Types of D.C. Armature Windings

The different armature coils in a d.c. armature Winding must be connected in series with each other by means of end connections (back connection and front connection) in a manner so that the generated voltages of the respective coils will aid each other in the production of the terminal e.m.f. of the winding. Two basic methods of making these end connections are:

1. Simplex lap winding
2. Simplex wave winding

1. Simplex lap winding.

For a simplex lap winding, the commutator pitch YC = 1 and coil span YS ~ pole pitch. Thus the ends of any coil are brought out to adjacent commutator segments and the result of this method of connection is that all the coils of the armature .ire in sequence with the last coil connected to the first coil. Consequently, closed circuit winding results. This is illustrated in Fig. (1.21) where a part of the lap winding is shown. Only two coils are shown for simplicity. The name lap comes from the way in which successive coils overlap the preceding one.

2. Simplex wave winding

For a simplex wave winding, the commutator pitch YC ~ 2 pole pitches and coil span = pole pitch. The result is that the coils under consecutive pole pairs will be joined together in series thereby adding together their e.m.f.s [See Fig. 1.22]. After passing once around the armature, the winding falls in a slot to the left or right of the starting point and thus connecting up another circuit. Continuing in this way, all the conductors will be connected in a single closed winding. This winding is called wave winding from the appearance (wavy) of the end connections.

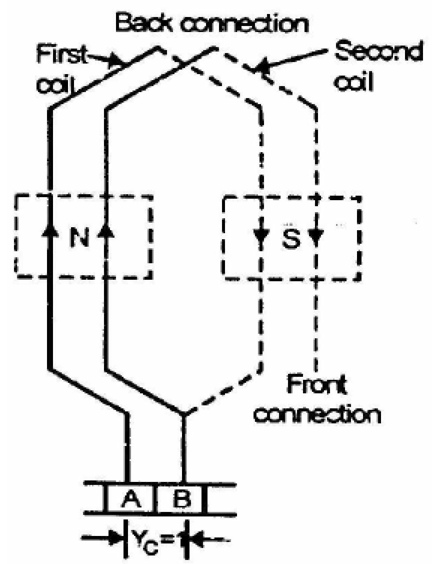


Fig. (1.21)

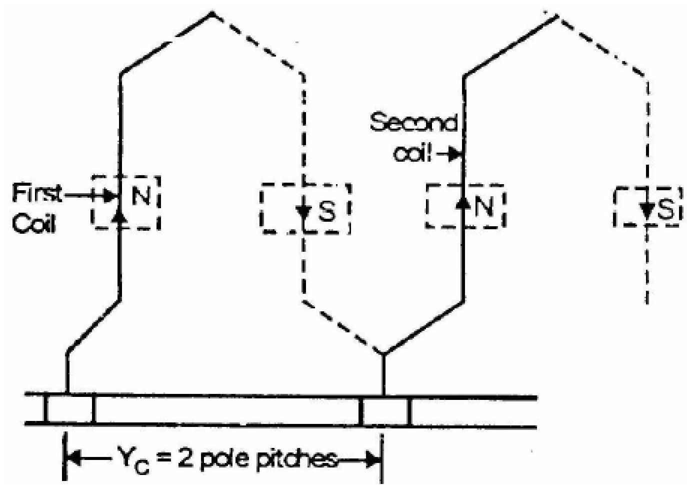


Fig. (1.22)

(i) Back Pitch (Y_B)

It is the distance measured in terms of armature conductors between the two sides of a coil at the back of the armature (See Fig. 1.23). It is denoted by Y_B For example, if a coil is formed by connecting conductor 1 (upper conductor in a slot) to conductor 12 (bottom conductor in another slot) at the back of the armature, then back pitch is $Y_B = 12 - 1 = 11$ conductors.

