Novel Dewatering Solutions within Corrugated Case Medium Manufacture

Summary

The drying section is responsible for 75% of the total energy consumption on the paper machine. Increasing the dryness of the paper web after pressing by one percent can reduce the drying energy consumption by 4%. Hence there are large potential energy savings to be made if the moisture content after the press can be reduced.

This project combined process water clean-up, dewatering and papermaking expertise, novel dewatering chemistries, evaluation tools and the pilot papermaking equipment needed to test and optimize dewatering at scale ahead of commercial demonstration. Focused Beam Reflectance Measurement provided, for the first time, real-time insight into floc formation and how process chemicals can be applied to optimize floc size and formation for increased press section dewatering.

The demonstration was carried out on PM4 at DS Smith Kemsley Mill which makes ~270,000 tpa of Dual Use and High Performance Medium grades (115-220gsm). An audit of mill process water revealed critical areas to improve water quality and dewatering on the paper machine. Improvements in dewatering were evidenced by 10% reduction in steam consumption and 3-5% reduction in vacuum on the couch roll across six different paper grades made over a six-day period.

The Industrial Energy Efficiency Accelerator (IEEA)

The IEEA programme supports the development of innovative technologies that will help industry reduce energy consumption and cut carbon emissions. It focuses on innovations with large potential cross-sector energy and carbon reduction impact - either new technologies or established technologies applied to new sectors. Over £15 million in public and private funding has been committed to develop solutions through partnerships between technology developers and industrial companies willing to test technologies on-site. The programme is funded by the UK government (BEIS) and managed by the Carbon Trust, with support from Jacobs.

Introduction

The genesis of this innovation was founded on the knowledge that process water cleanliness impacts negatively on the efficacy of dewatering and retention chemicals, and ultimately on the floc size and its formation in addition to its ability to be dewatered further in the press section. DS Smith and RISE Innventia considered that by focusing on improving water cleanliness and dewatering during formation and pressing that a 2.5% increase in sheet dryness after pressing could be achieved, thereby reducing drying energy consumption by 10%. The technologies to improve process water cleanliness and increased floc dewatering were already proven by RISE Innventia at lab scale. The next step was to prove the technology within operational mill conditions. IEEA funding for this project facilitated the step-up from controlled lab and semi-industrial conditions to refine and prove the technology in a less predictable, real-world production environment. The total project cost was £706,571 with £358,151 of grant support received from IEEA.

About the innovation

The technology focused on three areas:

1) Improve process water cleanliness with the aim of reducing conductivity and cationic demand by 20%
2) Optimise dewatering chemicals
3) Find the best floc size and formation for increased press section dewatering.

By improving the chemistry condition in the process water, the added dewatering and retention chemicals would be more efficient and an optimal floc size for increased water removal in the press section could be achieved. This in turn would lead to an increased sheet dryness after pressing with subsequent dryer energy reductions (Figure 1). The data for demonstrating the project performance was aimed to be generated over at least 5 days of operation.

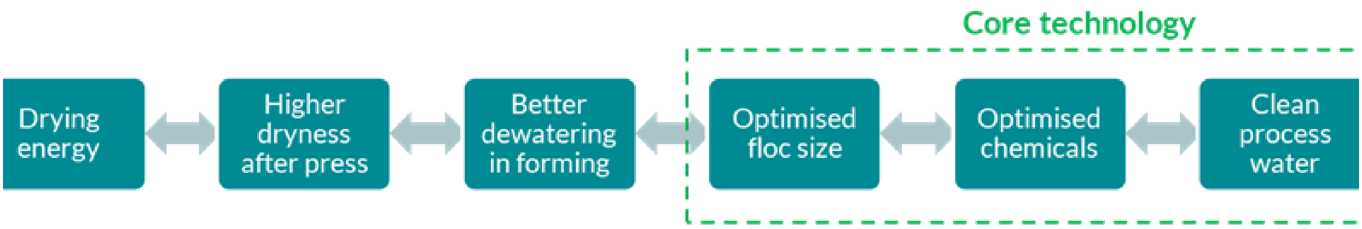

Figure 1 The link between dewatering, drying and process water quality

The demonstration

The demonstration was carried out on PM4 at DS Smith Kemsley Mill which makes ~270,000 tpa of Dual Use and High Performance Medium grades (115-220gsm) – Figure 2.

