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UNDERSTANDING STEAM EFFICIENCY

Abstract

Efficient energy consumption is a key requirement for ensuring profitable manufacturing and in the production of paper and board, the steam and condensate system constitutes one of the most energy demanding components of the manufacturing process. The design, operation and maintenance of steam and condensate systems are important factors in determining the overall profitability of a plant and key performance indicators such as specific steam consumption are often monitored closely by operatives, engineers and directors alike. However, the understanding of such indicators is often limited, which can lead to poor decisions on maintenance priorities and capital investments. Understanding and interpreting steam consumption figures requires accurate data from a number of sources which should be viewed in relation to the total production process. This paper will give guidelines for accurate flow measurement and the analysis of specific steam consumption in relation to overall plant efficiency, finishing losses and variations in sheet moisture, combined with real-life, practical examples of how to reduce steam consumption.

Introduction

Increasing the profitability of the production process is a major aim for manufacturers. In the drive for increasing profitability the consumption of energy and raw materials need to be constantly controlled, with the long-term goal to reduce consumption towards the minimum levels required for producing products to the required quality standards.

In the production of paper and board, one of the largest consumers of energy is the drying process. Significant energy is expended to evaporate the moisture from inside the paper web, using the expensive commodity of steam.

Across the wide spectrum of paper manufacturers in India, all will have a figure for their steam consumption. However, the accuracy and reliability of this figure varies wildly from plant to plant.

Discussions with plant operatives, mill owners and production heads over time have proven that there are different understandings and misconceptions about their machine's steam efficiency. Many mills record the steam consumption on a daily basis against the daily finished production, whilst others use different methods of monthly fuel consumption and assumed boiler efficiencies against monthly machine output. Whilst these methods can give a "feel" for the energy efficiency of a machine they are significantly compromised due to a number of inaccuracies in assumptions and measurements. These inaccuracies can lead to incorrect conclusions being drawn from the steam consumption figures, as in these models higher steam consumption is not always a signifier of poor steam system efficiency. When using these models of steam efficiency there are numerous other factors that can increase steam consumption, without necessarily any loss in steam system efficiency.

Once an accurate model of steam system efficiency is utilised, an equally important factor in understanding the true efficiency of a steam system is the flow meter measurement accuracy. Installation effects, incorrect specification and process fluctuations all have an impact on the measurement accuracy of the flow meter.

After analysing the steam consumption and measuring the steam flow accurately, the final stage to observing the steam system efficiency is physical observation. Overloaded condensers, wet steam, atmospheric steam vents, open dump valves, open trap drains and poor flash recovery are all indicators of an inefficient steam system. Identifying these and rectifying them is a key to improving the steam system's efficiency.

The following discussion elaborates further on the above points.

Discussion

Specific Steam Consumption

The use of specific steam consumption as a tool for monitoring the efficiency of a machine is common and practical. There are a number of methods employed for determining this value, the table below shows some common parameters to consider and discusses possible problems and best practice methods.

- **Consider the Variables**

Measured Energy Value	**Possible Problems**
Fuel mass used at boiler converted by calculation to steam generated	Does not account for changes in calorific values of some fuels. Assumed boiler efficiencies are not an accurate method of understanding steam quantity produced
All steam supplied to machine	Can include steam usage for dispergers, starch cooking, silo heating, pocket ventilation systems. Whilst important to know, these ancillary users can be batch use, have seasonal variations and their own inefficiencies. They should be separately measured to give a true understanding of what usage is occurring and where problems may lie
All steam supplied to the dryers only	*Best method for understanding steam system efficiency*
Measured Production Value	
Finished Throughput	Will account for finishing losses, downtime, sheet breaks
Pope Reel Throughput	*Best method for understanding steam system efficiency*

- Consider the Time Period

The above measured values are also time dependent, with some mills utilising daily averages and some mills working on a monthly basis or a combination of both. Using averaged figures in this way gives an overview, but also combines inefficiencies, such as sheet breaks, planned shuts and breakdowns, which do not have the same effect on production as they have on steam consumption. Each sheet break means that steam usage continues, whilst production stops. For every shut, there is a start-up which requires steam to warm-through the dryer section until saleable paper is made. So, it is important to understand that in these cases averaged steam consumption can look high, but the true cause can be due to runnability issues causing breakages or maintenance stoppages due to breakdowns.

