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A CASE STUDY OF OCCUPANT ENVIRONMENTAL COMFORT AT AUTOMOTIVE ASSEMBLY WORKSTATION

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ABSTRACT

The environmental factors assessment in the building has become a popular research area over the past decade. However, how the service life of a building affects the results of the environmental assessment of a building has not been emphasized previously. The aim of this study is to analyze how structural solutions and building design affect the results of the environmental assessment. Furthermore, how the environmental factors affects the productivity is analyzed. The environmental assessments in building were calculated for this study by Environment Factors Equipment. The current situation and the future of the environmental assessment of buildings are discussed. In addition, topics for further research are suggested which is the environmental impact of an occupant should be studied. The research concludes that comfort and productivity in the workplace is related more to design factors.

Keywords: Comfort, environmental affect, productivity

INTRODUCTION

Comfort is a qualitative aspect of ergonomics. Several definitions of comfort and discomfort exist. Hertzberg (1972) stated and people are conscious of discomfort only. Therefore, he simply defined comfort as absence of discomfort and that zero discomfort is equal to absence of pain. Hedberg (1987) might have similar thoughts defining comfort as no pain and discomfort as pain. That is partly in agreement with results from a questionnaire study (Zhang et al., 1996) about feeling associated with comfort and discomfort. They found that comfort was associated with a relaxed and less stressful situation where it is not necessary to think or concentrate at the task. Discomfort was associated with pain and ache.

When people discuss comfort relating to their daily life experiences, comfort normally implies something positive. Though, Branton (1969) did not fully agree with this, stating that comfort does not necessarily entail a positive effect. Corlett and Bishop (1976) defined industrial comfort as; "a threshold level below which the operator would not be distracted from his work". They use pain synonymously with discomfort and suggested that contributing discomfort factors are posture and effort.

As we known, one of the most concerned issues in our modern society is the health condition and environment factors could make relatively great contribution to people's health. We have created more comfortable and safe working and living conditions and facilities to protect the health of public, and we have produced more types of qualified goods for us to use but Fanger (1970) reminds us that the feeling of climate comfort is subjective and differs between individuals. So, unfortunately it is possible that different persons will have totally opposite opinions about the degree of comfort experienced. Furthermore, Reynolds (1993) stated the perception of comfort may also change over time. The goal and target of study is to test the influence of the differentiations in environment to workers perception.

METHODOLODY

One of the aspects of this field study is to study the environment factors in Hicom Yamaha Manufacturing Malaysia Sdn. Bhd. This environmental study is being done to study the effect of environmental factors in workers daily work. This study is important because by having environmental data, we may know that whether the workers' productivity and efficiency are being affected by current environment at their workplace. We can also compare the data that we get from this study to analyze on workers health problem whether the current working environment has resulted on them being unhealthy.

By using the Environment Factor Equipment designed by UKM as illustrate as Figure 1, we collect several environmental data for six hours at Final Inspection Workstation. Among the data that we collect using this equipment are carbon dioxide (CO_2) level, pressure, humidity, wind speed, temperature, sound, illumination (lux), and globe temperature. We also match the data with the production output produced by the workers at 10 minutes interval. The data summary of observations by experiment is being represented by the table below:

