Conduction and Convection Heat Transfer

Prof. S. K. Som
Prof. Suman Chakraborty
Department of Mechanical Engineering
Indian Institute of Technology- Kharagpur

Lecture 18

Now today, we will solve 1 or 2 problem relating to 1-dimensional steady state heat conduction in cylindrical geometry, cylindrical wall, that is in a pipe of circular cross section and a very interesting related problem is the critical thickness of insulation. So, let us solve 1 or 2 problems just to habits applications what yesterday also we solved a problem that is at the last class.

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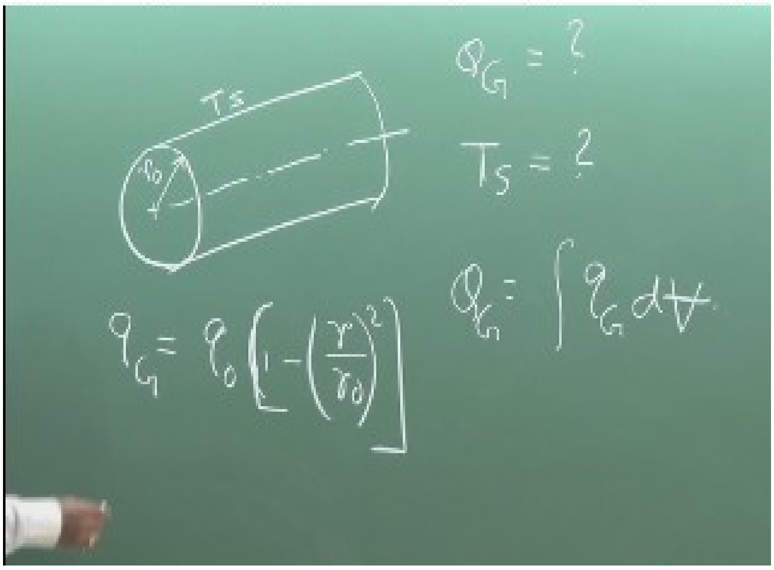

Now the problem states like this, I am telling if there is a cylindrical container, this is the axis; cylindrical container of radius r0 and the language of the problem is like that radioactive Os are packed in a long thin wall cylindrical container, that means the radioactive Os are packed that means ultimately works as a solid cylinder type of thing. The radioactive Os are packed in a long thin wall cylindrical container.

The waste generate thermal energy non uniformly according to the relation that the volumetric energy generation rate at a point is given by qG, q0*(1- r/r0) square, where q0 and r0 are constant. That means, it is varying with r, which means there is a cylinder solid, because this thin wall container is packed with the radioactive Os, quick generates in such a way.

So, what they want to obtain expression for the total rate at which the energy is generated, total rate of energy generation and use this result to obtain an expression for this surface temperature Ts. So, this is simplest again problem. First part is the total energy generation from the volumetric energy generation rate so it is nothing but qG is integral qG dV. I usually represent volume as a V with a cart to distinguish it from velocity.

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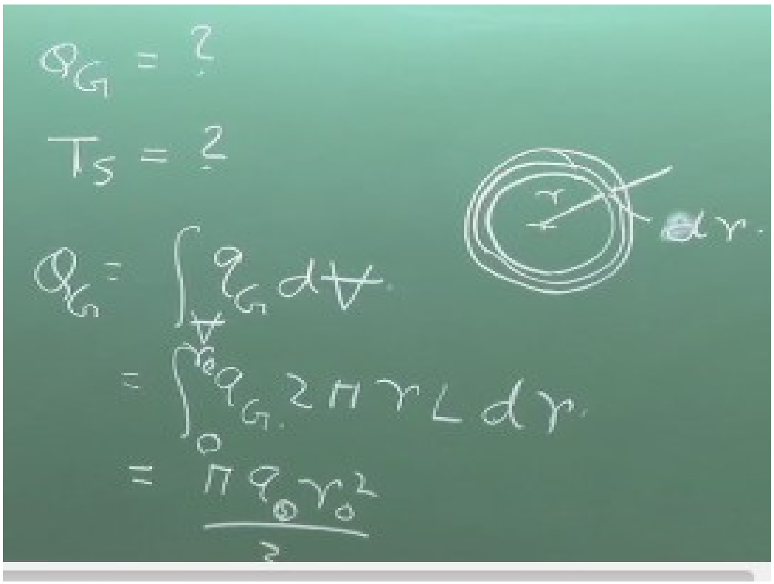

The convective heat transfer is associated with fluid mechanics fluid flow we use v as the velocity, that is why I use this big V, this V is the volume; dV is this small elemental volume, that means if we consider an elemental area like this in the container, thin cylindrical elemental area at a radius r and the thickness of this, is dr for example, then this will be nothing but qG. What will be the volume? 2 pi rL*dr.

