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Application Guidance Notes: Technical Information from STAMFORD | AvK

AGN 142 – Pole Slipping and Reverse Power

INTRODUCTION

Pole Slip events and Reverse Power are subjects that are well documented in text books and on the internet.

Pole Slipping

Low voltage alternators rated up to 2.5MVA should not encounter regular pole slip events. The scenarios that could result in pole slipping, all conclude that something within the Generating Set must have failed for that event to have occurred.

A pole slip event is a situation encountered most often, but not always, when Generating Sets are running in parallel in island mode or in parallel with a mains supply network.

When, for some reason, an alternator's level of excitation is reduced to the point that the rotor is no longer held electro-magnetically in 'rigid' synchronism with the rotating voltage in the stator, the engine forces the rotor to rotationally jump forward one pole. This is a pole slip event. The cause of reduced excitation – excitation loss - could be one or more of the following:

- Sudden system voltage level change.
- Sudden change to the prime mover power level.
- Mains supply network micro-interruption.
- Poorly executed synchronising.
- AVR malfunction, because of incorrect 'information' from a Power Factor Controller (PFC3) or similar external control element.
- AVR failure.
- Sudden load step change on the electrical system that promotes system instability.

- Excitation system failure, such as the failure of one or more of the rotating diodes.

A well-engineered Generating Set should be fitted with a level of protection – modules and devices – aligned to the Generating Set's application, and so based on a history of experienced stressful situations for that type of application.

When things do go wrong the Generating Set's behaviour with regard to export / import – kWe, kVAr, kVA, voltage and current levels – will rapidly change. The detection of such events should be linked to actions to protect the connected equipment.

There are pole-slip detectors. Fitting the alternator with an Excitation Loss Module is far cheaper and is always recommended for co-generation applications, whether the Generating Sets are running in parallel in island mode or in parallel with a mains supply network.

Pole slipping, or any event occurring within the connected load that results in a high voltage being induced into the rotor winding, will result in the rotating diode assembly being subjected to a dangerously high voltage level. To offer protection to the diodes within the rotating diode assembly a Voltage Dependant Resistor [VDR] is incorporated for transient voltage spike surge suppression. The physical size of the VDR is restricted by space and centrifugal force considerations and consequently, the 'energy' rating [Joules] of the VDR becomes compromised and restricted. However, careful choice of the VDR's characteristics results in a diode assembly, which is well protected from individual transient voltage spikes. Repetitive events, however; can cause the VDR to be subjected to a mean energy level that results in sacrificial failure. Many alternators will continue to operate with a 'blown' VDR, but are then at serious risk of a diode being damaged when the next transient voltage spike is generated in the main rotor winding.

Engineering measures to cope with operating conditions expected to result in regular occurrence of high voltage spikes being generated into the rotor winding would be:

- Fit a resistor on to the rotor assembly chosen to dissipate the watts associated with normal excitation dc voltage levels, but able to change the rise time of any occurring dc voltage spike. The space required, and parasitic loading would both require consideration and rotor assembly redesign. The VDR would still be required but its characteristics would need to be changed.

- The voltage generated within the rotor winding can damage rotor winding turn to turn insulation and so the rotor could be wound with copper wire with a special high dielectric strength coating. The coating would be thicker than the normal 'enamel', and so would reduce the actual space within the winding area for copper cross section and / or turns, thereby affecting the performance of the magnetic circuit. Re-design would be required to return to expected ratings and performance.

Based on service history and general electrical engineering experience, we regard the present level of engineering consideration to be acceptable for the product and its use.

Reverse Power

In addition to the guidance offered in AGN 018 – Regenerative Loads and Reverse Power, the following guidance is offered primarily to cover applications where Generating Sets are running in parallel in island mode or in parallel with a mains supply network.

Reverse Power is the product of a connected electrical load being capable of, or even designed and expected to, produce 'regenerative power'. An example being an electric motor drive system that is designed to push power back into its supply source as a designed feature being used as a method of slowing this motor's shaft speed. Examples of such systems are; a crane's hoist motor [RTG Crane], a building services passenger lift and a machine tool system using regenerative braking to control the slowing-to-stop of a high inertia heavy object being rotating and machined.

If the connected electrical equipment's 'regenerated' power is pushed into the terminals of an alternator then:

- This can be completely absorbed by the other connected loads, a condition which just reduces the power required by the Generating Set.

- The regenerative power level (kW) exceeds all other connected loads requirements, or is, in fact, the only load connected. Under such conditions this 'r-gen-power' which is being pushed into the alternator's stator is pushed onwards into the alternator's rotor and so, pushed onwards into the engine's crankshaft, with the result that the engine's crankshaft speed will increase.

- The engine's governor will react by reducing the amount of fuel being fed to each cylinder. But if the level of power being pushed into the Generating Set's terminals exceeds the losses of both the alternator plus the pumping losses of the engine, then the engine's crankshaft will be forced to 'over-speed' and subsequently, something may well break.

Typically each Generating Set can tolerate some 10% to 15% of its rated kW as reverse power and absorb this level as 'losses'. The resulting level of over-speed will be < + 5%.

There are reverse-power detectors available, but an over-speed situation will be detected by an Over Frequency Detection Module (all well considered Generating Sets have over / under voltage and frequency detectors).

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