HAZARDS OF TEXTILE INDUSTRY

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Hazards of the Textile Industry

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Better understanding of the hazards in any Industry could be achieved by getting acquanted with the process. The attached flow chart of the process gives you the summary of manufacturing of the cloth.

(1) Mixing Dept. : Cotton bales are opened and different types of of cotton are blended together for technical reasons. Blended cotton is collected in trolleys and brought to Blowroom.

(2) Blow Room : In this process after blending; the impurities such as dust, dirt, dry leaf particles, seeds, iron particles are removed and cotton laps are prepared.

(3) Carding : All the fibres of cotton during the clearing process are very much entangled together therefore these fibres are seperated and made in a "sliver".

(4) Combing : In carded sliver there are some dibres which are shorter than required length these short fibres are removed in the process.

(5) Drawing Frame : Carded or combed sliver have all the fibres in criss-cross manners they are made parallel to spin good yarn.

(6) Speed Frames : (Slubbing/Inter/Roving)
In these processes the sliver is reduced into diameter and increased in length. This material is called Roving.

(7) Spinning : Here the roving is further reduced in diameter and increased in length = warp and weft yarn are thus finally produced.

(8) Winding : For subsequent process the yarn is to be wound on bigger packages called "cheese and cones".

(9) Warping : About 500 ends of thread from cheese or cones are wound on a big beam.

(10) Sizing : Yarn is now impregnated with certain chemicals and sized material (starch,softners, & Antiseptics) so as to withstand the strain in weaving process.

(11) Drawing-in : Here the design of the cloth is determined. The setting of the design is a highly technical process, which requires good eye sight. (Manual process).

(12) Weaving : Weaving machine is called loom so the department is designated as loom shed. Here the warp (sized beam and weft yarn(directly from spinning) are interlaced together and the required design of the cloth is produced.

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(13) Grey Folding Dept. : Grey cloth received from Weaving is measured; inspected for defects. Some of it sold as Grey cloth hence goes for stamping and baling while remaining goes for further processing.

(14) Processing : (Bleaching/Mercerising)

Grey cloth is stitched in stitching process by sewing machine, thereafter the protruding fibres on the cloth are cut by shearing and cropping process. Thereafter the cloth is passed for singeing, Desizing; Scouring; Bleaching where in the cloth is given treatment with chemicals and enzymes. This cloth is later sent for Mercerising which gives the shining and luster to cloth (its again a chemical process).

(15) Dyeing : Bleached cloth is dyed on dyeing machine called Jiggers or Hot Flue and Dyed cloth gives for further processes of finishing.

(16) Printing : Done by two methods. 1) Machine upto 10 colours)
2) Screen Printing (over 10 colours).

(17) Finishing : Cloth received from Printing and Dyeing department has to pass through the processes of stentering (stretching effect and uniformity).

Calendering (Ironing effect) & Sanforizing (Antishrinkage)

(18) Bleach Folding : All cloth received is measured in metres, inspection for defect, handfolded and sent for stamping, bundling and baling.

6.11.73

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MANUFACTURING OF CLOTH

Department	Product Delivered from the Dept.
Cotton Godown	Cotton Bales
Mixing	Loose Mixed Cotton
Blow Room	Cotton Laps
Card Room	Carded Sliver
Combing	Combed Sliver
Drawing	Drawn Sliver
Speed Frames (Slubbing/Inter/Roving)	Roving
Spinning	Yarn
	Warp Yarn / Weft Yarn
Winding	Cheese or Cones
Warping	Warped Beams
Sizing	Sized Beams
Drawing-In	Drawn Beams (Through Healds & Reeds)
Loom Shed	Grey Cloth

20.8.1975

PROCESSING OF CLOTH

Department	Process given to Cloth
	Grey Cloth received from Loom Shed
GREY FOLDING	Inspection Yardage Measurement Cloth for Processing / Cloth for Grey Packing Plaiting Cutlooking Hand Folding
BLEACHING/ MERCERISING	Stitching Shearing and Cropping Singeing Desizing Scouring Bleaching Washing Scutching Mercerising (if required) Drying Bld Cloth / Bld Cloth for Dyeing / Bld Cloth for Printing
D Y E I N G	Batching Dyeing (On Jiggers or Hot Flue) Drying
P R I N T I N G	Batching Printing Curing or Ageing Washing Drying
F I N I S H I N G	Stentering Calendering/Felt / Raising Calendering Sanforizing (if required)
BLD. F O L D I N G	Plaiting Cutlooking Handfolding Stamping Make-up & Bundling Baling

20.8.1975

After having known about the various processes of the Textile Industry we have come to know that the important hazards are due to

1) Flying dust in the atmosphere as found in - Mixing, Blowroom, Carding, Spinning, Winding-warping and Weaving Departments.

2) Hazards of Humid Atmosphere as found in Mixing, Blowroom, Carding Spinning and Weaving departments (Maximum).

3) Hazards of Noise as found in Loomshed.

4) Dye stain - Drawing-in Department

5) Hazards of wet processing - Dyeing, Bleaching Finishing departments and Printing.

6) Accidental Injuries.

Hazards due to Flying Dust in Atmosphere

1) Mill fever

2) Byssinosis

3) Weavers Cough

4) Acute illness occuring amoungst people who handle low grade stained cotton.

Byssinosis - being the most important : Ishall discuss it first.

It is a progressive respiratory functional disability resulting in total disablement if exposure to cotton dust continues. It is characterised by a sensation of tightness of the Chest and is experienced principally on the first working day of the week after the week-ends leave or after periods of absence from the work spot. It is associated with a significant fall in the ventilatory capacity and a progressive increase in airways resistance during the course of the day. The disease may progress to Emphysema and cor-pulmonale and is usually reversible during its early stages or removal from the dusty atmosphere but may not be so after long periods of exposure - Predominant symptoms are :

1) Irritation of Throat 2) Cough	Early symptoms
3) Chest tightness 4) Breathlessness	Later symptoms

According to symptomatology it has been graded to Grade 1/2, 1,2,3.

Grade 1/2 - occassional chest tightness on the first day of working week.

Grade 1 - Regular chest tightness on the first day of working week. (Mondays - Europe and India, Saturday - Arab countries)

Grade 2 - Chest tightness on first and other days of working week.

Grade 3 - Grade 2 symptoms accompained by permanent in capacity from diminished effort intolerence and/or reduced ventilatory capacity.

Prevention is important as the pulmonary changes are irreversible.

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Methods of Prevention

1) Preventing the dust from permeating in the general atmosphere by enclosing Machinery, Local Exhaust.

2) Oiling the cotton

3) Dust protecting Equipment like Dust respirater, Mask.

