Forced Cooling of Steam Turbines

A power plant’s competitiveness is measured not only on performance, but also on overall plant operating economics. This includes having the ability to start up and shut down the plant quickly and effectively. Through extensive analysis Siemens is able to provide forced cooling of steam turbines allowing for the possibility of maintenance to begin significantly sooner than with traditional cooling methods, potentially getting your power plant back online faster.

Cool down gradients are determined using the finite element method, to help protect against excessive thermal distortion and differential expansion. Existing temperature measuring points are used to monitor the cool down gradients. This helps to maintain the recommended temperature limits during a forced cool down.

Our Solution
During forced cooling, the existing condenser air removal system is used to draw air from the turbine hall through the blade path of the turbines, and into the condenser, where it is ultimately exhausted from the system. This air flow allows for a greater amount of heat to be removed from the components, and for the steam turbine to cool down, more quickly than with natural cooling. Subsequent work on the unit can therefore be started much earlier, allowing for an increase in availability and improvement of the overall plant operating economics.

Implementation
Forced cooling is a reliable way of saving up to 5 days cool down time compared to natural cooling. Detailed analyses are performed for the cool down process taking into account material strength limits and usage factors. The forced cooling process combines a modified software package, filters and mechanical analyses. Siemens has developed this process into a patented product, which can be used to potentially speed up inspections and reduce plant downtime. Permanent installation of additional hardware or modification of existing hardware is not generally required. In some cases the installation of a nozzle and filter may be necessary at each turbine admission control valve. This nozzle is mounted on the existing flanges for the dehumidifiers. The process itself is monitored using the temperature sensors installed as standard in the turbine.

Fig. 1: Longitudinal section through an SSTx-5000 (HP/IP turbine).

Performance Enhancement – Steam Turbine

Answers for energy.
A distinction is drawn between two forced cooling procedures:

1) **Scheduled shutdown with a target deadline**
   Targeted shutdowns are divided into the following steps:
   - **Operational cool down of turbine**
     Prior to the plant shutdown, main steam/reheat steam temperatures are reduced to the minimum allowable value in accordance with allowable limits and protection criteria. Reducing the temperature during operation shortens the overall cool down time due to the lower starting temperature of the forced cooling process.
   - **Natural cooling**
     Once steady-state temperature conditions have been achieved with reduced steam temperatures the steam turbine is shut down. While on the turning gear, the turbine enters a natural cooling phase to permit the temperature differentials within the steam turbine to reach an equilibrium state.
   - **Forced Cooling**
     At the end of the natural cooling phase for the steam turbine, the nozzles provided for connecting dehumidifiers at the admission control valves are opened and the vacuum pumps are switched on. This again draws air via the control valves, which pass through the turbine blade path. The air flow is regulated using the control valves.

   After completion of these steps and sufficient reduction of temperature, the turning gear can be switched off and working access to the steam turbine can be commenced.

2) **Unscheduled shutdown (e.g. after unexpected steam turbine trip)**
   Unscheduled shutdowns are divided into the following steps:
   - **Natural cooling:**
     While on the turning gear, a natural cooling phase allows the temperature differentials within the steam turbine to reach an equilibrium state. Assuming the turbine was tripped at operating temperatures, the natural cooling phase in this case takes longer than it would after an operational cool down in the targeted shutdown procedure described above.
   - **Forced Cooling**
     The Forced Cooling phase is performed the same as if the steam turbine shut-down had been scheduled. At the end of the natural cooling phase for the steam turbine, the nozzles provided for connecting dehumidifiers at the admission control valves are opened and the vacuum pumps are switched on. This again draws in air via the control valves which pass through the turbine blade path. The air flow is regulated using the control valves.

   After completion of these steps and sufficient reduction of temperature, the turning gear can then be switched off and working access to the steam turbine can be commenced.

**Benefit to the customer**
Our forced cooling solution offers the following potential advantages:
- Power plant specific optimization
- Reduction of overall outage times for inspection
- Increased availability through shorter cool down times at no risk to the turbine
- Existing hardware and software can generally be used without modification.

**References**
Already more than 65 plants have been equipped with forced cooling (Status: April 2009).