3.2 PERMANENT MAGNET BRUSHLESS D.C. MOTORS

Conventional DC motors are highly efficient and their characteristics make them suitable for use as servomotors. However, their only drawbacks that they need a commutator and brushes which are subject to wear and require maintenance. When the functions of commutator and brushes were implemented by solid state switches, maintenance free motors were realized. These motors are known as brushless DC motors. The function of magnets is the same in both brushless motor and the dc commutator motor. The motor obvious advantage of brushless configuration is the removal of brushes. Brush maintenance is no longer required, and many problems associated with brushes are removed.

An advantage of the brushless configuration in which the rotor inside the stator is that more cross sectional area is available for the power or armature winding. At the same time conduction of heat through the frame is providing greater specific torque. The efficiency is likely to be higher that of a commutator motor of equal size and the absence of brush friction help further in this regard.

CONSTRUCTIONAL FEATURES OF BLPM MOTORS

Construction

The stator of the BLPM dc motor is made up of silicon steel stampings with slots in its interior surface. These slots accommodate either a closed or opened distributed armature winding usually it is closed. This winding is to be wound for a specified number of poles. This winding is suitably connected to a dc supply through a power electronic switching circuitry (named as electronic commutator).

Figure 2.1.1 construction of BLPMDCmotor
[Source: "special electric machines" by R.Srinivasan page:4.14]

Rotor is made of forged steel. Rotor accommodates permanent magnet. Number of poles of the rotor is the same as that of the stator. The rotor shaft carries a rotor position sensor. This position sensor provides information about the position of the shaft at any instant to the controller which sends suitable signals to the electronic commutator.

Merits and Demerits

There is no field winding. Therefore there is no field cu loss. The length of the motor is less as there is no mechanical commutator.

Size of the motor becomes less.

It is possible to nave very high speeds.

It is self-starting motor. Speed can be controlled.

Motor can be operated in hazardous atmospheric condition. Efficiency is better.

Demerits

Field cannot be controlled.

Power rating is restricted because of the maximum available size of permanent magnets.

A rotor position sensor is required.

A power electronic switch circuitry is required.

Comparison of brushless dc motor relative to induction motor drives

In the same frame, for same cooling, the brushless PM motor will have better efficiency and p.f and therefore greater output. The difference may be in the order of 20 – 50% which is higher.

Power electronic converter required is similar in topology to the PWM inverters used in induction motor drives.

In case of induction motor, operation in the weakening mode is easily achieved providing a constant power capability at high speed which is difficult in BLPM dc motor.

PM excitation is viable only in smaller motors usually well below 20 kw also subject to speed constraints, In large motors PM excitation does not make sense due to weight and cost.

Commutator and brushes arrangement

Because of the hetropolar magnetic field in the air gap of dc machine the emf induced in the armature conductors is alternating in nature. This emf is available across brushes as unidirectional emf because of commutator and brushes arrangement.

The dc current passing through the brushes is so distributed in the armature winding that unidirectional torque is developed in armature conductor.

A dc current passing through the brushes because of commutator and brushes action, always sets up a mmf whose axis is in quadrature with the main field axis, irrespective of the speed of the armature.

PRINCIPLE OF OPERATION OF BRUSHLESS PM DC MOTOR

Starting

When dc supply is switched on to the motor the armature winding draws a current. The current distribution within the stator armature winding depends upon rotor position and the devices turned on. An emf perpendicular to the permanent magnet field is set up. Then the armature conductors experience a force. The reactive force develops a torque in the rotor. If this torque is more than the opposing frictional and load torque the motor starts. It is a self- starting motor.

Demagnetization curve

As the motor picks up speed, there exists a relative angular velocity between the permanent magnet field and the armature conductors. AS per faradays law of electromagnetic induction, an emf is dynamically induced in the armature conductors. This back emf as per len‘s law opposes the cause armature current and is reduced. As a result the developed torque reduces. Finally the rotor will attain a steady speed when the developed torque is exactly equal to the opposing frictional load torque. Thus the motor attains a steady state condition.

Electromechanical transfer

When the load – torque is increased, the rotor speed tends to fall. As a result the back emf generated in the armature winding tends to get reduced. Then the current drawn from the mains is increased as the supply voltage remains constant. More torque is developed by the motor. The motor $\frac{2\pi NT}{60}$ will attain a new dynamic equilibrium position when the developed torque is equal to the new torque. Then the power drawn from the mains V *I is equal to the mechanical power delivered Pm =ωT and the various losses in the motor and in the electronic switching circuitry

CLASSIFICATION OF BLPM DC MOTOR

BLPM dc motors can be classified on the basis of the flux density distribution in the air gap of the motor. They are

(a). BLPM Square wave dc motor [BLPM SQW DC Motor]

(b).BLPM sinusoidal wave dc motor [BLPM SINE WAVE DC Motor]

BLPM Square wave motor

These are two types: 180Degree pole arc.

120Degree pole arc.

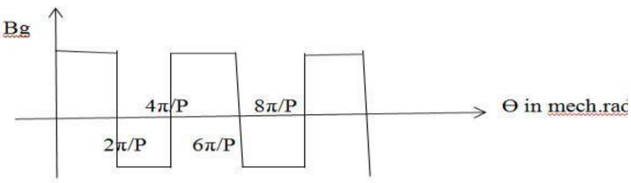

Figure 3.2.2 Air gap flux density distribution in 180 degree BLPM SQW motor.
[Source: "special electric machines" by R.Srinivasan page:4.18]

Air gap density distribution of BLPM DC SQW motor with 120 degree pole arc, as shown

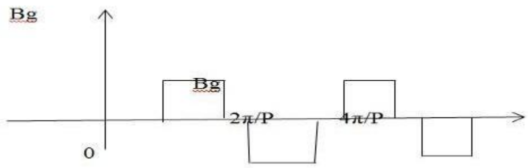

Figure 3.2.3 Air gap flux density distribution in 120 degree BLPM SQW motor.
[Source: "special electric machines" by R.Srinivasan page:4.18]

BLPM Sine wave DC Motor

Air gap density distribution of BLPM dc sine wave motor as shown in fig.3.2.3

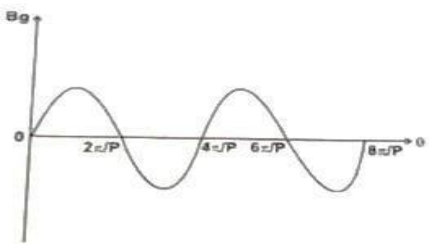

Figure 3.2.3 Air gap flux density distribution in 120 degree BLPM SW motor.
[Source: "special electric machines" by R.Srinivasan page:4.18]