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UNDERSTANDING THE IMPACT OF TEMPERATURE ON PILOT PERFORMANCE IN FLIGHT

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ABSTRACT

The cockpit of an airplane is the most important space for pilots to fly, interact and communicate with the necessary information. During flight, airplane pilots face various loads, one example is the comfortable working temperature in the cockpit. The health and performance of pilots is a crucial factor in maintaining aviation safety, considering that pilots are the most vital element in the safety aspect of the aviation industry. Currently, thermal comfort is still a topic that is not fully understood. One of the parameters related to thermal comfort in the cockpit is the room temperature in the cockpit to support the performance, comfort and health of the pilot during flight maneuvers. Based on the data that has been collected, the highest cockpit temperature is achieved at 50ºC with an aircraft altitude of 1500 ft and the highest human body temperature is achieved at 37.25ºC at a height of 1000 ft where based on this data according to SNI 03-6572-2001 thermal comfort is not achieved or even exceeds the threshold. borderline warm comfortable. Various things can affect thermal comfort, especially the effect of temperature on the cockpit, including cockpit design, air circulation, cockpit/aircraft materials, the effect of engine temperature and also several other factors that have a dominant role in influencing the temperature of the cockpit.

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1. INTRODUCTION

The cockpit on the aircraft is the most important space for the pilot in carrying out the flight, interacting and communicating with the necessary information. During the flight, aircraft pilots face various loads, one example of which is the working comfort temperature in the cockpit. The problem of working comfort temperature in the cockpit of the aircraft can be caused by several factors such as high thermal loads due to instruments, exposure to sunlight and heat transfer between inside and outside the cockpit. (Aman et al., 2023; Antonio et al., 2019)(Köse, 2022; Schennetten et al., 2021; Zhou et al., 2021)(X. Li et al., 2022)(Tong & Liu, 2020)(Yan et al., 2022)

In certain situations, the trainer aircraft used only has a cockpit design with a large transparent windshield and is not equipped with cooling technology. This makes the aircraft vulnerable to exposure to high heat and will greatly affect the temperature conditions of the pilot's work comfort in the cockpit, especially when flying at low altitudes.(Kuchár et al., 2023; Ong et al., 2023)(Aikio et al., 2012; Aikio & Selkälä, 2009; Becciu et al., 2019; Sarris et al., 2020)

Pilot health and performance are crucial factors in maintaining flight safety, considering that pilots are the most vital element in safety aspects in the aviation industry. Today, thermal comfort is still a topic that is not fully understood. One of the parameters related to thermal comfort in the cockpit is the room temperature contained in the cockpit to support the performance, comfort and health of the pilot during flight maneuvers. The purpose of this study was to determine the impact that arises based on changes in room temperature on performance, psychological impact and pilot health on the Cessna 172S trainer aircraft. (Kuncoro et al., 2022) (Prayitno et al., 2023)

2. LITERATURE REVIEW

2.1. THERMAL COMFORT

Thermal comfort is a condition in which a person feels thermally comfortable in a certain physical environment. Factors such as air temperature, humidity, wind speed, and heat radiation can affect a person's thermal comfort. (Wang et al., 2022)(Lai et al., 2020; Mansi et al., 2021; Yuan et al., 2022)

2.1.1. THERMAL COMFORT IN THE WORKING ENVIRONMENT

Thermal comfort in a work environment is very important because it can affect the productivity, well-being, and health of workers. Some factors to consider to achieve thermal comfort in the work environment include air temperature and heat radiation.(Che et al., 2019)

i. **Temperatures**

The comfortable air temperature in the work environment may vary depending on the type of activity performed and the clothes worn. In general, the recommended air temperature for the work environment ranges from 20-24 degrees Celsius. However, individual preferences can differ, and it is worth noting variations in temperature preferences between workers.(M. Li & Speakman, 2022; Liu et al., 2021)

ii. **Heat Radiation**

Exposure to heat radiation, such as direct sunlight or internal heat sources such as appliances, also needs to be considered. The application of good lighting, the use of heat-retaining curtains or glass, as well as the arrangement of heat-generating equipment can help manage heat radiation in the work environment.(Huang & Zhai, 2020)

