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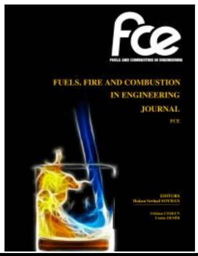

Bir Saha Çalışması: Süt Ürünleri Üretim Tesislerinde Termal Konfor

ÖZ

Bu çalışmanın amacı, sektörde çalışan işçilerin termal konfor durumlarını belirlemek ve soğuk ve sıcak etkilerine yönelik önlemler sunmaktır. Ölçümler Kocaeli çevresinde bu kapsamda faaliyet gösteren 9 işletmede 2016 Şubat ayı ile Ekim ayı arasında 123 noktada ISO 7726 standardına uygun olarak gerçekleştirilmiştir. Değerlendirmeler üç ana gruba ayrılmıştır; normal, soğuk ve sıcak ortamlar. Bu ortamları değerlendirmek için sırasıyla PMV, IREQ ve WBGT yöntemleri kullanılmıştır. Yöntemlerin kullanılmasında özel bir sıra izlenmiştir. Ayrıca çalışanların sosyodemografik özellikleri ve ortam kaynaklı şikâyet ve önerilerini belirlemek için anketler kullanılmıştır. Yapılan ölçümler sonucunda 20 noktada IREQ değeri elbise yalıtım değerinden küçük çıkmıştır. 10 noktada WBGT değeri referans değerin üzerinde çıkmıştır. 36 noktada ise sıcaklık WBGT sınır değerine çok yakın çıkmıştır. Anketlere göre ise genel olarak çalışanların havalandırma yetersizliğinden, iş kıyafetinden ve cereyan (hava akımı) etkisinden rahatsız oldukları görülmüştür.

Anahtar Kelimeler: Termal Konfor; İş Sağlığı ve Güvenliği; PMV

A Field Study: Thermal Comfort in Dairy Production Plants

ABSTRACT

aim of this study is to determine the thermal comfort conditions of workers in the industry and to provide measures for the effects of cold and heat. The measurements were carried out in accordance with ISO 7726 standard at 123 points between February 2016 and October in 9 enterprises operating in this scope in the Kocaeli region. The evaluations are divided into three main groups; normal, cold and hot environments. PMV, IREQ and WBGT methods were used to evaluate these environments, respectively. A special order has been followed in the use of the methods. In addition, questionnaires were used to determine the sociodemographic characteristics of the employees and their complaints and suggestions related to the environment. As a result of the measurements made, the IREQ value at 20 points was lower than the suit insulation value. At 10 points, the WBGT value exceeded the reference value. At 36 points, the temperature was very close to the WBGT limit value. According to the surveys, it was observed that the employees were generally disturbed by the lack of ventilation, work clothes and the effect of draft (air flow).

