International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 21, Issue 4 (April 2025), PP 75-83

DC Motor Commutator Failure Analysis

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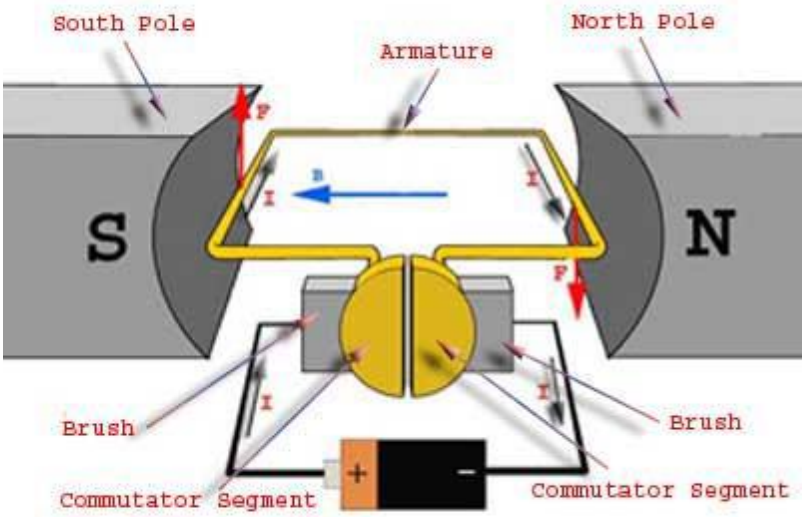
ABSTRACT
Carbon brushes are situated in a DC motors to covey supply current to the armature. The positioning of this brushes is very important in other to achieve effective performance of the motor. The rubbing of carbon brushes on the surface of commutator segment creates carbon deposits on the commutator segment surface. This carbon deposits if not get rid of causes sparks on the surface of the commutator segment. Hence the need for regular maintenance of the DC motor. Furthermore, the positioning of the carbon brushes is equally an aspect to check on a DC motor. If the brushes are not well placed it leads to poor commutation and severe sparks at the trailing edge of the commutator segment. The aim of this research is to study the problems associated with DC armature and how to proffer solutions for effective performance of the motor.

Date of Submission: 02-04-2025 Date of acceptance: 12-04-2025

I. INTRODUCTION

A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy. It's of vital importance for the industry today, and is equally important for engineers to look into the working principle of DC motor in details that has been discussed in this article. In order to understand the operating principle of dc motor we need to first look into its constructional feature.



Source [1]:

Figure 1.0

Commutation problem is not the only problem in DC machines. At heavy loads, the cross magnetizing armature reaction may cause very high flux density in the trailing pole tip in generator action and leading pole tip in the motor action.

Consequently, the coil under this tip may develop induced voltage high enough to cause a flashover between the associated adjacent commutator segments particularly, because this coil is physically close to the commutation zone (at the brushes) where the air temperature might be already high due to commutation process.

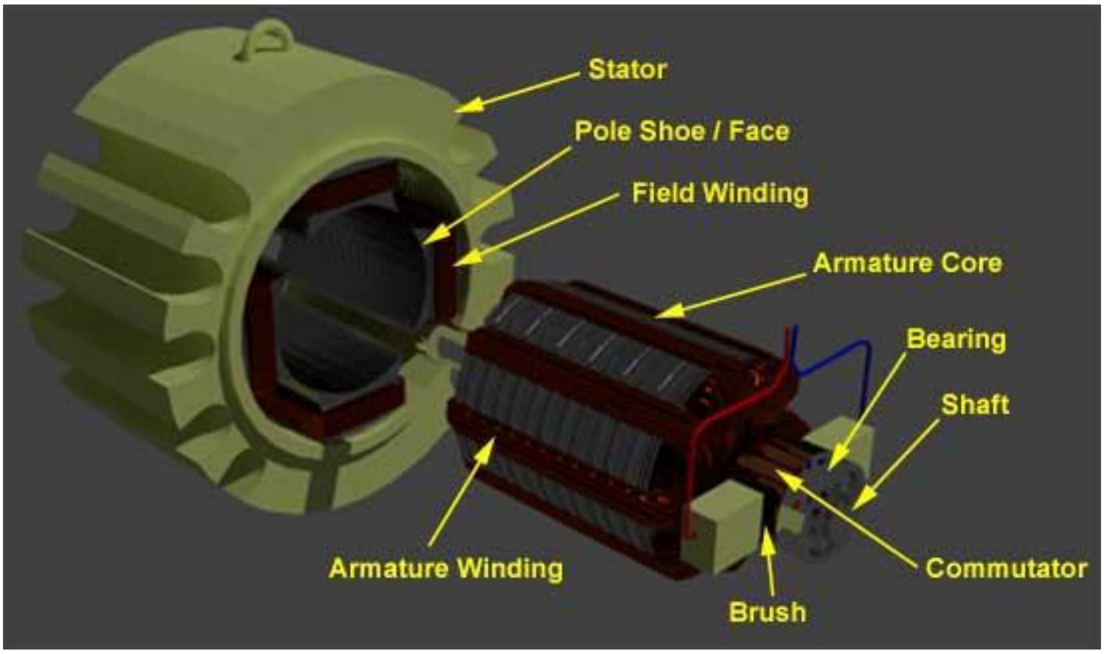


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Figure 1.1 Parts of DC Machines