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Time	CO_2	Pressure	Humidity	Wind speed	Temperature	Sound	Lux	Globe Temperature	Production Output (unit)	Remark
10:40:58	775.313	103.327	74.3	0.092	32.141	63.09	89.3	30.053	0	rest
10:50:58	687.5	103.327	72.643	0.193	31.919	78.91	69.8	30.164	7	
11:00:58	663.75	103.358	70.263	0.254	31.975	76.24	64.3	30.219	15	
11:10:58	640.625	103.358	69.174	0.325	31.869	62.29	45.9	30.219	14	
11:20:58	639.063	103.327	68.287	0.236	31.963	79.29	65	30.275	15	
11:30:58	636.563	103.358	67.863	0.191	32.078	68.45	69.7	30.386	14	
11:40:58	632.813	103.327	68.244	0.135	31.744	75.67	65.6	30.275	13	
11:50:58	621.563	103.358	71.773	0.662	31.419	74.01	65.5	30.164	15	
12:00:58	614.688	103.374	75.272	0.718	30.716	73.93	70.8	29.664	15	
12:10:58	620.938	103.327	75.526	0.518	30.344	71.26	88.1	29.108	15	
12:20:58	615.313	103.296	74.704	0.699	30.175	75.65	116.6	28.775	14	
12:30:58	610.938	103.296	75.497	0.466	30.316	77.7	193.5	28.608	16	
12:40:58	611.875	103.28	77.717	0.383	30.628	73.26	260.1	28.664	15	
12:50:58	604.688	103.233	74.929	0.204	31.163	76.81	368.7	29.053	15	
13:00:58	593.125	103.233	72.506	0.458	31.734	73.93	394.4	29.719	14	
13:10:58	591.25	103.171	66.513	0.595	32.731	61.68	372.7	30.553	0	rest
13:21:05	591.25	103.171	66.513	0.595	32.731	61.68	372.7	30.553	0	rest
13:30:58	607.5	103.124	63.842	0.398	33.297	62.83	295.5	31.886	0	rest
13:40:58	590	103.124	63.144	0.649	33.287	61.93	148.8	32.164	0	rest
13:50:58	582.5	103.124	62.071	0.148	33.319	73.47	194.1	32.108	7	work start at 13.45
14:00:58	580	103.092	59.753	0.714	33.275	75.42	149	32.164	15	
14:10:58	580.313	103.077	58.807	0.406	33.597	74.77	213.6	32.275	14	
14:20:58	575.938	103.077	54.953	0.206	33.734	78.88	166.5	32.441	14	
14:30:58	577.188	103.014	56.707	0.222	33.825	71.66	241.3	32.553	15	
14:40:58	565.938	103.045	54.056	0.239	34.009	79.17	268.3	32.775	15	
14:50:58	564.375	102.998	53.756	0.271	34.266	76.72	137.6	32.997	14	
15:00:58	557.188	102.998	53.671	0.144	34.094	71.95	78.1	32.997	14	

15:10:58	560.625	102.967	56.042	0.221	33.616	74.29	50.9	32.719	15	
15:20:58	549.688	102.967	56.622	0.149	33.222	78.78	77.2	32.386	15	
15:30:58	559.063	102.967	59.508	0.106	32.813	85.3	59.1	31.942	14	
15:40:58	557.5	102.967	60.291	0.17	32.244	61.7	118	31.442	0	rest
15:50:58	554.688	102.967	62.919	0.245	32.503	74.65	134.3	31.164	12	
16:00:58	561.875	102.967	61.494	0.275	32.731	71.9	158.4	31.219	15	
16:10:58	565.625	102.967	59.186	0.101	33.016	73.1	157.6	31.497	15	
16:20:58	557.188	102.998	58.742	0.288	32.859	72.1	135.2	31.664	16	
16:30:58	555.313	102.951	58.034	0.245	32.759	71.77	134.7	31.608	15	
16:40:58	560.313	102.967	59.117	0.413	32.756	72.51	124.5	31.553	15	

From this table, we plot the graph of Production Output versus all the environmental variables collected.

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Figure 1: Environment Factors Equipment

RESULTS AND DISCUSSION

The table above shows the overall pattern of the result which in this case is an acceptable, normal and harmless condition of environment. However, upon analyzing and comparing with actual environmental standard, we found out several variables might ergonomically being close to exceed the standard. The detail of each situation is being explained by each graph below.

According to American Society of Heating, Refrigerating and Air Conditioning Engineers Inc (ASHRAE), the permissible CO_2 level for workplace should be below than 700ppm. As presents as Figure 2, we can compare to the data that we gathered, the highest reading was 775 ppm where the amount of CO_2 is above the permissible level. This is due to the fact that during that time, the product tested was 2 stroke cylinder engines. As we know, 2 stroke cylinder engines produce more CO_2 compared to 4 stroke cylinder engines. That is because after the testing process for the 2 stroke cylinder engines completed at approximately 10.50 am, the level of CO_2 begins to decrease. The reason is they were switching to 4 stroke cylinder engines at approximately 11.00 am. As a recommendation, Hicom Yamaha management should recheck and recalibrate their suction ventilation system. This is to prevent the CO_2 from being leak to workers outside the testing chamber.

