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EVALUATION OF THERMAL COMFORT IN TERMS OF OCCUPATIONAL SAFETY IN WEAVING FACILITIES BY FUZZY LOGIC

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ABSTRACT

The fuzzy-based approach was chosen because fuzzy logic enables computerization of human reasoning. In recent years, Forecast accuracy and applicability to success in general. Models that show as fuzzy were developed. Data that are difficult to collect with exceptional predictive accuracy can be developed by utilizing the experience of fuzzy logic based models. One of the basic conditions necessary for a person to continue his life in a healthy way is to keep the body temperature at a normal temperature. Thermal comfort means that the majority of the workers in the working environment are in a certain comfort while continuing their physical and mental activities in terms of climatic conditions such as temperature, humidity and air flow rate. If the thermal comfort conditions are insufficient in the working environment, distress is felt and discomfort begins, and accordingly, the working capacity and work efficiency of the person decreases. In this article, temperature physiology and occupational health will be evaluated with fuzzy logic in weaving business. Recognition of risks in the work environment is the most important factor in preventing occupational disease, work-related illness and occupational accidents. The air flow velocity Va (m/s) read from the thermal micro air conditioner is a parameter related to how people in an environment perceive the environment in which the components of personal and environmental factors affecting thermal comfort are expressed mathematically, using PMV and PMV value. The index PPD change, which indicates the rate of change, was determined with the help of fuzzy logic.

Keywords: Weaving, Thermal, Fuzzy, Safety, Comfort.

1. INTRODUCTION

Creation of a suitable working environment as a combination of human and physical factors, temperature, humidity, light, air flow, hygiene, cleanliness, sound, vibration etc. possible by taking into account such matters.

The human organism has the ability to maintain body temperature at a (limited) almost constant level for a very short time. This thermoregulation is based on two mechanisms;
a) Chemical thermoregulation: Heat production as a result of metabolic work of the body in resting and working conditions,
b) Physical thermoregulation: Negative and positive heat exchange between the environment and the body through processes such as conduction, convection, radiation, sweat evaporation and respiration.

Under the influence of high temperature, the heart rate accelerates to keep the body's internal temperature low. Capillaries in the skin carry more blood, so both the cooling rate and body temperature gradually increase. If the thermal environment is able to withstand, these measurements reach a balance after a while where heart rate and body temperatures remain constant. If the equilibrium is not reached until the body temperature reaches 38.8°C, the corresponding two-liter sweating rate creates the danger of heat stroke.

The basic condition for the good functioning, health and life of the human body is provided by keeping the body temperature at a normal level. The person should have thermal comfort and live in thermal balance with the environment. This means: Excess heat that raises the body temperature, which consists of the metabolic work in the resting and working state or the heat absorbed by the organism from the environment, must be eliminated from the body surface (skin).

The thermal state of the environment, determined by the temperature, humidity and flow rate of the air, can affect the heat change in the human organism positively or negatively (the body gives or takes heat). This can be called the thermal effect of the environment. The combinations of the four components that make up the thermal state of the environment in different ratios can create the same thermal effect. For this reason, it should not be attempted to show the effect with a single numerical value.

In industry, problems arise from exposure to higher temperatures. The body constantly generates heat through its own metabolic process. The body process is so designed that it operates within a very narrow limit of temperature (35°C - 38°C). As soon as heat is produced, it must be lost so that the body can function effectively and well. A set of very sensitive and very fast acting thermostatic devices in the body also controls the speed of the temperature regulating process.

The temperature in the environment is not just a single variable. In addition to increasing or decreasing the temperature in degrees, the state of humidity and air flow rate also increases or alleviates the effect of temperature. As a result of various combinations of these three variables, the person may feel the same feeling of warmth and psychological effect. The effect of temperature, air humidity and air flow velocity on the person together is called effective heat. The various combinations of air temperature, air humidity and air flow velocity, which have an equal temperature effect on the person, are also called equivalent effective heat values.

In addition to temperature, the effect of humidity is also very important. The amount of humidity in the air is expressed as absolute and relative humidity. absolute humidity; represents the amount of water per unit of air. If relative humidity; It indicates what percent of the absolute humidity in saturated air at the same temperature contains the amount of moisture in the air.