1.1.1 Separately excited DC machine

The Separately-excited DC machine like other types of electrical machines has two sets of winding. The armature winding and the field winding. The excitation of the field winding is different from the source of excitation for the armature winding. The schematic diagram is as shown in figure 1.2.

1.1.2 Self-excited DC motor

The Self-excited DC machine are categorize in three, namely, series DC machine, shunt DC machine and compound DC machine.

1.1.2.1 Series DC machine

The series DC machine is equally made up of two windings. The field winding is in series with the armature winding. The schematic diagram is as depicted in figure 1.3.

1.1.2.2 Shunt DC machine

1.1.2.3 Compound DC machine

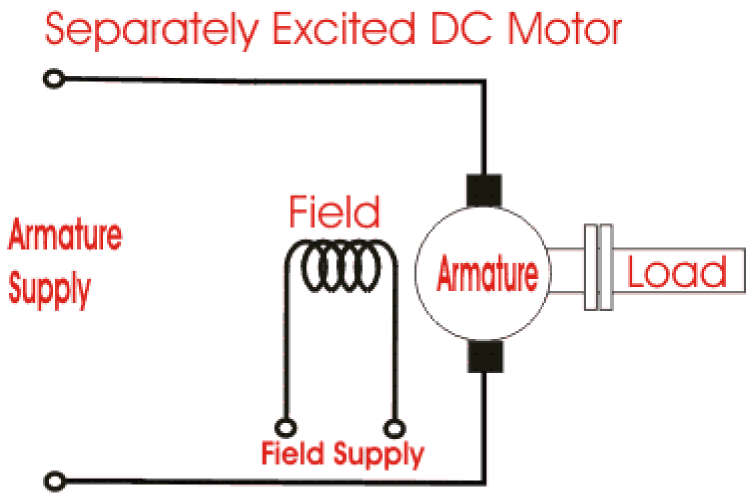

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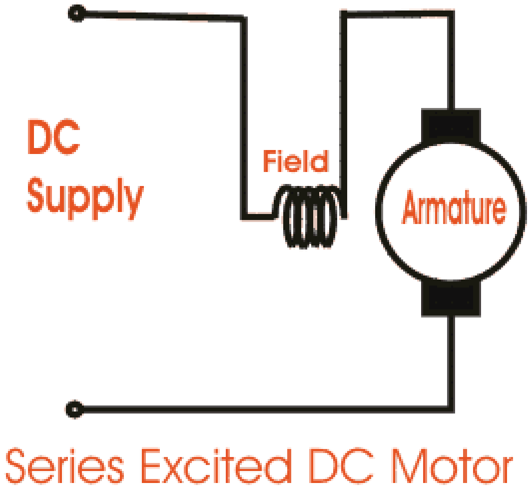
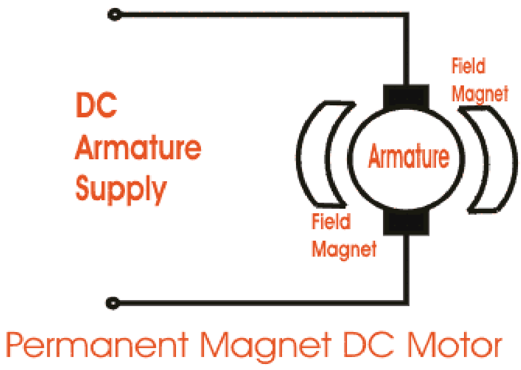
Figure 1.2 Separately-excited DC motor.