2.1.2. THE EFFECT OF COCKPIT TEMPERATURE ON PILOT PERFORMANCE

Temperature conditions inside the cockpit of an aircraft can significantly affect pilot performance. Temperatures that are too high or too low can impair the physical, cognitive and health performance of pilots, and can cause discomfort that can interfere with their focus and concentration. If the cockpit temperature is too high, for example due to excessive sun exposure or lack of an effective cooling system, pilots can experience discomfort, fatigue, and an increased risk of dehydration. High temperatures can also affect physical performance and decrease pilots' cognitive abilities, such as decreased reaction speed and suboptimal decision-making.(Loser, 2020)

On the other hand, temperatures that are too low inside the cockpit can cause physical discomfort, such as annoying cold and can impede the pilot's free movement. At very low temperatures, pilots can also experience freezing or inability to move the body properly, which is especially dangerous in emergency situations. It is important to achieve optimal temperature balance inside the cockpit to support good pilot performance. This involves setting up an effective HVAC (Heating, Ventilation, and Air Conditioning) system, good thermal insulation, and the use of appropriate materials to control the temperature inside the cockpit.(Bottenheft et al., 2023)

In addition, it is also important to pay attention to the individual preferences of pilots, as tolerance to temperature can vary between individuals. Some factors such as the type of clothing worn and the level of physical activity can also affect a pilot's thermal comfort.

3. RESEARCH METHOD

This research aims to determine the thermal conditions in the cockpit of the Cessna 172S aircraft. Data obtained through a literature review and direct measurements in the field with variations in altitude and 2 temperature variations, namely cockpit temperature and pilot body temperature. The findings of this research will reveal thermal problems that occur in the cockpit, which can later be a technical consideration in the development of the Cessna 172S aircraft related to the cognitive abilities and health of pilot cadets.

3.1. RESEARCH MINDSET

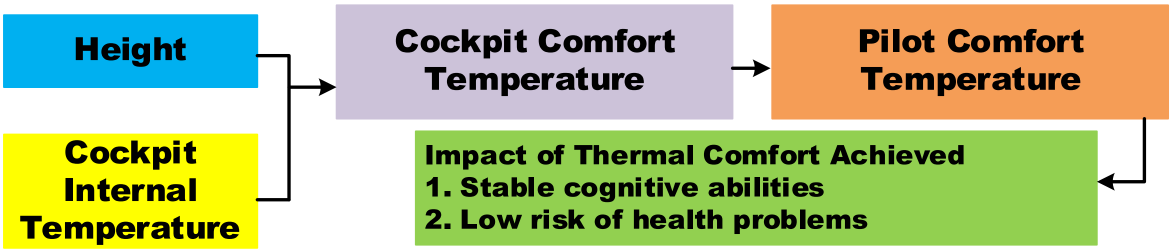


Figure 1. Research Framework

Based on the frame of mind in figure 1. So it can be explained that the altitude and internal temperature in the cockpit can affect the comfort temperature in the cockpit, it can be known that temperatures that are not properly conditioned in the cockpit will cause comfort and work performance for pilots to be disturbed. Pilot health and performance are crucial factors in maintaining flight safety, considering that pilots are the most vital element in safety aspects in the aviation industry.

3.2. DATA COLLECTION TECHNIQUES

The data obtained in this study used direct temperature collection of the aircraft cockpit and temperature collection of pilots and questionnaires that will be given to pilots related to thermal comfort conditions affected by pilots during flight. Temperature collection is carried out at intervals of 10 minutes for 50 minute flight Furthermore, the two temperatures obtained will be compared and further analysis will be carried out. The second data is obtained from a questionnaire that will be given directly to pilots related to temperature changes on impacts based on aircraft altitude.

3.3. DATA RETRIEVAL METHODS IN THE COCKPIT

Measurement of temperature data using temperature sensors placed in the cockpit and body temperature in the pilot. The research scheme can be illustrated in figure 2.

