A REVIEW ON THE PROTECTION SCHEMES FOR THE ALTERNATOR

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Abstract— **In this paper, the different types of faults occurring on the alternator were discussed. The causes and effects of faults occurring on the alternators were also discussed. The protective methods used for alternators were elaborated. The necessity of alternator protection was studied. All the causes and effects of alternator faults were given in different sequence diagrams. This paper would be useful for young engineers to at least study the important faults occurring in the alternators**

I. INTRODUCTION

Protection of alternators is complex due to the following reasons:

1) Generators are very large machines producing very high voltages and are connected to bus bars.
2) Various equipments such as prime movers, excitation systems, voltage regulators, cooling systems were always associated with the generators. So, protection of generators must consider the presence of these higher equipments also.
3) Generators were very costly and expensive in the power system.
4) Generators should not shut off as far as possible because generator shut off will result in the power shortage.

II. Generator Faults

The different types of faults occurring in the alternators were

1) Stator faults.
2) Rotor faults.
3) Abnormal running conditions.

2.1 Stator faults

- Faults associated with the stator of the generator.
- Faults associated with the three phase windings of the generator

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- These faults were mainly due to the insulation failure of the armature windings.

2.1.1 Types of Stator faults:

1) Phase to earth fault-common fault.
2) Phase to phase fault.(not very common difficult to detect)
3) Inter-turn fault.

2.1.2 Phase to Earth Faults

Causes:

- This fault mainly occurs in the armature slots.

Effects

- These faults were dangerous and cause severe damage to the alternator.
- Severe burning of stator core will occur due to high fault current.
- Laminations should be replaced.

1) Costly
2) Time consuming

Protection

- Sensitive earth fault protection is necessary for the generators along with the earthing resistance.

2.1.3 Phase to Phase Faults

Causes:

- Short circuit between two phase windings.
- Theses faults were uncommon due to the large insulation between the coils of different phases in a slot.
- But once phase to earth fault occurs, due to overheating, phase to phase fault may occur.
- This occurs at the end connections of the armature windings which were over heating parts outside the slots.

Effects

- Severe arcing with very high temperature.
- Melting of copper if the insulation was not fire resistant.

Protection

- Fire resistant insulation.

2.1.4 Stator inter turn faults

- Short circuit between the turns of one coil occurring in multi turn coil alternators was called as inter turn fault.

Causes:

- Due to current surge across the turns.

Protection

- In single turn coils this fault won't occur.
- Single turn coils were used up to 50KVA.
- For multi-turn coils, protection against inter-turn faults was must.

2.2 Rotor Faults

The different types of rotor faults were

1) Conductor to earth fault
2) Short circuit between the turns of field winding

2.2.1 Conductor to Earth fault

- Field winding is not grounded.
- So no Line to Ground fault current due to single Line to Ground fault.
- Second LG fault will cause unsymmetrical field system.
- Unbalanced force on the rotor.
- Pressure on bearings.
- Shaft distortion.
- Negative sequence currents.
- RMF in opposite side.
- Emf in rotor winding
- Overheating of the rotor. Figure 1 shows the sequence of effects of conductor to earth faults.

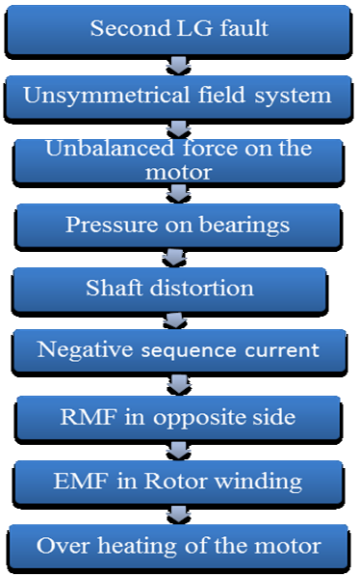

Figure 1 Sequence of effects of Conductor to Earth fault

Protection

- Rotor earth fault Protection.
- Rotor temperature indicators.

2.3 Abnormal running Conditions

1) Overloading
2) Over speeding
3) Unbalanced loading
4) Over voltage
5) Failure of prime mover
6) Losses of excitation
7) Cooling system failure

2.3.1 Over loading

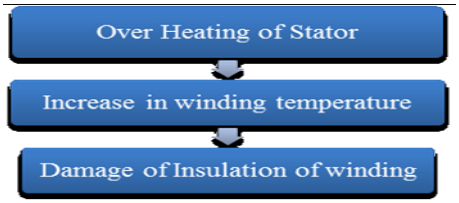

Figure 2 Sequence of effects of Overloading

2.3.2 Over speeding

Causes

1) Sudden loss of load
2) Fault in turbine governor

2.3.3 Unbalanced load

Causes

1) Occurrence of unsymmetrical fault near generating station.
2) Failure of Circuit breaker near generating station.

