Characteristics and Applications of DC Motors

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MOTOR CHARACTERISTICS:

1) Torque and armature current (T_a/I_a) characteristic. It is also known as electrical characteristic.
2) Speed and armature current (N/I_a) characteristic.
3) Speed and torque (N/T_a) characteristic. It is also known as mechanical characteristic.

While discussing motor characteristics, the following two relations must be always kept in mind:

$$T_a \propto \emptyset\, I_a$$

$$N \propto \frac{E_b}{\emptyset}$$

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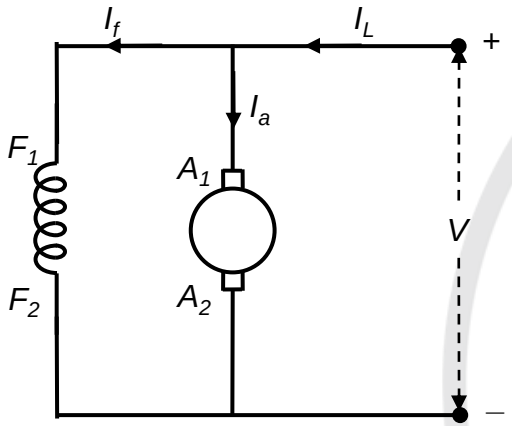
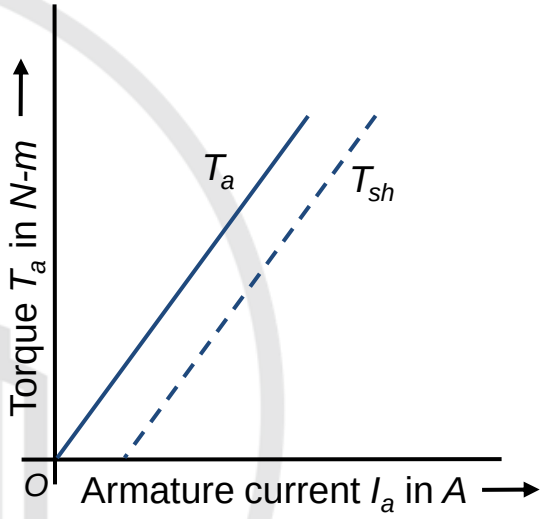
CHARACTERISTICS OF SHUNT MOTORS:





T_a/I_a characteristic:

The flux per pole ϕ is constant because the field current I_f is constant.

At heavy loads, ϕ decreases slightly due to increased armature reaction. However, practically the flux ϕ can be assumed constant.

$T_a \propto \emptyset\, I_a$, as ϕ is constant, $T_a \propto I_a$

Hence the characteristic is practically a straight line through the origin.

Shaft torque T_{sh} is less than armature torque T_a.

As the starting torque is low, shunt motor should never be started on heavy load.

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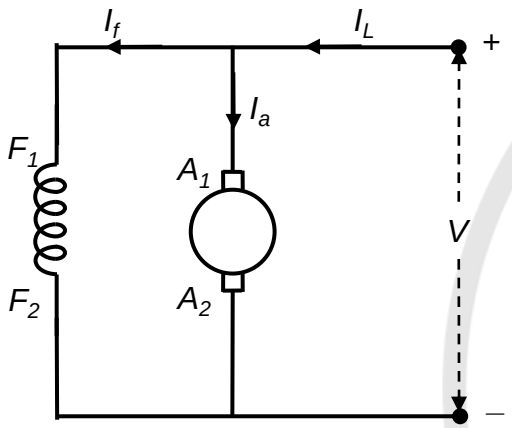

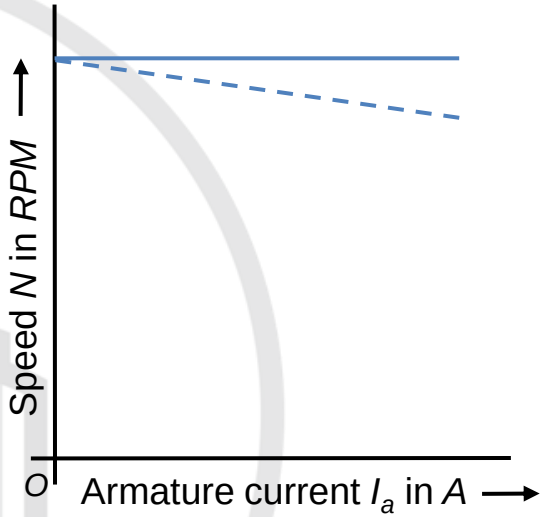

N/I_a characteristic:

$N \propto \frac{E_b}{\phi}$. If ϕ is assumed constant, then $N \propto E_b$.

E_b is also practically constant because the armature resistance R_a is very small.

Actually, when the load is increased, E_b and ϕ both decrease.

