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EFFECT ON PRODUCTIVITY DUE TO WORKER'S EXPOSURE TO POOR AMBIENT CONDITIONS

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Abstract

The purpose of this study is to assess the variation in productivity of industry workers with a better understanding of the impacts of adverse ambient conditions viz. humid or dry atmosphere, thermal stress, poor illumination, excessive noise or poor ventilation. Once the impact of ambient conditions on the overall organizational productivity may be understood, the working area comfort for the workers may be more emphasized. Environmental parameters have been measured both during day and night time, and wherever required, Time Weighted Average (TWA) have been implied to obtain accurate results. Productivity models were further used to analyze the collected data. The model results demonstrated that poor environmental parameters decrease worker's productivity, whereas ambient quality comfort at workplace could have resulted in an improved productivity.

Keywords: productivity, industry workers, Environmental parameters, workplace.

Introduction

In this study, the author conducted an on-site study in Raipur District of Chhattisgarh State (India). Data compiled here is based on continuous and direct observations of the shop floor working environments of steel plant workers. Data were collected to assess the impact of various environmental parameters viz. humidity, thermal stress, illumination levels, noise and ventilation in the productivity of a group of workers. Worker's productivity was measured based on the direct work time, indirect work time and idle time, which are measures of efficiency in terms of time rather than completed work. Next, productivity models were created to study the impacts of adverse environmental conditions on worker's productivity. The fatigue conditions of rolling millers and steel melters during the day were also discussed. Parameters recorded were during the extreme summer condition between 20.05.2024 to 30.05.2024, when the ambient temperature in the surrounding reaches to the tune of 46.5^0C.

Productivity represents a relationship between the output and the associated input in a production process. Because labor wages/salaries accounts for nearly 25–35% of the total manufacturing cost in a steel industry, hence manpower is the dominant resource in a production unit. Being the other cost viz. cost of raw material, process cost, quality control cost, energy & logistic costs are more or less constant (varying between 5-10% in a steel plant), worker's productivity is the most prominent factor for measuring productivity. The American Association of Cost Engineers International (AACE International) also defines productivity in the industry as the "rate of output per unit of time or effort, usually measured in labor hours".

Productivity can be explained mathematically by the following equation

$$Labor\ productivity = (Unit\ output)/(Labor\ inputs)$$

a. Humidity :

Humidity is defined as the concentration of water vapour in the air or the amount of water vapor present in the air is called **humidity**. The gaseous state of water is known as vapor. If the air contains a huge amount of water vapor the humidity will be high.

a.1 | Effects of high humidity on a worker

- Dehydration
- Heat exhaustion
- Fainting & Heatstroke
- Causes hypothermia, etc

a.2 | Effects of low humidity

- Bloody noses & Itchy throat
- Static electricity
- Allergy and asthma

The formula to calculate relative humidity is given below:

R_H = (Actual Vapor Density / Saturation Vapor Density) × 100%

b. Wind Speed

The rate at which air is moving in a particular area is known as wind speed. They are atmospheric quantities caused by air moving from high to low pressure. Humidity and wind speed are highly related to each other. The high speed of wind decreases the level of humidity and low wind speed causes a high level of humidity. They also affect worker's human body.

c. Noise :

Noise and vibration are both fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term 'noise' to indicate unwanted sound. Noise and vibration can harm workers when they occur at high levels, or continue for a long time. Exposure to loud noise can destroy these hair cells and cause hearing loss.

c.1 | Symptoms of High Noise Exposure Levels :

Noise may be a problem at workplace if a worker experiences the following :

- Hear ringing or humming in his ears when he leaves work.
- Have to shout to be heard by a co-worker an arm's length away.
- Experience temporary hearing loss when leaving work.

c.2 | Measurement criteria :

During the current cycle of hygiene survey, a noise dosimeter capable to directly measure Leq, Lp and Lx readings for a given exposure time have been used and accordingly measurements were recorded.

Whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A-scale (slow response) or, equivalently, a dose of fifty percent.

d. Heat Stress :

Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress. Exposure to extreme heat can result in occupational illnesses and injuries. Heat stress can result in heat stroke, heat exhaustion, heat cramps, or heat rashes. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness. Burns may also occur as a result of accidental contact with hot surfaces or steam. During this study, it has been revealed that heat levels in the shop floor area substantially affect the worker's productivity.

e. Ventilation

As per clause 5.0 of National Building Code 2005, general ventilation of a building is required to supply fresh air for respiration of occupants, to dilute inside air to remove any products of combustion or other contaminants in air and to provide such thermal environments as will assist in the maintenance of heat balance of the body in order to prevent discomfort and injury to health of the occupants.