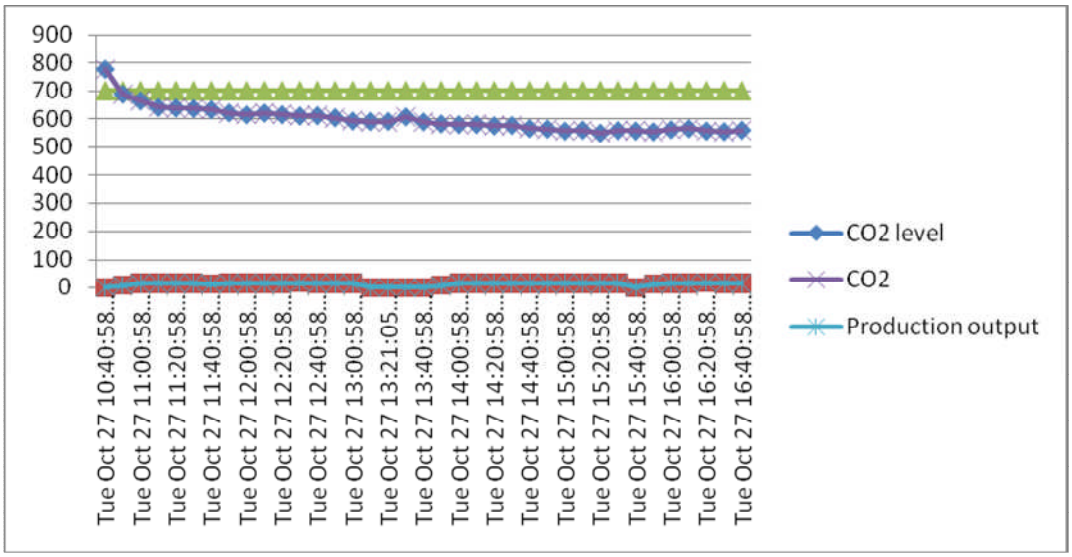

Figure 2: Comparison production output and CO_2 assessment in Final Inspection Workstation

Based on a report published by US Environmental Protection Agency and US Department of Health and Human Services on Building Air Quality, air pressure level is being described as the air quantity that is supplied to and removed from a room. If *more air is supplied than exhausted*, the excess air leaks out of the space and the room is to be under *positive pressure*. Meanwhile, *negative pressure* indicates that less air is supplied than exhausted; the *air is pulled in to the room.* The Figure 3 shows the air pressure throughout the six hours period is constant at 103 N/m^2. Although this figure seems quite high, it does not affect workers productivity if we compare it to production output during that period of time.

According to ANSI, humidity recommended is in the range of 30% to 60%. However, this range might not suit Malaysian climate since Malaysia is more humid compared to US. That is why Malaysian Meteorological Department, based on the humidity sensor stationed at Petaling Jaya, recorded the range of relative humidity is between 78% and 98%. Figure 4 provides humidity varies throughout the six hours period. This is because during the study, the weather keeps changing from hot in the morning to rain in the afternoon and hot again after 4 pm. As for workers, they did experience a lot of body sweating, especially at morning time and before rain started to pours. However, the management of Hicom Yamaha Manufacturing Malaysia tries to balance the humidity by putting several industrial fans at strategic area to make workers comfortable to their workplace.

