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Thermal Comfort Determines User Subjectivity in Lamongan Grand Mosque

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Abstract

Mosque is a place of worship, which requires comfort to enhance the quality of worship, thermal comfort being one of the considerations in the prayer space of the mosque. This study aims to analyze the level of thermal comfort and thermal preferences of users in the interior space of the Grand Mosque of Lamongan. The method used is quantitative, collecting data through surveys at the Grand Mosque of Lamongan. Some of the data collected include personal data (clothing and activities) and measurements of environmental parameters; air temperature, air humidity, and wind speed. At the same time, users were asked to fill out a questionnaire asking about their perceived level of comfort at that time. The results of the study show that the interior space of the mosque has an average temperature ranging from 28.4 ºC to 29.08 ºC, while the survey questionnaire results indicate that 89.1% of respondents can accept the existing thermal conditions. This may be due to the fact that the temperature inside the mosque is much lower compared to the outdoor temperature.

Keywords*: Mosque, Comfort, Thermal, Perception, Users.*

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Introduction

Architecture is a container for human activities so that these activities can be carried out comfortably. In other words, one of the main functions of a building is to provide both physical (Agustapraja, 2019; Agustapraja & Maulidina, 2019; Agustapraja & Wahab, 2023) and psychological comfort for building users (Prasetia & Nugrahaini, 2020). Physical comfort consists of space comfort (Hadi et al., 2020; Sugini, 2014), hearing comfort, visual comfort and thermal comfort (Willyanto, 2017). Thermal *comfort* is a state of mind where satisfaction is expressed or expressed towards the surrounding thermal or comfortable conditions (Prasetia & Nugrahaini, 2020). Mosques are one of the public buildings that demand comfort (Hidayatullah, Agustapraja, Kartikasari, & Affandy, 2022), not only audibly but also thermally, so that the congregation can solemnly perform their worship (Syamsiyah & Nur Izzati, 2021).

Research on thermal comfort in the interior of buildings has been carried out in various places in the world (Hamzah, Mulyadi, & Amin, 2016), including; (Buratti &

Ricciardi, 2009 (Buratti & Ricciardi, 2009); Corgnati et al., 2009 (Corgnati, Ansaldi, & Filippi, 2009) ; Corgnati et al., 2007; Hwang et al., 2006; Kwok & Chun, 2003; Mors et al., 2011 (ter Mors, Hensen, Loomans, & Boerstra, 2011); Teli et al., 2012 (Teli, Jentsch, James, & Bahaj, 2012), including in tropical areas, namely in Singapore (Wong & Khoo, 2003). Unfortunately, this research is still lacking in Indonesia, especially in Lamongan.

Thermal comfort standards such as ASHRAE standard 55 (Absar Alam, Kumar, Yadav, Arya, & Singh, 2023; Pang et al., 2020; Rajkumarsingh, Ah King, & Joomun, 2024; Xiao et al., 2024; Yang et al., 2024) and ISO7730 (Bucur, 2021; Sirhan & Golan, 2021; Udrea et al., 2020) have been widely used as thermal comfort standards in various countries. However, this standard is more widely used for rooms with artificial conditioning (AC). In buildings with natural conditioning, existing standards are unsuitable (Latif, Rahim, & Hamzah, 2016). Fanger (Jing, Lei, Song, & Wang, 2024) proposed a Predicted Mean Vote (PMV) to predict the thermal comfort felt by indoor occupants. PMV is calculated based on environmental parameters in the form of air temperature and radiant temperature, relative humidity, airflow speed, and personal parameters, including activity (metabolic rate) and clothing worn (clo). In order to measure the thermal comfort felt by users, according to this standard, a survey was carried out using a questionnaire based on a study conducted by Fanger (Jing et al., 2024). This questionnaire asks about the thermal sensation felt by the user on seven scales, namely: hot (value 3), warm (value 2), slightly warm (value 1), neutral (value 0), slightly cool (value -1), cool (value -2), and cold (value -3). However, long before that, Bedford (Rajkumarsingh et al., 2024) had also proposed a method for measuring thermal comfort, which also consists of seven scales, namely much too warm (value 3), too warm (value 2), comfortably warm (value 1); comfortable (value 0); comfortably cool (value -1); too cool (value -2); and much too cool (value -3).

