

Implementation of Freeness advanced control in a carton board machine

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Abstract— *Special cartonboards requires restricted raw materials specifications. Klabin's Paper Machine 09 produces some of the best cartonboards of the world, and the requirements for this are quite narrow. Freeness is the most important variable for pulp stock preparation. Thinking at this, a MPC control was developed to refining control.*

Keywords— *carton board machine, Klabin, Paper Machine.*

I. INTRODUCTION

Klabin unit Monte Alegre is based in a small countryside city in Brazil, this unit produces some of the best cartonboards of the world. These prime papers requires that specific variables to be under narrow control. Freeness is one of the most important variables for papermaking, having this on mind the company has developed a MPC (Model Predictive Control) for Freeness control at Paper Machine 09.

This controller should be capable to delivery freeness with the desired specification, to produce prime paper. Before of this implementation, this site tried to use a PID control, without success, and an expert system from Valmet to control this variable. This expert system works good in several paper machines, but because of the narrow specification of this paper machine, this control wasn't enough to delivery desired specification.

So Monte Alegre unit was looking for a way to achieve the specifications, and as described at this paper, MPC was a good solution.

Descriptive Information

The constant modernization of Packaging conversion machines using cartonboard as a fundamental raw material and the increasing competitiveness of the market requires constant manufacturers' innovation and optimization of its processes, so that you can meet the high performance product requirements, with tolerances increasingly smaller, variability specifications and the new quality requirements which arise each year.

For better results, companies are investing in training its staff, new equipment and manufacturing processes, excellence can only be achieved with the use of advanced control tools, which are able to maintain the streamlined process 24 hours a day, reducing the dependence of the

level of operators' training, their level of attention and their attitude to intervene on process variations.

Within a paper machine, maintenance of physical properties of paper is strongly influenced by the stability of physical properties of pulp and the stability achieved in the process before leads to an efficient dewatering control of the pulp in different process steps. The physical properties of the pulp and the dewatering on the paper machine are strongly influenced by a characteristic of pulp called "drainability". This characteristic is measured using a test known as: Freeness, established through Tappi T227 om-94 method.

The Freeness analysis provides a measure of the drainage rate of a dilute pulp suspension 3 g / L and the result obtained is the volume in ml of filtrate drained through the side orifice standard equipment specifically designed for this assay.

The equipment used for this work Freeness measurements was KajaaniMAP analyzer, which allows one Freeness analysis every four minutes, thus providing sufficient information to allow the use of an advanced control tool.

The stage of paper machine process which is responsible for ensuring compliance with Freeness specifications is called refining. Refining takes place in a device known as refiner, which is responsible for the mechanical treatment of fiber suspension in order to improve the bonding requirements between them and ensure an adequate level of drainability for the production of paper with the desired features.

Due to the strong correlations between the physical properties of the paper and the degree of drainability Freeness is the most important variable to be controlled in the pulp feeding for paper machine.

II. METHODS AND MATERIALS

There are four common ways to control refining systems:

- Manual Control – means that the gap between the refiner plates is controlled by hand, or by an automated gap system operated manually to adjust the gap. Flow and consistency has a direct impact on the refining load, hence the freeness. So, when gap is kept constant, changes in flow or consistency will change the thickness of the fiber flow between the plates, affecting directly the Freeness. For this control strategy, consistency and flow should be narrow controlled.
- Power Control – the load of the refiners is kept constant, so the gap adjustment works to maintain a constant load, but variations on fiber flow or consistency has direct impact on Freeness.
- Specific Refining Energy Control – flow and consistency are measured and controlled before the refining. The objective of this control strategy is to apply the same amount of energy for each unit weight of solids on the stock. This controller uses flow, consistency and power measurement to calculate the amount of load to be applied, keeping the specific energy constant. This control works pretty good if the raw material has no changes at its properties; difficult at most of industries.
- Freeness Control – probably the best way to assure physical properties of fiber. This strategy needs a Freeness measurement after the refiner, Fig.1 [1], and will manipulate the load as needed to keep the Freeness constant, or at the desired setpoint. Hopefully with some time, a new technology will measure freeness continuously, and then a simple PID control will handle Freeness control.

