Chapter 8
Performance of DC Machines

ABSTRACT

In this chapter, the authors provide an overview of the issues related to losses and efficiency of D.C. machines. Speed control is then discussed. Solid state speed control is discussed afterwards. Speed Control using thyirstors. After finishing the discussion on speed control, the authors discuss braking DC motor, regenerative braking, dynamic braking, and finally this chapter concludes with plug braking.

8.1 LOSSES AND EFFICIENCY OF DC MACHINES

The losses in rotating electric machines may be classified as

1. Electric losses
2. Rotational losses

The electric losses in d.c. machines (motor as well generator) include I^2 R losses in the field circuits and the armature circuits, while rotational losses include windage, friction plus brush friction losses and stray load losses.

The stray load losses result from the load and cannot be measured directly. These include eddy current and hysteresis losses.

The rotational losses are also called no-load losses and can be determined by no-load tests.

Efficiency is defined as the ratio of the useful output to the input, and the expression preferred for calculations of efficiency as:

$$\text{Efficiency} = 1 - \frac{\text{Losses}}{\text{input}}$$

If the losses are know for a given output, the input is the sum of the losses and the output and the efficiency can be calculated to a high degree of accuracy even if there are small errors in the losses. The brush contact loss is usually taken as 2Ia. An example will illustrate the calculations of efficiency.

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Example 8.1

The following data apply to a 100 kw, 250V, 6-pole 900 rpm shunt compound generator. No-load rotational losses = 3840 W. Armature resistance 0.012 Ω; Series field resistance = 0.004 Ω shunt field current = 2.60 A.

Assume a stray load loss of 1% of the output and calculate rated load efficiency.

Solution

Since the generator is long shunt compound hence the total resistance (not including brushes) is the sum of the resistance of the armature, series field and commentating pole field windings.

$$Ra = 0.012 + 0.004 + 0.004 = 0.020©$$

The armature current is the sum of the load current and the shunt field current or

$$Ia = \frac{100,000}{250} + 2.6 = 402.6A$$

The losses are as follows.

No. load rotational losses = 3840

Armature circuit copper loss = $(402.6)^2$ x 0.02 = 3240

Brush contact loss (2Ia) = 2 x 402.6 = 805

Shunt field copper loss = 250 x 2.6 = 650

Stray load loss 0.01 x 100,000 = 1000

Total loss = 9535 W

The input at rated is therefore, 100,000 + 9535 = 109,535 watts and the efficiency is

$$I - \frac{\text{Losses}}{\text{Input}}$$

$$I - \frac{9535}{109535} = 0.915$$