How much is steam balancing performance gap worth at your mill?

For the past 20 years, AFRY's Process Dynamics Group has been carrying out extensive research into the control of industrial power-plant steam nets. The work has not only concentrated on method development, but more importantly, determining and calculating the economic losses that inefficient steam balancing causes to industrial power plants all over the world. After carrying out dozens of in-house studies and three thesis on the subject, we have learned that the annual losses vary between EUR 0.2-2.0 million at all mills. This unnecessary waste of money should not be accepted by any mill manager, as in many cases only minor software changes to the power-plant automation system are required to bring the performance up to an optimal level.

The most important product of an industrial CHP plant is process steam; electricity is only a bi-product, although a very important one. Therefore, when discussing optimising steam balancing of an industrial power plant, the main focus is always on ensuring the highest possible steam availability and reliability of the steam supply.

Real-life problems that have an easily calculable financial side

The challenge in the day-to-day running of an industrial power plant seems to be better known to the actual operators than to the engineers who design them. Power-plant design methods that are in use today presuppose that the steam consumption of an industrial host is completely even during one day's or one hour's operation. The reality at industrial plants, such as pulp and paper mills, just couldn't be more different: steam load is typically shifting all the time up and down as breaks on big paper machines and batch digester cycles take place. This naturally causes problems for the operators, but there is also a financial side to this question.

If the optimal heat balance (ie. the power-plant equipment is operated in the most economical way throughout the year) is compared to the actual figures, there is typically a notable discrepancy. This gap, which is called the steam balancing performance gap, is in financial terms worth EUR 0.2 – 2.0 million annually at all sites.

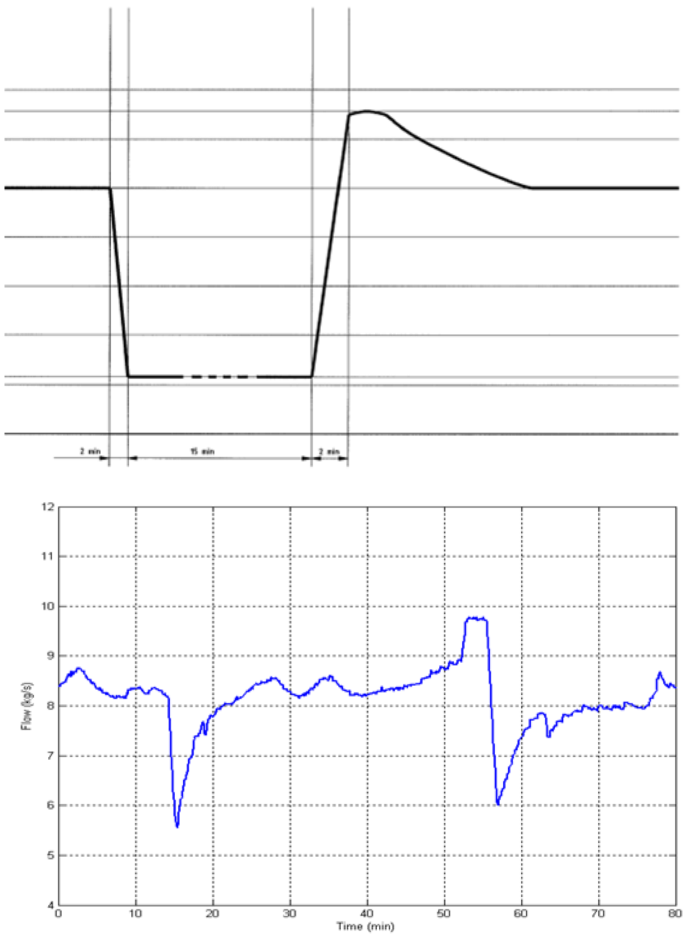

Figure 1. Typical trend curves of a paper machine web break and batch digester steam consumption.

Why do the industrial power plants fail to meet the maximum performance?

There is a fundamental error in the way the steam balancing, ie. steam-net controls, are designed. For historical reasons all control loops as well as turbine control systems are still separated in the power-plant engineering and no-one thinks about their interaction, let alone integrates the control systems together. During stable conditions and when the shifts in the steam loads are minor, the power plant runs just fine. However, if more severe disturbances occur, steam pressures in the headers start to swing readily, particularly when the controls are designed in an old-fashioned way and they are separated.

