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## The Impact of Workers Productivity under Simulated Environmental Factor by Taguchi Analysis

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### Abstract

The objective of this study is to determine the dominance impact of environmental factors such as illuminance, humidity and temperature on worker productivity by Taguchi Method. A study was conducted under simulated environment factor which examined were the illuminance, humidity and temperature of the surrounding workstation area in the closed simulation lab. A set of representative data including the illuminance, humidity and temperature level and production rate were collected during the study. The production rate data were collected through observations and survey questionnaires while the illuminance, humidity and temperature level measured by valid apparatus and equipment. The Taguchi method was utilized to find the sequence of dominant factors that contributed to the productivity of the operator at that specified production workstation. The study reveals that the dominant factor that contributed to the productivity was temperature followed by illuminance and relative humidity.

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### 1. Introduction

Manufacturing industry is one of the dominant industries that contribute to Malaysian economic growth.

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Most of the assembly line in manufacturing industries operates in manual or semi-automatic. Thus, the comfort of the working environment should be emphasized in order to improve the health and safety, performance and productivity. However, those studies carried out involving only one environmental factor and not on the effect of workers' performance on various combinations of environmental factors. This study aims to investigate the effect of the dominant environmental factors such as illuminance, relative humidity and temperature on workers' performance. The study was conducted in a closed simulation lab adapted based on a production line involving the installation of the components manually. 12 subjects were involved in this study responsible for installation works. The subjects divided into two groups that are 6 subjects used for data acquisition while the remaining six subjects used for confirming the results of the study. 6 subjects exposed to the nine sets of experiments while performing a light components assembly work. Productivity rates have been observed and recorded for every 10 minutes for 4 hours for each data set of environment parameters. The same experiment was repeated by the other six subjects. Next the data obtained were analyzed using the Taguchi Method in order to the interaction and dominance of environmental parameters on the performance. Taguchi Method results revealed that the dominant factor is the temperature, followed by the illuminance and relative humidity. It also shows that there is a positive impact on workers' performance at 24°C temperature, relative humidity at 40% and illuminance of 500 lux.

### *1.1. Illuminance, Relative Humidity & Temperature*

Light is a simple part of the electromagnetic spectrum that enables human to see the objects of surrounding. Illuminance is one of the characteristic of light and it is a reflectance of light on subject to human to perform their visual activities. Illuminance (E) is a quantity that used for light incident on a surface and its standard unit is lux (lm/m<sup>2</sup>) with symbol *lx*. According to A. R. Ismail (2013), the measurement of illuminance is ratio of luminous flux (*lm*) to the area of illuminated surface (m<sup>2</sup>). Several studies has been reveal that bad illuminance can affect the health of people such as causing visual discomfort, fatigue, eyestrain, migraine, and mood changes (HSE, 1997; Boyce, 2003; Hemphälä and Eklund, 2012). Besides that, Caballero-Arce et al. (2012) concluded that inadequate illuminance can also affect humans' alertness and circadian rhythms. Moreover, Juslén (2006) stated that good illuminance can be a positive impact on human performance because it improves the visual performance and visual comfort which affect the productivity indirectly.

Relative humidity (RH) is an amount of the moisture in the air, compared to the potential saturation level. In 2009, Ismail, A. R. et al. has been concluded that relative humidity can affects thermal comfort of human wellbeing as well as humidity can influence the heat transfer quantity from skin to environment. According to the Industry Code of Practice on Indoor Air Quality (2010), the suitable range for relative humidity is 40-70 %. Moreover, Atmaca and Yigit (2006) also stated that when the relative humidity is high, latent heat dissipation ability of the body decrease, where increasing in vapor pressure and sweat rate over the body also affecting the latent heat dissipation. The studied by Atmaca and Yigit (2006) stated that humidity may be one of the factors that cause discomfort to human with the reason of uncomfortably high level of skin wittedness or inhalation of humid and warm air. Moreover, Tsutsumi et al. (2007) have done a research on relative humidity with 4 conditions which are 30%, 40%, 50% and 70% relative humidity. He found that the subject who stayed at 70% will be more tired than others. In addition, the subjects in that study found that they felt discomfort while the relative humidity is less than 30% and more than 50%. Relative humidity is an element that will affects human performance. Therefore, relative humidity can't be ignored in determining which parameter will affect the human performance.

Temperature is a measure of the degree of heat intensity. According to Parsons (2003), temperature can be assumed as the average kinetic energy (heat) in a body at a molecular level. It is one kind of physical property of a subject which normally cause cold or hot to the subject. When the temperature increases, then

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