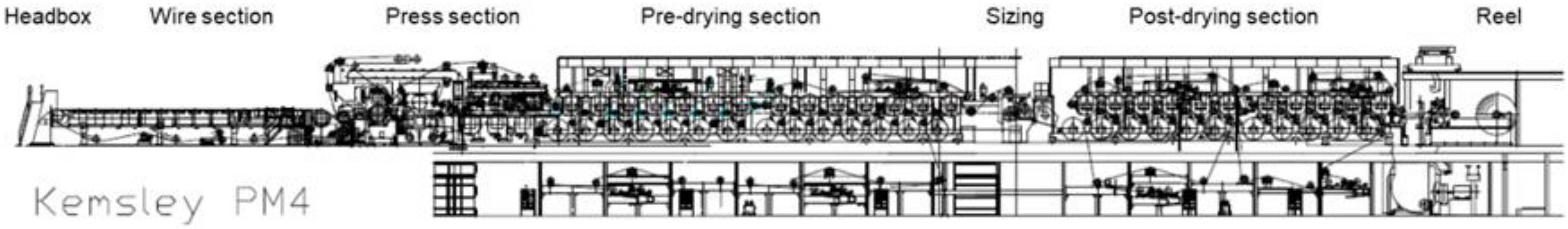

Figure 2 DS Smith Kemsley PM4 – main dewatering sections

The current process

Dewatering is a key element of papermaking and an energy intensive part of the process. Improvements in dewatering therefore offer opportunities for significant process energy savings. Dewatering starts in the wire forming section where water is removed first by gravity and later by applying vacuum in suction boxes. The web is then transferred to the press section at a dryness of 20-25%. In the press section water is pressed from the web in press nips. The dryness of the paper web after the press section is ~45%. The drying section is responsible for 75% of the total energy consumption on the paper machine. Increasing the dryness of the paper web after pressing by one percent could reduce the drying energy consumption by 4%. Whilst it is recognised that even a modest increase in dryness of the sheet web by just 2.5% could lead to dryer energy savings of 10%, the means to deliver this increase in solids content without reducing the speed on the paper machine has remained elusive to date.

Key project stages

Establishing a link between improved process water cleanliness, increased efficiency of dewatering and the retention chemicals, and optimised floc size for increased dewatering in the press section was demonstrated within RISE Innventia's semi-industrial FEX plant. This included installing a Focused Beam Reflectance Measurement (FBRM) device (Mettler-Toledo Particle Track E25) to assess if such a technique could measure floc formation 'real time' and allow the control of process chemical addition to increase dewatering. The results from the pilot scale studies were significant and provided a new pathway for DS Smith to increase the dryness of the paper web after pressing at full scale to deliver the anticipated energy savings.

The FBRM device was installed at DS Smith and water clean up and dewatering trials were carried out at full scale over six days of operation. The COVID pandemic curtailed planned full-scale trials to combine the technologies to optimize dewatering after the press section. Further work will be required in the future to gain further operational data before all of the improvements identified can be rolled out across the mill.

Improving process water quality

The cationic demand and conductivity of process waters associated with the PM4 fibre preparation, stock approach and sheet forming were measured and critical areas to improve process water quality were identified (Figure 3).