Keywords: Thermal Comfort; Occupational Health and Safety; PMV

1. INTRODUCTION

Thermal comfort is important in almost every aspect of daily life. But this is not always possible. Various measures are taken for this. For example, different equipment and methods are used in cold environments to cool off in hot environments. In a way, it is tried to make the environment suitable for working or living. Many factors/dangers affect human health and need to be addressed in the workplace environment. These are noise, vibration, lighting, cold and hot, airborne particles, gases, air pressure, etc. can be listed as. How these factors affect people is taken into consideration to maintain the work done in health and safety. So, the reactions of people working in this environment are important. For this, the effect of environments on employees should be examined. These responses are handled in three groups; health, comfort, performance [1]. As the metabolism of a human working in a cold environment constantly wants to maintain its internal temperature, as time passes, the blood at the extremes begins to come to the inner points. As a result, the extremes are exposed to cold. The longer the exposure time, the greater the damage to the body. As a result, freezing and tissue loss may occur at the extremes. In addition to this general cooling of the body, injuries may also occur in contact with cold surfaces. [2-4]. When working in a hot environment, the internal temperature of the body starts to rise. As a result of this temperature rise, metabolism wants to expel the excess heat from the body through sweating. The operation of the sweating mechanism allows the body's internal temperature to decrease, but in the meantime, the metabolism experiences water and salt loss. If you continue to work in a hot environment and the fluid and salt need of the metabolism is not met, exposure to heat begins. [5, 6]. When the body temperature is less or more than the optimum level, this situation damages the human metabolism mentally and physically [7]. Various diseases can occur depending on the duration of exposure and the metabolism of the worker. Such as heat stroke, cold bite, hypothermia, etc. The disturbances seen in the cold environment increase even more with the effect of wind and also cause an increase in the number of accidents due to the slippery ground. In the hot environment, especially in the summer months, there is an increase in complaints due to the increase in outdoor temperature [4, 8]. Turkey is an important sector of manufacture of food products and in particular, there are over 400 thousand employees. The food industry is one of the places where cold and hot effects are frequently seen. The main purpose of this study is to determine the thermal comfort conditions of the workers working in this sector and to provide measures for the effects of cold and heat. Because cold environments and hot environments are needed as a requirement of the work. The reason for the need for cold environments is to keep the products in freezing or cold storage, the method frequently used to keep products fresh and intact. The reason you need warm environments is; required for pasteurization and sterilization processes. In this case, employees in the mentioned work environments may have to work in cold or hot environments all day long. This negatively affects the health and performance of the employees [9]. Therefore, thermal comfort conditions of employees should be determined and precautions should be taken against possible exposures. For example, the use of a type of heater in cold work increases the finger temperature by 7 ºC and the use of protective clothing increases by 3 ºC [10].

A mathematical model has been developed that calculates the required clothing insulation (IREQ) for heat balance under certain climatic and activity conditions. The IREQ specifies the required final insulation that must be provided by the garment group worn. Clothing insulation is normally defined by the value obtained with a static, standing thermal mannequin. The IREQ model corrects the value for the effect of movements and wind. If the corrected value does not match the IREQ value, a recommended exposure time for a defined amount of body cooling is calculated [13].

Also, the IREQ method can be used to determine the adequacy of work clothes and limit times to work with existing clothes. On the other hand, the risk of thermal stress in warm environments can easily be determined by WBGT.

Alfano et al. conducted an integrated study of the thermal conditions of customers and staff in the refrigerated areas of four supermarkets in Central Italy. It has shown that thermal comfort conditions are generally in line with ISO 7730 requirements. It has been observed that the PMV values are generally below -2, tending towards cold both in autumn and summer months. In summer, due to the lower air temperature values (compared to outside) combined with the usual low thermal insulation of the garments, the thermal environment is cold and the IREQ model revealed dangerous conditions for customers in three of the areas studied for the time being. In the fall, times greatly exceeded 1 hour. The results of the subjective survey conducted at two sales points for 35 customers are consistent with the objective survey. Finally, local discomfort from the cold foot effect appears to be more consistent for women, due to the low distribution of clothing on the lower parts of the body [11]. Hawila et al. used a validated model to perform a comparative building simulation study between PMV-based comfort control and conventional thermostatic control, as well as a sensitivity study based on the Experimental Design technique. The results show that PMV-based comfort control is a reasonable solution to neutralize the balance between thermal comfort and heating energy consumption in the European winter season studied. In addition, the results show that energy consumption using comfort control is more sensitive to external climatic conditions than thermostatic control. Furthermore, the results show that energy consumption in a comfort-controlled space is highly sensitive to occupant-related parameters (metabolic rate and clothing level) and mean radiant temperature, compared to other parameters such as relative humidity. Finally, a meta-model was obtained to be used as a quick and simple way to predict energy consumption in a comfort-controlled room [12].

Zare et al. [14] presented a study with regard to the correlation between heat stress indices (UTCI, WBGT, WBDT, and TSI), the strongest association was detected between UTCI and WBDT. The relationships between other indices were not that much strong. Furthermore, no significant correlation was observed between heat stress indices and physiological parameters. Considering UTCI mean score, the workers were exposed to extreme heat stress; however, in the light of WBGT and ISO 7243 standard, they were not exposed to heat stress. It is thus recommended that further studies should be conducted to examine the relationships between rational and experimental indices. Such studies will eventually result in the identification of the optimal heat stress index for various environments and different temperatures.

