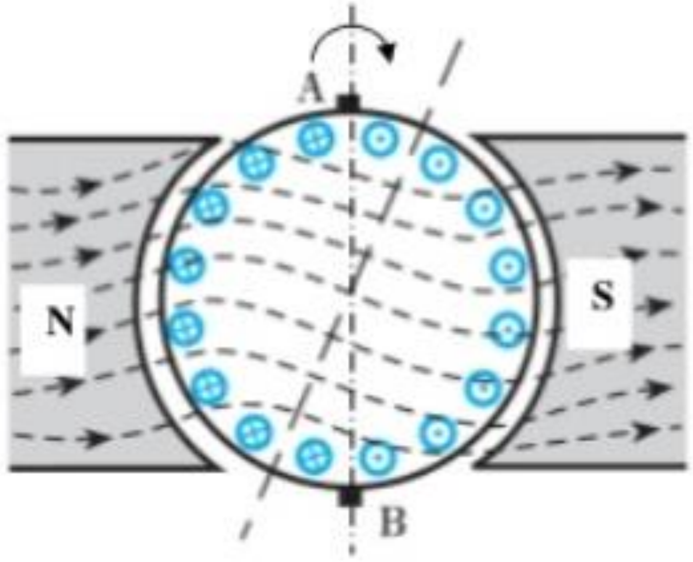
EEE363

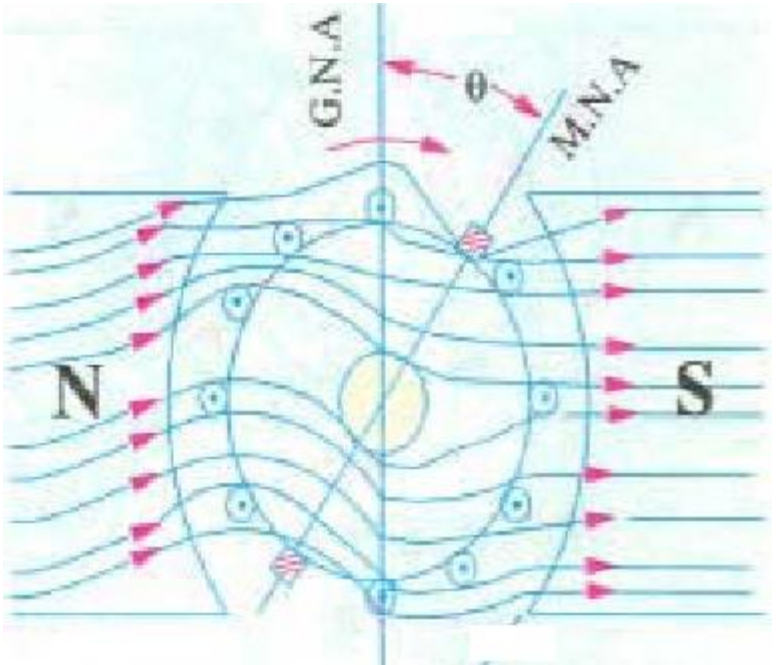
Electrical Machines

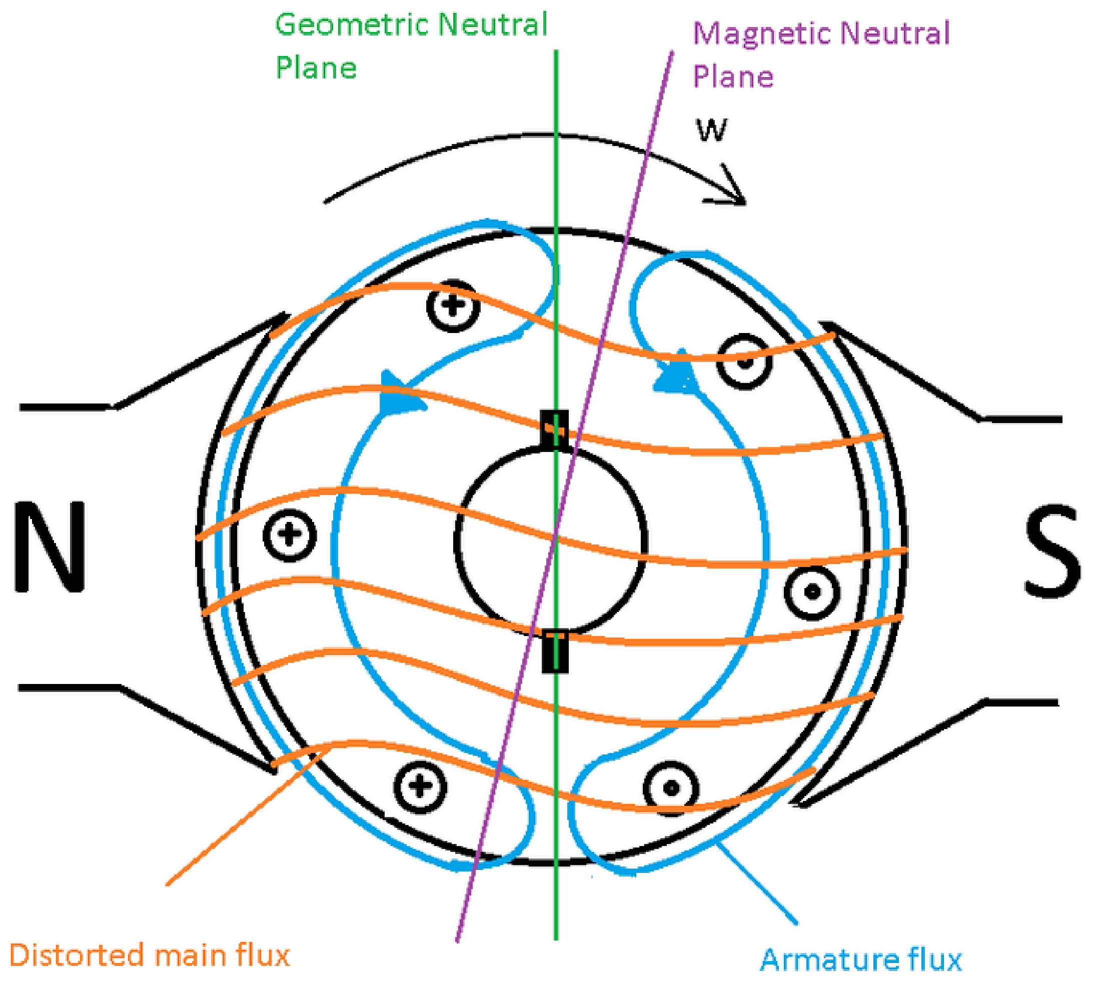
Lecture # 6

Dr Atiqur Rahman

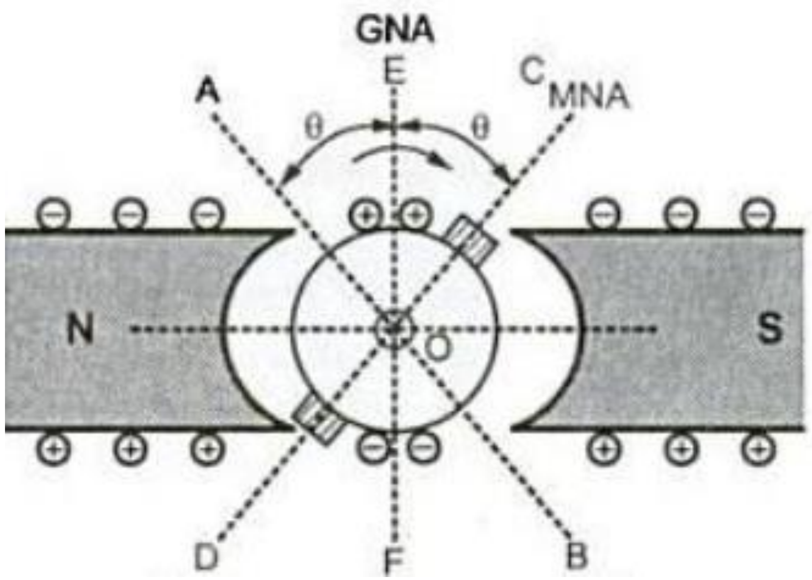
Resultant Flux

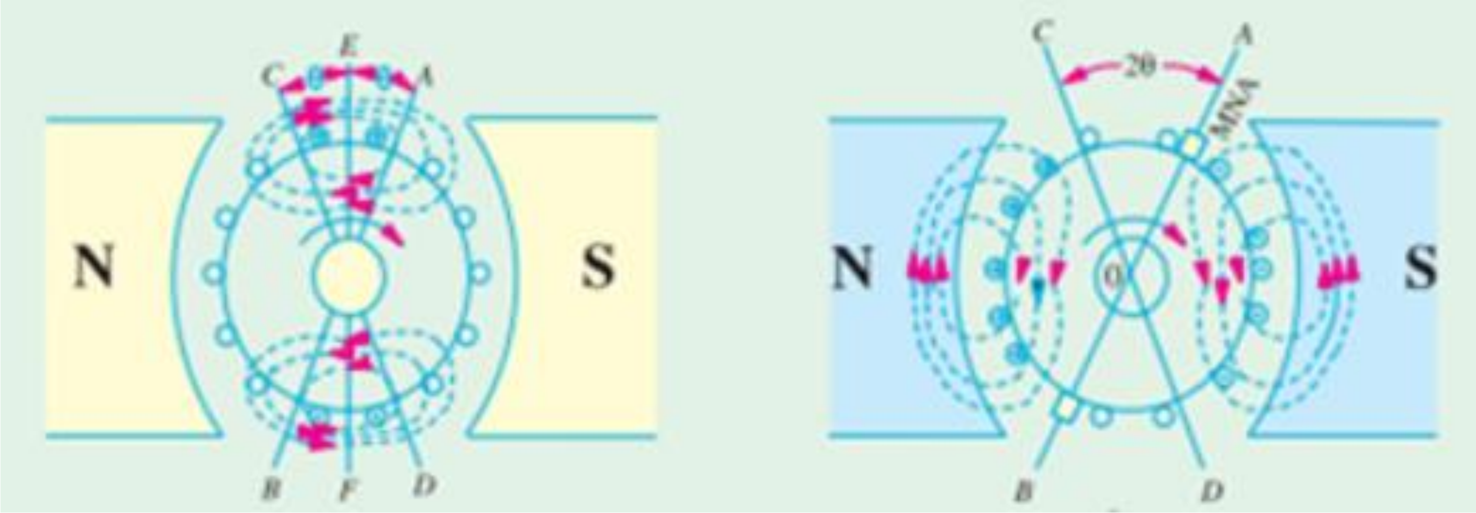






