Heat Transfer Simulation on Window Glass Using COMSOL Multiphysic

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Abstract. One physical event related to heat transfer is expansion. Where expansion of a substance is an event of changes in the geometry of an object due to the influence of heat. In this study will be discussed about heat transfer based on expansion on window glass due to the effects of heat and solar radiation based on Stefan-Boltzman law. Heat transfer on the window glass will be simulated with a numerical method, namely the finite element method with the COMSOL Multiphysic 5.2a program. The results of this study will show the maximum heat transfer on a window glass that only has 9 degrees in approximately 2.2 seconds.

1. Introduction

Heat transfer is one of the natural phenomena where energy transfer occurs due to temperature differences. As is known, heat transfer can be through three ways, namely convection, conduction, and radiation. In this study, the heat transfer that will be observed and given in the form of simulation is heat transfer by radiation. The object of observation is a window glass with a size of $1m \times 0.5m \times 0.005m$. Where the simulation will be carried out is to see the length of time the heat transfer occurs based on the radiation from the sun’s rays on the window glass.

This research was carried out because of the phenomenon of global warming that has occurred. Where this research is the beginning of the next research that will see the effects of excessive warming⁴. The limit in this study is only to see the simulation of heat transfer on the window glass. The main objective of the research is to look at the heat transfer process on window glass caused by overheating due to global warming based on radiation from the sun which causes the air temperature to feel hotter than usual.
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2. Methods

2.1. Radiation

Radiation is the transfer of heat that occurs due to the emission or rays of particles or electromagnetic waves without the need for intermediate substances. As is known, every object emits heat radiation. Radiation from an object can be seen because when the temperature exceeds 1,000 K. At that temperature objects start to glow red like a heating coil of an electric stove. At temperatures above 2,000 K white or yellow glowing objects, like white incandescent from incandescent lamp filaments. As the temperature of the object continues to increase, the relative intensity of the spectrum of light emitted changes. This results in a shift in the observed spectrum colors, which can be used to determine the temperature of an object.

In solving this radiation problem, Stefan-Boltzman law is used. Radiation energy every second of broad unity is called radiation intensity \( I \). Joseph Stefan and Ludwig Boltzman have measured the rate of heat energy of radiation emitted by an object, later known as the Stefan-Boltzman Law. Whereas Stefan-Boltzman’s law is as follows:

\[
I = \frac{P}{A} = \varepsilon \sigma T^4
\]

where \( I \) is the radiation intensity (\( \text{watt/m}^2 \)), \( P \) is the radiation power (\( \text{W} \)), \( A \) is the object surface area (\( \text{m}^2 \)), \( \varepsilon \) is the emissivity coefficient, \( T \) is the absolute temperature (\( \text{K} \)), and \( \sigma = 5.67 \times 10^{-8} \text{Wm}^{-2}\text{K}^{-4} \) (Stefan-Boltzman constant). Judging from power emissions, the object is divided into three kinds:

(i) Absolutely white.
   Absorb light, without emitting again. Emissivity \( \varepsilon = 0 \)

(ii) Gray body.
   Emissivity \( 0 < \varepsilon < 1 \)

(iii) Blackbody.
   Absorb 100%, emit 100%. Emissivity \( \varepsilon = 1 \)

2.2. Model structure

The simulation model in this study uses a COMSOL Multiphysic 5.2a program. Where this program is based on finite element method. For window glass density of \( \text{kg/m}^3 \). While the thermal conductivity is \( 1.15 \text{W/m.K} \). For the initial temperature of 297 K and the warmest temperature due to radiation is 306 K. The simulation model for glass measuring \( 1m \times 0.5m \times 0.005m \) is described as follows
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(a) Windows Glass Model  (b) Mesh Windows Glass

Figure 1. Window Glass Structure Model with COMSOL Multiphysic

3. Result and discussion

The results obtained with the COMSOL Multiphysic program are as follows. Can be seen in Figure 2 the more red the color on a surface, the lower the temperature. While the more white the higher the temperature. From Figure 2.a it can be seen that the surface temperature of about 297 degrees Kelvin at the first time is exposed to radiation. Whereas in Figure 2.b, it will look increasingly yellow for the back surface where the temperature on the window glass is approximately 302 degrees Kelvin.

For figure 2.c you can see the surface temperature is getting closer to 306 degrees Kelvin. And can be seen in figure 2.d the maximum temperature has occurred. At
the maximum temperature, in the next study will be seen how expansion occurs on the window glass. Where the impact of excessive expansion will cause the window glass to break.

4. Conclusions

Based on this research, it can be seen that in just 2.2 seconds, the temperature of a glass has changed completely. Where changes in total temperature can cause expansion to be carried out in subsequent studies. So that this study aims in the next research reference and for readers who are doing almost the same research.

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5. References

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