Speed Regulation

$$SR = \frac{\omega_{m,nl} - \omega_{m,fl}}{\omega_{m,fl}} \times 100\%$$

five types of DC Motor

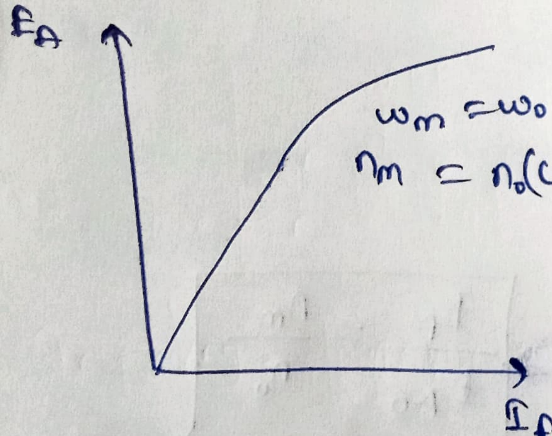
1. Separately Excited DC Motor
2. Shunt ⟶
3. Permanent-Magnet ⟶
4. Series ⟶
5. Compound ⟶

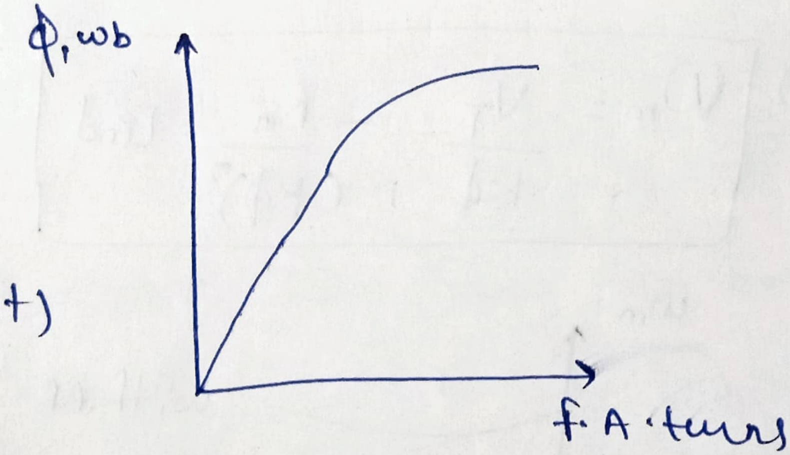
$E_A = K\phi\omega_m$ —(2)   ef. magnetomotive force

$\tau_{ind} = K\phi I_A$ $F = N_f I_f$ —(1)

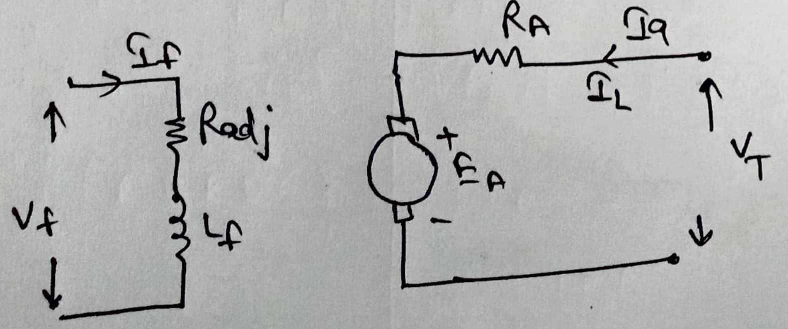
from eq (1) and (2)

