

Figure 1

The use of strip foil conductors in large, high power transformers, to replace the conventional round or rectangular magnet, wire has been commonplace for many years. Technical problems, however, had not encouraged the use of foils in small transformers.

For example, the principal advantage to using aluminum foil rather than copper in transformers is the reduction in weight. The density of copper is .32117 lbs. per cubic inch while that of aluminum is .09765 lbs. per cubic inch. For a given winding volume, the aluminum winding would weigh one-third the weight of the copper. However, aluminum has only 60% the conductivity of copper. If the winding volume is increased by 40% to raise the aluminum conductivity to that of copper, it still leaves the aluminum coil weighing only 42% of the equivalent copper coil.

Unfortunately, one cannot simply increase the winding volume of a transformer to make use of the aluminum foil. Increasing the winding volume or area necessitates increasing the magnetic path length and, therefore, the amount of magnetic material used. The physical geometry changes; the core losses change; the efficiency, regulation and temperature rise all change, thus making the change from copper to aluminum a fairly complex operation.

By suitable design techniques, the problems indicated above can be obviated. First, consider the space factor. The most efficient use of winding space is to layer wrap using magnet wire as shown in Figure 1A. Depending upon the size of the wire used, there is a percentage of the winding area which cannot be used for the conductors.

This lost area is made up of the space between the wires and the insulation with which each wire is coated.

As the voltage stress of the winding is increased, it is often necessary to add inter-layer insulation creating more lost space, thus decreasing the available conductor area. The foil-wound coil illustrated in Figure 1B can be designed to make optimum use of the available winding area. Each turn of the foil extends edge-to-edge of the coil and is separated from the next turn by one thickness of insulation. There is no lost winding space which means that foil with the same circular mil area as wire will fit into a smaller winding area, or conversely, more circular mils of foil may be wound into the same winding area.

Secondly, consider the operating temperature of the transformer which effects its rating, efficiency and voltage regulation. The allowable operating temperature is the major factor in determining the size, weight and performance of a transformer. As in any other electrical device, current flowing through the resistance of the coil wire results in heat generation. This generated heat plus the losses associated with the magnetic material will cause an increase in temperature. How high the temperature will rise depends on how much and how fast the heat is generated and also how fast and efficiently this heat is wholly or partially removed. Figure 2 shows to what surface temperature a black body would rise above ambient as a function of watts power square inch of surface area of heat being dissipated into still air. The assumption is that all internal losses appear at the surface to be radiated to the ambient air.

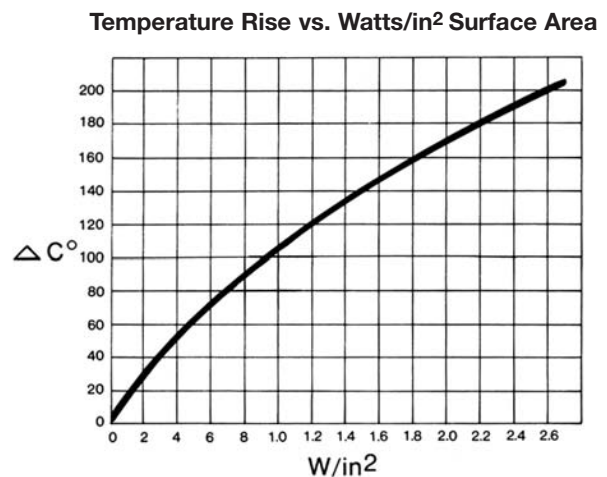


Figure 2