Armature Reaction

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1 Armature Reaction

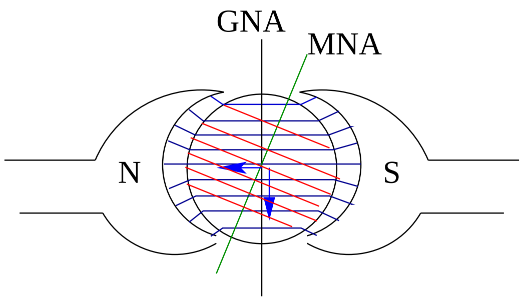

Figure 1: Armature reaction

Armature reaction is unavoidable for a dc machine. A current carrying armature conductor produces its own magnetic field around it. This field interacts with the magnetic field produced by the machine poles. This interaction is known as the **armature reaction**.See figure1.

1. **Cause:** A motor draws current from the power supply. This current flows thorough the armature conductors. These current carrying conductors produce their own magnetic field, which interacts with the main field and gives rise to armature reaction. In case of a generator, as soon as it is loaded, current flows through the armature conductors and new magnetic field is produced. This gives rise to armature reaction.

2. **Effects:** Two main effects are observed.

   (a) **Demagnetization:** The newly generated field partly opposes the main field. This reduces the total magnetic flux slightly. Reduction in field strength results in lesser terminal voltage for generators and lesser torque produced for motors. In case of motors, slight *increase* in speed is observed.

(b) **Cross-magnetization:** The newly generated magnetic field is in quadrature with the main field. This distorts the flux path through the armature core. As a result, magnetic neutral axis shifts through a certain angle. Position of brushes is affected by this.See figure 1

3. **Remedies:** Following techniques work to minimise the effect of armature reaction.

   - **Strengthen the main field:** Make the main field so strong that cross magnetizing effect is almost negligible. However, this may result in saturation of armature core.
   - **Increase the reluctance of magnetic path:** This can be done by increasing the air gap near the pole tips. Punching holes behind the pole faces also increases reluctance.
   - **Interpoles:** These are small poles situated in between two consecutive main poles. They are useful to minimize the effect of cross magnetization. Windings which magnetize the interpoles are in series with armature. This trick works like an automatic negative feedback.
   - **Compensating windings:** These windings appear on the pole-face. They are wound such that, their field opposes the demagnetizing component of armature reaction. Like interpole windings, these windings are also in series with load, to give the effect of negative feedback.

4. **DC shunt generator & AR:** Resultant flux in armature core is decreased due to armature reaction. As generated emf is directly proportional to flux ($E_a \; \alpha \; \Phi$), E_a and V_t are reduced at higher loads. At higher loads current is more so effects of armature reactions are more prominent.

5. **DC series motor & AR:**

$$
\begin{aligned}
\tau &= k * \Phi * I_a \\
\textit{but in series motors,} & \\
\Phi & \quad \alpha \quad I_a \\
\textit{so,} & \\
\tau &= \Phi^2
\end{aligned}
$$

Thus due to decrease in flux (due to AR) torque decreases at the square rate. At higher loads, this effect is prominently observed.

2 Armature reaction Numerical

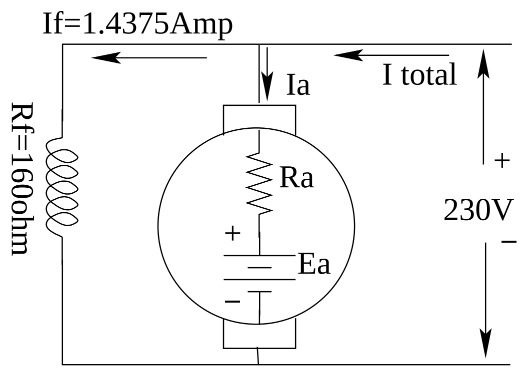

Figure 2: DC shunt motor

2.1 Problem statement

A 230V, d.c. shunt motor, takes an armature current of 3.33 Amp at rated voltage and at no load speed of 1000 rpm. The total resistance of the armature circuit and field circuit are 0.3 ohm and 160 ohm respectively. The line current at full load and at rated voltage is 40 Amp. Calculate at full load, the speed and the developed torque in case the armature reaction wakens the no load flux by 4 %.

2.2 Solution

From the given data,

$$V = 230V \quad (1)$$
$$I_{a0} = 3.3Amp \quad (2)$$
$$RPM_0 = 1000 \quad (3)$$
$$R_a = 0.3\Omega \quad (4)$$
$$R_f = 160\Omega \quad (5)$$
$$I_{fl} = 40.0Amp \quad (6)$$
$$\Phi_{fl} = 0.96 * \Phi_0 \quad (7)$$

We calculate the following:
Refer to the figure 2

$$\begin{aligned} I_f &= \frac{230}{160} = 1.4375Amp \\ I_{afl} &= 40.0 - 1.4375 = 38.5625Amp \end{aligned}$$

Formulae used in this problem :

$$\begin{aligned} \omega &= \frac{V_t - I_a R_a}{k * \Phi} \\ \omega_0 &= \frac{rpm * 2 * \pi}{60} = 104.71976 \end{aligned}$$

From no load condition,

$$\begin{aligned} k * \Phi_0 &= \frac{V_t - I_{a0} R_a}{\omega} = 2.186884 \\ Now\ using\ equation\ 7, & \\ k * \Phi_{fl} &= 2.09940 \\ and & \\ \omega_{fl} &= \frac{V_t - I_{afl} R_a}{k\Phi_{fl}} \\ &= \frac{230 - 38.5625 * 0.3}{2.09940} = 104.0441 rad/sec \\ So\ the\ \textbf{full load rpm is}, &= 993.5486 rpm \\ To\ get\ \textbf{torque required,} & \\ \tau_e &= k * \Phi_{fl} * I_a = 2.0994 * 38.5625 = 80.9581 N-m \end{aligned}$$