Aalto University
Design Factory

Case article:

VALMET OPTICALENDAR METAL BELT

Smoother paper with optimal heat treatment

The pulp and paper industry represents a significant portion of global manufacturing and business. The industry is mostly dominated by companies operating in North American, European, and East Asian countries. Despite digitalization, consumption of paper products is still high, at an average annual consumption per person of approximately 60 kg on a global scale. In Finland, average consumption is as much as 194 kg/person/year (Bajpai, 2013), and these numbers have remained relatively stable (Environmental Paper Network, 2018). This poses a great demand for paper production.

One of the main products in paper production is plain paper and cardboard, aiming at making the produced paper as smooth as possible. This requires heating up cellulose and compressing it into thin sheets in a smoothing process called calendering. However, the stiffness and thickness of the product suffers when the paper is pressed and heated in order to achieve the desired smoothness. Thus, a common challenge is to make the paper as smooth as possible without damaging the stiffness too much (Vernhes et al., 2009).

A traditional calender machine comprises a series of hard pressure rollers between which paper or carboard sheet is rolled through. There are some variations in existing calender designs, as some have rolls that are heated or cooled depending on the purpose, and calenders can also be used in further processing to apply coatings to the sheets. Heat treatment during calendering is a way to achieve a gentler pressing of the sheets. Usually, the heating is provided only briefly from the rolls and therefore it affects the sheet for just a few seconds (Vernhes et al., 2009).

Valmet is a longstanding Finnish manufacturing company producing technologies, automation, and services for pulp, paper, and energy companies. In 1995, Valmet identified a need and a possible novel solution for maximizing the smoothness of paper without harming its stiffness. This kind of innovative calender machine had the potential to improve Valmet's competitive position in the market.

The company ended up designing a new kind of calender, during a ten-year iterative process. The original inventor of the idea was a master's thesis worker at Valmet, tasked with developing a new product concept to solve the problem of stiffness loss. As the inventor started to inspect the paper production process, he noticed that the calendering process at the time limited the cellulose and lignin heat treatment time, as heat was provided only when the paper was in contact with the calender rolls. In practice the paper ran through a few millimeters wide section between calender rolls for a few milliseconds, which was not long enough for efficient heat conduction. The inventor concluded that finding a solution where the heat treatment time could be increased would be the key factor. This sparked the development process of the OptiCalender Metal Belt, named at ValZone at the time.

The inventor first attempted to design a solution with existing, traditional, heated paper rolls. While sketching, he came up with an idea of having another, heated sheet going through the rolls at the same time with the paper sheet to extend heating to a longer period. The outcome of this ideation was to use a heated belt of some sort in the calendering process to keep the paper sheet heated continuously. After some theoretical calculations, the inventor performed initial prototyping in his own kitchen, using a clothes iron and an oven plate as the surfaces. This testing provided initial validation that the idea had at least theoretical potential for practical application.