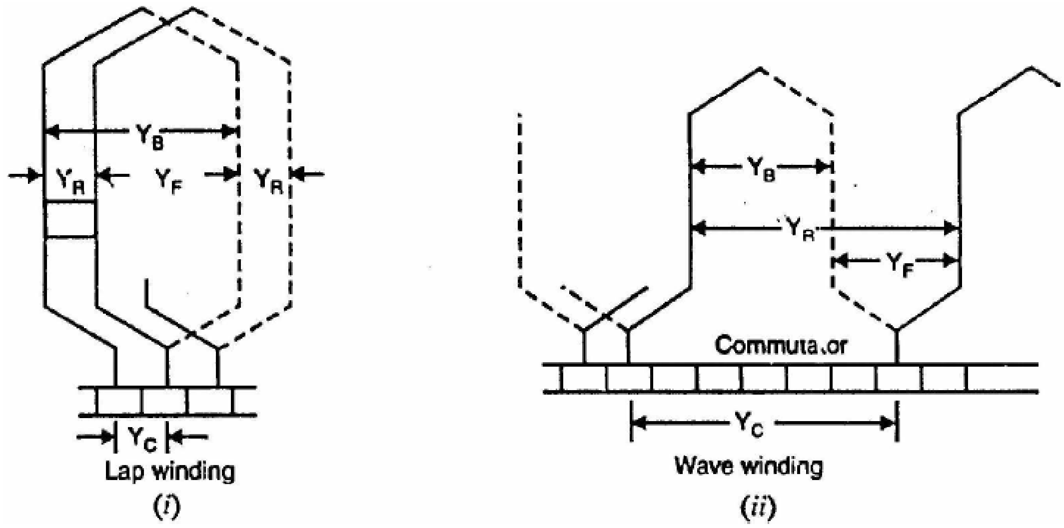


Fig. (1.23)

(ii) Front Pitch (Y_F)

It is the distance measured in terms of armature conductors between the coil sides attached to any one commutator segment [See Fig. 1.23]. It is denoted by YF For example, if coil side 12 and coil side 3 are connected to the same commutator segment, then front pitch is YF = 12 - 3 = 9 conductors.

(iii) Resultant Pitch (YR)

It is the distance (measured in terms of armature conductors) between the beginning of one coil and the beginning of the next coil to which it is connected (See Fig. 1.23). It is denoted by YR. Therefore, the resultant pitch is the algebraic sum of the back and front pitches.

(iv) Commutator Pitch (YC)

It is the number of commutator segments spanned by each coil of the armature winding. For simplex lap winding, YC = 1 For simplex wave winding, YC ~ 2 pole pitches (segments)

(v) Progressive Winding

A progressive winding is one in which, as one traces through the winding, the connections to the commutator will progress around the machine in the same direction as is being traced along the path of each individual coil. Fig. (1.24) (i) shows progressive lap winding. Note that YB > YF and YC = + 1.

(vi) Retrogressive Winding

A retrogressive winding is one in which, as one traces through the winding, the connections to the commutator will progress around the machine in the opposite direction to that which is being traced along the path of each individual coil. Fig. (1.24) (ii) shows retrogressive lap winding. Note that YF > YB and YC = - 1. A retrogressive winding is seldom used because it requires more copper.

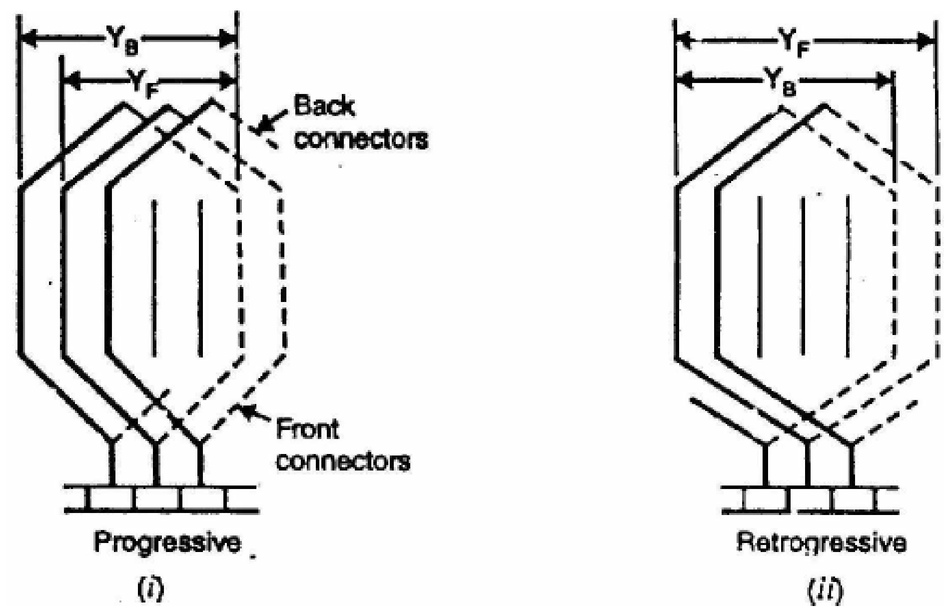


Fig. (1.24)

General Rules For D.C. Armature Windings

In the design of d.c. armature winding (lap or wave), the following rules may be followed:

(i) The back pitch (YB) as well as front pitch (YF) should be nearly equal to pole pitch. This will result in increased e.m.f. in the coils.

(ii) The number of commutator segments is equal to the number of slots or coils (or half the number of conductors). No. of commutator segments = No. of slots = No. of coils It is because each coil has two ends and two coil connections are joined at each commutator segment

(ii) The winding must close upon itself i.e. it should be a closed circuit winding.

