Application of dc series motor

INTRODUCTION:

Ø The essential features of a dc machine are :-

Ø The stator has salient poles and is excited by one or more field coil.

Ø The air-gap flux distribution created by the field windings is symmetric about the center line of the field poles. This axis is called the field axis or direct axis.

Ø The ac voltage generated in each rotating armature coil is converted to dc in the external armature terminals by means of a rotating commutator and stationary brushes to which the armature leads are connected.

o The commutator-brush combination forms a mechanical rectifier, resulting in a dc armature voltage as well as an armature-mmf wave which is fixed in space.

o The brushes are located so that commutation occurs when the coil sides are in the neutral zone, midway between the field poles.

o The axis of the armature-mmf wave is 90 electrical degrees from the axis of the field poles, i. e., in the quadrature axis.

o The armature-mmf wave is along the brush axis.

DIRECT CURRENT MOTOR

A direct current (DC)motoris a simple electricmotorthat uses electricity and amagnetic fieldto produce torque, which turns themotor. A DCmotorrequires two magnets of opposite polarity and an electric coil, which acts as anelectromagnet. The repellent and attractive electromagnetic forces of the magnets provide the torque to theDCmotor.

DC motors are divided into three classes, designated according to the method of connecting the armature and the field windings as shunt-series and compound wound. When a permanent magnet is positioned around a loop of wire that is hooked up to a D. C. power source. In order to make the loop of wire spin, we have to connect a battery or DC power supply between its ends, and support it so it can spin about its axis. To allow the rotor to turn without twisting the wires, the ends of the wire loop are connected to a set of contacts called the commutator, which rubs against a set of conductors calledthebrushes. The brushes make electrical contact with the commutator as it spins, andare connected to the positive and negative leads of the power source, allowing electricity to flow through the loop. The electricity flowing through the loop creates a magnetic field that interacts with the magnetic field of the permanent magnet to make the loop spin.

DC MOTOR PRINCIPLE

An electric motor is a machine which converts electric energy to mechanical energy. Its action is based on the principle that when a current carrying conductor is placed in magnetic field, it experiences a mechanical force whose direction is given by flemming left hand rule and whose magnitude is given by F= BIl newton.

Where B is the field strength in teslas, Ic is the current flowing through the conductor in amperes and lc is the length of conductor in meters.

WORKING OF DC MOTORS:-

When the motor is connected to the dc supply mains, a direct current passes through the brushes and commutator to the armature winding while it passes through the commutator it is converted into ac so that the groups of conductors under successive field poles carry currents in the opposite directions. Also the direction of current in the individual conductors reverses as they pass away from the influence of one pole to that of the next.

CONSTRUCTION :-

DC motor consist of rotor mounted winding and stationary winding. In all DC motors , except permanent magnet motors, current must be conducted to the armature winding by passing current through carbon brushes

that slide over a set of copper surfaces called a commutator , which is mounted on the rotor. The commutator bars are soldered to armature coils. The brush/ commutator combination makes a sliding switch that energize particular portion of the armature, based on the position of the rotor. This process creates north and south magnetic poles on the rotor that are attracted to or repelled by north and south poles on the stator, which are formed by passing direct current through the field winding. This magnetic attraction and repulsion that causes the rotor to rotate.

ADVENTAGES OF DC MOTORS :-

DC motors provide excellent speed control for acceleration and deceleration with effective and simple torque control. The fact that the power supply of a DC motor connects directly to the field of the motor allows for precise voltage control, which is necessary with speed and torque control applications. DC motors perform better than AC motors on most traction equipment. They are also used for mobile equipment like golf carts, quarry and mining equipment. DC motors are conveniently portable and well suited to special applications, such as industrial tools and machinery that is not easily run from remote power sources.

SERIES MOTOR DIAGRAM

The series motor provides high torque and is able to move very large shaft loads when it is firet energized. From the diagram we can see that the field winding in the motor is wired in series with the armature winding. This is the attribute that gives the series motor its name.

Since the series field winding is connected in series with the armature, it will carry the same amount of current that passes through the armature. For this reason the field is made from heavy-gauge wire that is large enough to carry the load. Since the wire gauge is so large, the winding will have only a few turns of wire. In some larger DC motors, the field winding is made from copper bar stock rather than the conventional round wire used for power distribution. The square or rectangular shape of the copper bar stock makes it fit more easily around the field pole pieces. It can also radiate more easily the heat that has built up in the winding due to the large amount of current being carried.

The amount of current that passes through the winding determines the amount of torque the motor shaft can produce. Since the series field is made of large conductors, it can carry large amounts of current and produce large torques. For example, the starter motor that is used to start an automobile’s engine is a series motor and it may draw up to 500 A when it is turning the engine's crankshaft on a cold morning..

