Preethika_exp1_composite_wall

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###

EXP 1 HEAT TRANSFER THROUGH COMPOSITE WALLS

0.0.1 Objective:

- To study the conduction heat transfer in composite wall.

0.0.2 Aim:

- To determine total thermal resistance and thermal conductivity of composite wall.
- To determine thermal conductivity of one material (Press wood)
- To plot temperature gradient along composite wall structure.

0.0.3 Theory:

- When a temperature gradient exists in a body, there is an energy transfer from the high temperature region to the low temperature region. Energy is transferred by conduction and heat transfer rate per unit area is proportional to the normal temperature gradient:

$$Q = -kA\frac{\partial T}{\partial X}$$

when the thermal conductivity is considered constant. The wall thickness is ΔX, and T_1 and T_2 are surface temperatures. If more than one material is present, as in the multiplayer wall, the analysis would proceed as follows:

The heat flow is same in all the sections and it is written as:

$$Q = \frac{T_1 - T_7}{\Delta X_A/K_A A + \Delta X_B/k_B A + \Delta X_C/k_C A}$$

0.0.4 Procedure:

1. Start the supply of heater by varying the dimmerstat.
2. Adjust the power input at the desired value.
3. Start taking readings of all the temperature sensors after one hour at each five-minute interval until observing three consecutive readings are approximately the same and if not go for the 4th set of reading.
4. Note down final steady state readings in the observation table.

0.0.5 Experimental Setup:

1. **Entire setup**:
2. **Composite wall apparatus**:

[51]:
```
import numpy as np
from matplotlib import pyplot as plt
from scipy.interpolate import interp1d
```

[88]:
```
#calculations
d = 0.25
t_cast = 19e-3
t_bake = 17e-3
t_wood = 12e-3
K1 = 52
K2 = 1.4
#Experimental data
T1 = np.array([31.2,33.8,36.6])
T2 = np.array([30.2,33,35.8])
T3 = np.array([29.1,31.7,34])
T4 = np.array([29.1,31.7,34])
T5 = np.array([26.1,27.7,29.6])
T6 = np.array([26.3,28,29.8])
T7 = np.array([23.6,24.6,25.7])
T8 = np.array([23.9,24.6,25.6])
V = np.array([50,55,60])
I = np.array([0.21,0.23,0.25])
Q = V*I/2
A = np.pi*(d**2)/4
q = Q/A
delT_u = np.abs(T1-T7)
delT_l = np.abs(T2-T8)
delX = t_cast + t_bake + t_wood
print("q = {} W/m2".format(q))
```

```
q = [106.95212176 128.85184193 152.78874537] W/m2
```

[89]:
```
Rt_u = delT_u/q
Rt_l = delT_l/q
Keff_u = delX/Rt_u
Keff_l = delX/Rt_l
K3_l = t_wood/(delT_l/q - (t_cast/K1 + t_bake/K2))
K3_u = t_wood/(delT_u/q - (t_cast/K1 + t_bake/K2))
print("lower side thermal resistance = {} m2 C/W".format(Rt_l))
print("upper side thermal resistance = {} m2 C/W".format(Rt_u))
print("K effective (lower) = {} W/m C".format(Keff_l))
print("K effective (upper) = {} W/m C".format(Keff_u))
print("K of press wood (lower) = {}".format(K3_l))
```

