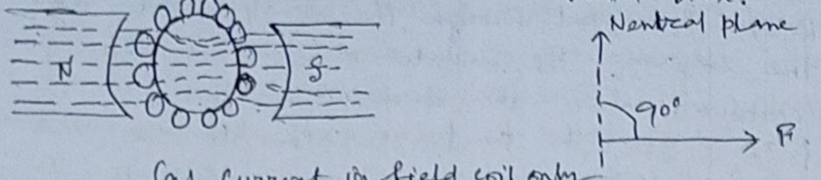
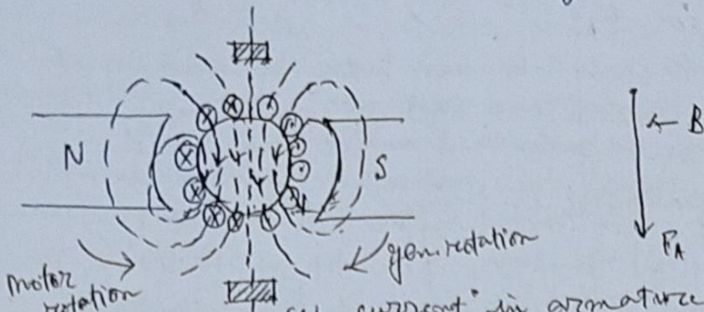
Armature reaction in D.C generators:-

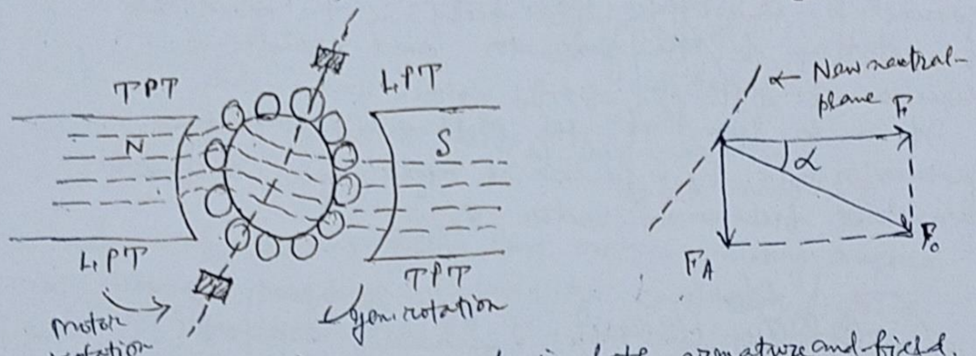
Armature reaction is the effect of flux produced by the armature current on the main field flux.



(a) current in field coil only



(b) current in armature only



(c) current in both armature and field.

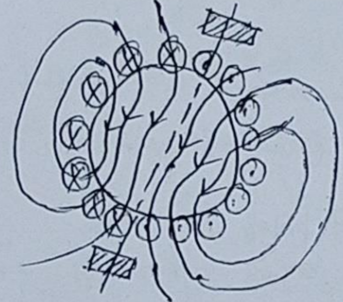
Effect of armature reaction on field of generator

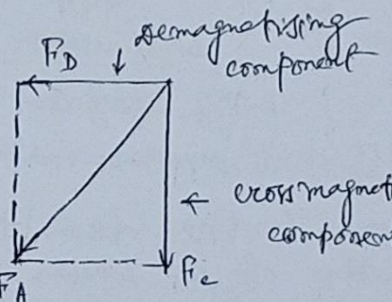
Fig.(a)- shows the flux from the field poles through the armature of a bipolar generator when there is no current in the armature conductors. This flux is produced entirely by the ampere turns of the field. It is distributed symmetrically with respect to the polar axis, that is the centre line of N and S poles. The neutral plane, which is a plane perpendicular to the direction of the flux, coincides with the geometrical neutral of the system. Vector F represents the magnitude and direction of the mmf producing this flux.

Fig. (b) - Shows the armature conductors carrying current with no currents in field coils. The current flows in the same direction in all the conductors lying under one pole. The mmf's of these conductors combine to send flux downward through the armature, as shown in the diagram. The direction of flux is determined by corkscrew rule. The direction of this flux is perpendicular to the polar axis. The armature mmf. is represented in magnitude and direction by a vector F_A.

