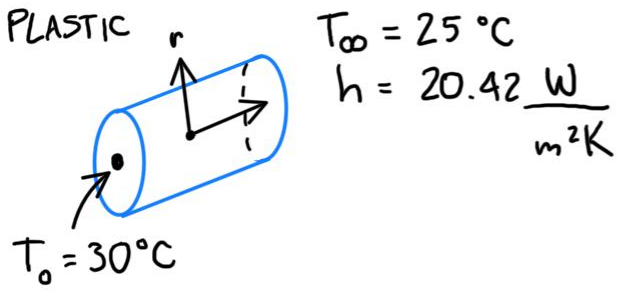
Test 3 - Joel Adriano

Question 1

Purpose

The purpose of the first question of this test is to observe transient conduction.

Drawings & Diagrams



Sources

Heat Transfer Fundamentals 1st Edition, Begell House, Inc. by Yildiz Bayazitoglu & Necati Ozisik

Design Considerations

The substance being observed is a plastic rod with a thermocouple at the center of it. The substance is placed in a colder fluid instead of ambient air.

Data & Variables

$T_i = 70°C$

$T_\infty = 25°C$

$h = 20.42\ \frac{W}{m^2K}$

$t = 1338s$

$T_o = 30°C$

$\rho = 1190\ \frac{kg}{m^3}$

$c_p = 1465\ \frac{J}{kgK}$

$K = 0.19\ \frac{W}{mK}$

Procedure

The first thing for transient conduction problems is to determine the Biot Number because if the biot number is between 0 and 0.1, the Lumped Capacitance Method can be applied. Otherwise, the process of iteration will be needed. The diameter and length of the plastic rod can be solved using iterations on Excel.

Calculations

$$\alpha = \frac{k}{\rho c_p} \Rightarrow \alpha = \frac{0.19\ W/mK}{(1190\ kg/m^3)(1495\ J/kgK)}$$

$$\alpha = 1.07E-7$$

$$Bi = \frac{h L_c}{k} \Rightarrow Bi = \frac{(20.42\ W/m^2K)(0.011\ m)}{0.19\ W/mK}$$

$$Bi = 1.19$$

INTERPOLATION Bi

1.0	1.2558
1.19	1.3211
2.0	1.5994

Summary

During the iterative process, it was found that the biot number was over 0.1 which consequently meant that the lumped capacitance method could not be used. Conversions were a problem solved because the biot number was dependent on the radius naught, the number appeared big, but it was solved converting cm to m. Plugging in x values was needed to find the temperature at the surface and at half the radius.

Materials

Plastic Rod

Analysis

The overall diameter of the cylinder is 0.02 m or 2 cm. The surface x is 0.01 m or 1 cm and the r/2 x is 0.005 m or 0.5 cm. The surface temperature is cooler at 119°C while the r/2 temperature is at 127°C. This is because the surface of the cylinder is coming into contact with a fluid that is 30°C.