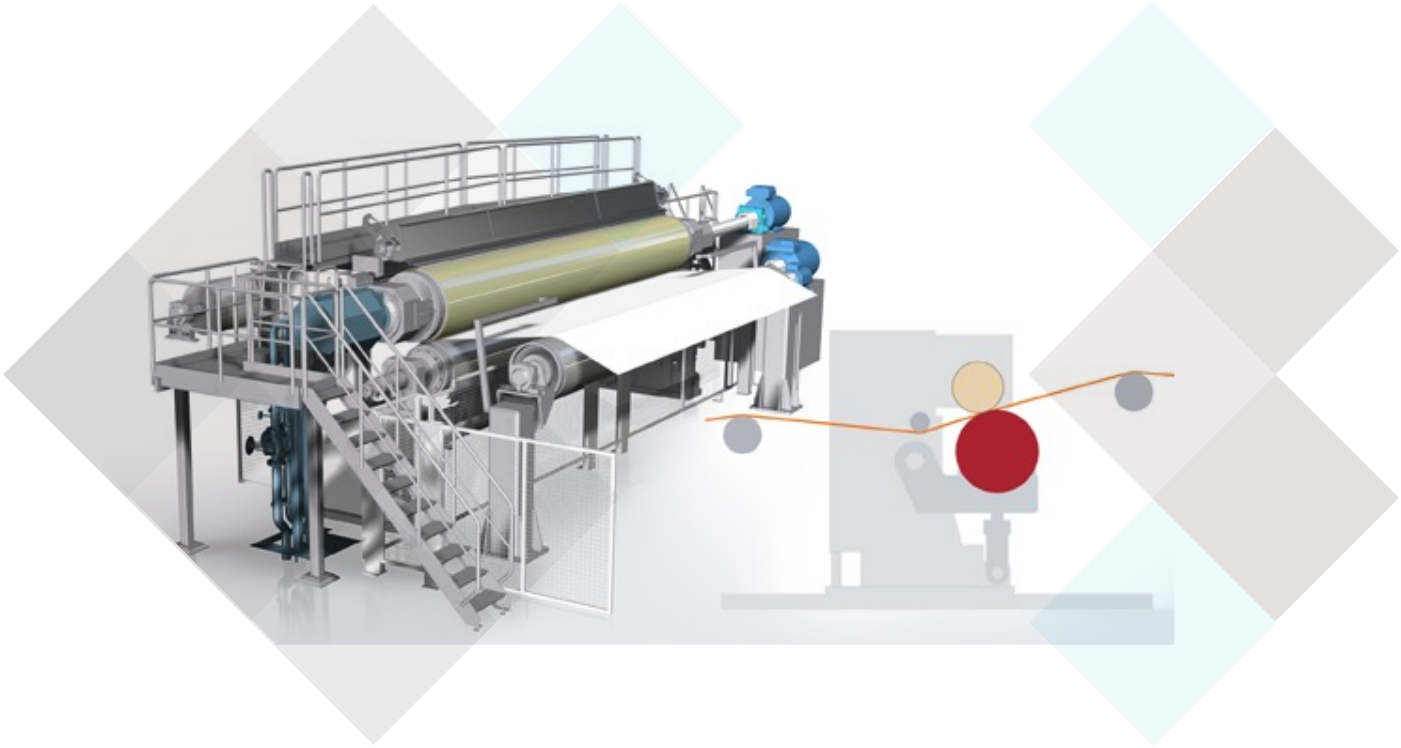

Image: TRADITIONAL HARD NIP CALENDERING (VALMET, N.D.)

Meanwhile, a large US based paper machine manufacturer went bankrupt, leaving a huge gap in the market. This was a lucky strike for the new calender design project: Valmet was able to buy the company's old machines, giving the new calender project a kick start with plentiful testing parts available. IA few old paper machines and several containers full of other equipment and components were shipped to Finland. The very first small prototype was built from these scrap parts, with the calender machine equipped with a urethane belt used in the heating. However, the prototype performed poorly, stretching too much to achieve the needed belt tightness with it. As a result, the design direction was changed, replacing urethane with metal as the belt material.

Soon after this, the first prototype with a metal belt was implemented in a scale that was able produce paper in A4 size. This version was used to gather laboratory performance data, and it was a good starting point for testing and further development as it was mobile, compact and it enabled demonstrations to different stakeholders. This was important, because in a large company, there had to be some proof about the idea to get it moving forward and to receive project funding. Indeed, securing resources was one of the major challenges: it was a slow process to get such a novel project started, requiring a lot of supporting evidence until the needed people were convinced of the potential of the concept. Luckily, the functional small-scale prototype helped the developers to demonstrate the potential of the solution, and a full-scale version was implemented based on the promising results of the smaller scale version.

At this point, a client came along who bought the first metal belt calender product, and the official product development project of the solution was launched. (This is typical in manufacturing large, expensive, heavy industry machinery - often only the first sold product kicks off official product development.) A team of approximately ten people started working on the development project. The team and the support that team members provided to each other were key in enabling this exploration. The core team came to consist of people who were truly interested in the metal belt project, as some team members that lost interest left to work on other projects as the development went on for years. The highly motivated remaining team understood and trusted each other's working procedures, enabling working without distractions. Additionally, supportive leaders that believed in the project helped the team to proceed when other decision-makers in the company were doubtful.

In 2006, the current version of the product – the OptiCalender Metal Belt – was ready and launched (originally called the ValZone metal belt calender). The final product has a one-meter-long machine-direction calendering zone with a heated metal belt and a thermo roll. This enables constant heat treatment as the paper lies on the metal belt which is heated by the rolls throughout the process. This way, the heat treatment is gentle and does not decrease stiffness as much as the traditional solutions, representing a clear quality improvement.