$$\boxed{I_f \propto \phi}$$





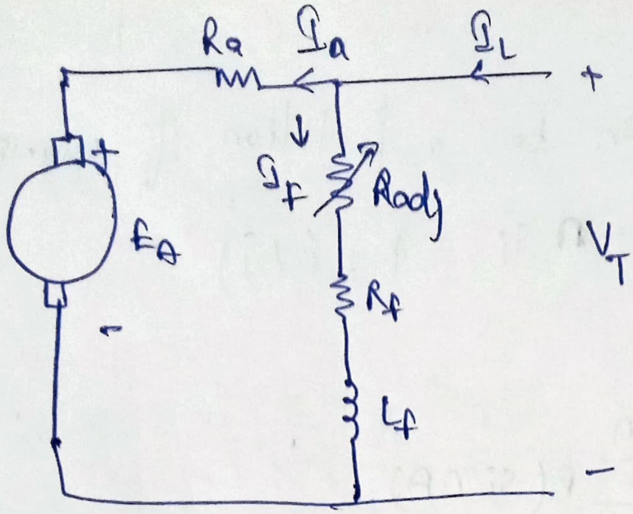
Seperately Excited DC Motor



$$I_f = \frac{V_f}{R_f}$$

$$V_T = E_A + I_A R_A$$

$$I_L = I_A$$



$$I_f = \frac{V_T}{R_f}$$

$$V_T = E_A + I_a R_A$$

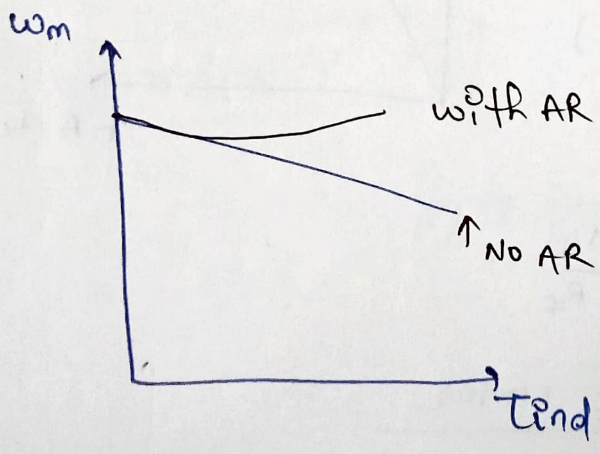
$$I_L = I_a + I_f$$

As $V_T = E_A + I_a R_a$; $E_a = K\phi\omega_m$

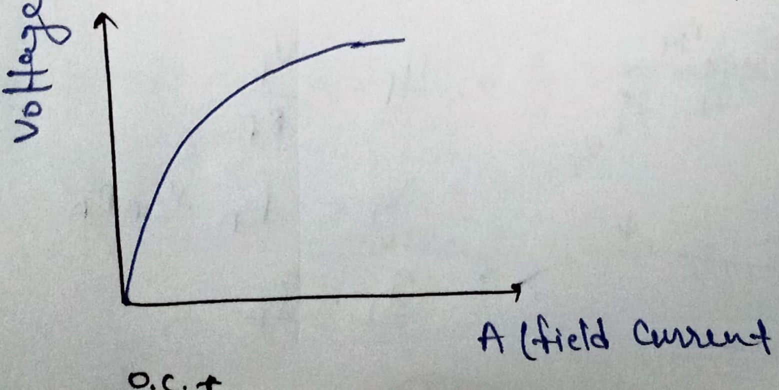
$\Rightarrow V_T = K\phi\omega_m + I_a R_a$; $\tau_{ind} = K\phi I_A$

$$V_T = K\phi\omega_m + \frac{\tau_{ind}}{K\phi} \cdot R_a$$

$$\Rightarrow \boxed{\omega_m = \frac{V_T}{K\phi} - \frac{R_a}{(K\phi)^2} \cdot \tau_{ind}}$$



$$\boxed{\frac{E_A}{E_{A0}} = \frac{n_m}{n_0}}$$



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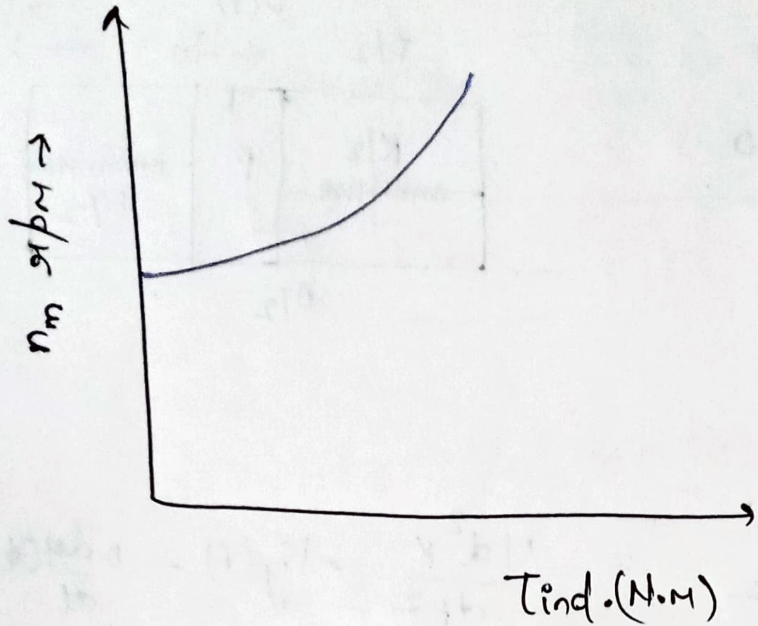


Torque speed characteristics. of motor with AR.