Demagnetizing & Cross-magnetizing conductors





Demagnetizing Effect

Let

Z = Total number of armature conductors

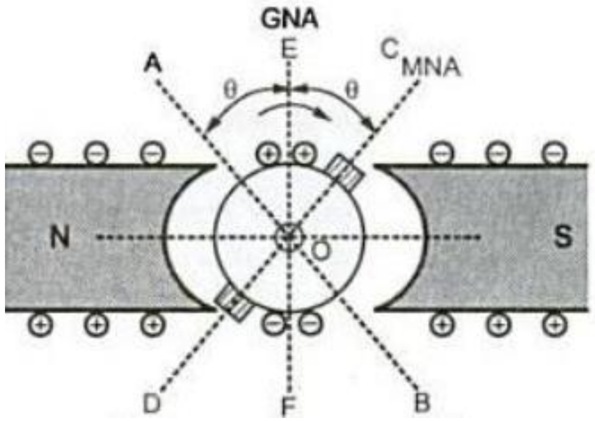
P = Number of poles

I = Armature conductor current in Amperes

= $I_a/2$ for simplex wave winding

= I_a/P for simplex lap winding

θ_m = Forward lead of brush in mechanical degrees.



Total number of armature conductors lying in angles AOC and BOD $= \frac{4\theta_m}{360} \times Z$

Since two conductors from one turn, Total number of turns in these angles $= \frac{1}{2} \cdot \frac{4\theta_m}{360} \times Z = \frac{2\theta_m}{360} \times Z$