However, E_b decreases slightly more as compared to ϕ.

Hence the actual speed curve is slightly drooping as shown by the dotted line.

For all practical purposes, shunt motor is considered as a constant speed motor.

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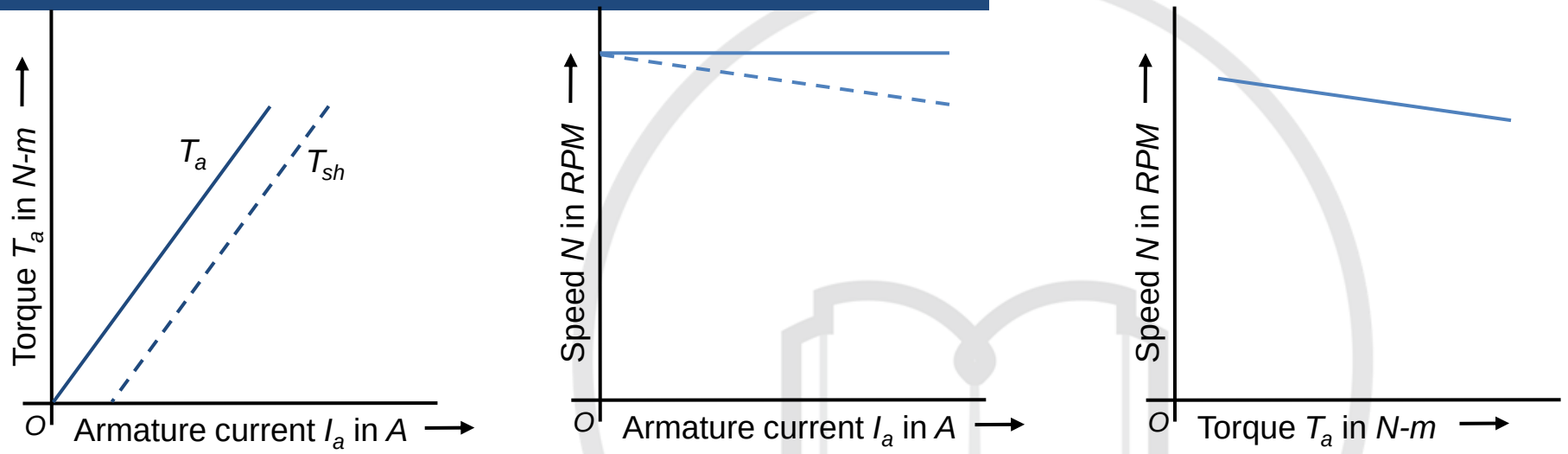

N/T_a characteristic:

It can be found from first two characteristics.

When armature current increases, torque increases linearly.

With increase in armature current, speed slightly decreases.

Thus, with increase in torque, speed decreases.

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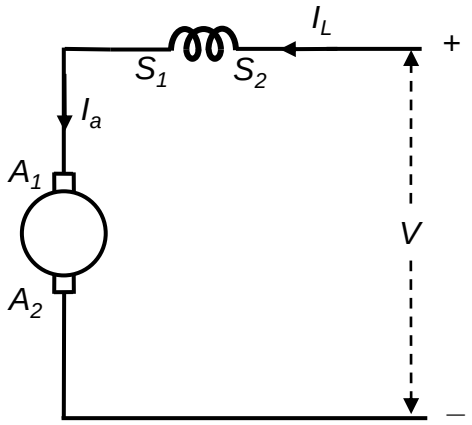
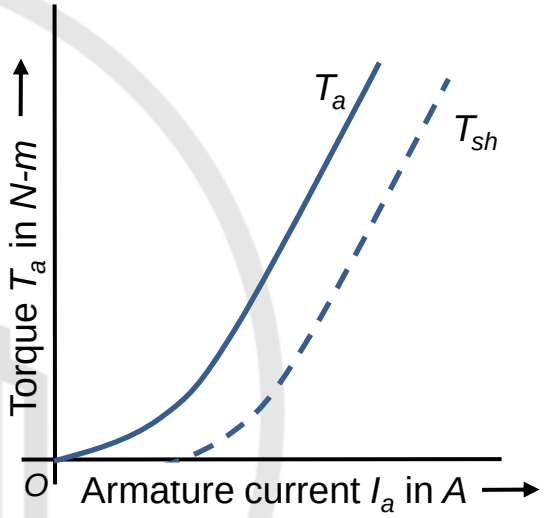
CHARACTERISTICS OF SERIES MOTORS:





T_a/I_a characteristic:

$T_a \propto \emptyset\, I_a$

Field winding also carries armature current I_a, $\therefore \emptyset \propto I_a$ up to the point of magnetic saturation.