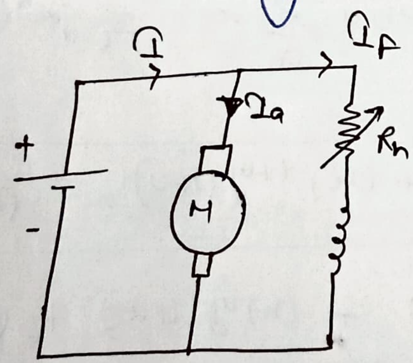
Speed control of shunt DC Motor

2 Most Common Method:-

1. field Resistance Adjustment
2. the terminal voltage applied to armature adjustment
3. connecting res. in series combination with the armature (rarely used).

1. flux control Method:-

to control flux, A rheostat is added in series with the field winding.



$$I_f = \frac{V_T}{R_f}$$

$$I_f \propto \phi$$

As $R_h \uparrow$ $\phi \downarrow$ $N \uparrow$

$$\boxed{E_A = K\phi w}$$

$$\boxed{T_{ind} = K\phi I_A}$$

$$\boxed{I_A = \frac{(V_T - E_A)}{R_a}}$$

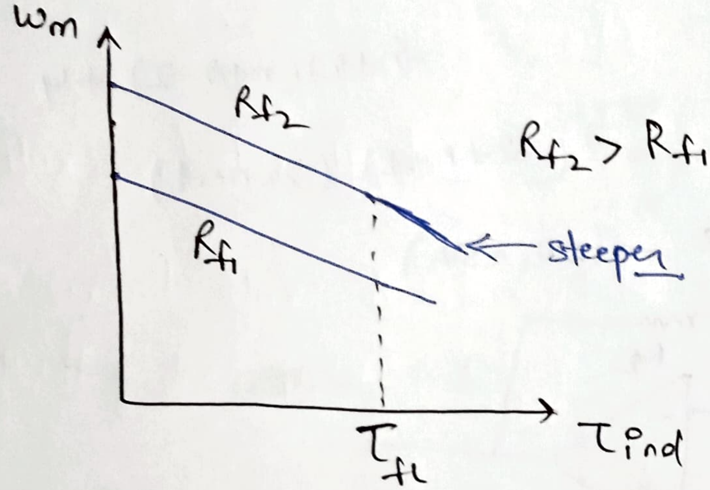
NOTE:— With decrement in flux of one %, 49% increment in armature current.

- increment in Armature Current dominant to decrement in flux that's why T_{ind} will also $\uparrow$.

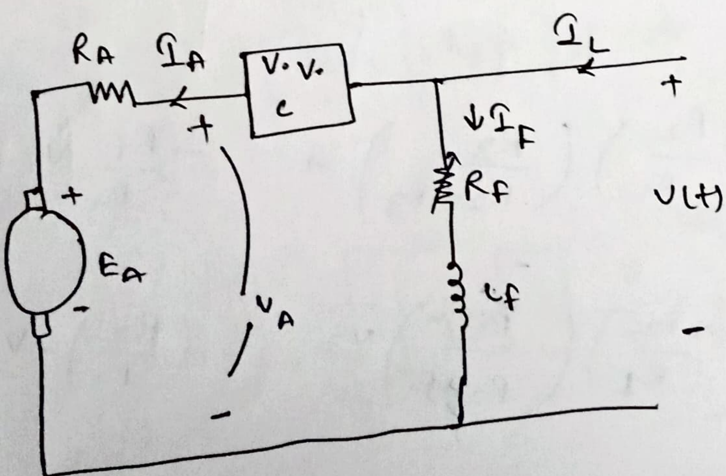
So T_{ind} larger than T_{load} so speed will ↑.

⑥ Now. due to ↑ in speed internal generated voltage E_A ↑ that cause to decrement in Armature current.

As Armature current ↓ Torque Induced ↓ to become equal to T_{load}.



changing Armature Resistance:—



• The Motor should be in seperately excited for armature voltage control.