An old study states that the thermal quality of a classroom influences student learning achievement (Hamzah, Mulyadi, et al., 2016), The same thing applies to the thermal quality of the mosque's interior, and the user's thermal comfort can influence the level of devotion in worship. Based on the description above. This research was carried out to reveal the thermal conditions of the space in the Lamongan Grand Mosque, a historic and significant building for the Lamongan community (Agustapraja & Aslamiyah, 2022). The level of thermal comfort experienced by mosque users depends on various factors. These results can guide the design of mosque spaces that provide a comfortable environment for the people using them.

Method

This research was conducted at the Lamongan Grand Mosque, which is located in Jl. Kyai H. Hasyim Ashari No.16, Tumenggungan, Kec. Lamongan, Lamongan Regency, East Java 62214. This research uses quantitative methods as well as qualitative methods, in the discussion. Data was collected through a survey divided into two parts: (1) objective measurement survey, which includes room temperature, wind speed, and air humidity, (2) subjective measurements to measure the level of thermal comfort felt by mosque users. This is done by respondents filling out a thermal comfort survey questionnaire. The questionnaire was created based on the questionnaire from Wong and Khoo (Wong & Khoo, 2003) The total sample was 91 respondents with a population of 1000, calculated using the Slovin formula (Agustapraja, 2018). The data collected was processed and analyzed using Microsoft Excel software.

The equipment used is an HTC-2 Thermo Hygrometer to measure air temperature and air humidity and a Digital Anemometer to measure wind speed. The tool is placed at a height of 1 m above the floor surface. It can be shown in the picture as follows;


Figure 1 Anemometer Digital

Figure 2 Hygrometer HTC-2

Results and Discussion

Results and Discussion of Objective Measurements

Measurements were carried out in the interior of the Lamongan Grand Mosque for two days at times according to prayer times (figure 3). Measurements were carried out from Saturday, 26 March 2023, to 27 March 2023, with five measurements in one day. Fajr (04.00-05.00), Dhuhur (11.00-13.00), Asr (14.00-16.00), Maghrib (17.00-19.00) and Isha' (19.00-20.00). Thermal measurements were conducted in March because the research was scheduled.

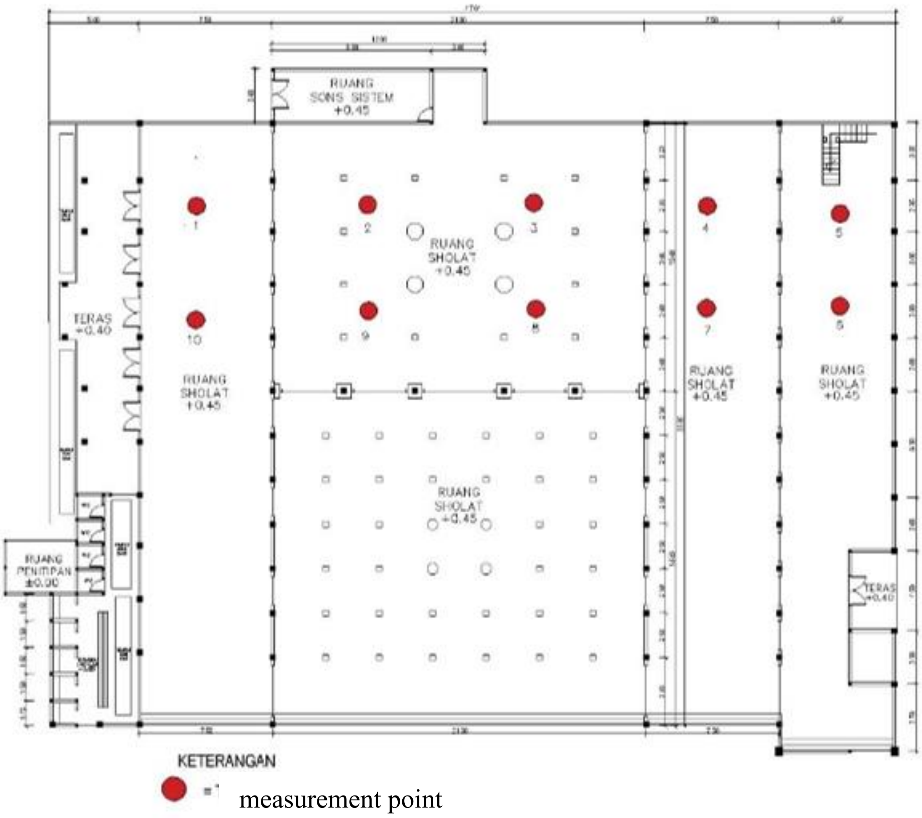


Figure 3 Thermal Measurement Points on the Plan of the Lamongan Grand Mosque

Figure 4 shows the results of air temperature measurements. The average air temperature shows that from 04.00 to 20.00, the lowest air temperature is at point 5, with an average temperature of 28.40 ºC, while the highest air temperature is at point 1, with an average temperature of 29.08 ºC.