Therefore, before saturation, at light loads, $T_a \propto I_a^2$. Hence, T_a/I_a curve is a parabola.

After saturation, ϕ is almost constant and hence $T_a \propto I_a$ only. So the characteristic becomes a straight line.

Hence, series motors are used in cases where a huge starting torque is required for accelerating heavy loads quickly.

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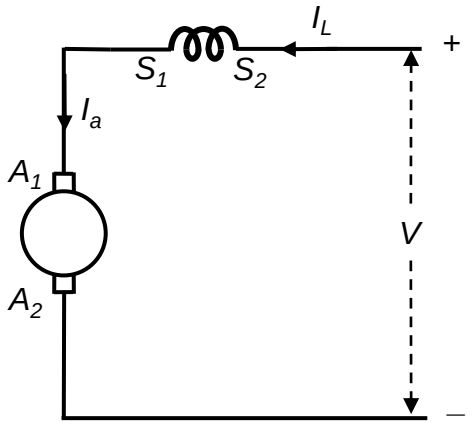

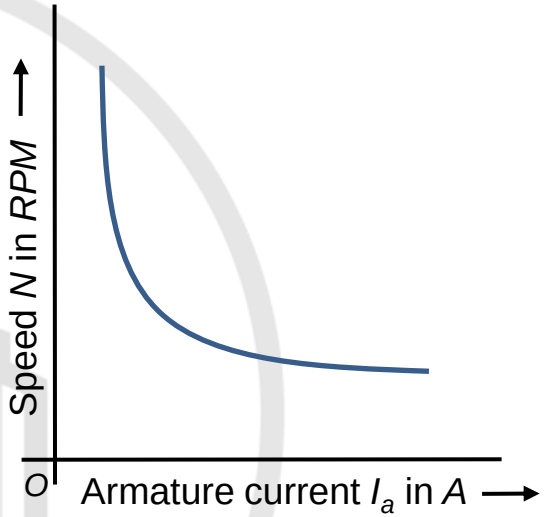

N/I_a characteristic:

$$N \propto \frac{E_b}{\emptyset}$$

Change in E_b, for various load currents is small and hence it may be neglected.

With increase in load current I_a and hence ϕ also increases.

Hence, speed varies inversely as armature current as shown by the characteristic.

When the load current and hence I_a is very small, speed becomes dangerously high.

Hence, series motor is never be started without some mechanical load on it.

Series motor is a variable speed motor.

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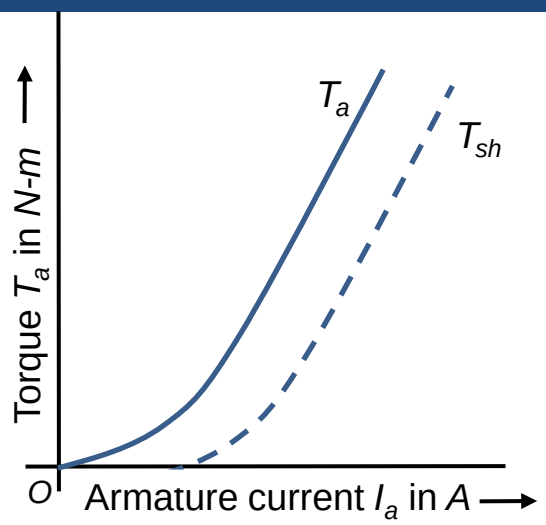

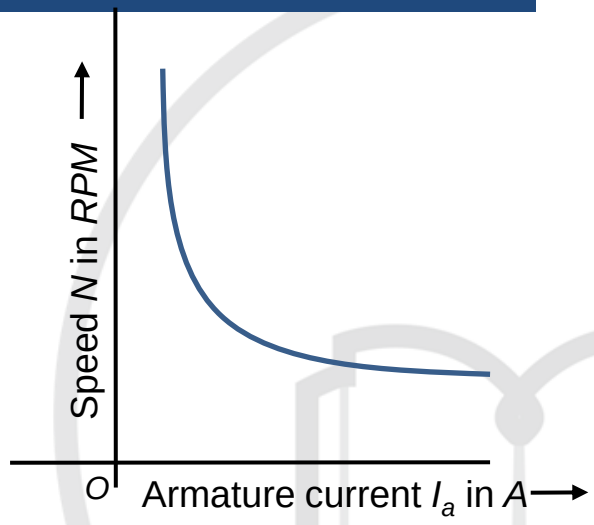

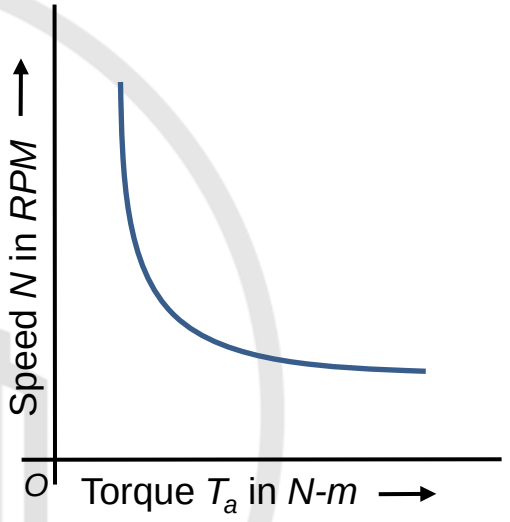

N/T_a characteristic:

It can be found from first two characteristics.

