

Effects of heat exposure and its mitigation measures at work place

Sujith dowlra¹, Jaivardhan Mugi², Prof. Abhishek Nandan³, Prof. Surender varadarajan⁴

^{1,2}M TECH HSE, University of Petroleum & Energy Studies, Dehradun, Uttarakhand,

^{3,4}Dept of HSE, university of petroleum and energy studies.

Abstract:

Occupational heat exposure is a health issue with several negative health outcomes. In recent years the wide array of research mentioned this risk factor. The aim of this paper is to study the occupational heat exposure and its impacts on health. Occupational heat exposure endangers the worker's health during heat exhaustion and it impairs the performance of worker as well. In addition to that, high humidity, personal protective clothing which also includes respiratory creates thermal stress to the worker. There are several acceptable heat prevention techniques and various mitigation measures for protection against heat stress. Various methods are used for assessing workplace heat stress, one of the widely used method among these is WBGT. Proper guidelines and standards can help to overcome the problem. Exposure to excessive heat is an issue for health. Due to global warming, countries like India which has almost 22 most polluted cities out of 30 in the world listed by WHO is experiencing a significant increase in temperature. The intention of this paper is to highlight the impacts on health-related issues while working in a hot environment in all the sectors and design the methods to maintain the health of the workers particularly those who are getting exposed to extreme heat

Keywords: Environment, heat stress, work-related heat exposure, Industrialization, WBGT.

Introduction

Heat stress can cause fatigue and increased physiological stress which diminishes efficiency, execution failures and could cause increased mishap rates. In this way, understanding the impacts and recognizing the best methods for lowering such impacts has been the focal point. The dangers of too much of heat exposure have verifiably been all around recognized, for example, in the military, mining, firefighting and industries. In some of the developing nations as well as developed nations, the danger of abnormal heat prevalence is maybe significantly higher because of excessively hot atmospheric conditions, due to the climate change and workplace occupational heat exposure. But, the effects of occupational heat exposure are not much valued in many developing counties, as they are more concerned about the productivity. Additionally, change in climatic conditions and expanding worldwide temperatures have worsened the extent of exposure due to heat in different locations throughout the world. Global scenario of climate change in the past few decades has been an issue that requires a special attention. This paper deals about present and forthcoming dangers related with carrying out work in the heated conditions and effective techniques for keeping up the wellbeing and profitability of manpower.

The resistivity of a worker against the heat exposure is identified with what sort of dress is worn and the ecological conditions. Some factors like garments worn by the workers, their behavior and moreover their requirements for working at excessive heat exposure play an extensive role in effecting the workforces. Manual workers in such situations are in danger of enduring ill-health outcomes because of extreme heat prevalence. The trouble with precisely figuring out which laborers are most in danger of over excessive work-related heat subjection is that heat resistance fluctuates extensively among people and even inside a person on an everyday premise. This is on the grounds that natural conditions, action of the worker as well as the type of work a person is carrying out can move and change to raise the danger of work-related heat subjection.

Global scenario of climate change

Climate change is one of the serious issues among all the global issues which humans are dealing with. Over the past four decades, global temperatures have risen up drastically due to the excessive usage of greenhouse gases. Industrialization is one of the major factors that influenced the abrupt change in climatic conditions. Fifty to sixty years from now, the climatic conditions were pretty much predictable. But things have really changed after excessive anthropogenic activities. The drastic change in climatic conditions was observed by the majority of the countries, which eventually led to the revelations of the term “Global Warming”. This term was coined by an oceanographer named Wallace Smith back in 1975. Global Warming was the next big issue that the human race was going to face in the coming years. CO₂ was discovered to be the major greenhouse gas which was responsible for the global temperature rise. As the demands of the people were increasing due to the increase in population, the production of the goods was speeding up. None of the countries was concerned about the impact of their rapid production on the environment. Carbon emissions were escalating, polar ice caps started to melt drastically resulting in global sea level rise. The global temperature started rising at a rate of 0.8°C every decade, which eventually made the average global temperature to rise. This change was clearly visible and on the verge of being inevitable. This situation resulted in various agreements among the countries to reduce the carbon emissions, greenhouse gases emissions, CFCs and to look out for alternative renewable energy consumption. Increase in global temperature has adverse effects on human health like heat stroke, heat cramps, unconsciousness, dehydration etc.

In the last decade 2000-2010, almost 370000 fatalities were recorded all around the globe due to heat-related illness which was around 19% higher than its previous decade. Almost 43% of the countries recorded the highest temperatures ever during 2000-2010, whereas only 23% of the countries recorded the highest temperatures ever during 1990-2000. The growth of 20% of countries experiencing temperatures like never before within the span of a decade is alarming.