Diagnosis : Clinical examination, Xray and other investigations as well as post mortem apprearances have not demonstrated any appriciable differences from cases of chronic Bronchitis, Asthma and Emphyserna whether in the textile or non textile workers. Therefore Medical research councils committee has recommended Roach and Schilling's questionnaire for the purpose of dignosis of cause when pulmonary function test facilities are available. They aid to conclude the diagnosis.

Incidence is about 4 to 6 % in almost all the series. The highest incidence was found in Age group 51-60 years.

Peak value for age incidence of various grade

Age for Grade	1/2	- 21 - 30	years.
" " "	1	- 31 - 40	"
" " "	2 & 3	- 51 - 60	"

Highest incidence is found amongst stripper and Grinders; as they are exposed to heavy dust concentration during working period.

Mill Fever : Almost all workers suffer from Mill fever and cotton cold. Arlidge described this condition in 1892 on flax dust. Mill fever differs from Monday fever. Monday fever accurs only after exposure of more than eight years, to cotton dust and it is the first stage of Byssinosis.

Mill fever occurs among cotton workers who have not been previously exposed to cotton dust. We get this problem with Trainee workers when they join the Carding department. Tolerence is usually developed within few days although symptoms may reappear following absence from work for a time as short as two to four weeks.

Symptoms : 1) Dryness of throat
2) Headache
3) Sense of feeling ill and slight rise of temperature.
4) Short dry cough accompained by sneezing.
5) Urticarial Rash on fore arms in women employees.

Symptoms usually arise when they go home; next day morning pt. is o.k. Temperature again goes up followed by malaise, nausea, vomitting, some time followed by Epistaxis.

(3) Weavers Cough : (Sizing and Weaving Departments)

An acute respiratory illness varying in severity from dry cough to severe ashthma have occured in loom shed. Many more times it has occured in out breaks.

1) Outbreak due to Mildwed yarn (1913 Collis)

2) An outbreak of weavers cough in Italy (1954)
(In this case sized material was corn flour, Locus beam gums, Potato starch.

3) An outbreak associated with Tamarind seed powder.
(India 1952) which was replaced by starch.

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In all these outbreaks the sized material was responsible, sizing of the yarn is a necessary priliminary process before weaving to give the yarn strength to withstand the friction in loom. Materials which have been used for sized were sago, farina, maize, potato strach and carb flour (locus bean gum). Research is continously going on to have better sizing agents. At present we use maize starch, softners like soft soap, Turkey red oil and antibactrial agents like MILTON I.C.I.

In all these cases the symptoms were cough purulent sputum Dyspnoea. On exertions and Asthmatic spell. Investigations reveled that due to sizing material Mildew had developed, which contained mould allergens. Sometime it was containing particular vegetable allergen such as dust of Kernel of Tamarind seed. There is of course other possible reason that vegetable dust either from cotton or from size or both is in haled sweeles up to produce small areas of atelectasis.

4) Acute Respiratory illness from contaminated cotton

A seperate distinct clinical entity was reported in 1943 from united states of America where in, the coarse cotton was used to manufacture the mattrasses. Symptoms begin 6 hrs. after exposure like generalise aches; Anorexia, Nausea, Vomittings, High temperature and Abdominal pain.

Causative agent was detected to be Endotoxin Aerobacter cloacea.

Hazards of Humid Atomosphere and High Temperature

A standard Releative Humidity is to be maintained in certain departments like Carding, Spinning and Weaving so that, yarn should not break during the process. There is slight variation of temperature seasonwise in dry and wet bulb; but the average humidity is maintained at 88%.

		Summer	Monsoon	Winter
Dry Bulb	Average	86	84	87
Wet Bulb	Average	83	81	84
Relative Humidity	"	88	88	88

Hazards :
1) Excessive sweating (salt depletion, Heat exhaustion)
2) Prickly heat
3) Cramps
4) Heat exhaustion
5) Heat stroke

) This is not our problem. More with continous dry heat.

Clinical fatures of salt depletion

1) fatigue 2) giddiness 3) Anorexia 4) Nausea
5) Vomitting 6) High temperature.

Mill Cramps :

Etiology
1) Lack of loss of acclamatisation is a significant but in constant factor.
2) Men often get heat cramps when they return to work after a day or two of leasure.
3) Alcoholic (Releative absentism due to heavy Alcoholism)
4) Sub-nutration and increasing age.
5) Some individuals have a micular susceptibility.

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Heat Cramps : This is common with those who sweat profusely and drink large amount of unslated water. It is probably because of .chloride loss and water intoxication. The acute onset suggests extracullular salt dilution than depletion. In either case heat exhustion and cramps some extracellular water will move into cells and cause their over dilution or water intoxication.

There are few fibrillatory twitchings of the muscles, varying from person to person and occur towards the end of days work. Mild cramps are passed unnoticed, or workers don't take it as occupational hazzard hence reporting is very poor. Mild to moderate cramps last for 1/2 minute or so, and is relieved by rest and drinking salted food or fluide.

Pain of severe cramp in excruciting and patient cries in agony; muscle is contracted to become stony hard. This may last even three minutes. Cold water bath and drinking cold water stabilises spasm. Such person are advised to have salt tablets with the. This practice is withdrawn nowadays.

Skin lessions : 1) Prickly heat 2) Anhidrotic exhaustion

1) Prickly heat : A common entity in tropics which is due to persistant wetting of skin by un evaporeted sweat.

2) Anhidrotic heat exhaustion : Its heat intolerance affecting men exposed for several months to a hot climate, characterised by numurous vesicles in the skin mainly trunk and proximal muscles and diminished sweating in affected areas (anhidrosis). There is obstruction to the delivery of sweat to the skin surface and its production may also be diminished. There is no hormonal or central failure in production of sweat.

Hazards of Noise : All research units in occupational health have been working on this problem. Dr. Chatterji and Dr. Harwansingh of C.L.I. have been doing commendable work in this field and the results are awaited.

This particular problem we have to face in loom shed (weaving department) The noise in this department is produced by

1) The shuttle which moves in the loom with the speed of about 60 m.p.h. Its too and fro movements with this speed and a picking stick which propels it very fast to make the atmosphere noisy.

2) Vibration of Machine 3) Loose fitting of the Machine 4) Reflection sound from the walls 5) Loose fitting gears or jammed gear wheels to avoid these factors following could be of use.

1) Walls to be made sound proof
2) Foundation base of the loom should of rubber base
3) Gears should be of nylon or fibres.

H a z a r d s :

1) Air condtction Deafness : It is not the usual occupational injury. This is inveriably the result of and explosion or sudden intense noise rather than sustained invironmental noise. The raptured ear drum usually feel so that hearing is temporarily affected, unless the amount of tear is unusually extensive or serious secondary infection sets in.