Buonamo et al. [15] gives the experimental results of the comparison between direct and indirect methods to evaluate the WBGT index. The experimental analysis is carried out on the basis of an experimental apparatus designed and made up at the University of Cassino Laboratory of Industrial Engineering. The experimental analysis shows that, the Δ_{WBGT} errors decrease as the relative humidity and the air velocity increase. A maximum value of 2.18 °C was found. However, the influence of the mean radiant temperature on Δ_{WBGT} errors cannot be neglected. Also, the Δ_{WBGT} errors have the same trend as the Δt_{nw} errors. In addition, the experimental differences between the direct and indirect methods are generally greater than the corresponding uncertainties on the WBGT index. The experimental differences are due to a systematic error in the indirect model thereby implying that the Sullivan indirect method needs improvement.

Fang et al. [16] studied based on the regression models of MTSV and the three thermal comfort indices, including WBGT, PET, and UTCI, the heat stress categories were modified. The maximal acceptable levels of WBGT, PET, and UTCI were 27.54 °C, 25.06 °C, and 32.29 °C, respectively. When WBGT exceeded 32.65 °C, PET exceeded 53.90 °C, and UTCI exceeded 44.90 °C, the thermal environment was located in an insufferably hot state, which may lead to danger. Thus, the outdoor training should not be conducted in an insufferably hot outdoor thermal environment.

2. MATERIALS AND METHODS

Thermal comfort is defined as the perception of the environment in which the person is content to be satisfactory [17]. Comfort perception is a concept that varies from person to person. The parameters affecting this perception can be listed as air temperature, average radiant temperature, humidity and wind, and the metabolic rate of the person and the clothes above. Although these parameters have an important effect on the person's perception of the environment in terms of thermal, measuring all these parameters will not give an absolute correct result since thermal comfort is also a state of mind. Nevertheless, methods have been developed to predict thermal comfort to pre-design working environments and to ensure ergonomic conditions at the optimum level. The most widely accepted method is the PMV (Predicted Mean Vote) method developed by Fanger, which takes its place in the international standard (TS EN ISO 7730).

If people who are in the same environment are told to evaluate the temperature of the environment, it will evaluate some environments as warm, some warm, some cool, and so on. In other words, each individual may perceive the environment differently, but when the results are evaluated statistically, it will be seen that the answers given correspond to the normal distribution. Based on this information, the PMV method has been developed. This method predicts whether the environment is thermally comfortable with mathematical equations. Also, the ratio of those who are not satisfied with the environment (PPD) can be calculated with this method. This method is not sufficient to evaluate thermal comfort as a whole. Because the results are significant at 10 to 30 ºC. In the literature, the WBGT (Wet Bulb Globe Temperature) method is frequently used for rapid control of warm environment exposures. On the other hand, to minimize the risk of cold exposure, the IREQ method is used to evaluate whether the insulation of the garment is sufficient.

Within the scope of the study, measurements were conducted at 123 points in 9 dairy farms operating in Kocaeli. Measurements were made following ISO 7726 standard. Evaluations were divided into three main groups; normal, cold, and warm environments. PMV, IREQ, and WBGT methods were used to evaluate these environments. The first two digits of the measurement media; the measuring operation, followed by the letters KZ, CZ, HZ, and TZ respectively, comfort, cold, warm and normal environments; The two digits after the letters are coded to indicate the order of that point between the measurements and the last two digits to indicate the month of measurement. Also, questionnaires were used to determine sociodemographic characteristics and environment-related complaints and suggestions of employees.

2.1. Normal Environment

The most commonly used method for evaluating thermal comfort conditions is the PMV method. PMV method is the expression of environmental factors (air temperature, humidity, average radiation temperature, relative air velocity) and physical factors (metabolic activity level, the amount of insulation provided by clothes) by mathematical equations that affect thermal comfort. The method also calculates the PPD (Predicted Percentage of Dissatisfaction), which expresses the dissatisfaction rates of the people in the environment. PMV values range from -3 to +3 and comfort conditions are maintained from -0.5 to +0.5. PMV results were significant between -2 and +2. Also, the air temperature must be between 10 and 30 °C [17] to apply the method [17]. PMV values were calculated by the computer.

