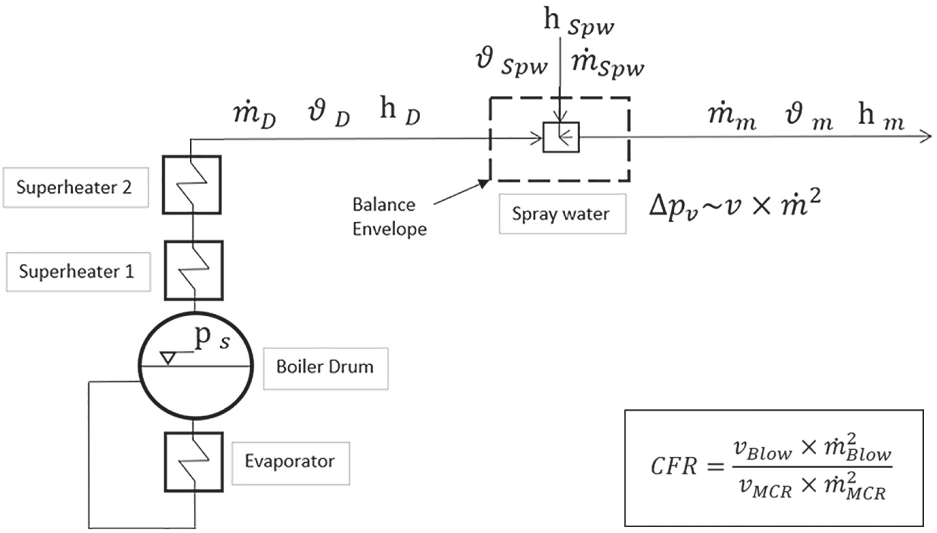
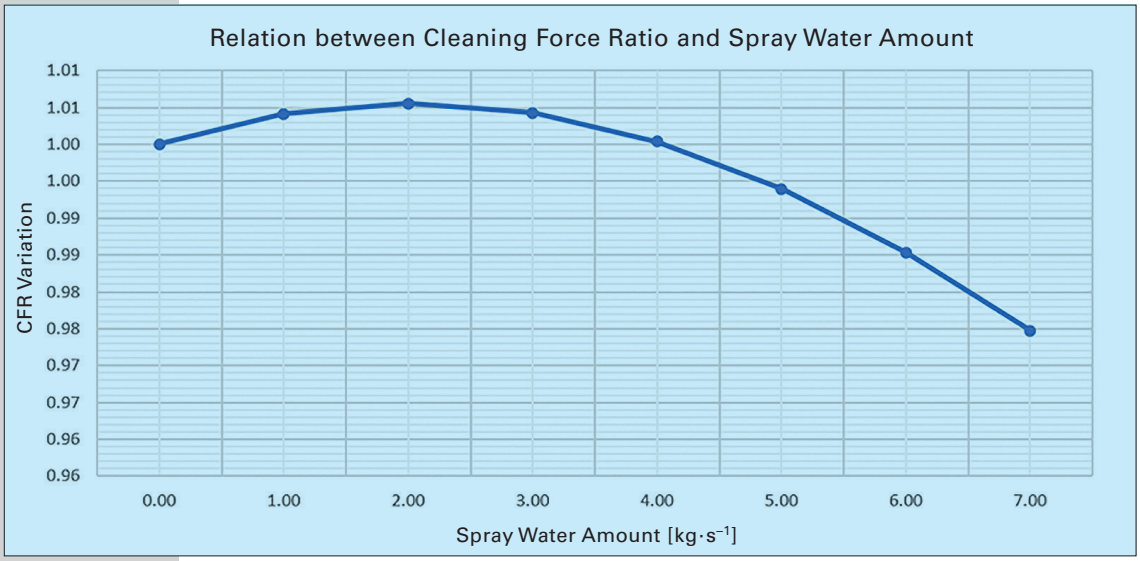
Hints from the Experts

How IAPWS-IF97 can be used to optimize the so-called "Cleaning Force Ratio" during the steam cleaning of power plants



Throughout the entire process of the fabrication and construction of newly erected power plants, contaminants are introduced into the systems of the steam generator and the water/steam cycle due to the nature of the work. Some of these contaminants may not be removed successfully during chemical cleaning. Thus, due to the cleanliness requirements regarding the absence of particles, steam systems of power plants must undergo steam-blow operation prior to commencing the first steam admission to the turbine.

