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Simulation and optimisation of a high grade coated paper mill

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Abstract

A process simulation of a high grade coated paper mill has been developed as part of a process integration study. Data necessary to calibrate and validate the simulation developed with the Cadsim Plus® software were obtained by: measurements, samples analysis and estimations through partial and local mass balances. The simulation was designed in a way that allows grade changes to reproduce the mill operation. The simulation is used to support process studies to optimise water and raw materials consumption and to evaluate results obtained by mathematical optimisation. Different scenarios were studied in order to evaluate the feasibility and the effects of process redesign of the mill's networks.

Keywords: Paper mill; Simulation; Water; Optimisation

1. Introduction

The pulp and paper industry have an impact on the environment since it is energy intensive, uses large amounts of water, a renewable resource (wood fibres) and other raw materials. It also generates atmospheric emissions, liquid effluents and solid wastes. This impact must be minimized and made as benign as feasible. The European paper industry has significantly improved its energy efficiency over the last decade. Regional greenhouse gas emissions from the European pulp and paper industry declined by 7–36% per tonne of output between 1990 and 2000.

The Spanish paper industry has significantly improved its energy efficiency over the last decade. Over the last four years, the emissions have decreased by 19% for NO_x, by 13% for SO_2, and by 30% for solid particles, while CO_2 emissions remained constant. In the last 10 years, the volume of water used to manufacture cellulose and paper products has diminished by 28%, in spite of the growth in production. The reduction in unitary consumption has been 47% during the last decade. For 1 t of cellulose processed the water consumption reduction is 39%. The development and implementation of clean technologies have brought about a reduction of effluents pollution load by 29% in the last 10 years on the basis of the total liquid effluent produced by pulp and paper mills; by tonne of production, the reduction has been 46%.

To maintain competitiveness the industry is involved in a continuous innovation drive. Process Integration techniques such as water network analysis, system closure or pinch analysis have been applied to case studies to improve energy efficiency, effluent reduction and waste minimisation.

2. Objectives and methodology

The aim of this project is to illustrate a methodology which has been used to efficiently develop schemes to

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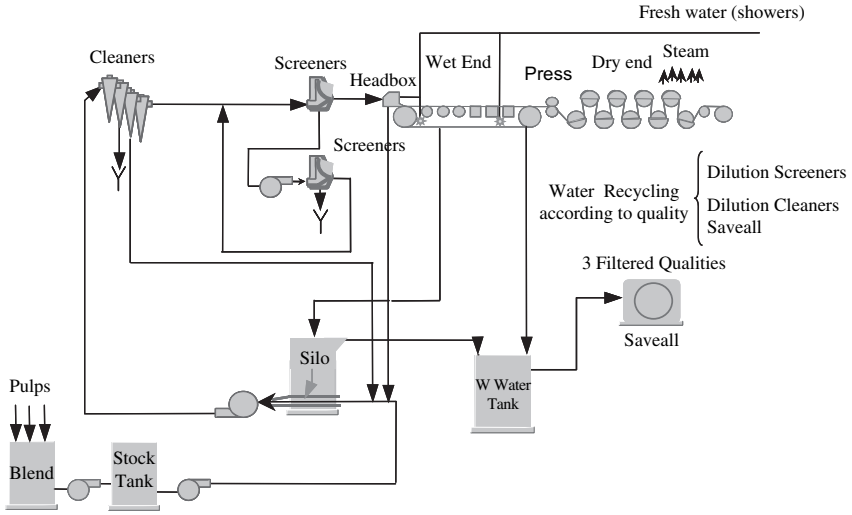

Fig. 1. Simplified process flowsheet.

minimize water consumption and improve system closure of in existing high grade paper mill by retrofit. A combination of process simulation and optimisation technique was used to this effect.

The first step of the project was the development of a representative simulation of the process. The simulation had to reproduce the operation of the mill which undergoes frequent changes in operating conditions. For this purpose the required data was collected from different sources. A new retention model was incorporated in the simulation to take into account fines and fillers retention in a more realistic way than the lumped default model. The simulation was validated to ensure the reliability of the results. The validated simulation was used to generate data satisfying mass and heat balances for the optimisation step. The optimisation step used a genetic algorithm (GA) to identify potential new process configurations that would reduce water consumption and material losses. Several reconfigurations of the whitewater network were identified by optimisation and were tested by simulation to check their technical feasibility.

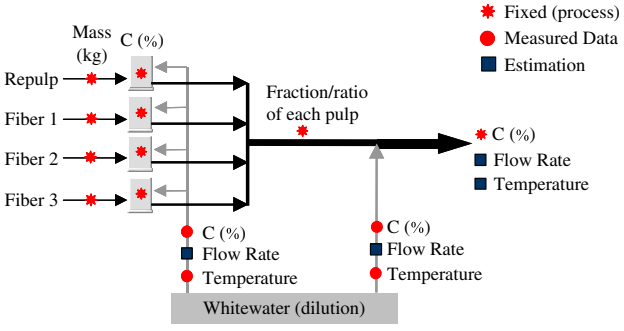

Fig. 2. Data estimation through local mass and heat balances.

In summary, the methodology involved the following steps:

1. problem definition, scope and objective statement,
2. collection of data required to solve the mass and energy balances and to develop the simulation,
3. development of a process simulation, collection of additional data by sampling and analysis to validate the simulation,
4. process optimisation by means of genetic algorithm,
5. evaluation of results feasibility by simulation: the new network configuration is implemented into the process simulation to evaluate potential effects on the mill operation.

3. Case study

3.1. Process description

A non-integrated paper mill producing high quality and high grade coated paper with basis weight varying from 90 to 280 g/m^2 was studied. It has a single production line with one paper machine using purchased kraft pulp. The production range is between 300 and 350 t/d. Daily fresh water average consumption is about 2500 m^3. Cadsim Plus was used to simulate operations from stock preparation to paper drying (Fig. 1).

The mill uses two different types of kraft pulp with different fibre length to produce thin paper sheets. Medium and thick grades use only one pulp, but the degree of refining can be varied to produce the required paper quality. The mixed pulp goes through a sequence of primary screening, cleaning and secondary screening, to produce the paper machine feed stock. Whitewater is