The results of measuring air humidity can be seen in Figure 5. Average air humidity shows that from 04.00 to 20.00, the lowest is at point 1, with an average air humidity of 61.2%. In comparison, the highest air humidity is at point 10, with a humidity air average of 65.3%.

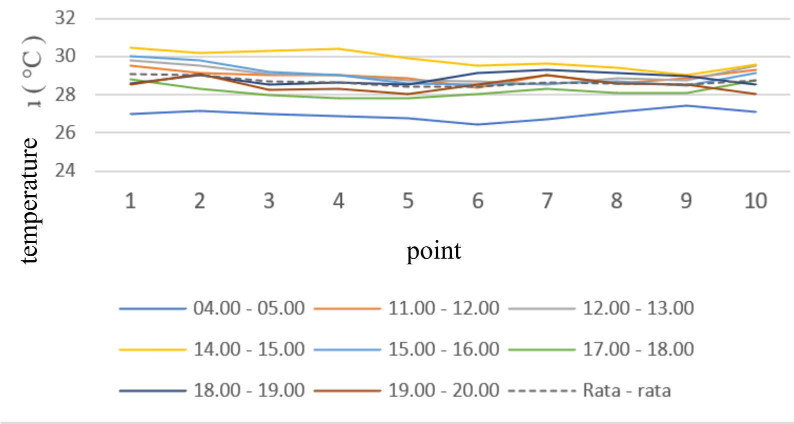


Figure 4 Graph of average air temperature values (Celsius)

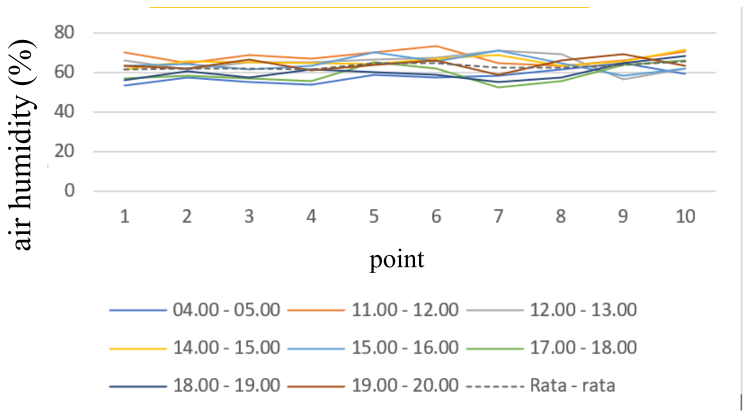


Figure 5 Graph Graph of average value of air humidity (%)

Figure 6 shows the results of wind speed measurements. The average wind speed shows that from 04.00 to 20.00, the lowest wind speed was at point 1, with an average speed of 0.1 m/s, while the highest wind speed was at point 8, with an average speed of 0.46 m/s.

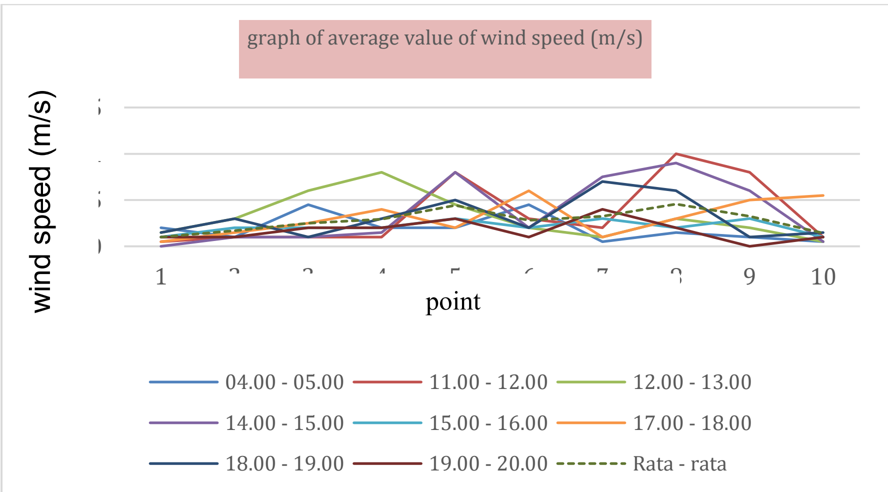


Figure 6 Graph of average value of wind speed (m/s)