2) Occupational Deafness : This because of the injurious effect to the nerve endings of the organ of corti. If the vibration reaching these nerves receptors are to intense - two things occur. 1) Reversible faigue phenomenon resulting in a less-ened, transmission of nerve impuless and 2) and irreversible destruction of the receptors of the orgain of corti the kind of deafness resulting from damage to orgain of cori is known as nerve deafness. Such deafness cannot be improved by hearing aids. This is generally caused by exposure to high noise level over a long period of time - months or years. Hearing loss usually appears in the region of 4000 cycles per second (mild stage) when person is unaware of his deafness.

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We have only one observation to say that our weavers have a tendency to talk loudly when they go out door. Occupational deafness has not been noticed as yet. Real solution is serial audiogram of the exposed workers whereby we may be able to get early possitive cases, who could be transferred to other jobs. Reduction of noise levels where unsafe levels are found is recommended.

Eye Strain : This hazards is commonly found in Drawing-in department. This is skilled job wherein the design of cloth is determined by adjusting very thread individually on a beam. Consequently during course of year they develop asthenopic symptoms. Periodic eye checkup is done to rule out such cases.

Hazards of wet processing and printing department

Wet processing consist of dying, bleaching, finishing and printing department. Workers are regularly coming in contact with various dyes, paints cuastic, liquor ammonia and various chemicals. Most of the processes are automatic hence hazards are occasional. Since mostly dermatitis is produced by long continued intimate contact with the material personal cleanliness to reduce the duration of contact is the most important preventive programme. Use of barrier creams has been a boon for avoiding contacts with chemicals. Good general house-keeping of the plant is equally important in preventing dermatitis.

Oil Dermatitis : is found in fitters, jobbers and oilers of various departments. This skin condition results from contact with cutting oils or similar oils. It starts with irritation of skin by continuous contact with oil with formation of black heads or commedones. This then gets infected to form oil pimples. When oil dermatitis becomes serious it always results from Dirty workmen in dirty oil. Individuals vary in susceptibility but given sufficient exposure and time any one will develop the condition.

Atheletes foot : Fungus infection of foot is found in Bleaching department due to continuous wet feet. Fungus over the floor and machine is transmitted to the webs of foot and gets a chance to grow it if fingers are not dried and cleansed.

Accidental Hazards : Table No. X of IHD Report 1971 shows the comprative statement of accidents by causes. Amongst them the commonest large group consists of 1) Dropping of Stationery objects 2) Material Handling 3) Knocking against stationery objects. Interesting injuries are shuttle injuries and bobbin cut injuries.

Therefore, in conclusion I have to say that proper handling of the materials, Machinery and their maintenacne, Educative training to workers, and regular periodic Medical check-up will reduce the dreadful hazards of any Industry.

VPP:KSG
7.11.73

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T.T.A. SERVICES LIMITED

DEPARTMENT OF INDUSTRIAL HEALTH

DUTIES OF AN INDUSTRIAL PHYSICIAN

Aim of Occupational Health - I.L.O./W.H.O. - "The promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations, the prevention amongst workers of diseases caused by their working conditions; the protection of workers in their employment from risks to health, the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological equipment, and to summarise the adaptation of work to man and each man to his job."

This aim could be achieved through the following activities : -

I. Curative :

1. Immediate treatment of medical and surgical emergencies occurring at the place of employment.
2. Complete treatment of families and employees not covered by Employees' State Insurance Scheme.

II. Preventive :

1. Pre-employment Medical Examinations.
2. Periodic Medical Examinations -Maintenance of individual and group sickness records (Medical Record Card).
3. Specific Examinations of :
   (a) Persons returning to work after long illness or injury.
   (b) Persons who are for transfer or promotion.
   (c) Persons exposed to occupational hazards.
4. Follow-up Examinations of : -
   (a) Persons suffering from chronic ailments like Tuberculosis, Lepresy, diabetes, heart diseases etc.
   (b) Persons rehabiliated after accidents and injuries.
5. Preventive inoculation - smallpox, cholera, typhoid, tetanus etc.
6. To study and working environment and their effects on health of the employees through Industrial Hygiene Surveys and Job Analysis.
7. Accident prevention Campaign.
8. Canteen : Medical supervision to ensure cleanliness, good quality and physiological adequacy (caloric value) of the food.
9. Creche - Medical supervision of childern with respect to health and nutrition and prompt treatment of all illness and preventive inoculations.
10. Family Planning Activities - eg. Advice, Exhibitions, Sterilisations.

III Training and Education :

1. Training in "First-aid to the Injured"
2. Health and safety education of employees - personal hygine, sanitation, ante-natal and post-natal care (to mothers), family planning, nutrition, etc. by posters, leaflets, talks, health weeks, films etc.
3. Advice to employees on all health matters relating to their work and working capacity.
4. Mental Fist Aid.

IV. Advisory :

1. The hygine of work place - (lighting, ventilation, sanitation, anti-mosquito measures, water supplies, washing facilities, and other aspects of working environment - heat, humidity, noise, vibration, dust, gas, etc.) which may affect the health of employees.
   Architectural plans at the blue-print stage should be discussed with Industrial Physician.
2. The general health of workers - sickness absence statistics.
3. The occurrence and risk of dangerous hazards - advising on the control of hazards.

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4. Accident prevention campaign - participation in safety committee, departmental committee - investigation and analysis of accidents and recommendations to prevent recurrence.

5. Statutory requirements in relation to health, safety and welfare - E.S.I.C. Factory Acts, Workmen Compensation Act, Maternity Benefit Act, etc.

6. Rehabiliation - persons returning after sickness or injury - work may be recommended in accordance with the patients' conditions.

7. Committees - advise those committees viz. works committee, safety committee, welfare and benefit fund committee, canteen committee etc. or problems pertaining to health, safety and welfare of the employees.

V. Liaison

Liaison with outside agencies viz. Factory Inspection Office, E.S.I.C., Hospitals, Panel doctors, medical associations.

VI. Research :

Environmental hygiene - nutrition - occupational disorders - mental health etc.

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19.8.1973

GOVERNMENT OF INDIA
MINISTRY OF LABOUR
DIRECTORATE GENERAL FACTORY ADVICE SERVICE AND LABOUR INSTITUTES
BOMBAY

INDUSTRIAL PHYSIOLOGY DIVISION

REPORT NO. 16

PHYSIOLOGICAL EFFECTS OF INCREASED AIR MOVEMENT IN A HOT-DRY ENVIRONMENT

Part III: Studies in an Engineering Workshop in Northern Region

By

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&

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ISSUED BY:

Central Labour Institute
Sion, Bombay - 400 022.