In normal habitable rooms devoid of smoke generating source, the content of carbon dioxide in air rarely exceeds 0.5% to 1% and is, therefore, incapable of producing any ill effect. The amount of air required to keep the concentration down to 1% is very small. The change in oxygen content is also too small under normal conditions to have any ill effects; the oxygen content may vary quite appreciably without noticeable effect, if the carbon dioxide concentration is unchanged.

DISCUSSION

The thermal comfort of a person lies between temperature range of 25°C and 30°C with optimum condition at 27.5°C. Air movement is necessary in hot and humid weather for worker's body cooling. A certain minimum desirable wind speed (2m/s is optimum) is needed for achieving thermal comfort at different temperatures and relative humidities. Mechanical means of ventilation have been adopted by the organization to gain this wind speed in enclosed areas.

- During current cycle of hygiene survey, ventilation in all areas found adequate. Oxygen level measured through multigas detector was found within the specified range of 19.5% to 23.5%, LEL, CO and H_2S was absent as measured through gas detector in the areas having human habitation.
- Traces of hydrochloric acid fumes and zinc was found NIL as measured through air sampling in potential area i.e. galvanization plant where HCl fumes are generated during hot dipping of metals in acid baths.
- Ambient temperature inside shop floor area was found exceeding 38.5°C. It was substantially high near steel melting furnace.
- Ventilation was provided through mancoolers and exhaust fans with enough air circulation to emit the contaminated air from inside shop floors. Cable galleries were also found duly mechanically ventilated.
- Cross ventilations are provided in the office rooms and conductive air-conditioning system provided in the CCM, panel rooms and switchgear rooms.
- The productivity of workers in outdoor high-temperature environments may decrease because of workers automatically decreasing their activity to prevent their bodies from generating excessive heat.
- In addition, the side effects of working in high-temperature, humid, suffocated or noisy environments are reflected in delays, irritability, restlessness and reduced enthusiasm in daily work performed by a worker.
- Moreover, such an impact on productivity due to adverse atmospheric parameters is more intense on the outdoor workers than the workers engaged inside shed/building area.

LIMITATION

- In the subject study, workers from an integrated steel plant were sampled and their productivity was studied. Impacts of adverse working environments on productivity present limitations that require further investigations with more realistic and comprehensive perspectives depending on type, size, location and hazard considerations in respective industry.

TABLE : 1
WORKER'S PRODUCTIVITY & WORK-REST SCHEDULE MEASURED
*Note : Data reflects an average 8 (eight) working hours including lunch break & tea break

Work Zone	TEMPERATURE ^{0}C		RELATIVE HUMIDITY in %		WIND VELOCITY m/s		O2 LEVEL	VENTILATION	*PRODUCTIVITY	*WORK REST SCHEDULE
	MAX	MIN	MAX	MIN	MAX	MIN	HOURS	%	HR:MIN	HR:MIN
Admin building	29.1	18.7	38.9%	33.2%	0.10	0.00	20.3	0.00	7:13	0:47
Canteen kitchen area	32.8	19.8	39.3%	32.1%	0.12	0.00	20.9	0.00	7:39	0:21
Furnace DG End	38.6	36.4	41.6%	47.8%	0.11	0.00	20.3	0.00	6:43	1:17
CCM/Billet caster	38.1	37.4	57.3%	44.5%	0.34	0.05	20.8	0.00	6:38	1:22
Under Furnace DG End	37.5	37.3	55.3%	48.9%	0.31	0.00	20.8	0.00	6:43	1:17
Furnace-3 Hydraulic	37.2	37.1	56.5%	43.2%	0.28	0.00	20.8	0.00	6:54	1:06
Furnace-2	32.5	30.7	56.8%	46.7%	0.21	0.01	20.8	0.00	**6:18**	**1:42**
Furnace-1 panel area	29.3	18.4	53.4%	45.9%	0.08	0.00	20.9	0.00	6:44	1:16
Induction Transformer Furnace	29.8	26.4	48.2%	45.5%	0.18	0.02	20.3	0.00	6:23	1:37
Recoiler **(not in operation at present)**	34.4	26.8	63.7%	47.8%	2.30	0.31	20.9	0.00	0:00	0:00
Bundling machine	34.5	33.8	49.7%	44.5%	0.08	0.00	20.3	0.00	7:12	0:48
Mill roughing area	35.9	34.7	45.3%	41.9%	3.12	1.22	20.9	0.00	7:10	0:50
Rolling mill flywheel side	36.2	34.4	47.8%	35.2%	3.17	1.38	20.9	0.00	6:52	1:08
Mill stand	34.5	33.2	44.5%	36.8%	0.89	0.12	20.3	0.00	6:53	1:07
Pipe Mill 1&2 (RLA 1&2)	37.2	34.3	48.9%	41.2%	3.45	0.11	20.3	0.00	7:14	0:46
Pipe Mill ACB room/ACB panel	29.6	24.6	43.2%	35.3%	1.35	0.04	20.8	0.00	7:43	0:17
Finished goods storage &	34.4	33.8	46.7%	27.7%	0.89	0.12	20.8	0.00	7:35	0:25
GP compressor room	31.8	31.6	45.9%	34.1%	3.97	2.12	20.3	0.00	6:32	1:28
Galvanizing dispatch yard	39.4	38.6	45.5%	38.2%	3.83	1.37	20.3	0.00	7:05	0:55
Galvanizing near HCl tank	37.6	34.5	45.8%	34.4%	3.77	1.28	20.3	1.00	7:13	0:47
Galvanizing panel room	29.3	28.7	44.3%	31.6%	0.83	0.12	20.3	0.00	7:21	0:39
Near Diesel Storage area	32.2	31.4	46.7%	35.3%	2.78	0.98	20.4	0.00	7:44	0:16
Near Oil Storage	33.2	30.8	46.8%	37.6%	2.67	0.83	20.4	0.00	7:32	0:28
Tool shed	34.3	29.8	45.4%	36.6%	0.90	0.10	20.9	0.00	7:44	0:16
Effluent Treatment Plant	33.2	31.8	44.8%	37.8%	0.38	0.00	20.9	0.00	7:21	0:39
Main Gate security office	28.4	26.6	47.3%	28.7%	0.22	0.00	20.6	0.00	6:23	1:37

