5 Characteristics of DC Motor

5.1 Shunt Motor

Fig. 3 shows the connections of a D.C. shunt motor. The field current I_{sh} is constant since the field winding is directly connected to the supply voltage V which is assumed to be constant. Hence, the flux in a shunt motor is approximately constant.

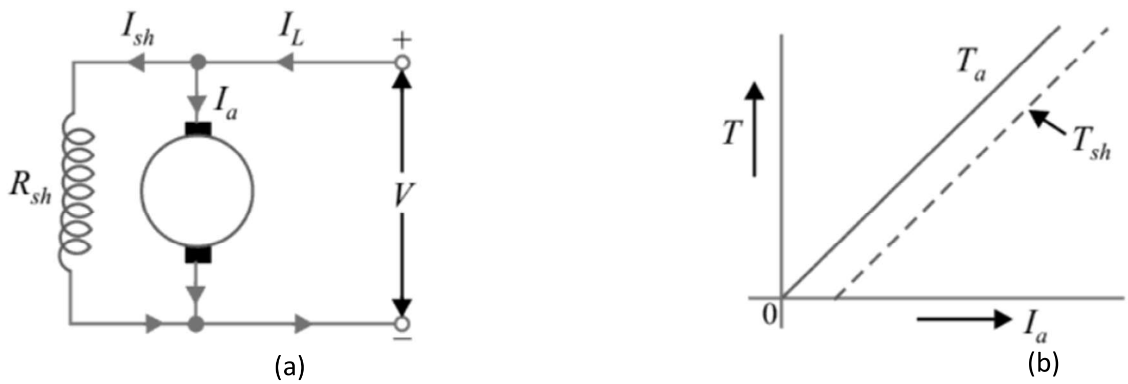

Fig. 3 DC Shunt motors.

(i) ***T_a/I_a* Characteristic**. We know that in a D.C. motor,

$$T_a \alpha \ \emptyset I_a \tag{21}$$

Since the motor is operating from a constant supply voltage, flux is constant (neglecting armature reaction).

$$T_a \alpha \ I_a \tag{22}$$

Hence T_a/I_a characteristic is a straight line passing through the origin as shown in Fig. 3 (a). The shaft torque (T_{sh}) is less than T_a and is shown by a dotted line. It is clear from the curve that a very large current is required to start a heavy load. Therefore, a shunt motor should not be started on heavy load.

(ii) ***N/I_a* Characteristic**. The speed N of a motor is given by;

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$$N \; \alpha \; \frac{Eb}{\emptyset} \tag{23}$$

The flux and back e.m.f. E in a shunt motor are almost constant under normal conditions. Therefore, speed of a shunt motor will remain constant as the armature current varies (dotted line AB in Fig. 4(a)). Strictly speaking, when load is increased, E (= V – IR) and Ø decrease due to the armature resistance drop and armature reaction respectively. However, Eb, decreases slightly more than Ø so that the speed of the motor decreases slightly with load (line AC).

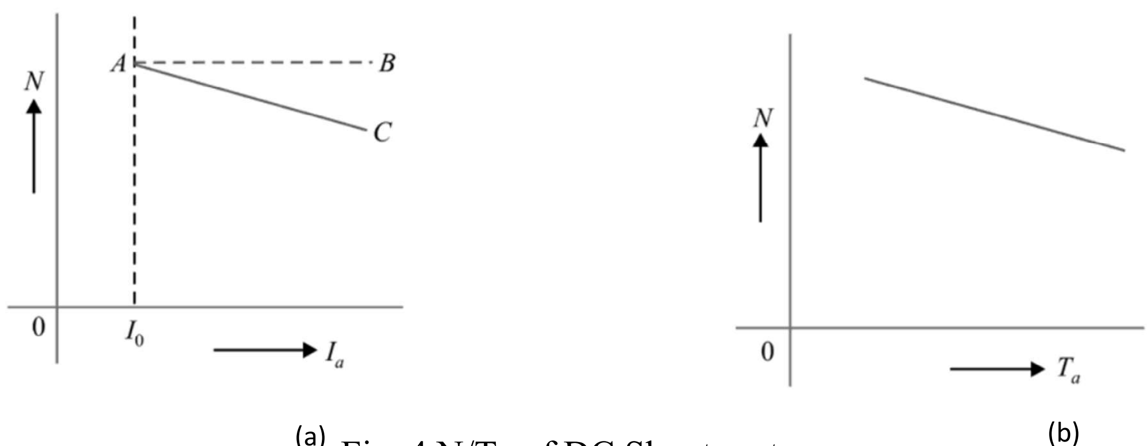

Fig. 4 N/Ta of DC Shunt motors.

(iii) ***N/T_a Characteristic***. This curve is obtained by plotting (fig 4(b)) the values of N and T_a for various armature current. It may be seen that speed falls some what as the load torque increases.

The following two important conclusions are drawn from the above characteristics:

- There is slight change in the speed of shunt motor form no load to full-load. Hence it is essentially a constant-speed motor.
- The starting torque is not high because $T_a \; \alpha \; I_a$.

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5.2 Series Motor

Fig. 5(a) shows the connections of D.C. series motor. Note that current passing through the field winding is the same as that in the armature. If the mechanical load on the motor increases, the armature current also increases. Hence, the flux in a series motor increases with the increase in armature current and vice-versa.