Results and Discussion of Subjective Measurement of Questionnaire Results

The survey results on respondent characteristics can be seen in Table 1. The percentage of research subjects consisting of gender and occupational group variables. The total number of respondents was 91, consisting of 58 (48.7%) men and 33 (27.7%) women. The occupations of the respondents were six civil servants (5.4%), 27 people (22.69%), 27 people (22.69%), 33 people (27.73%), 19 people (27.73%), 19 people (15.97%) and six others (5 .04%).

Tabel 1. Respondent Characteristics

Variable	Number	Percentage
	sex	
male	58	63,7 %
female	33	36,3 %
total	**91**	**100 %**
	profession	
Civil servants	6	6,6 %
Self-employed	27	29,6 %
Student	33	36,3 %
Trader	19	20,6 %
Other	6	6,6 %
total	**91**	**100 %**

The results of the Thermal Sensation Vote (TSV) survey can be seen in Figure 7. TSV is measured using seven scales, namely hot (value 3), warm (value 2), slightly warm (value 1), neutral (value 0), slightly cool (value -1), cool (value -2), and cold (value -3). Respondents generally chose cool, value -2, and slightly cool, value -1. This choice shows that 35.2% of respondents felt cool, 29.7% felt slightly cool, 14.3% felt neutral, 5.5% felt cold, 7.7% felt slightly warm, 4.4% felt warm, and the remaining 3.3% felt the heat.

The results of the Thermal Comfort Vote (TCV) survey can be seen in Figure 8. TCV was measured using seven scales, namely much too warm (value 3), too warm (value 2), comfortably warm (value 1), comfortable (value 0), comfortable cool (value -1), too cool (value -2), and much too cool (value -3). Respondents generally chose a comfortable, cool value of -1 and a comfortable value of 0. This choice shows that the majority, 60.4% of respondents, felt comfortable cool, 20.9% felt comfortable, 9.9% of respondents felt comfortable warm, and 6.6% of respondents felt comfortable felt it was too cool. The remaining 2.2% of respondents felt it was too cool.

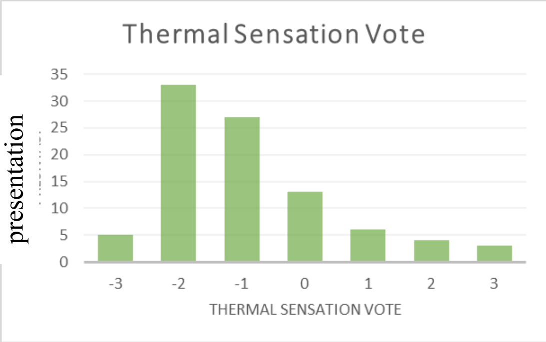


Figure 7. Thermal Sensation Vote Graph

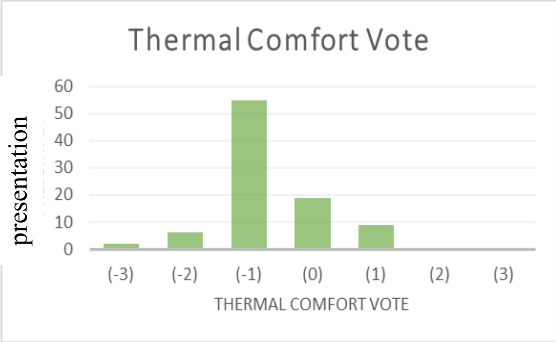


Figure 8. Thermal Comfort Vote Graph

The results of the Thermal Preference survey can be seen in Figure 9. There are three options for thermal preference: hotter, no change, and cooler. Most respondents chose to make changes to make the room cooler, 73.6%; 26.4% already felt comfortable with the existing conditions, while 0.0% of respondents hoped for an even hotter room.

Figure 10 shows the results of the Thermal Acceptance survey. There are two options for accepting thermal conditions: accepted or not Accepted. Responses to Thermal Acceptance showed that the majority of respondents, 89.1%, chose to accept the room's thermal conditions, and only 10.9% did not.

