D.c Machine Windings

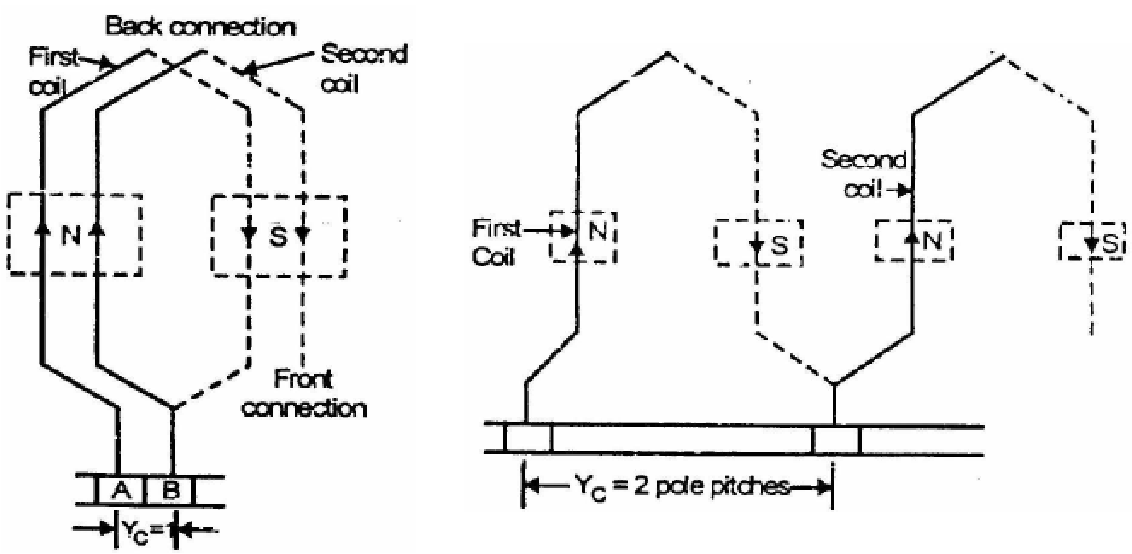
3.1 Introduction :-

As shown in chapter 2, the armature composed slots carrying two layers of conductors. These bundled conductors are connected to each other and to the commutator segment in a certain way such that, the machine can use them totally and in the hall time of rotation.

In machine winding we have two main types of windings these are (a***) lap winding***. (b) ***Wave winding*** as shown in figure (3-1).

In each type three are two modes (Progressive and Retrogressive).

In the following only the simplex, two layers types will be discussed in order to declare the main ideas.



Simplex lap winding Simplex wave winding

. Figure (3-1)

3.2 *Definitions and Rules:-*

Pole pitch (τ) : is the region affected by the pole as shown in figure (3-2.

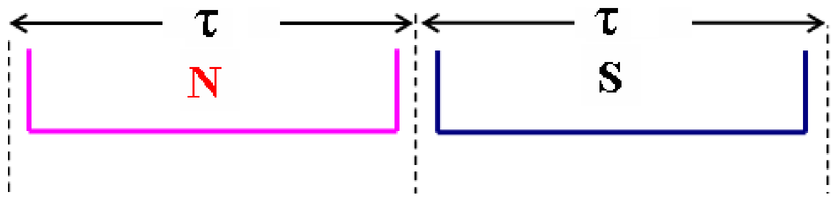


Figure (3-2)

Coil: is a winding of wire composed of many turns with two common terminals only.

Number of Brushes = Number of Poles (P).

Number of commutator segments = Number of Slots S

pole pitch $\tau = \dfrac{S}{P}$ slot.

Distance between brunches = τ as shown in figure (3-3).