2.2. Cold Environment

The IREQ method given by the TS EN ISO 11079 standard is used to determine the suitability of the insulation values and exposure limit periods of the workers in cold environments. The IREQ value is calculated based on the continuous regime energy balance between the environment and the human body. IREQ calculation can be made under conditions where the air temperature is less than 10 °C, the relative air velocity is in the range of 0.4 to 18 m/s and the insulation value of the garment is 0.5 clo and above. Two values are calculated for IREQ as minimum and neutral. The calculated values are compared with the garment insulation value (Icl, r). When the garment insulation value is less than $IREQ_{min}$, the garment insulation is insufficient and D_{lim} (Duration Limited Exposure) is calculated as the maximum working time under these conditions. Similarly, for the $IREQ_{min}<I_{Cl,r}<IREQ_{neutral}$ condition, D_{lim} is calculated. For $I_{Cl,r}> IREQ_{min}$, the amount of garment isolation should be reduced [18]. Calculation of IREQ values was done by the computer.

2.3. Warm Environment

The risk of heat stress that a person exposed to a warm environment has to endure can be quickly determined by the WBGT. Detailed analysis of the effect of heat stress on the environment requires knowledge of 4 basic parameters: air temperature, average radiation temperature, air velocity, and absolute humidity [4]. The WBGT index combines two derived parameter measures, the natural wet-chamber temperature (t_{nw}) and the sphere temperature (t_g), and in some cases a basic parameter measure, air temperature (t_a) (dry chamber temperature).

WBGT value is calculated with equations [19]. For internal and external structures without solar load:

$$WBGT = 0.7t_{nw} + 0.3t_g$$

For external structures with solar loads:

$$WBGT = 0.7t_{nw} + 0.2t_g + 0.1t_a$$

The data collected in this way is compared with the reference values and then,

- Direct reduction of the heat pressure or stress at the workplace by appropriate methods
- A more detailed heat stress analysis can be performed using more detailed, but very difficult and often time-consuming methods.

In this study, WBGT was calculated for solar load structures. Data are given in table 1.

Table 1. Coded Measurement Points and Calculated WBGT values

Environment Code	PMV	WBGT	Environment Code	PMV	WBGT
7.RZ.38_07	1,51	23,18	4.RZ.12_04	2,1	23,48
2.RZ.37_02	1,51	20,58	2.RZ.11_03	2,1	23,19
2.RZ.35_02	1,56	21,66	10.RZ.10_10	2,13	26,32
10.RZ.36_10	1,56	23,08	6.RZ.9_05	2,15	25,39
2.RZ.34_02	1,58	20,46	4.RZ.8_04	2,26	25,92
2.RZ.31_02	1,59	21,98	8.RZ.7_08	2,31	26,95
2.RZ.32_02	1,59	22,76	10.RZ.5_10	2,52	26,82
2.RZ.33_02	1,59	20,38	7.RZ.4_07	2,58	27,72
2.RZ.30_02	1,62	21,74	8.RZ.3_08	2,74	27,97
3.RZ.29_04	1,63	21,15	7.HZ.10_07	2,8	29,18
3.RZ.28_04	1,64	22,45	7.RZ.2_07	2,82	28,93
2.RZ.27_03	1,64	23,69	6.RZ.1_05	2,83	28,79
10.RZ.26_10	1,69	23,83	7.HZ.9_07	3,3	30,58
2.RZ.25_03	1,74	22,82	7.HZ.8_07	3,39	30,9
3.RZ.24_04	1,76	23,74	5.HZ.7_04	3,51	29,72
2.RZ.21_02	1,84	22,32	2.HZ.6_03	3,9	32,3
3.RZ.20_04	1,86	24,22	10.HZ.5_10	4,2	29,72
3.RZ.19_04	1,89	23,22	2.HZ.4_03	4,89	33,6
3.RZ.18_04	1,91	23,32	7.HZ.3_07	5,04	37,71
6.RZ.15_05	2	24,63	4.HZ.2_04	5,2	33,57
8.RZ.13_08	2,03	25,22	3.HZ.1_04	5,2	45,29
10.RZ.14_10	2,03	25,65			

2.4. Evaluation of Steps

In this study, when the ambient thermal conditions were evaluated, a sequence was followed.

