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Power consumed in Delta Connection

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Abstract- The power consumed in delta connected load is considered as √3/ V_L. I_L with power factor as unity. The power measured by the watt meter also confirms this value. But analysis indicate that the power consumed by a load in delta connection is 18.75% more than what is normally believed. This unaccounted power may be getting unknowingly booked to reduce efficiencies of loads and systems.

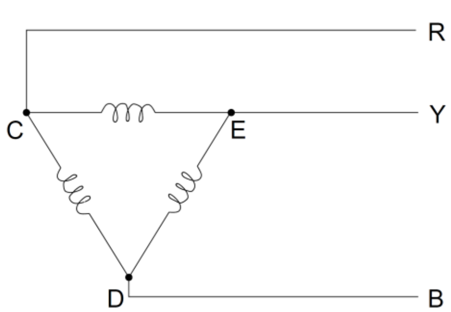
Index Terms- Delta connection, rms current, heat generation.

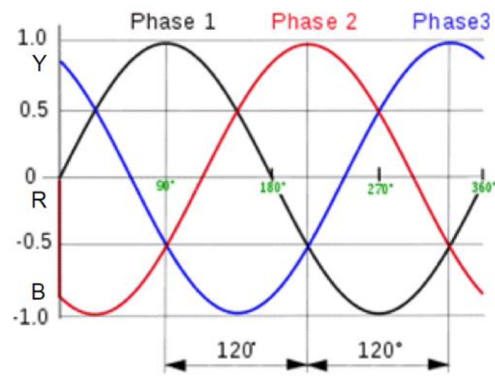
I. Introduction

In addition, the published research work also provides a big weight-age to get admissions in reputed varsity. Now, here we enlist the proven steps to publish the research paper in a journal. The three phase system can be considered as consisting of branches carrying positive and a negative currents. As per the Kirchhoff's law, the sum of all the currents in a circuit should be always zero. It means that the positive and the negative currents will be always equal. When one line is conducting a positive current, second line alone or along with third line will carry return current to the generating station. From the following analysis, it will be seen that current carried by a phase of a load is $\frac{\sqrt{3}}{2}$ I for 0 to $\frac{2\pi}{3}$ and zero from $\frac{2\pi}{3}$ to π . This gives higher heat generation than the normally assumed.

The current in delta connection is assumed to be $\frac{1}{\sqrt{3}}$ of line current. The power consumed by delta connected load is worked out accordingly and is considered as √3 / V_L. I_L cos ϕ …… where V_L, I_L & cos ϕ have their usual meaning but the following analysis gives a different result.

In the delta system, the phase voltage is same as line voltage and the phase current is $\frac{1}{\sqrt{3}}$ of line current, I





Consider phase R, Y & B connected to a delta load. The flow of current can be understood from the behavior of d.c. When the current in R phase starts flowing from 0, Y is positive and equal to $\frac{\sqrt{3}}{2}$ I or 0.866I and B, ahead of R by 240°, is negative with value equivalent to $-\frac{\sqrt{3}}{2}$ I or - 0.866I. The current of R phase will find a return path via phase B up to 60° when Y will be zero and change its sign. From 60° to 120° the current of phase R will be shared by phases Y & B and the current of phase R after 120° will be totally carried by phase Y. The return line current of phase R after 60° will get divided as phase currents in phase Y & B.

As far as phase CD of load is concerned, the current flows as a sine wave from the phase 'R' up to 60°. Thereafter from 60° to 120° will follow Sine wave corresponding to phase B.

II. Current Flow

1. The rms current flowing through phase CD up to 60° is worked out as under:-

$$i = I \sin\theta$$

$$I_{rms}^2 = \frac{I^2}{\pi/3}\int_0^{\frac{\pi}{3}} Sin^2\theta.d\theta$$

$$= \frac{I^2}{\pi/3}\left[\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right]_0^{\pi/3}$$

$$= \frac{I^2}{\pi/3}\left[\frac{\pi/3}{2} - \frac{\sin 2\pi/3}{4}\right]$$

$$I_{rms}^2 = 0.29I^2$$

$$I_{rms} = 0.54\ I \qquad \text{…………… (1)}$$

2. RMS current from 60° to 120°

$$= I^2 \int_{\pi/3}^{2\pi/3} sin^2(\theta + 240)\, d\theta$$

$$= \left[\frac{\theta + {}^{2\pi}/_{3}}{2} - \frac{\sin 2\theta\,(\theta + {}^{2\pi}/_{3})}{4}\right]_{\pi/3}^{2\pi/3}$$

$I_{rms}{}^{2} = 0.29I^2$

$I_{rms} = 0.54$ I same as in (1) above

3. No current will flow in phase CD from ${}^{2\pi}/_{3}$ to π
   i. The heat generated in the half cycle, current flowing for ${}^{2}/_{3}$ rd of the time.

$= (0.54)^2.I^2.r \times (2/3)$/phase

$= 0.19\ I^2.r$ ……'I' is the peak current & 'r' is resistance per phase.

   ii. Conventional heat generation:-

'I' & 'r' have the same meaning as above.

$I_{rms} = \frac{I}{\sqrt{2}}$

I phase $= \frac{Irms}{\sqrt{3}}$

$= \frac{I}{\sqrt{2}.\sqrt{3}} = \frac{I}{\sqrt{6}}$

$= 0.4$ I

Heat generated in half cycle $= (0.4)^2.\ I^2\ .r$

$= 0.16\ I^2\ .r$

The heat generated is $0.19I^2$ .r as against $0.16\ I^2$ .r conventionally assumed. The heat generation is thus 18.75% more than normally assumed.

III. Measurement of Quantities

For measuring a current or voltage, an instrument peaks up the peak value of the alternating quantity. This value corresponds to the full scale deflection.

The maximum current the phase of load is $\frac{\sqrt{3}}{2}$ of the peak line current which is the value of sin 60 ^{0}.

The rms value corresponding ot this value is $\frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{2}}$

This current flows for ${}^{2}/_{3}$ rd of the half cycle.

∴ The current recorded will be $\frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{2}} \times \frac{2}{3}$ of IL

$\frac{1}{\sqrt{3}\ \sqrt{2}}$ of IL or 0.4 IL

The measured current in phase will be 0.4I and the actual current will be 0.369 I.

0.369 I is ${}^{2}/_{3}$ rd of 0.54I. The difference being small does not get noticed. But the difference in power consumed and power measured is substantial. The unaccounted power would get accounted as loss as T& D loss or loss in machines. Recognisation of this difference will benefit the utility providers, designers and users equally.

IV. Conclusion

The relationship of phase current equals to $\frac{1}{\sqrt{3}}$ of line current in delta connection needs a revisit. The power consumed in delta configuration is 18.75% more than what is normally assumed.

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