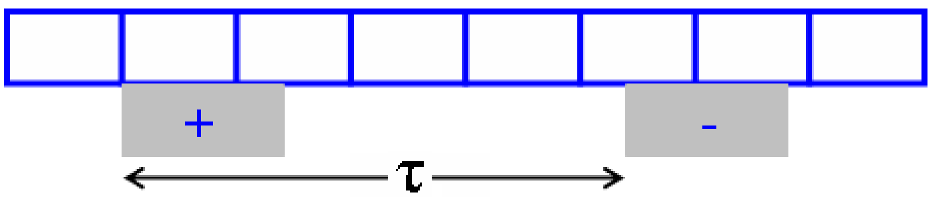


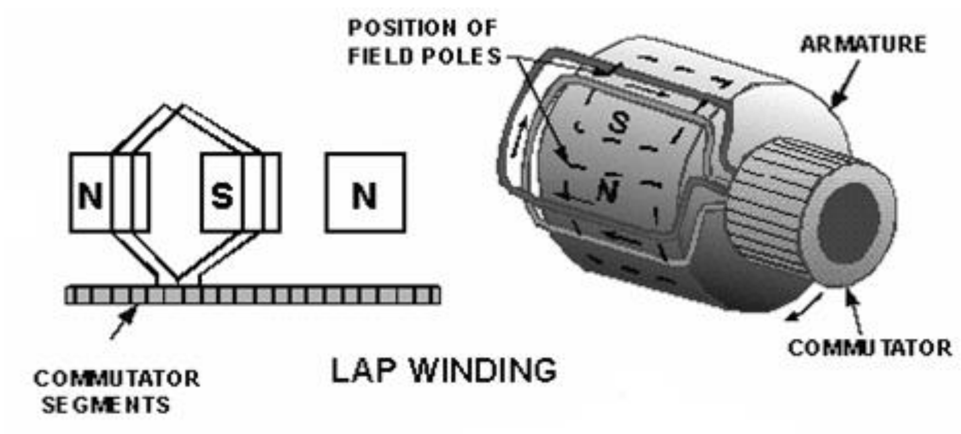
Figure (3-3)

Back Pitch (y_b) : It is the distance measured in number of slots between the back ends of the coil.

Front Pitch (y_f) : It is the distance between the end of the coil and the beginning of the follower coil from the front side of the armature.

Commutator Pitch (***y_c***) : it is the distance between the beginning of each cascaded two coils.

The pitches (***y_b***), (***y_f***) , and (***y_c***) are shown in figure (3-4) and figure (3-4)



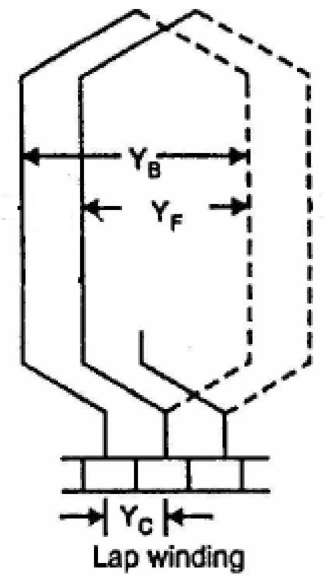


Figure (3-4)

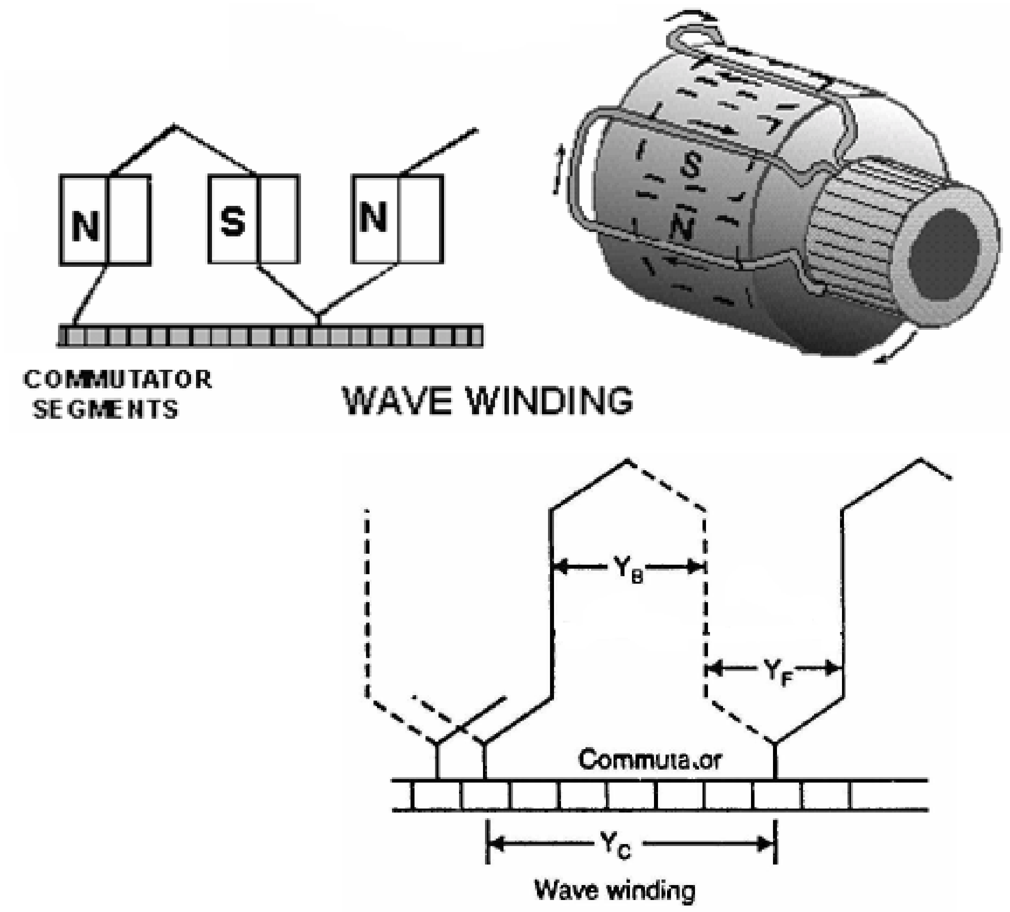


Figure (3-5)

Lap Winding

This type of winding used to achieve low voltage high current d-c generator or low voltage high torque d-c motor, as will be shown.