1) Measuring or estimating personal factors (level of metabolic activity, insulation value provided by clothing)

2) Measuring physical factors (air temperature, humidity, relative air velocity, average radiation temperature)

3) Calculation of PMV in the range of 10 to 30 ^{o}C

- -0,5<PMV<+0,5, the environment is comfortable.
- If PMV>+1.5, the WBGT is calculated.
- If PMV<-1.5, the IREQ is calculated.

4) Calculation of the IREQ value where the air temperature is below 10 ^{o}C.

- If $Ic_{l,r}$ <$IREQ_{min}$, the garment insulation is increased. D_{lim} is calculated.
- No action is required if $IREQ_{min}$ <$Ic_{l,r}$ <$IREQ_{neutral}$. D_{lim} is calculated.
- If $Ic_{l,r}$>$IREQ_{neutral}$, clothes isolation is reduced.

5) Calculation of WBGT where the air temperature is above 29 ^{o}C. If the reference WBGT is less than the calculated WBGT value, precautions are taken for exposure to heat.

Data are given in table 2.

Table 2. Coded Measurement Points and Calculated PMV values.

Environment Code	PMV	Environment Code	PMV
7.CZ.2_07	-3,03	5.KZ.5_04	0,21
2.CZ.3_02	-2,7	3.KZ.6_04	0,29
9.CZ.5_09	-2,60	3.KZ.8_04	0,36
4.CZ.6_04	-2,6	3.KZ.11_04	0,4
2.CZ.4_02	-2,6	5.KZ.14_04	0,45
5.CZ.7_04	-2,48	5.KZ.15_04	0,5
4.CZ.8_04	-2,44	2.TZ.2_02	0,6
2.CZ.9_03	-2,13	3.TZ.6_04	0,6
4.CZ.10_04	-2,1	9.TZ.5_09	0,6
2.CZ.11_03	-2,08	9.TZ.9_09	0,67
9.CZ.12_09	-2,07	2.TZ.10_02	0,7
3.CZ.13_04	-2,058	9.TZ.11_09	0,73
6.CZ.14_05	-2	4.TZ.12_04	0,81
10.CZ.15_10	-1,84	8.TZ.14_08	0,85
7.CZ.16_07	-1,82	3.TZ.18_04	0,9
7.CZ.17_07	-1,6	2.TZ.19_02	0,91
3.CZ.18_04	-1,49	2.TZ.20_02	0,92
7.CZ.19_07	-1,44	9.TZ.21_09	0,92
8.CZ.20_08	-1,34	2.TZ.24_02	0,93
2.CZ.21_03	-1,31	2.TZ.23_02	0,93
2.TZ.41_03	-1,18	2.TZ.27_02	0,95
5.TZ.25_04	-0,95	5.TZ.28_04	0,96
2.TZ.16_02	-0,87	9.TZ.26_09	0,96
8.TZ.13_08	-0,84	2.TZ.29_02	1
7.TZ.7_07	-0,62	2.TZ.33_02	1,09
2.KZ.13_02	-0,4	9.TZ.32_09	1,1
2.KZ.7_02	-0,32	2.TZ.15_02	1,1
5.KZ.2_04	-0,09	6.TZ.34_05	1,11
2.KZ.1_02	0	2.TZ.35_03	1,12
10.KZ.3_10	0,1	4.TZ.37_04	1,16
3.KZ.4_04	0,14	2.TZ.38_02	1,16
3.TZ.39_04	1,2	2.RZ.25_03	1,74

