**Thermal energy, $W_{th}$**

$W_{th} = mc\,\Delta T$

m = mass

C = specific heat capacity is the heat required to rise the temperature of 1 Kg of substance by 1 degree (J/Kg.K)

Example: Owing to a short circuit, a copper conductor having a cross sectional area of 25 $mm^2$ carries current of 20000 A for 30 milliseconds. Neglectting heat loss, calculate the temperature rise of the conductor. Assume the specific heat capacity of copper to be 390 J/Kg.k, density to be 8900 Kg/$m^3$ and resistivity to be 0.018 μΩm.

Solution: since heat loss neglected, then all the electric power or electric energy is converted to thermal energy i.e. $W_e = W_{th}$

$W_e = P.t = I^2R\,t$, $W_{th} = mc\,\Delta T$

The volume of conductor, V = A.L

$W_e = W_{th}$

$I^2R\,t = mc\,\Delta T$

$I^2\,\rho\frac{L}{A}t = \rho_d\,Vc\,\Delta T$

Where $\rho_d$ is the density

$I^2\,\rho\frac{L}{A}t = \rho_d\,A.L\,c\,\Delta T$

$\Delta T = \frac{i2\,\rho t}{A2\,\rho d\,c} = \frac{2(20\,000)2*0.18*10-6*30*10-3}{(25*10-6)2*8900.390} = 0.216/2.169*10^{-3} = 99.585$ K

**POWER**

the term power is applied to provide an indication of how much work (energy conversion) can be accomplished in a specified amount of time; that is, power is a rate of doing work.

1 watt (W) = 1 joule/second (J/s)

$$P = \frac{W}{t} \quad \text{(watts, W, or joules/second, J/s)}$$

with the energy (W) measured in joules and the time t in seconds

1 horsepower ≅ 746 watts

P = Fu

P = ωT

$$P = \frac{W}{t} = \frac{QV}{t} = V\frac{Q}{t}$$

But $$I = \frac{Q}{t}$$

so that $$P = VI \quad \text{(watts, W)}$$

By direct substitution of Ohm's law, the equation for power can be obtained in two other forms:

$$P = VI = V\left(\frac{V}{R}\right)$$

and $$P = \frac{V^2}{R} \qquad \text{(watts, W)}$$

or $$P = VI = (IR)I$$

and $$P = I^2R \qquad \text{(watts, W)}$$

The power supplied by a battery can be determined by $$P = EI \qquad \text{(watts, W)}$$

The importance of Eq. above cannot be overstated. It clearly states the following: The power associated with any supply is not simply a function of the supply voltage. It is determined by the product of the supply voltage and its maximum current rating.

ENERGY

For power, which is the rate of doing work, to produce an energy conversion of any form, it must be used over a period of time.

Since power is measured in watts (or joules per second) and time in seconds, the unit of energy is the wattsecond or joule (note Fig. 15). The wattsecond, however, is too small a quantity for most practical purposes, so the watthour (Wh) and the kilowatthour (kWh) are defined, as follows:

$$\text{Energy (Wh)} = \text{power (W)} \times \text{time (h)}$$

$$\text{Energy (kWh)} = \frac{\text{power (W)} \times \text{time (h)}}{1000}$$

consider that 1 kWh is the energy dissipated by a 100 W bulb in 10 h

**The kilowatthour** meter is an instrument for measuring the energy supplied to the residential or commercial user of electricity

**EXAMPLE 14** What is the total cost of using all of the following at 11¢ per kilowatthour?

A 1200 W toaster for 30 min
Six 50 W bulbs for 4 h
A 500 W washing machine for 45 min
A 4300 W electric clothes dryer for 20 min
An 80 W PC for 6 h

***Solution:***

$$W = \frac{(1200\text{ W})(\frac{1}{2}\text{ h}) + (6)(50\text{ W})(4\text{ h}) + (500\text{ W})(\frac{3}{4}\text{ h}) + (4300\text{ W})(\frac{1}{3}\text{ h}) + (80\text{ W})(6\text{ h})}{1000}$$

$$= \frac{600\text{ Wh} + 1200\text{ Wh} + 375\text{ Wh} + 1433\text{ Wh} + 480\text{ Wh}}{1000} = \frac{4088\text{ Wh}}{1000}$$