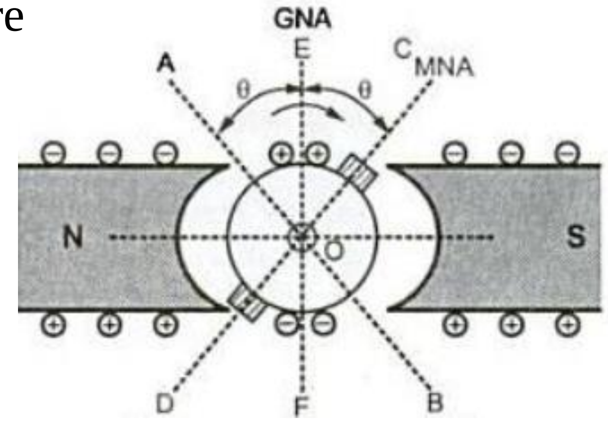
$$\text{Demagnetising amp-turns} = \frac{2\theta_m}{360} \times IZ$$

$$\text{Demagnetising amp-turns / pole} = \frac{\theta_m}{360} \times IZ$$

$$\boxed{AT_d \text{ per pole} = ZI \times \frac{\theta_m}{360}}$$

Cross-magnetizing Effect

The conductor which are responsible for cross magnetizing ampere turns are lying between the angles AOD and BOC, as shown in the Fig.



Total armature-conductors / pole = Z/P

$$\text{Demagnetising conductors / pole} = Z \cdot \frac{2\theta_m}{360}$$

$$\text{Cross magnetising conductors/pole} = \frac{Z}{P} - Z\frac{2\theta_m}{360} = Z\left[\frac{1}{P} - \frac{2\theta_m}{360}\right]$$

$$\text{Cross magnetising amp-conductors / pole} = ZI\left[\frac{1}{P} - \frac{2\theta_m}{360}\right]$$

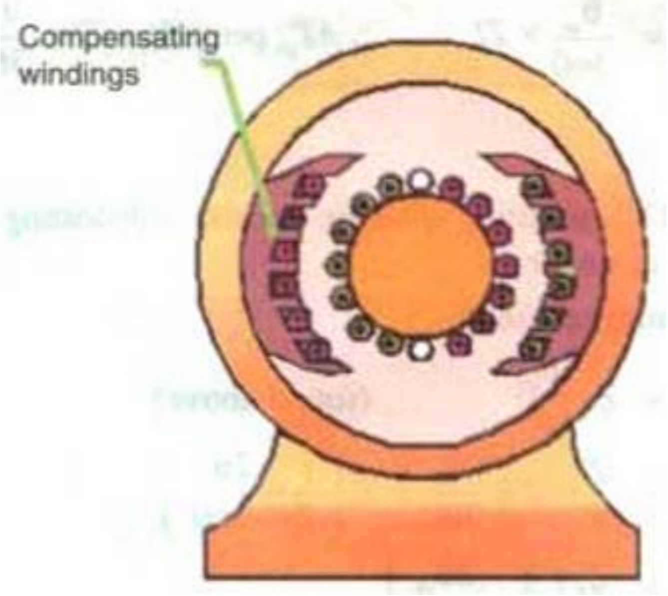
Since two conductors from one turn,

$$\text{Cross magnetising amp-turns / pole} = \frac{1}{2} \cdot ZI\left[\frac{1}{P} - \frac{2\theta_m}{360}\right] = ZI\left[\frac{1}{2P} - \frac{\theta_m}{360}\right]$$

$$\boxed{AT_c \text{ per pole} = ZI\left[\frac{1}{2P} - \frac{\theta_m}{360}\right]}$$

Remedy for De/Cross-Magnetizing Effect

- ✓ Demagnetizing effect ⇒ Additional field turns
- ✓ Cross-Magnetizing effect ⇒ Compensating winding



Compensating winding

Compensating Winding (CW)

- Windings are embedded in slots in the pole shoe and are connected in series with the armature.
- Used for large DC machines which are subject to large fluctuations in load.
- In the absence of compensating winding, the flux will be shifting forward and backward with every change in load.
- This change in flux causes statically induced emf in armature coil and thus results in sparking between commutator segments.

Problem # 1

A 4-pole generator has a wave-wound armature with 722 conductors, and it delivers 100 A on full load. If the brush lead is 8°, calculate the armature demagnetising and cross-magnetising ampere turns per pole.

$$I = I_a/2 = 100/2 = 50\text{A};\ Z = 722;\ \theta_m = 8°$$

$$\text{AT}_d / \text{pole} = ZI.\frac{\theta_m}{360} = 722 \times 50 \times \frac{8}{360} = 802$$

$$\text{AT}_c / \text{pole} = ZI.\left(\frac{1}{2\,P} - \frac{\theta_m}{360}\right)$$

$$= 722 \times 50\left(\frac{1}{2 \times 4} - \frac{8}{360}\right) = 3718$$

Problem # 2

An 8-pole generator has an output of 200 A at 500 V, the lap-connected armature has 1280 conductors, 160 commutator segments. If the brushes are advanced 4-segments from the no-load neutral axis, estimate the armature demagnetizing and cross-magnetizing ampere-turns per pole.

