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Gas Fired Generation Thermal Expansion Mismatch Control

Introduction:

Nova Scotia Power (NSPI) operates two (2) General Electric (GE) Aeroderivative, LM6000PC, natural gas fired generating units at Tuffs cove. Currently there is a major problem with reduced clearance between rotor blade tip and respective cases in the high-pressure (HP) compressor occurring with these generating units. Some instances contact is made. Due to cold ambient air being drawn into the encloser through the generator and turbine vent fans.

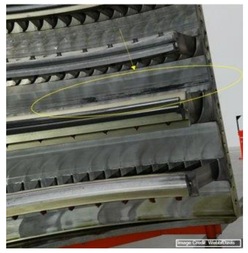

Figure 1. LM6000 LPC blade to case contact (Webb, 2021)

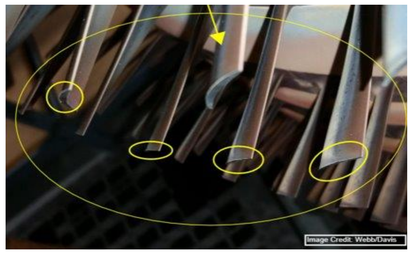

Figure 2. LM6000 LPC blade contact results (Webb, 2021)

When an abnormal load is applied there is damage related to tip to case contact. As unexpected loads on the blade roots exceed the design loads, coating wear begins to occur. With coating wear exposing the blade root assembly to excess movement, vibrations, and loading, there has been issues of blade liberation and significant subsequent damage. NSPI has previously quoted potential Variable Frequency Drive solutions but have not yet selected a final system.

Design Process:

- Root cause analysis, involving review of electrical power distribution, control and automation drawings. Review of current Mark Vie programmable logic control.
- **Problem Statement**: Large inlets of cold ambient air through generator and turbine vent fans cause undesirable temperature differential between the rotor (rotating blades) and the stator (enclosure casing) in the high-pressure and low-pressure compressor. This temperature differential causes flash cooling of compressor casing and as a result, rotor blade contact is made with the casing.

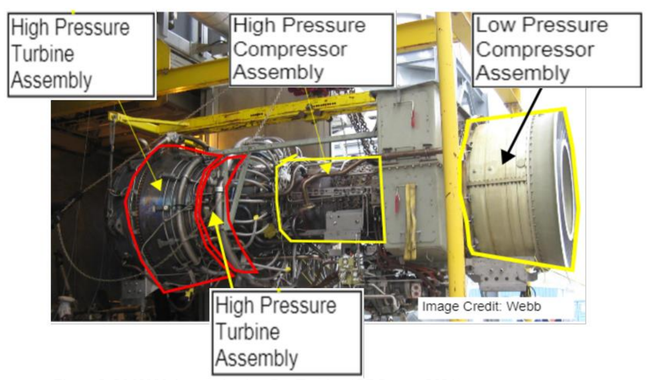

Figure 3. LM6000 Aeroderivative Gas Turbine (GE Power, 2021)

Details of Design:

The final control system, aims to have precise temperature control inside the LM6000PC turbine enclosure. Achieved by driving turbine and generator vent fans at adequate speeds to reduce air flow through the turbine. Specifically, during winter months when the fans are drawing in high volumes of cold ambient air into the system.

- System Logic Design
  - Mark Vie programmable logic control (PLC) system manages all the field instrumentation connected to LM6000PC generating unit and respective enclosure.
  - Signals are sent from transmitters to Analog I/O modules that scale and transmit their values to USCB controller.
  - The controller transmits information status to and receives commands from operator interface. Controllers can also transmit information status to external equipment such as a Drive.
  - Solution will require new programming within the MKVIe control system. Initial idea are having turbine enclosure and ambient air temperature feedback signals as inputs to new vent fan control specific MKVIe logic to compute and output a percent demand to each drive controlling the generator and vent turbine fans.
  - Other feedbacks would include differential pressure between Generator and turbine, fire and gas detection.

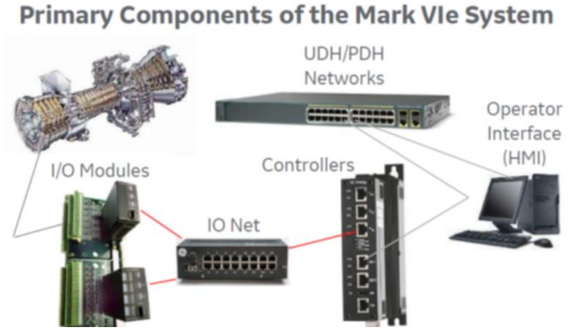

Figure 4. LM6000 LPC blade to case contact (Webb, 2021)

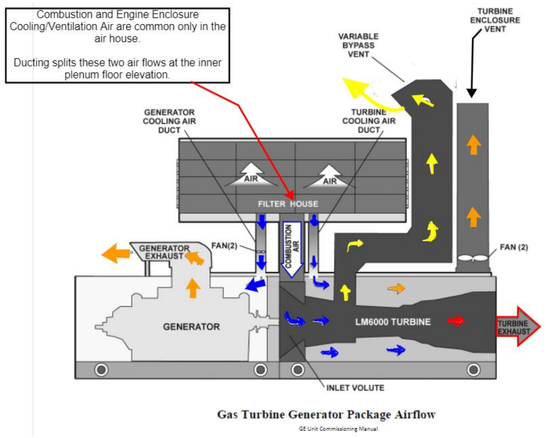

Figure 5. Gas Turbine Generator Package Airflow (Webb, 2021)

System Requirements:

Fan motor ratings – Turbine vent fan (460V, 3-phase, 60Hz, 156FLA, 125HP, 1780rpm) and generator vent fan (460V, 3-phase, 60Hz, 94FLA, 75HP, 1780rpm)	Fans must maintain same fire & gas detection operation. Full stop when fire detected or max speed when gas detected.
Power cables rated for full load amps (FLA). Suggested cable length less than 100m to avoid harmonic distortion	Operational temperature when operating fans at lower speed (ensure fans do not exceed temp. ratings)
Precise air flow and temperature control	Precise air flow regulation. Through effective temperature sensing.

Project Plan:

To meet the project deadline of November 2021 the following plan will be used as reference.

- Perform tests on-site to determine adequate air flow/motor speed.
  - Ensure motor can operate at this speed without overheating.
- Obtain quotes of adequate Drive solutions from different manufacturers.
- Perform technical analysis on valid options.
- Design proposed system Electrical drawings.
- Develop New Programming for MKVIe control system
- Determine total project budget.
- Create final Turnover package for client.

Conclusion:

It is crucial that the final solution will allow for precise temperature control inside the LM6000 generating unit enclosure by adequately changing the airflow. Resulting in a more regulated enclosure temperature and no flash cooling of components while meeting all the requirements of the current system. Ensuring the project team will perform engineering due diligence to provide NSPI with a solution that best fits their needs.

References:

- Ge.com. 2021. *LM6000 Aeroderivative Gas Turbine | GE Power*. [online] Available at: <https://www.ge.com/power/gas/gas-turbines/lm6000>
- Webb, D., 2021. *Variable Frequency Drives LM6000 Site Project Summary*. NSPI P&W and LM6000 Fleet.
- GE Packaged Power, L.P., 2021. *Flow & Instrument Diagram Ventilation & Combustion Air System*.