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Heat Transfer through Composite Cylinder

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Abstract - *Multilayer cylinder applications are more common and are used to reduce heat loss in pipes. The pipes are generally covered with one or more layers of insulation called Lagging of pipe. Such cylinders covered with multi layer are called is known as composite cylinder. In this present project we are going to find out the heat transfer through these composite cylinders. Here we compared the values obtained from the analysis through Ansys software and theoretical values obtained from calculations done by us.*

Key Words: Composite cylinder, Ansys, Temperature, Heat Transfer.

1. INTRODUCTION

Cylinders covered with multi layer are called composite cylinder. Let us consider a cylinder of radius $\mathbf{r_1}$ lagged with two layers of insulation having conductivities $\mathbf{K_1}$ and $\mathbf{K_2}$ as shown in fig.1. The outer surface of the cylinder is at $\mathbf{T_1}$ and the outer most surface is at $\mathbf{T_3}$. Let $\mathbf{T_1 > T_3}$ and heat passes through the two layers of insulation.

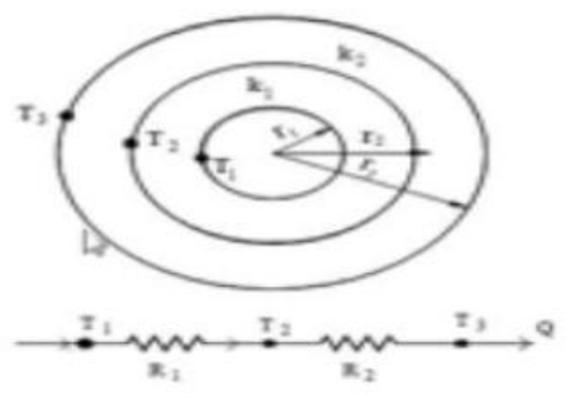

Fig.1- Composite cylinder

1.1 Modelling and Analysis

Both the modelling and analysis was done in Ansys workbench only.

The problems statement taken was:

Calculate heat loss from a meter length of insulated pipe with inside radius of 5cm which is at a temperature of 200 °C. The outer radius of the pipe is 8cm. Assume the thermal conductivity of the pipe material is 10 W/m-K. Also calculate the outer temperature of the lagging material when the ambient air is at 25 °C with a convective heat transfer coefficient of 10 W/m^2-K.

The analysis figs are shown below:

Fig.2 shows the temperature distribution at the nodes.

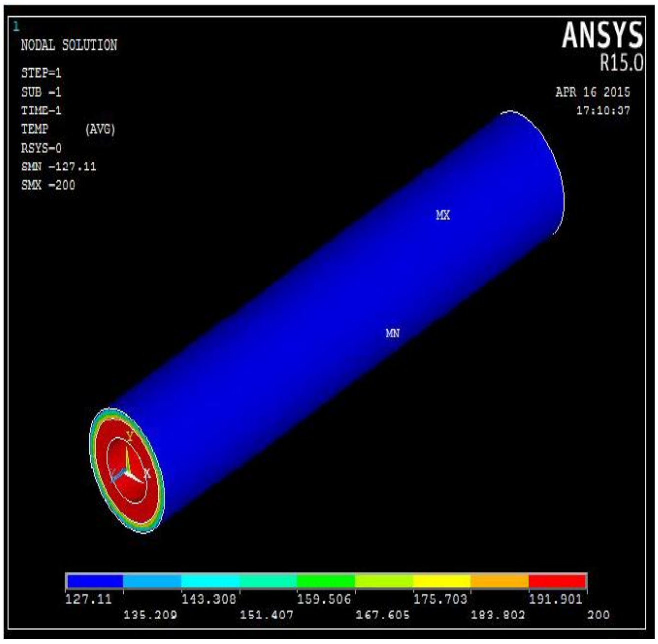

Fig.2- Temperature at the nodes.

Fig.3 shows the temperature variation across the cylinder.

Fig.3- Temperature variation across the cylinder.

Therefore, from the Ansys analysis surface temperature of insulation is 127.11 ^{o}C.