In lap winding

$$y_b = \left|\frac{S}{P}\right| = |\tau|$$

$$y_c = \mp 1$$

$$y_f = y_b - y_c$$

Example : Draw a developed diagram of armature in a 4-pole d-c machine lap winded (Progressive) (two layers), knowing that number of slots = 17. Draw also the equivalent armature circuit and the sequence diagram of the armature. Assigne the direction of currents when operates as a motor.

$S=17$, $P=4$

$\tau = \frac{S}{P} = 4.25$

$y_c=1$

$y_b=|\tau|=4$, $y_c=1$

$y_f = 4-1 = 3$

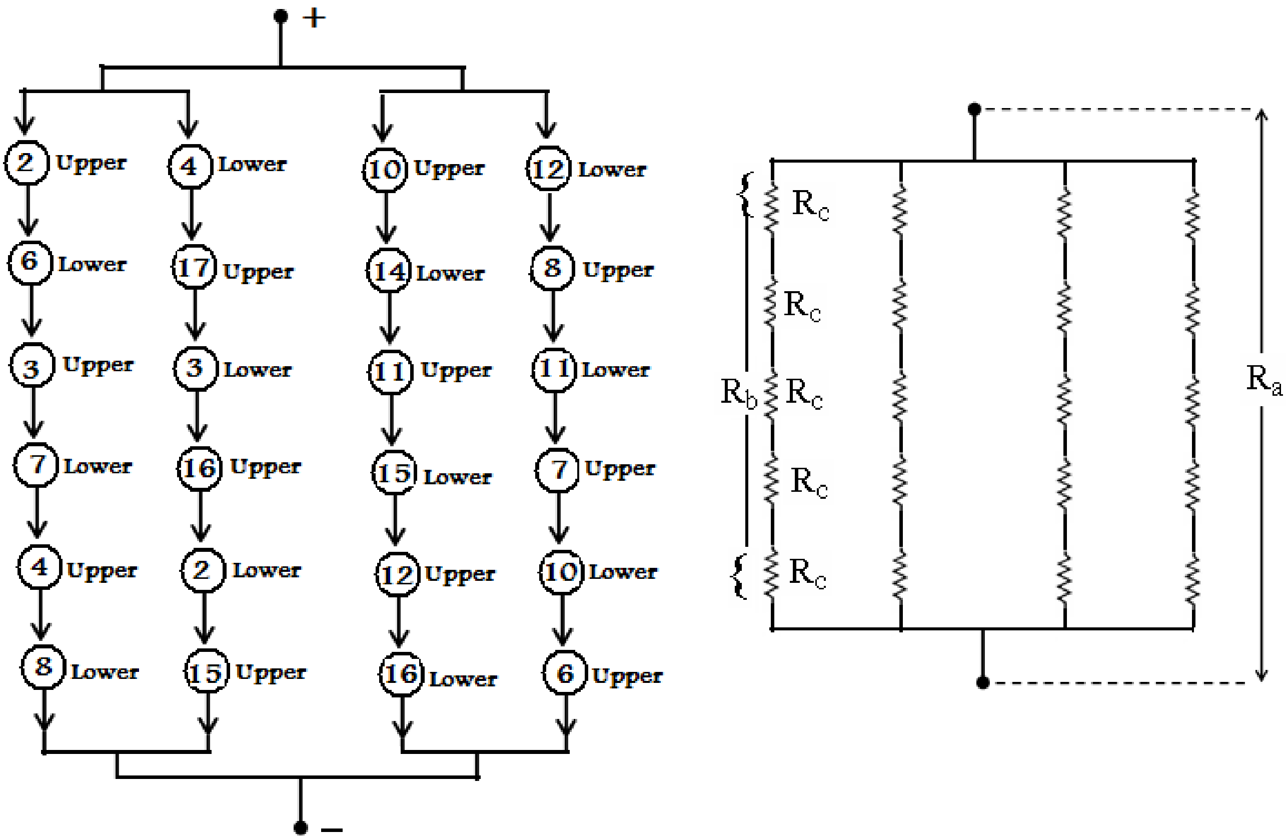


Figure (3-7) Equivalent circuit

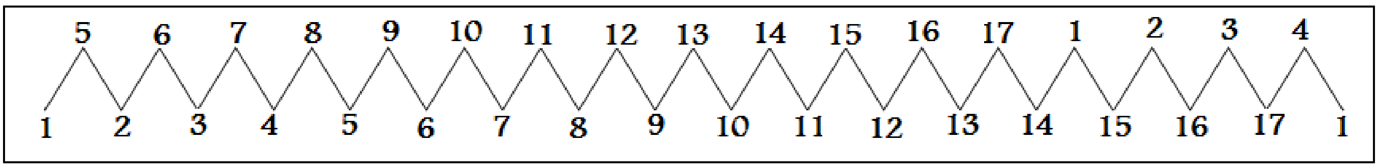


Figure (3-8) Sequence Diagram

4 Discussion of Lap Winding

Fig. (3.6) show this winding clearly, it is a progressive type of winding. Many important results and procedures should be considered as follows :-

- The direction of current shown in figure represent a motor operation. This motor will be rotated CCW due to application of R.H.R. You have to study the generator currents !!
- The brush width = 1.5 commutator segment. The brush position should be such as to be connected to the commutator segment which is connected to coil sides laying in slots exists at the interpole regions (as near as possible to the Magnetic Natural Axis "M.N.A").
- Fig. (3.7) represents the current distribution inside the armature in order to understand the machine operation and to draw the armature equivalent circuit. This circuit represents that the armature is divided into four parallel paths or branches, each contains equal number of coil sides connected in series and the branches are connected in parallel so it leads to :

a-The machine voltage is the branch voltage

or $V_t = V_b$