- Consider the Moisture

The moisture carried in the sheet from the press section is one of the most influential factors on steam consumption. Increasing moisture content in the web leaving the press increases the evaporation requirements of the drying section. As more water needs to be evaporated, more energy has to be transferred to the sheet to enable this and therefore the steam consumption of the dryer section increases. In this respect the specific steam consumption per tonne of paper can be misleading in terms of system efficiency, a 1% increase in press dryness can increase steam consumption by up to 5%, dependent on the machine configuration.

To analyse the moisture content of the sheet, the moisture ratio should be calculated for the entering and exit dryness to a dryer section.

Moisture Ratio = (Sheet Dryness Leaving Dryer Section / Sheet Dryness Entering Dryer Section) - 1

A good target level for most Indian paper machines is a consumption of 1.35 tonnes of steam per tonne of water evaporated, based upon continuous production and for the dryer section only. This benchmarked figure multiplied by the moisture ratio will give a good target figure for a machine's specific steam consumption. However, some caution should be taken with this method as on multi-section machines separate figures need to be calculated for the pre-dryers and post dryers before combining and taking differences in sheet weight into account.

Figures below 1.35 tonne steam per tonne of water evaporated are good figures, with world bests being around 1.2 tonnes of steam per tonne of water evaporated. Advancements in insulation materials used, flow measurement accuracy, steam quality, heat recovery and steam system control need to be made to achieve these figures.

Best Practice Summary

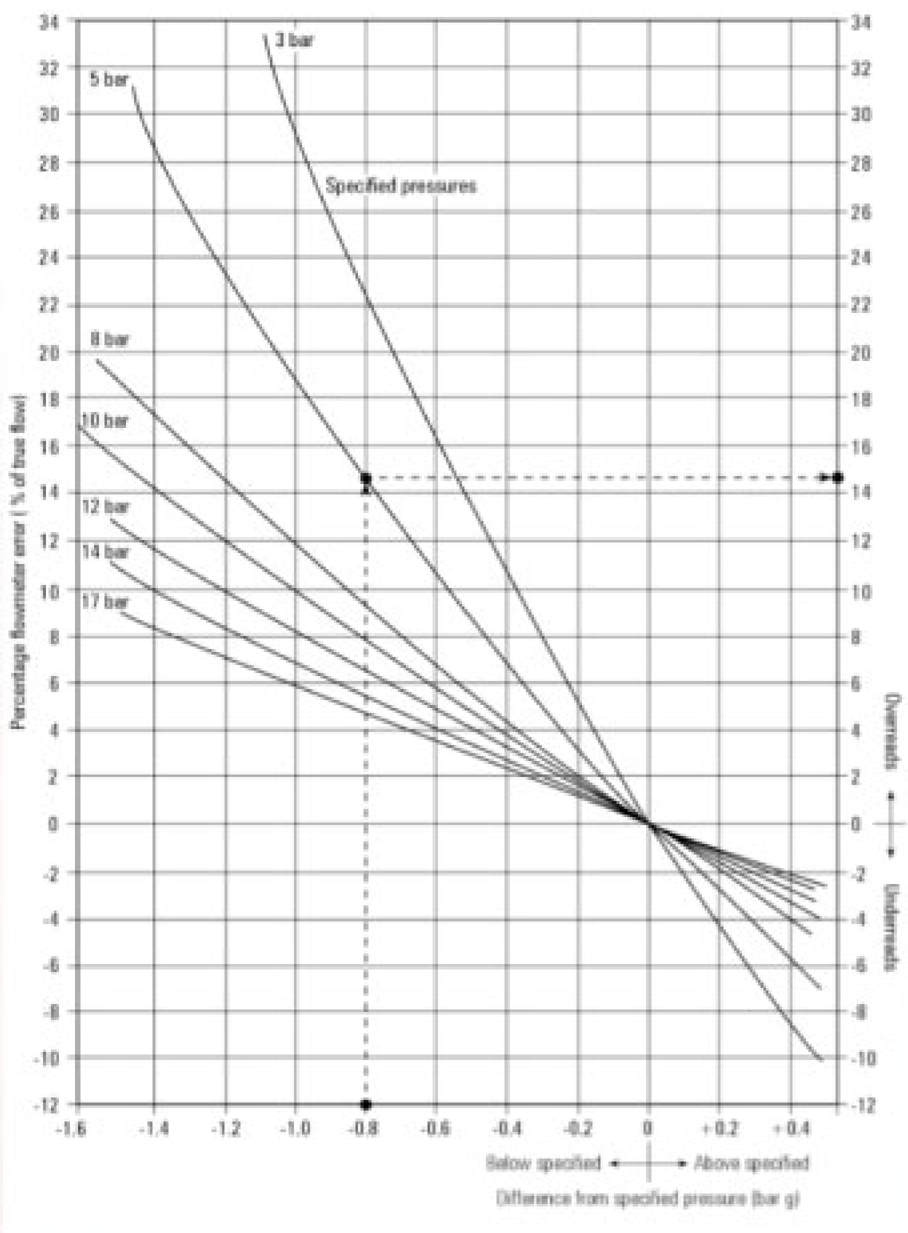
For best practice, the steam system efficiency should be measured during a prolonged stable run of a certain grade and for the drying section only. The steam flow over a stable period can then be monitored and averaged, not including sheet breaks. A benchmark for each grade can then be made. Press section moisture samples should be taken and analysed to TAPPI standards, referenced against each grade complete with moisture readings entering and leaving each sub-section of the dryers.

