

Compound Wound motors are required for application to reciprocating compressors, stokers, reciprocating pumps when started under loaded conditions, and also when applied to similar equipment where high starting torque is required. Whenever frequent starting makes high starting and accelerating torque desirable, or where sudden changes of load are encountered, compound wound motors are used.

Series Wound motors find only limited application in a few special cases and are available in only a limited range of sizes.

Speed Characteristics

Direct current motors are available with speed characteristics of four types:

1. Constant speed.
2. Adjustable speed.
3. Adjustable varying speed.
4. Varying speed.

Constant Speed motors may be shunt wound or compound wound. Shunt wound motors have a nearly flat speed-load characteristic, with a speed regulation, when hot, from full load to no load of 15 per cent for up to $\frac{3}{4}$ hp, 12 per cent for one to 5 hp and 10 per cent for $7\frac{1}{2}$ hp and larger, based on full load speed. Compound wound motors have a speed regulation over the range from full load to no load of not more than 25 per cent, based on full load speed.

Adjustable Speed motors are usually shunt wound since it is impracticable to maintain the proper relation between the shunt and series fields of compound wound motors when wide variations of the field strength are required to obtain the speed adjustment.

Adjustment of the speed of shunt wound motors is obtained by field control on motors rated at $\frac{3}{4}$ hp and larger, with the minimum or base speed at full field strength and higher speeds at reduced field strength (obtained by adding resistance in the field circuit). The speed regulation from no load to full load will not exceed 22 per cent for 2 to 5 hp; nor 15 per cent for $7\frac{1}{2}$ hp and larger. Below 2 hp, the regulation may exceed 22 per cent. If closer speed regulation is required, specially wound motors must be obtained.

Motors with a speed range by field control of 3 to 1 or more are considered as adjustable speed, with less than 3 to 1 as constant speed. These motors can be rated on the basis of: (1) tapered continuous horsepower output with constant minimum rated output up to a speed ratio of $1\frac{1}{2}$ to 1 and increasing horsepower up to 3:1 and constant maximum horsepower (next horsepower rating above minimum rated horsepower) above 3:1; with variable motor temperature rise; (2) constant minimum horsepower from 1:1 to 4:1 with variable temperature rise; and (3) constant maximum horsepower from 1:1 to 4:1 with constant temperature rise for one hour operation and then the motor allowed to cool before further operation. High efficiency is maintained over the entire speed range.

Adjustable Varying Speed motors may be either shunt or compound wound and speed adjustment is obtained by adding resistance in series

with the armature. The speed thus obtained is always below the rated full field speed. Any standard shunt or compound wound constant speed motor may be used in conjunction with the proper armature resistor. The usual range of speed reduction is 50 per cent. The speed obtained for any setting of the resistor depends on the load of the motor and will vary with this load.

The speed regulation at high speed is comparable to a constant speed motor, but becomes poorer as the speed is decreased. When operating at reduced speed, an increased torque requirement which the motor could easily handle at rated speed is easily sufficient to stall the motor; for example, a motor operating at two-thirds speed would be stalled by a torque about 50 per cent in excess of the normal requirement.

The efficiency of the motor is reduced as the speed is reduced, since the loss in the resistor is greater at lower speeds. Speed reduction by armature control is usually selected where:

1. A wide speed range is not required.
2. Close speed regulation is not necessary.
3. Operating time at reduced speed is short.
4. Operating load at reduced speed is small so that the reduced efficiency can be ignored.
5. The rating is less than 1 hp.

By proper field, and armature voltage control, motors are available for speed ranges of 8:1 to 16:1 in sizes up to 30 hp. Below basic speed the motors are rated at constant torque and speed control is obtained by armature voltage control. Above basic speed, speed variation is obtained by field control and the motors are rated at constant horsepower. The motors will operate continuously, without injurious temperature rise, in normal ambient, to a speed of one-sixth of basic speed. Below one-sixth basic speed, motors should be operated intermittently only, because of reduced ventilation at the lower speed.

Varying Speed motors are series wound and the speed varies with the load on the motor. They should be used where: (1) the load is practically constant or increases with speed, and (2) the motor can easily be controlled by hand. They should not be used where there is a possibility of operation without load or at a reduced load, as the speed of the motor may become dangerously high.

For shunt wound motors with full field strength, the starting torque varies almost directly with the starting current, which is dependent on the resistance in the armature circuit. With varying positions of the starting rheostat, it is possible to obtain a wide range of starting torque, within the limits of starting current permitted by the power company.

A compound wound motor requires somewhat less current for the same starting torque. The maximum torque of shunt, series, and compound wound motors is limited by commutation.

ALTERNATING CURRENT MOTORS

Alternating current motors may be divided into two principal classifications, namely, (1) those motors which may operate on single phase