$I = 200/8 = 25\ \text{A},\ Z = 1280,\ \theta_m = 4 \times 360/160 = 9^\circ\ ;\ P = 8$

$\text{AT}_d/\text{pole} = ZI\theta_m/360 = 1280 \times 25 \times 9/360 = 800$

$\text{AT}_c/\text{pole} = ZI\left(\frac{1}{2p} - \frac{\theta_m}{360}\right) = 1280 \times 25\left(\frac{1}{2\times 8} - \frac{9}{360}\right) = 1200$

Problem # 3

A 4-pole generator supplies a current of 143 A. It has 492 armature conductors (a) wave-wound (b) lap-wound. When delivering full load, the brushes are given an actual lead of 10°. Calculate the demagnetising amp-turns/pole. This field winding is shunt connected and takes 10 A. Find the number of extra shunt field turns necessary to neutralize this demagnetisation.

$$Z = 492\ ;\ \theta_m = 10^\circ\ ;\ AT_d/\text{pole} = ZI \times \frac{\theta_m}{360}$$

$$I_a = 143 + 10 = 153\text{ A}\ ;\ I = 153/2 \quad \text{(wave winding)}$$

$$= 153/4 \quad \text{(Lap winding)}$$

(a) $\therefore AT_d/\text{pole} = 492 \times \frac{153}{2} \times \frac{10}{360} = \mathbf{1046\ AT}$

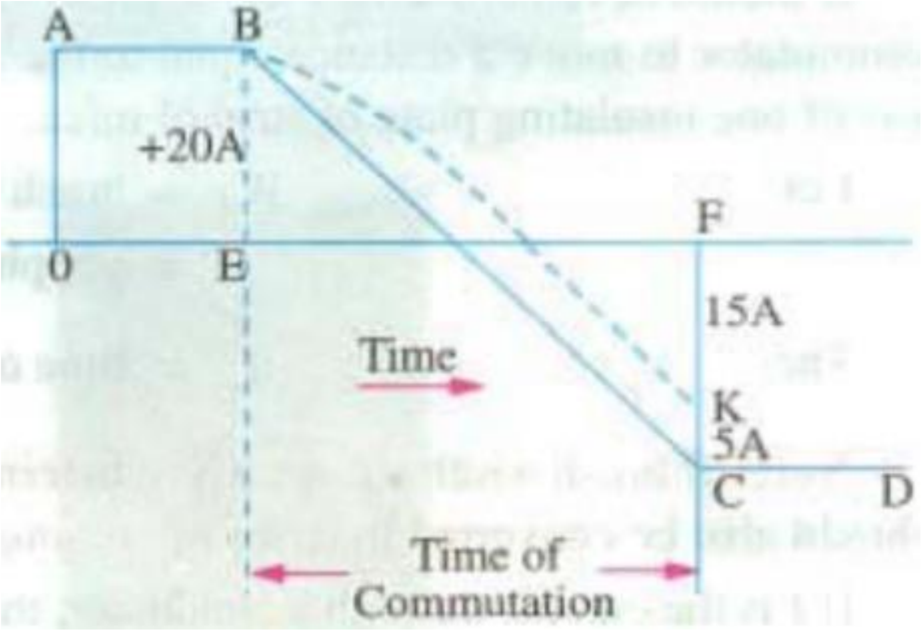
Extra shunt field turns = 1046/10 = **105 (approx.)**

(b) $AT_d/\text{pole} = 492 \times \frac{153}{2} \times \frac{10}{360} = \mathbf{523}$

