TECHNICAL SYSTEMS

CONTROL OF THE AREPA TOASTER

1. HEAT TRANSFER

1.1 HEAT CAPACITY OF CORN

$$Cp_{corn\_above\_frezzing\_point} = 0{,}79\frac{BTU}{lb\cdot°F} = 3302\frac{J}{Kg\cdot°C}$$

$$Cp_{corn\_below\_frezzing\_point} = 0{,}42\frac{BTU}{lb\cdot°F} = 1755.6\frac{J}{Kg\cdot°C}$$

Sources:

- http://fairway.ecn.purdue.edu/~lorre/16/presentations/doc/Pilot%20Scale%20Viscosity%20Poster%20LORRE%2028thsym.pdf
- http://trc.ucdavis.edu/jmkrochta/fst50/finals.htm

1.2 HEAT TRANSFERRED INTO THE CORN

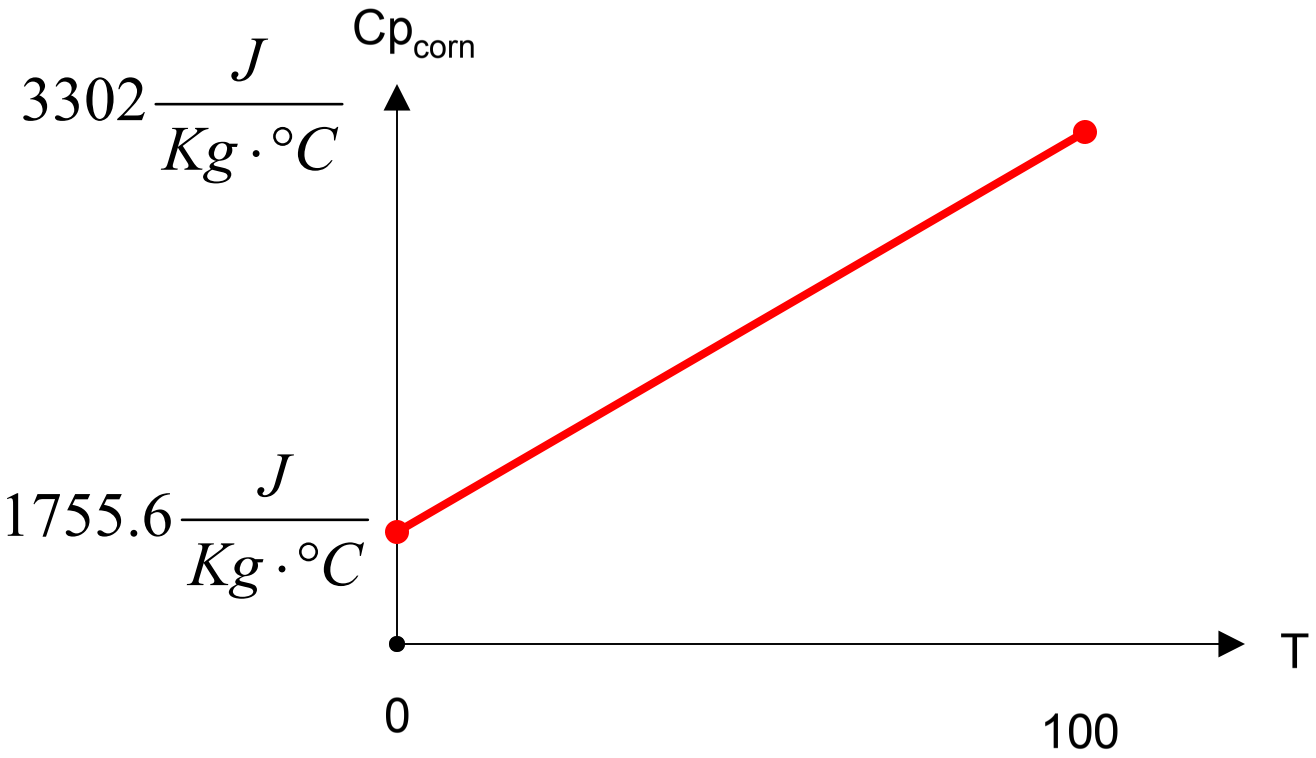
$$Q = \frac{dU}{dt} = m \cdot Cp_{corn} \cdot \frac{dT}{dt}$$

$$dU = m.Cp_{corn} \cdot dT$$

$$\int_{U_0}^{U_f} dU = \int_{T_0}^{T_f} m \cdot Cp_{corn} \cdot dT$$

$$\Delta U = m \int_{T_0}^{T_f} Cp_{corn} \cdot dT$$

Since Cp depends upon temperature, a relationship must be found



Or even easier just to work with an average value

$$Cp_{corn} = 2528.8 \frac{J}{Kg \cdot °C}$$

1.2.1. Density of Corn

$$\rho_{corn} = \frac{61g}{80424mm^3} \cdot \frac{(1000mm)^3}{m^3} \cdot \frac{1Kg}{1000g} = 758\frac{Kg}{m^3}$$

