.

4.0 CONCEPTUAL FRAMEWORK PROPOSED TO EVALUATE THE TURBINE ROOM TEMPERATURE

The theoretical framework is theorizing the link among many different factors related to the study. It is known as a conceptual model that elaborates the relationship among the variables under study. It also describes the nature and direction of the relationship.

The conceptual framework has been developed in this paper according to the factors that affect the workers in the turbine room that have been identified through literature and the survey that is conducted in the power station.

The study includes four independent variables and one moderator that affect the workers performance in the power station. Workers performance is taken as dependent variables and temperature in turbine room as a moderator while turnover intention, performance pressure, workplace area and bad environment are also taken as independent variables. Therefore, the dependent and independent variables are measured by the feedback. Based on the written work review, the association between performance and air temperature in turbine room can be predicted as below:

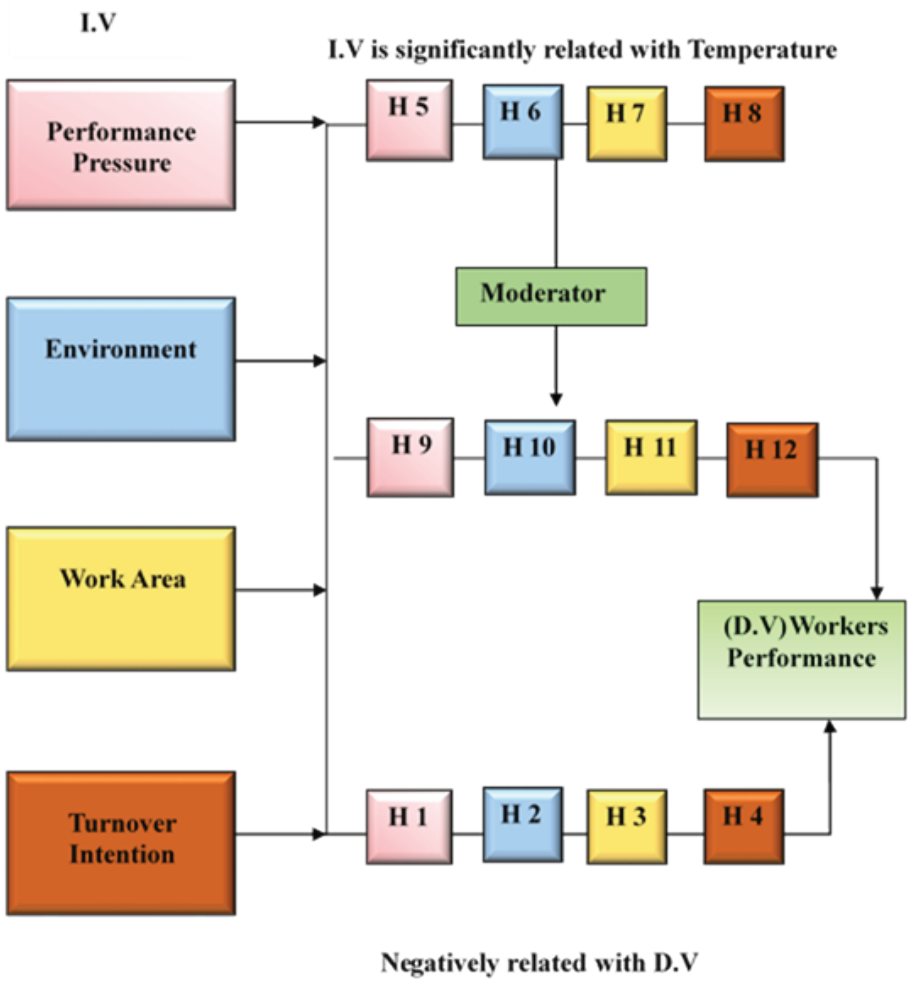

Figure 2: Proposed Conceptual Framework

5.0 CONCLUSION

Regulations requiring environmental friendliness, intense competition amongst power generating companies are required in the design of appropriate operational policies for power generating companies by improving conditions of operation including improving the temperature of turbine room. This paper aims to evaluate the impact of the increase in the air temperature in the workplaces in the turbine room to test the performance of workers and then raise the level of performance in the power stations. A systematic review of this paper affirms that the improved thermal comfort conditions in the turbine room will increase the level of performance of workers in the power stations. This paper has investigated the moderator influence temperature on the workers performance in the power stations. The conceptual model was designed to check the relationship between dependent variable (workers Performance) and independent variables (Performance Pressure, Environment, work Area, and turnover Intention) and Mediator between the dependent Variable and independent variables.

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