1974

PHYSIOLOGICAL EFFECTS OF INCREASED AIR MOVEMENT IN A HOT-DRY ENVIRONMENT

PART - III : Studies in an Engineering Workshop in Northern Region

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P R E F A C E

The report covers the findings of the third phase of the survey on the effects of increased air movement under hot-dry conditions on the comfort level of workers. Earlier two phases of the study were carried out at Nagpur. The current studies were confined to an engineering plant in Kanpur during the summer of 1974. The results revealed no significant changes in the physiological responses due to forced ventilation of 185 cm/sec. under the hot-dry conditions met. In these studies, unlike in the second phase at Nagpur, even the subjective sensation of discomfort was absent. With the results obtained so far we may be able to fix the critical temperature level beyond which high air movement of the order of 180 to 280 cm/sec. is likely to produce subjective discomfort. Such level seems to fall between 38.5°C/32% R.H. and 41.7°C/18% R.H. However, before drawing such generalised conclusions and working out guidelines for Managements, it is necessary to collect more information on the subject.

I would like to record our appreciation to the Management of the factory for providing necessary facilities for the conduct of the study. Co-operation of the workers who participated in these studies is also acknowledged with thanks.

(Brig. G. R. CHAINANI)
Director-General

Bombay,
December, 1974.

C O N T E N T S

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1. INTRODUCTION

Two studies were earlier carried out by this Organisation in 1972 and 1973 summers in Vidarbha region, to observe the effects of increased air movement on the physiological functions of the workers and also on their subjective feeling of comfort while working in a hot-dry environment. The present study is the continuation of the earlier ones, the aims and objectives being to examine the validity of the earlier findings by performing the study in the northern region during the summer months.

2. MATERIAL & METHODS

2.1. Subjects : 10 workers from the Machine Shop Unit of an engineering factory in Kanpur were studied. The nature of job for these workers might be classified as light manual work. The working posture was standing upright.

2.2. Climatology : Dry Bulb (D.B.) and Wet Bulb (W.B.) temperatures were recorded with the help of a Sling Psychrometer. Air movement (A.M.) was measured by Kata Thermometer (range : 130 to 125°F). These readings were taken in the immediate neighbourhood of the individual workers. The radiant temperature was recorded with the help of a Globe Thermometer kept at the central place of the shop. The outside environmental conditions were measured at the entrace to the shop (in the shade).

The forced ventilation was provided by means of air circulators kept at a distance of 10 feet from the workers.

Corrected Effective Temperature (C.E.T.) values were worked out from the climatic values following the basic scale.

2.3. Physiological findings : All the physiological measurements were taken at every two hours. Pulse rate was measured by manual counting of carotid pulse. Oral temperature was recorded with the help of a standard clinical thermometer. Skin temperature (forehead) was measured with the help of a Hartman-Braun Electrical Thermometer. Sweat loss during the period was measured by recording the difference in body weights at the start and at the end of that period and considering the weight of the fluid, of solid food taken and the amount of urine/faeces output.

2.4. Subjective rating of discomfort : Individuals opinion regarding the feeling towards the thermal environment was taken in every two hours. Rating was done in the way shown below :

Comfortable	.. ..	1
Warm	.. ..	2
Hot	.. ..	3
Very hot	.. ..	4

3. RESULTS

3.1. Physical characteristics : Age, length of service, height, body weight and body surface area of the workers are shown in Table 1. All the workers were middle-aged; the length of service was indicative of their expected adaptability to the local climate.

TABLE - 1 : PHYSICAL CHARACTERISTICS OF THE SUBJECTS

Sl. No.	Sub.	Age (Yrs.)	Length of service (Yrs.)	Height (Cm.)	Body Weight (Kg.)	Body Surface Area (M^2)
1	RK	30	11	170	52.9	1.61
2	PL	36	14	164	74.6	1.80
3	KP	34	8	166	54.6	1.60
4	VM	32	10	162	52.0	1.54
5	KK	44	8	178	57.5	1.72
6	RG	34	9	175	64.5	1.88
7	GP	34	10	159	47.4	1.46
8	MS	32	10	167	74.5	1.84
9	IA	32	9	166	61.8	1.69
10	QM	33	12	172	85.9	1.98

3.2. Climatic findings : Tables 2 and 3 show the climatic conditions of the outside and inside environments respectively. The D.B. and Relative Humidity (R.H.) values in the outside and inside environment show a very hot-dry condition except on 7.6.1974, when the D.B. dropped considerably. In comparison to Vidarbha's climate*, however, the D.B.

* Physiological effects of increased air movement in a hot-dry environment - Part I. : Studies in an engineering plant in Vidarbha region, 1972.
Physiological effects of increased air movement in a hot-dry environment -Part II. : Further studies in Vidarbha region, 1973.

was less and humidity was higher at the time of the present study in Kanpur.

TABLE - 2 : CLIMATIC CONDITIONS OF THE OUTSIDE ENVIRONMENT
(Daily average values)

Date	D.B. (°C)	W.B. (°C)	R.H. (%)	G.T. (°C)	A.M. (Cm./Sec.)	C.E.T. (°C)
31.5.74	40.35	23.33	25	42.36	112	28.41
3.6.74	38.75	24.03	28	41.25	107	28.50
4.6.74	38.61	23.03	28	40.00	182	27.65
5.6.74	38.89	24.58	31	40.97	235	28.25
6.6.74	40.07	23.47	27	42.08	302	27.98
7.6.74	37.15	23.19	30	39.51	91	27.51
Mean :	38.97	23.75	28	41.03	171	28.05

TABLE - 3 : CLIMATIC CONDITIONS OF THE INSIDE ENVIRONMENT
(Daily average values)

Date	Subjects studied	Experimental condition	D.B. (°C)	W.B. (°C)	R.H. (%)	G.T. (°C)	A.M. (cm./sec.)	C.E.T. (°C)
31.5.74	1, 2	N.V.	39.38	23.57	26	40.35	83	28.25
3.6.74	1, 2	F.V.	38.75	24.33	30	39.58	195	27.79
4.6.74	3,4,5,6	N.V.	38.05	24.26	31	38.75	84	28.00
5.6.74	3,4,5,6	F.V.	38.22	24.63	33	38.61	180	27.65
6.6.74	7,8,9,10	N.V.	38.82	23.47	27	40.00	63	28.10
7.6.74	7,8,9,10	F.V.	36.30	23.38	33	37.29	217	26.21

N.V. = Natural Ventilation
F.V. = Forced Ventilation

It might be seen from Table 3 that in the case of the first 6 workers studied on 31st May, 3rd, 4th and 5th June, 1974, the D.B. values were more or less similar in the natural and the forced ventilated conditions, whereas in the case of other 4 subjects, the D.B. dropped considerably on the day of the work with forced ventilation (7th June, 1974). As a result, the comparison of the physiological findings as well as the subjective rating with reference to increased air movement will be misleading, unless the effect of D.B. is dissociated.

3.3. Physiological Observations : Table 4 shows the daily average values of the climatic variables at the immediate neighbourhood of the individual worker, physiological findings and subjective discomfort rating. For comparison between the mean responses towards natural and forced ventilation, the mean values were also worked out separately from the observations on 6 workers because of the sharp drop of D.B. on 7.6.74, as mentioned. These values are presented at the bottom of the table.