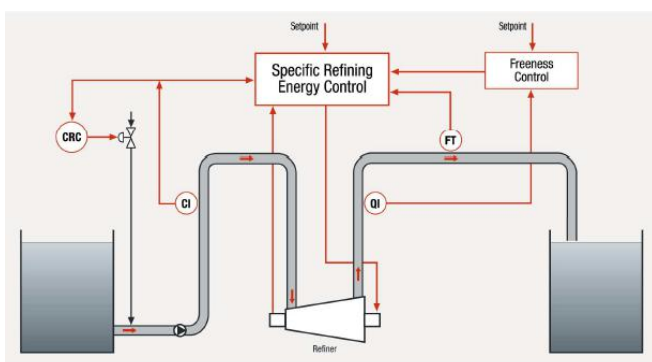


Fig.1: Freeness Control.

The main challenge for Freeness control is the dead time, this sampled analysis took more than 7 minutes for each sample, and the system has a rise time lower than 2 minutes. Conventional PID controller can't control system with this behavior, the sampling by itself is already a big issue for PID control, together with the ratio between dead

time and rise time, makes this system real hard to have an effective PID control.

So, a model predictive control was selected for this challenge, it should be capable to handle the sampling, and the dead time caused by the sampling. This controller should be capable to take a control action and predicts what will happen until the next sample, which takes 7 to 9 minutes.

The advanced control tool used was the Profit Suite controller by Honeywell Inc, which is an APC (Advanced Process Control) that follows the steps below using MPC (Model Predictive Controller), until you reach your final product:

- 1) Modeling - Fig.2: some steps or bumps were made in the process and the responses were observed on the major refining variables;
- 2) Controller configuration for process;
- 3) Development of Human Machine Interface, Fig.3;
- 4) Deployment and assisted operation of the controller, Fig.4.

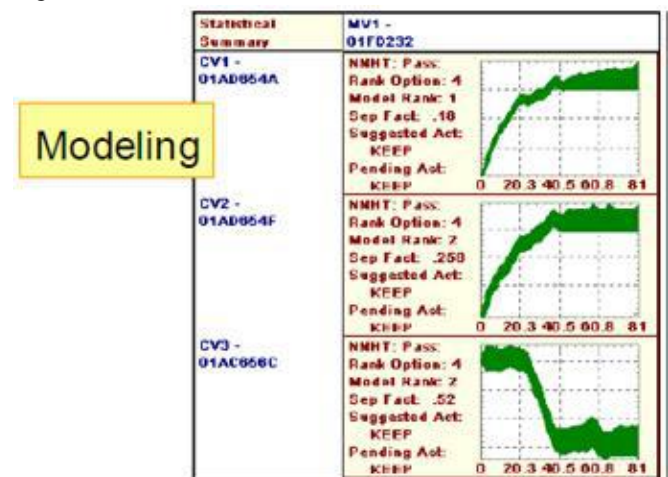


Fig.2: Controller Modeling.

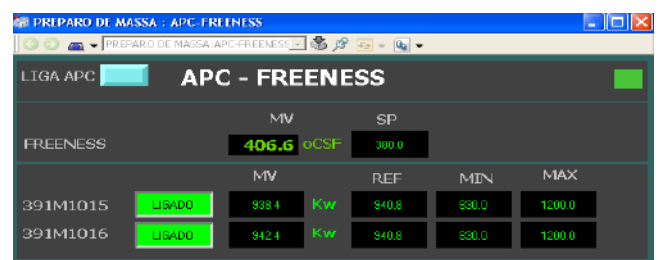


Fig.3: Human Machine Interface.

Briefly speaking, the controller action happens as follows: At each sampling, the controller and optimizer read the main operational process parameters (power, flow, consistency and Freeness), calculates the optimum value of the movements to be implemented in the manipulated variables (refiner drive motor power), taking into account

the limits of each parameter and the prediction of future behavior (future Freeness).



Fig.4: Controlling the Process.

These changes are then written in the power setpoint of the refiners and the cycle is restarted.