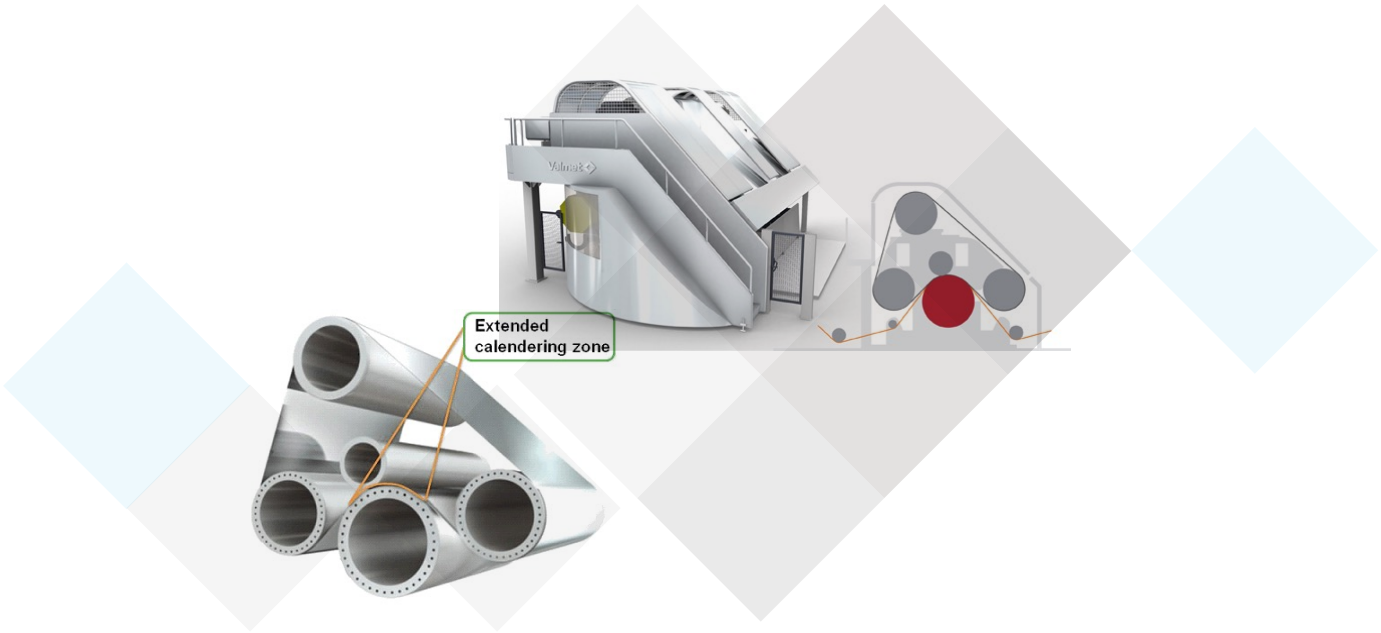

Image: THE OPTICALENDER METAL BELT CALENDER (VALMET, N.D.)

Even though Valmet is an old company with established product lines for paper machine and equipment manufacturing, the metal belt concept in calendering was based on a new technological approach. Embarking on new territory, the developers themselves discovered additional advantages: in addition to the intended benefit of a significantly longer heat treatment zone, leading to better quality as well as lower raw material consumption, the heat treatment turned out to improve the impact of pre-calendering treatments before coating. This created an even stronger value proposition for the OptiCalender Metal Belt in the market. Further development leveraging the technology continues, with constant development being a key for retaining a competitive edge in the field.

References:

- Vernhes, P., Bloch, J. F., Blayo, A., & Pineaux, B. (2009). Effect of calendering on paper surface micro-structure: A multi-scale analysis. Journal of Materials Processing Technology, 209(11), 5204–5210. https://doi.org/10.1016/J.JMATPROTEC.2009.03.005
- Bajpai, P. (2013). Introduction. In Recycling and Deinking of Recovered Paper (p. 315). Elsevier. https://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=1573356
- Environmental Paper Network. (2018). The State of the Global Paper Industry. https://environmentalpaper.org/wp-content/uploads/2018/04/StateOfTheGlobalPaperIndustry2018_FullReport-Final-1.pdf
- Valmet (n.d.) hard nip calendering: https://www.valmet.com/board-and-paper/board-and-paper-machines/calendering/hard-nip-calendering/

Further material:

- More about OptiCalender Metal Belt: https://www.valmet.com/board-and-paper/board-and-paper-machines/calendering/metal-belt-calendering/
- Marcus Wallenberg Prize for the developed technology (an international prize for the promotion of scientific research in the forest industry): https://www.valmet.com/media/articles/all-articles/metsos-mika-viljanmaa-receives-marcus-wallenberg-prize-2012/

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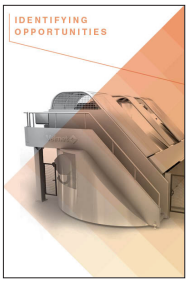
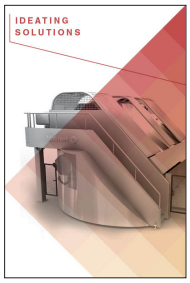
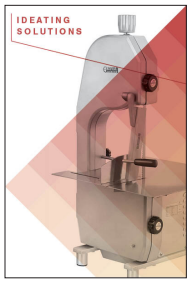


KEY PHENOMENON

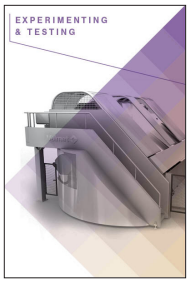


RELAX CONSTRAINTS

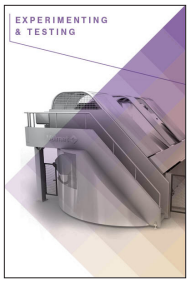


ANALOGIES

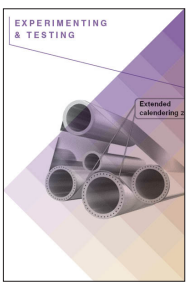
SIMPLE PROTOTYPE



SUB-SYSTEM ISOLATION



SIMPLE PROTOTYPE



CRITICAL PROTOTYPING

SEQUENTIAL PROTOTYPING