A chocolate candy is being extruded onto a conveyor belt to cool before packaging. It initially starts at 150oF and must cool to 75oF to be adequately packaged. The belt length is 100 ft and the speed of the belt is adjustable.

Assume the chocolate is being extruded in a cylindrical shape with radius 0.25 inches with the following properties (assumed to be constant):

Density = 3.7 gm/in3

Heat capacity = 4.26 J/gm-oF

R = 0.25 inch

q

Tinf

To

v

Heat leaves the candy by convective heat transfer, q = h\*A\*(T-Tinf), where A=surface area, h is convective heat transfer coefficient, T(x) is candy temperature, and Tinf is surrounding air temperature (assumed constant). Thermal energy is also transferred axially by conduction. The thermal conductivity is k.

Tinf = 70oF

To = 150oF

h= 0.1 J/in2-oF-min

k=0.7 J/min-in- oF

Using Euler’s method, determine the belt speed (ft/min) required to allow the candy to cool adequately so it can be cut/packaged by the time it reaches the end of the belt.

1. Marketing wants to make a larger radius product. They want to make R= 0.5 in. Can the current system be used to do this? If so, what is the belt speed?

T=150 at t=0

Tinf

q

x

For this problem, the distance traveled (L) equals the velocity\*time (v\*t). Hence, t = L/v, or dt = dL/v (assuming a constant v).

dx

Exposed surface area = 2Rdx

Volume = R2dx

Energy balance: In – Out = Acc

No energy in, so Out = Acc

Out =Q=-h\*area\*(T-Tinf)

Acc = VCp dT/dt

-h\*area\*(T-Tinf) = VCp dT/dt

-h\*2Rdx\*(T-Tinf) = R2dxCp dT/dt

-h\*2\*(T-Tinf) = RCp dT/dt

dT/dt = -2h/RCp (T-Tinf) = /R (T-Tinf)

Plugging in the given parameters, gamma = -0.069 in/min

Using Euler’s method with step sizes 1 and 0.1, give belt speeds of 1.33 ft/min.