Therefore, all steam pipes routed to the steam turbine must be steam-blown by using enough "force" to remove solid contaminants effectively. The so-called "Cleaning Force Ratio" (CFR) is used to determine whether this required "force" is achieved during steam cleaning.

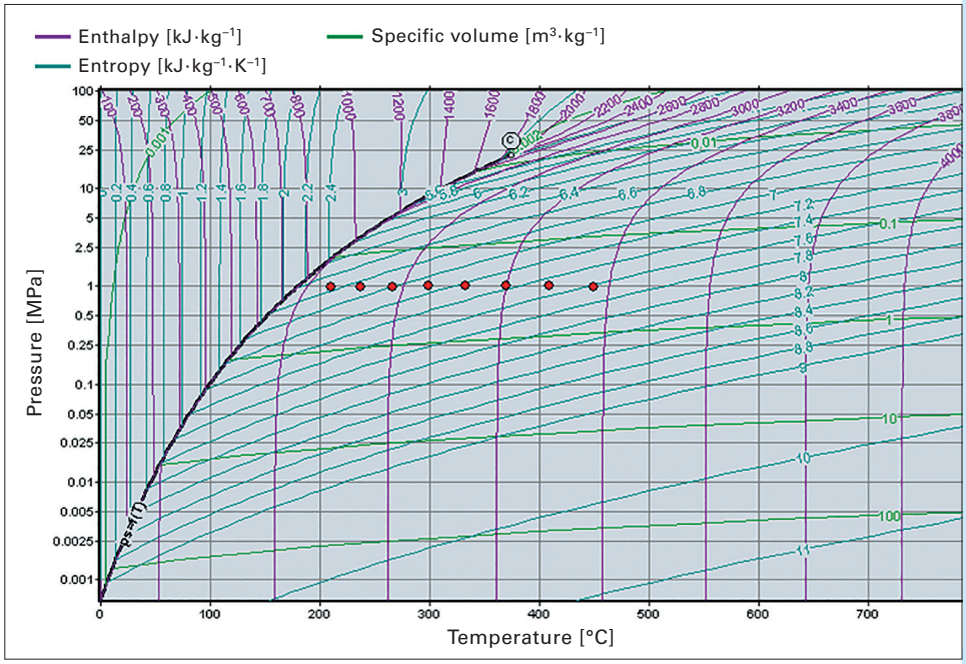


The CFR describes the rate of the impact pressure during steam cleaning in relation to the impact pressure generated during operation at the maximum continuous rating, i.e., at the baseload of the plant. Therefore it should be greater

or at minimum equal to "1". The reason behind the approach utilizing the CFR for determination is that any remaining particles will either be removed during steam cleaning or they won't be mobilized in the system later on, hence, they will cause no "issues" throughout the entire lifetime of the plant.

To determine the progress of the cleaning process, so-called "target plates" made of shiny polished unalloyed steel are positioned in the center of the steam flow. These are used to evaluate the system's cleanliness regarding particles, in size and number, by thoroughly assessing the impacts on a defined area of the target plate. Steam cleaning must continue until the specified requirements of the steam turbine manufacturer are met.

Depending on the steam parameters at the outlet of the superheater, a specific amount of spray water, which can be thermodynamically determined, can be used to maximize the CFR downstream of the spray water nozzle. However, only a certain amount of spray water should be used as too much spray water will deteriorate the CFR again. Superheating of the steam should be at a minimum of 15K to avoid droplet erosion.



The evaluation of the optimal spray water mass flow is done by considering the state variables pressure and temperature of the steam and the subcooling of the spray water, including the generated steam mass flow at the outlet of the superheater. Using the "IAPWS-IF97" [1] properties of water and steam, a calculation can be performed to determine the optimal spray water mass flow for the desired maximization of the CFR.

The optimized CFR is of course limited to the steam sections downstream of the spray water injection point. The CFR upstream of it remains unchanged.

[1] *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, 2007. The International Association for the Properties of Water and Steam, IAPWS R7-97(2012). Available from http://www.iapws.org.*

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