

4 Armature Windings

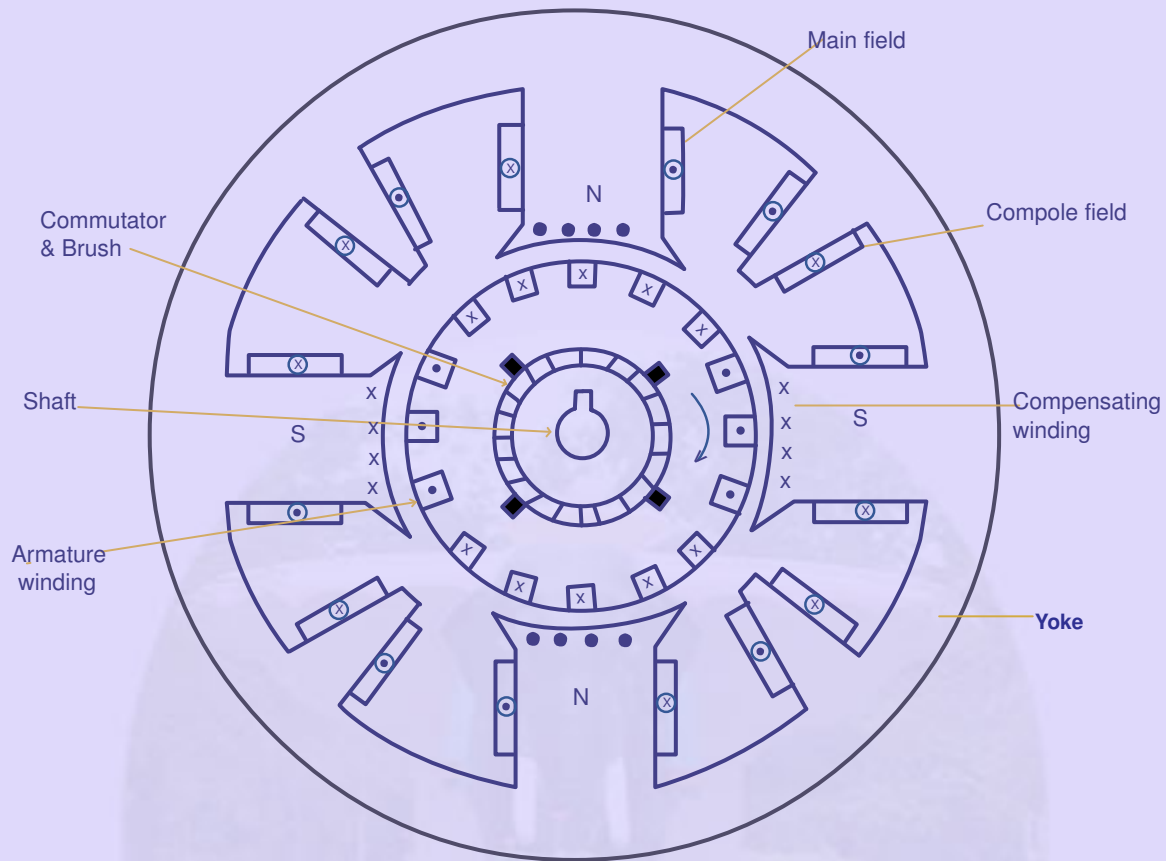


Figure 10: Cross sectional view

Fig. 10 gives the cross sectional view of a modern d.c. machine showing all the salient parts. Armature windings, along with the commutators, form the heart of the d.c. machine. This is where the emf is induced and hence its effective deployment enhances the output of the machine. Fig. 11(a) shows one coil of an armature of Gramme ring arrangement and Fig. 11(b) shows one coil as per drum winding arrangement. Earlier, a simple form of this winding in the form of Gramme ring winding was presented for easy understanding. The Gramme ring winding is now obsolete as a better armature winding has