Summary type armature winding

1. Lap Winding

- **Connection:** The end of each coil is connected to the **adjacent commutator segment**.
- **Number of parallel paths (A):** Equal to the number of poles (**A = P**).
- **Used for: Low-voltage, high-current** machines.
- **Types:**
  - **Simplex lap winding**
  - **Duplex or multiplex lap winding** (for more parallel paths)

Example:
If a DC generator has 4 poles, it will have 4 parallel paths in the armature.

2. Wave Winding

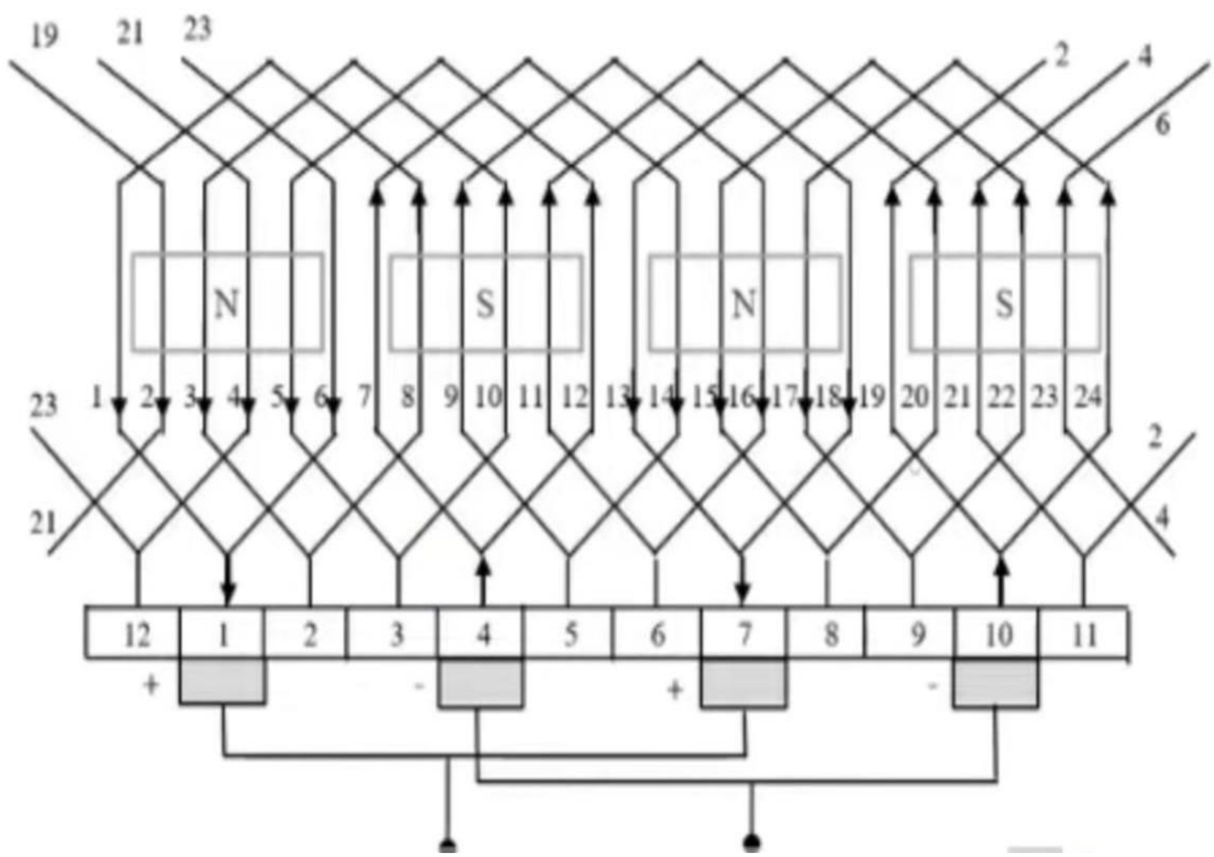
- **Connection:** The end of each coil is connected to a **commutator segment about two poles apart**.
- **Number of parallel paths (A):** Always **2**, regardless of the number of poles.
- **Used for: High-voltage, low-current** machines.
- **Types:**
  - **Simplex wave winding**
  - **Multiplex wave winding** (for more parallel paths if needed)

Example:
A 4-pole or 6-pole wave-wound generator will still have 2 parallel paths.

Summary Table

Type of Winding	Parallel Paths (A)	Suitable for	Connection Type	Typical Use
Lap Winding	A = P	Low Voltage, High Current	Adjacent segments	DC Generators
Wave Winding	A = 2	High Voltage, Low Current	Distant segments (two pole pitches apart)	DC Generator

1. Simplex lap winding.



Conclusions

From the above discussion, the following conclusions can be drawn:

(i) The total number of brushes is equal to the number of poles.