Source [1];

Figure 1.3 Series DC motor



Source [1];

Figure 1.4 Permanent Magnet DC motor

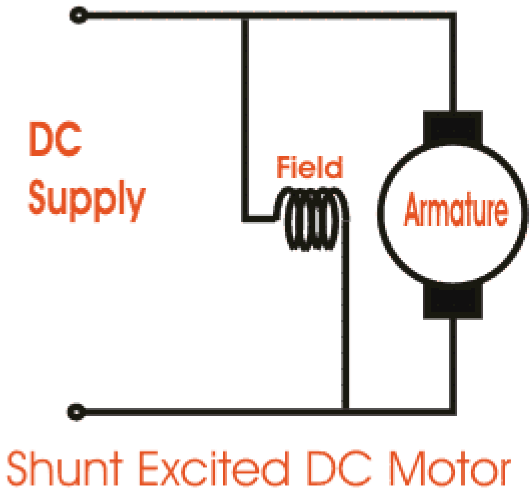


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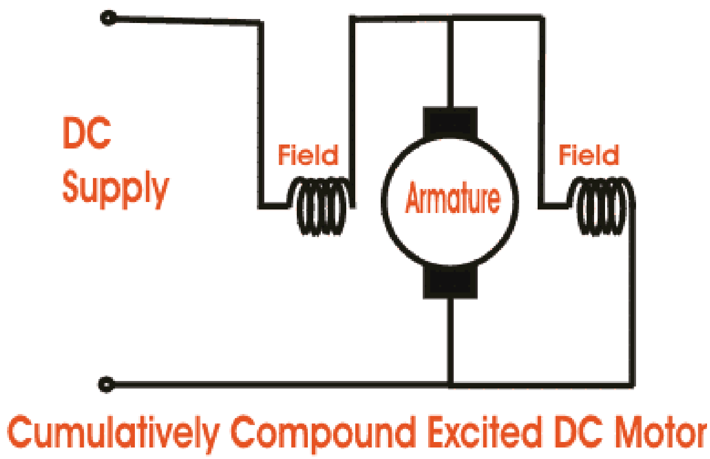
Figure 1.5 Shunt DC motor



Source [1];

Figure 1.6 Compound DC motor.

II. METHODS OF IMPROVING COMMUTATION

There are two practical ways of improving commutation i.e. of making current reversal in the short-circuited coil as spark-less as possible. These methods are known as (i) resistance commutation and
(ii) EMF commutation (which is done with the help of either brush lead or inter-poles, usually the later).
Resistance Commutation: This method of improving commutation consists of replacing low-resistance carbon brushes by comparatively high-resistance carbon brushes.
EMF Commutation: In this method, arrangement is made to neutralize the reactance voltage by producing a reversing EMF in the short-circuited coil under commutation.
This reversing EMF as the name shows, is an EMF in opposition to the reactance voltage
and if its value is made equal to the latter, it will completely wipe it off, thereby producing quick reversal of current in the short-circuited coil which will result in spark-less commutation. The reversing EMF may be produced in two ways: (i) either by giving the brushes a forward lead sufficient enough to bring the short-circuited coil under the influence of next pole of opposite polarity or (ii) by using inter-poles. The first method was used in the early machines but has now been abandoned due to many other difficulties it brings along with.
Inter-poles of Com-poles: These are small poles fixed to the yoke and spaced in between the main poles. They are wound with comparatively few heavy gauge Cu wire turns and are connected in series with the armature so that they carry full armature current. Their polarity, in the case of a generator, is the same as that of the main pole ahead in the direction of rotation. The function of inter-poles is two-fold:
(i) As their polarity is the same as that of the main pole ahead, they induce an EMF in the coil (under commutation) which helps the reversal of current. The EMF induced by the com-poles is known as commutating or reversing EMF. The commutating EMF neutralizes the reactance EMF thereby making commutation spark-less. With inter-poles, sparkles commutation can be obtained up to 20 to 30% overload with fixed brush position. In fact, inter-poles raise sparking limit of a machine to almost the same value as heating limit. Hence, for a given output, an inter-pole machine can be made smaller and, therefore, cheaper than a non-inter-polar machine.
As inter-poles carry armature current, their commutating EMF is proportional to the armature current. This ensures automatic neutralization of reactance voltage which is also due to armature current.
(ii) Another function of the inter-poles is to neutralize the cross-magnetizing effect of armature reaction. Hence, brushes are not to be shifted from the original position.

III. RESULT ANALYSIS

Carbon deposits on the surface of the commutator segment is not uncommon to DC machines. Such deposit will render the DC machine not performing to maximum efficiency. This condition is as shown in figure 3.0.
The appearance of the commutator surface are as follows

- Smearing of the film
- Damage of the film
- Groove formation

• Brush wear

Source: [3]

Figure 3.0 Carbon deposits on the Commutator segment

The other various forms of poor condition of the commutator segment are shown in figures 3.1, 3.2 and 3.3.

