

The information and data contained in this document were prepared by a technical committee of the Association. The committee and the Association assume no liability or responsibility in connection with the use of such information or data, including but not limited to any liability under patent, copyright, or trade secret laws. The user is responsible for determining that this document is the most recent edition published.

Recovery boiler energy efficiency improvements

Scope

Opportunities are identified for improving the net steam and power generation from a recovery boiler. These opportunities include factors internal to the boiler (steam generation and consumption) and factors external to the recovery boiler (liquor properties).

Savings estimates are based on a 250 tonne/hr (550,000 lb/hr) boiler, using a steam value of \$15/tonne (\$6.8/1000 lb) for high pressure steam and \$10/tonne (\$4.5/1000 lb) for low pressure steam. These are typical steam costs for a pulp mill burning coal to make incremental steam.

Safety precautions

Changes to recovery boiler equipment and operating practices should be reviewed by qualified and experienced personnel prior to implementation.

Strategies to increase recovery boiler net thermal efficiency

In this section, the strategies that should be applied to maximize net steam generation from a recovery boiler are summarized and discussed, including:

1. Maximizing the fired liquor solids concentration or percent solids
2. Maximizing steam temperature
3. Minimizing excess air
4. Minimizing fouling
5. Minimizing sootblowing
6. Stabilizing steam flow

Maximizing the fired liquor solids concentration

Maximizing the percent solids fired in a recovery boiler will reduce the thermal losses for heating the water associated with the black liquor. This water exits the boiler as steam or water vapor in the stack gases. The heat of vaporization of water, and some sensible heat, will be lost up the stack. A typical recovery boiler will gain about 0.4% efficiency for each 1% increase in the percent solids fired in the recovery boiler. An exact prediction of this change can be obtained by using a recovery boiler thermal balance program, such as the TAPPI Short Form. Using the example boiler and a 5% increase in percent solids, the annual value of the additional high pressure steam is about \$1,000,000/yr. The additional steam use in the evaporator/concentrator, with a steam economy of 5, would be worth \$125,000/yr. The net value would thus be \$875,000/yr

The limitations in raising the fired solids concentration are a function of the evaporators and concentrators used to concentrate the black liquor.

In the case of direct contact units, the use of dilution water on cascade or cyclone evaporators should be avoided. The percent solids to the black liquor oxidation system should be maximized given the constraint of maintaining low residual sulfide levels in the black liquor. This will result in the highest possible solids to the recovery boiler. A target of 68-69% would be good practice.

The percent solids target for a concentrator should be consistent with the capability of the unit to produce the high percent solids liquor while not requiring excessive boil outs. Depending on the equipment used, this could range from 68% to more than 80% solids.

Controls should be used to help stabilize the high firing solids concentration. A continuous measurement of the percent solids out of the product evaporator or concentrator can be made available using either the boiling point rise or a refractometer.

Maximizing steam temperature

Higher steam temperatures are important as they result in additional power generation in the turbine. The main factor in determining steam temperature is the design of the recovery boiler superheater. All superheaters are designed for a maximum outlet temperature, which is a function of the materials used to construct the superheater.

In actual performance, many superheaters cannot maintain the design exit steam temperature throughout the annual operating period between maintenance shutdowns. This is usually due to insufficient superheater surface or excessive fouling of the superheater. Fouling is addressed in a following section.

In some cases, a superheater is controlled to less than the design temperature due to past problems with corrosion. Check with a turbine expert to see what this is costing you in terms of power generation. It may be that some improvements to the boiler operation, or changes in the materials of construction for the superheater, can be made to enable operation at a higher steam temperature.

The superheater outlet temperature can also be improved by taking the sootblower steam off after the primary or intermediate superheater rather than from the final superheater. This will also reduce the desuperheating required for the sootblower steam. Note though that it is better from an overall energy perspective to use a source steam header that is closer to the operating pressure of the sootblowers (300-450 psig normally). Most boilers produce steam at much high pressures, and use of this high pressure steam, pressure-reduced down to a pressure suitable for sootblower operation, eliminates an opportunity to generate electrical power.

While the steam temperature can usually be increased by raising the feedwater temperature, there are some exceptions. Determining the energy benefit requires a careful check of your mill's energy balance to determine if this is a worthwhile approach. In general, this approach will be favored by higher electricity prices and lower fuel prices.

The actual value of an increase in steam temperature is highly dependent on the steam cycle and fuels used to produce incremental steam; as a result, rules-of-thumb are of little use.

Minimizing excess air

Excess air is the amount of air that must be used above the theoretical requirements in order to complete combustion. Complete combustion can be defined based on carbon monoxide (CO) levels in the flue gases. In general, if the concentration of CO is less than 50 ppm, then combustion is essentially complete. On most recovery boilers with a modern air system design, this will require between 1.5 and 2.5% O₂ or about 7.5 to 10% excess air. With older air systems, excess air requirements could be as high as 3.0% O₂, or about 15% excess air.