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A Review on Types of DC Motors and the Necessity of Starter for Its Speed Regulation

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Abstract: The speed of any motor has to be increased from zero and should be brought to the operating speed, this is called as starting of a motor. DC motors speed can be controlled over wide range either by changing the voltage or by changing strength of current in its winding. Initially DC motors were powered by existing direct current power distribution system so these motors were the first to be widely used. A DC motor is a self starting motor, yet certain external methods are used for starting DC motor. This paper gives the study of different types of DC motors and the need of an external starter for these DC motors.

Keywords: DC Motors, Speed Regulation, Armature, Field winding.

I. INTRODUCTION

Most of the mechanical development seen around us is accomplished by an electrical motor. The electrical motors convert one form of energy into another. An electrical motor is a machine that converts the electrical energy into mechanical energy. Motors are broadly classified into two types AC motors and DC motors. The AC motors operate on alternating current where as the DC motors operate on the direct current. The input to AC motor is alternating current/voltage and its output is in the form of torque, similar is the output of DC motor it differs from AC motors at its input side, i.e. the input of a DC motor is the direct current/ voltage. This paper focuses only on DC motors, its types and speed regulation of these motors.

There are four different types of DC motor.

1. Permanent Magnet Motor
2. DC Series Motor
3. DC Shunt Motor
4. Compound Motor.

Most of the DC motors have same internal mechanism. The working principle of DC motors is based on Fleming's left hand rule.

Speed Regulation of a DC motor is the change in speed when the load on motor is reduced from rated value to zero, it is expressed in % of rated load speed.

$$\% \text{ speed regulation} = \frac{\text{No load speed} - \text{Full load speed}}{\text{Full load speed}} \times 100$$

II. LITERATURE SURVEY

[1] This paper gives the study of need for starter DC motors. Different commonly used method for the starting of dc motors. It also introduces a technique of soft starting. The device which is based on triggering of thyristor. [2] This paper gives the study of different types of starters used in industries, i.e. 3-coil starter and 4- point starter. The paper also explains why the motor burn if the starters are not used.

III. PERMANENT MAGNET MOTOR

A permanent magnet motor does not have a field winding; instead it uses permanent magnet to supply the field flux. Permanent magnet motor has a good starting torque along with a better speed. As the field supply is fixed due to permanent magnet and cannot be varied, this motor does not have an adjustable speed control function. So the permanent magnet field is well preferred in small motors.

However, large permanent magnets are costly, as well as dangerous and difficult to be assembled, this favours wound fields for large machines.

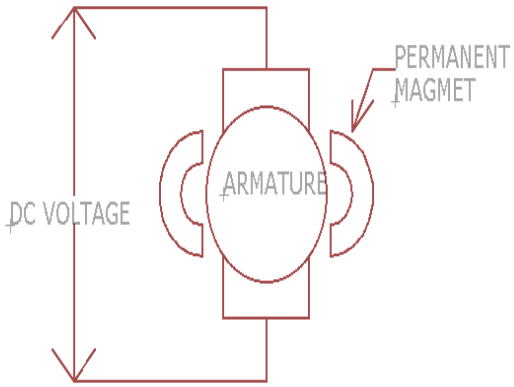

Fig 1: Permanent Magnet Motor

Permanent magnets are best suited for small motors to eliminate the power consumption of the field windings. To minimize the overall weight and size permanent magnet motors may use high energy magnets.

The major disadvantage of permanent magnet DC motor is that they are limited to the amount of load, due to its preferred smaller size. These motors are also found to have low horsepower applications. Another disadvantage is that its torque is limited to 150% of the rated torque to prevent demagnetization of the permanent magnets used in the motor.

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IV. DC SERIES MOTOR

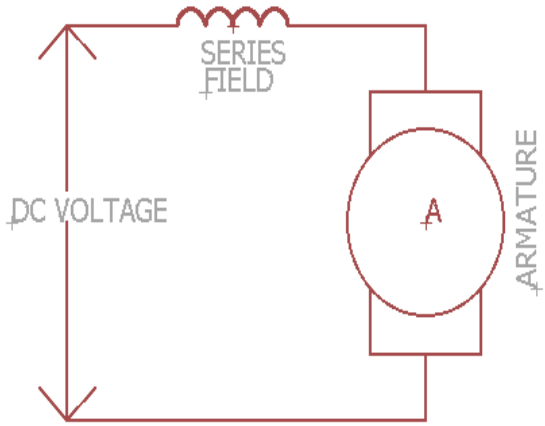

Fig 2: DC Series Motor

The series motor is widely known as series wound motor. In a DC series motor the field winding is connected in series to the armature winding. The field strength varies with the variation in armature current. The series motor provides high starting torque and is commonly used for starting high inertia loads, such as trains, elevators, etc. Speed of a series motor varies widely between the no load and the full load conditions. Series motor cannot be used where a constant speed is required under varying loads, this is because the velocity of this motor varies greatly with the varying load [3].

A series motor should never be started with no load, because with no mechanical load the current is low, so the back emf is weak and the armature starts rotating faster to produce sufficient back emf to balance the supply voltage, and the motor can get damaged due to over speed, the speed of a series motor with no load increases to a point where the motor could get damaged therefore some load should always be connected to a DC series motor.

The series motor is also known as universal motors as they can also be operated on alternating current as well as direct current. Since armature voltage and the field direction reverses at the same time, torque is continuously produced in the same direction, however it runs at lower speed with low torque on AC supply as compared to the DC supply [4].

Series motors have many advantages such as it has high starting torque, motor is cost efficient, easy to design and maintain, simple construction, etc.