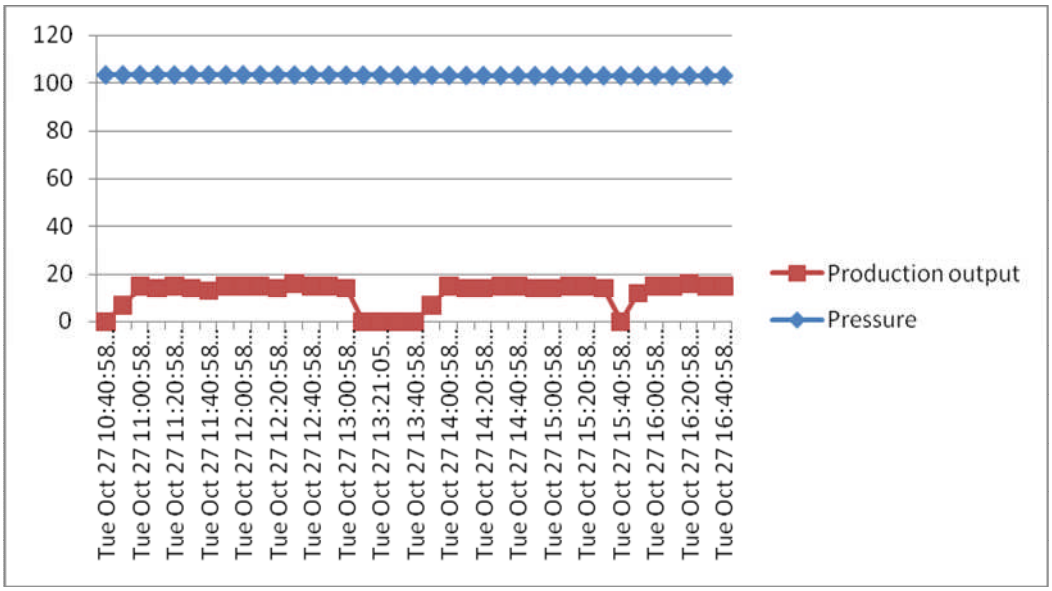

Figure 3: Comparison production output and pressure assessment in Final Inspection Workstation

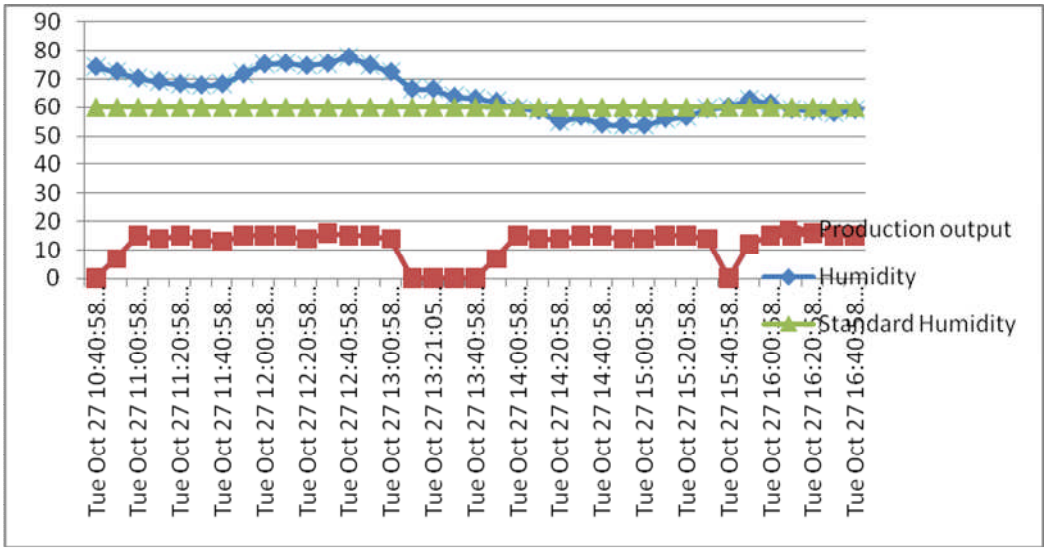

Figure 4: Comparison production output and humidity assessment in Final Inspection Workstation

According to ASHRAE, the recommended wind speed is 0.2 m/s. This is because according to their research, slow air movement contributes to a comfortable working environment. This is because wind speed contributes to effective temperature (ET). Wind speed helps promotes improvement of humidity through convection and radiation. Based

on our data represented by the Figure 5, the wind speed varied throughout the six hours period. This might be caused by the industrial fan located nearby the equipment and also due to the rain. However, in this case, wind speed did not affect the productivity of the workers since they were producing constant output throughout the six hours period of study.