(ii) The armature winding is divided into as many parallel paths as the number of poles. If the total number of armature conductors is Z and P is the number of poles, then,

$$\text{Number of conductors/path} = Z/P$$

In the present case, there are 40 armature conductors and 4 poles. Therefore, the armature winding has 4 parallel paths, each consisting of 10 conductors in series.

(iii) E.M.F. generated = E.M.F. per parallel path

$$= \text{average e.m.f. per conductor} \times \frac{Z}{P}$$

(iv) Total armature current, $I_a = P \times$ current per parallel path

(v) The armature resistance can be found as under:

Let ℓ = length of each conductor; a = cross-sectional area

A = number of parallel paths = P for simplex lap winding

$$\text{Resistance of whole winding, } R = \frac{\rho\ell}{a} \times Z$$

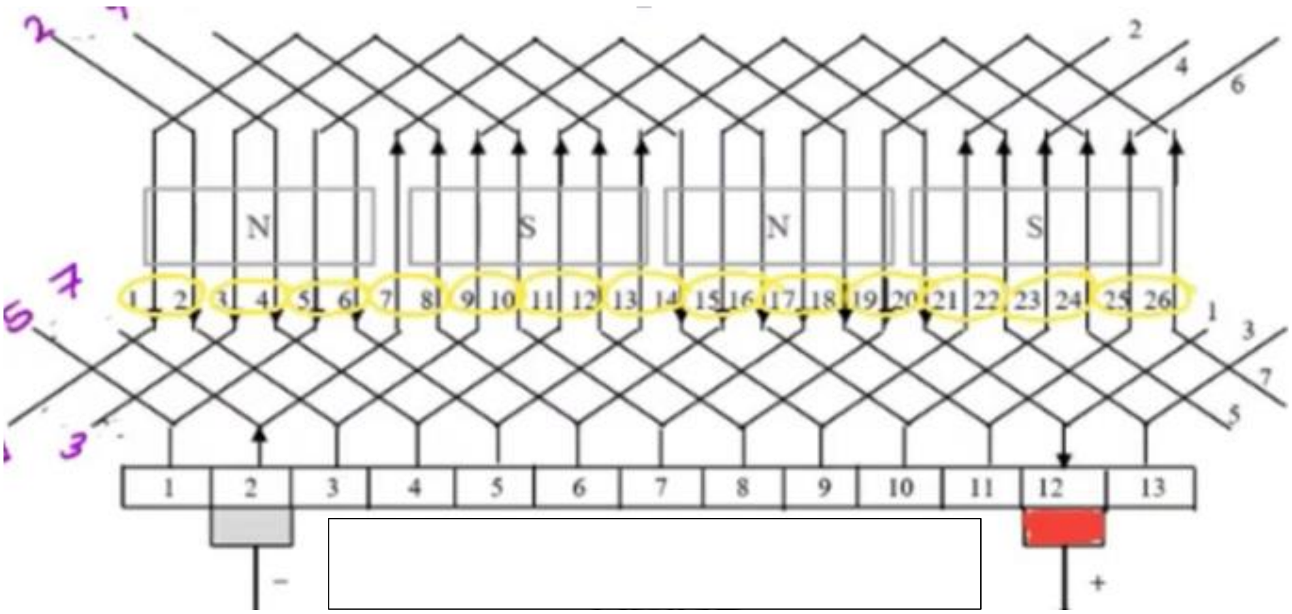
$$\text{Resistance per parallel path} = \frac{R}{A} = \frac{\rho\ell Z}{a \times A}$$

Since there are A (= P) parallel paths, armature resistance R_a is given by:

$$R_a = \frac{\text{Resistance per parallel path}}{A} = \frac{1}{A}\left(\frac{\rho\ell Z}{a \times A}\right)$$

$$\therefore \quad R_a = \frac{\rho\ell Z}{aA^2}$$

2- Simplex Wave Winding



Conclusions

From the above discussion, the following conclusions can be drawn:

(i) Only two brushes are necessary but as many brushes as there are poles may be used.

(ii) The armature winding is divided into two parallel paths irrespective of the number of poles. If the total number of armature conductors is Z and P is the number of poles, then,

$$\text{Number of conductors/path} = \frac{Z}{2}$$

(iii) E.M.F. generated = E.M.F. per parallel path
= Average e.m.f. per conductor x —

(iv) Total armature current, $I_a = 2 \times$ current per parallel path

(v) The armature can be wave-wound if Y_A or Y_C is a whole number.