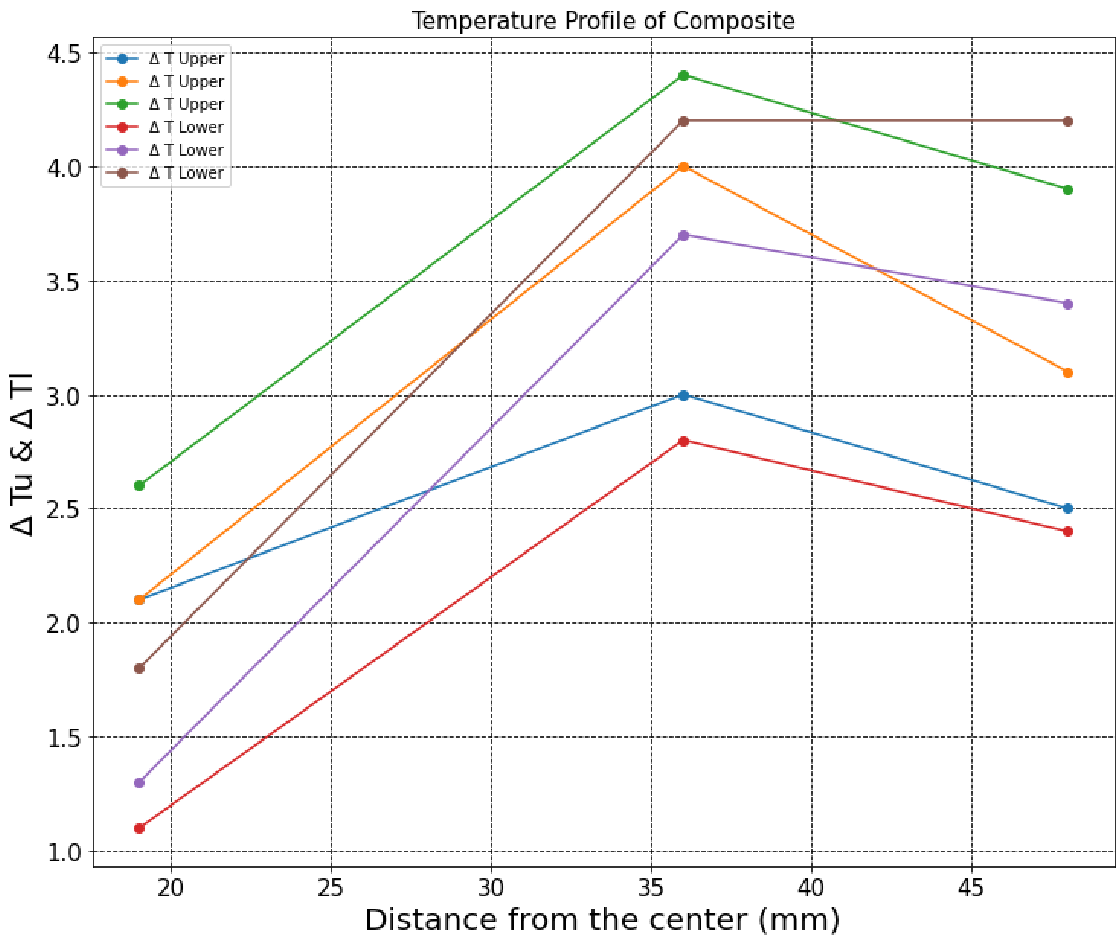
```
print("K of press wood (upper) = {}".format(K3_u))
```

```
lower side thermal resistance = [0.05890486 0.06519115 0.06675884] m2 C/W
upper side thermal resistance = [0.07105983 0.07139983 0.07134033] m2 C/W
K effective (lower) = [0.81487331 0.73629624 0.71900586] W/m C
K effective (upper) = [0.67548708 0.67227048 0.67283117] W/m C
K of press wood (lower) = [0.25863953 0.22777785 0.2211957 ]
K of press wood (upper) = [0.20494746 0.20376423 0.20397031]
```

0.0.6 Observations & Calculations:

[100]:
```
#graph
s = np.array([0.019,0.036,0.048])*1e3
Tu = np.array([(T1-T3),(T3-T5),(T5-T7)])
Tl = np.array([T2-T4,T4-T6,T6-T8])
```

[97]:
```
#plt.plot(s,Tl)
plt.xlabel('Distance from the center (mm)',fontsize=20)
plt.ylabel('\u0394 Tu & \u0394 Tl',fontsize=20)
plt.grid(True,linestyle = '--',color="black")
plt.rcParams["figure.figsize"] = (12,9)
plt.plot(s,Tu,label="\u0394 T Upper",marker = 'o')
plt.plot(s,Tl,label="\u0394 T Lower",marker = 'o')
plt.tick_params(axis='x', labelsize=15)
plt.tick_params(axis='y', labelsize=15)
plt.title("Temperature Profile of Composite",fontsize=15)
plt.legend(loc="best")
plt.show()
```



0.0.7 Conclusions / Inferences:

1. The thermal conductivity of the composite is within the range of 0.672 - 0.814 $W/m°C$
2. The calculated thermal conductivity of press wood is within the range of 0.204 - 0.258 $W/m°C$
3. The graph is plotted for ΔT_U / ΔT_L vs distance from the centre of the composite. The peak temperature difference is at 36 mm from the centre and after which it again decreases.

0.0.8 Reccomendations:

1. Improved insulation.
2. Heater with higher heating rate so that steady state can be achieved relatively faster.

0.0.9 Industrial Applications:

High-temperature materials are critical to aviation applications. Aircraft engines can reach temperatures as high as 2100°C, and vehicles at high altitudes are subject to extreme temperature fluctuations. Thrust reversal systems help to slow the aircraft by rerouting engine exhaust toward the front of the vehicle, creating air resistance and reducing the speed of the aircraft. Insulation must be used to protect surrounding components from the extreme heat of the released exhaust.

This is accomplished by designing a network of composites. Window gaskets which is a combination of EPDM and ceramic material are installed to seal the glass and sheet metal around aircraft windows, and must withstand extreme temperature fluctuations and pressure at high altitude. Similarly, fuel door gaskets are used to seal the fuel system from harsh external environments. To be fully effective, fuel door gaskets must also be resistant to corrosion from the harsh chemicals in jet fuel.