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SHOE PRESS TECHNOLOGY AND MARKET DEVELOPMENT

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ABSTRACT

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TAAVILA, ANTTI:
Shoe Press Technology and Market Development

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Paper and board making process in its basic form is removing water from pre-prepared cellulose fibre – water mixture, pulp furnish. Shoe press is an appliance installed in the paper or board machines press section, the part which removes water by applying force to the web formed by fibres. This thesis will look on the shoe press more closely.

In thesis, a general paper making process and the functions and theory behind the press section are studied. In the shoe press part, a deeper look is taken into how it works, how it affects to dewatering efficiency and quality of the paper and why it has become so popular appliance over the past decade in the rebuilds and new paper machines built. Also its effect on special application, tissue making and pulp drying, is examined.

The thesis explains the history behind the innovation of the shoe press from idea to functioning part of the modern paper and board machine. Also different manufacturers and their different solutions and the shoe press belt, needed piece of paper machine clothing to operate the shoe press, will be presented as well.

Finally, a shoe press market study with a goal to map potential new customers for a belt manufacturer and to create basis for marketing and sales investments was done. Due to nature of the sources used and data collected, the results of the study have been classified as confidential.

TIIVISTELMÄ

Tampereen Ammattikorkeakoulu
Paperi-, tekstiili- ja kemiantekniikan koulutusohjelma
Kansainvälinen paperi- ja sellutekniikka

TAAVILA, ANTTI:
Kenkäpuristimien teknologia- ja markkinakehitys

Opinnäytetyö 24 sivua, joista liitteitä 0 sivua
Elokuu 2017

Paperin- ja kartonginvalmistus on yksinkertaistettuna paperikoneella tapahtuvaa vedenpoistoa selluloosakuitu-vesiseoksesta. Kenkäpuristin on laite paperikoneen puristinosalla, osalla, jossa nimensä mukaisesti poistetaan vettä puristamalla kuitujen muodostamaa verkkoa. Tässä opinnäytetyössä keskityttiin kenkäpuristimen toiminnan tutkimiseen.

Työssä tutustuttiin yleisesti paperinvalmistusprosessiin sekä puristinosan toimintoihin ja teoriaan. Kenkäpuristimeen syvennyttiin tarkemmin tutkimalla, kuinka se toimii, miten se vaikuttaa paperikoneen vedenpoiston tehokkuuteen ja laatumääreisiin lopputuotteessa ja miksi siitä on tullut niin yleinen paperikoneiden modernisoinneissa ja uusien koneiden osana. Lisäksi tutkittiin kenkäpuristimen erikoisempia sovelluksia pehmopapereiden valmistuksessa ja sellunkuivauksessa.

Työssä tutustuttiin kenkäpuristimen historiaan ideasta toimivaksi modernin paperikoneen osaksi. Myös eri valmistajat ja heidän kenkäpuristimiensa erot sekä kenkäpuristimen toiminnalle välttämätön paperikonekudos, kenkäpuristinhihna eli beltti, käytiin läpi.

Osana opinnäytetyötä tehtiin kenkäpuristinten markkinatutkimus, jonka tavoitteena oli löytää uusia potentiaalisia asiakkaita kenkäpuristinhihnavalmistajalle ja luoda pohja markkinointi- ja myynti-investointeja varten. Johtuen käytettyjen lähteiden ja kerätyn datan laadusta, tutkimus julistettiin salassa pidettäväksi työn tilanneen yhtiön pyynnöstä.

Key words: papermaking, shoe press, press section, dewatering
Asiasanat: paperinvalmistus, kenkäpuristin, puristinosa, vedenpoisto

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CONTENTS

GLOSSARY or ABBREVIATIONS AND TERMS (choose one or other)

N	Newton, unit of force
Pa	Pascal, unit of pressure, N/m^2
psi	Pounds per square inch, old unit of pressure. 6894,757 N/m^2
s	second
min	minute
Nm	Newtons per metre, unit of moment

1 INTRODUCTION

Strive to meet the increasingly strict emission standards along with cost reductions via energy savings has led to various innovations across the field of manufacturing industry, as new and more efficient ways and applications of production are constantly under development. The pulp, paper and board industry is a capital-intensive industry where the added value of the majority of the products is low and produced quantities high, thus increasing the impact of efficiency of the production process. In paper and board industry the manufacturing process consists, in a heavily simplified form, stages of removing water from prepared furnish. This furnish, or pulp, is a dilute suspension of separate cellulose fibers and additives in water that forms a uniform sheet of paper after the excess water has been removed.