3.3.1. Pulse rate : There was no significant difference in the daily average values of the pulse rate under the two conditions. The values were found to be corresponding to light manual work.

3.3.2. Oral temperature : The mean oral temperature was 37.23°C in the natural climate and it was 37.12°C in the forced ventilated conditions. The difference is insignificant statistically.

3.3.3. Skin temperature : It does not show any significant variation under these two different conditions.

3.3.4. Sweating rate : With forced ventilation, the rate was found to be a little higher, but the difference was not significant.

3.3.5. Subjective discomfort rating : Considering the findings from all the 10 subjects, the mean subjective discomfort reduced significantly with forced ventilation (from 2.47 to 1.80, $p < 0.01$), but as it has been mentioned earlier, this may largely be due to the drop in ambient temperature on the day of experiment on 7.6.74 with forced ventilation. When the findings on the first 6 workers were considered, it was found that with increasing air movement from 85 to 185 cm/sec. the reduction in discomfort was not significant.

Table 5 shows the correlation coefficients of subjective discomfort rating with the D.B., A.M., and C.E.T., and partial correlation between subjective discomfort and A.M. after partialling out D.B. Discomfort showed strong positive correlation with D.B. ($r = 0.890$, $p < 0.001$) and with C.E.T. ($r = 0.884$, $p < 0.001$) and a strong negative correlation with A.M. ($r = -0.713$, $p < 0.001$).

The influence of D.B. on the correlation of A.M. and the subjective discomfort rating was dissociated by computing the partial correlation between the subjective discomfort with A.M. after partialling out D.B. and a significant negative correlation was obtained ($r = -0.571$, $p < 0.01$

TABLE - 4 : CLIMATIC FINDINGS, PHYSIOLOGICAL MEASUREMENTS AND SUBJECTIVE DISCOMFORT RATINGS UNDER NATURAL AND FORCED VENTILATED CONDITIONS (Daily average values)

Sl. No.	Sub.	Experimental conditions	D.B.(°C)	RH(%)	A.M. Cm/Sec.	CET (°C)	PR beats/min.	OT (°C)	ST (°C)	SR gms/hr/m²	Subjective rating of discomfort
1.	RK	N.V.	39.31	27	26	28.65	77	37.37	31.6	240	2.33
		F.V.	38.75	31	103	28.27	86	37.12	34.9	243	2.33
2.	PL	N.V.	39.45	26	140	27.85	71	37.28	32.9	250	2.33
		F.V.	38.75	30	287	27.31	67	37.03	35.1	262	2.33
		N.V.	38.12	31	107	27.83	88	37.05	33.7	185	2.33
3.	KP	F.V.	38.26	33	168	27.65	75	37.02	33.4	199	2.33
		N.V.	38.12	32	85	28.15	80	37.18	35.1	181	2.33
4.	VM	F.V.	38.26	33	263	27.19	83	37.18	33.2	210	2.00
		N.V.	37.92	31	82	27.93	83	37.29	35.5	153	2.33
5.	KK	F.V.	38.19	33	156	27.89	82	37.20	34.4	222	2.00
		N.V.	38.05	31	69	28.10	83	37.23	35.9	260	2.33
6.	RG	F.V.	38.19	33	134	27.89	79	37.15	34.5	272	2.00
		N.V.	38.89	27	43	28.23	87	36.94	34.4	255	2.67
7.	GP	F.V.	36.25	33	173	26.47	86	36.85	34.7	227	1.33
		N.V.	38.89	27	59	28.09	70	36.95	35.2	200	2.67
8.	MS	F.V.	36.25	33	219	26.18	74	36.85	35.0	249	1.33
		N.V.	38.67	28	87	27.98	87	37.10	35.9	186	2.67
9.	IA	F.V.	36.39	32	258	25.98	83	37.13	35.8	227	1.33
		N.V.	38.67	28	87	27.98	99	37.08	36.7	203	2.67
10.	QM	F.V.	36.39	32	258	25.98	80	37.02	36.1	210	1.33
	Mean ± SD	Natural (N.V.)	38.61 ±0.51	29 ± 2.2	78.5 ±30.5	28.08 ±0.23	82.5 ±8.2	37.15 ±0.138	34.79 ±1.497	211 ±35.3	2.47 ±0.167
		Forced (F.V.)	37.57 ±1.04	32 ± 2.2	202 ±60.0	27.09 ±0.82	79.5 ±5.7	37.05 ±0.297	34.61 ±1.052	232 ±22.6	1.80 ±0.401
	Mean ± SD (Sub.1 to 6)	Natural (N.V.)	38.49 ±0.631	30 ± 2.3	84.8 ±34.8	28.08 ±0.28	80.3 ±5.34	37.23 ±0.100	34.12 ±1.529	211 ±40.2	2.33 ±0.000
		Forced (F.V.)	38.40 ±0.249	32 ± 1.2	185.0 ±67.0	27.70 ±0.37	78.7 ±6.24	37.12 ±0.070	34.25 ±0.715	235 ±26.6	2.11 ±0.155

N. V. = Natural Ventilation; F.V. = Forced Ventilation

TABLE - 5 : CORRELATION COEFFICIENT (r) AND PARTIAL CORRELATION ($r_{12.3}$) OF SUBJECTIVE DISCOMFORT RATING WITH D.B., A.M., AND C.E.T.

	Correlation Coefficient (r)			Partial Correlation $r_{12.3}$
	D. B.	A.M.	C.E.T.	
Subjective Discomfort Rating	0.8903 $p < 0.001$	- 0.713 $p < 0.001$	0.884 $p < 0.001$	- 0.571 $p < 0.01$

1 = Subjective discomfort rating; 2 = A.M.; 3 = D.B.

4. DISCUSSION

From the physiological findings observed in the natural climate, it appears that there was no undue strain among the workers. It has been reported earlier that ventilation over a certain value in a very hot-dry condition has been found to be detrimental (Lind, 1964*). No thorough studies have, however, been carried out in this direction to ascertain the particular D.B./R.H. combination at which A.M. over a certain value causes the extra heat-gain through the convection current over the heat-loss by aided evaporation. In earlier studies conducted by this organisation in an engineering factory in Vidarbha region, the reference of which was already made on page 2, increased air movements to a value of 146 to 189 feet per minute (74 to 96 cm/sec.) (1972 study) and to a mean value of 200 feet per minute (102 cm/sec.) (1973 study) did not show any objective signs of heat stress in comparison with the findings observed in the natural climate. In 1973 study in Vidarbha region, the subjective discomfort was, however, found to increase with greater air movement and it was concluded that the usual parameters like oral temperature, sweating rate and pulse rate failed to show this discomfort which was but happening to the man working in that very hot (D.B. : 41.7 $\pm$ 1.79°C) and very dry (R.H. : 18 $\pm$ 5.3%) environment. In the present study, when D.B.was relatively less and R.H. was relatively

*Lind, A.R. (1964) : The Assessment, Management and Control of Heat Stress, in : Heat Stress and Heat Disorders by C.S. Leithead and A.R. Lind, pp.36, Casell & Co. Ltd., London.

higher than that of the findings of 1972 and 1973 studies, the greater air movement meant significantly less discomfort and the air movement, after partialling out the influence of D.B., showed a significant negative correlation with subjective discomfort. No significant differences in the physiological parameters were, however, observed with increased air movement.

