UNIT 2.5 FLASHOVER

OBJECTIVES

On completion of this unit, you should be able to:
- Describe the cause of flashover.
- Detect a machine running with the risk of flashover.
- Suggest remedial actions.

STRUCTURES

1. Introduction
2. The trouble
   2.1 Dirt
   2.2 Loss of contact
   2.3 Sudden extreme load changing
3. The ultimate effect
4. Detection and remedy
5. Summary
6. Self-assessment exercises

1. INTRODUCTION

Flashovers are caused. They do not just happen. Something seems puzzling and mysterious only if it is not understood. With the gain of knowledge, the mystery disappears. If any one can find out what flashovers are and how are they caused, what to do to prevent them, that makes sense.

A generator flashover, seen for the first time, is truly awesome. The blast of fire, the smoke and noise are enough to make one jump as if it was a stroke of lightening. The traction motor flashover is also caused in the same way.

The commutator is the stage on which the flashover appears. Fig. 1 shows how the commutator is built up of copper segments separated from each other by thickness of mica. Each pair of segments has an armature coil connected between them. Electricity enters by way of one set of brushes, through the copper segments and into the winding. When it reaches the segment under the other set of brushes, it leaves. The mica insulation separates the copper segments and keeps the electricity flowing through the armature coil. If this insulation breaks down, electricity will short cut across the surface of the commutator. Almost instantly, the current jumps from one brush holder to other brush holder with explosive force forming an arc. This is known as flashover.

2. THE TROUBLE

The voltage between the segments of a machine is quite low and the thicker mica has an insulation capacity many times greater for the purpose. What then causes such relatively wide spaces to breakdown and permit the machine to flashover ? (Fig. 2 indicates the distribution of voltage.) Across the top of the mica, there is an air space. If dirt does collect at these spaces and packs between the segments, the current begins to leak through it. The space is made wide so that it will take longer to fill with dirt and be harden to bridge. If the space is not cleaned in time, insulation breaks down and flash over may result. These insulating space may also be bridged by copper fins or copper dust left over from stoning and resurfacing the commutator. Dirt and foreign materials are not the only cause of flashover. Air, being a good insulator is broken down into conductive gas by the action of intense heat. The change of air to a conductive gas is known as ionisation. It can be caused by flame or spark, by high voltage or by certain kinds of radiation.

Under certain operation conditions, motor or generator brushes will spark. The affect of this is not always serious. What happens depends upon how intense the sparking is and how long it lasts. Under some abnormal condition the spark at the brush may be so vicious and hot that it blasts a cloud of conductive gas and fiery particles across the commutator surface. These bridge the spaces between segments and electricity short cuts across the commutator surface. Every thing is then set for a flashover. The intense spark that sets off a flash over may occur when a brush bounces off the commutator while the machine is carrying a load. It may also occur when there is a sudden extreme change in load, for greater than the machine can handle. The insulating spaces between the segments may be bridged by hot conducting gases generated by the intense heat resulting from :-

i) Dirt between segments which burns when current flows through it.
ii) Loss of contact of brushes from commutator which draws a hot spark.
iii) Intense sparking at the brushes caused by sudden extreme load changing.

2.1 DIRT

Dirt and foreign particles in the insulating space between commutator segments caused the majority of the flashover. When enough dirt collects to bridge the space between segments, current begins to leak across (Fig. 5A) . The dirt heats and fuses into a better path. Current flow increases, specially as the operating voltage increases. The spot grows , and finally begins to glow (Fig.5B). As the commutator turns, these glowing spot looks like a continuous ring of fire. Finally the spot gets white hot. Then it irrupts conductive gases and incandescent particles (Fig.5C). As the commutator turns (Fig.6A), these form a fiery trail behind the spot. These breaks down the insulating air space between segments that may not be glowing and sets the stage for next act.

The current short cuts (Fig.6B) from the hot spot, across the segments bridged by the fiery gases, back to the brush holder in a sizzling vicious spark. The intense heat and energy in these spark blast conductive gases across the commutator circuit (Fig.6C) with explosive violence. The gas cloud races ahead of the glowing spot and breaks down the air resistance across the rest of the commutator from brush to brush, then full power of the machine jumps across (Fig.6D) in the final flashover.

2.2 LOSS OF CONTACT

Dirt may be the most frequent, but it is not the only cause of flashover. Sometimes loss of brush contact will be to blame. These may be expected at high speed with a rough commutator surface or weak brush holder springs. It may also occur when brushes are jammed in the holders by muck or dirt so that they cannot follow the commutator surface quickly enough. Severe mechanical shock may jar the brush off the commutator.

If brush breaks contact with the commutator, it draws an electric arc (Fig.7). If these are severe enough, it will spray conductive gases over the commutator. If the fiery gas bridges enough segments, the collective voltage will cause the current to arc back to the brush (Fig.6B). The blast of conductive gas from these arc back may reach across the surface of the commutator to the next brush (Fig.6C). The full power of the machine then flashes over these short cut path (Fig.6D). Again, instead of doing useful work, the energy will be expanded in the terrifically hot, destructive blast of flashover.

