Losses in a Transformer

An ideal transformer is the one which is 100% efficient. This means that the power supplied at the input terminal should be exactly equal to the power supplied at the output terminal, since efficiency can only be 100% if the output power is equal to the input power with zero energy losses. But in reality, nothing in this universe is ever ideal. Similarly, since the output power of a transformer is never exactly equal to the input power, due a number of electrical losses inside the core and windings of the transformer, so we never get to see a 100% efficient transformer. Transformer is a static device, i.e. we do not get to see any movements in its parts, so no mechanical losses exist in the transformer and only electrical losses are observed. So there are two primary types of electrical losses in the transformer:

1. Copper losses
2. **Iron losses**

Other than these, some small amount of power losses in the form of 'stray losses' are also observed, which are produced due to the leakage of magnetic flux.

Copper losses

These losses occur in the windings of the transformer when heat is dissipated due to the current passing through the windings and the internal resistance offered by the windings. So these are also known as ohmic losses or I2R losses, where 'I' is the current passing through the windings and R is the internal resistance of the windings.

These losses are present both in the primary and secondary windings of the transformer and depend upon the load attached across the secondary windings since the current varies with the variation in the load, so these are variable losses.

Mathematically, these copper losses can be defined as:

$$P_{ohmic} = I_pR_p + I_sR_s$$

Iron losses

These losses occur in the core of the transformer and are generated due to the variations in the flux. These losses depend upon the magnetic properties of the materials which are present in the core, so they are also known as iron losses, as the core of the Transformer is made up of iron. And since they do not change like the load, so these losses are also constant.

There are two types of Iron losses in the transformer:

1. Eddy Current losses
2. **Hysteresis Loss**

Eddy Current Losses

When an alternating current is supplied to the primary windings of the transformer, it generates an alternating magnetic flux in the winding which is then induced in the secondary winding also through Faraday's law of electromagnetic induction, and is then transferred to the externally connected load. During this process, the other conduction materials of which the core is composed of; also gets linked with this flux and an emf is induced.

But this magnetic flux does not contribute anything towards the externally connected load or the output power and is dissipated in the form of heat energy. So such losses are called Eddy Current losses and are mathematically expressed as:

$$P_e = K_e f^2 K_f^2 B_m^2$$

Where;

- K_e = Constant of Eddy Current
- K_f^2 = Form Constant
- B_m = Strength of Magnetic Field

Hysteresis Loss

Hysteresis loss is defined as the electrical energy which is required to realign the domains of the ferromagnetic material which is present in the core of the transformer.

These domains loose their alignment when an alternating current is supplied to the primary windings of the transformer and the emf is induced in the ferromagnetic material of the core which disturbs the alignment of the domains and afterwards they do not realign properly. For their proper realignment, some external energy supply, usually in the form of current is required. This extra energy is known as Hysteresis loss.

Mathematically, they can be defined as;

$$>P_h = K_h B_m^{1.6} fV$$

These are the different kinds of losses happened to occur in transformer and an electrical engineer must take care of their losses and try to reduce them as low as possible.

Transformer has two states of operations, one is without load and the other is with load. Most of these errors appear when the load is applied on the transformer.

Source: http://engineering.electrical-equipment.org/electrical-distribution/losses-in-a-transformer.html