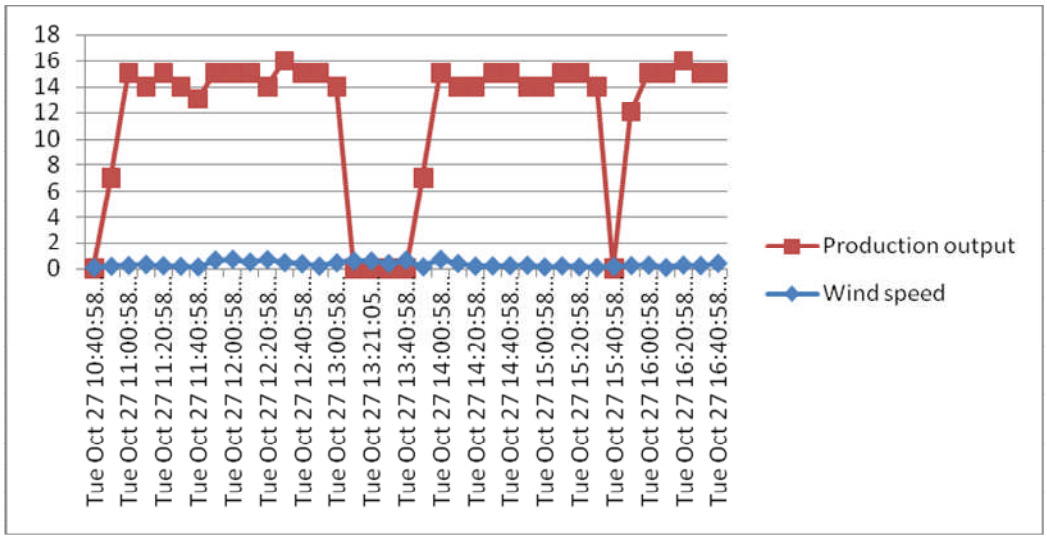

Figure 5: Comparison production output and wind speed assessment in Final Inspection Workstation

According to ASHRAE, the recommended room temperature should be from 19 ^{o}C and 26 ^{o}C. However in our study, Figure 6 shows that the room temperature for Hicom Yamaha is in range of 30 ^{o}C to 33 ^{o}C. This data presents that the workers might experience unwanted heat due to the temperature of their working place. The effort of the management of Hicom Yamaha to provide industrial fan in the workplace might help in reducing humidity of the area but did not help in stabilizing the room temperature of that area.

According to OSHA standard, the permissible exposure durations for various sound pressure levels are 8 hours for 90 db. Figure 7 provides the comparison production output and sound assessment in Final Inspection Workstation. Since Hicom Yamaha workers at Final Inspection area only exposed to average 80 db and their normal working hour is around 8.5 hours per day, therefore we can assume that the amount of sound being exposed to the workers is acceptable according to OSHA standard. However, we did feel for Quality Inspection workers who had to absorb consistent noise during the engine testing period although we did not manage to get the data for that working area. Therefore for future study we would like to measure the sound level in that area.

According to Illuminating Engineering Society of North America, the recommended illumination level is between category C and D where 150 to 350 lux are needed for comfort working condition. However, in this case, as illustrate in Figure 8, we do think category C where 150 lux is acceptable due to the nature of the job. Based on the data collected, we cannot help but notice the fluctuation of the luminance factor in this working area. This area light source mainly originated from the natural light source and pendarflour

lamp placed at that area. Therefore we can conclude that the luminance provided for the workers to perform their function is not according to standard and the Hicom Yamaha management might need to improve their lighting system or luminance flow.

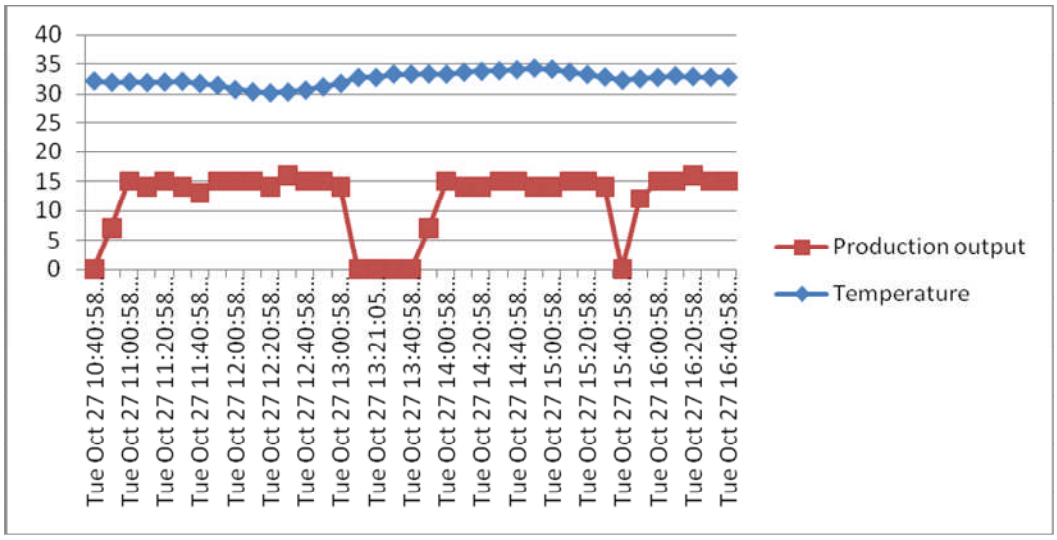

Figure 6: Comparison production output and temperature assessment in Final Inspection Workstation

