Heat stress among 500-660 mm pipe workers on Oil Rig Jackets assembly
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INTRODUCTION

Hot condition may result in heat stress to the employees who work in industrial area which contain many works that need to be done in hot area such as furnace or outside the building at an open space where direct sunlight cannot be avoided. The main source of heat at heavy industries included hot environment, hot metal, furnace, sunshine and welding work (Encharang, 1991). This situation occurs at heavy industry yard which involved employees who work for the onshore job at an open space under direct sunlight. Working in high temperatures will induce heat stress when more heat is absorbed into the body than can be dissipated out (Christine, 2003). Some companies experience losses when they keep pushing the employees to work hard to meet the goal and end up with many injury and accident occur. Heat stroke can cause death or permanent disability if emergency treatment is not provided (Glazer, 2005).

Safety procedure is a must for any company to implement it into their program as in Malaysia there is a rules and regulations that restrict the safety procedure for employer to practice among them and their employees. Some of the safety procedure that the employees need to follow is that they need to wear the personal protective equipment (PPE). Human body generates heat through muscle activities by doing work, if the work is overload then the heat generated is excessive too. Metabolic rate is a major contributor to heat stress even when environmental conditions would suggest that worker is not at risk (Morris, 1994). The material handling sometimes needs to be done manually and if there is an overload work then the possibility of heat stress from happening is high. Nature of sea that evaporates from direct sunlight may increase the humidity of the air around. Higher humidity environment at the working area may cause the human skin cannot operate to release the heat through sweating and cannot be dried out (Ozaki, 2005). This factor might increase more when the working hours are near noon period. Heat in the human body need to be balance by extracting it from the body which heat input must be equal with the heat released. This can be done from human skin, respiratory system and hygiene (Christopher et al., 2004). Heat stress causes multivariative problems on workers’ efficiency and productivity, especially when the workers are engaged in endurance-type activity (Ahasan et al., 2001).

The Wet Bulb Globe Temperature (WBGT) is a composite temperature used to estimate the effect of temperature, humidity, wind speed (wind chill) and solar radiation on humans. Data on WBGT-actual taken by using Thermal Environment Monitor QuesTemp°34 and has been analyzed to measure level of heat stress in the yard.

METHOD

The research study is focusing on workers who work inside the pipe for module and jacket assembly. The pipe used in this research is 508mm and 660mm pipe. Using Environment Heat Monitor, QuesTemp°34 the data on WBGT at the corresponded area of work has been gathered. The monitor used to measure the WBGT for outdoor which can be compute using equation. It is derived from the following formula:

\[
WBGT_{\text{outdoor}} = 0.7T_w + 0.2T_g + 0.1T_d \quad (1) \\
\]

where \(T_w\) is Wet Bulb temperature, \(T_g\) is Globe Temperature and \(T_d\) is Dry Bulb Temperature. The actual WBGT will are compared with WBGT Index recommended by ISO 7243 to yield the result of heat stress occurrence at the working area.

Figure 1: Environment Thermal Monitor QuesTemp°34
To gain a data from actual environment of working inside the pipe, the QuesTemp°34 monitor have been located at approximately 0.3 meters from the workers inside the pipe. Figure 2 show the monitor been located with all equipment for welding job inside the pipe.

Data gathered from QuesTemp°34 then transferred into computer software, QSPII to interpret result using Percentage Mean Value (PMV) and Percentage Person Dissatisfaction (PPD). PMV used range from -3 (too cold) to +3 (too hot) while PPD used percentage to measure human level of dissatisfaction which is 0% is good and 100% is dissatisfaction. This computer software has considering the factors of clothing, metabolic rate and windspeed. Result showed as a pdf formatted report on thermal comfort data, stay time data, logged table data and logged data chart.

Other methods used in the study are questionnaire and observation. This method has been added up to support and strengthen the data from QuesTemp°34. Questionnaire has been distributed to workers that involved in the working inside pipe environment. This consists of 30 respondents which includes the welder and grinder. The questionnaire includes 6 sections with total of 42 questions related to knowledge of heat stress, workplace behavior, thermal comfort, clothing, working environment and general information of workers. For comparing the result from questionnaire, observation has been made using observation sheet which includes 6 sections observing the air velocity, clothing, work rate, thermal radiation and humidity. All data gathered are analyzed using SPSS for windows software. SPSS software used to interpret the result into several graph, report and correlation of variables.

Uncontrollable factor such as bad weather must been taken into considering since it affected the value of data gathered.

Result & Discussion

QuesTemp°34 is capable of recording several temperatures such as Wet Bulb, Globe and Dry Temperature at the same time measuring surrounding level of humidity. Figure 3 shows the logged data chart for working environment inside 508 mm pipe while Figure 4 shows logged data chart for 660 mm pipe. Figure 3 and 4 (a) shows the chart which represent the working area without using blower while Figure 3 and 4 (b) shows working area with the used of blower as safety procedure. The data is recorded in duration time of 10 minutes for each reading.

