

The calculated densities for a redesign will not always be near the values given in Table 18.1. If they are too high, a high-temperature insulation system can be used (refer to Pages 42 - 45) or the motor must be weakened. If they are low, the motor may be strengthened. To strengthen or weaken a motor, however, it is not necessary to go through the long flux-per-pole and density calculations again. The proper number of turns can be calculated more quickly using the ratio (short) method. Of course, strengthening or weakening the motor will change the rated output power.

The three density formulas are:

$$\text{Air-gap density} = \frac{1.57 \times \text{flux per pole} \times \text{poles}}{\text{air-gap area}}$$

$$\text{Tooth density} = \frac{1.57 \times \text{flux per pole} \times \text{poles}}{\text{tooth area}}$$

$$\text{Back-iron density} = \frac{\text{flux per pole}}{2 \times \text{back-iron area}}$$

These formulas show that when redesigning a given core for a given number of poles and one or more of the densities is too high or too low, the only way to change the density is to change the flux per pole. The density will vary in direct proportion to the change in the flux.

The formula for calculating flux per pole is:

$$\text{Flux per pole} = \frac{22,500,000 \times \text{phase voltage} \times \text{phases} \times \text{circuits}}{\text{frequency} \times \text{turns per coil} \times \text{coils} \times \text{dist. fact} \times \text{chord fact.}}$$

If the connection, circuits and span are not changed, the flux per pole will vary inversely in proportion to the change in number of turns. As the turns increase, the flux per pole decreases. As the turns decrease, the flux per pole increases. Therefore, since the densities vary in direct proportion to a change in flux, and the flux varies inversely as the number of turns change, the densities will vary inversely as the turns change.

$$\text{New calculated densities} = \frac{\text{original calculated densities} \times \text{original calculated turns}}{\text{new calculated turns}}$$

It is not necessary to calculate the new value of the flux per pole. Simply multiply the densities by the inverse ratio of the turns change. The output power will vary by the square of the inverse ratio of the turns change.

$$\text{Recalculated output} = \text{calculated output} \times \left(\frac{\text{original calculated turns}}{\text{new calculated turns}} \right)^2$$

For high densities, take the one *furthest* away from the recommended value and add turns until a desirable value is reached. For low densities, start with the one *closest* to the recommended value and reduce the turns. After arriving at the proper number of turns, recalculate the other two densities and the rated output power.

The above is an excerpt from EASA's AC Motor Design.

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