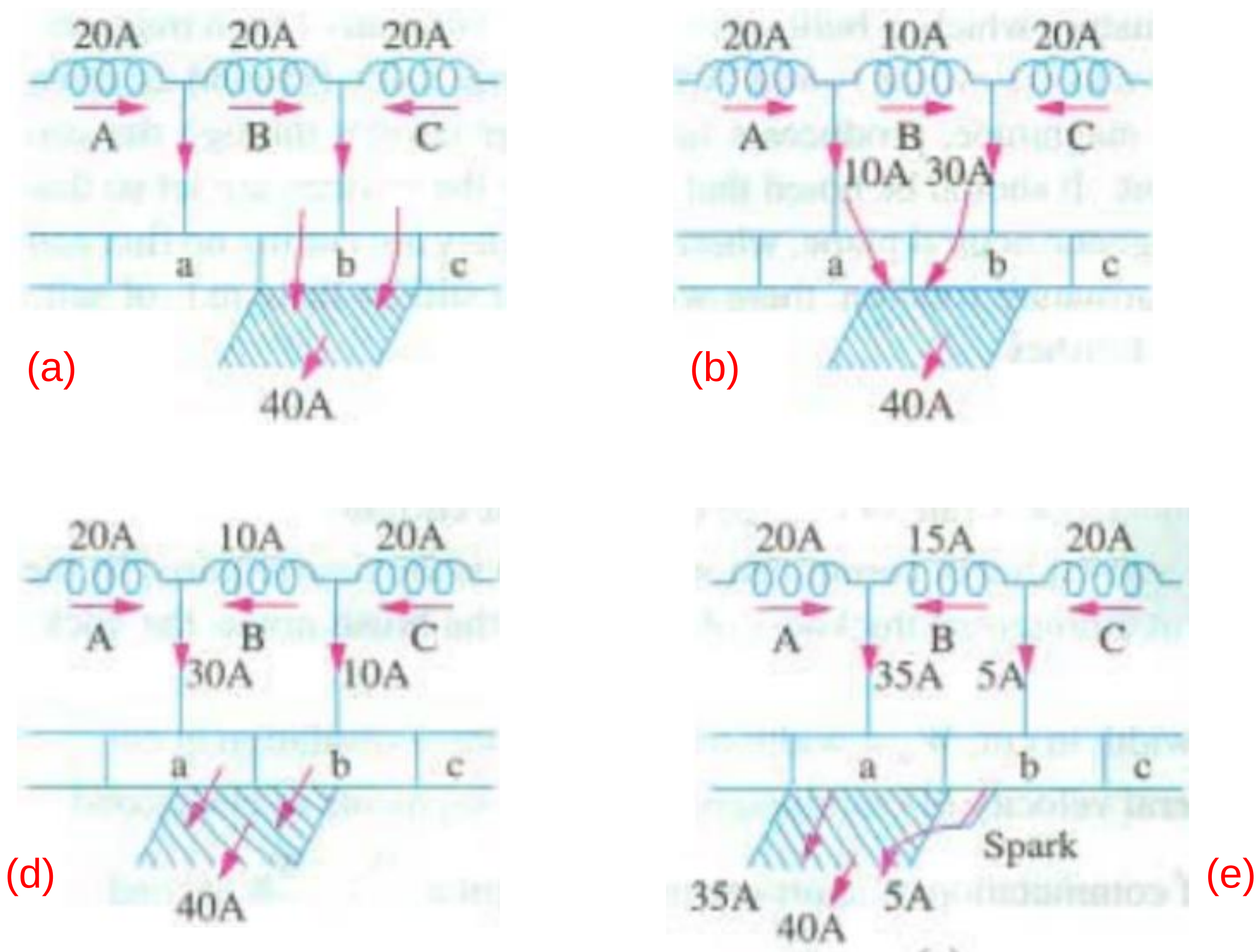
Extra shunt field turns = 523/10 = **52 (approx.)**

Problem in Commutation

- ✓ The process by which the current in the short circuited coil is reversed while it crosses the MNA is called commutation.
- ✓ Time taken to complete the process is called commutation period.
- ✓ If current reversal is not complete by that time, sparking occurs between brush and commutator segment



Commutation problem demonstration



Cause of Commutation problem

- ✓ Self induced emf in the armature coil that prevents currents from reversing on time.
- ✓ Or, the inductive property of the armature coil prevents current from reversing.

