Laffy Taffy ® is made as a molten (fluid) candy and run out on a moving belt to cool. It initially starts at 250oF and must cool to 75oF to be adequately cut/handled/packaged. The belt length is 200 ft and the speed of the belt is adjustable.

Assume the Laffy Taffy® is a rectangle (Z x Y) with the following properties (assumed to be constant):

Density = 2.54 gm/in3

Heat capacity = 8.26 J/gm-oF

Y = 1 inch

Z = 0.25 inch

Heat leaves the candy by convective heat transfer, q = h\*A\*(T-Tinf), where A=surface area (top and sides, assume bottom is insulated), h is convective heat transfer coefficient, T(x) is candy temperature, and Tinf is surrounding air temperature (assumed constant). (Note: What is the energy balance assuming the laffy taffy is the system?)

Tinf = 70oF

To = 250oF

h= 0.2 J/in2-oF-min

Using Euler’s method, determine the belt speed (ft/min) required to allow the candy to cool adequately so it can be cut/packaged (T = 75oF) by the time it reaches the end of the belt.

Process picture/diagram

What is occurring in this process? What does the candy temperature look like?

If you were sitting by the conveyer belt at a fixed position (Eulerian perspective], how does the candy temperature change? If you were moving along with the candy [LaGrangian perspective], how does the candy temperature change?

v

z

y

Tinf

q

To

T=250 at t=0

Tinf

q

For this problem, note that time is equivalent to length/velocity.

Hence, for the given length (200 ft) need to figure out the velocity which gives the adequate time to cool.

z

y

dx

Exposed surface area = y\*dx+2z\*dx (top surface and 2sides)

Volume = z\*y\*dx

Energy balance: In – Out = Acc

No energy in, so Out = Acc

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

Acc = m\*Cp\*dT/dt m=density\*volume

-h\*area\*(T-Tinf) = density\*volume\*Cp\*dT/dt

-h\*(y\*dx+2\*z\*dx)\*(T-Tinf) = density\*z\*y\*dx\*Cp\*dT/dt

-h\*(y+2\*z)\*(T-Tinf) = density\*z\*y\*Cp\*dT/dt

dT/dt = [-h\*(y+2\*z)\*(T-Tinf)]/[density\*z\*y\*Cp]= gamma\*(T-Tinf)

Plugging in the given parameters, gamma = -0.057196

Using Euler’s method with step sizes 1 and 0.1, give belt speeds of 3.25 ft/min and 3.19 ft/min, respectively.

Since this ODE has an analytical solution, T(t) = Tinf+(To0Tinf)\*exp(-gamma\*t)

Solving this for t gives a belt speed of 3.19 ft/min.

Solving this using MathCad ODE solver

Alternatively, using an ODE solver from MathCad



















