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The Challenge of Measuring Inlet Humidity on Combustion Turbines

The Cinergy Madison Generating station, located north of Cincinnati, Ohio, came into commercial operation in July 2000. The plant has eight GE 7EA simple cycle combustion turbines that are used to generate electricity primarily for peaking duty. Total generating capacity is 576 megawatts. Initially, these units were not equipped with anti-icing protection for winter operation. However, during the first winter of operation, a sister site experienced ice damage to the compressor. Subsequently, the manufacturer was requested to install anti-icing protection which was accomplished before its second winter of operation.

Output power variation

During the winter of 2001-2002, several of the Madison turbine units experienced inconsistent measurements from the chilled mirror dewpoint/humidity instrumentation, resulting in erratic inlet bleed heat valve operation for the anti-icing system. The output power from the units was subsequently varying by several MW, making it difficult for the operators to maintain hourly output accurately. Further, the cycling action on the unit hardware would eventually have an adverse impact on component life. Also, the operators of the electricity grid were not pleased with the fluctuating power generated. A study was undertaken to identify the cause of the erratic measurements and to possibly recommend a replacement dew point/humidity sensor.

Many humidity sensors used on gas turbines determine dewpoint using a chilled mirror hygrometer. Chilled mirror hygrometers are accurate and provide repeatable measurements. However, contamination of the mirror surface is a common problem and this requires proper maintenance. Contamination can result in substantial measurement error, which is remedied with mirror cleaning. Consequently chilled mirror systems tend not to experience drift with time but can be maintenance intensive. Other technologies, such as the polymer (capacitance) sensor, do have some minor drift, but are lower cost and much lower maintenance.

The original factory supplied humidity sensor in the Madison GE 7EA units used a chilled mirror device. The output is dewpoint, which is fed into the GE control system where the specific humidity is then calculated. The device puts out a 4 – 20 milliamp signal. The GE interface can accept either a 4 – 20 milliamp or a 0 – 10 volt signal.

Study of technologies

An investigative study was conducted to identify the technologies used by different dewpoint/humidity sensors and their suitability for a combustion turbine environment assessed. Other parameters considered included accuracy, maintenance, power supply, output signal and cost. Since the Madison units also have inlet fogging systems for hot day operation, the impact of very high humidity on the dewpoint/humidity sensor was another consideration These are some of the conclusions of the study:

1. All the dewpoint/humidity products evaluated in this study were considered to be capable of satisfying the need to provide the humidity information necessary for determining the need to activate inlet bleed heat for anti-icing.

2. The chilled mirror sensors, while very accurate, seemed to have a difficulty with contamination of the mirror and required frequent maintenance (cleaning). The capacitance system appears to be more tolerant of contamination problems.

3. While the chilled mirror systems are the most accurate,

Editor's Note (May 2014): The HMP235 and HMP247 have been since replaced by the HMT330 series.

the capacitance systems are certainly acceptable for the 7EA inlet humidity measurement.

4. Costs vary sufficiently to be a factor in which system to select.

5. Several dewpoint/humidy sensors have been certified by the OEM.

6. Some dewpoint/humidity sensors are direct drop-in replacements, while others will require modifications to the existing duct opening. Generally, the chilled mirror units have everything mounted on the inlet duct side wall, while the capacitance sensors have the probe mounted on the duct side wall with the transmitter located separately.

An evaluation table was used to rank and prioritize the various parameters, mentioned earlier, to be considered in the selection of the replacement sensor instrumentation. The Vaisala Humidity and Temperature Transmitter HMP235 was initially determined to be the best value for the cost. The capacitance technology avoids much of the chilled mirror maintenance and Vaisala has an excellent reputation for reliability. The HMP235 is the same as the Vaisala Humidity and Temperature Transmitter HMP247 except it does not have the heated sensor head which eliminates dew formation in condensing environments (i.e. downstream of foggers). For this reason, the final selection was the HMP247 transmitter. Vaisala had also developed an adapter mounting system that made use of the existing instrumentation location.

The Madison turbines are now operating with the HMP247 transmitters installed. The instruments have been reliable and trouble-free, enabling us to improve the overall performance of the generating station.●