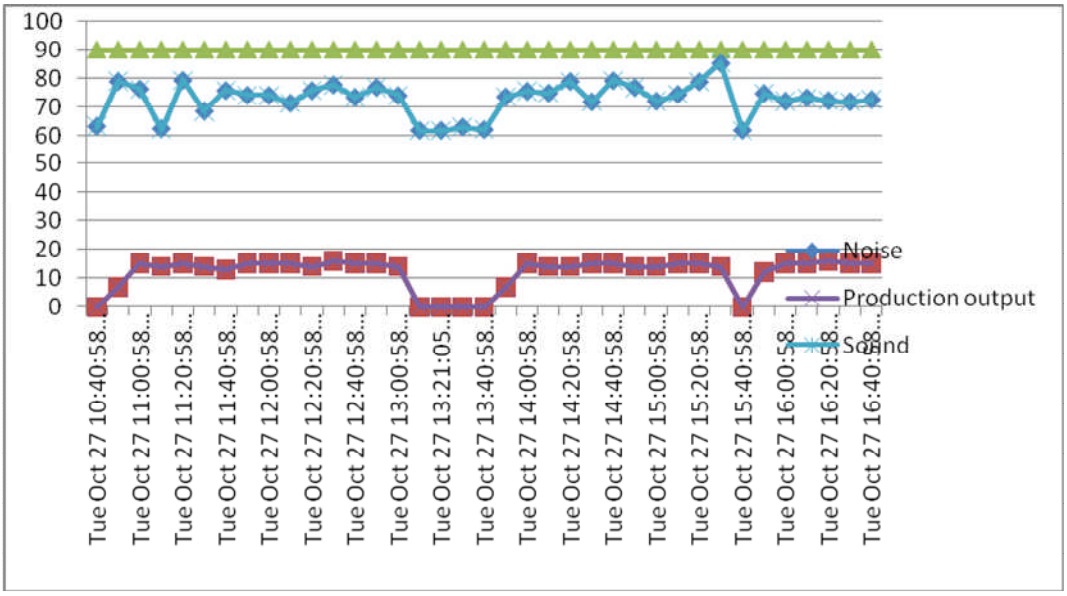

Figure 7: Comparison production output and sound assessment in Final Inspection Workstation

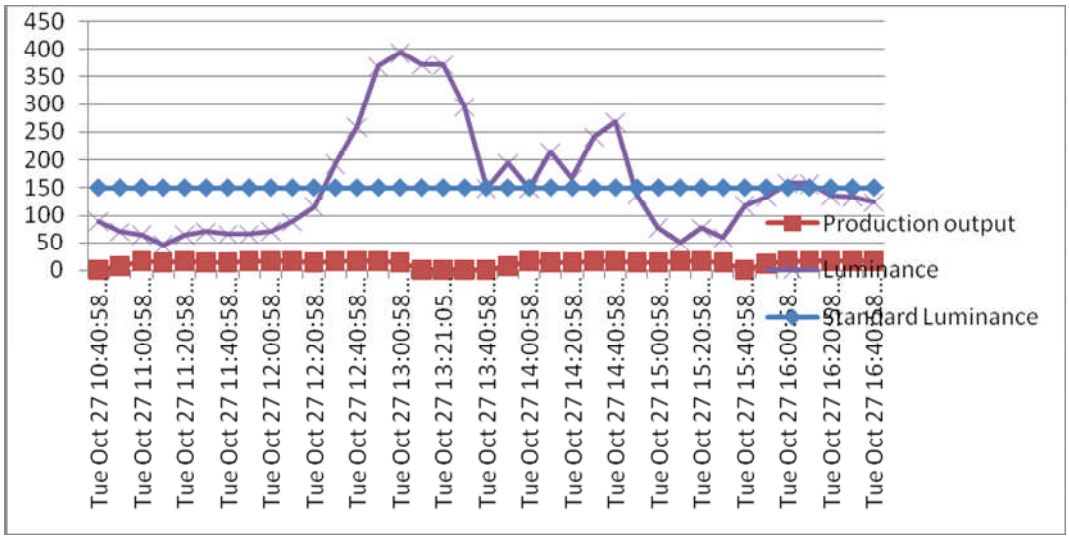

Figure 8: Comparison production output and illuminantion assessment in Final Inspection Workstation