3.TZ.40_04	1,17	3.RZ.24_04	1,76
2.TZ.42_02	1,19	2.RZ.21_02	1,84
3.TZ.44_04	1,2	3.RZ.20_04	1,86
2.TZ.43_02	1,2	3.RZ.19_04	1,89
2.TZ.45_02	1,22	3.RZ.18_04	1,91
3.TZ.46_04	1,22	6.RZ.15_05	2
2.TZ.47_02	1,22	8.RZ.13_08	2,03
2.TZ.49_02	1,23	10.RZ.14_10	2,03
2.TZ.50_02	1,272	4.RZ.12_04	2,1
2.TZ.51_02	1,29	2.RZ.11_03	2,1
6.TZ.52_05	1,3	10.RZ.10_10	2,13
2.TZ.53_02	1,31	6.RZ.9_05	2,15
2.TZ.54_02	1,35	4.RZ.8_04	2,26
2.TZ.55_02	1,39	8.RZ.7_08	2,31
2.TZ.56_02	1,4	10.RZ.5_10	2,52
2.TZ.36_02	1,41	7.RZ.4_07	2,58
2.TZ.57_02	1,49	8.RZ.3_08	2,74
7.RZ.38_07	1,51	7.HZ.10_07	2,8
2.RZ.37_02	1,51	7.RZ.2_07	2,82
2.RZ.35_02	1,56	6.RZ.1_05	2,83
10.RZ.36_10	1,56	7.HZ.9_07	3,3
2.RZ.34_02	1,58	7.HZ.8_07	3,39
2.RZ.31_02	1,59	5.HZ.7_04	3,51
2.RZ.32_02	1,59	2.HZ.6_03	3,9
2.RZ.33_02	1,59	10.HZ.5_10	4,2
2.RZ.30_02	1,62	2.HZ.4_03	4,89
3.RZ.29_04	1,63	7.HZ.3_07	5,04
3.RZ.28_04	1,64	4.HZ.2_04	5,2
2.RZ.27_03	1,64	3.HZ.1_04	5,2
10.RZ.26_10	1,69		

2.5. Metabolic Speed and Garment Insulation

It is difficult and costly to measure the metabolic rate and garment insulation in the workplace environment. Also, the fact that personal perceptions change activity levels and insulation values change according to the person's movement makes it difficult to measure these values [5]. Since the same business line is examined in the study, the activities carried out are generally similar. It also has similar features in the clothes provided to the workers in companies. While special clothing is provided to cold workers in only one establishment, it has been observed that no special clothing is given to employees working in hot conditions. Accordingly, instead of determining the exposure of individual workers, a general evaluation was intended. Therefore, as an average value, garment insulation 0.7 clo, and metabolic rate 130 W/m^2 were chosen.

3. RESULTS AND DISCUSSION

As a result of the measurements, the IREQ value was lower than the insulation value at 20 points. At 10 points, the WBGT value was higher than the reference value. At 36 points, the temperature was very close to the WBGT limit value. 201 employees were asked three open-ended questions in the surveys. These are, respectively; "Do you have any illnesses that you think originating from the environment you are working", "Do you have something that you think negatively affects your health in the working environment" and "What can be done to reduce the effects of hot or cold in the working environment". Participants in the survey frequently answered the first question as flu, musculoskeletal disorders and headache; the second question as hot, cold, draft, noise, gas and finally the third question as ventilation systems should be better, sections should be partitioned with doors and work clothes should be better.

3.1. Normal Environment

PMV values were calculated for each point at the end of the measurements in all environments. According to Figure 1, there are a total of 12 environments in the comfort zone. These points are (2.KZ.13_02), (2.KZ.7_02), (5.KZ.2_04), (2.KZ.1_02), (10.KZ.3_10), (3.KZ.4_04), (5.KZ.5_04), (3.KZ.6_04), (3.KZ.8_04), (3.KZ.11_04), (5.KZ.14_04), (5.KZ.15_04), respectively. The number of regions where precautions to be taken to prevent exposure is calculated as 43 in warm environments and 20 in cold environments. The average dissatisfaction rate in the remaining 68 regions was 27%. The cold zone exposure limit was determined as -1.31, which is the PMV value in an air temperature of 10 °C. The warm zone exposure limit is defined as the level where the PPD value exceeds 50%. PMV equivalent of this value is 1.5.