Techniques to improve commutation

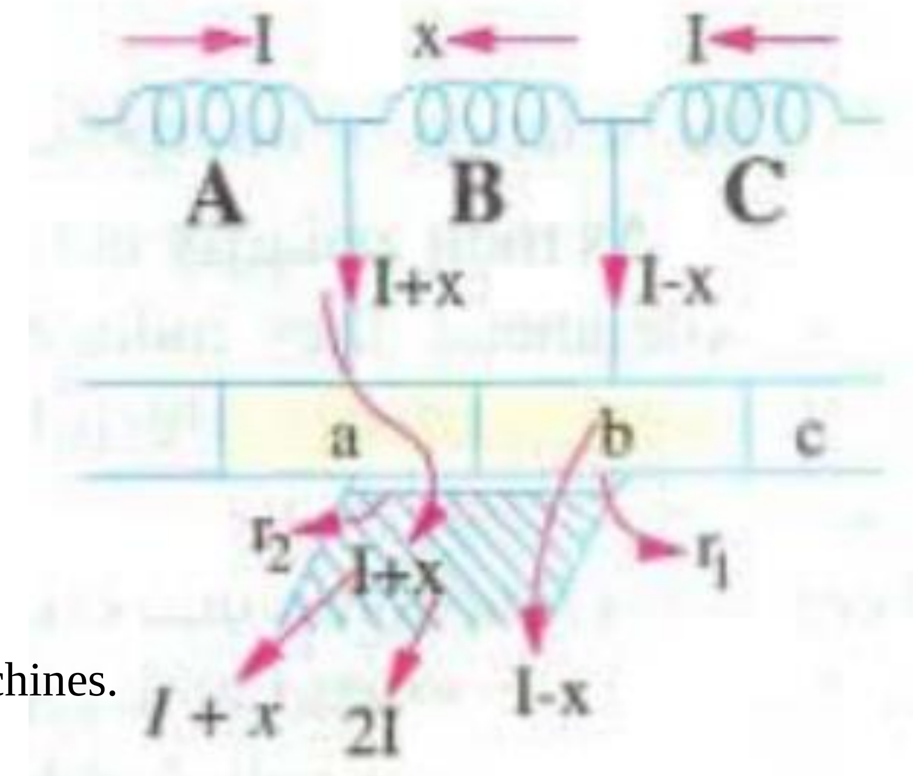
i. Resistance commutation

ii. EMF commutation

Resistance commutation

- This method of improving commutation involves replacing

  low resistance Cu brush with high-resistance Carbon brush.



Additional advantage

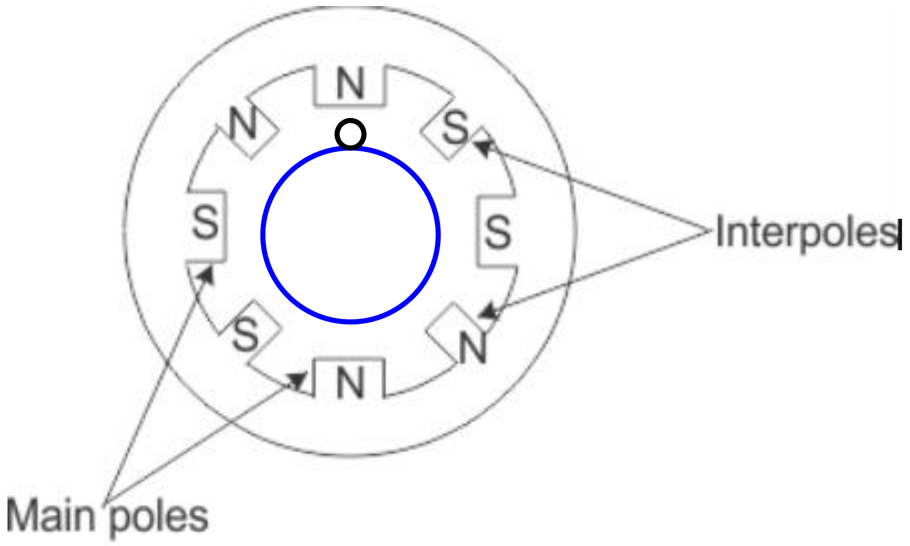
- ✓ Self-lubricating to some degree.
- ✓ Should sparking occurs they damage commutator less

Disadvantage

- Due to high resistance they are not suitable for smaller machines.
- Commutator has be made somewhat larger.
- Need larger brush holder

EMF Commutation

- Involves inserting smaller poles (called Interpoles) in between the main poles.
- Their job is to start the current reversal process a bit earlier.
- Interpoles are also called Compoles.



Interpole Commutation