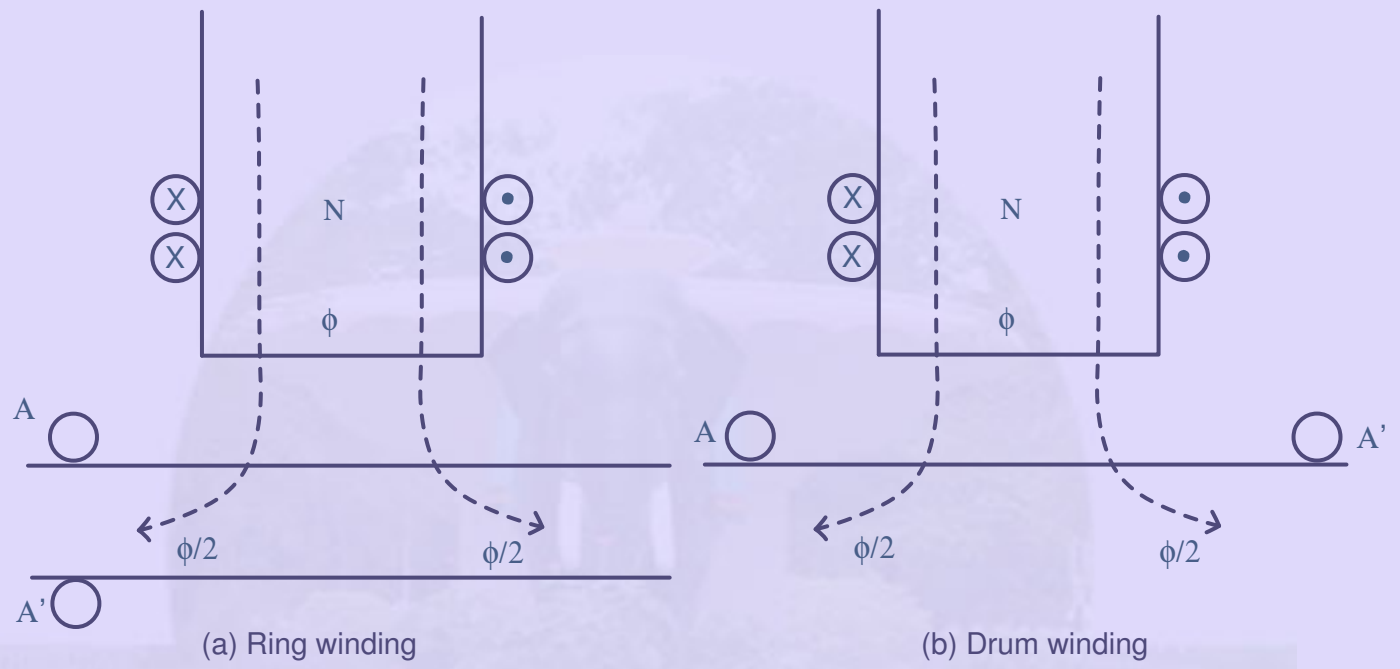


Figure 11: Ring winding and drum winding

been invented in the form of a drum winding. The ring winding has only one conductor in a turn working as an active conductor. The second conductor is used simply to complete the electrical connections. Thus the effectiveness of the electric circuit is only 50 percent. Looking at it differently, half of the magnetic flux per pole links with each coil. Also, the return conductor has to be wound inside the bore of the rotor, and hence the rotor diameter is larger and mounting of the rotor on the shaft is made difficult.

In a drum winding both forward and return conductors are housed in slots cut on the armature (or drum). Both the conductors have emf induced in them. Looking at it differently the total flux of a pole is linked with a turn inducing much larger voltage induced in the same. The rotor is mechanically robust with more area being available for carrying the flux. There is no necessity for a rotor bore. The rotor diameters are smaller. Mechanical problems that existed in ring winding are no longer there with drum windings. The coils could be made of single conductors (single turn coils) or more number of conductors in series (multi turn coils). These coils are in turn connected to form a closed winding. The two sides of the coil lie under two poles one north and the other south, so that the induced emf in them are always additive by virtue of the end connection. Even though the total winding is a closed one the sum of the emfs would be zero at all times. Thus there is no circulating current when the armature is not loaded. The two sides of the coil, if left on the surface, will fly away due to centrifugal forces. Hence slots are made on the surface and the conductors are placed in these slots and fastened by steel wires to keep them in position. Each armature slot is partitioned into two layers, a top layer and a bottom layer. The winding is called as a double layer winding. This is a direct consequence of the symmetry consideration. The distance, measured along the periphery of the armature from any point under a pole to a similar point under the neighboring pole is termed as a pole pitch. The forward conductor is housed in the top layer of a slot and the return conductor is housed in the bottom layer