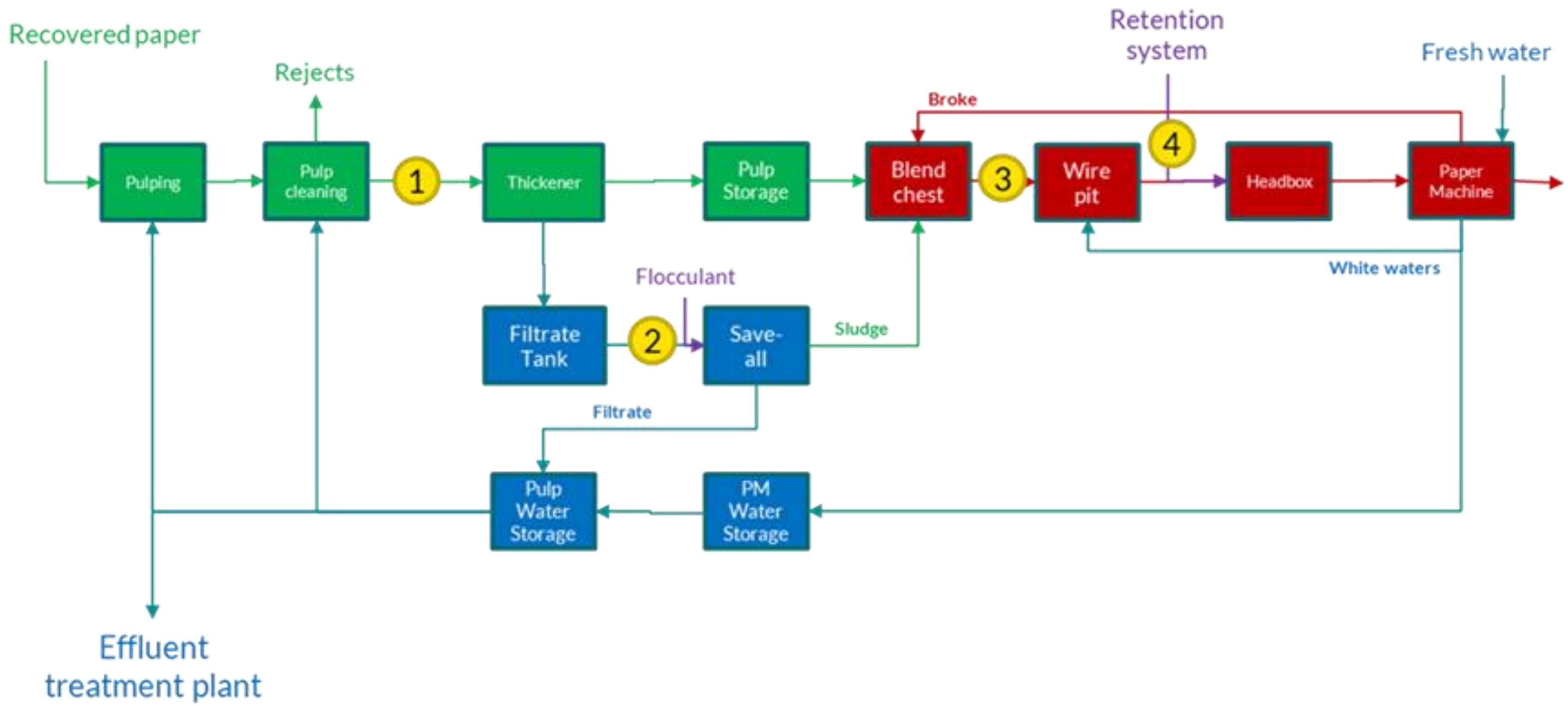

Figure 3 Overview of PM4 process water streams and identification of critical areas for process water clean-up

The following measures were undertaken at each of the critical areas identified:

1) Treatment of pulp before the thickener to fix anionic trash to fibre and improve process water cleanliness. This in turn improved flocculation and dewatering thereby reducing the amount of water carried over to PM4.
2) A consequence of reducing high cationic demand filtrate solids from the thickener, meant that 30% less cationic polymer was required to be added to the Save All. This in turn improved retention aid efficacy and dewatering on PM4.
3) Further fixation of anionic trash to the pulp after the blend chest improved water quality leading to further improvement in dewatering.
4) Optimising the retention system chemicals to that improved pulp enabled the control of the floc size in the headbox and delivered the required dewatering improvements.

Dewatering and drying

The FBRM was installed in the approach flow to PM4 to monitor flocculation by measuring the number of fibre flocs in the pulp suspension and their chord length (Figure 4). The FBRM provided, for the first time, real time information on floc formation to allow the control of process chemicals to optimise floc size for dewatering and higher dryness after press.

Figure 4 FBRM probe installed in the approach flow to PM4 (L). Progressive removal of water from the paper web by gravity and vacuum suction on the wire section of PM4 (R)

Monitoring

Base line performance was determined by collecting mean value data from the mill data system during normal operation for a range of paper grades (Table 1). These base line data included energy, process and quality parameters since the ultimate objective is to manufacture saleable tonnes but with reduced energy consumption. The base line data were compared with data gathered during the manufacture of a range of paper grades whilst operating with ‘enhanced dewatering’.

Table 1 PM4 operational parameters

PM4	Forming section	Press section	Pre-drying	Sizing	Post drying
Quality	Total vacuum applied	Nip load	Total steam (kg/t)	Solids, %	Total steam, kg/t
Wire speed	Steambox	Press speeds	Steam pressure	Sizing flow, l/min	Steam pressure
Reel speed	Backwater	Ecoflow	Steam temp	Nip Load	Steam temp
Production		VMP pressures	Pocket vent	Temperature	Pocket vent
HB temp			Moisture before sizing		Reel moisture %

Results

A number of water clean-up and dewatering tests were carried out at full scale. One of the most striking results obtained was through the application of a fixative to the pulp after the blend chest to improve water quality (Figure 3 and Figure 5). The impact of fixative addition on sheet dewatering and drying was assessed by analysing the change in couch vacuum and steam consumption in the pre-dryer section of the paper machine. Couch vacuum was 3-5% lower and steam consumption reduced by 10% across six different grades made over a 6-day period.