$$W = 4.09\text{ kWh}$$

$$\text{Cost} = (4.09\text{ kWh})(11¢/\text{kWh}) \cong \mathbf{45¢}$$

## EFFICIENCY

Energy input = energy output + energy lost or stored by the system

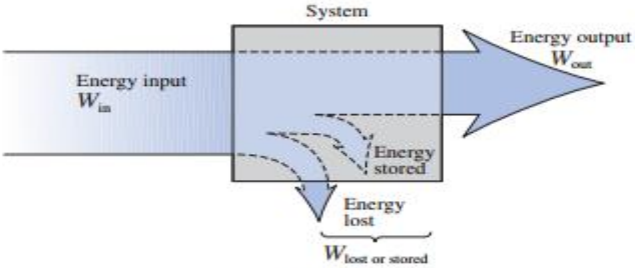



**FIG. 18**
*Energy flow through a system.*

Dividing both sides of the relationship by $t$ gives

$$\frac{W_{in}}{t} = \frac{W_{out}}{t} + \frac{W_{\text{lost or stored by the system}}}{t}$$

Since $P = W/t$, we have the following:

$$P_i = P_o + P_{\text{lost or stored}} \quad \text{(W)}$$

The **efficiency** ($\eta$) of the system is then determined by the following equation:

$$\text{Efficiency} = \frac{\text{power output}}{\text{power input}} \quad \text{and} \quad \eta = \frac{P_o}{P_i} \quad \text{(decimal number)}$$

where $\eta$ (the lowercase Greek letter *eta*) is a decimal number. Expressed as a percentage,

$$\eta\% = \frac{P_o}{P_i} \times 100\% \quad \text{(persent)}$$

In terms of the input and output energy, the efficiency in percent is given by

$$\eta\% = \frac{W_o}{W_i} \times 100\% \quad \text{(persent)}$$

$$\eta_1 = \frac{P_{o_1}}{P_{i_1}} \qquad \eta_2 = \frac{P_{o_2}}{P_{i_2}} \qquad \eta_3 = \frac{P_{o_3}}{P_{i_3}}$$

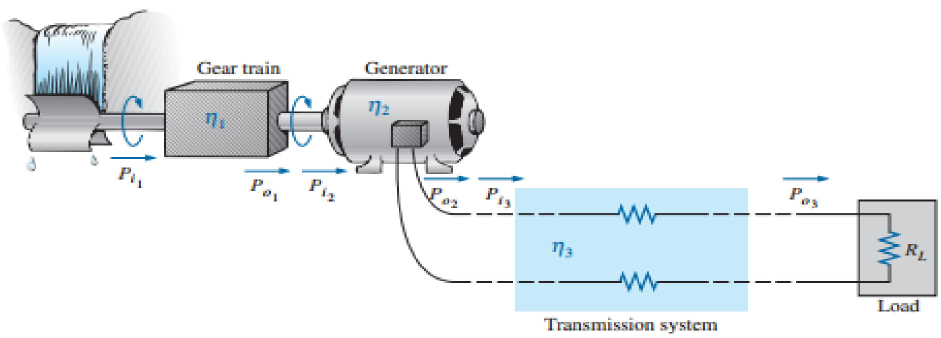
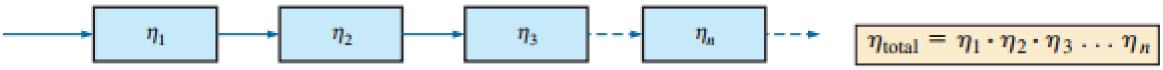



**FIG. 19**
*Basic components of a generating system.*

If we form the product of these three efficiencies,

$$\eta_1 \cdot \eta_2 \cdot \eta_3 = \frac{\cancel{P_{o_1}}}{P_{i_1}} \cdot \frac{\cancel{P_{o_2}}}{\cancel{P_{i_2}}} \cdot \frac{\cancel{P_{o_3}}}{\cancel{P_{i_3}}} = \frac{P_{o_3}}{P_{i_1}}$$

and substitute the fact that $p_{i2}=p_{01}$ and $p_{i3}= p_{o2}$, we find that the quantities indicated above will cancel, resulting in $p_{o3}/p_{i1}$ , which is a measure of the efficiency of the entire system.




Q1: A hydro-electric generating plant is supplied from a reservoir of capacity $20*10^6$ $m^3$ with ahead of 200m. The hydraulic efficiency of the plant is 0.8 and the electric efficiency is 0.9. what is the total available energy ?

Q2: A hydro-electric generating plant is supplied from a reservoir has ahead of 200m. The hydraulic efficiency of the plant is 0.8 and the electric efficiency is 0.9. The plant supplies a load of 12 MW for 4 hours. Calculate the fall in the level of the reservoir during this period if the area of the reservoir is $3Km^2$.

Q3: the reservoir in the previous problem is a supplied by a river at the rate of 2m3/sec. Assuming constant head efficiency, what does this flow represent in terms of mega watts, mega watt hours per day and giga watt hours per annum?

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