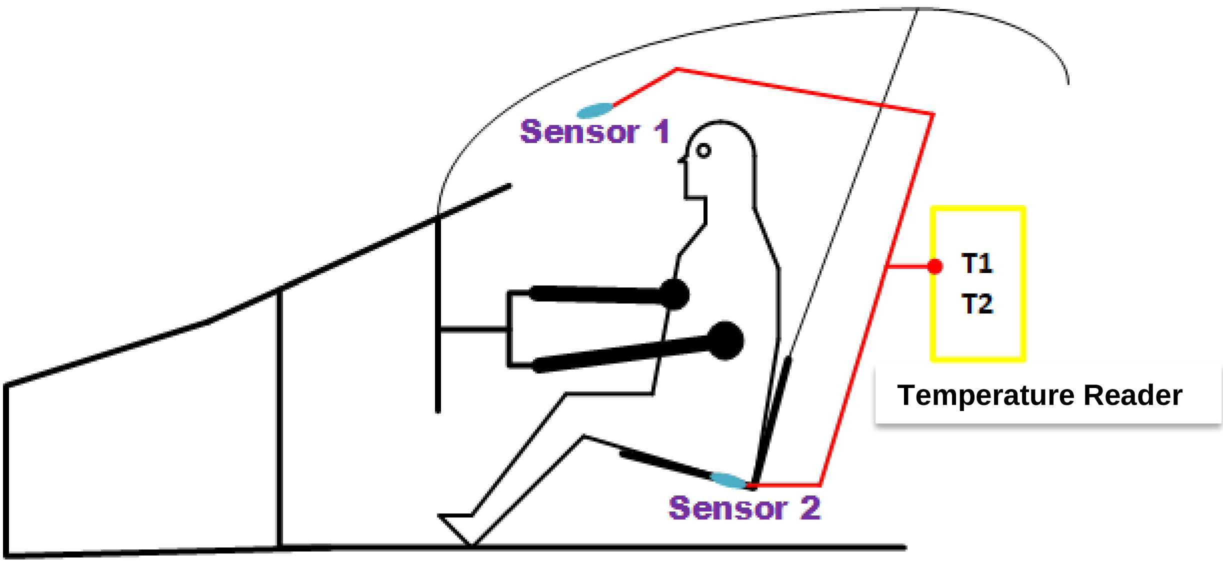


Figure 2. Data Retrieval Illustration

4. RESULTS AND DISCUSSIONS

The data obtained in this study was in the form of temperature measurements of the cockpit and cadets who had flown for 50 minutes using a Cessna 172 type aircraft and questionnaires.

4.1.1. DATA HASIL PENGUKURAN SUHU

Data obtained during 50 minutes of flight and every 5 minutes of temperature data recording will be shown in Table 1. As well as in the measurement of the altitude of the aircraft carried out with the application Flight Radar will be shown in Figure 3.