1.2.2. Example for the white arepa

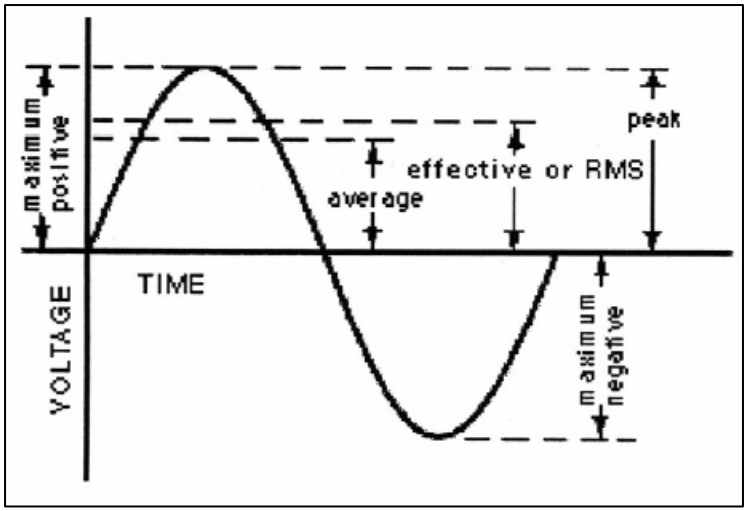
Diameter = 150 mm
Thickness = 5 mm
Volume=8.83E-05
Mass=0,067Kg

$$\Delta U = 0{,}067Kg \cdot 2528{,}8\frac{J}{Kg \cdot °C} \cdot (100 - 22)°C = 13215J$$

Which is the energy needed to heat up an arepa from 22 to 100 Celsius degrees.

2. ELECTRICAL POWER

2.1. Sinusoidal Signals



$$Veff = \frac{V}{\sqrt{2}}$$

rms voltage = 0.707 peak voltage

peak voltage = 1.414 rms voltage

average voltage = 0.637 peak voltage

✓110VAC is actually the RMS value which is usefull for the energy company. But the voltage peak value is 155.55V.

Measuring Tip:

✓When used to measure ac voltages or currents, the multimeter gives you something called the **effective value**, or **rms value**.

✓While using the oscilloscope, it gives the peak to peak value.

Reactive and Resistive Power; Power Factor

With resistors, the voltage and current are always proportional at every moment. When AC currents are applied, the voltage across them and the current that flows through them are in phase. For inductors and capacitors, this is not the case. Inductors and capacitors are fundamentally different from resistors. They can store energy, while resistors dissipate all energy that passes through them. Ideal inductors store and release energy in a magnetic field; ideal capacitors store and release energy in an electric field. The terminal relation between voltage and current in these devices is not proportional – it is derivative.

Physically, the reactive components store and release energy in fields, but don't dissipate it. The internal fields act like springs—over an AC cycle, energy is stored and withdrawn.

2.2 Experiment Results

Arepa	#Pans	I inic Amp	I final Amp	T inic C	T final C	time
Blanca	2	7.5	6.5	22	100	5´
Chócolo	2	7.5	6.5	22	100	3´20”
Queso	2	7.5	6.5	22	80	2´40”

2.3. Characteristics of the resistive material

Resistance (R1)=26Ω
Inductance=????

Vrms=110VAC
I=3,7A

But during the experiment we implemented 2 resistive pans connected in parallel.

$$R_{eq} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{R_1^2}{2R_1} = \frac{R_1}{2} = \frac{26\Omega}{2} = 13\Omega$$

Vrms=110VAC
Iinic=7,5A
Ifinal=6.5A

$$P = \frac{V_{eff}^2}{R} = \frac{(110V)^2}{13\Omega} = 930Watts$$

Since we were using only half of both pans, the power should be considered half as well.

$$P_{1\_PAN} = 465Watts$$

2.4 Time required to toast the white arepa

T=5min=300s

2.5 Total energy dissipated thorugh the resistive material

$$E = 465Watts \cdot 300s = 139615J = 0{,}039KWh$$

2.6 Efficiency of the experiment

$$\eta = \frac{E_{out}}{E_{in}} = \frac{13215J}{139615J} = 9{,}4\%$$

Therefore if we finally embed the resistive material within isolating material, we can finally reduce the losses due to unwanted convection and radiation.

Let´s set a goal of at least 60% of efficiency!

3. TEMPERATURE SENSOR

http://catalog.sensing.honeywell.com/vsg_compare.asp?FAM=TemperatureSG&ITEMLIST=281190,281194,281191,281192,281193,281195