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SAVING ENERGY THROUGH SYNERGISTIC INNOVATION WITH DIGITALIZATION

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Abstract:

Energy cost is one of the main cost drivers in paper production [1]. With prices rising sharply in recent times, savings opportunities are becoming increasingly important for papermakers in order to remain competitive. At the same time, low CO2 emissions are becoming the focus of the global paper industry and there is a constant pressure for higher productivity and better process control. But how much energy can be saved without putting production line at stake? And in order to do that, what are the levers available outside our conventional methodologies? Thanks to in-depth know-how and a strong focus on innovation, all Voith products are ideally harmonized with each other to make paper production as resource-efficient as possible. Besides, the digitalization (Papermaking 4.0) portfolio [2] offers optimization opportunities in every area that can be quickly implemented and pay off for the paper producer after a short time.

This paper explains the transformative impact of digitalization technology (Efficiency Solutions) [3] on the papermaking industry & explores its synergies with process control in order to reduce specific energy consumption and revolutionizing the traditional papermaking process by leveraging data analytics and artificial intelligence [4].

Over the last years, Voith gathered extensive experience with implementing such technologies for a large variety of applications through digitalization (OnEfficiency) modules having specific objectives like optimizing vacuum energy in the former, optimizing deinking and by that lowering flotation cell's pump energy consumption, reducing starch addition leading to lower steam energy consumption and reducing web breaks leading to lower specific energy consumption.

Key words: *Energy, Digitalization, Analytics, Artificial Intelligence (AI), Model Predictive control (MPC), Efficiency Solutions, Virtual sensors (VS), Dewatering, Vacuum, Strength properties.*

1. Introduction

One easy way to save energy is to adopt new energy efficient components / equipment but this is often not possible for the existing mills. To address the energy issue in a boarder spectrum one must strategize the existing process optimization leveraging available digitalization technologies through a KPI driven approach. Such optimization will reduce the operating cost of the running mill directly and can be monitored even on hourly basis. Normally such processes involve robust implementation steps and result in moderate to low amortization time (<1 years) with higher return of investment (ROI). Papermaking is very complex task as it involves multivariate interactions in real-time. Digitalization technology involving artificial intelligence algorithm & analytics is the wise way to decipher the patterns and behaviors among the parameters, using statistical correlations, and to optimize the overall process by improving its availability (output), efficiency (cost) and product quality.

The technologies presented in this paper focus on direct energy savings, higher productivity and better paper quality by -

A. **Reducing vacuum energy through optimized dewatering -** Normally, the operators adjust the wet line without knowing the impact on the ply dryness hence ply bond. As a result, higher variability in ply dryness and strength is being observed along with higher vacuum consumption. Dewatering module enhances dewatering efficiency, improves paper quality, and lowers vacuum energy consumption achieved through its collaborative implementation with vacuum systems (a closed loop control regulate setpoint of vacuum system).

B. Saving pumping energy of flotation cells - Deinking module uses foam level and flotation cell feed pump's RPM as the levers for optimizing yield and brightness of a de-inking plant. The pump energy is the direct power savings potential in this regard.

C. Reducing water content saves steam energy - Strength module leverages the full fiber strength potential, e.g., by optimizing the strength distribution between CD & MD. Depending on the paper grade, it allows to reduce starch application and by that increases the dryness after the size press or it replaces fibers with ash, which is much easier to dry hence resulting lower steam energy consumption.

D. Reducing paper break improves productivity hence specific energy consumption – Web break prevention module identifies (using artificial intelligence algorithm) the correlations & behavior of the process, clusters the patterns related to paper break reasons and displays the countermeasures (coordinated suggestions by Technologists) for each break pattern which is reducing the risks of a break, hence the unplanned downtime and specific energy consumption as well.

2. Materials and methods:

It all starts with collecting real-time data (from field instruments and sensors) followed by collection, storage and transformation of data (through data historian), then visualized, analyzed and operationalized (through analytics platform) in order to generate value out of it and finally the optimization of the processes is being carried out with the help of advanced process control (APC) / model predictive control (MPC) tools (over cloud / on-premises) [5].

In some cases, a physical sensor may not be available to measure paper properties in real-time. Hence, multivariate statistical correlations with other measurable parameters is being exercised to establish a Virtual Sensor (VS) [6] for those properties. Strength properties are of such kind where VS are being used as a part of an APC/MPC.

Evaluation of such VS is being done through prior process assessment by experts along with mill operation team and then being utilized as part of an APC/MPC.

