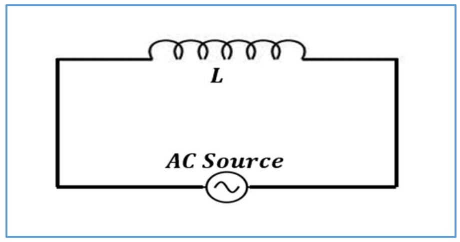
Energy Stored in an Inductor (coil):

Let us consider an inductor of inductance (L) is connected with an AC source as shown in the figure. When changing current passes through the coil, the magnetic flux linked with the coil changes which ultimately results in the induction of emf in the coil.



The induced emf can be written as,

$$\varepsilon = L\frac{dI}{dt} ------ (1) \text{ (magnitude)}$$

Let I be the instantaneous value of current flowing through the inductor. The instantaneous power developed in the inductor is,

i.e. $$P = I\varepsilon$$

$$or, P = IL\frac{dI}{dt} -------- (2)$$

Let dW be the small work done in time dt, i.e.

$$or, dW = Pdt$$

$$or, dW = IL\frac{dI}{dt}dt$$

$$or, dW = ILdI ------(3)$$

Now, the total amount of work done on increasing the current from $0 \; to \; I_0$ can be obtained by integrating equation (3) from limit $0 \; to \; I_0$.

i.e. $$W = \int_0^{I_0} dW = \int_0^{I_0} ILdI$$

$$or, W = \int_0^{I_0} ILdI$$

$$or, W = L\int_0^{I_0} IdI$$

$$or, W = L\left[\frac{I^2}{2}\right]_0^{I_0}$$

$$or, W = \frac{1}{2}LI_0^{\,2} -------- (4)$$

This work done is stored as energy in the inductor (coil) in the form of potential energy and used to set up a magnetic field around the coil.

Therefore, Energy stored in an Inductor is,

$$\boldsymbol{U = \frac{1}{2}LI_0^{\,2}}$$

Note:

1. The energy stored in inductor in magnetic field $[U = \frac{1}{2}LI_0^{\,2}]$ is similar to the energy stored in capacitor in electric field $[U = \frac{1}{2}CV^2]$. In both cases, work is to be done to establish the field.
2. In a pure inductor (ideal inductor) where there is no resistance the energy is conserved without any dissipation in other form of energy.
3. When the current decreases from I_0 to 0 then same amount of energy is released and flows to the external circuit.
4. Where there is no current, the energy stored is zero.