2.3 SUDDEEN EXTREME LOAD CHANGING (The surprise attack)

Flashovers, that occur when the commutator is in perfect mechanical and electrical condition are most complex. These are caused by sudden and extreme change in load, too great for machine to handle. Fig. 8A shows that, in a machine, current divides as it enters the winding. It remits and leaves through the out going brushes. Current flows in one direction when the coil is on one side of the brush and in the opposite direction when it gets to the other side. So the current must reverse in the split second it takes for the coil to pass under the brush, which is known as commutation.

If the current does not reverse in time the coil will come out from under the brush with the current still flowing in old direction. The meeting point with the current in other part,
which is known as neutral point will no longer will be in the brush. This shifting of neutral point crowds the current to one edge of the brush. Then it breaks out over the surface of the commutator in a spark to reach in a shifted point (Fig.8B).

The greater the current, the harder it is to get it all completely reversed as the coil zips under the brush. Machines have interpoles or commutating poles , to speed up this current reversal and keeps the neutral point under the brush. These are smaller poles located between the main poles in the machine frame. They help commutation only. The magnetism of these poles builds up a voltage in the armature coil as they pass through the zone covered through the brush contact. This voltage speeds up the current reversal to get it done before the coil leaves the brush contact.

These poles are designed to do a good commutating job up to, and even beyond full load. When , however, a very overpowering current flows through the winding, the magnetism in the iron cannot build up quickly enough. This means there is not enough voltage to reverse the current in time and sparking results. Moreover, as after saturation of the pole pieces no more magnetism can be expected , hence, there is a limit to the help the pole can give in reversing the current in the coil. When the current gets so heavy that this help is not enough then this sparking is the ultimate result.

When the machine is operating at full voltage, the jolt of sudden extreme overload causes vicious sparking at the brushes. Conductive gas bridges segments (Fig.8C). Current starts leak over the commutator surface (Fig,6B). The blast of fiery gas completes the short circuit between the brush holder (Fig.6 C&D).

Every day motors and generators demonstrate their ability Still the flashover occur if anything goes wrong. For instance, a contactor fails to operate momentarily, short circuiting generator.

A sudden surge of current occurs during high speed wheel slip. Taking a cross over at high speed may cause a brush of motor to bounce and flash a motor over. It is just like short circuiting of the generator because the current is no longer flowing through the motor winding, but short cutting across the commutator. So the current drawn from the generator reaches unreasonably high value. It knocks the generator off balance. The heavy sparking and flashover is the knock out blow.

3. THE ULTIMATE EFFECT

The space surrounding the commutator is filled with flame and conductive gases. These reach between brush holder and also over the frame part of the machine. Current can now flow from the brush holder to the frame and through the frame back to opposite brush holder.

Flashover current can also strike from the commutator circuit through the fiery gases to the steel commutator cap. From here it finds its way to ground through shell, armature shaft and bearing. This is the cause of electric pitting of roller bearings and races.

When the confined space around the commutator is filled with ionised air and flame, the current can strike in many directions with destructive force (Fig.9). String bands are burnt, brush holders are flashover, bearings are damaged and if grease and dirt are present they may be set on fire. However, the current strikes the ground and it is detected by the ground relay.

4. DETECTION AND REMEDY

Detection of these types of defects can only be done visually. Insulation resistance between the segments cannot be taken with the help of a meter as they are connected to the windings. Megger readings and high pot tests are of no good because they check what is called resistance to ground.

Inspecting the defects visually, they can be rectified by cleaning, undercutting mica so that they look white or grey, air curing the machine or by blowing the commutator surface with compressed air. In case of improper or inadequate brush pressure, the brush gear can also be attended. Polishing, grinding or machining may also be required if the commutator surface is rough, having the defects of high bar etc. In some of the cases short circuited or open circuited winding may also cause flash over and can be detected by bar to bar milli-volt drop test or taking the micro ohm readings.

5. SUMMARY

Flashover of DC machines is a chronic disease. It is the prime cause of pre-mature failures of most of the DC machines. Moreover, it remains a mystery to the user that when the machine will fail and how an expert rectified the fault. This unit describes the causes of the flashover due to dirt deposition, loss of contact of carbon brushes and sudden extreme load changing, which are very common in case of traction machines.
Stage wise development of defects and ultimate effect on the machine has been elaborately described to help the maintainer to understand these defects and take remedial measures. Checking to judge the healthiness of the machine has also been described.

6. SELF ASSESSMENT EXERCISES

1. Describe how does the dirt deposition on the commutator surface lead to flashover.
2. Describe the reason of flashover due to loss of contact between the carbon brush and commutator.
3. Describe the process of detection and remedy of a machine suffered from flashover.