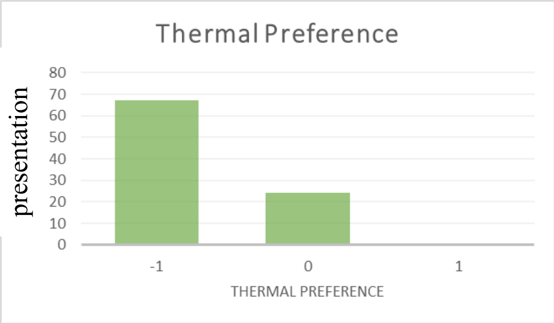


Figure 9. Thermal Preference Graph

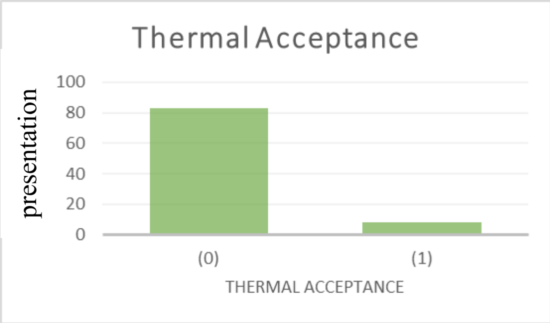


Figure 10. Thermal Acceptance Graph

The results of the Air Velocity Vote survey can be seen in Figure 11. There are five options on the questionnaire to assess whether there is an airflow (Air Velocity) felt by respondents, namely no airflow (value - 2), little airflow (value -1), suitable airflow (value 0), strong airflow (value 1), very fast airflow (value 2). The majority of respondents 65.93% felt that the airflow was appropriate in the room (value 0), there were 20.88% of respondents felt there was little airflow (value -1), there were 6.59% of respondents felt the airflow was strong (value 1) while the remaining 6.59% of respondents chose no airflow (value -2).

The results of the Air Velocity Preference survey can be seen in Figure 12. There are three options in the questionnaire to assess respondents' preferences for perceived air flow (Air Velocity) in the room, namely reduced speed (value -1), no change (0 value), and increased speed (value 1). The majority of respondents, 59.3%, wanted an increase in the airflow speed in the room (value 1), there were 39.6% of respondents who felt the airflow was appropriate (value 0), and only 1.1% of respondents wanted the airflow to be reduced (value - 1).