Source: [3]

Figure 3.1

Source: [3]

Figure 3.2

Appearance

- Oxidation in the non-applied area of the commutator
- Groove formation
- Commutator wear out

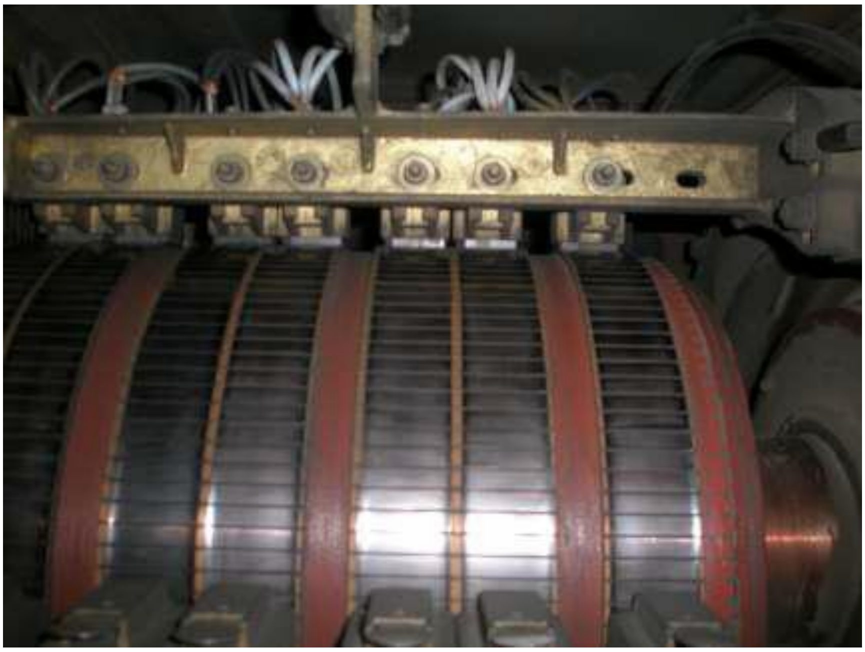
Source: [3]

Figure 3.3

Source: [3]

Figure 3.4

Appearance
• Brush vibration
• Brush sparking
• Markings of brush chattering
• Broken brush at the edges
Problem
• Brush holder distance too high
Remedial action
• Adjust holder distance to 2,5mm



Source: [3]

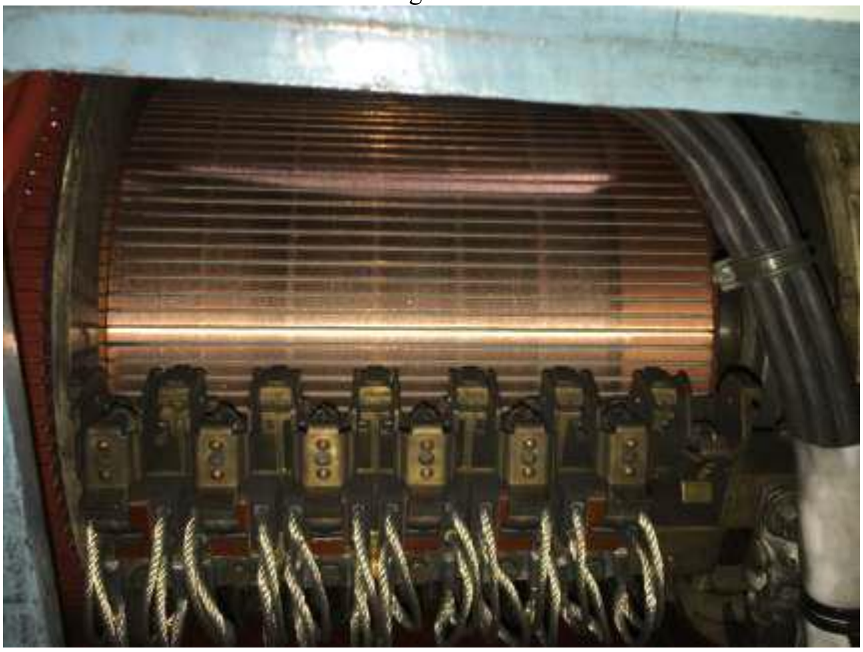
Figure 3.5

Appearance
Problem
Remedial action
• Extreme brush sparking
• Overload
• Wrongly set neutral zone
• Wrong brush grade
• Poor brush pressure
• Debris into the brush pocket
• Check the load conditions
• Check the neutral zone
• Choice the right brush grade
• Improve the brush design
• Check the brush pressure
• Clean the brush pocket

Source: [3]

Figure 3.6

Appearance
• Good brush surface
• Good commutator surface
• Full contact point in the brush surface as shown in figure 3.3



Source: [3]

Figure 3.3

IV. CONCLUSION

The research work is analyzing the faults associated with armature of DC motor and how to proffer solutions to the faults. The causes of such faults and ways of preventing them formed part of the research work.

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