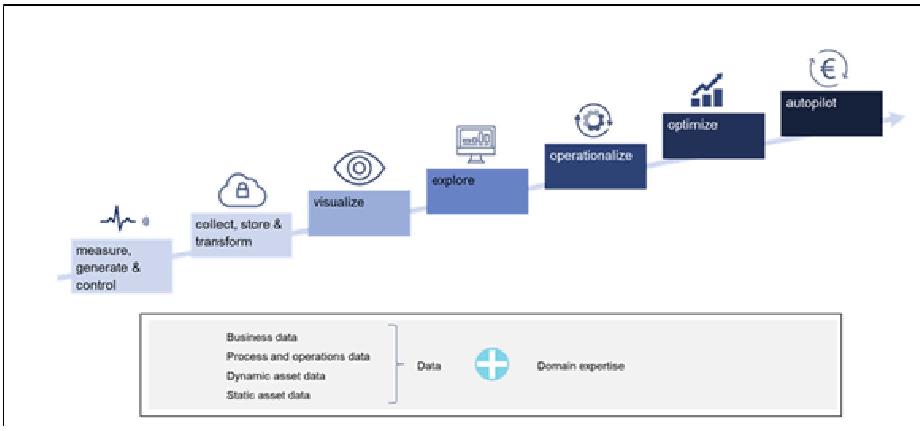

Figure 1: Methodologies involved in the optimization process

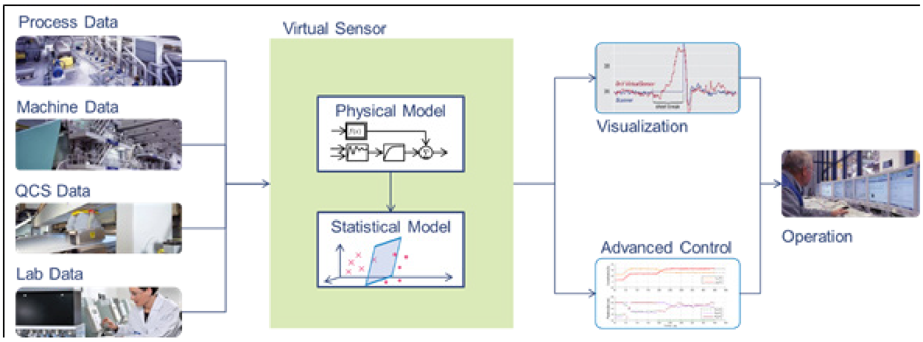

Figure 2: Concept of a virtual sensor

3. Result and Discussion:

3.1 Dewatering module (OnControl.Dewatering):

It consists of a water weight measurement (using a FormingSens sensor which is installed, calibrated and maintained by Voith) and operates as a closed loop control of the vacuum set points (and by that also on vacuum pump energy consumption), which leads to stable dryness at couch point.

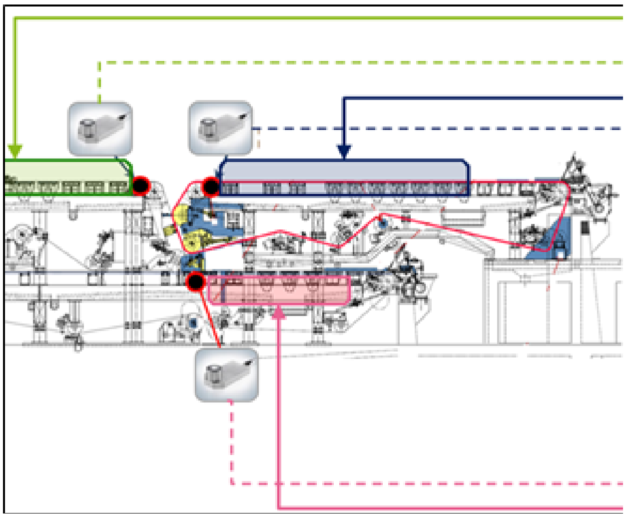

Figure 3: Installation of FormingSens

The implementation of the module for a machine (newsprint, 320k TPA) showed following results,