The value of relative humidity is important in terms of occupational health and safety. While evaluating the relative humidity of a workplace environment, other conditions such as temperature and air flow rate should also be evaluated. However, it is generally recommended that the relative humidity be between 30% and 80% in any workplace. High relative humidity suffocates if the ambient temperature is high, and if it is low, it gives a feeling of cold and chill.

In order to expel the polluted air generated in the workplace and replace it with fresh air, there must be a suitable ventilation in the environment, and therefore a suitable air flow. However, if this airflow exceeds 0.3 m/s, disturbing breezes occur.

Humid heat is encountered in places such as paper, textile, canned food and underground mining operations. Dry heat is encountered in the iron-steel, rubber, glass and cement industries.

Considering that people are significantly affected by the working environment, the temperature value of the environment, humidity, etc. The negative effects of thermal conditions on the employee must be taken into account. It is possible that the work accidents will increase as a result of the decrease in the attention of the person who is negatively affected by the work environment and being psychologically affected. For this reason, thermal comfort in working environments should be kept under constant control.

Due to the large amount of time that an individual spends indoors on the average, indoor environmental quality has a significant effect on the health, comfort, and productivity of workers [1]. A good thermal environment could help reduce occupants' complaints and absenteeism. Furthermore, it contributes to occupants' retention and saves money for agencies. Therefore, it is important to study the

relationship between the parameters of thermal environment and productivity.

The elusive relationship between thermal environment and productivity has attracted the attention of researchers for many years. Numerous international studies and projects were aimed at demonstrating and documenting the postulated impact of working space quality on occupants' productivity [2]. However, the relationship has been insufficiently explored [3-5].

2. MEASURES TO IMPROVE THERMAL COMFORT

Some measures to be taken in the workplace can bring thermal comfort conditions to a better level. Since the environmental conditions of each business may be different, the measures to be taken will be different. However, what can be done in general can give positive results in many businesses. There are four main factors affecting thermal comfort conditions. Temperature, humidity and air flow rate. An increase or decrease in air temperature adversely affects the adaptation of employees to work. In industry, there is usually a high temperature problem. Overheating causes fatigue and drowsiness.

2.1. Precautions to be Taken Against the Heat

a) It is possible to cool the workplace at the desired level with a suitable ventilation system, but it is not always possible to apply this in operating conditions.
b) If possible, local type, aqueous medium coolers or ventilators can be placed in appropriate places.
c) If there is a process or machine that causes the temperature to rise in the working environment, local ventilation can be done there.
d) Windows can be used for ventilation.
e) Covering the facility with a good insulation material during the construction phase gives positive results both in summer and winter months.
f) Appropriate clothing and sun protection hats, umbrellas, etc. for the personnel working outdoors. equipment can be provided.

2.2. Precautions to be Taken to Keep the Air Flow Velocity within the Appropriate Range

a) The recommended range for air flow velocity is 0.1 m/s to 0.3 m/s. If the air flow is low, evaporation becomes difficult in the body and this causes suffocation. If the air flow is high, discomfort such as colds may occur.
b) Ventilation systems are the most effective method to adjust the air flow rate, but it is not always possible to do this under operating conditions.

2.3. Precautions to be Taken to Keep the Moisture Amount within the Appropriate Range

a) It is very difficult to adjust the humidity in the working environment. Even if the humidity is adjusted with the equipment that will give water vapor to the environment in the enterprises where the humidity is low, it is necessary to keep it under control and constantly control it depending on the atmospheric conditions.
b) In enterprises with high humidity, measures can be taken by making local ventilation systems for process-related situations.
c) Heating and ventilation equipment can be used in enterprises with high humidity due to atmospheric conditions [6-8].

3. METHOD AND DEVICES USED IN THE MEASUREMENT

Thermal comfort measurements; Determination of PMV and PPD Indices in Moderate Thermal Environments Determination of Conditions for Thermal Comfort was made using the TS EN ISO 7730 standard. In thermal comfort measurements, Lsi Lastem brand Heat Shield model thermal comfort device, Lsi Lastem brand Thermal Comfort Device Air Flow Velocity (anemometer), Lsi Lastem brand (Dry, Wet, Sphere: Tg – Tnw – Ta) Thermal Comfort Device Dry, Wet, Globe and Moisture Chamber Apparatus are used.