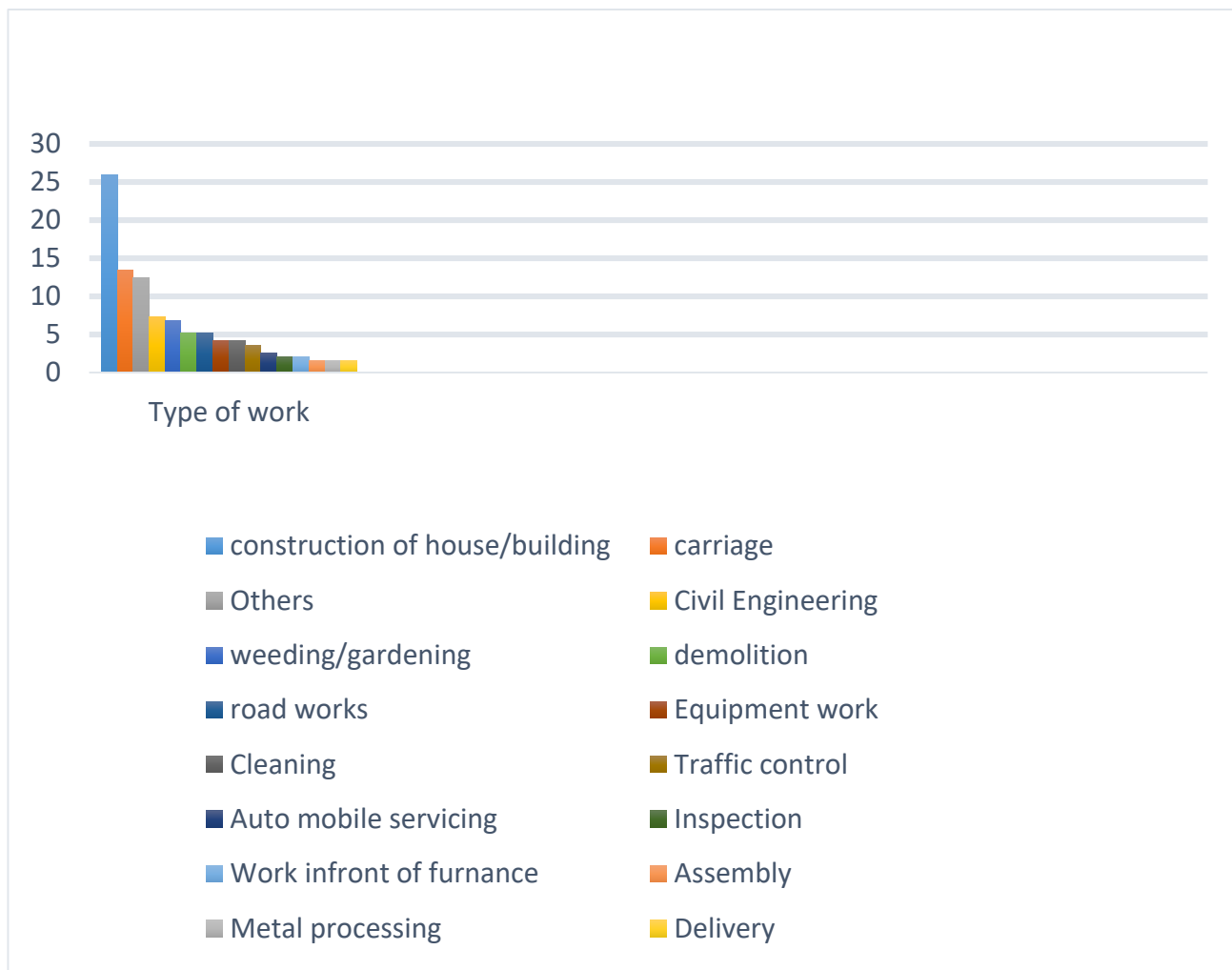


Fig. 1 Percentage of casualties at workplace due to heat related illness(Horie 2013)

Impacts of heat stress

Conduction, radiation, convection plays a key role in maintaining the physiological state of the body. The important factor in every industry is thermal stress. The core body temperature is 37°C. If a worker carrying out any work, energy release in the form of the heat and it is necessary to transfer into workers external environment. If the temperature exceeds the core body temperature above-set point having a chance of risk to organs and also difficult to work and ultimately leads to less production and blood flows through skin increases and sweating is started. Temperature above 38°C there is a threat of heat exhaustion and if temperature increases beyond lead to failure of the body's regulatory system. (Lundgren, Kuklane et al. 2013)

