Advanced Process Control: The Key To Energy Efficient Paper Making

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Introduction

Pulp and paper making is rightly regarded as highly energy-intensive manufacturing processes. Rising energy prices squeeze operating margins and are a significant contributor to mill closures, as newer, more efficient designs, come along that can do more with less.

But no matter the design, huge amounts of steam are still needed to drive moisture from the sheet. Recent figures suggest that the UK average energy consumption is around 4 MWh per tonne of paper; around 80% of this is accounted for by dryer steam. Based on UK PLC papermaking capacity, the total energy used is more than 20,000 GWh per year, equivalent to a city of 3 million people.

Paper Type	Energy Consumed
Packaging Board	2-3 MWhr/t paper made
Newsprint	3-4 MWhr/t
Tissue	5-7 MWhr/t
Fine Papers	4-6 MWhr/t
Speciality Papers	Up to 20 MWhr/t
UK Average	**4 MWhr/t**

By improving dewatering in the forming and press sections, a 1% reduction in sheet moisture equates to a 4% reduction in dryer section load. But a coordinated strategy is required

- Over-drying of the sheet is common; sheet moisture is controlled to avoid MD peaks; higher steam consumption is the price paid to avoid weak spots in the sheet.
- Sheet basis weight is typically controlled to err on the side of caution; low basis weight may result in quality failures in sheet strength, or even poor runnability. While this offers a small saving in energy (lower weight means less water to be removed), the main benefit would be in reduced fibre costs.
- Dryer efficiency, measured as the mass of water evaporated per mass of steam used, is normally around 50%. Dryer hood operation is rarely optimised, nor are steam or differential pressures. Condensate recovery rates could also be improved.

The challenge for a standard control system is that these processes are constantly changing and are highly multivariable; adjusting one parameter will affect many others in different ways and with varying delays. A multivariable problem cannot be solved using conventional control strategies without accepting compromises, either in sheet quality, machine efficiency, or energy consumption.

Advanced Process Control (APC) is the umbrella term for a host of technologies that were born in the petrochemical industry. Models of asset performance and behaviour can be developed from a combination of operational data and non-invasive response tests applied to the machine. These models serve two purposes: first, they deliver a deeper insight into the complex interactions between multiple variables within the process, highlighting the impact that disturbances will have on each part of the process; second, they identify the adjustments that can be made **before and during** each disturbance, to minimise its impact. This is the most significant benefit of APC - predicting how best to control the asset under any set of circumstances.

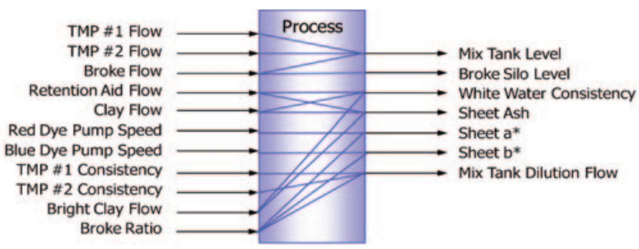
However, the model must also be flexible enough - and robust enough - to cope with real time changes in operating priorities, such as grade changes or paper breaks. Therefore, optimisation must be a continuous, dynamic and automatic function within the controller; this is something that can only be delivered with Advanced Control.

Model Development

The first step is to understand the relationships between different process variables, using a set of tools that identifies the strength of correlation between them. We then develop a model which captures how each variable affects - or is affected by - others to which it is correlated. Models can be defined for different grades, if each grade relies on different process behaviour. Finally, the structure of the controller can be described; we now know what to adjust, when to adjust it, and by how much, in order to achieve the desired goal. The example (below) is taken from a control scheme for newsprint:

What are we trying to improve?

Reducing variability at the forming section is the key to improving overall machine efficiency. For our newsprint solu-