In the modern papermaking, the water removal from pulp is achieved with an industrial machinery by draining and in the further stages by applying external force in forms of pressing and heating the pre-drained randomly interwoven fiber mat. Shoe press, also referred as extended nip press, is a technology application in paper or board machine's press section designed to improve the dewatering in press section of the paper- or board machine and reduce energy usage in the removal of excess water in later stages (i.e. drying section) of the machine.

The heat-induced evaporation in the drying section is a major energy consumer in paper making. The potential to use less energy in the drying section, as there is less water to be removed, means the efficiency of the press section has a big impact on the energy efficiency of the whole manufacturing process. Drive towards the more energy- and cost efficient manufacturing applications and methods without compromising quality can be considered as a megatrend nowadays, and shoe press is one of the biggest energy-saving innovations regarding hardware in paper machinery in the recent centuries.

The focus on this thesis is in the development arch of shoe press technology to where it is today, the applications and theory behind the function of the shoe press. Also, comparison of the different manufacturer's solutions, specific paper machine clothing required and markets of the shoe presses are studied.

2 PRESS SECTION

Making paper or board is basically a process of mixing and then separating water with cellulose fibers to create a uniform fiber web structure, paper. To simplify the basic functions of the process, in this chapter no distinction is made between paper and board machine, since the basic operations are the same and the term ‘paper machine’ is used to refer to common structure of the both paper and the board machine. As discussed earlier, process takes place in three stages; furnish preparation, paper machine operations and finishing the paper or board to specific end usage.

Before the furnish is ready to be fed through paper machine, it needs to be prepared by processing the pulped wood and/or waste paper and mixing it with additives and chemicals (those vary depending on the paper/board grade) in water. In this stage the dry solid concentration is low, about 1%. To remove the excess water from prepared furnish it is fed to paper machine. In the paper machine, the needed final dry solid content, also called dryness of the paper, is achieved in three sections and the dryness increases as the paper web moves through the paper machine.

In the first section, the forming section, the water is drained from the furnish. As the term indicates the forming section is responsible for forming the paper web, and sometimes suction-aided draining takes the dry solid content from 1% up to about 20%. The press section, where the water is squeezed out of the web by driving it through a number of rolls loaded against each other, known as press nips, the dryness of about 45% is achieved. After pressing the sheet moves to the drying section where heat is applied to paper sheet to evaporate the remaining water and final dry solid content of around 95% is reached. After the paper machine the finishing operations such as calendaring and cutting are applied to finish the product ready to be delivered to customer.

3 TECHNOLOGY AND DESIGN

Even though the primary function of the paper machine is to remove water from the sheet, different sections act in different ways. When only to amount of water removed is considered, approximately 96% of the total water is drained on the forming section, 3% is pressed and 1% of the total amount of water removed is evaporated. (Jermo, 1999, 1.) However, when energy consumption is taken into account, it drastically changes the economic importance of each of the sections; the largest amount of energy per kilogram of water removed is utilized in the drying section, roughly 65% of the total energy consumption. Considering the machine economy, one can see that the major improvements in the specific energy consumption per ton of paper are thus achieved by improving the energy efficiency of the drying section, or by enhancing dewatering in the press section. Shoe press, as the name implies, is one of the latter. (Martin et al. 2000)

When pressing is concerned, a way to improve dewatering is to increase nip impulse. Nip impulse is a product of two variables; pressure and dwell time, i.e. the magnitude and the duration of the pressure applied to the paper sheet in the nip. Since the nip is short in a conventional roll press, the load of the nip could not be increased over a certain limit due to damage to paper sheet (roughly 400 kN/m), and the dwell time suffers due to higher machine speeds in modern paper machines, remaining option is increasing the nip length. Shoe press is a press design taking advantage of increased nip length in dewatering, dividing a greater linear load to a larger surface area. (Jermo. 1999, 1; Pikulik. 1999, 88-92.)

