ECE 320: Lecture 29

Notes

Starting DC Motors:

- When the motor is not rotating, the armature voltage will be zero
- The motor can draw a large current from the dc power source
- This current determines the starting torque. In most cases this is the largest torque the machine produce.

$$\tau = k_a \cdot \phi \cdot i_a$$

- The other variable in this equation is the flux produced by the field
- As discussed above, this depends on the field circuit connection
- For a series field motor, it will basically bootstrap itself up to speed.
- For a seperately excited, shunt, or permanent magnet machine, the armature current may be too large.
- This could result in damage to the machine, or
- In some cases this could even damage the load by producing excessive starting torque.

Motor Starting Options:

- Reduced voltage starter:

1. Reduce terminal voltage by reducing output of dc source (power converter or dc generator)
2. Resistive voltage divider (similar to starter box used in the labs). The voltage divider is bypass or switched out of the circuit once the back emf (armature voltage) is sufficiently high to limit current.

- Reduce excitation (doesn't limit the current, just the torque)

Motor Speed Control Options

- Vary the field current. As the field flux decreases, the speed increases (if no flux, infinite speed). This method will be used in the last lab
- Vary Vt (varies Ia) . Options to control Vt:

1. Use a dc generator and vary the field excitation or speed to vary its voltage
2. Resistive voltage divider
3. Power converter with the ability to control voltage (we'll see an example of this in the next section)

Motor Power and Torque Limits as a Function of Rotor Speed:

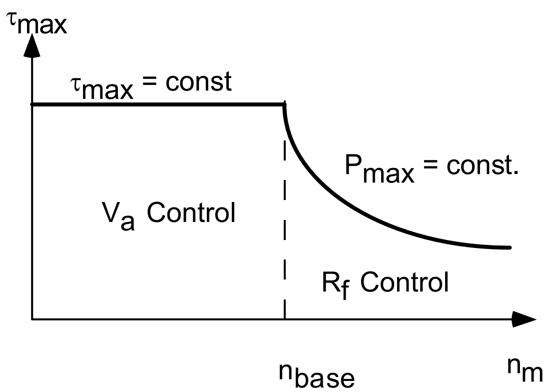
- Maximum Torque limited by armature current limit (Ia_max)

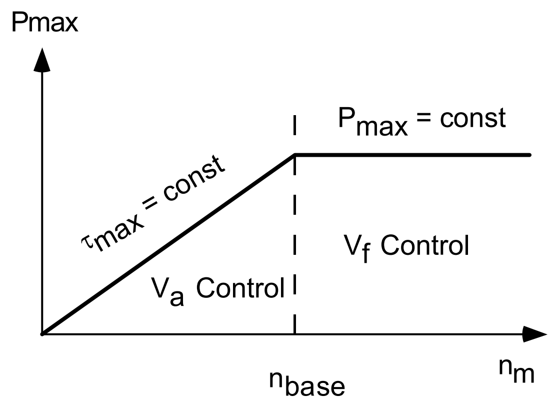
$$\tau_{max} = K \cdot \phi I_{a\_max}$$

- Maximum power related to speed and torque limit

  $P_{max} = \tau_{max} \cdot \omega$

These combine to provide safe operating limits for the motor. Different control methods can be u to vary Vt, If (or Vf where max Vf is a limit).

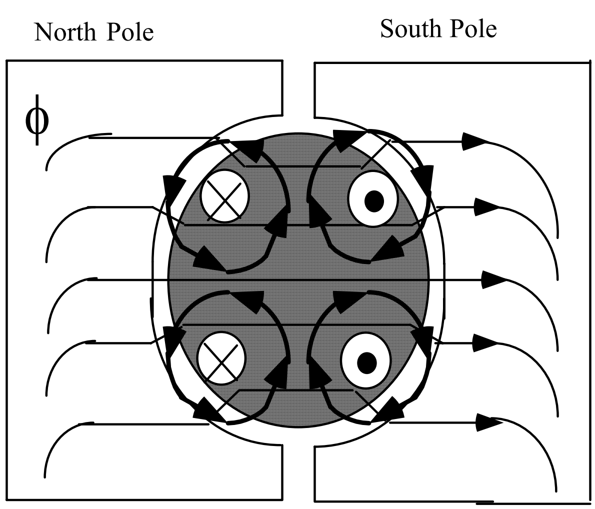




- Below the base speed (ususally rated speed), the armature current is the limiting factor fo motor capability, limiting torque to a maximum level
- Above the base speed, the total power limit is the limiting factor. This is because of the limits of the maximum voltage that can be produced on the armature (and the field)

Armature reaction:

- The current flowing through the armature winding will induce flux around each conductor. O one side of the conductor this will add to the flux from the external field, other other side it w oppose the field flux. Key impacts:



1. The axis of the flux is shifted, so the zero point in the armature voltage moves. The commutator segments are no longer aligned properly, and there will be arcing since the current won't be zero when the brushes pass the gap.

2. The total flux where the armature reaction flux and the field flux add will cause saturat of the iron in the pole faces and possibly in the rotor itself. This will weaken the total fiel and will result in the following:

a. In a generator, there will be a drop in the internal voltage E_a as the armature current increases (strenghening the flux around the armature conductors).

b. In a motor, especially a seperately excited or shunt excited motor, the speed wil not drop off as much as expected as load increases.

Possible fixes:

1. Shift the brush locations so they are aligned with the new location of the axis of the fie (aligned with the zero point in the E_a or I_a) at the most commonly used current level (this only a fix for a small range of currents).

2. Add interpoles (sometimes called commutating poles). These are series field winding, l the pole faces for these are located in the gap between pole faces. The flux from these varies with the armature current, and is aligned to oppose the armature reaction flux. The machines we are using in the lab have interpoles.

3. Compensating windings. A new winding is added in the pole faces a set of turns across the air gap from each of the sets of turns of the armature winding. These are again alignec roduce flux to oppose the armature reaction flux. These added windings carry the armatur current.