5. SUMMARY & CONCLUSION

10 workers in an engineering factory in Kanpur were studied one day under natural climatic condition and the other day with forced ventilation on the six days of summer when environmental conditions were very hot and dry.

The mean air temperature and relative humidity were 38.3°C and 30% respectively. The natural air movement was sufficiently high (70 cm/sec.)

The job was light manual work in the standing upright posture.

The daily mean values of the pulse rate, oral temperature and sweat rate indicated that in natural climate the subjects did not experience any undue stress. The daily mean values of the subjective discomfort rating for the natural climate were varying in between warm to hot.

All the 10 workers were subjected to forced ventilation of a magnitude of about 200 cm/sec. No significant change in the pulse rate, oral temperature, skin temperature and sweating rate was observed due to increased air movement.

Subjective discomfort was found to be reduced significantly with increased air movement.

It seems, therefore, that in an environmental condition prevailing in the summer of Kanpur, the increased air movement was beneficial towards the feeling of comfort of the workers, whereas the same caused more discomfort in the workers in the summer of Nagpur (1973 study). In this connection the following comparison between the findings of these two studies is made (Table 6).

TABLE - 6 : COMPARISON OF THE FINDINGS OF THE PRESENT STUDY WITH THAT IN NAGPUR, 1973

	Nagpur study, 1973	Kanpur study, 1974
D.B.	41.7°C	38.4°C
R.H.	18%	32%
Physiological parameters	No significant change with increased air movement (170 cm/sec. or 330 ft/min.)	No significant change with increased air movement (185 cm/sec. or 360 ft/min.)
Subjective Discomfort	In most of the cases increased air movement caused acute discomfort	Discomfort reduced significantly with increased air movement

It seems logical to conclude from the above findings that somewhere in between these two combinations of D.B./R.H. (viz.41.7°C/18% and 38.5°C/32%), the increased air movement around 180 cm/sec. produces discomfort by adding more heat to the body through aided convection current than what it takes away from the body by aided evaporation. The critical evaluation of that particular combination, however, requires laboratory study under controlled environmental conditions.

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GOVERNMENT OF INDIA
MINISTRY OF LABOUR
DIRECTORATE GENERAL FACTORY ADVICE SERVICE
AND LABOUR INSTITUTES
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INDUSTRIAL PHYSIOLOGY DIVISION

REPORT NO. 14

PHYSIOLOGICAL EFFECTS OF INCREASED AIR MOVEMENT IN A HOT-DRY ENVIRONMENT

Part II : Further Studies in Vidarbha Region

By

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ISSUED BY :

Central Labour Institute
Sion, Bombay - 400 022.

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P R E F A C E

In our earlier study of last year, it was noticed that when workers engaged in light manual activities were exposed to high air movement (102 cm/sec.) under very hot and dry conditions, no adverse physiological responses resulted. It was decided to repeat the studies and also extend to other regions. Accordingly, studies were initiated inthe same industry at Nagpur during the summer of 1973 also. In these studies subjective impressions were also recorded. The results are discussed in the current report.

The results show that even when the air movement was increased to a much higher level of 170 cm/sec., physiological responses indicating heat strain were nil. However, some of the subjects were expressing a feeling of discomfort. In view of the importance of the problem, it is necessary to extend these investigations to other hot-dry regions and go in depth to study the problem.

Our grateful thanks are due to Shri M.K.Patankar, Chief Inspector of Factories, Maharashtra and Shri V.N. Kulkute, Deputy Chief Inspector of Factories, Nagpur, for their help during the conduct of the study. Thanks are also due to the Management of the factory for providing the necessary facilities. The whole-hearted co-operation by workers who served as subjects in the study is gratefully acknowledged.

Bombay,
December, 1973.

(Brig. G. R. CHAINANI)
Director-General

C O N T E N T S

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1. INTRODUCTION

In connection with the draft rules on Ventilation and Temperature framed by the Directorate General Factory Advice Service & Labour Institutes in 1969, a study* was carried out in Vidarbha region during 1972 summer to observe the effects of increased air movement on the physiological functions of the workers working in a hot-dry environment. Observations on the workers revealed no distress in terms of objective physiological findings at forced ventilation of about 80 cm/sec.(160 ft/min.), in the dry and hot climatic conditions of Vidarbha. The present study is in continuation of the aforesaid study, the aims and objectives being to examine the validity of the earlier findings under identical industrial work situations.

2. MATERIAL & METHODS

2.1. Subjects : Eleven workers from an engineering factory (the same factory, where the earlier study was carried out) in Nagpur, performing light manual work, mostly done in sitting, were selected.

All the eleven subjects were first studied for the whole day in terms of their physiological reactions in the natural climate; of them 9 were available for the study with forced ventilation.A subjective opinion study was also conducted on 6 workers.

2.2. Climatology : Dry Bulb (D.B.),Wet Bulb (W.B.) and Black Globe Thermometer (G.T.) readings were taken at the work place and also outside the shop (in the shade) in each hour of the shift (8.30 to 16.30 hrs.). Air movement (A.M.) at the workplace as well as outside was measured with the help of a Kata Thermometer (Range : 125-130 °F).

Forced ventilation was kept at an average level of 170 cm/sec. (340 ft/min.) at the beams, with the help of a blower which was kept at a distance of about 10 feet from the workers. The Corrected Effective Temperature (C.E.T.) was worked out from these climatic values using the basic scale.

2.3. Physiological Findings : Pulse rate and oral temperature during work were recorded in each hour of the shift. Pulse rate was

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*Physiological effects of increased air movement in a hot-dry environment, Part I : Studies in an engineering plant in Vidarbha region, 1972.

measured by counting carotid pulse. Oral temperature was recorded with the help of a standard clinical thermometer kept in the mouth under the tongue for at least three minutes.

Sweat loss during work was measured in each two hours by recording the differences in body weights and considering the weight of the fluid or solid food taken and the weight of urine and stool passed by the workers during the period of observation.

2.4. Subjective Opinion Study : The subjective opinion study was conducted on 6 subjects. Opinions were taken in each hour against the following statement. Rating was done in the way shown below. For an individual worker average rating for the whole day was obtained. Increase in the rating means greater discomfort.