They are two parameters which will determine the body heat balance

- Climatic
- Non-climatic

Climatic parameters:

1. Ambient temperature
2. Humid climate
3. Radiant temperature
4. Wind speed

Non-climatic parameters:

1. Clothing
2. Heat generated due to physical work in a hot environment(Kjellstrom, Holmer et al. 2009)

If body cooling is not sufficient with sweating the heat generation due to metabolic activity must be reduced to avoid heat stress and heat stroke. In a hot environment, if the physical activity is very high, the worker is at the threat of increasing the core body temperature, which would decrease the work activity, physiological task ability and which would result in heat stroke. The main contributing factors for these effects are raise in core body temperature, Dehydration and insufficient liquid.

Effect of heat exposure at different occupations

The workplace heat exposures vary from occupation to occupation. There is a chance of increasing threat of occupational accidents due to heat exposure. The effect of heat exposure especially severe on the worker who works in outdoor such as mining, automobile assembly, heavy vehicle manufacturing, glass manufacturing industry, steel industry, leather industry, electricity generation industry, textile manufacturing industry, fertilizers industry, and agriculture industry as well as fire-fighters. (Balakrishnan, Ramalingam et al. 2010). Without proper heat dissipation, exposing to heat for short-term can result in rise of core body temperature. Long-term exposure can result in chronic health effects like mental health problem, heart diseases like cardiovascular, irritability and kidney related problem. Elevation in core temperature has a negative impact such as fatigue, and loss of capability. (Xiang, Bi et al. 2013)

Hazard of heat exposure

The workers who work daily in a hot environment will be influenced by heat disorders or heat-related issues. The meaning of heat stress is that person or worker is exposed to extreme heat, as a result, his or her health is negatively affected. At a low level of heat stress, there is no effect on health even people may feel discomfort. Keeping the work zone at the safe temperature it is easy to eradicate the heat stress totally. Basically, two types of exposures are there i.e. short-duration exposure and long-duration exposure. Short-term exposure leads to acute illness and long-term leads to chronic illness.(Dukes-Dobos 1981)

Types of heat-related illness:

Heat Exhaustion: It occurs when a person working in a hot environment or humid place due to loss of body fluids in the form of sweating. The symptoms include fatigue, rapid heartbeat, vomiting, dizziness and loss of coordination and concentration. A patient who suffers from the heat exhaustion should remove clothes and moved to the cool environment. Prefer fluids to replace the salt that loss through sweating. Due to loss of consciousness, it results in self-injury or injury to the other workers. Increase in the flow of blood to the skin causing a decrease in the flow of blood to organs which leads to mild shock.(Becker and Stewart 2011)

Heat cramps: Heat cramps are basically caused due to performing of hard physical work in the hot environment. It is the first indicator that the body is facing difficulty with the heat. The cramps caused by electrolyte imbalance problems. Loss of Minerals like sodium, potassium from the body can lead to cramps.

Heat rashes: Heat rashes are the most common ill effect in a hot environment. Heat is present in the form of red papules where clothing is constructive and skin is persistently humid. When the affected worker or person moves to a cool environment heat rash will disappear. This causes mild burning sensation over the skin resulting in redness of the skin

Heat stroke: Heat stroke occurs when the temperature regulation system of the body's fails and temperature of the core body rises to a threatening level. The temperature of the body can rise to 105°C or ever higher within a span of 10 to 15 minutes. The signs of heat stroke are usually lack of sweating and confusion.(Rogers, Stiehl et al. 2007)

Probability Factors for heat-related illness:

1. Age is the primary factor for heat-related illness.
2. Consumption of alcohol
3. Fatigue
4. Wearing personal protective equipment's for a long time
5. Overweight
6. Usage of drugs

