DIFFERENTIAL EXPANSION

By Scott MacFarlane

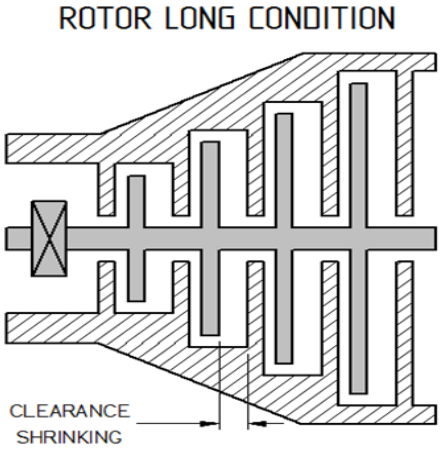
Temperature always seems to be a prevalent factor when discussing steam turbine operations and it should be. The temperature of the casing, machine components, steam and rotor always play a crucial role in the turbines performance. From start-up to shut down, the steam turbine's temperatures should always be closely monitored for both safety and reliability reasons.

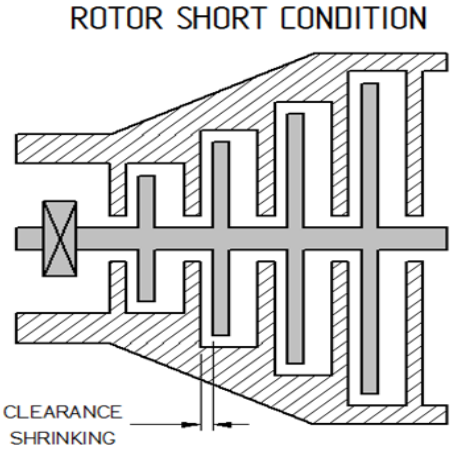
Temperature fluctuations cause differential expansion in machines which alters axial clearances and alignments of internal components. Calculating differential expansion rates helps identify these variations to protect against axial rubs between rotating and stationary components. If the differential expansion gets too severe, it can lead to a failure which results in either expensive repairs or entire machine replacement. Steam turbines were designed for axial fluctuations when following proper procedures from start-up, through transient conditions to stable operation and back to shut down.

The rotor position is fixed at the thrust bearing to restrict its axial movement within the turbine casing. This means the rotor will thermally grow away from the thrust collar and contract towards thrust collar during differential expansion. This is important to remember when setting rotors and determining start-up and shut down time periods.

There are two main conditions that can occur for differential expansion. There is the rotor long condition and rotor short condition. Both conditions can negatively affect the internal clearances of the turbine which can lead to failures. These internal clearances include the axial distance from the rotor blades to the casing diaphragms as well as axial clearances between stepped seals.

Rotor long condition is referred to when machine temperature is increased rapidly. This causes the rotor to thermally expand at a faster rate than the casing due to the difference in masses and materials of components. This rotor long condition can mainly be seen during start-ups when both the casing and rotor start at the same temperature and experience the greatest thermal excursion. Manufacturer specified start-up procedures help control the thermal growth and maintain internal clearances as needed. Steam temperatures, flow and start-up time or soak period can be controlled to help maintain a safe rate of thermal expansion for both the rotor and casing simultaneously.





Rotor short condition is similar to rotor long condition but occurs during shut-down. When the turbine is subjected to rapid cooling, the rotor contracts at a faster pace than the turbine casing, which can lead to axial rubs. This rotor short condition can mainly be seen during emergency shut downs when steam is shut off to the turbine in an uncontrolled manner. Rotor short condition is usually of greater concern because clearances upstream of the wheels are generally smaller than downstream for stage efficiency purposes.

To help prevent axial interferences due to thermal transients, it is important to maintain the manufacturer's design rotor axial positions and turbine internal clearance specifications during rebuilds. Dimensions outside of the tolerance should be considered with thermal expansion in mind. Follow published start-up procedures and take a common sense approach to start-ups after an emergency shut-down.

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