a) ~ 10% less energy consumption of the former

b) ~ 10% longer fabric life time

c) dry content is on set point and stable : reduction of off-spec production

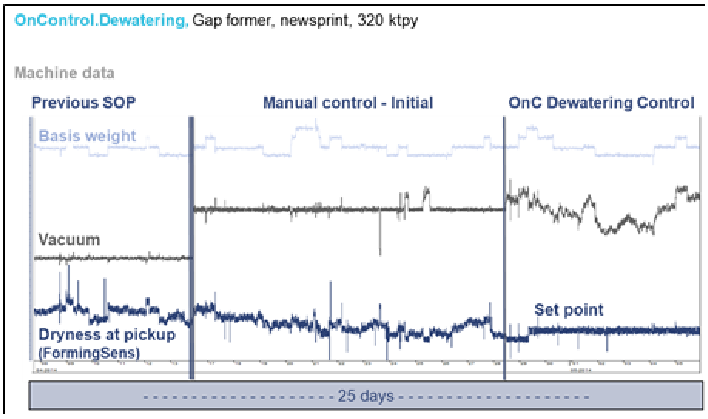

Figure 4: Stable dryness and optimal vacuum

3.2 Deinking module (OnEfficiency.DIP):

It keeps ash and brightness (and depending on grade also dirt specks) in specification at reduced energy and chemical cost and improved yield. It utilizes (in a closed loop control) the foam level, weir edge height, dosing chemicals, flotation cell feed pump speed (RPM) in order to reach

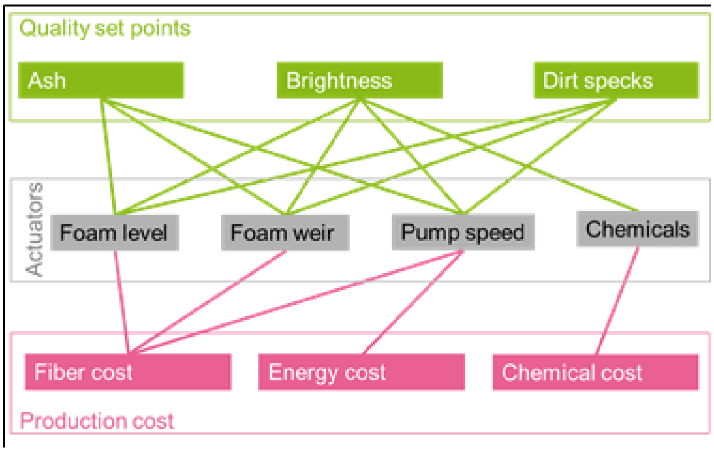

Figure 5: APC model for DIP module

the yield and brightness as per specification.

The implementation of the module for a machine (newsprint, 350k TPA) showed following results,

a) ~ 34% less energy consumption in flotation pumping energy

b) ~ 2.4%-point yield (or ~2.8%) improvement

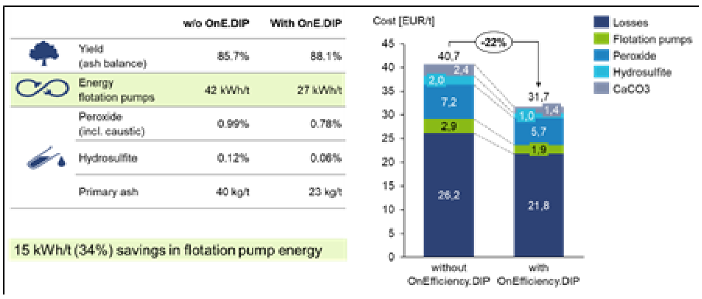

Figure 6: Savings resulted (newsprint, 350k TPA)

c) ~21% savings on dosing chemical (Peroxide)

3.3 Strength module (OnEfficiency.Strength):

Strength module keeps the target quality parameters within the specification, while reducing cost. It's implementation depends on the paper grade. For packaging grades, the standard concept is to control SCT, CMT, tensile, burst and reduce cost by optimizing strength distribution between CD and MD and minimizing starch (by that increases the dryness after the size press) and also helps to replace fiber with ash. The operator only supervises the control and, if necessary, adjusts the settings

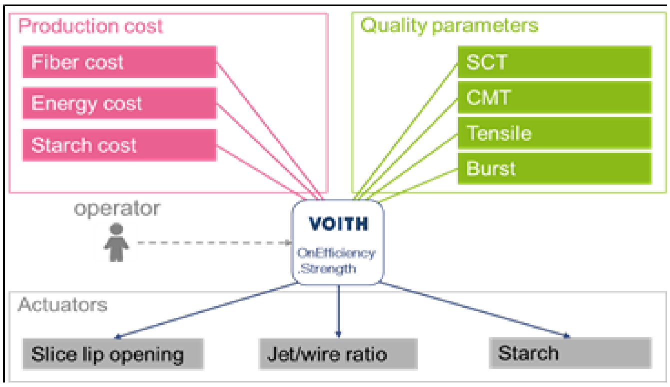

Figure 7: APC model for strength module

The implementation of the module for a machine (TL/CM, 450k TPA) showed following results,

a) ~ 4.5% less steam consumption (estimated) in ADS.