$$I = \frac{\mathrm{P\ LL}}{t}$$

in which I = press impulse

P_{LL} = linear load, kN/m

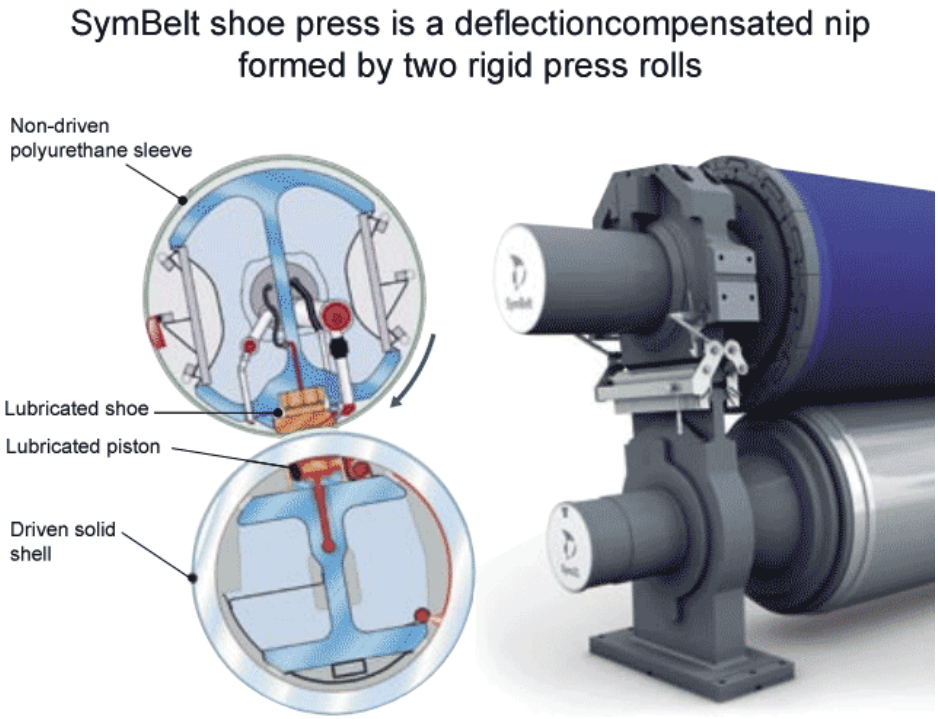
t = dwell time, ie. nip length (m) / machine speed (m/s)

Design parameters	Roll press	Shoe press
Length of press or nip width (cm)	4 – 7	25 – 30
Linear load (kN/m)	150 – 450	1,000 – 1,500
Press impulse (kN*s/m^2)	3.0 – 5.0	15 – 21

(Based on Wedel. 1993)

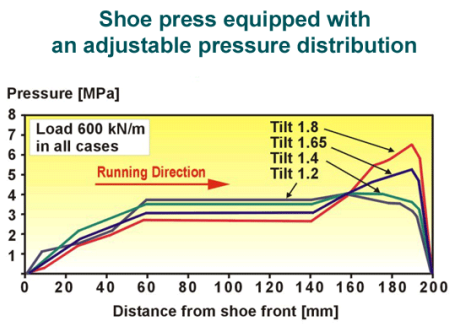
Compared to traditional roll press, shoe press replaces the loaded mating roll with a stationary concave-shaped shoe loaded against the fixed-position press roll. Nowadays backing press roll is typically deflection-compensated (or so called variable crown) roll.

The nip is formed between typically around 25 centimeter (in machine direction) long concave shoe and the backing roll, lengthening the pressing time and thereby increasing nip impulse without increasing the nip pressure. As the shoe press replaces one roll with a stationary shoe, paper sheet and felts required in transporting the sheet slide through the nip instead of rolling relative to the shoe, a lubrication is needed between the shoe and the moving felts (and paper sheet). The new needed piece of paper machine clothing is called belt (or sleeve), an elastic, impermeable shell between the felt and the shoe. Oil needed for lubrication is supplied between the belt and the shoe to act as a load transfer medium, as the short belt affixed to the rotating end plates in the press form an oil-tight roll-like structure. (Jermo. 1999, 7)