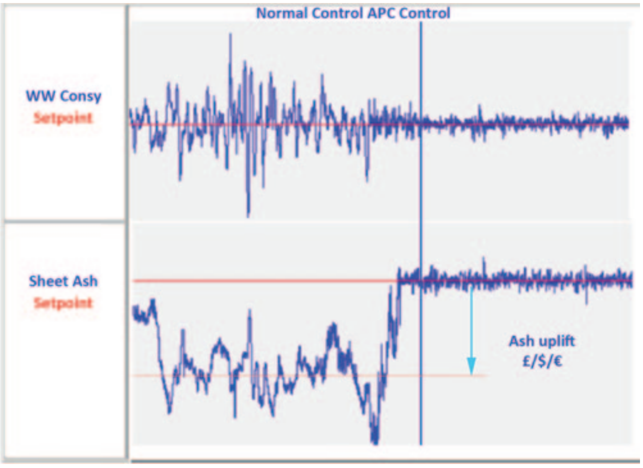


tion, our target is to reduce variation in sheet ash and improve machine stability. Options such as colour control may also be included. The models are run in real-time on a standard PC, interfaced to the papermill's PLC and SCADA. The software running the models - Perceptive's ControlMV® - acts as a super-operator auto-pilot. When selected, ControlMV will determine an optimal series of control moves every few minutes then write out appropriate setpoints to the mills DCS.

Case Study 1 – Newsprint Machines

A reliable measure of wet end stability is the variation in white water consistency; tray solids are an accurate reflection of what is happening on the wires. Typically, the APC reduces the standard deviation of white water consistency by at least 60%. The variability in sheet quality parameters are also immediately improved - for example, standard deviation of a* / b* colour was reduced by 66% in a North American mill. Sheet ash variability has been reduced by more than 50% across all installations, permitting higher mean sheet ash levels to be maintained and fibre costs to be cut.

A more stable wet end, and more consistent control of sheet solids (and moisture) leaving the wire had a positive impact on steam requirements at this mill. Average steam consumption reductions of 10% are common.



Example White Water Consy and Sheet Ash Control (UK Mill)

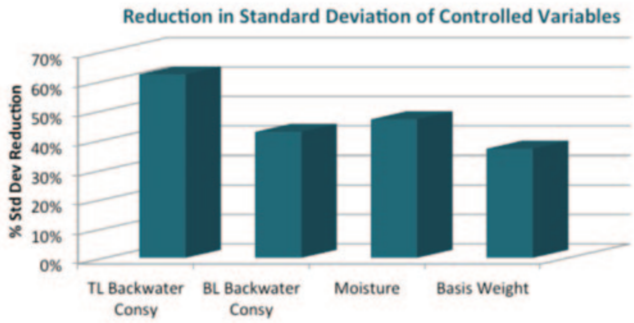
Case Study 2 – Twin Ply Board Machine

The same techniques were used to improve the efficiency of a UK board machine, with the additional challenge of reducing variability of backwater consistency on both the top and bottom layers. To do this, addition of the drainage aid chemicals was optimised against steam costs. Again, there was no compromise allowed to board quality.

Steam Consumption (t/t)			
	Normal	ControlMV	% Change
Grade 1	1.820	1.600	12.1
Grade 2	1.835	1.674	8.8
Grade 3	1.858	1.613	13.2
Grade 4	1.854	1.688	8.9
Grade 5	1.894	1.745	7.9
Grade 6	1.825	1.649	9.6
Averages	**1.848**	**1.662**	**10.1**

The APC adjusts the thickstock flow, dryer pressures and retention aid dosages in real-time to deliver significant improvements in sheet quality and wet-end stability. This included a reduction in variability of sheet moisture and basis weight of 47 and 37% respectively:

As well as reducing variability, Basis Weight was now controlled tightly to set-point. Before the new controller was implemented, there was an average 0.95gsm error between set-point and actual (the sheet was an average of 0.95gms heavy). With the controller in operation, this error was reduced to 0.07gsm. For the same grade, fibre savings of more than £120,000 per year were realised.



Improved wet-end stability resulted in a more consistent sheet entering the dryers. Steam consumption was reduced by 4.4%, from 1.83 Te per tonne of board, to 1.75 Te/t. At a generated cost of almost £15 per tonne, this equated to a further saving of over £240,000 per year, along with the associated increase in production capacity.

Conclusion

Advanced control offers a proven, robust mechanism for enabling complex manufacturing plants - such as paper machines - to achieve their full potential. The investment required to upgrade the existing control systems is paid for within the first few months of operation. For an industry seeking every competitive advantage, APC deserves a closer look.

About the co-author Paul Austin (1948 - 2012)

Paul was born in July 1948 and died in October 2012. The projects described in this article where some of the last he worked on for Perceptive Engineering. Earlier this year, he received a posthumous award from the Institute of Professional Engineers New Zealand (IPENZ). The prestigious Skellerup Award was given in recognition of his contributions in the field of Advanced Process Control. More details can be found here:
http://www.ipenz.org.nz/IPENZ/News_and_Policy/newsitem.cfm?ID=506