b) over 10% savings in starch consumption

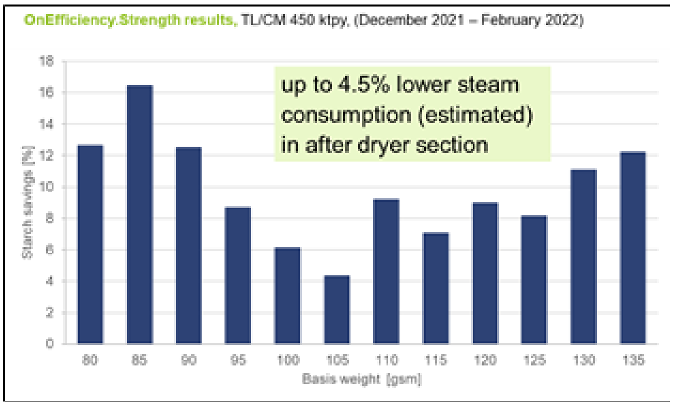

Figure 8: Savings resulted (TL/CM, 450k TPA)

For graphic grades, there's a different control concept, which allows to save energy as a side effect of reducing basis weight and increasing ash & final moisture of the paper (by that there is less water in the wet paper sheet). The implementation of the module for a machine (WFU, 540k TPA) showed following results (keeping stiffness above quality requirement),

a) ~ 0.5% basis weight reduction and ~ 0.3% ash increase

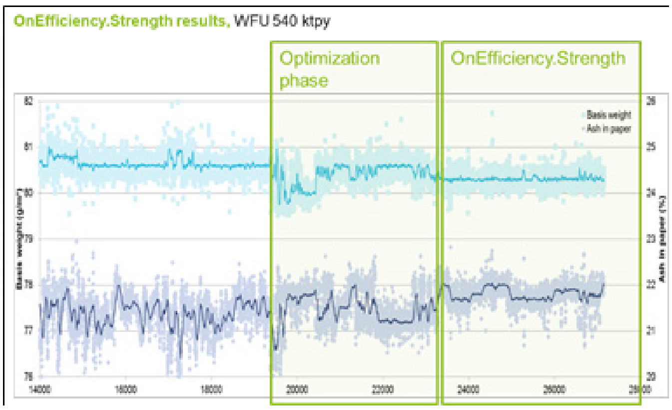

Figure 9: Savings resulted (WFU, 540k TPA)

3.4 Web break prevention module (OnEfficiency.BreakProtect):

It is prudent that during web breaks lots of energy is wasted without any output. Hence, reducing breaks is another puzzle piece in reducing specific energy consumption.

Today's state of the art solution for reducing breaks is to do a break analysis with help of web monitoring cameras. By that paper makers basically identify symptoms and try to fight them – with moderate success. In contrast to that, the web break prevention module (OnEfficiency.BreakProtect) allows to understand the underlying root cause and cure it; sustainably and sometimes forever.

The analysis follows below steps,

i) data from entire production process is made available to cloud platform.

ii) an advanced algorithm (with the help of AI) identifies the correlations and behavior of the process and clusters the patterns related to certain break reasons / root causes ("break segment")

iii) For each break segment a countermeasure can be defined, which can range from small rebuilds to one-time optimizations and actions to be taken each time the break risk increases. In the latter case, the defined countermeasures are displayed in due time to the operator, so that breaks can be prevented pro-actively [7].

Indicative distribution	Segments in OnEfficiency.BreakProtect (root cause / "illness")			
Break report (symptoms)	Retention aid	Broke dosage	Shrinkage	Fiber recovery
Dirt from top ply HBX	3	1	0	6
Lump at top wire turn roll	15	2	0	8
Dirt from bottom edge master	2	6	0	4
Unknown	5	6	7	7
Hole in size press	10	4	2	8
Wrinkles size press	0	11	25	4

Figure 10: Symptoms visible in web monitoring systems don't directly correlate with actual root causes

The implementation of the module for a machine (CM/TL 450k TPA) resulted in 70% break reduction (from 3-4 breaks per day to <1 breaks per day) which saves around 3% specific energy consumption.