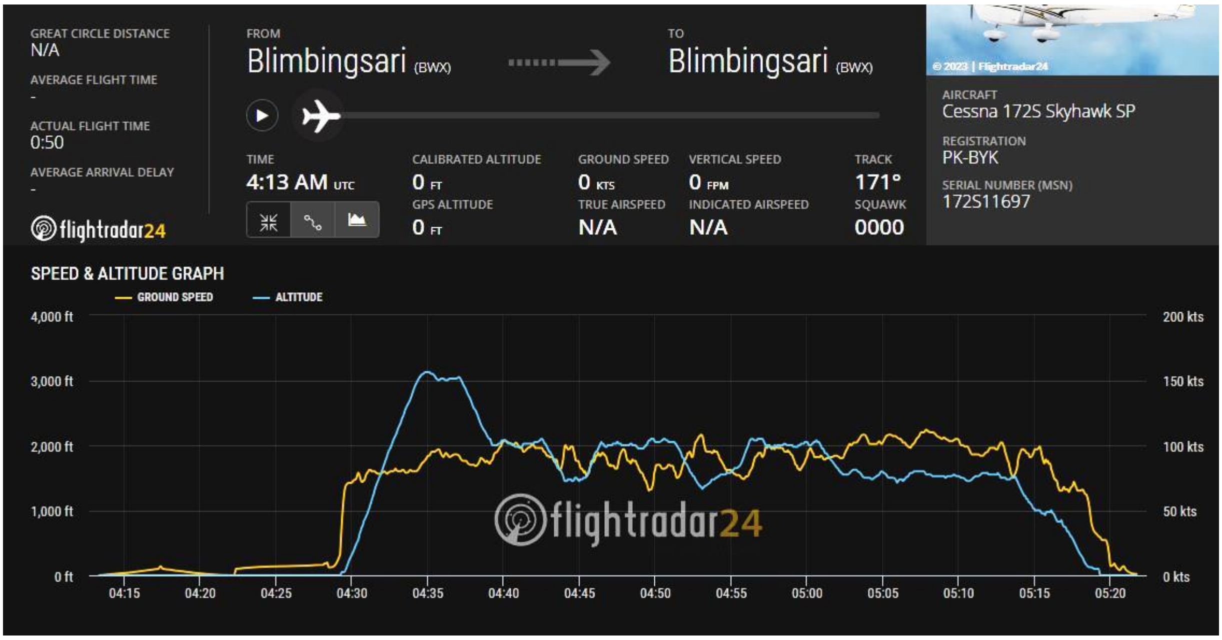
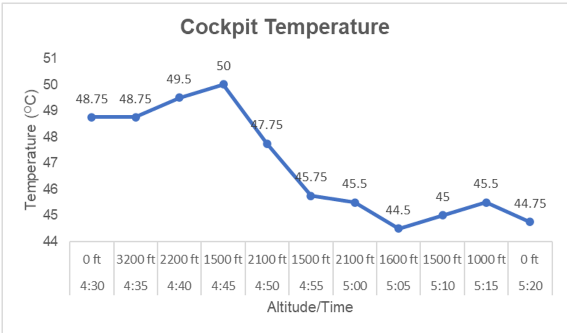


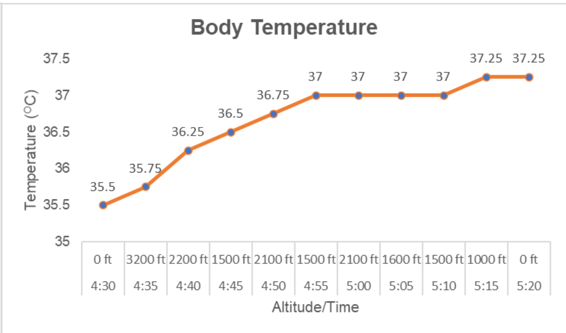
Figure 3. Flight Radar

Table 1. Measurement Data

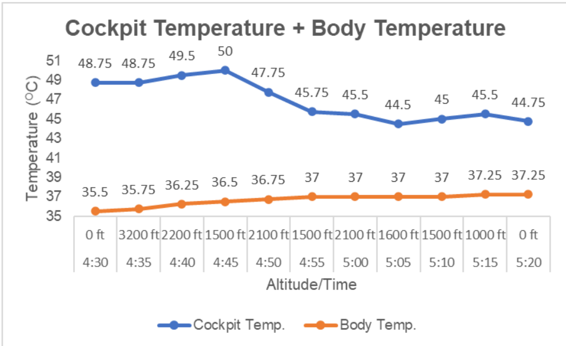
Flight Time	Altitude	Cockpit Temp.(°C)	Body Temp.(°C)
4:30	0 ft	48.75	35.5
4:35	3200 ft	48.75	35.75
4:40	2200 ft	49.5	36.25
4:45	1500 ft	50	36.5
4:50	2100 ft	47.75	36.75
4:55	1500 ft	45.75	37
5:00	2100 ft	45.5	37
5:05	1600 ft	44.5	37
5:10	1500 ft	45	37
5:15	1000 ft	45.5	37.25
5:20	0 ft	44.75	37.25



(a)



(b)



(c)

Figure 4. (a) Cockpit temperature **(b)** Body temperature **(c)** Cockpit + Body Temperature

Based on the data obtained, if referring to the thermal comfort limit according to SNI 03-6572-2001 shown in Table 2.

