HYDROSTATIC TESTING OF STEAM TURBINE CASING

By Timothy Coull

When refurbishing a steam turbine, it is good industry practice to perform a hydrostatic test, or "hydro-test", of the casing when any changes bring into question its structural integrity or sealing capabilities. For example, turbine casings are generally hydro-tested when rerating to higher operating conditions, if any part of the casing is stress-relieved, or when the casing is weld repaired and/or machined.

Hydro-testing is designed to ensure that the casing can withstand the turbine operating pressures, is free of leaks and has adequate contact at the joints for sealing. A casing is isolated, blanked off, and pumped with liquid to a pressure designed to simulate operating conditions. This pressure is maintained for 30 minutes while the casing is inspected for leaks. Water is the most common working fluid because it is cheap and easy to obtain, dispose of and remove from the turbine. Hydro-tests are desired over air-tests because of the essentially incompressible nature of liquid. Since air is compressible, decompression requires the loss of a large volume of gas. High-pressure gas in a casing tends to want to rapidly expand, and if a crack were to initiate it would provide a path to do so and could potentially explosively rupture the casing. In a hydro-test, loss of a miniscule amount of water could result in total decompression, essentially eliminating the chance of explosion. Not to mention, it is also much easier to identify a leak with weeping liquid than it is with an invisible gas.

When designing for hydro-test pressure, API 612 calls for a 1.5X design factor, as well as a correction factor for deterioration of at-temperature casing mechanical properties listed in ASME Boiler and Pressure Vessel Code, Section 2. Let's take as an example a turbine casing made from cast ASTM A216 WCB that is operating at 550 psig and 725 °F. At ambient temperature, the allowable working stress of the material is 24.0 ksi, whereas the same at operating-temperature is 16.0 ksi. To calculate the minimum required hydro-test pressure, one would use the following formula:

$$(550\,\text{psig}) \bullet (1.5) \bullet \left(\frac{24.0\,\text{ksi}}{16.0\,\text{ksi}}\right) = 1237.5\,\text{psig}$$

Hence, the minimum required test pressure per API 612 and the ASME Code is 1237.5 psig. Since the unit is to be tested independently of the process in which it is to run, blank plates must be designed to seal off any open flanges, including inlet, exhaust, extraction, or admission flanges, as well as leak-offs, drains, exposed joints, and seal bores. In multi-segmented machines experiencing different pressures, casings can be partitioned or tested as separate pieces. Each segment of casing should be tested to the worst-case combination of temperature and pressure experienced in that portion of casing. Blanks and partitions must be of adequate thickness to contain the pressurized fluid without failing. Where practical, tie-bolts may be used to mitigate excessive stress in a plate.

The test setup must also be designed to allow for filling and draining of the fluid and venting of air while filling. When filling a casing or portion of a casing with water or any other fluid, as much air as possible should be removed. Trapped air results in unreliable pressure readings. Also, in the event of springing a leak, excessive compressed air can hinder rapid decompression and can even rapidly propagate a crack, thus marginalizing the advantage of using an incompressible test fluid as previously outlined. Though the point of the test is to examine the integrity of the machine and highlight any potential flaws, it is desirable to find and repair them before they become even more of a problem.

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