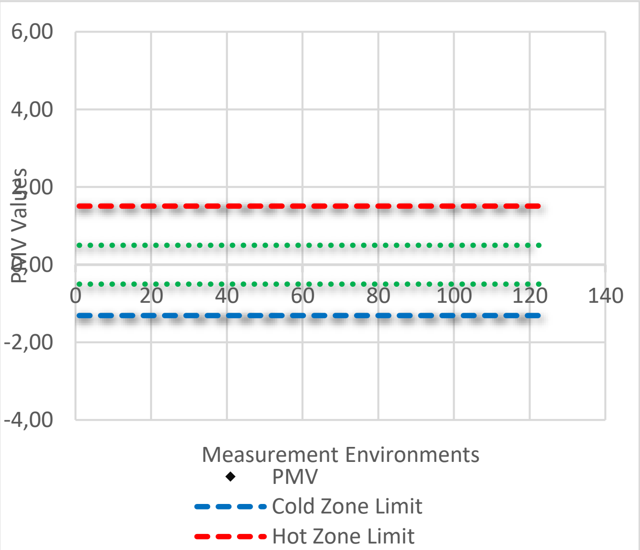

Figure 1. Exposure Limit Values and Calculated PMV Values.

3.2. Cold Environment

IREQ values were calculated at 20 points where the air temperature was below 10 °C. According to the results, the garment insulation value at 20 points was lower than $IREQ_{min}$. According to these results, the maximum duration (DLE) that individuals can work without exposure was calculated. IREQ values and exposure limit times for 20 points are as shown in Figure 2.

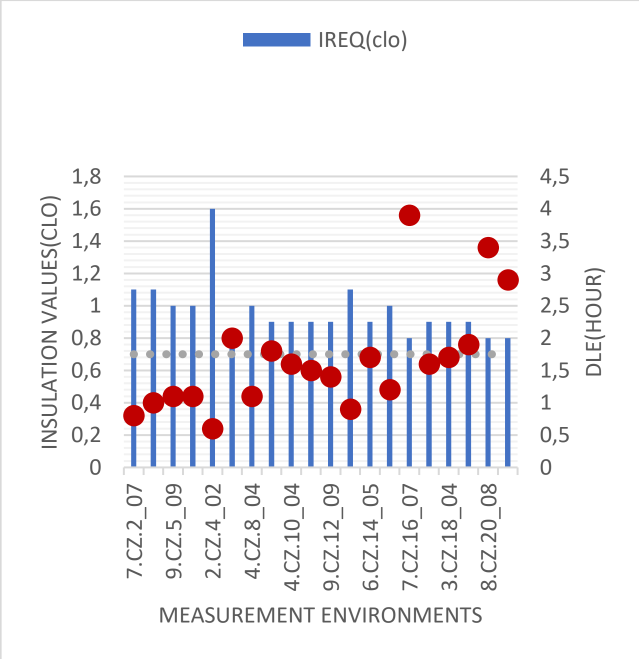

Figure 2. IREQ and Exposure Limit Times

3.3. Warm Environment

As is known, WBGT is a method used to quickly evaluate the heat stress in the environment. The reference WBGT value was determined as 29 °C for workers working in warm environments. In the measurements, 10 WBGT values were higher than the reference value. These environments are (7.HZ.9_07), (7.HZ.8_07), (5.HZ.7_04), (2.HZ.6_03), (10.HZ.5_10), (2.HZ.4_03), (7.HZ.3_07), (4.HZ.2_04) (3.HZ.1_04), respectively.

However, since the measurements started in February and continued until October, they were determined in the environments close to the reference value. Because the heat pressure increases in the summer months depending on the weather conditions. Accordingly, the PMV value exceeds 1.5 in 36 points was identified as a risky region.