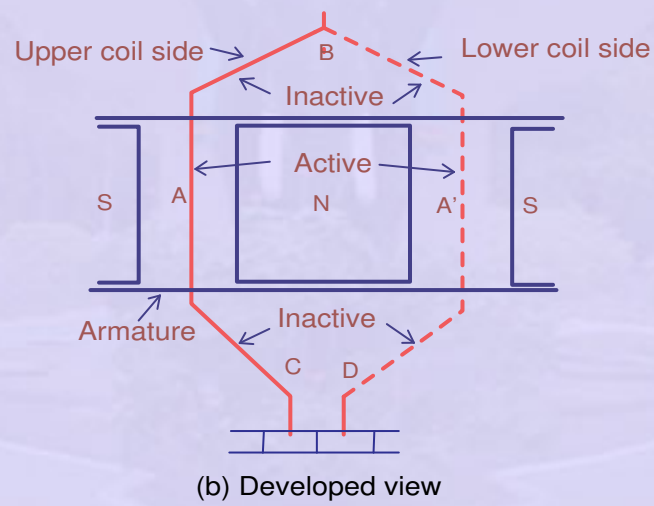
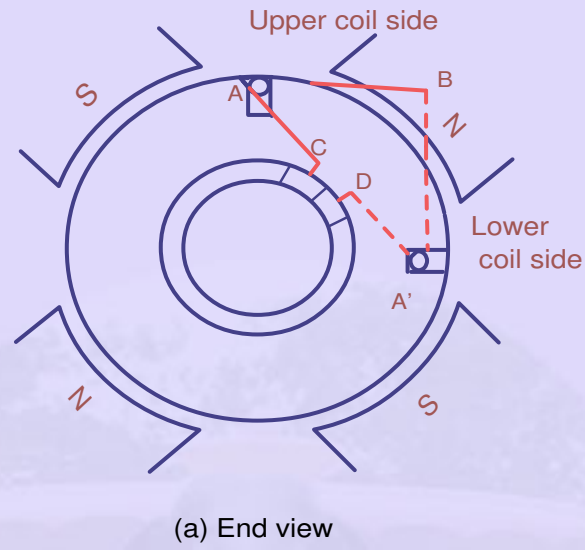


Figure 12: Arrangement of a single coil of a drum winding

of a slot which is displaced by about one pole pitch. The junction of two coils is terminated on a commutator segment. Thus there are as many commutator segments as the number of coils. In a double layer winding in S slots there are $2S$ layers. Two layers are occupied by a coil and hence totally there are S coils. The S junctions of these S coils are terminated on S commutator segments. The brushes are placed in such a manner that a maximum voltage appears across them. While the number of parallel circuits in the case of ring winding is equal to the number of poles, in the case of drum winding a wide variety of windings are possible. The number of brushes and parallel paths thus vary considerably. The physical arrangement of a single coil is shown in Fig. 12 to illustrate its location and connection to the commutators.

Fig. 13 shows the axial side view while Fig. 13-(b) shows the cut and spread view of the machine. The number of turns in a coil can be one (single turn coils) or more (multi turn coils). As seen earlier the sum of the instantaneous emfs appears across the brushes. This sum gets altered by the voltage of a coil that is being switched from one circuit to the other or which is being commutated. As this coil in general lies in the magnetic neutral axis it has a small value of voltage induced in it. This change in the sum expressed as the fraction of the total induced voltage is called as the ripple. In order to reduce the ripple, one can increase the number of coils coming in series between the brushes. As the number of coils is the same as the number of slots in an armature with two coil sides per slot one is forced to increase the number of slots. However increasing the slot number makes the tooth width too narrow and makes them mechanically weak.

To solve this problem the slots are partitioned vertically to increase the number of coil sides. This is shown in Fig. 14. In the figure, the conductors a, b and c belong to a coil. Such $2/3$ coils occupy the $2/3$ top coil sides of the slot. In the present case the number of coils in the armature is $2S/3S$.