TS EN ISO 7730 - Determination of PMV and PPD Indices for Moderate Thermal Environments It is the Standard for Determination of Conditions for Thermal Comfort. This standard provides the environmental conditions considered acceptable for general thermal comfort, as well as conditions representative of local discomfort, allowing thermal comfort to be determined and interpreted analytically using PMV (estimated average vote) and PPD (estimated

dissatisfaction rate) calculation and local thermal comfort criteria. Predictive Average Verdict (PMV) is an index that estimates the average value of the votes of the human population on a 7-point heat sense scale, according to the heat balance of the human body. Heat balance is achieved when the internal heat production of the body is equal to the heat loss by release to the environment. Images related to the weaving business are given below [9].

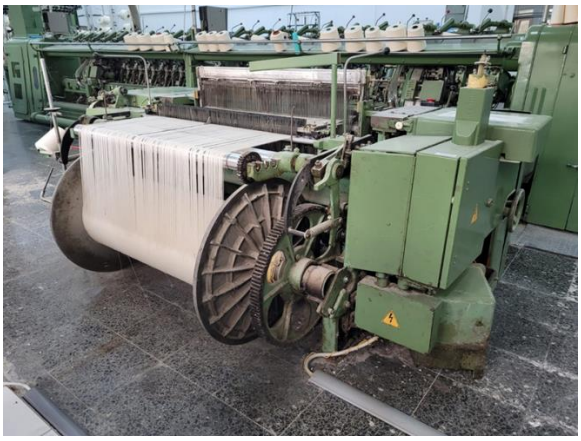

Figure 1. Weaving Enterprise view (a)

Figure 2. Weaving Enterprise view (b)

Seven-Point Temperature Sense Scale are shown in Table 1.

Table1. Seven-Point Temperature Sense Scale[10]

>3	hot
+2	Warm
+1	Slightly Warm
0	Neutral
-1	Light Cool
-2	cool
-3	cold

PMV can be calculated for different combinations of metabolic rate, clothing insulation, air temperature, mean radiant temperature, air velocity and air humidity. The PMV index can be applied by calculating the time-weighted averages of the variables during the previous 1-hour period.

4.THERMAL COMFORT CONDITIONS MEASUREMENTS

PMV-PPD measurements were carried out on people working at 5 different points in the weaving mill. Measured PMV-PPD values and screenshots of the thermal microclimate measuring device are given below, respectively.
Clo: The clothing coefficient entered in the thermal micro-climate device belonging to the person being measured
Met: The metabolic rate entered into the device of the person being measured
Rh (%): Relative humidity read from thermal micro conditioner
Va (m/s): Air flow velocity read from the thermal micro air conditioner
Tg (°C): Sphere thermometer temperature read from the thermal microclimate device
WBGT: Experimental index showing the heat stress to which the person is exposed.
PMV: It is the value in which the components of personal and environmental factors affecting thermal comfort are expressed mathematically. It is a parameter related to how people in an environment perceive the environment.
PPD: An index that indicates what percentage of people in the environment are dissatisfied with the thermal environment using the PMV value [11-13]. PMV-PPD results for A1-A5 people are shown in Table 2-Table5.

Table 2. PMV-PPD Results of A1

Personal Made Person	Va (m/s)	Tg (°C)	PMV	PPD(%)
A1	0,07	2595	0,95	24,55

Table 3. PMV-PPD Results of A2

Personal Made Person	Va (m/s)	Tg (°C)	PMV	PPD(%)
A2	0,07	27,63	1,42	46,74

Table 4. PMV-PPD Results of A3

Personal Made Person	Va (m/s)	Tg (°C)	PMV	PPD(%)
A3	0,08	27,75	1,42	46,78

Table 5. PMV-PPD Results of A4

Personal Made Person	Va (m/s)	Tg (°C)	PMV	PPD(%)
A4	0,11	27,02	1,21	35,68

Table 6. PMV-PPD Results of A5

Personal Made Person	Va (m/s)	Tg (°C)	PMV	PPD(%)
A5	0,09	25,75	0,89	22,08

The most important concept that puts fuzzy logic into operation is fuzzy (indeterminate) sets, which were first defined in 1965 [14]. Although this concept partly evokes mathematics, it actually refers to the area where rejected absolute values are clustered. When the values belonging to an indefinite set are expressed graphically, the bell curve (sometimes triangular or sometimes trapezoidal) that appears as in the sigmoid function is called the "belonging curve", which can take any value between 0 and 1 [15]. The main models commonly used in fuzzy logic studies are; Mamdani and Takagi – Sugeno type fuzzy models [16].