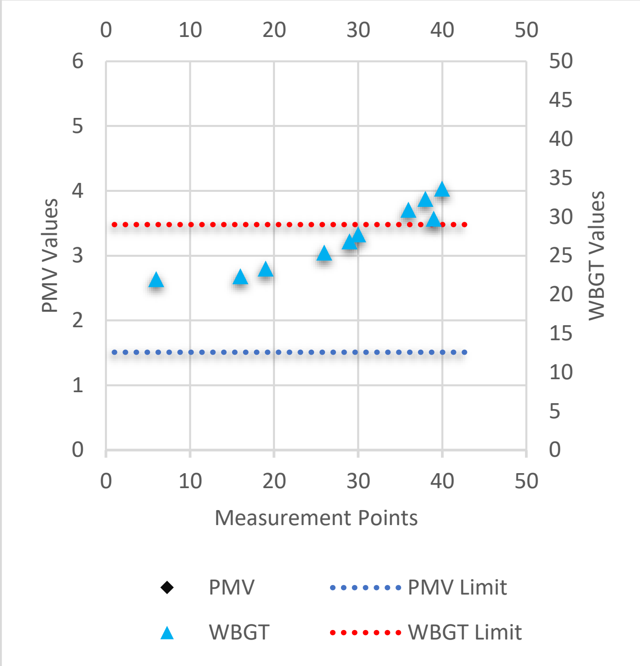

Figure 3. Warm Environments: WBGT and reference value

They are common physical factors in cold and warm work environments. These factors can be found in metal, glass, mining, food sectors, and almost everywhere. These factors can lead to various health problems and performance degradation in employees. Employees may be exposed to cold and heat as required by the work. In some cases, employees may spend part of their working hours in the cold and part of the work during the day. For these reasons, it is important to determine the thermal conditions in the workplace and to take the necessary precautions.

Periodic measurements are the first steps to be taken to determine the thermal comfort/comfort situation. Also, data from subjective assessments may be useful. For example, it may contribute to unknown aspects of the response. However, it should be remembered that the measurement results should be acted upon. Because subjective assessments are particularly suitable for revealing environmental disturbance, it is difficult to design because there are potential side-effects in the method. Also, subjective methods are not suitable for assessing what has an impact on health. For example, a person, whether male or female, can never detect that he is fully under physiological strain. Because the environmental impact prevents him from making a reliable assessment. Also, the method always works with a representative group, which is difficult to set [1]. Nevertheless, knowing what the employees are uncomfortable with within the environment may be helpful in the diagnosis and treatment of diseases.

In the research, first, the preliminary examination was made and the points to be measured were determined. Then the measurements were carried out and cold, warm, and normal environments were determined. Subjective evaluations were divided according to these results. Accordingly, it was seen that the average age of workers working in cold environments was lower than other environments, and the average number of workers working in this environment for a maximum of 5 years was 3 years. Again, it was concluded that the employees had more difficulty in summer compared to the winter months. Complaints related to the environment increased in the summer months. In the measurement results, the average PPD value was 50%. In other words, half of the employees are not thermally comfortable in the environment they work in. This rate was 78% in warm areas and 78% in cold areas.

According to the answers given to open-ended questions, ventilation and work clothes were found to be insufficient. In particular, an increase in complaints from the current has been observed where different parts within the plant (for example, the pasteurization area and the butter packing area are different). Employees' responses to the questionnaires are similar to those measured. Garment insulation was found to be insufficient by workers in cold environments. It has been shown that the insulation of the clothes is insufficient in the IREQ calculations. According to the health evaluations of the employees, it can be said that advanced examinations should be performed. Because it has been observed that there are complaints from the gases and odors in the environment.

On average, 200 workers are employed in cold environments, calculated in 20 environments, where the garment insulation value is smaller than IREQmin. Only one company provided suitable clothing to employees (20 people) in this environment. The remaining 180 workers are exposed to cold every day. To eliminate the exposure, the company was advised that the clothes should be renewed according to the calculated IREQ values. Also, measurements should be made after this process and suit suitability should be tested.

The WBGT method does not contribute to the improvement of warm environments. It only shows the presence of thermal stress. Accordingly, further assessments should be made for 7 environments in which the reference value is exceeded. Also, measures to prevent possible exposures are required for 36 environments that are calculated as risky.

4. CONCLUSION

A significant number of workers working in the food industry, especially those working in cold and warm environments, are exposed to these factors. Workers working in cold environments should be reviewed in consideration of the calculated exposure limit periods. Similarly, those working in warm environments should take frequent breaks and meet their fluid needs. Employees should be provided with air-conditioned rooms for resting. Also, clothes should be rearranged to suit the environment in which they work. Studies on this subject are limited. For this reason, in this study, PMV, WGBT and IREQ methods was used for analyze the situation. These methods are very useful for this kind of thermal comfort studies as given in the literature. Environment measures in this sector are over 400 thousand employees in Turkey should be done regularly to avoid possible health problems and performance losses. Comfort perception is an important parameter affecting productivity. Studies can be conducted to show how and to what extent performance losses affect yield in the future. Thus, employers can be encouraged to take measures.

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