7. Dehydration due to insufficient intake of food and water
8. Distress
9. Body fat

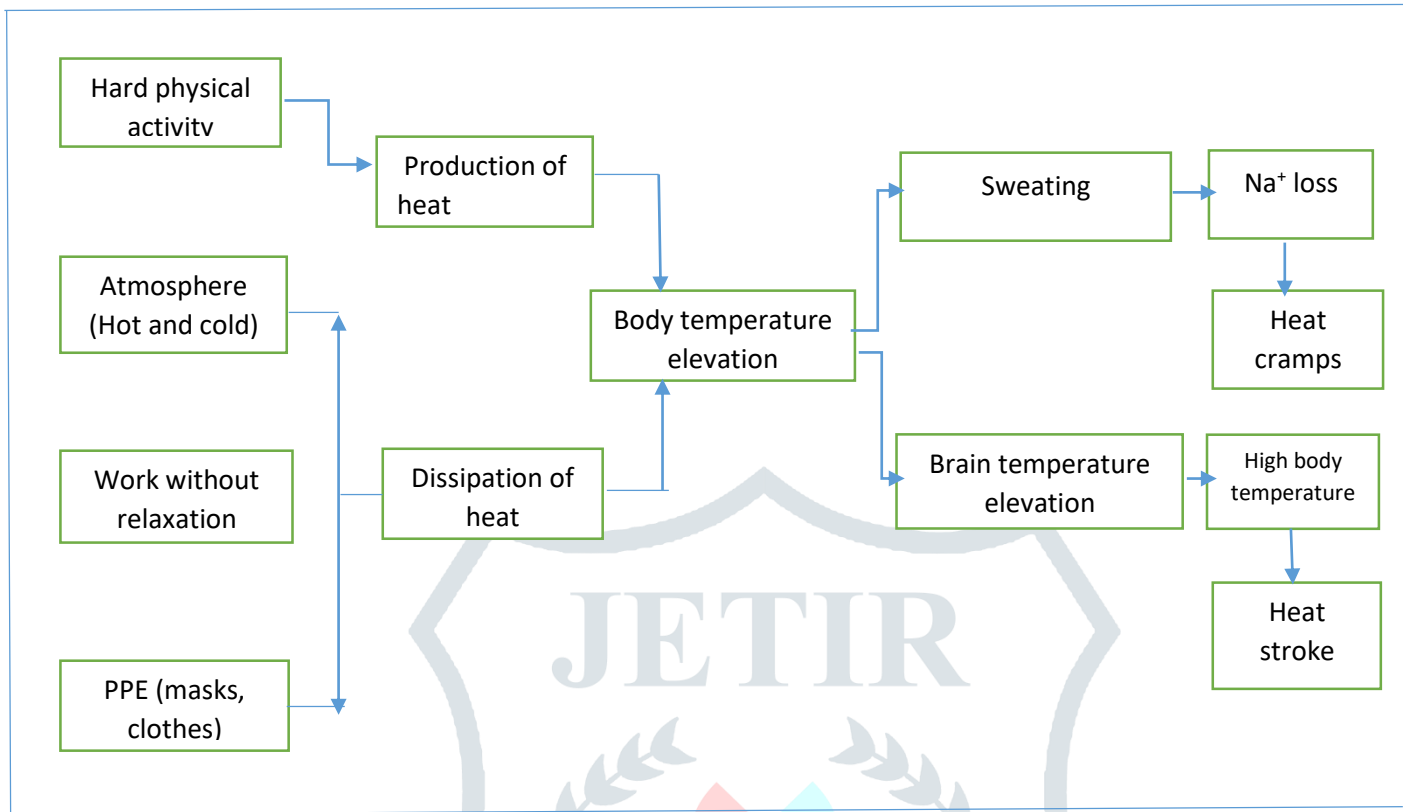


Fig. 2 Mechanism of heat related illness occurrence in work location(Horie 2013)

Assessing workplace heat stress

In order to save the worker from the heat exposure effects, Indices for heat stress and proper guidelines are developed. The common technique for estimation of heat stress in the occupational workplace is Wet Bulb Globe Temperature (WBGT). US-based Army has developed WBGT index decades ago. The exposure to heat stress was estimated by the calculation of WBGT. The WBGT particularly assess the contributing factors. Area heat stress monitor will carry out the measurements for WBGT. American conference of governmental industrial hygienist (ACGIH) set the standard and instrument which is used for the measurements should compile with the standard. The workers are exposed to heat stress which in-turn is dependable on environmental factors. They are wind speed, ambient temperature, humidity and mean temperature. Heat indices is classified into three categories.

1. Direct indices
2. Rational indices
3. Empirical indices(Epstein and Moran 2006)

Calculation of WBGT

With no Direct sun load for indoors & outdoors:

$$WBGT = 0.7 * Temp_{wb} + 0.3 * Temp_{gb}$$

$Temp_{wb}$ = Wet bulb Temperature, $Temp_{gb}$ = Globe temperature

With direct sun load for indoors & outdoors:

$$WBGT = 0.7 * Temp_{wb} + 0.2 * Temp_{gb} + 0.1 * Temp_{db} \text{ (Srivastava, Kumar et al. 2000)}$$

TWA-WBGT: The thermal conditions at workplace varies widely with respect to time. Hence time-weighted average (TWA) is used to calculate the exposure of heat

$$\text{TWA-WBGT} = \frac{t_1 * \text{WBGT} + t_2 * \text{WBGT} + \dots + t_n * \text{WBGT}}{t_1 + t_2 + \dots + t_n}$$