- If we ↑ armature Votage V_A due to Arm. current also ↑

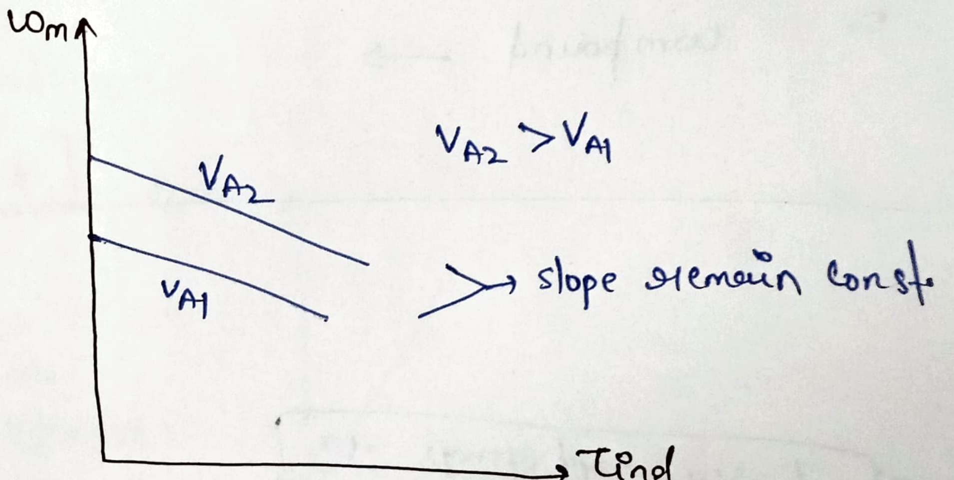
$$I_A = \frac{V_A - E_A}{R_A} \; ; \quad \tau_{ind} = k\phi I_A$$

As I_A ↑ with ↑ in V_A

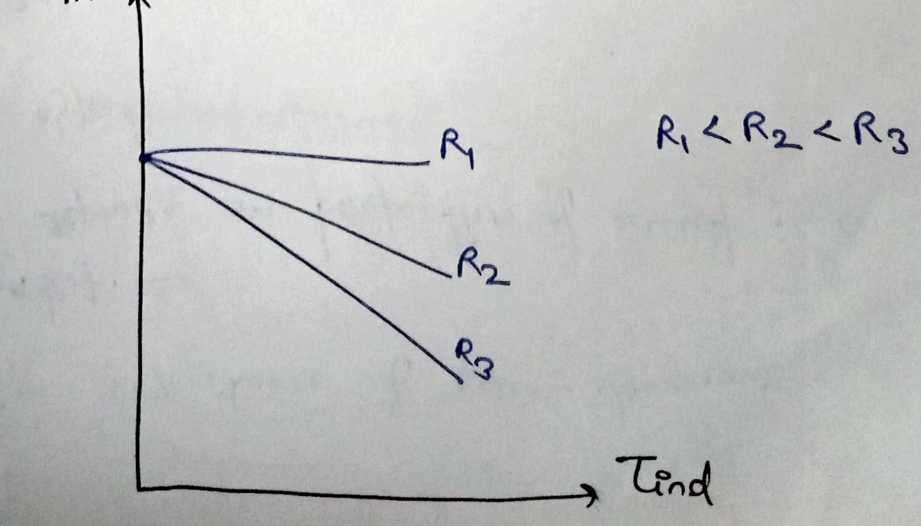
due to this τ_{ind} ↑ > τ_{load} ⇒ N ↑ (speed)