In order to prevent the boilers from tripping and to keep the steam flowing to the manufacturing process, the operators typically do a lot of operations that are fairly expensive such as:

— start an auxiliary gas or oil boiler
— take turbines or reducing stations into manual control and in this way reduce power generation
— vent steam excessively into the atmosphere during process upsets
— increase condensing power generation despite it not being profitable

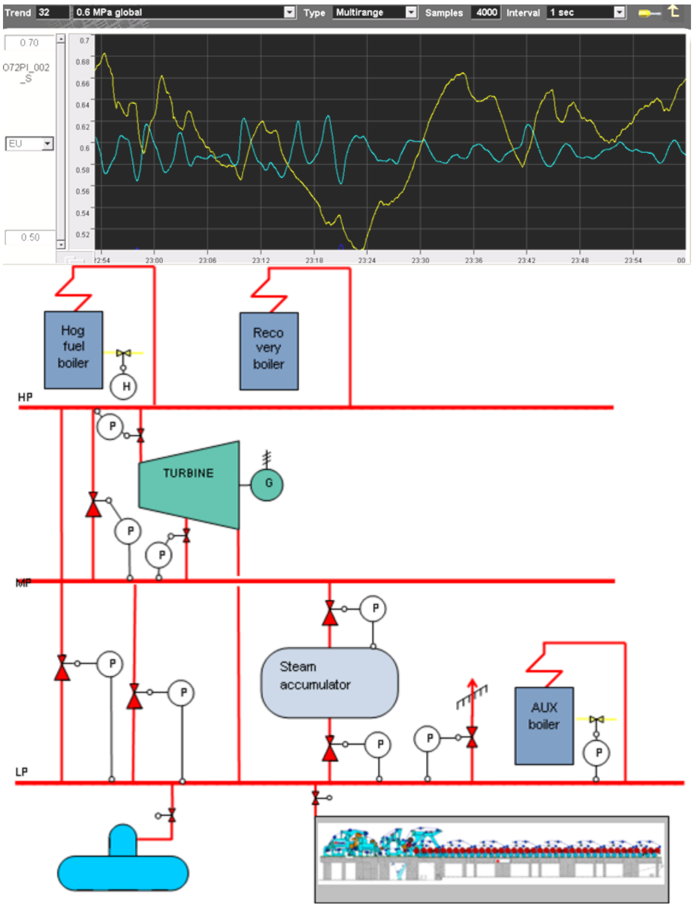

Figure 2. Typical control configuration at CHP plants: controllers and control systems are dispersed. Corresponding trend curves of header pressures from a typical case plant in July 2009, before control modifications.
High-pressure swings: ±6 bar
Low-pressure swings: ± 0.3 bar

Measurement errors between control loops can be avoided with an integrated control structure

Based on our extensive research on the subject, most of these uneconomic operations can be avoided by integrating the dispersed controllers and control systems together, and in this way getting rid of the root cause for the problems: the erroneous differences in measurements between the control loops. The optimised control concept not only stabilises the headers, but reduces operators' work to simple monitoring. The solution only requires reconfiguration of the steam-net controllers in the plant DCS, in other words only software changes. However, in some cases an investment in a steam accumulator further increases savings.

