PRODUCT INFORMATION

If the heat transfer from the center of the transformer is restricted, then the internal temperature will be hotter than the exterior and will seriously effect the efficiency, regulation and power rating. It is apparent then that any transformer design that reduces the rate of heat generation and/or increases the rate of heat transfer can result in:

- A unit that is smaller and lighter with the same ratings.
- A unit that has the same size and rating but a lower operating temperature.
- A unit that is the same size, operates at the same temperature, but can have a higher rating.
- A combination of any of the above.

Referring to Figure1A, consider the same initial current flowing in each turn of the coil, and each turn starting with the same resistance, and that an equal amount of heat will be initially generated by each turn. Since all of the heat generated must make its way to the outer surface of the coil before it can be dissipated, a temperature gradient starting from the outside turn (the coolest) to the center turn (the hottest) is immediately established. Further, the temperature of this central inside turn will be very high since the path the heat must travel to get to the coil surface is through many layers of wire insulation which in themselves are very poor thermal conductors.

To further complicate the situation, the resistance of each turn of wire will now increase slightly due to its increased temperature. This in turn will increase the heat generated and this cycle will repeat until a temperature stabilization level for each turn is reached.

Analysis of Figure 1B shows the unique advantage that a foil-wound unit has relative to the problem of dissipating the generated heat. Each turn extending the full width of the coil has two edges in contact with the surrounding air. The tremendous advantage of the solid metal conducting path that each turn has for getting the heat directly to the outer surface of the coil is very apparent. The net result for an aluminum foil design, even with its higher resistivity figure (and consequently more heat generated per unit increment), is a sharply reduced temperature gradient from the outside to the center of the coil.

Thus, in the example described, the use of the aluminum foil winding is such that there is a smaller percentage of increase in the resistance from no-load to full-load (high I^2R) than with a wire wound coil. This then reduces the need for the aluminum foil to have the same conductivity of the copper wire to produce the same results.

A third advantage of the foil wound transformer is the voltage stress between adjacent turns. In the wire wound unit, the insulation on the wire must withstand a higher voltage gradient than the foil insulation. For instance, assume both coils in Figure 1 to be made of 100 turns with 500 volts on the coil. Then, each coil will have a 5-volt drop per turn. In the continuous wound wire coil, turn number 20 is in direct contact with turn number 1 and therefore, the insulation must be capable of withstanding 100 volts. If the coil was random wound, the actual voltage difference between adjacent turns can be in the order of several hundreds of volts. This could not only cause dielectric breakdown but also corona degradation. In the foil wound unit (Figure 1B), each turn is only 5-volt different from its next turn and can never be more than 5 volts between any two turns.

One further advantage occurs in the mechanical strength of the foil unit. Abrupt electrical stresses or mechanical vibrations and shock can cause the wire wound coils to fail because of the friction and abrasion between turns unless solidly cast in an epoxy resin. The expansion and contraction of the foil wound unit, because of mechanical or electrical extremes, causes no movement between the turns, thus eliminating any degradation.

SUMMARY

The design of any transformer is a compromise wherein the designer can optimize for one of many characteristics at the expense of the others. Designing for minimum weight will up the operating temperature and lower the efficiency and regulation. However, the judicious use of foil can produce a lightweight transformer without compromise of the other characteristics.

electrocube®
1307 S. Myrtle Avenue • Monrovia, CA 91016
TEL: (800) 515-1112 • FAX: (626) 357-8099
www.electrocube.com