Scales		Rating
Comfortable	..	1
Comfortably warm	..	2
Warm	..	3
Feeling hot	..	4
Feeling very hot	..	5

3. RESULTS

The physical characteristics and personal data of the workers are presented in Table 1. All the workers were observed to be young. None of them were found to be obese and as it is revealed from their length of service, all of them were expected to be acclimitised to the regional climate.

The climatic condition of the outside environment is shown in Table 2.

The climatic conditions inside the factory and the physiological findings (2-hourly) and also the overall values for the whole shift are presented in Table 3. The mean and standard deviation of these values for 9 workers under two different ventilatory conditions - natural and forced are shown.

3.1. Climatic Findings : Dry bulb reading and relative humidity values show a very dry hot condition, typical of Vidarbha's extreme summer (Table 2).

TABLE - 1 : PHYSICAL CHARACTERISTICS OF THE WORKERS

Sl. No.	Sub.	Section	Age (Yrs.)	Length of Service (Yrs.)	Height (Cm.)	Weight (Kg.)	B.S.A. (M2)
1)	MBM	Machine Shop	27	2	163.0	49.5	1.52
2)	SSS	"	26	2	151.0	45.5	1.38
3)	MDD	Develop-ment	30	2	165.5	45.5	1.45
4)	AAJ	"	23	3	167.0	41.0	1.42
5)	VPC	"	24	2	163.0	41.5	1.40
6)	MTK	Paint-ing	25	3	169.5	59.5	1.68
7)	RPM	"	22	2	163.5	50.0	1.53
8)	BKR	"	28	2	165.0	54.0	1.59
9)	CRM	"	24	2	165.5	47.5	1.51

TABLE - 2 : MEAN & RANGE OF THE CLIMATIC CONDITION OF THE OUTSIDE ENVIRONMENT

Variables	2-hourly observations				Average of the whole shift
	8.30-10.30 hrs.	10.30 - 12.30 hrs	12.30 - 14.30 hrs.	14.30 - 16.30 hrs.	
D.B. °C	38.99 (36.94-41.28)	40.96 (38.78-42.50)	42.10 (40.72-43.88)	42.24 (40.56-43.88)	41.08 (36.94-43.88)
G.T. °C	39.68 (37.67-41.67)	41.80 (39.89-43.33)	43.25 (41.56-44.58)	43.27 (41.00-44.88)	41.99 (37.67-44.88)
W.B. °C	22.46 (20.83-24.33)	22.08 (20.55-24.33)	21.69 (20.83-24.05)	21.59 (20.72-23.78)	21.97 (20.55-24.33)
R.H. %	24.1 (16-33)	19.1 (13-29)	15.3 (11-24)	14.6 (10-25)	18.0 (10-33)
A.M. Cm./Sec.	112.1 (50.5-168.3)	96.6 (47.4-191.3)	117.0 (70.4-262.7)	86.9 (36.7-130.1)	105.1 (36.7-262.7)
C.E.T.°C	27.31 (26.89-28.16)	27.91 (27.19-28.83)	28.07 (27.72-28.83)	28.13 (27.94-28.39)	27.85 (26.89-28.83)

TABLE - 3 : MEAN ± STANDARD DEVIATION FOR THE NINE DAYS' OBSERVATIONS ON CLIMATIC CONDITIONS AND PHYSIOLOGICAL REACTIONS OF THE WORKERS UNDER NATURAL AND FORCED VENTILATED CONDITIONS

Variables	Experimental conditions	2-hourly observations				Average of the whole shift
		8.30 - 10.30 hrs.	10.30 - 12.30 hrs.	12.30- 14.30 hrs.	14.30 - 16.30hrs.	
D.B.°C	N.V.	39.32 ± 1.23	41.18 ± 0.81	42.23 ± 0.90	42.57 ± 0.61	41.48 ± 0.80
	F.V.	39.45 ± 1.32	41.57 ± 1.17	42.86 ± 0.36	43.15 ± 1.45	41.71 ± 1.19
G.T. °C	N.V.	39.93 ± 1.44	42.06 ± 0.99	43.48 ± 1.02	43.60 ± 0.83	42.41 ± 0.93
	F.V.	39.82 ± 1.24	42.31 ± 1.23	43.69 ± 1.00	43.89 ± 1.32	42.43 ± 1.15
W.B. °C	N.V.	21.63 ± 0.42	21.52 ± 0.81	21.52 ± 0.43	21.25 ± 0.16	21.52 ± 0.41
	F.V.	22.76 ± 1.47	22.65 ± 1.22	22.09 ± 0.93	21.75 ± 0.86	22.30 ± 1.88
R.H. %	N.V.	19.7 ± 2.83	16.9 ± 2.96	14.7 ± 2.62	13.2 ± 1.68	16.0 ± 2.45
	F.V.	24.1 ± 7.08	19.2 ± 5.03	15.9 ± 4.63	14.0 ± 4.69	18.1 ± 5.31
A. M. cm./Sec.	N.V.	35.0 ± 26.7	25.9 ± 13.9	31.9 ± 12.3	24.9 ± 12.3	28.2 ± 12.0
	F.V.	177.5 ± 17.6	174.0 ± 21.7	167.0 ± 27.4	171.3 ± 12.6	170.3 ± 17.3
C.E.T. °C	N.V.	27.47 ± 0.53	28.05 ± 0.24	28.37 ± 0.14	28.40 ± 0.14	28.12 ± 0.15
	F.V.	27.24 ± 0.52	28.05 ± 0.43	28.24 ± 0.25	28.15 ± 0.16	27.90 ± 0.30
Pulse Rate (beats/min.)	N.V.	76.1 ± 10.0	69.2 ± 8.4	75.8 ± 9.8	69.2 ± 10.2	71.0 ± 9.0
	F.V.	76.3 ± 9.5	69.9 ± 8.6	73.3 ± 7.05	75.2 ± 7.7	73.0 ± 8.0
Oral Temp. °C	N.V.	36.77 ± 0.42	36.88 ± 0.40	36.92 ± 0.42	36.93 ± 0.21	36.87 ± 0.34
	F.V.	36.78 ± 0.37	36.73 ± 0.34	36.66 ± 0.44	36.81 ± 0.16	36.78 ± 0.35
Sweat loss gm./2-hrs.	N.V.	500.9 ± 88.3	571.1 ± 111.7	672.4 ± 145.4	651.3 ± 106.5	599.2± 97.4
	F.V.	594.1 ± 210.0	671.8 ± 80.3	646.0 ± 171.4	741.1 ± 156.3	689.1± 99.0

N.V. = Natural Ventilation ; F.V. Forced Ventilation

The difference in mean G.T. and D.B. value shows that there was very little radiant temperature inside the shade.

The average natural air movement in the workplaces was observed to be 28.2 cm/sec. and the average forced ventilation 170.3 cm/sec.