Globe temperature is different from room temperature because globe temperature reduces the risk of the heat strain. Normally, the reading should be 1 -2^{o}C difference compared to room temperature. In this case, based on the Figure 9, we can see that globe temperature differ from room temperature by 1 -2^{o}C.

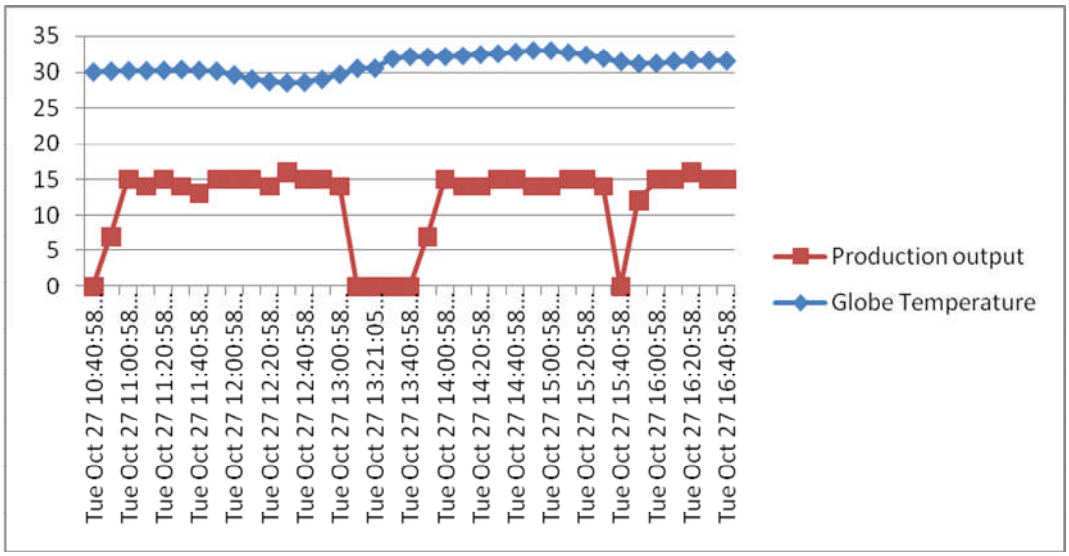

Figure 9: Comparison production output and globe temperature assessment in Final Inspection Workstation

CONCLUSION

The number of eight workers has been interviewed during the study. Range of the subjects working at the workstation is from 3 months to more than 5 years with age from 23 to 35 year old. All of subjects agreed with the statement that they are not having health affection while working at this workstation. They also rated that overall condition at working area is satisfactory.

From management side, ergonomics is part of their consideration when dealing with man, machine and methodology, material and working environment. Example of industrial ergonomics related activities currently being implemented are:

- Continuous training to all workers on environmental, safety and health.
- Health check to all workers at least once a year.
- Conduct periodical 5S and Safety audit to ensure all working area are in good condition at all situation and to identify any improvement required.
- Space of working areas for a subject decided based on recommendation by R&D Division at Head Quarter, Japan.
- Employee Suggestion Scheme where employees are encouraged to give a suggestion to management for any improvement from quality, cost, delivery, safety and morale point of view. The practical suggestion will be implemented by management and reward will be given.
- However, there are rooms for improvement can be implemented to improve industrial ergonomics at working area such as improvement of man-machine interaction which to provide more effective instruction to workers when dealing with machines. When industrial ergonomics were in place when necessary, it will helps organization obtained a benefits by:
- Reduction of machine downtime due to proper man machine interaction.
- Productivity improvement when workers comfortable with the working area.
- Reduction of product rejection when workers able to give full concentration to their tasks.

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