EFFECT OF UNBALANCED VOLTAGES ON INDUCTION MOTOR OPERATION :

It is well known that unbalanced line voltages when applied to a polyphase induction motor, will adversely affect its operation. There will be unbalanced currents in the motor accompanied by a decrease in available torque and efficiency and an increase in slip, vibration , noise and motor heat losses. The presence of even a small unbalance in the line voltages will cause a disproportionately large unbalance in the line currents which unless guarded against by a relay, might lead to serious overheating or and damage to the winding.

The effect of applying unbalanced voltages is equivalent to the superposition of negative sequence voltage on the positive sequence voltage. The presence of a small negative sequence voltage will cause a large negative sequence current to flow in the machine because at the stator terminals, the input admittance of the machine for negative sequence current is very large compared to that for positive sequence current. The ratio of the negative to positive sequence admittance depends on the type of rotor.

Considering the heating in the stator, the negative and positive sequence currents will produce the same amount of heating per ampere, because the resistance of the stator winding is the same for both namely, the resistance at normal supply frequency. The heating caused by negative sequence current in the stator is quite considerable even with a small amount of negative sequence voltage.

In the rotor much more heat per ampere is caused by negative than by positive sequence current. This is because the rotor resistance to negative sequence current is much higher than that offered to the positive sequence current. The former is the resistance at approximately twice the supply frequency while the latter is the resistance at slip frequency. The ratio of these two resistances depends on whether the rotor is single cage or double cage. Further, the ratio of rotor to stator current is higher for negative than for positive sequence. Therefore, the increased heating caused by the former in the rotor is large in comparison with that caused in the stator. However, due to good conduction of heat and ventilation prevailing in a cage rotor, this increased heating may not be injurious. The conditions in the stator are not so favourable because of the insulation. The extra heating by negative sequence currents leads to uneven partial distribution of heat and, consequently, to high temperatures and hot spots. Hence, in the presence of unbalanced voltages, the load on the motor must be reduced below the rated load so as to limit the temperature rise to the normal value. If unbalanced line voltages are likely to persist indefinitely or permanently, the use of overrated motors then becomes necessary, the degree of overrating depending upon the severity of unbalance.

It is worthwhile to reproduce here an extract from NEMA (US) Standard MG 1-14.33 regarding the effects of unbalanced voltages on the performance of polyphase motors.

Extract from NEMA (US) Standard MG 1-14.33: When line voltages applied to a polyphase induction motor are not exactly the same., unbalanced currents will flow in the stator winding, the magnitude depending upon the amount of unbalance. A small amount of voltage unbalance may increase the current to an excessive amount. To avoid possible damage to the motor or depreciation in operating characteristics, the supplier of power should be notified of such unbalance in order that the situation can be corrected.

The voltages should be evenly balanced as closely as can be read on the usually available commercial voltmeter.

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