Steam Flow Measurement

Accurate steam flow measurement is essential to understanding steam consumption. There are a few simple, but necessary points to address when measuring steam flow to get the most accurate flow meter reading. These points relate specifically to orifice plate meters, given their abundance in the field.

- Installation, ensure that the flow meter is installed with sufficient upstream and downstream straight lengths of pipe to achieve laminar flow
- Impulse lines to differential pressure transmitter should be as short as possible, with the fill pots installed at the same elevation. Lines should be free from any obstruction or debris, air should always be bled from the connection to transmitter before start-up
- Specification, ensure that the orifice plate is correctly designed to the production conditions operated and that the range in the transmitter matches the design range
- Orifice plates should be designed and installed with a drain hole at the bottom of the plate to ensure any small quantity of condensate passes through the plate without causing measurement errors.
- Density compensation should be installed for pressure and temperature, both compensations need to be made as each variable individually affects density quite significantly, see fig.1 for effect of pressure variations on an un-compensated orifice meter

Steam quality should be optimised. For accurate flow measurement the steam needs to be dry at the point of measurement. This requires some superheat in the supply line, practically this should be around 7-10°C.



Reducing Steam Consumption (examples)

(UK) Testliner & Fluting Machine, 840TPD machine.
It was found from observing the condenser in an overload situation that a significant amount of flash steam was being sent there directly. The flash steam represented a significant loss of energy, which was successfully reclaimed by changes to the steam system. A new flash recovery vessel was installed which all group separators drained to. This low pressure flash recovery system captured the flash steam under pressure control and re-distributed it to a profiling steam box located on the machine's couch roll. This flash steam supply supplemented the existing live steam feed with the effect of reducing the overall steam consumption to the machine by around 5%.

(India) MG Kraft, 250 TPD machine
A visual observation of the final condensate tank showed over-pressurisation and a high quantity of steam escaping to atmosphere. A trap based steam system was found to be in a bad state of repair, with many traps bypassed, or passing, resulting in steam being directed straight to atmosphere. Condensate drainage from this machine was very good, because steam was blowing the condensate straight through the dryers, so fixing the traps would reduce the heat transfer and lower production. The machine steam system was completely re-designed with modern differential pressure control, reliable stationary syphons and flash recovery. The result was a decrease in steam consumption of over 10%.

Conclusion

Monitoring and recording steam consumption is a highly useful tool to help analyse where efficiency savings can be made. Following a set methodology to benchmark steam system performance as a distinct area within a mill's total energy usage and also benchmarking this against an expected performance for the evaporation load can help to understand if a system is truly underperforming. This allows mill management to smartly target their investments and drive the maintenance focus in the correct direction.

References

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