As speed ↑ ⇒ internal voltage E_A ↑ ⇒ I_A ↓ ⇒ τ_{ind} ↓

& $\tau_{ind} = \tau_{load}$

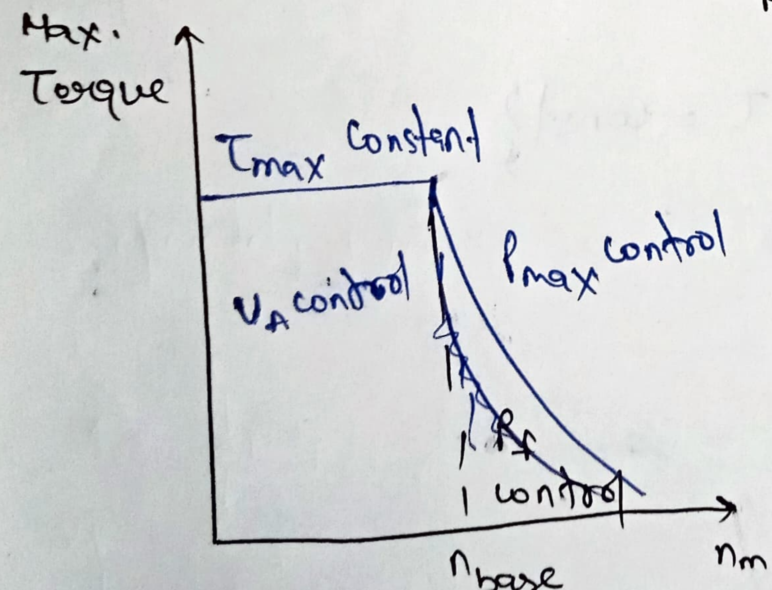


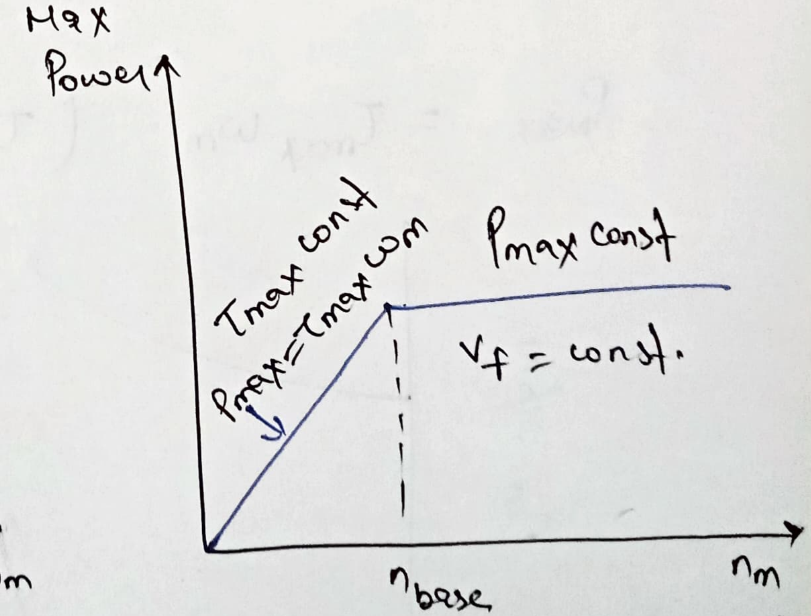
Inserting of Resistance in series with Armature winding:-



Base speed:—

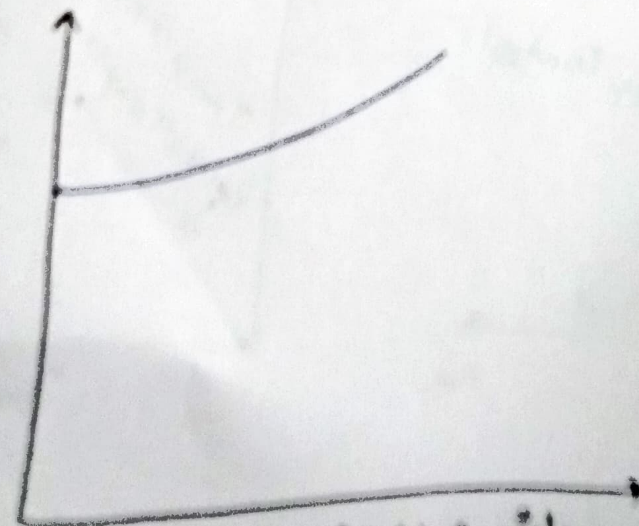
If motor is operating at its rated terminal voltage, power, and field current, then it will be running at rated speed, also known as base speed.