If you do that, you get the expression this as, pi q0 r0 square/2, very simple. You put this 2 pi L will come out so r, dr r square/ 2 that is r0 square /2. Because this now will be; this is for the entire volume. Now when I put in terms of d r, it will be 0, 2r0. So, the first term will be dr, rdr that is r0 square/2 and second term will be r square /r0 square, rq/r0 square dr, that means r0,4 and denominator r0 square, it will be again r0 square/2.

So, ultimately you get pi q0 or 0 square/2. This thing, I am not doing in the class. So, this is the expression (()) (5:51) nothing, but what is the Ts? Now to find Ts, expression at the surface temperature, you have to apply certain intelligence that always we do not want a routine (()) (6:06), that we have to find out a temperature distribution, heat generation; is not required. Simply, the gross energy balance, the total heat which is being generated or total thermal energy which is being generated must go out from the surface.

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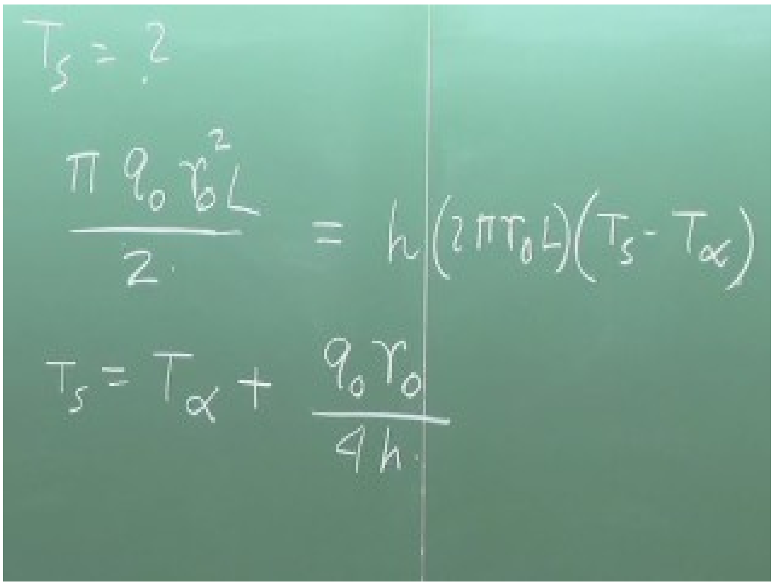

Because the problem is prescribed by a heat transfer coefficient h and the T infinity. This problem is prescribed that the container is immersed in a liquid or fluid that provides a uniform convection coefficient h and at a temperature T infinity and expressed Ts in terms of T infinity, h and q0. So, therefore what we can write? We can write pi q0 r square/2. This is per unit length. So, therefore, these as to be this. So, this is qG per unit length. I am sorry.

The result I have written since I have not worked it out here that is why this mistake is there that qG/L is pi q0r0 square/2. So, this L is there, so L is comes out, L will come out so qG/L. So, the total qG is this, this must be =h*outer surface area which will be twice by r0*L*Ts-T infinity. So, therefore from here we get Ts, Ts will be = T infinity that is the ambient temperature +, pi, pi will cancel, so 4 will be there that means q0r0/4h, pi r0 q0 r0 square, pi r0 q0 r0 /4h.

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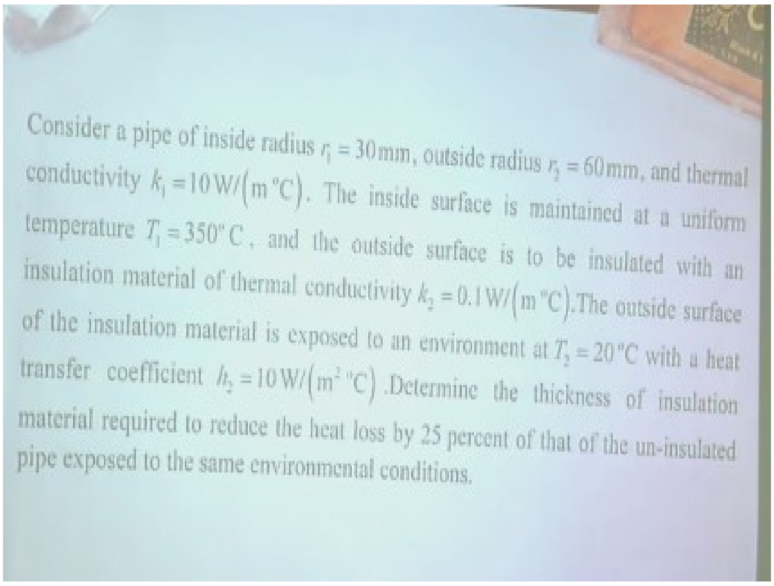

I think it is okay. This is the problem.