Fig. (c) - Shows the result obtained when the field current and the armature current are acting simultaneously which occurs when the generator is under load. The armature m.m.f. crowds (concentrates) the symmetrical field flux shown in fig. (a), in to the upper pole tip in the N-pole and in to the lower pole tip in the S pole. It may be observed that the effect of armature reaction current is to displace the field in the direction of rotation of the generator and against the direction of rotation of the motor.

It can be seen that the field mmf. F_I and the armature mmf. F_A - combine at right angles to form the resultant field mmf. vector F_0.



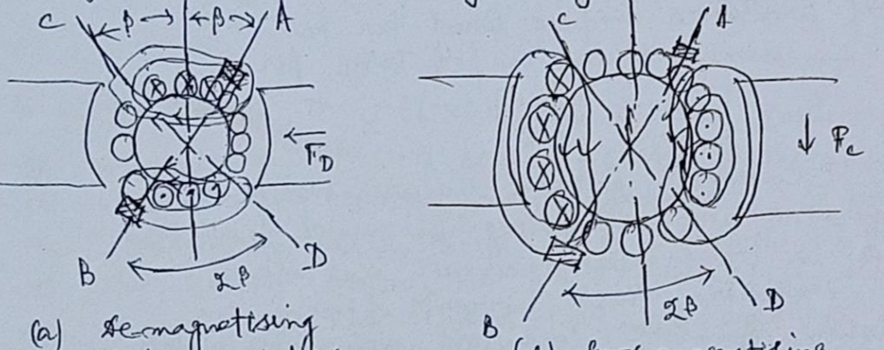


(d)

As the resultant flux is shifted by an angle α in the direction of rotation of the armature, the neutral plane is also shifted by an angle α. As the brushes have to be set in the neutral plane for better commutation, the brush axis is also shifted by an angle α, in the direction of rotation of the armature. Fig. (d) - shows the direction of current in the armature due to the shift of brush axis and also the resultant armature m.m.f.

The direction of armature field moves with the brushes. Its axis always lies along the brush axis. F_A - may be resolved into two components, F_D - parallel to the polar axis and F_C - perpendicular to this axis. F_D - acts in direct opposition to F_1 the main field. Therefore, it tends to reduce the total flux and is called demagnetising component of the armature reaction. F_C - acts at right angles to F_1 producing distortion and is called the cross-magnetising component of the armature reaction.

Demagnetising and cross magnetising ~~Ampere-turns~~ Ampere-turns :-



(a) De-magnetising Ampere conductors

(b) Cross-magnetising Ampere conductors

The nature of de-magnetising and cross-magnetising ampere turns can be readily calculated by considering the above figure. If the brush ~~lead~~ lead is β° (electrical), then the direction of currents in the band of conductors between the lines AB and CD in the interpolar zones, spread over $2\beta^\circ$ at the top and ~~bottom~~ bottom of the armature, is such as to produce a flux opposing the pole flux, the rest of conductors carrying current produce only cross magnetising effect.

Let, Z = Total no. of conductors in the armature

P = No. of poles

β° = Brush lead in electrical degrees.

$\therefore$ Total no. of conductors per pole $= \frac{Z}{P}$.

If I_c - is the current in each armature conductor, the total armature ampere-turns per pole

$$= \frac{1}{2} \times \frac{Z}{P} \cdot I_c.$$

These ampere-turns are spread over one pole pitch (= 180° electrical).

The armature ampere-turns per degree electrical $= \frac{1}{2} \times \frac{Z}{P} \times \frac{I_c}{180}$.

∴ The demagnetising ampere-turns per pole

= Armature ampere turns per degree × 2β

$= \frac{1}{2} \times \frac{Z}{P} \times \frac{I_c}{180} \times 2\beta$

$= \frac{Z}{P} I_c \times \frac{\beta}{180}$ amp-turns.