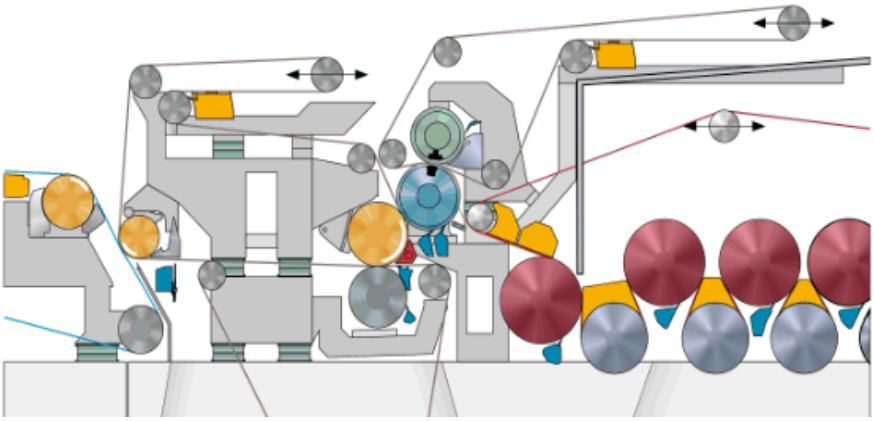


Picture 1: shoe press, (KnowPap. N.d. a.)

The loading system for the shoe can be either hydrodynamic or hydrostatic, depending on the manufacturer (more detailed look on each manufactures applications later). (Jermo. 1999, 7-8, 10.) A papermaker can adjust the nip pressure curve by changing the "tilt," the pressure difference between the enter- and exit-phase in the nip.

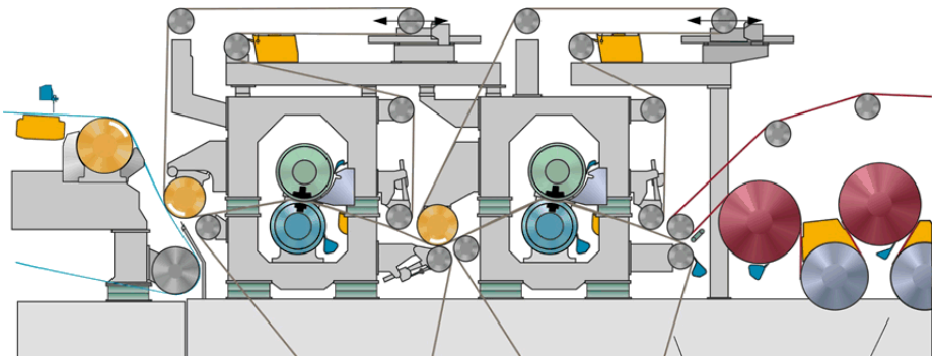


Picture 2: tilt angle variations, (KnowPap. N.d. a).



Picture 3: center roll configuration, blue/green nip indicating the shoe press, (KnowPap. N.d. b.)

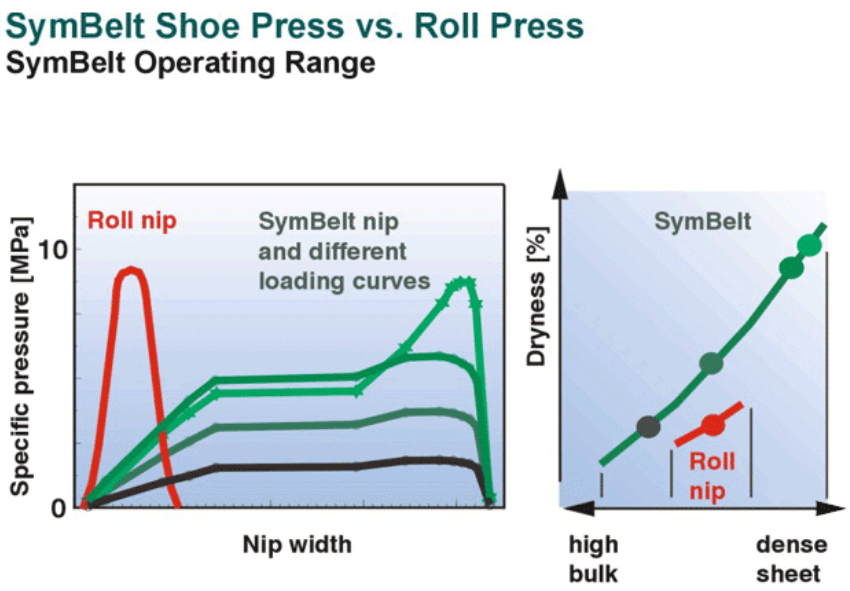
Shoe could be applied to a more traditional center-roll based press section or as usually is the case with the modern machines, a fully felt-supported straight through-press section with two shoe presses in linear configuration one after another. This configuration reduces breaks and makes higher machine speeds achievable through the possibility to support the paper sheet with a felt through the whole press section without any open draws from one nip to another. (Jermo. 1999, 36-37.)