$T_{max} = K\phi I_{a,max}$ $\{\phi = \text{const}\}$

$P_{max} = T_{max}\,\omega_m$ $(T = \text{const}\}$



The Series DC Motor:—

$$V_T = E_A + I_A(R_A + R_S)$$

$$\tau_{ind} \propto \phi \quad , \quad \phi \propto I_A \Rightarrow \phi = cI_A$$

$$\tau_{ind} \propto I_A^2$$

$$\Rightarrow \boxed{\tau_{ind} = k\phi I_A}$$

- flux in this machine is directly proportional to its armature current (at least the metal saturates).

$$I_A = \sqrt{\frac{\tau_{ind}}{kc}}$$

$$\Rightarrow V_T = k\phi\omega_m + \sqrt{\frac{\tau_{ind}}{kc}}(R_A + R_S)$$

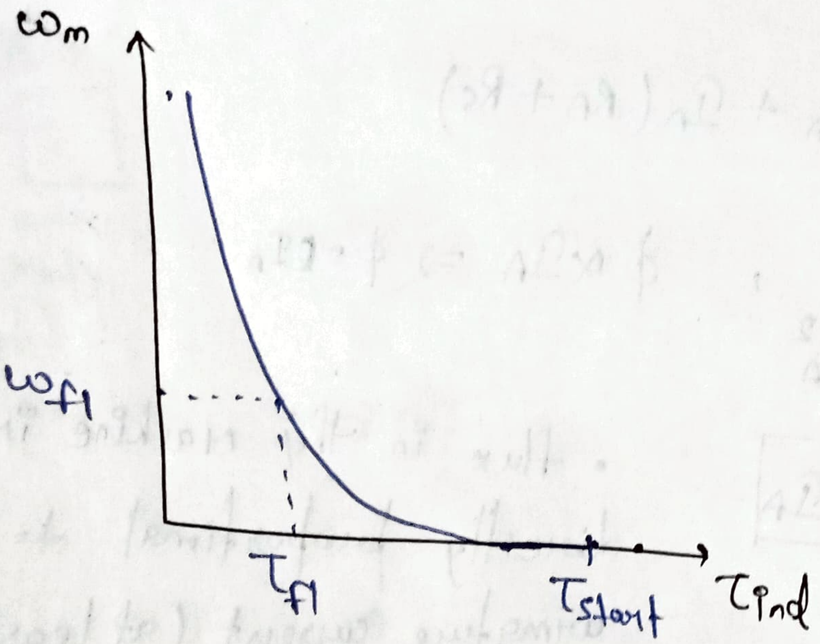
As $I_A = \frac{\phi}{c}$

$$\tau_{ind} = \frac{k}{c}\phi^2 \Rightarrow \phi = \sqrt{\frac{c}{k}}\sqrt{\tau_{ind}}$$

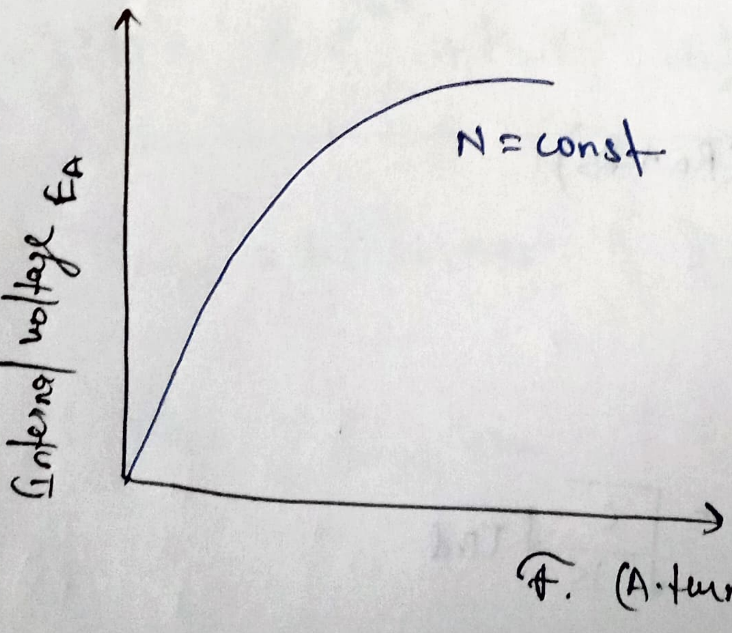
$$\omega_m = \frac{V_T}{\sqrt{kc}} \cdot \frac{1}{\sqrt{\tau_{ind}}} - \frac{R_A + R_S}{kc}$$

if $\tau_{ind} = 0$ speed $= \infty$ (very high) practically.

• Never unload series motor.
with load there will be ~~stray~~, mechanical and core losses so Torque will not be zero.



torque speed char. of a Series Dc motor.



$$VR = \frac{V_{nl} - V_{fl}}{V_{fl}} \times 100\%$$