

Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 133 - Water Turbine Applications

INTRODUCTION

The following is offered as general guidance regarding the suitability of a standard production AvK or STAMFORD alternator for applications where an over speed situation could occur. For these applications, the alternator design and construction must be carefully considered. The comments below are based on a request for a capability to cope with an over speed situation of <3000rpm. Further detail on alternator operating speed can be found in AGN 041.

ROTOR CONSTRUCTION

To be able to advise about the rotor's ability to cope with an over speed situation of double rated speed for a 4-pole alternator [3000rpm] is rather difficult without being provided with guidance regarding the time duration of this extreme over speed condition. Another area of consideration is the potential damage that may be caused by this over speed event. After such an over speed occurrence, an inspection of the complete turbine and alternator must be conducted, to ensure that all rotating parts have not been damaged and remain within commissioned balance factors; therefore ensuring acceptable - and designed for - equipment vibration still exists.

It has to be said that the existing standard production build of a 4-pole rotor would not survive a 3000rpm over speed situation without considerable movement of the winding coils. This will affect the balance factor of the rotor assembly. Any movement of rotor windings will result in a cracking of the winding insulation impregnation system and in the damp atmosphere surrounding a water turbine application, will result in premature winding failure. Damage to the exciter armature and the rotating diode assembly is also very likely.

For an alternator to be approved for such an extreme over speed condition, requires consideration of manufacturer's liability. AvK and STAMFORD alternators are manufactured in compliance to engineering standards IEC60034 and NEMA MG1. In addition, the EU legislation of the Machinery Directive 2006/42/EC. Therefore, a requirement exists to meet a construction standard for every rotating assembly. The 4-pole rotor assembly must be safe when operating at 1.25 x the maximum continuous speed, which would be the 60Hz output of 1800rpm. This results in a legal requirement for the safe over speed condition of $1800 \times 1.25 = 2250\text{rpm}$ for any standard production 4-pole rotor.

For an over speed situation of 3000rpm, the complete rotor construction would need to be modified, with consideration to the following:

- The main rotor winding supports and insulation materials under rotor pole tips would need very careful consideration to ensure the winding is correctly supported to withstand the centrifugal forces. The rotor winding support 'spring clips' would also need consideration.
- The exciter assembly and rotating diode assembly would also need to be manufactured with an engineered route to provide support for out hangs and unsupported leads associated with the diodes.
- The bond-strength of the impregnation material is very important and as this reduces with operating temperature, the final kVA/kW rating of the alternator would need to ensure that winding assembly temperature rise is not too high.
- The rotor assembly 'critical speeds' would need to be considered. The hand-building of a 'SPECIAL' rotor would be possible in a manufacturing area that is not main-stream standard production.

OVERSPEED DETECTION

This should be a designed feature of the generating equipment's overall control system. AVR's have an internal Under Frequency detection, but when this situation is recognised, the 'information' is not available outside the AVR's own internal circuitry. AVR's have no designed feature to recognise over speed situations.

CONCLUSION

It is clear from the design analysis of the rotor construction and over speed detection circuitry, that it is not feasible to modify the standard production rotor assembly or excitation system.

Standard production AvK and STAMFORD alternators have been supplied for water turbine driven applications in the past. However, the water turbines have been fitted with a sophisticated control system to detect an over speed situation and to immediately introduce a control scheme to ensure the over speed situation is limited in both percentage of over speed and duration of occurrence.

Typically, the over speed requirements in the water turbine application during load rejection or in very rare occasions, during “runaway” speed situation where the turbine’s governing action fails, are identified as not exceeding 2500rpm for a period of 30seconds, or 2250rpm for a period of up to 15mins.

It is important to remember that standard STAMFORD AvK alternators are capable of typically 1.25 times the rated speed for a duration of 2 minutes only.

For applications that use standard production AvK and STAMFORD alternators, all power supply equipment must be maintained at an acceptable level and periodicity to ensure continued serviceability. Vibration levels must be checked frequently to ensure balance factors of all rotating parts have not been adversely affected by this periodic over speed situation.