Picture 4: Linear configuration, (KnowPap. N.d. b.)

4 QUALITIES IN PAPER

Shoe press has some major advantages when compared to more conventional press section solutions. Higher sheet dryness is achieved at the exit of the pressing section and depending on the grade produced, the increase is about 5 to 10% compared to conventional pressing. Higher dryness leads to a better runnability (runnability defines how smoothly paper runs through a paper or board machine or printing machine without breaking the sheet) and a possibility to increase machine speeds thus resulting a higher production capacity. (Wedel. 1993, 31-33.)



Picture 5: pressure curve & dryness in shoe press vs. roll press. The areas under the curves are the press impulse (1 psi = 6.9 kN/m2. (KnowPap. N.d. c.)

Secondly, a higher dryness achieved in the press section reduces demand for steam in the drying section. This leads to an improvement in machines energy efficiency despite the increased electricity consumption, as the drying section is major energy consumer in the paper machine when amount of water removed with a certain amount of energy is concerned, as mentioned earlier. (Sirrine. 1982)

A third advantage in the form of improvement in the product quality properties can be seen. The press section has a major effect on paper or board properties because paper's most physical properties are in some way related to the density of the sheet. Pressing, as the name applies, always makes the sheet more dense, or in other words to lose its bulk.

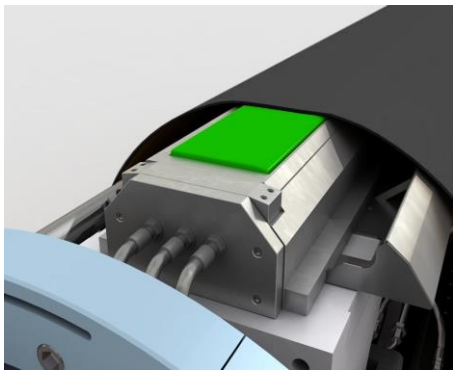
With a shoe press the peak pressure applied to the paper sheet in the nip can be lowered without compromising linear load, thus retaining the same sheet dryness with lower sheet density. Decrease in the loss of bulk also make possible to use less fiber, which directly reduces furnish costs. This has proven to be one of the major benefit for paper makers along with the original thought of cost savings through less use of drying energy. (Lange. 1996, 435-438; Wahlstrom. 1991, 18-27.)

There are also some disadvantages with a shoe press. Running a shoe press requires continuous lubrication, so energy is needed for running the oil pump systems. This however is offset by the energy savings made elsewhere. However, as the lubrication is critical for the operation of shoe press, faults in the system oil feed can cause major pauses in production. The belt material can withstand continuous use in below 80 °C oil operating temperatures, and with modern fast machines generating higher oil temperatures shorter belt life can be assumed. Also when operated, the belt remains in high stress around the edges where the belt must bend from concave-shaped shoe to round end plates of the press, so monitoring the belt condition is critical to avoid any unplanned breaks. (Jermo. 1999, 9-10.)

Concerning water removal characteristics, some rewetting occurs in the end of the shoe if the pressure is not decreased rapidly enough. Also, when high amounts of water are removed, the lack of space for water in the belt becomes evident especially in the single-felted printing paper machines. Grooved or blind-drilled belts were developed to fix the problem, but can cause marking in fine paper grades. (Valmet. 2014, 14-16; Schuwerk. 1997, 53-55.)

4.1 In tissue and pulp drying

Although the shoe press was first introduced to board and fine paper grades, it found its way to tissue machines during the late 1990s. In the tissue machine, a shoe press differs a bit from the ones found in board and paper machines: instead of dedicated backing roll, tissue shoe acts against the Yankee-cylinder and uses flexible shoe instead of rigid metal one to adapt to the Yankee surface, as the normal Yankee deformations over its width would cause uneven linear loads over the nip’s width.



Picture 6: elastic shoe element (green) on a tissue shoe press. (Valmet. 2017.)

For the tissue paper its important to save bulk, while the low linear loads also require less fiber usage, contributing to savings in the need of expensive virgin fiber. As with the board and paper, in tissue shoe press can also save energy used in drying by achieving greater dryness in the press section (app. 20% energy saving in with the 5% increase in dryness after press section). (Rothenberg. 2014)

Nowadays shoe press is also used in the pulp dryer machines for market pulp, as the same advantages apply to market pulp sheet with the shoe press lowering post-press section energy usage by achieving higher dryness in the press section.

