The harsh conditions in a turbine nacelle give pressure and temperature sensors a critical role ensuring equipment there functions properly and safely.

Pressure and temperature transmitters 101

When the factory floor is 80m in the air, it is not possible to do a simple and daily walk-around equipment inspection. That makes necessary remote ears and touch in the form of pressure and temperature sensors. These should be installed on most anything with lubricant and cooling fluid.
The forces operating on a wind turbine nacelle are extremely powerful, producing stresses that can push pressures and temperatures beyond normal operating parameters and cause component failure. These conditions give pressure and temperature sensors a critical role ensuring nacelle subsystems function smoothly and safely. And, because nacelles are typically difficult to access, repairs and downtime are extremely costly. That’s why it pays to understand the role of pressure and temperature transmitters, how to select appropriate sensor designs, and how to handle common installation and troubleshooting issues. Years of experience provide valuable insights on identifying transmitter characteristics suitable for wind-turbine applications.

**The role for sensors**

In modern wind turbines, sensors measure hundreds of different parameters, most of which involve rotational, positional, vibration, and electrical factors. But a wind turbine is a complex system that incorporates heat-ejecting generators and electric devices, as well as fluid-power transmissions involving temperature and pressure limits.

Wind-turbine operation, for example, depends on maintaining proper hydraulic pressure. Pressure rises at wind-turbine startup and is released at shut down. A minimum charge pressure is required to maintain proper lubrication and rotational operation. Depending on the pump size and the manufacturer, minimum hydraulic pressure must be maintained at 50 psi (3.4 Bar). To enable turbine operation, the hydraulic system must produce 1,450 psi (100 Bar) to activate hydraulic cylinders that will pitch each blade for best rotational efficiency.

A minimum hydraulic oil pressure also serves as a failsafe during turbine operation. Loss of pressure activates the failsafe to halt turbine rotation. Similarly, proper oil pressure must be maintained to prevent activation of the mechanical disc brake. In cooling circuits and gearbox lubrication, pressure must be monitored to ensure proper cooling and lubrication flow. In the heat exchanger, a high-pressure alarm should signal internal problems.

Temperature is a critical factor in almost all subsystems — the hydraulic unit, generator, drive shaft, gearbox, gearbox oil, electronic cabinets, and cooling systems, as well as in ambient conditions. For example, when wind turbine rotation must start at low temperatures (generally 35°F and below) the hydraulic oil must first be warmed, necessitating oil-temperature monitoring and control.

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Braking action during high wind speeds can generate pad and disc temperatures up to 1,300°F (700°C), considerably more than the 570°F (300°C) measured on car brakes. In other subsystems, temperature is monitored as a precaution to detect abnormal conditions and prevent breakdown. For example, if a bearing in the gearbox overheats by just a few degrees, its life is significantly reduced, leading to turbine downtime.

Pressure and temperature signals are used by controllers to adjust valves, pumps, and other equipment to maintain stable operation and increasingly, for safety functions. Because transmitters provide a critical link between control-system fluids and components, pressure and temperature transmitters must be carefully selected.

**Selecting sensors**

There are hundreds of industrial-grade temperature sensors to choose from. However certain features are more useful in wind-turbine applications. For example, in gearbox applications, a temperature sensor with a spring loaded insertion probe will maintain contact with internal gearbox components to ensure accurate monitoring. Also, selecting a temperature sensor with a linear output, such as a Platinum Resistive Temperature Device (Pt 100 RTD), makes for easy interface with standard controllers.

In contrast to the selection simplicity of temperature devices, selecting pressure transmitters can be downright confusing. A range of sensor technologies, digital electronics, and feature enhancements create overlapping capabilities. Because repair work in a nacelle is difficult, employing high-quality, cartridge-type pressure transmitters — like those typically used in heavy-duty mobile and industrial equipment — is well worth the upgrade and cost.

The characteristics of pressure transmitters relevant to wind-turbine applications include thermal stability, zero displacement due to overpressure, high pressure cycle life capabilities, and high resistance to electro-magnetic interference caused by other electrical components in the nacelle. The good news is that pressure transmitter features developed for use in harsh industrial environments are ideal for accurate pressure measurement within a nacelle. For example, transmitters with a built in pulse snubber should be used for hydraulic systems exposed to potentially destructive conditions, such as cavitation, liquid hammer, or pressure spikes.

The table above highlights the more significant pressure transmitter specifications relevant to nacelle applications.

**Installation and troubleshooting**

When manufacturing nacelle components, proper factory installation will minimize costly field repairs. Important application considerations include over pressure, dirt contamination, excessive temperatures, liquid cavitation, poor electrical wiring conditions, and water drain problems from the pressure port (where applicable). Following a few recommendations can make the sensors function longer and more reliably than otherwise. For instance, to prevent:

- **Temperature transmitters**, such as the MBT 5310 from Danfoss, features a spring-load sensor to ensure close and reliable contact, especially when on equipment that vibrates, as does most everything in a nacelle. It is rated to 200°C.
Over pressure or liquid cavitation, use a pulse snubber on the pressure transmitter. A pulse snubber is an angled inlet orifice that protects the pressure transmitter from instantaneous pressure surges. It also protects the pressure transmitter from liquid cavitation in applications where a component inadvertently draws a vacuum.

Dirt contamination - Proper hydraulic-fluid filtering can reduce the number of floating particles. Mounting the transmitter so it is not the highest point in the system helps prevent floating particles from gathering there. Also, mounting the transmitter away from the lowest point avoids sinking particles. The ideal location is where oil circulates, rather than in a position where particles are concentrating within the fluid.

Excessive temperature - Mount the pressure transmitter away from the highest heat-generating components. Choosing a protected location keeps the pressure transmitter from being exposed to excessive oil temperature during operation.

Poor electrical wiring conditions - Use a durable electrical connector (DIN plug, M12 connector, Deutsch connector) that will not break free during operation and will maintain ideal electrical contact in high-vibration applications. To relay the pressure transmitter signal back to the central controller, use a shielded cable with a tough outer layer that can withstand abuse while minimizing electronic noise and interference in the signal.

Water drain problems - Especially for applications in which a transmitter mounts on a water line that is subject to freezing, install the transmitter to allow for proper draining while mounted vertically. The transmitter should also have a larger inlet port diameter so surface tension does not prevent the inlet port from draining properly.

Ensuring equipment reliability
In extreme environmental and operating conditions, wind turbines are subject to forces that can exceed the design envelope and cause breakdowns. Pressure and temperature sensors play a critical role in maintaining operation within that envelope and ensuring consistent, safe, and smooth functioning. Based on decades of experience in European wind farms, transmitters have been developed with features suitable for demanding wind-turbine applications. However, proper selection and installation of these devices are essential when building a nacelle capable of generating electricity in harsh ambient conditions year after year.

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