The series motor can safely handle large currents since the motor does not operate for an extended period. In most applications the motor will operate for only a few seconds while this large current is present.

OPERATION OF SERIES MOTOR

Operation of the series motor is easy to understand. The field winding is connected in series with the armature winding. This means that power is applied to one end of the series field winding and to one end of the armature winding (connected at the brush).

When voltage is applied, current begins to flow from negative power supply terminals through the series winding and armature winding. The armature is not rotating when voltage is first applied, and the only resistance in this circuit will be provided by the large conductors used in the armature and field windings. Since these conductors are so large, they will have a small amount of resistance. This causes the motor to have a large amount of current from the power supply. When the large amount of current starts to flow through the field and armature windings, it produces a strong magnetic field . Since the current is so large, it will cause the coils to reach saturation, which will produce the strongest magnetic field possible.

OPERATING CHARACTERSTIC OF DC SERIES MOTOR

Ø SPEED CURRENT CHARACTERSTIC.

Ø TORQUE CURRENT CHARACTERSTIC.

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SPEED CURRENT CHARACTERSTIC :-

The mmf due to the exciting coils increases in direct proportion to the line or armature current, so the value of flux varies with the load current according to the magnetization curve. Due to the larger current the magnetic circuit gets saturated and flux á¶² tends to approach a constant value.

From the speed equation , the speed is proportional to the back emf Eb and inversely proportional to the flux per pole á¶². With the increase in armature current voltage drop in armature circuit and series field [I(Ra+Rse)] increases and back emf Eb decreases.

Torque current characterstic :-

Torque is directly proportional to the product of flux per pole á¶² and armature current Ia. Upto saturation point flux is proportional to field current and hence to the armature current, because Ia= If.

After saturation point flux á¶² is independent of the excitation current and so that the current is proportional to the armature current i. e. T α Ia . So the characterstic becomes a straight line. The useful torque is less than the total torque developed. This is due to torque lost in iron and friction and windage losses.

SPEED TORQUE CHARACTERSTIC :-

The speed torque characterstic also known as mechanical characterstic, sharply falls with the increasin torque for smaller value of load. But at higher load, the speed drops linearly but slowly with increasing torque.

Hence series motors are best suited for services where the motor is directly coupled to the load such as fanswhose speed falls with the increase in load torque.

SPEED CONTROL OF DC MOTOR

There is two method of speed control i. e. armature voltage control and flux control method. The voltage control can be from a variable voltage source like Ward-Leonard arrangement or by the use of series armature resistance. Unlike the starting conditions the series resistance has to be in the circuit throughout in the case of speed control. That means that the energy is lost in these resistors. These resistors must be adequately cooled for continuous operation. The variable voltage source on the other hand gives the motor the voltage that is needed by it and the losses in the control gear is a minimum. This method is commonly used when the speed ratio required is large, as also the power rating. Field control or flux control is also used for speed control purposes. Normally field weakening is used. This causes operation at higher speeds than the nominal speed. Strengthening the field has little scope for speed control as the machines are already in a state of saturation and large field mmf is needed for small increase in the flux. Even though flux weakening gives higher speeds of operation it reduces the torque produced by the machine for a given armature current and hence the power delivered does not increase at any armature current. The machine is said to be in constant power mode under field weakening mode of control. constant flux mode with increased applied voltage can be used. For weakening the field, series resistances are used for shunt as well as compound motors. In the case of series motors field weakening is done by the use of ‘ diverters’ .

Diverters are resistances that are connected in parallel to the series winding to reduce the field current without affecting the armature current.

BRAKING OF DC MOTOR

When a motor is switched off it ‘ coasts’ to rest under the action of frictional forces. Braking is employed when rapid stopping is required.

The electric braking may be done for various reasons such as :-

1. To augment the brake power of the mechanical brakes.

2. To save the life of the mechanical brakes.

3. To regenerate the electrical power and improve the energy efficiency.

4. In the case of emergencies to step the machine instantly.

5. To improve the through put in many production process by reducing the stopping time.

In many cases electric braking makes more brake power to the braking process where mechanical brakes are applied. This reduces the wear and tear of the mechanical brakes and reduces the frequency of the replacement of these parts. By recovering the mechanical energy stored in the rotating parts and pumping it into the supply lines the overall energy efficiency is improved. This is called regeneration. Where the safety of the personnel or the equipment is at stake the machine may be required to stop instantly.

Basically the electric braking involved is simple. The electric motor can be made to work as a generator by suitable terminal conditions and absorb mechanical energy.