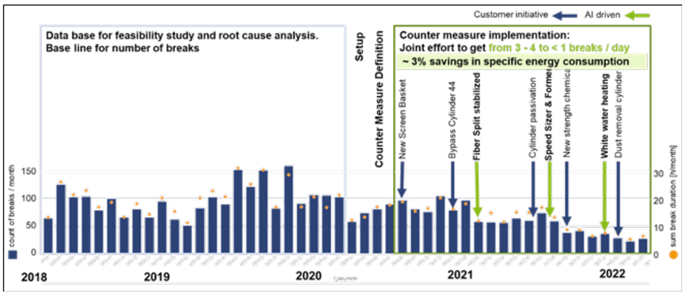

Figure 11: Savings resulted (CM/TL, 450k TPA)

In summary, the presented modules and their key highlights are tabulated below,

Modules	Sensors	Actuators	Energy savings resulted
Dewatering Module (OnControl.Dewatering)	FormingSens (Water weight)	Vacuum set point (Vacuum pump RPM)	Up to 10% vacuum energy savings in former section
Deinking Module (OnEfficiency.DIP)	Ash, Brightness, Dirt specks	Foam level, weir height and flotation pump RPM	Up to 30% pump energy savings in flotation cells
Strength Module (OnEfficiency.Strength)	Virtual Sensor (depending on grade, for packaging typically SCT, CMT and burst)	Depending on basis weight, for packaging grade typically jet / wire ratio and starch addition	Up to 4.5% less steam consumption (estimated) in ADS
web break prevention module (OnEfficiency. BreakProtect)	Statistical correlation for multivariate process	Depending on break reasons countermeasures	up to 3% specific energy reduction

Table 1: Summary of the modules with resulting savings

The strength module purely depends on paper grade and below is a summary of the same,

Grade	Control parameters	Manipulated parameters	Optimization goals
CM (corrugated medium), TL (testliner), fluting	SCT, CMT, tensile, burst (only TL)	Basis weight, slice lip opening, jet/wire ratio, starch	Reduce cost by minimizing starch usage
WTL (white top liner), WTKL (white top kraftliner), WTTL (white top testliner)	SCT, CMT, tensile, burst, RCT	Basis weight white fibers, basis weight brown fibers, jet/wire ratio, filler, starch	Reduce cost by minimizing starch and white fiber utilization and maximizing filler content
KL (kraftliner)	SCT, burst	High / low-cost fiber ratio, refining, jet/wire ratio, basis weight	Reduce cost by minimizing high-cost pulp usage and basis weight
FBB (folding boxboard), WLC (white lined chipboard), LPB (liquid packaging board), SBS / SBB (solid bleached sulfate/board)	Bending stiffness, delamination (e.g., Scott bond), thickness	High / low-cost fiber ratio, refining, filler, basis weight, starch	Reduce cost by minimizing starch and high-cost fiber dosage and maximizing filler content
WFC (wood free coated) WFU (wood free uncoated) Copy	Bending stiffness, tensile, volume/bulk	Refining energy, basis weight, filler content, calender load	Reduce cost by maximizing filler content
SC (super calendered)	BW, tensile, volume/bulk	Refining energy, fiber weight, filler content, calender load	Reduce cost by maximizing filler content

Table 2: Paper grade specific typical set up for strength module

4. Conclusion:

Digitalization represents a significant leap forward in the quest for sustainable and efficient paper manufacturing. The collaboration between papermaking and the synthesis of these technologies sets a new standard for the paper industry, paving the way for a future characterized by sustainable, efficient, and high-quality paper production at lower energy cost, which Indian industry can adopt. The paper concludes with a call to action for Indian paper manufacturers to embrace digitalization and join the movement towards a greener and more sustainable paper making.

5. References:

[1] Dylan D. Furszyfer Del Rio, Benjamin K. Sovacool, Steve Griffiths, Morgan Bazilian, Jinsoo Kim, Aoife M. Foley, David Rooney, Decarbonizing the pulp and paper industry: A critical and systematic review of sociotechnical developments and policy options, Renewable and Sustainable Energy Reviews,

Volume 167, 2022, 112706, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2022.112706

[2] Voith Paper Digitalization Portfolio - Link

[3] Efficiency Solutions case studies from Voith Paper - Link

[4] How to Maximize Your Use of Data to Make Smart Decisions : FischerSolve Article - Link

[5] Kotsiopoulou G., Smith M., Rodriguez W. and Braicu A., Advanced Process Control - a Cornerstone of Digitalization and Operational Excellence, Advanced Process Control - a Cornerstone of Digitalization and Operational Excellence, Volume 2022, page 1-5, https://doi.org/10.3997/2214-4609.202239062

[6] Martin, D., Kühl, N. & Satzger, G., Virtual Sensors : Bus Inf Syst Eng 63, 315–323 (2021), https://doi.org/10.1007/s12599-021-00689-w

[7] Functions of Break prevention module of Voith Paper - Link