While comparing D.B. and W.B. of the two different sets of experimental conditions, namely, with and without forced ventilation, it was observed that there were differences, though not statistically significant. But this could perhaps only be avoided in an experimental laboratory condition.

The climatic conditions of the inside and outside environment were almost same, excepting the natural air velocity which was significantly lower inside the shop.

3.2. Physiological Observations :

3.2.1. Pulse Rate : The overall mean value of pulse rate was 71 beats/min. and 73 beats/min. respectively in natural and forced ventilated conditions. In both the conditions, the diurnal variations in pulse rate were not much. Also, no significant differences were there for the values in natural or in forced ventilated conditions.

3.2.2. Oral Temperature : The overall mean values of oral temperature in natural and forced ventilated conditions were 36.87 and 36.78°C respectively, none indicating any heat strain. In natural climate, there was a gradual increase in the oral temperature since morning to the period of 12.30 - 14.30 hrs., afterwards it was stabilised; the differences were, however, never significant. In forced ventilated conditions, no such clear trend was observed.

No significant differences were found between the mean values for natural and artificially ventilated conditions.

3.2.3. Sweat Loss : In natural climate, the overall values of the sweat loss in the workers correspond to moderately heavy physiological stress. The sweat loss, like oral temperature, increased since morning till 12.30 to 14.30 hrs. period. In forced ventilated condition, the highest mean value of sweat loss was observed in the last observation (14.30 to 16.30 hrs.).

The overall mean value of sweat loss was higher (669 gm/2-hr.) in forced ventilated condition than that (599 gm/2-hr.) observed in natural climate. The difference was not statistically significant.

3.3. Subjective Opinion Study : The overall mean score of discomfort index for each worker for natural and forced ventilated climates are shown in Table 4. Observed that 4 out of 6 workers complained of more discomfort with forced ventilation; 2 workers' opinion went in favour of forced ventilation.

TABLE - 4 : SUBJECTIVE OPINION STUDY (Individual's mean rating for the whole shift hours)

Sub.	Natural Ventilation	Forced Ventilation	Increase / Decrease in discomfort
MDD	2.22	3.11	+
AAJ	2.00	2.78	+
MTK	3.22	3.67	+
RPM	2.00	1.56	-
BKR	1.90	3.89	+
CRM	2.33	2.11	-

4. DISCUSSION

Heart rate, body temperature and sweat loss are the physiological parameters which are most commonly used in evaluating the heat strain. Observed that in natural climate (D.B./W.B. : 41.5/21.5°C), these values were not depicting any strain on the workers. This was due to the fact that the metabolic load in their jobs was very light and also in a hot-dry climatic condition the heat losing mechanism by sweating is highly favoured. The increased ventilation further facilitates evaporation of sweat and thus makes the physiological mechanism of sweating more effective.

The increased ventilation also causes a loss/gain in heat by the body by convention, if the air temperature is lower/higher respectively than that of the skin temperature.

When the air temperature is higher than the skin temperature (as it is expected in the present case), there is a critical limit of air movement, above which the heat losing mechanism by aided evaporation cannot compensate for the amount of heat gained from the surrounding by way of the convection current produced at that air velocity.

This critical limit depends on the air temperature and humidity in the climate. For example, for a dry bulb temperature of 48.9°C (120°F) at a relative humidity of 25% (Wet Bulb Temperature 29.4°C or 85°F), air movement over 100 ft/min. (51 cm/sec.) has been found to be detrimental (Ref. Lind, 1964*). In the present case, the dry bulb temperature was less than 48.9°C, but relative humidity was also much lower. The detrimental effect was thus expected. And the comparatively greater mean value of sweat loss with increased ventilation is indicative of this extra heat gain with increased ventilation.

But, as it is shown in Table 2, no increase in pulse rate and oral temperature was observed in the workers because of this extra heat gain induced on the workers and also the increase in sweating rate with forced ventilation was not significant statistically.

Thus, the present findings corroborate with the earlier findings that increased ventilation does not show any sign of heat strain, as it was probed with pulse rate, oral temperature and sweat loss and this held true even when the forced ventilation of high magnitude, viz. 170 cm/sec. (340 ft/min.) was maintained in the present study.

The subjective opinion study showed that in most of the cases (4 out of 6), the forced ventilation was causing greater subjective discomfort. Further enquiries revealed that all these 4 workers wanted to remove the fan and complained of headache while working under forced ventilation. These workers had the following things in common :

1) They were almost continuously sitting and
2) were working in a place directly beamed by the fan.

In the 2 workers in whose case the subjective opinion study went in favour of forced ventilation, the following things were observed to be common :

1) In both the cases, the mean overall air temperature was lower in the day of study with forced ventilation than that in natural climate.
2) Their job required standing,
3) They were not stationary in a same place and moved

*Lind, A.R. (1964) : The Assessment, Management and Control of Heat stress. In : Heat Stress and Heat Disorders by C.S. Leithead and A.R. Lind, pp.36, Casell & Co. Ltd., London.

around in an area of 5' x 4' and they were not exposed to the direct beam of the fan.

5. CONCLUSION

Even in the extreme of dry hot summer in Vidarbha, acclimatised workers while performing a light engineering job did not show any objective sign of heat strain, as it was shown in their pulse rate, oral temperature and sweating rate values during work. The forced ventilation (avg. 170 cm/sec.) increased the sweating rate suggesting an extra heat gain from the environment. There was no other sign of heat strain. Pulse rate and oral temperature values were not different in natural and forced ventilated conditions. Also, the increase in sweating rate with forced ventilation was not of any significant measure.

Subjective feeling of discomfort at forced ventilation was, however, very prominent in 4 of the 6 workers studied for the purpose. All these 4 complained of headache and badly wanted to remove the fan. The other two workers, whose opinion went in favour of forced ventilation, were found to differ from the other 4 workers in that they were not exposed to the direct beam of the fan, their job requiring a moving around in an area of about 5' x 4'; also in these two cases, on the day of study with forced ventilation the mean ambient temperature was less than that observed in the day, when they were studied in natural climate.

All these suggest that in a hot-dry environment the increase in ventilation to a level of about 170 cm/sec., instead of giving any beneficial effect produces subjective discomfort which is but hardly accounted in terms of common physiological parameters denoting heat strain such as pulse rate, oral temperature and sweating rate. As a matter of fact, the demarcation between discomfort and comfort, as it is sometimes revealed by subjective opinion studies is not always identified by physiological observations. The objective evaluation of heat strain restricted itself to the measurement of pulse rate, body temperature and sweat loss in the present study. In both the cases, with and without forced ventilation no heat strain was observed, as there was not much heat production due to work. Subjective feeling of

discomfort was due to the hot wind that they experienced at the skin itself, which is hardly accounted for by means of the parameters used in the study. Measurement of skin temperature might have thrown some light in this regard.

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