Reply To Thread # 341-360043

Numerical analysis by computer programing or spreadsheet would be my approach as I would get a sense of the temperature profile throughout the rubber sample. The sketches shown below help in the development of heat transfer equations at the nodes of interest. All external surfaces are considered isothermal boundaries. Expect the center line temperature for which you are interested to have a temperature gradient.

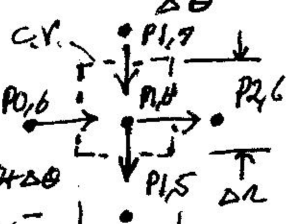
The programing should start at cross section (X.S) "P1" from the outward node "P1,9" and proceed downward to "P1,℄"; repeat the analysis with X.S. "P2" ". "P3" is the center line of the rubber pad thickness and is the last plane to consider at time "θ". Restart the analysis for successive "θ+Δθ" until the longitudinal centerline temperature is reached.

Nomenclature:

$\Delta\theta$ - time interval; ΔL - slice thickness; Δr - radial increment; $\Delta\alpha$ - angular increment;
ΔV - volume increment; T^{θ} & $T^{\theta+\Delta\theta}$ - nodal temperatures at time "θ" & "θ+Δθ"
P0, P1 ... P6 - X.S's numbering system; P0,℄ ... P0,... nodal numbering system at X.S. "P0"; P1,℄ ... P1,... etc. are similar nodal numbers at other planes; $0 \le r \le R$; $0 \le \alpha \le 360$

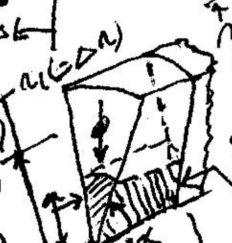
HEAT BALANCE IN TRANSIENT STATE

general equation: $\sum \dot q = \rho \Delta V_{CV} \frac{(T^{\theta+\Delta\theta} - T^{\theta})_{CV}}{\Delta\theta}$; C.V. - control volume
@ each node



Selecting node "P1,6"

$\dot q_{P1,7\to P1,6} + \dot q_{P0,6\to P1,6} - \dot q_{P1,6\to P1,5} -$
$\dot q_{P1,6\to P2,6} = \frac{\rho(r\Delta\alpha\Delta r\Delta L)}{\Delta\theta}(T^{\theta+\Delta\theta}_{P1,6} - T^{\theta}_{P1,6})$

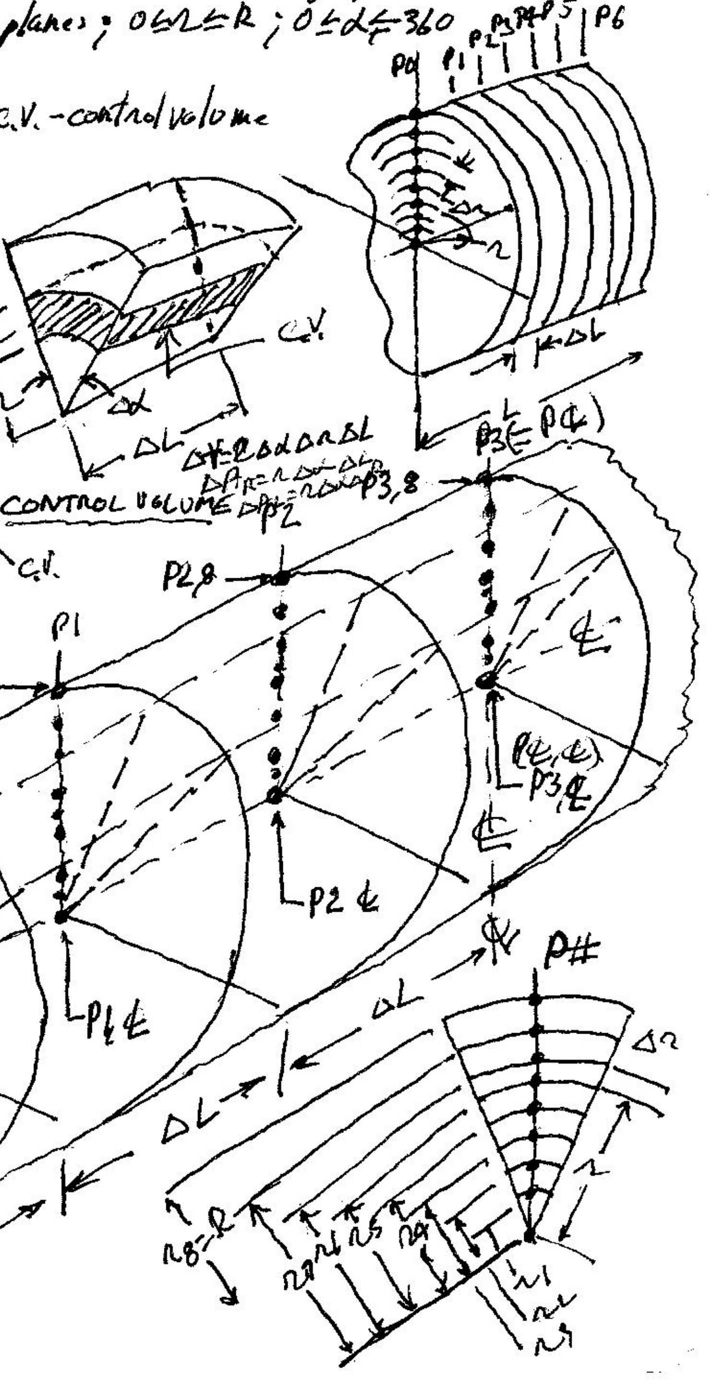


$\dot q_{P1,7\to P1,6} = (k\Delta A_r/\Delta r\Delta\theta)(T^{\theta+\Delta\theta}_{P1,6} - T^{\theta}_{P1,6})$
$\dot q_{P0,6\to P1,6} = (k\Delta A_L/\Delta L\Delta\theta)(T^{\theta+\Delta\theta}_{P1,6} - T^{\theta}_{P1,6})$
$\dot q_{P1,6\to P1,5} = (k\Delta A_r/\Delta r\Delta\theta)(T^{\theta+\Delta\theta}_{P1,6} - T^{\theta}_{P1,6})$
$\dot q_{P1,6\to P2,6} = (k\Delta A_L/\Delta L\Delta\theta)(T^{\theta+\Delta\theta}_{P1,6} - T^{\theta}_{P1,6})$

Solve for $T^{\theta+\Delta\theta}_{P1,6}$ since all other variables are known

Notes: $\Delta A_r = r\Delta\alpha\Delta L$; $\Delta A_L = r\Delta\alpha\Delta r$
w/exceptions at centerline nodes
@ nodes P1,℄, ... P3,℄ (= P℄,℄)
$\Delta A_r = \frac{1}{2} r_1^2 \Delta\alpha$; $\Delta A_L = \frac{1}{2} r_1 \Delta\alpha\Delta L$

@ nodes P3,1 (= P℄,1) ... P3,7 (= P℄,7)
$\Delta A_r = \frac{1}{2}(r\Delta\alpha)(\Delta L)$
$\Delta A_L = \frac{1}{2}(r\Delta\alpha)(\Delta r)$



Final note, increasing the number of ΔL's, Δr's & Δα's improves the accuracy of the centerline temperature profile which you are seeking