## 4.9 POWER FACTOR OF CABLE

If the temperature continues to increase, the cable insulation will be damaged. a length of 6 km. The cable is operated at 60 Hz and 7.2 kV. The dielectric constant is 3.5, the dielectric power factor is 0.03 ($\delta = Cos\phi_d$) and dielectric resistivity of the insulation is $1.3x10^7$ MΩ.cm

### 4.9.1 HEATING OF CABLE

The temperature rise of cable depends on the following factors:

1. The production of heat within the external periphery of the cable.

2. The conveyance of the heat as far as the periphery - that is, up to the boundary of the surrounding medium.

3. The conveyance of the heat through this medium, and therefore away from the cable.

4. The current rating of the cables.

5. The nature of the load, i.e. whether continuous or intermittent; not infrequently the rating under short-circuit conditions has to be considered.

**Heat generation in cable**

Following are the sources of heat generation in the cable

a) $I^2R$ losses in the conductors

b) Dielectric losses in the cable insulation

c) Sheath and armour loss

**a) $I^2R$ losses in the conductors**

Copper loss is the term often given to heat produced by electrical currents in the conductors, or other electrical devices. Copper losses are an undesirable transfer of energy, as are core losses, which result from induced currents in adjacent components.

The term is applied regardless of whether the windings are made of copper or another conductor, such as aluminium.

Resistance of conductor at an temperature of 70 deg. C (assumed) is determined from the resistance given in standard table (usually at 20 deg,C) from the following relation-

$R_h = Ra(1+\alpha\ (70-20))$

Where $R_h$, $R_a$ are the hot resistance, resistance at 20deg.C.

**b) Dielectric losses in the cable insulation**

The energy losses occurring in the dielectric of cables are due to leakage and so called dielectric hysteresis.

The charging current of cable $I_c$ is assumed to have two components –

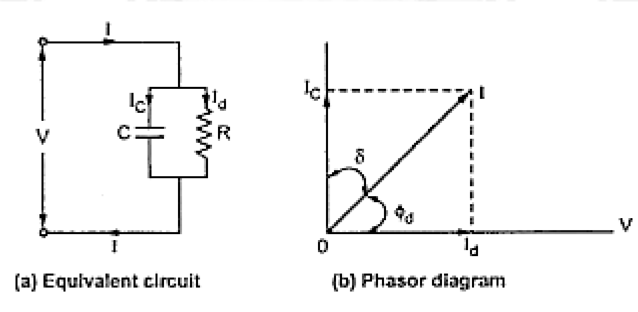


**Figure 4.2.1 Belted Cable**

*[Source: https://bralpowerassociate.blogspot.com/2013/11/heating-in-cable.html*

One being true capacitance current which is equal to ωC V and leads the applied voltage by 90deg.

· The other being the energy component which in phase with the applied voltage and represents the dielectric loss components of current.

If V is the applied voltage, C is the capacitance, of cable, Φ is the phase angle between voltage and current called the power factor of the cable and δ is the loss angle of the dielectric,

Charging current, $I_c = V/X_c = \omega C\ V$

The dielectric loss, due to leakage and hysteresis effects in the dielectric, is usually expressed in terms of the loss angle, $\delta$:

$\delta = 90 - \varphi$

Where, $\varphi$ is the dielectric power factor angle.

Dielectric loss $= \omega C V^2 \tan\delta$,

Where,

C= capacitance to neutral

V= phase voltage

A typical value of $\tan\delta$ lies in the range 0.002 to 0.003. In low voltage cables the dielectric loss is negligible, but is appreciable in EHV cables.

**c) Sheath loss**

In 3 core cable the effect is negligible but for single core cable the effect is of great importance. The electromagnetic fields produced by the current flowing through the conductors induce emfs in sheath and under certain condition heavy currents are set up therein. The actual current flowing along the sheath depends magnitude and frequency of the current in the conductor, the arrangement and spacing between the cables. Two different cables having sheath electrically connected are bounded or unbounded. The induced sheath currents are of two types-

i) The currents, which have both outward and inward directions, called the sheath eddies.

ii) The currents, which have outward and inward current path in separate sheath called the sheath circuit eddies.

The approximate formulae for eddy loss for unbounded cables given by Arnold is as under-

$$Sheath\ loss = I^2\left[\frac{78\omega^2}{R_s}\left(\frac{r}{d}\right)^2 \times 10^{-9}\right] watts/phase$$

Where,

I = current per conductor,

r = mean radius of sheath,

d=inter axial spacing of conductors

$R_s$ = sheath resistance in ohm