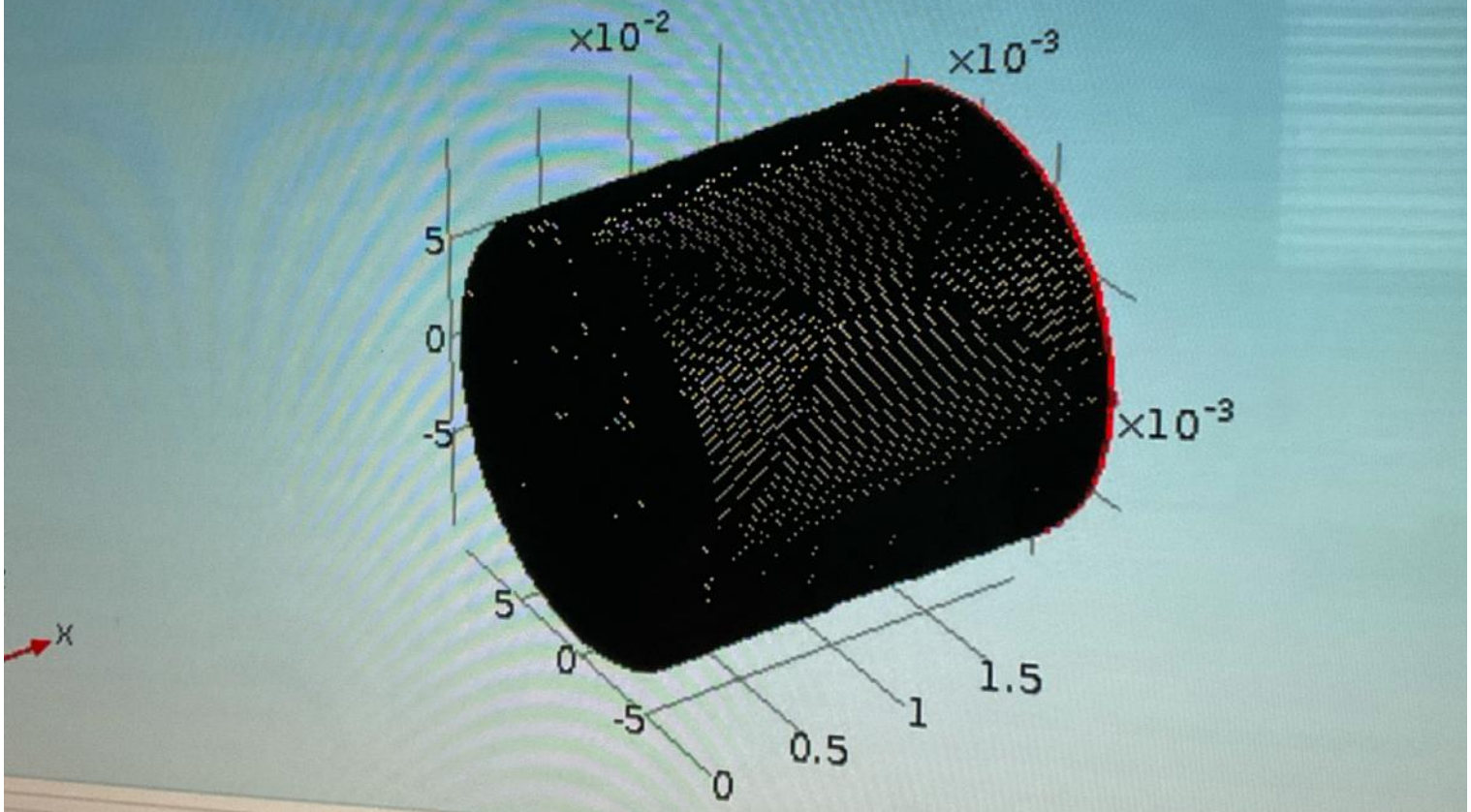
Question 2

Purpose

This question needs to be solved with COMSOL.

Drawings & Diagrams

Transfer in Solids
Physics
Build Mesh
Mesh 1
Mesh
Compute
Study 1
Add Study
Study
Select Plot Group
Add Plot Group
Results
Physics
Convergence Plot 1



Progress
Log

er of degrees of freedom solved for: 2297818 (plus 60830 internal DOFs).
er of degrees of freedom solved for: 2297818 (plus 60830 internal DOFs).

8.63 GB | 9.06 GB

Sources

Heat Transfer Fundamentals 1st Edition, Begell House, Inc. by Yildiz Bayazitoglu & Necati Ozisik

Design Considerations

Calculated variables going to be inputted into Excel is going to be used. The cylinder has a diameter of 2 cm and an arbitrary length (2cm). The temperatures achieved from the previous question is 273°C at r/2 and 254°C at surface.

Data & Variables

$\phi = 0.02m$ OR $2cm$

$r_o = 0.01m$

$x_{r/2} = 0.005m$

$T_s = 254°C$

$T_{r/2} = 273°C$

Procedure

The steps to find the temperatures at r/2 and surface of the cylinder is to add the properties into the material tab which does not have the specific plastic, so I plugged the specific variables into it. The next step is to add the different heat transfer modes to the cylinder. These were heat flux, temperature of the thermocouple, and the initial values. Calculate a a time dependent study on a fine mesh cylinder. Put the time settings to 0, 0.5, 1338 because this is a measurement on a transiently heated substance. Lastly, calculate the r/2 and surface temperature and put together a report.

Calculations

Calculations were performed in COMSOL itself.

Summary

My work by hand and in excel did not match the COMSOL. The temperature at r/2 at 1338s is 27.768°C and the temperature at surface is 26.952°C.

Materials

COMSOL

Analysis

COMSOL displayed the right results because the most heat was inside the cylinder at 30°C and the fluid is cooling the cylinder at 25°C. Therefore, the 27.768°C at half radius and 26.952°C at surface makes sense.