Tabel 2. Thermal Comfort Limits According to SNI 03- 6572-2001

Category	Effective Temperature	Moisture
Cool comfortable threshold	20,5°C – 22,8°C	50%
	24°C	80%
Convenient optimal threshold	22,8°C – 25,8°C	70%
	28°C	
Warm comfortable threshold	25,8°C – 27°C	60%
	31°C	

Source: SNI 03-6572-2001

It can be concluded from the data that has been collected and refers to Table 2, that the comfort of the cockpit of the Cessna 172 aircraft is above the warm comfortable category. Looking at Table 1, in the various altitudes reached by the aircraft, displays different data on cockpit temperature and human body temperature. The highest cockpit temperature is reached at 50°C with an aircraft altitude of 1500 ft and the highest human body temperature is reached at 37.25°C with an altitude of 1000 ft.

Various things can affect thermal comfort, especially the influence of temperature on the cockpit including cockpit design, air circulation, cockpit / aircraft materials, the effect of engine temperature caused and also several other factors that have a dominant role in influencing the temperature of the cockpit(Qiram et al., 2022). The effect of changes in cockpit room temperature will significantly affect the body temperature of a cadet / pilot. Where changes in temperature and exposure to temperatures that are relatively above the warm comfortable threshold will affect the stability of psychological and cognitive aspects and can cause a decrease in health.

4.1.1. CADET/PILOT QUESTIONNAIRE RESULT DATA

The next data that will be displayed is a questionnaire containing several questions given to 17 cadets or pilots of a Cessna 172 aircraft where the contents of the questionnaire will contain several questions about the comfort of cadets or pilots during the flight. The questionnaire result data will be shown in Table 3.

Tabel 3. Questionnaire Results

Question	Answer	Answer Results
Do you feel hot when flying on a Cessna 172 aircraft?	Yes	11 Answer
	No	6 Answer
	Other	0 Answer
If you feel hot or hot while flying, do you feel restless or uncomfortable during the flight?	Yes	8 Answer
	No	7 Answer
	Other	1 Answer
Do you feel the effects of hot temperatures when flying affecting your body temperature?	Yes	13 Answer
	No	4 Answer
	Other	0 Answer
When flying, have you ever felt the temperature shift from cold to hot or vice versa?	Ever	11 Answer
	Never	6 Answer
	Other	0 Answer
Does being hot or cold while flying affect your level of focus?	Yes	11 Answer
	No	5 Answer
	Other	2 Answer
What do you do when the cockpit temperature feels too hot?	Keep Flying	16 Answer
	RTB	0 Answer
	Other	1 Answer
When it's hot and you sweat while flying, which part of your body sweats first?	Hand	4 Answer
	Body	9 Answer
	Head	8 Answer
Does high cockpit temperature affect your visibility?	Yes	1 Answer
	No	16 Answer
	Other	0 Answer

Based on the questionnaire data that has been collected, cadets or pilots generally feel the heat in the cockpit of the Cessna 172 aircraft and this affects the ability of cadets and pilots to make flights.

5. CONCLUSION

The results of this study concluded that the heat generated in the cockpit of the Cessna 172 aircraft had a significant effect on the cadets and cadet instructors. Some of the effects are decreased cognitive ability, anxiety, sweating, which in the long run will affect the health of cadets and cadet instructors. Factors that cause an increase in temperature in the cockpit include the design of air circulation in the cockpit, the material of the dashboard in front of the cockpit which tends to reflect heat, and also several other factors that have a dominant role in affecting the cockpit temperature.

hopefully in the future there will be research that touches on the factors that cause an increase in temperature in the cockpit or temperature in cadets.

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