This converted mechanical power is dissipated/used on the electrical network suitably.

Braking can be broadly classified into:

1. Dynamic

2. Regenerative

3. Reverse voltage braking or plugging

These are now explained briefly with reference to shunt , series and compound motors.

DYNAMIC BRAKING

• SHUNT MACHINE

In dynamic braking the motor is disconnected from the supply and connected to a dynamic braking resistance RDB. This is done by changing the switch from position 1 to 2 . The supply to the field should not be removed. Due to this rotation of the armature during motoring mode and due to the inertia, the armature continues to rotate. An emf is induced due to the presence of the field and the rotation. This voltage drives a current through the braking resistance. The direction of this current is opposite to the one which was flowing . Thereforethe torque produced is reversed. The machine acts like a brake. The torque speed characteristics separate by excited shunt of the machine under dynamic braking mode for a particular value of RDB. The positive torque corresponds to the motoring operation. The dynamic braking of a shunt excited motor and the corresponding torque-speed curve. The machine behaves as a self excited generator. Below a certain speed the self-excitation collapses and the braking action becomes Zero.

• SERIES MOTOR

In the case of a series machine the excitation current becomes zero as soon as the armature is disconnected from the mains and hence the induced emf also vanishes. In order to achieve dynamic braking the series field must be isolated and connected to a low voltage high current source to provide the field. The motor is made to work like a separately excited machine. When several machines are available at any spot, as in railway locomotives, dynamic braking is feasible. Series connection of all the series fields with parallel connection of all the armatures connected across a single dynamic braking resistor is used in that case.

• COMPOUND GENERATOR

In the case of compound machine, the situation is similar to shunt machine. A separately excited shunt field and the armature connected across the braking resistance are used. A cumulatively connected motor becomes differentially compounded generator and the braking torque generated comes down. If large braking torques are desired. there is necessary to reverse the series field

REGENERATIVE BRAKING

In regenerative braking as the name suggests the energy recovered from the rotating masses is back into the d. c. power source. Thus this type of braking improves the energy efficiency of the machine. The armature current can be made to reverse for a constant voltage operation by increase in speed/excitation only. Increase in speed does not result in braking and the increase in excitation is feasible only over a small range, which may be of the order of 10 to 15%. Hence the best method for obtaining the regenerative braking is to operate the machine on a variable voltage supply. As the voltage is continuously pulled below the value of the induced emf the speed steadily comes down. The field current is held constant by means of separate excitation. The variable d. c. supply voltage can be obtained by Ward-Leonard arrangement. Braking torque can be obtained right up to zero speed.

PLUGGING

The third method for braking is by plugging. method of connection for the plugging of a shunt motor. Initially the machine is connected to the supply with the switch S in position number 1. If now the switch is moved to position 2, then a reverse voltage is applied across the armature. The induced armature voltage E and supply voltage V aid each other and a large reverse current flows through the armature. This produces a large negative torque or braking torque. Hence plugging is also termed as reverse voltage braking. The machine instantly comes to rest. If the motor is not switched off at this instant the direction of rotation reverses and the motor starts rotating the reverse direction. This type of braking therefore has two modes i. e.

1) plug to reverse and

2) plug to stop.

If we need the plugging only for bringing the speed to zero, then we have to open the switch S at zero speed. Plugging is a convenient mode for quick reversal of direction of rotation in reversible drives. During plugging it is necessary to limit the current and the torque, to reduce the stress on the mechanical system and the commutator. This is done by adding additional resistance in series with the armature during plugging.

- **SERIES MOTOR**

In the case of series motors plugging cannot be employed as the field current is reversed when reverse voltage is applied across the machine. This keeps the direction of the torque produced unchanged. This fact is used with advantage, in operating a d. c. series motor on d. c. or a. c. supply. Series motors thus qualify to be called as ‘ Universal motors’.

- **COMPOUND MOTOR**

Plugging of compound motors proceeds on similar lines as the shunt motors. A cumulatively compounded motor becomes differentially compounded on plugging. The mmf due to the series field can ‘ over power’ the shunt field forcing the flux to low values or even reverse the net field. This decreases the braking torque, and increases the duration of the large braking current. To avoid this it may be advisable to deactivate the series field at the time of braking by short circuiting the same. In such cases the braking proceeds just as in a shunt motor. If plugging is done to operate the motor in the negative direction of rotation as well, then the series field has to be reversed and connected for getting the proper mmf. Unlike dynamic braking and regenerative braking where the motor is made to work as a generator during braking period, plugging makes the motor work on reverse motoring mode.

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