The graphical representation of the same is as shown in the fig.4

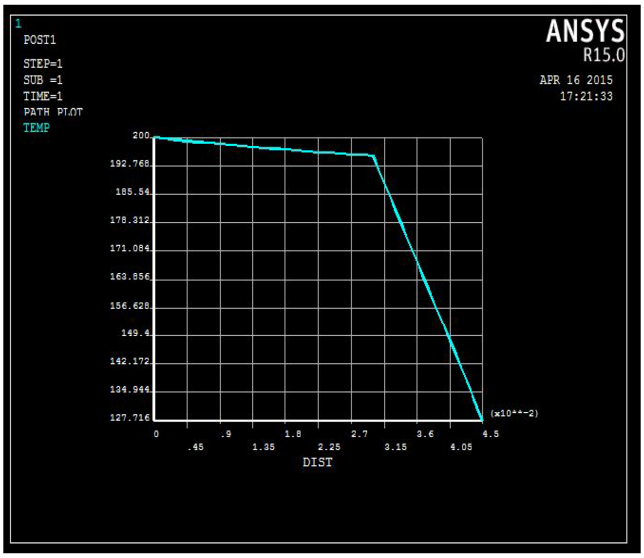

Fig.4- Graphical representation.

NODE	HEAT
14066	0.43152E-01
14067	0.65813E-01
14068	0.66415E-01
14069	0.42863E-01
14070	0.59738E-01
14071	0.41906E-01
14072	0.57051E-01
14073	0.10552
14074	0.12433
14075	0.82473E-01
14076	0.25021
14077	0.86711E-01
14078	0.11975
14079	0.33107E-01
14080	0.11350
14081	0.12071
14082	0.55996E-01
14083	0.22675
14084	0.16028
14085	0.15842
14086	0.13360
14087	0.15448
14088	0.10512
14089	0.12673
14090	0.91495E-01
14091	0.52591E-01
14092	0.47316E-01
14093	0.47031E-01
14094	0.51817E-01

And from the Ansys analysis Heat transfer across the cylinder is **615.96 W/m.**

1.2 Theoretical

Given conditions from the problem statement:
Given

$$r_1 = 5 \times 10^{-2} m$$
$$r_2 = 8 \times 10^{-2} m$$
$$r_3 = 9.5 \times 10^{-2} m$$
$$k_1 = 10 \frac{W}{mK}$$
$$k_2 = 0.25 \frac{W}{mK}$$
$$h_0 = 10 \frac{W}{m^2 K}$$
$$T_\alpha = 25°C$$
$$Q = \frac{\Delta T}{R_{total}}$$

Resistance,

$$R_{total} = R_{pipe} + R_{insulation} + R_{outside\ convective}$$

$$R_{pipe} = \frac{1}{2\pi k_1 L} ln \frac{r_2}{r_1} = \frac{1}{2\times\pi\times10\times1} ln \frac{8}{5} = 0.0075$$

$$R_{insultion} = \frac{1}{2\pi k_2 L} ln \frac{r_3}{r_2} = \frac{1}{2\times\pi\times0.25\times1} ln \frac{9.5}{8} = 0.109$$

$$R_{conv} = \frac{1}{h_O A_O} = \frac{1}{10\times2\times\pi\times9.5\times10^{-2}\times1} = 0.1677$$

Therefore, $Q = \frac{200-25}{R_{total}}$ = 615.19 W/m

To find surface temperature of the insulation:

$Q = \frac{T_3 - T_\alpha}{R_{total}}$ => $T_3 = T_\alpha + Q.R_{conv}$

T_3 = 25+0.1677(615.9) = **128.3 °C.**

2. Results

Surface Temperature of Insulation = 128.3 °C. (From Theoretical)

(From Ansys analysis) = 127.11°C

Heat transfer across cylinder = 615.19 W/m
(From Theoretical)

(From Ansys analysis) = 615.96 W/m

3. CONCLUSIONS

From this we have found out the temperature variation across cylinder and surface temperature of a given composite cylinder using both Ansys and theoretical solution. Both the solutions were almost equal.

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