In order for a certain modeling to be done using fuzzy logic, a "rule base" is created in which all the elements that play an active role in the process are included. In addition to the rule base, the "knowledge base" should contain all the information based on the observation and mathematical or physical formula on the subject. The healthier this process is, the more precise and accurate the results will be. The functioning of the fuzzy logic system starts with the fuzzification of the exact inputs. In the next step, the set of fuzzy inputs is taken to the inference process within the framework of the established rules and knowledge base. Obtained fuzzy outputs are clarified to obtain precise output.

The fuzzy logic method used in solving the problem is given in Figure 3.

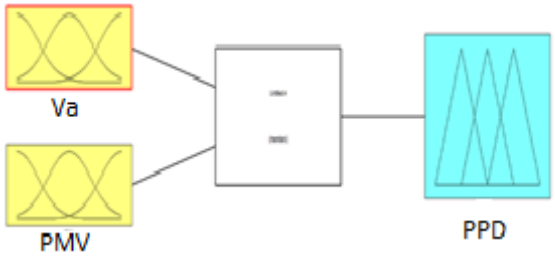

Figure 3. Fuzzy logic method created for thermal comfort

Membership function numbers and foot widths of PMV and Va variables, which are effective in determining PPD, were selected for each measurement by using the data obtained from experimental studies and the opinions of experts. Here, our input membership functions Va are selected in the range of five legs and PMV in the range of seven legs. The number of PPD, which is our output function, is determined in the range of seven feet. In order to understand the effect of the relationship between the determined membership functions on the result, it was created with thirty-five rule bases.

The results of the relationship between the input and output membership functions from the obtained values (according to the Mamdani method) are given below in three-dimensional graphics. The change in Va and PMV with PPD is clearly seen (Figure 4).

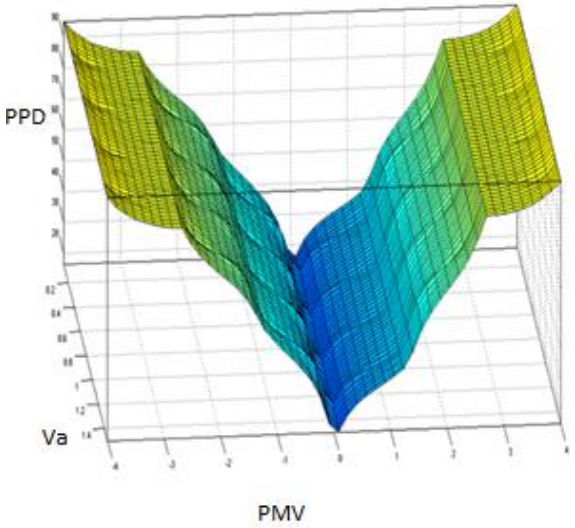

Figure 4. Thermal comfort change

5.RESULTS

Product variety and production factors create a heat hanger on employees in terms of thermal. Health problems related to thermal risks constitute a group of occupational diseases that

can be easily prevented when they are recognized and intervened early. Efficient working environments are only possible in working environments where thermal comfort conditions are provided. Although exposure to heat is found in many business lines and creates thermal stress that can cause health problems, it is not included in written guidelines and regulations in terms of occupational health and safety. Employees should be informed through educational and stimulating activities in business lines with a high risk of thermal stress.

PMV-PPD measurements were carried out on people at 5 different points in the weaving mill. It was observed that the values measured according to the PMV scale (Table 1) were not greater than +2. Table 7. The PMV-PPD Results are Equivalent to the PMV Scale.

Table.7 Equivalents According to PMV Scale

Measurement Person	PMV Result	PPD Result	Equivalent to PMV Scale
A1	0,95	24,55	Warm(Neutra)
A2	1,42	46,74	Warm(Slightly Warm)
A3	1,42	46,78	Warm(Slightly Warm)
A4	1,21	35,68	Warm(Slightly Warm)
A5	0,89	22,08	Warm(Neutra)

As a result; Fuzzy logic method, in the determination of thermal comfort values in the weaving business; Va will help to determine the given ambient parameters in terms of energy and time saving by showing how the connection between PMV and PPD changes. In this way, by monitoring the change in thermal comfort in the environment under the given conditions, approaches that will give good results in terms of optimizing the employees in a certain comfort while maintaining their physical and mental activities in terms of climatic conditions such as temperature, humidity, air flow rate will be able to be obtained.

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