∴ The cross-magnetising ampere-turns per pole

= Total armature ampere turns per pole − demagnetising ampere-turns per pole

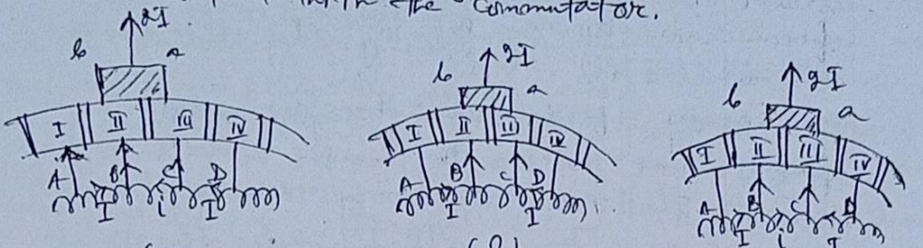
$= \frac{Z}{P} I_c \left[\frac{1}{2} - \frac{\beta}{180} \right]$.

Commutation:— Currents induced in armature conductors of a d.c. generator are alternating. To make their flow unidirectional in the external circuit, we use a commutator. Moreover, these currents flow in one direction when armature conductors are under N-pole and in the opposite direction when they are under S-pole. As conductors pass out of the influence of a N-pole and enter that of S-pole, the current in them is reversed. This reversal of current takes place along magnetic neutral axis or brush axis i.e, when the brush spans and short-circuit that particular coil undergoing reversal of current through it. This process by which current in the short-circuited coil is reversed while it crosses the M.N.A. is called commutation.

To produce efficient commutation, the current in the coil should be completely reversed during the time of short-circuit, and that at the end of this time there would be no difference between the current in the coil and that in the rest of the conductor to be connected with it. This would reduce any tendency towards sparking.

There are two practical ways of improving commutation —
(i) Resistance Commutation (ii) E.m.f. commutation.

(i) Resistance Commutation :- Resistance commutation is effected by the use of carbon brushes which are found to produce a fairly high contact resistance when in contact with the commutator.



(a) (b) (c)

Fig.(a)- Shows the state of affairs just at the commencement of commutation of coil BC. The edge of the brush is just making contact with segment III, so that the circuit of coil III C is closed through the resistance of the brush. Before the brush touched segment III, the current in BC would have been equal to that in the coils on the right hand side of the brush position (coils CD etc), say I amps, passing from C to B. When the brush touched segment III, some of the current from coil CD passes direct to the brush by way of this segment instead of continuing through BC. The current in BC therefore falls. Suppose that the current flowing in the armature coil from C to B is now i amperes, then the current flowing from connection C to segment III is ~~(i+I)~~ (I−i) amps. The current passing from connection B to segment II is (i+I), since a current I amps flows towards the brush through the left hand half of the armature and this combines with the current i amps, flowing from the coil BC.

Fig.(b)- Shows the position when the brush is equally spaced over segments II and III. The currents in coils AB and CD are each I amps, flowing in opposite directions, so that there is no tendency for a current to flow in coil BC and therefore the currents from coils AB and CD.

flow to the commutator by way of the connections B and C respectively. The current in the coil BC is thus zero. Fig. (c) shows the conditions when coil BC is nearing the end of its period of commutation. A large portion of the current from AB will pass through coil BC, since resistance of this path is small. If this current through BC is i amps. and the current from connection C to segment-III and the brush will be (I+i) amps..

Finally, from the foregoing considerations, it appears that when the brush breaks contact with segment-II, the coil BC will carry the full current of I amps. from B to C and therefore, the current in BC will have been completely reversed during the time of short-circuit.

However, effect of self-inductance of coil BC should be considered. A current will still be flowing from B to segment II and to the brush at the instant that the brush breaks contact with segment-II and as is usual when an inductive circuit carrying a current is opened, a self-induced e.m.f. will be set-up and sparking will occur between segment II and the leaving edge of the brush. This sparking is undesirable, since it burns away the commutator segments and the brushes and involves a wasteful dissipation of energy. [Sparking at the brushes which results in poor commutation is due to the inability of the current in the short-circuited coil to reverse completely by the end of short-circuit period.]

(*) short-circuited coil under the influence of next pole of opposite polarity or (ii) by using interpoles.

e.m.f. commutation:— In this method