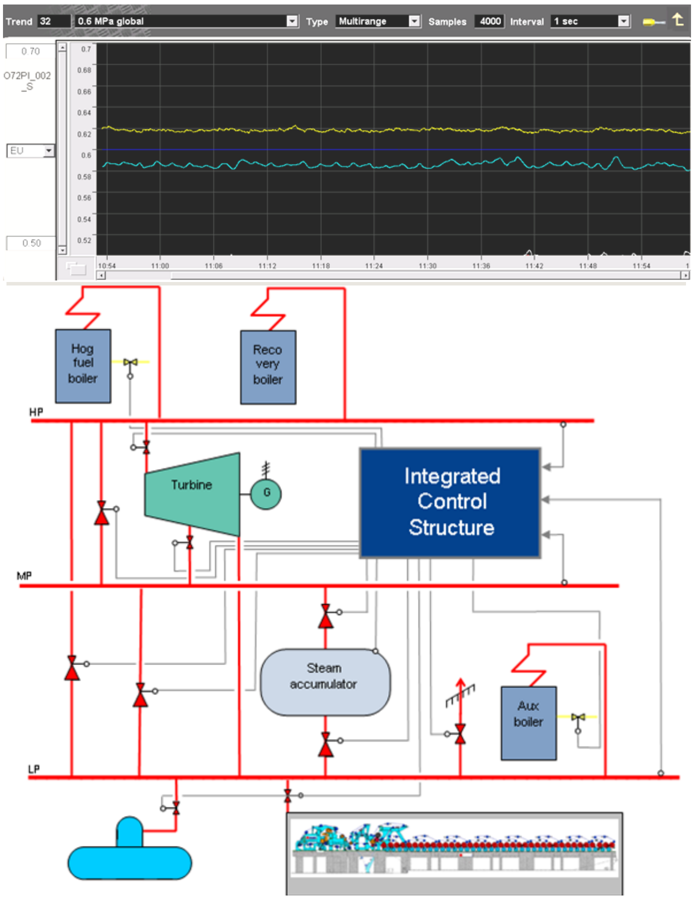

Figure 3. An integrated control structure. One master pressure transmitter (with back-up) allowed for each pressure level. Corresponding trend curves of header pressures from the case plant in November 2009, after control modifications (scale same as in Fig 2)
High-pressure swings: ±1 bar
Low-pressure swings: ± 0.05 bar

The results are compelling

Our experience has so far without exception been that once the power-plant manager and the operators see the integrated control systems in action, they start to wonder why it is not a standard. Why even today in the 21st century industrial power plants still suffer from unstable steam networks and consume a huge amount of money trying to cope with the problem, when the solution is so simple?

The reason probably is that although integrating control systems is not rocket science, it requires thorough experience and is bound to go wrong without! Another factor is that it is not typically a required discipline in power-plant engineering and very few companies in the world can actually pull off successful control system integration.

Recently, the trend has been that the overall awareness has been rising and it is becoming more common. However, most of the industrial power plants still try to survive the day-to-day operation without control system integration – losing a lot of money at the same time.

What should every power-plant manager check at his site?

Alarming signs that indicate a notable performance gap are the following:

1. The power plant could meet the total steam demand with cheap fuels, but still a huge amount of gas or oil is used in an auxiliary boiler to stabilise pressures in headers. **Gap up to EUR 2 million**.

2. Condensing power generation is not profitable as the primary fuel is gas or oil. Yet the condensing turbine is running on a fairly high load all the time in order to cope with the steam load shifts. **Gap up to EUR 1.5 million**

3. A lot of steam venting and condensing takes place - although it is not profitable. **Gap up to EUR 0.8 million**

4. Several operators are sitting in the control room and constantly making adjustments to the turbine loads and steam valve positions. **Gap up to EUR 1 million.**

5. Turbines could be loaded up. Yet they are constantly bypassed. **Gap up to EUR 1.5 million.**

How much is my power-plant wasting money because of inefficient steam balancing? How should the steam-balancing performance gap be determined?

Calculate the optimal annual heat balance, ie. the economically sound way of operating all the power-plant equipment: loading boilers and turbines in such a way that power production is maximised and fuel costs are minimised.

In reality the operators are operating the plant uneconomically in order to cope with the swings in the process steam load and the power generation is smaller and fuel bill higher. This gap is the steam-balancing performance gap, which can be very likely removed with steam-net optimisation.

Other benefits that exist, but are more difficult to define in economic terms, are

— stabilisation of pressures significantly extends operating life of boiler's high- pressure parts

— stable steam network encounters fewer boiler and turbine trips, and the manufacturing process is disturbed less.

— process steam pressure remains within ±0.1 bar under all circumstances, which improves paper machine temperature control

3 real-life examples

1. A European tissue mill

Power plant was almost completely operated manually.

Marginal fuel is gas.

Operators were performing well, yet process steam was vented into atmosphere, worth EUR 1.5 million annually.

By automating power-plant operation steam venting could be reduced by third.

Steam balancing performance gap: EUR 500,000

2. A European pulp/paper mill

Power-plant has a steam accumulator, which is operated based on steam flows and therefore not properly engaged

Auxiliary gas boiler is constantly running

Steam pressures are swinging badly

District heating end of the turbine is not utilised completely

With an integrated control structure accumulator is engaged in steam-net stabilisation instead of an auxiliary boiler

Steam balancing performance gap: EUR 700,000

3. A US paper mill

Huge shifts in the steam loads caused by the paper machine and batch digester operations

Power plant could produce all steam with recovery boilers and bark boilers, yet an auxiliary gas boiler is constantly running.

By implementing an integrated control structure and a steam accumulator, the auxiliary boiler can be put safely into stand-by mode.

Steam balancing performance gap: EUR 2,000,000

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