From the detail report on QSPII data sheet, it has been recorded that average WBGT for 508mm pipe without blower is 30.52°C at 2.05 p.m. while 508mm pipe with blower recorded WBGT of 29.65°C at 11.30 a.m. Even though from the observation, the weather is not continuously hot, both condition showed WBGT is higher than recommended value which is 28°C and resulting in heat stress occurrence at the working area.
continuously hot and still, both condition showed WBGT is higher than recommended value which is 28°C and resulting in heat stress occurrence at the working area. From the view of actual situation, the organization practice rest tolerance which workers will take a short break around 15-30 minutes at 10 a.m. and 3 p.m. everyday excluding the official resting time at 12-1 p.m. Hence, the time region which heat stress would occur according to the data is between two unofficial short breaks which are approximately from 11 a.m. – 2 p.m. Encharang (1991) also found that the workers at heavy industry are exposed to the heat stress for a duration time of 6-7 hours per working day while Buglie (2005) have concluded that 74% of the trainee soldier wearing helmet during training are exposed to the heat stress for 6 hours per day.

Due the limitation of working in confine space such as inside the pipe, the workers need to work with awkward posture with the job that requires a high concentration to ensure quality finish product. These awkward posture increases the metabolic rate of workers hence increase the deep body temperature to generate more heat. Wearing PPE such as gloves, mask, double layer cotton cloth, additional full head cover and safety boot decrease the sweating process through skin. Heat also generated from the welding work and the usage of light bulb inside the pipe. Figure 5 show the posture of workers while doing welding and grinding inside the pipe.

Figure 5: Several postures workers inside pipe

(a) laying upward

(b) stranding stooped

(c) crouching

Even though the data showed a result from heat stress occurrence in the work place, but there is no history of case that workers experiencing from heat stress while working inside the pipe. This is because the company are practicing three resting time per day in which workers can refresh and gaining back their motivation towards work. Workers usually takes 15 to 30 minutes of resting time which is enough to cooling down the excessive heat in the body according to American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV). Questionnaire and observation studies found that the behavior of workers during work significantly reducing the possibilities of heat stress from occurs. This happened because workers tend to take rest and drink cool water when they feel heat is increases at their work surrounding. This situation is possible because they have flexibility on managing their resting time as long as the work responsible to them is following the schedule.

Figure 6: Bar chart (a) show the action taken when workers feel hot and pie chart (b) show the workers responded to reduce heat

As can be seen in Figure 6 (a), 14 workers out of 30 tend to take short break while 10 of them stop working immediately when they feel excessive heat. This action followed by 40% of them open their PPE, 27% finding shaded area while 30% going for air-conditioner building. Only 3% are drinking water. This condition happen because there is lack of training been given to the workers on the hazard of heat stress and step to prevent it from happening. Other data from questionnaire also showed that workers are likely to work in the morning and continue till midnight to finish their work schedule. This happen because workers tried to avoid from working in the afternoon in which the working environment is hot. This proved the result from Figure 3 and 4 that heat stress might occur if the workers work at 11 a.m. to 2.30 p.m. This situation also will reduce the company efficiencies and increasing the cost of production.

There are several recommendations that can be implemented at the yard to improve the working environment in order to reduce more heat stress possibility from occurring. Some of the recommendation step is suggested by the workers that are more experience in the current working environment. This suggestion must been taken into consideration by the
organization since to avoid any accident that might occur in the future. According to the workers, it is more comfortable to work in the pipe which is arrange following through the wind from the sea. Even though the organization is ordering the worker to used two blower inside the pipe but they tend to avoid it and only use one blower because the direct air flow from the blower may interrupting the quality of welding process. The blower also brings in the hot air from the yard into the pipe. Other factors that workers does not like to use two blower is that there will be no emergency exit if accident occurs inside the pipe since both of pipe end is covered with blower. When heat rises, one of the action taken by workers is to find shaded area which been provided by organization. The problem occurs when there is not enough shaded area and existing shaded area are crowded. When resting, human will release the heat from the body, therefore there is not efficient to reduce body heat when crowded place been used for resting in the hot environment. Following this problem, some workers are taking dangerous action by sleeping inside the pipe. To solve this matter, sufficient shaded area is needed and is closed enough from the working area.

Training on safety precaution step is very important to avoid from dangerous act been conducted by workers. This can reduces compensation cost if there is any accident occurs in the yard. Workers should been train and be reminded periodically to increase awareness of type of hazard in the working environment. Signboard can be located to the significant area to ensure workers are continuously following the right procedure of work. Lack of training can be seen in workers behavior since only 3% workers drink water in hot condition. The important of drinking water to reduce heat should been known by workers as well as to the organization, therefore as been observed the number of water dispenser at the yard are less than enough. The location of water dispenser also is too far from the working area where workers need to walk around 10-15 minutes before they can refill the water on their bottle. Since the yard consist of 100 acre of area, more water dispenser machine should been located in the specific area which can be reach at any time by workers.

**Conclusion**

In this paper, the combination of several methods used such as WBGT-Index, QSPII software, questionnaire and observation has interpret the result on heat stress for workers working inside the pipe. In current working condition conclude that the workers are experiencing heat stress when working inside the pipe. With the implementation of blower, the level of heat stress had been reduce to 3% for 508 mm pipe while 6% for 680 mm pipe. However there is no reported cases on heat stress occurrence in the yard, this is because of workers behavior who tried to acclimatize with the surrounding working environment. Level of heat stress can be reduce even more by improving the yard layout and adding additional shaded area, water dispenser and train workers to know the hazard at their working environment and the precaution step to prevent it.

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