where V_t = terminal voltage, & V_b = branch voltage

b-The armature rated current "which is the motor or generator rated current", equal to the sum of the branch currents (I_b). But, it is clear that number of parallel branches equal to the number of poles. Hence $I_a = p.I_b$ Where I_a = armature current c-The armature resistance can be calculated as

$$R_a = \frac{R_b}{P}$$

Since (a) represents the number of parallel branches in the armature then (a=p) in such a type of winding.

d- Fig. (3.8) represents the "Sequens Diagram" which is usefull during machine winding.

e-The retrogressive winding can easily be drawn by choosing y_c= -1.

3.5 Wave winding

The type of winding is useful in case of generating high voltage low current using the same armature previously winded by lap winding as will be shown later. In this type

$$y_b = \left|\frac{S}{P}\right| = |\tau|$$

$$y_c = 2\left(\frac{S \mp 1}{P}\right) \qquad \begin{array}{ll} + & \text{for progressive} \\ - & \text{for retrogressive-} \end{array}$$

$$y_f = y_c - y_b$$

Hence for 4-pole, 17 slots machine, progressive wave

Fig. (3-9) and fig. (3-10) show the winding completely (the developed diagram, sequence diagram, and equivalent circuit). From the equivalent circuit it is clear that there is only two parallel branches whatever the number of poles is, and the voltage of the generator increased about twice that of the lap in this case (only). This means that the output power is constant in both cases.

Figure (3-9) Devloped Diagram

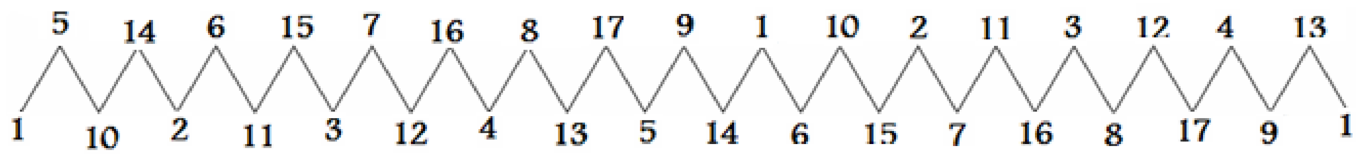


Figure (3-10a) Sequence Diagram

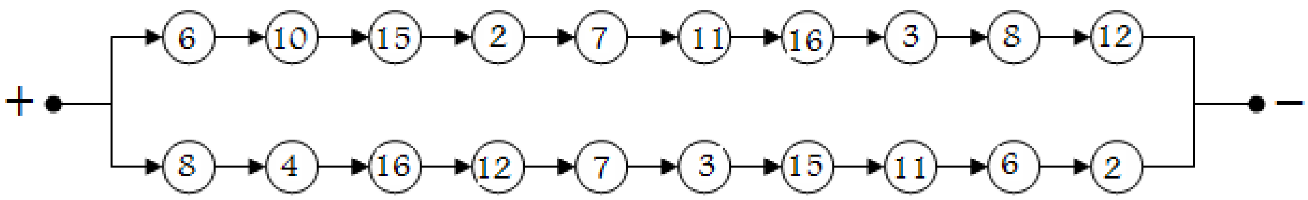


Figure (3-10b) Equivalent circuit