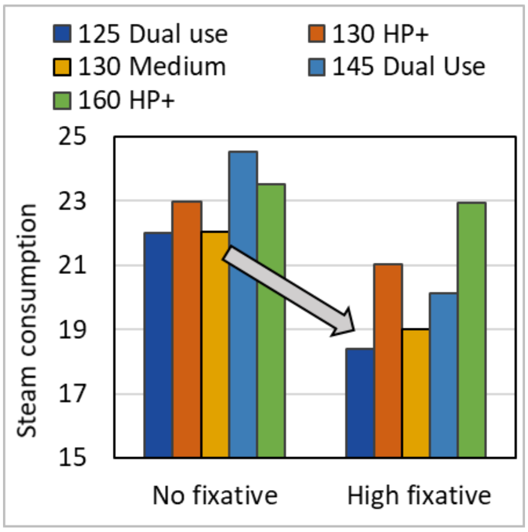

Figure 5 Steam consumption with and without fixative for different paper grades

The improvements seen in Figure 5 were linked to improved flocculation in the headbox, as can be seen in Figure 6. At a higher amount of fixative, even without the addition of Cationic Starch (CS), a better dewatering was seen. Also, a linear correlation between the number of particles measured (counts) and the dryness in the wire section (referred as couch vacuum) was observed, enabling the possibility for on-line control and development of dewatering soft sensors based on the FBRM. Estimated costs, energy savings and payback are shown in Table 2.

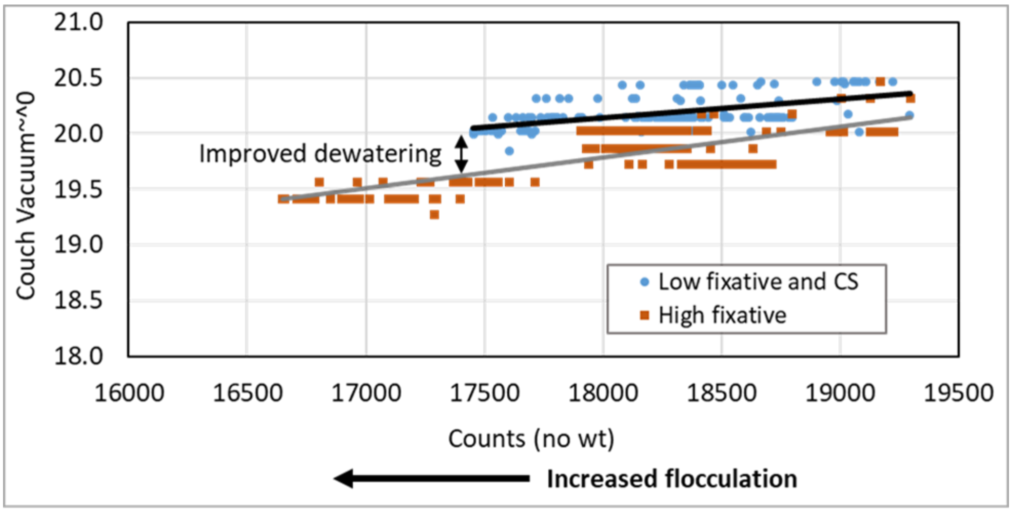

Figure 6. The couch vacuum vs flocculation at different addition levels of fixative and cationic starch.

Table 2 Estimate of costs, energy savings and payback period

	£
Total capital costs	**645,000**
Additional chem spend	**459,000**
Depreciation	**64,500**
TOTAL ANNUAL COST	**523,000**
Annual saving	**877,500**
Net annual saving	**354,000**
Capex payback	**1.82**

Future impact

UK CCM manufacturing is the largest pulp and paper sub-sector manufacturing 1.68 million tonnes/year out of a total of 4.1 million tonnes. Manufacturing occurs across four sites with DS Smith Kemsley Mill being the largest site operating three paper machines to deliver 830,000 tonnes of CCM/year. Energy consumed to dry the paper sheet is estimated to be 1,000 to 1,200kWh/tonne with the whole sub-sector consuming between 1.7 and 2.0 million MWh annually. Achieving 10% sector wide savings in drying energy alone would deliver annual savings of between 1.7 to 2.0 GWh/yr.

Innovation lessons

Innovation is difficult to achieve and mostly incremental within large process industries, where meeting production targets are the prime objectives. The critical lesson learnt by the innovation partner was that to deliver this (and any) demonstration project it is crucial to ensure 'buy-in' from industry that the theory, lab and pilot scale work can be translated into improvements in the full-scale operating environment without affecting production. In this project, DS Smith provided financial support to undertake the original scientific investigation and lab/pilot work. This work provided confidence to the mill that energy savings could be delivered at full scale. Funding was then sought from BEIS through the IEEA to support the scale-up and realise these energy savings. The work carried out in this project is pioneering and provides new insights into the impacts of process water cleanliness, floc-formation and enhanced paper web dewatering. The application of the FBRM to provide real time information on floc formation for enhanced dewatering is novel. The challenge to the mill now is to use this new information/insight to embed changes within day-to-day production to gain further energy and sheet quality improvements.

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