General control measures for heat-related illness at workplace

Human beings have to deal with heat exposure effects either by utilizing preventive measures or adjusting to the prevailing situations. It is much better to adjust to changing climatic conditions, but more focus is shown on carrying out impulsive control measures rather than gradual adaptable approach. Heat-related illness during work can be prevented by reducing the extent of heat exposure from the source. A body temperature measuring devices, usual inspection techniques. These basic preventive measures must be applied whenever there is a possible chance of excessive heat exposure during work, and this can be applied to each and every work dealing with workplace heat exposure. Distinctive approach of preventive measure is mostly used for a particular kind of work.

Some of the engineering's control that's could be utilized at the workplace are proper reactive planning, cooling using water as hydrant, air-based cooling, air permeable fabric, avoiding tight-fitting clothes, cooling areas, movable shade providing structures, reduced insulated clothing. The ambient air around the workplace can be maintained with artificial dehumidification to ensure reduced temperatures at the workplace. Air permeable fabric allows the ambient air to flow through it, which does not allow the heated air to get trapped inside the clothing. Special additional materials can be applied all over the clothing which either liberates heat or traps the heat depending upon latent heat of vaporization or latent heat of fusion. It has a heating effect when it crystallizes and cools down when the material melts. Whereas, clothing integrated with phase changing substance could be costly and not feasible in the developing countries. Utilization of fans and air conditioners at the workplace is also one of the controls available, but it is not feasible when the temperatures are really high and not at all cost effective as well. An alternative approach to this problem is to utilize solar-powered equipment to supply dry air near the areas required at the workplace. Dry air has the tendency to hold more amount of water in it, which helps the worker in cooling down his body temperature by taking away the sweat from his/her body, in turn reducing the stickiness. (Lundgren, Kuklane et al. 2013)

Workplace environment can be designed with a large number of trees and eco parks, designing the buildings which decrease heat dissipation. Work rest is another measure that can be utilized by the administration to reduce the effects of excessive heat exposure, reducing the length of relentless work, avoiding heavy physical workload Proper training to the workers is also essential as well. Cooling areas under the shade for rest must be prepared, cool wet towels should be made available near the washrooms and cooling drinking water facilities shall be provided. Regular consumption of water and salts to ensure proper metabolic activities. (Horie 2013)

Conclusion

Heat stress poses risk to health and safety of worker in various occupation. In industry, heat stress is one of the major problems. Due to global climate change, heat exposure is likely to produce occupation threats. The heat exposure constitutes a significant factor which has an adverse impact on workers capability and therefore a negative impact on production as well. Heat stroke in work location is due to the humid climate and hot environment. It can be suppressed by upgrading the work location environment and by taking minerals like sodium. Education and early involvement are solutions to avoid heat-related illness and diminishing the effects of elevated temperatures. Different preventive measures are utilized all over by various countries depending upon the economical standards of individual industries. In the present context with global temperatures soaring, it is difficult to maintain standard working environment naturally. So, artificial working environment is need to be created by dehumidifying the workplace, increasing the vegetative propagation around the industries.

References:

- Balakrishnan, K., et al. (2010). "Case studies on heat stress related perceptions in different industrial sectors in southern India." Global health action **3**(1): 5635.
- Becker, J. A. and L. K. Stewart (2011). "Heat-related illness." American family physician **83**(11).
- Dukes-Dobos, F. N. (1981). "Hazards of heat exposure: a review." Scandinavian journal of work, environment & health: 73-83.
- Epstein, Y. and D. S. Moran (2006). "Thermal comfort and the heat stress indices." Industrial health **44**(3): 388-398.
- Horie, S. (2013). "Prevention of heat stress disorders in the workplace." JMAJ **56**(3): 186-192.
- Kjellstrom, T., et al. (2009). "Workplace heat stress, health and productivity—an increasing challenge for low and middle-income countries during climate change." Global health action **2**(1): 2047.
- Lundgren, K., et al. (2013). "Effects of heat stress on working populations when facing climate change." Industrial health **51**(1): 3-15.
- Rogers, B., et al. (2007). "Heat-related illnesses: the role of the occupational and environmental health nurse." AAOHN journal **55**(7): 279-287.
- Srivastava, A., et al. (2000). "Heat exposure study in the workplace in a glass manufacturing unit in India." The Annals of occupational hygiene **44**(6): 449-453.
- Xiang, J., et al. (2013). "Health impacts of workplace heat exposure: an epidemiological review." Industrial health: 2012-0145.