Synchronous Motor w/ Increasing Loads Phasor Diagram

- The mechanical power out of the motor is roughly proportional to the electrical power into the motor. From earlier

$$P = 3V_\phi I_A \cos\theta = \frac{3V_\phi E_A \sin\delta}{X_S}.$$

- Assume an 'infinite bus' where the terminal voltage V_T for the motor and V_ϕ as well as electrical frequency ω are constant. This implies phasor $\overline{V}_\phi = V_\phi \angle 0°$ is constant.
- Assume $E_A = \left|\overline{E}_A\right| = k\phi\omega$ is constant when I_f & ω are constant. Implies phasor $\overline{E}_A$ traces an arc of constant radius as torque angle δ changes.
- Only things that can change with the load are $\underline{I_A \cos\theta}$ or $\underline{E_A \sin\delta}$ (because of $\sin\delta$), i.e., $P \propto I_A \cos\theta$ or $P \propto E_A \sin\delta$. From earlier phasor diagrams, these quantities are the vertical distances from tip of $\overline{E}_A$ to line of $\overline{V}_\phi$.
- As the load increases, the vertical distance $\propto P$, δ, and I_A all **increase**. Further, angle θ, associated with the PF becomes more and more lagging.

Figure 5–32 (a) Phasor diagram of a motor operating at a leading power factor. (b) The effect of an increase in load on the operation of a synchronous motor.