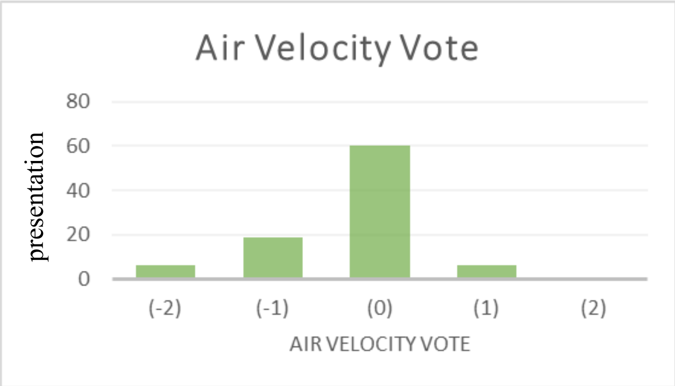


Figure 11. Air Velocity Vote Graph

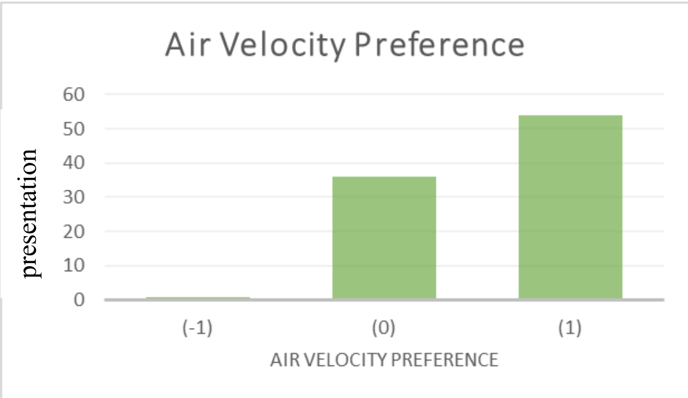
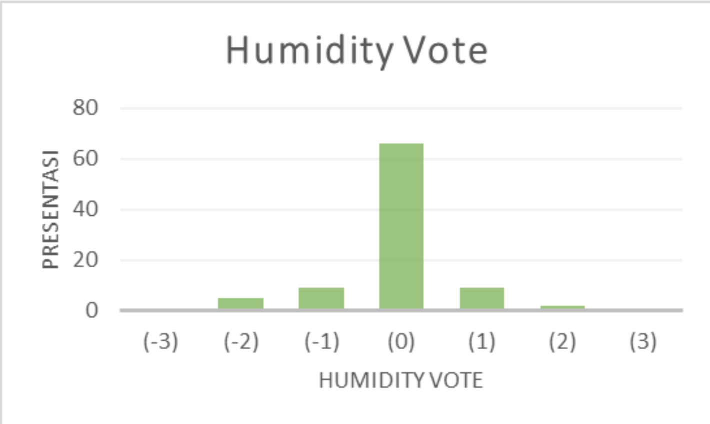


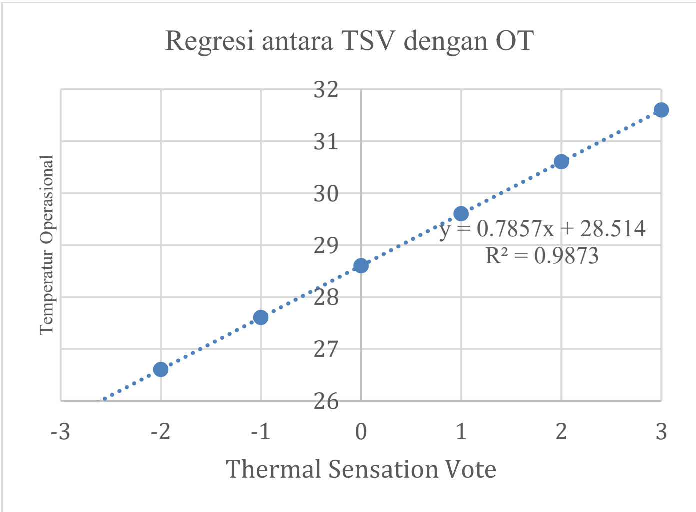
Figure 12. Air Velocity Preference graph

The results of the Humidity Vote survey can be seen in Figure 13. There are seven options on the questionnaire to assess respondents' responses to relative air humidity (humidity vote), namely very too humid (value -3), very humid (value -2), slightly humid (value - 1), suitable (value 0), slightly dry (value 0), somewhat dry (value 1), very dry (value 2), very dry (value 3). The majority of respondents 72.53% felt it was appropriate (value 0), there were 9.89% of respondents felt the room was a bit damp (value -1), there were 9.89% of respondents felt it was a bit dry (value 1), there were 5.49% respondents felt the room was very humid (value -2) and the remaining 2.2% of respondents felt the room was very dry (value 2).

The regression graph between Thermal Sensation Vote (TSV) and Operational Temperature (OT) can be seen in Figure 14, showing that the Operational Temperature (OT) value ranges from 26.4 ºC to 30.7 ºC. We get a Neutral Temperature (Tn) of 28.6 ºC using the existing regression equation. These Neutral Temperature results are similar to those obtained by Wong and Khoo (Wong & Khoo, 2003), with a Tn value of 28.8 ºC based on research conducted in Singapore, while Baharuddin Hamzah (Hamzah, Ishak, Beddu, & Osman, 2016; Hamzah, Kusno, & Mulyadi, 2019) found a Tn value of 29.6 ºC based on research conducted in one of the classrooms, university.



Gambar 13. Grafik Humadity Vote



Gambar 14. Regresi antara TSV dengan Temperatur Operasional

Conclusion

The interior conditions of the Lamongan Grand Mosque indicate average temperature values between 28.4 ºC and 29.08 ºC, average air humidity values between 61.2% and 65.3%, and average wind speeds ranging from 0.1 m/s to 0.46 m/s. While these values suggest a thermal environment at the upper comfort threshold, survey results reveal that most users find the existing thermal conditions acceptable, reflecting a general sense of comfort. Among the measured factors, room temperature significantly influences the users' thermal comfort levels.

The research found that the comfortable or neutral temperature is 28.6 ºC, where respondents feel at ease. This is likely because the temperature inside the mosque is significantly cooler than the outside.

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