The advanced controller used for this work, has its core based on multivariable predictive technology, called in industry of model predictive control (MPC). The main goals of this technology are:

- Increase process stability;
- Better operational efficiency;
- Lead the process to an optimal operational target;
- Assure process specifications.

The target desired at Klabin's Paper Machine 09 (PM09) was stable freeness, despite of energy saving. The reason for this is the prime cartonboard produced at this paper machine, in this case, quality is everything.

III. RESULTS

As showed in Fig.5, the freeness control exceeded the expectations, the figure has just a few points out of control range. The control range has a 20 °CSF of amplitude, and the site specification are 350 to 420 °CSF, what means that in eight hours of operation, not even one point was out of specification.



Fig.5: Eight Hours of Operation.

The standard deviation for freeness was reduced by 47%, delivering a stable freeness for the process. Fig.6 contains some statistical analysis for freeness.

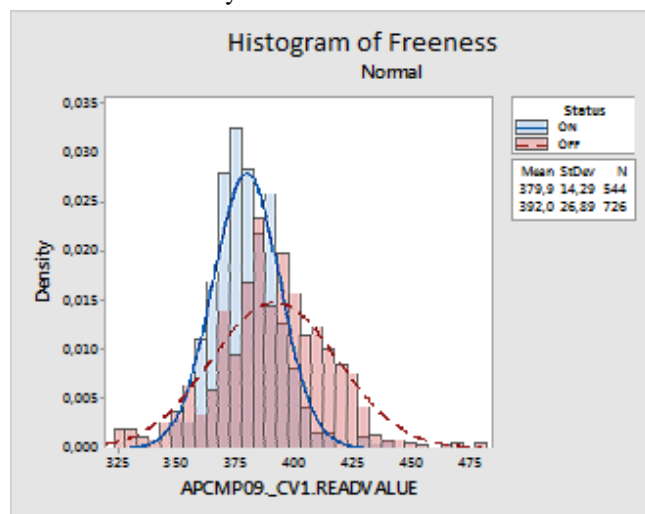


Fig.6: Reduction of 47% for Freeness Standard Deviation.

Fig.7 says that only 16% of the data are outside of control limits, which has an amplitude of 20 °CSF, a way below of 40 °CSF from the specification. This means that we have no more freeness out of specification for this paper machine.

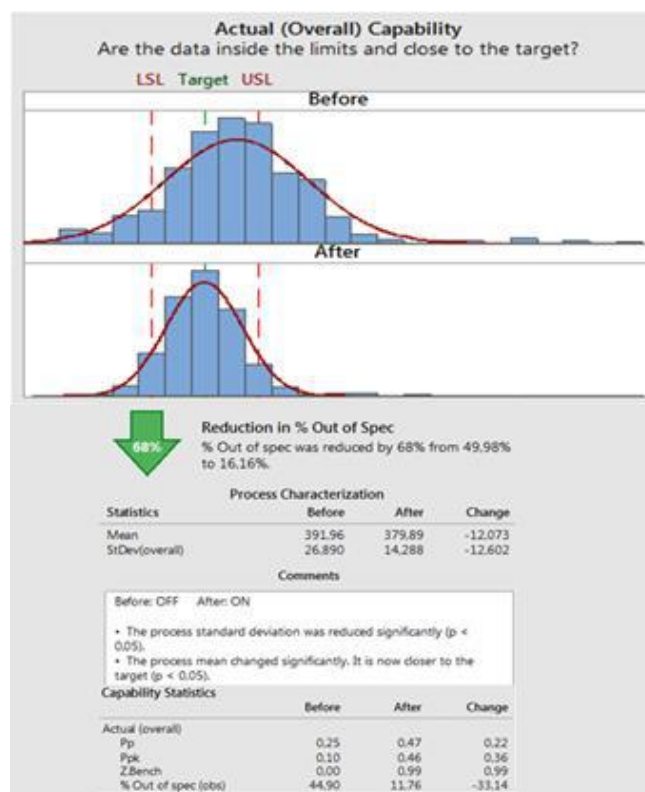


Fig.7: Capability Analysis for Freeness.

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