Water complex – water tank &	28.9	28.4	44.5%	33.1%	0.12	0.01	20.8	0.00	7:25	0:35
Laboratory	23.4	18.7	48.9%	39.2%	0.12	0.01	20.9	0.00	**7:54**	**0:06**
Rest room & OHC	28.5	27.6	43.6%	33.4%	0.11	0.00	20.9	0.00	7:45	0:15
Finished storage goliath crane bay	32.3	30.5	43.7%	35.5%	1.28	0.23	20.9	0.00	7:21	0:37

Obviously, the productivity of the workers working in laboratory area was found maximum i.e. 7:54hours with a Work-Rest schedule of 0:06hours, whereas it is found minimum in Furnace-2 capacitor area which is 6:18hours with a Work-Rest schedule of 1:42hours. It may be interpreted with respect to working environment and ambient air conditions in both these areas. Laboratory is having a functional air-conditioning to maintain the room temperature below 26^0C due to testing requirement, whereas Furnace area is subjected to high rate of heat stress. Hence productivity has accordingly been varied, workers are taking more time to resume to their work in an adverse atmospheric condition than in a comfortable room.

Overall variation in the productivity of the workers between these 2 extreme conditions is 20.253% i.e. the worker's productivity is 20.253% higher where ambient parameters were comparatively comfortable.

Oxygen level was found moderate in all the enclosed area (marked as "Close" in above list) and confined spaces i/c cable galleries. Acceptable range of O_2 is 19.5% to 23.5% and all the readings have fallen within this range. Hence safe.

CONCLUSION

Certain relevant studies have been conducted in India by various researchers regarding industrial worker's output in different industries; however, these studies did not involve direct measurements of labor productivity. Most previous studies of adverse ambient conditions vis-a-vis productivity lack on-site data for support. Current methods used to measure productivity have numerous limitations.

Traditionally, productivity in an industry is measured in terms of hourly output, which is defined using the number of workers work hours as an input value to obtain the physical quantity of work as an output. However, the production rates among different jobs can lead to differences in measured productivity, even when workers perform the same type of work. For example, workers are efficient, but machines are not efficient or they are outdated. Electricity fluctuation in an industrial area is another prominent reason for poor output. Flow of production due to non-availability of raw materials may be common in few of the areas, hence worker's productivity cannot be measured accurately without taking such factors into account.

Moreover, the current methods of measuring worker productivity under heat stress focus on the ratio of the allowable metabolic rate to the full metabolic rate.

Hence it is concluded that if workplaces are reviewed for ambient conditions, and desirable humidity, temperature, wind velocity, illumination and noise can be maintained, it will bring positive results in the form of improved output.

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