V. DC SHUNT MOTOR

In a DC shunt motor the field winding is connected in parallel (shunt) to an armature with the common DC power supply.

The field winding can be either separately excited or be connected to same source as that of armature. DC shunt motors have different working characteristics than that of DC series motor.

The shunt Connected motors offer good speed regulation, but does not have as much starting torque as that in DC series motor [5]. Due to its ability of self regulation the switching of motor from no load to full load conditions there is no considerable change in its running speed. As the shunt field coil is made up of thin wire it cannot produce large current for starting like in DC series motor, this implies that DC shunt motors have extremely low starting torque [3]. The DC shunt motors have best speed regulation.

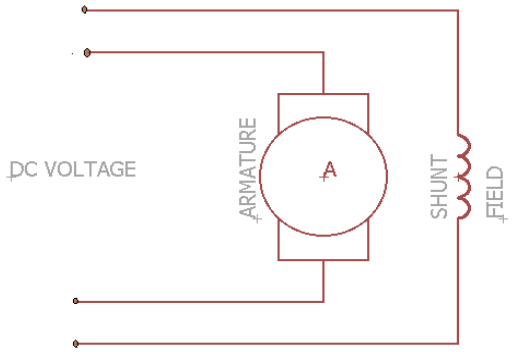

Fig 3: Separated Excited DC Shunt Motor

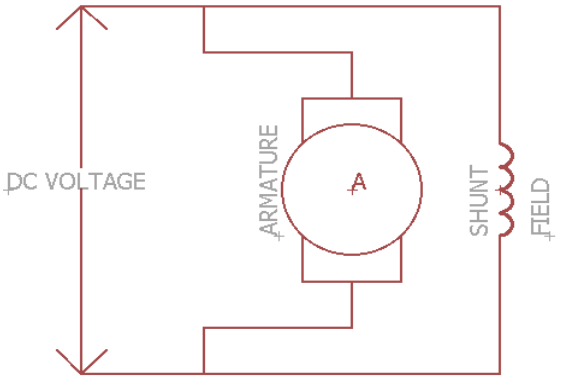

Fig 4: Common Source DC Shunt Motor

In a shunt motor as the input voltage is supplied it first passes through the field winding and the armature current slowly increases as the current in the field winding decreases. This is given by an equation i.e.

$$I_a = I_t - I_f .$$

Where

- I_t = Total Current
- I_a = Armature current
- I_f = Field current

Simple control performance, results in high flexibility for solving complex drive problems. Very smooth running, therefore low mechanical stress and high dynamic control process. The motor has low speed and wide control range this characteristic makes it preferable to be used in industries on large scale.

VI. COMPOUND MOTOR

Compound motors have a field connected in series with armature and a separately excited shunt field; hence it provides the characteristics of both series as well as shunt DC motors. The series field provides better starting torque and a shunt field provides better speed regulation.

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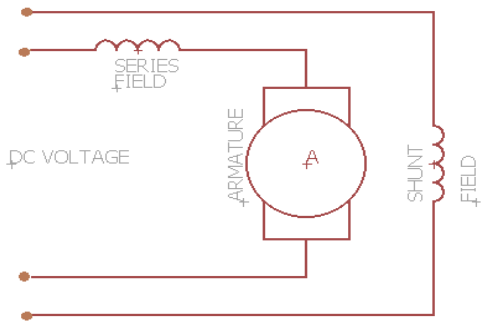
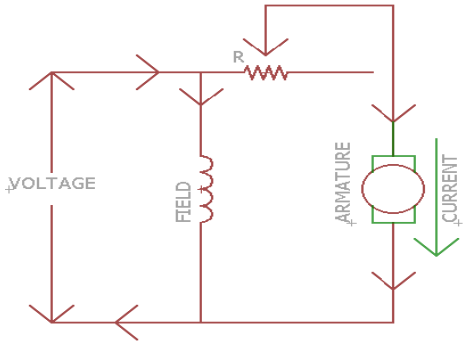


Fig 5: Compound Motor

VII. NECESSITY OF A STARTER TO DC MOTORS



The current drawn from the motor armature is given by the relation

$$I_a = (V - E_b) / R_a$$

Where

- I_a = Armature current
- V= Supply Voltage
- E_b = Back emf
- R_a = Armature resistance

When a motor is at rest, there is no back emf developed in the armature. If , full load is applied across the stationary armature, it will draw very large current because resistance is relatively small. This excessive amount of current is capable of blowing out the fuses, prior to that it will damage the commutator and brushes etc, to avoid such happenings , a resistance is introduced in series to the armature only for the starting 5 to 6 second duration of time[6].The starting resistance is gradually cut off as the motor gains speed and develops the emf which regulates its speed.

Very small motors may however, can be started from rest by connecting them directly to the supply line, it does not result in any harm to the motor for the following resons

1. Such motors have a relatively high armature resistance than the large motors hence starting current in not high
2. Being small, they have low moment of inertia, hence they speed up quickly.
3. The momentary large starting current taken by them is not sufficient to produce a large dirsturbance in voltage regulation of supply line[6].

VIII. CONCLUSION

Hence from this paper it can be concluded that most of the DC motors need the external starter for its stating application, only for initial 5 to 6 sec and then these starters can be later cut off. Starter provides a protected start up supply voltage from zero to rated voltage. It also limits the starting current to a safe value till the DC motor achieves rated speed and torque. The same process could even be repeated during the stop of a motor so as to ensure smooth, jerk free, controlled starting as well as stopping of DC motors.

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