Figure 3 shows the Sequence of effects of unbalanced load

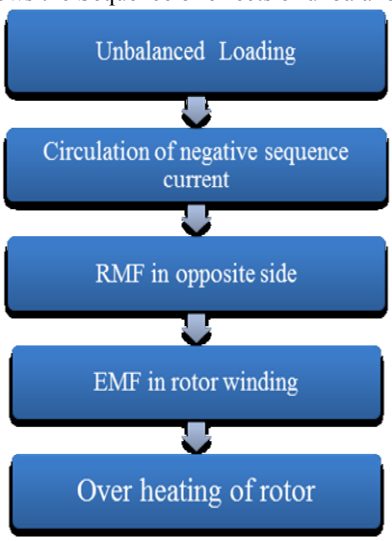

Figure 3 Sequence of effects of unbalanced load

Protection

Negative sequence protection.

2.3.4 Overvoltage

Causes

1) Over speeding of generators
2) Faulty operation of voltage regulators
3) Internal over voltage- switching surges
4) External over voltage- lightning surges

Protection

- Surge arresters and surge capacitors
- Modern CBRC surge suppressors used in reducing switching surges
- Resistance earthing used to reduce transient voltages due to arcing.

2.3.5 Failure of prime movers

Figure 4 shows the Sequence of effects of failure of prime movers

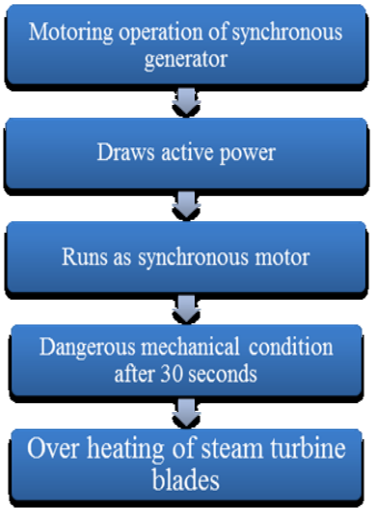

Figure 4 Sequence of effects of failure of prime movers

Protection

- Reverse power protection achieved by directional power relay.

2.3.6 Loss of excitation

Causes

- Field failure
- Reduced excitation
- Opening of field winding
- Short circuit in the field
- Fault in exciter

Effect

- Loss of synchronism
- Increase in speed of generator
- Works as an Induction generator
- Draws reactive power from the bus
- Overheating of the Stator winding and the rotor body
- Pole slipping
- Voltage reduction

Protection

- Tripping scheme to trip generator CB under field failure.

2.3.7 Cooling System Failure

Effect

1. Overheating above safe temperature limit.
2. Insulation failure

Protection

- Thermo couples or resistance thermometers were used in large machine to sensor the temperature.

2.4 Merz Price protection

- Used for the protection of alternator stator windings
- It is called as biased differential protection and percentage difference protection.

2.4.1 Construction

Figure 5 shows the Merz Price Protection of Alternators.

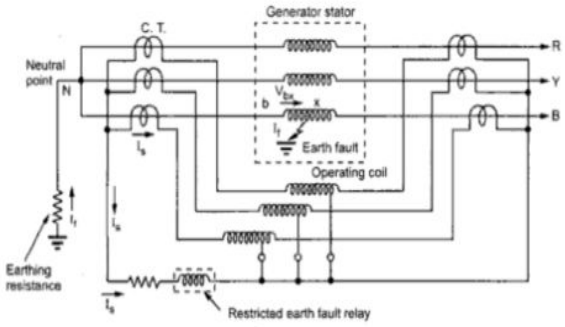

Figure 5 Merz Price Protection of Alternators

Current Transformer:

- To measure currents at the two ends of the protected section

Pilot wires:

- Wires connecting the relay coils to the secondary of Current Transformer were called as pilot wires.

2.4.2 Operation

Normal Condition

1) No fault in windings
2) Current in pilot wires are equal
3) Different circuit is zero
4) Relay is in operative
5) Balanced condition

Faulty condition

1) Fault occurs
2) Different current flows the operating coils of the relay
3) Relay operates
4) Trips generator CB to isolate the faulty section
5) Field is disconnected and discharged through suitable impedance

Conclusions

In this paper, the different types of faults occurring on the alternator were mentioned clearly. The causes and effects of faults occurring on the alternators were also elaborated. The protective methods used for alternators were discussed. The necessity of alternator protection was studied clearly. All the causes and effects of alternator faults were given in neat sequence diagrams. This paper would be useful for young engineers to at least study the significance of protection of alternators.

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