When the speed is high, torque is low.

When the toque is high, speed is low.

Thus, with increase in torque, speed decreases.

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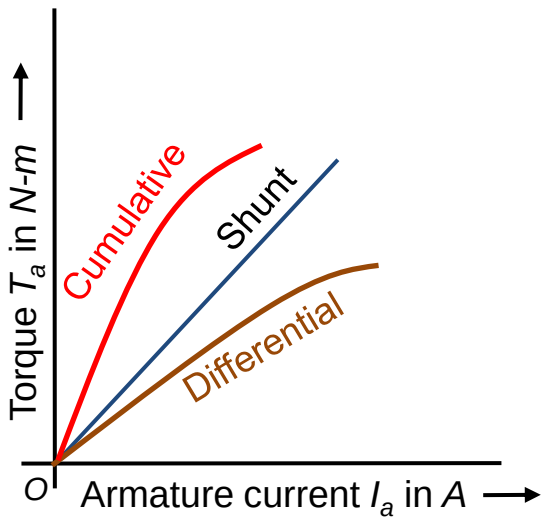
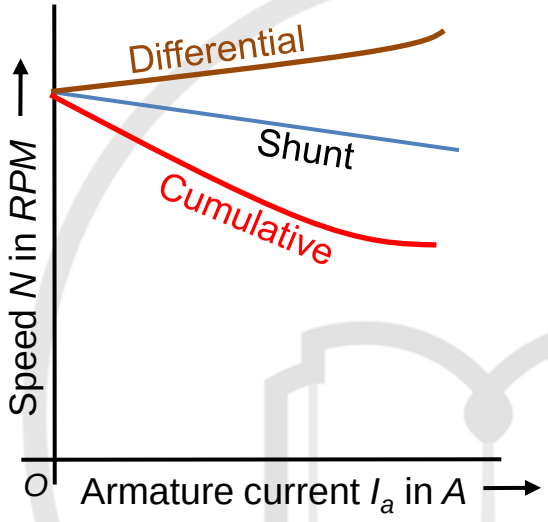
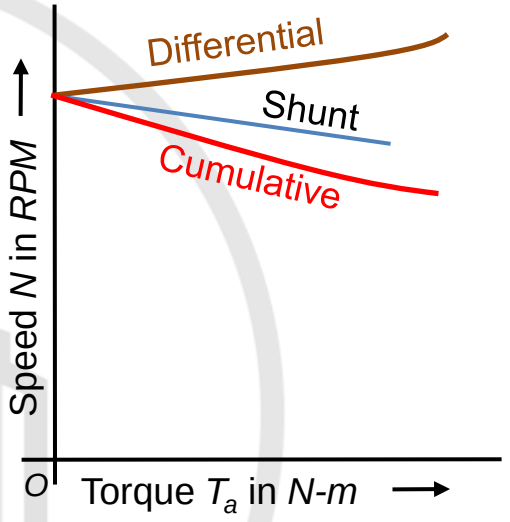
CHARACTERISTICS OF COMPOUND MOTORS:







These motors have both series and shunt field winding.

If series field and shunt field are in the same direction, then the motor is said to be cumulatively compounded.

If the series field opposes the shunt field, then the motor is said to be differentially compounded.

Cumulatively compounded motors are suitable for heavy machine tools with pulsating load. The speed at no load will not become excessively high due to shunt winding and the motor is able to take heavy loads due to series winding.

In differential compounded motor, with increase in load, flux decreases and therefore, speed increases. If the motor is not properly designed, there is a tendency of speed instability.

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APPLICATIONS OF DC MOTORS:

Type of motor	Characteristics	Applications
Shunt	Approximately constant speed Adjustable speed Medium starting torque	For constant speed applications like – Lathes Centrifugal and reciprocating pumps Machine tools Blowers and fans etc.
Series	Variable speed High starting torque Adjustable speed Cannot be operated without mechanical load	For applications requiring high starting torque like – Traction i.e. electric locomotives Hoist and cranes Conveyors Trolly cars etc.
Cumulative compound	Variable speed High starting torque Adjustable speed Can be operated without mechanical load	For intermittent high torque loads like – Shears and punches Heavy planers Rolling mills etc.

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