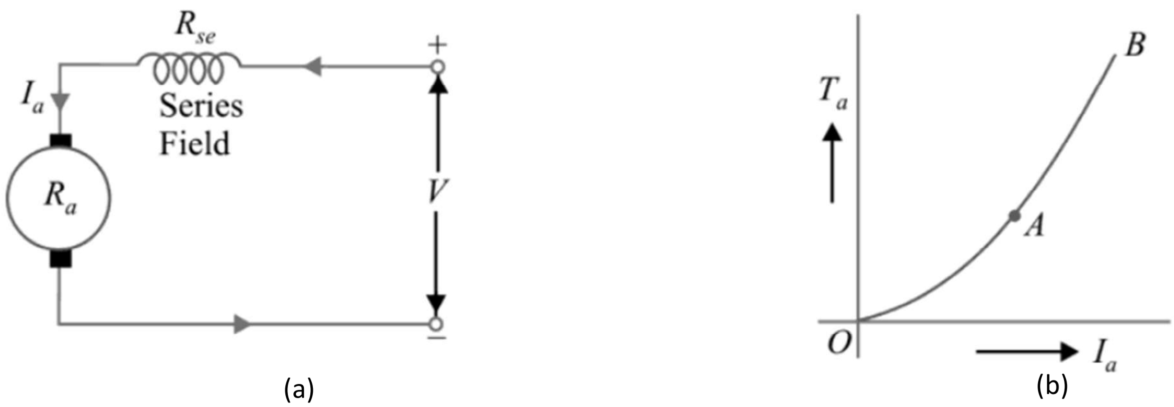


Fig. 5 N/Ta of DC Shunt motors.

(i) ***T_a/I_a Characteristic***. We know that

$$T_a \propto \phi I_a \tag{24}$$

Up to magnetic saturation, we have

$$\phi \propto I_a \tag{25}$$

After magnetic saturation, ϕ is constant so that $T_a \propto I_a$

$$T_a \propto I_a^2 \tag{26}$$

Thus, upto magnetic saturation, the armature torque is directly proportional to the square of armature current. If I_a is doubled, T_a is almost quadrupled. Therefore, T_a / I_a curve upto magnetic saturation is a parabola (portion OA of the curve in Fig. 5(b)). However, after magnetic saturation, torque is directly proportional to the armature current. Therefore, Talla curve after magnetic saturation is a straight line (portion AB of the curve).

It may be seen that in the initial portion of the curve (i.e. upto magnetic saturation), T_a. This means that starting torque of D.C. series motor will be very high as compared to a shunt motor (where T_a α I_a).

(ii) ***N/Ia* Characteristic**. The speed N of a series motor is given by;

$$N \alpha \frac{\text{Eb}}{\emptyset} \tag{27}$$

Where $E_b = V + I_a(R_a + R_{se})$

When the armature current increases, the back e.m.f. E, decreases due to I_a (R_a+ R_{se}) drop while the flux ∅ increases. However, I_a (R_a + R_{se}) drop is quite small under normal conditions and may be neglected.

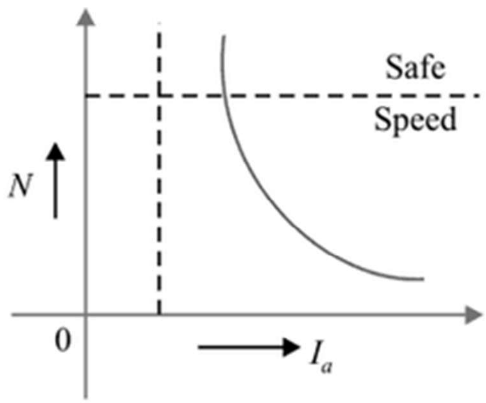
$$N \alpha \frac{1}{\emptyset} \tag{28}$$

$$N \alpha \frac{1}{I_a} \tag{29}$$

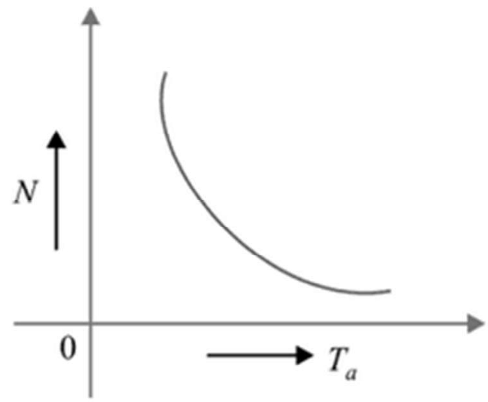
Thus, upto magnetic saturation, the N/ I_a curve follows the hyperbolic path as shown in Fig. 6(a). After saturation, the flux becomes constant and so does the speed.

(ii) N/ T_a, Characteristic.

The N/ T_a characteristic of a series motor is shown in Fig. 6(b). It is clear that series motor develops high torque at low speed and vice-versa. It is because an increase in torque requires an increase in armature current, which is also the field current. The result is that flux is strengthened and hence the speed drops ($N \alpha 1/\emptyset$). Reverse happens should the torque be low.



(a)



(b)

Fig. 6 N/Ta of DC Series motor.