Turbine water induction prevention

Background

Water ingression into a steam turbine can occur from a number of sources, and may have catastrophic consequences. It follows that any protection against water ingression must be wholly reliable. The 2462 Hydratect electronic system, designed to be fail operative, provides the ultimate protection.

Problem

Water ingress into steam turbines may have catastrophic consequences and it is essential that automatic protection devices are in place to prevent this occurring. Even a small amount of water can cause enormous damage to the turbine blades, the cylinders, and the housing.

There is very little chance of an operator assessing a deteriorating situation quickly enough to judge whether or not water, water droplets, or flash steam are present in bled steam lines. This is complicated by the fact that a manually initiated trip of the turbine may further aggravate the situation, as the decay of pressure in the turbine stages to vacuum can potentially cause reverse flow.

Causes of water ingression

Water can reach the turbine from various feedwater plant items and under a number of operating conditions. For example:

(a) High water level in either HP or LP feedheater, usually caused by tube leaks or the failure of the drainage arrangement.

(b) High water level in the de-aerator: if there is a mismatch between the inflow and outflow the vessel can flood. In each of these cases the water may flow, via the bled steam lines and against the steam flow, towards the turbine.

(c) Un-drained bled steam lines. Wet steam can deposit water on the pipework walls, and condensation can occur at bends in the pipework and at valves. Condensation is also a problem during start up when the steam lines are being warmed.

(d) A unit trip or sudden load reduction, resulting in a pressure reversal. During a trip, the HP turbine pressure decays rapidly and the IP/LP pressure falls to condenser vacuum almost immediately. In contrast, the pressures in the feed system change relatively slowly. Large pressure differentials are created which will tend to stimulate flow towards the turbine from the feed system.

(e) Reverse steam flow in the bled steam lines can potentially carry water from heaters or un-drained low points to the turbine with consequential damage.

Water ingression is not only a problem when the turbine is at operating speed; water flowing onto hot cylinders while the turbine is on turning gear can cause severe chilling with distortion or cracking of the cylinders.

Design philosophy

The Hydratect system detects either water or steam where they are not wanted. An all-electronic system, it is completely reliable by design. It uses the difference in resistivity between water and steam across an electrode to inform the user of an unexpected condition. It continuously checks the measurement electronics, connecting cables, and electrodes for correct operation. It is fault tolerant, informing the user of a fault condition but continuing to operate normally.

The electrodes of the 2462 operate equally efficiently over the complete temperature and pressure range experienced in steam generating plant; pressures from vacuum to 300 bar (4350 psi) and temperatures from 0 to 560 °C (32 to 1040 °F).

Each 2462 has two independent, separately powered channels. These may be used to provide a fully validated output, for example in a tripping circuit, or separately to open and close a drain valve.

Typical installation sites in feedwater heating systems for the 2462 include:

(a) Alarm annunciation and drain operation on main steam lines

(b) De-aerator tanks for high water level alarms against turbine water ingression and low level alarms to prevent the boiler feed pump from being starved.

(c) Drain operation on bled steam lines feeding both high pressure and low pressure heaters, de-aerator.

(d) Condenser hotwell for high water level alarms and extraction pump operation.

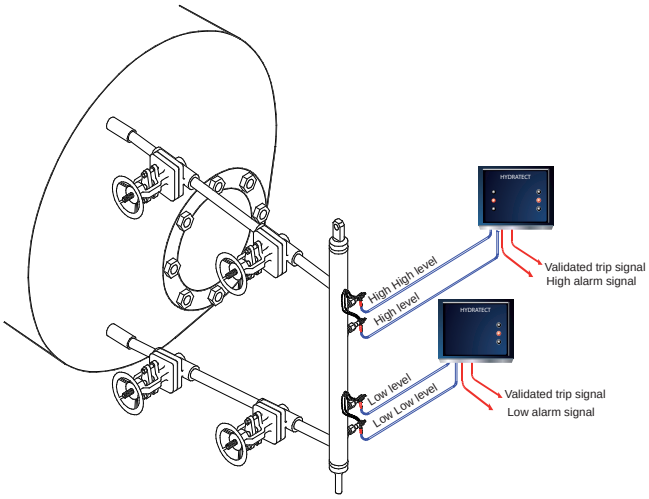

Figure 1. Storage tank with both high and low alarms and trips

In Figure 1, both high and low alarms are fitted. The inner electrode provides an alarm output and the outer electrode gives a trip, providing that the inner electrode validates it.

If the 2462 has detected either electrode to be faulty then the trip is inhibited and a fault output is provided.

In Figure 2, the lower electrode in the manifold is configured for water normal, the upper electrode for steam normal. When the water level in the drain pot reaches the upper electrode the status output changes, opening the drain valve and setting a latch. As the water level falls below the lower electrode, its status output changes, resetting the latch and closing the drain valve. In critical situations, a second 2462 could be fitted to provide high and low level alarms in the case of the valve failing.

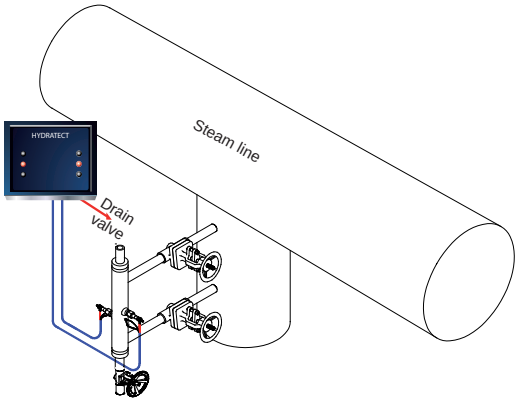

Figure 2. Automatically operated drain valve for bled steam lines

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