Table 1: effects of shoe press in tissue paper. (KnowPap. 2017)

Forming	Single-nip	Double-nip	Shoe Press
Energy consumption	+++	++	++
Operation cost	+++	++	+
Investment cost	+++	++	+
Runnability	+++	+++	++
Dryness before Yankee	++	++	+++
Softness	+	+	++
Bulk	+	-	++
Quality	++	+	++

+ = extremely good
++ = very good
+++ = good
- = bad

PÖYRY

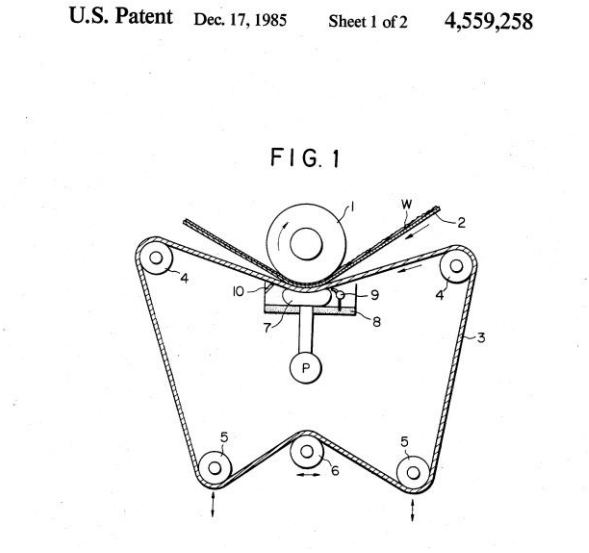
5 HISTORY

The first shoe press ever installed on a machine was Beloit's ENP (Extended Nip Press), installed to Weyerhauser board mill in Springfield, Massachusetts back in 1980 (Wicks. 1983, 61-64.). Even though the operating principle was the same as with the modern shoe presses, with concave shoe and a press roll, the design itself was a bit different in few important ways. More on that later.

Before the first installation Beloit had been developing the concept since the late 1960s. The principle and idea behind extending pressing time in the nip and the importance of nip impulse to dewatering effectiveness was known among others, US machine supplier Beloit was the only company behind the development for a long period of time. Research on the area of wet pressing became more active during the 60's, and researchers from different machine manufacturers, Wahlstrom and Schiel, independently became forward with the idea of "press impulse" in the international wet pressing conference in 1968, pressing time in the nip became a target of studies regarding water removal along the nip pressure. (Schiel. 1969, 71-76; Wahlstrom. 1969, 349-369.)

During the summer 1968 it was also detected in the Beloit's R&D pressing simulations that the water removal process optimization in the nip was both pressure- and time dependent. (Daane. 1973.) After a lab scale models were built in Beloit's Rockton lab to test the effect of pressing time to the dryness of the paper sheet, and after lab testing a paper was presented at the TAPPI Engineering Conference in October 1970. (Busker. 1971, 373-378.) Beloit also filed a series of patents to protect the concept, even though it wasn't yet quite clear what kind of extended pressing time-type press could be built. During the test phase of numerous different solutions, it was an American paper company Weyerhauser that showed interest to the project, and a prototype shoe press was installed at Weyerhauser White Pigeon mill Michigan. It quickly became clear that the technology was not yet ready to be applied in the industrial scale. (Daane. 1973.) After series of ups and downs, project found a new drive during the late 1970s. Interest towards the project was again showed by Weyerhaeuser late in 1978.

During January 1979, serious testing was performed using Weyerhaeuser's linerboard furnish, and as a result the first order of commercial shoe press was placed for the first ENP unit in June 1979 based on the previous Beloit concept design known as the X-1 press. (Wicks. 1983, 64.)



Picture 7: Beloit's original ENP-shoe design. Open structure is clearly visible in this early patent picture. (Kiuchi. 1985.)

Also a suitable belt needed for operating such a press system was needed, so a fabric supplier was involved in the later stages of development. (Dutt. 1993.) After the of successful testing and installation, three other machine suppliers started to look in to the possibility of developing their own versions of the shoe press.

Beloit's original ENP had its flaws, mainly related to the way it was operated; compared to modern closed shoe presses, original ENP was an open system, it did not have the round end plates to fix the belt in place and to keep the oil inside the press system. In the ENP (or as later referred, the ENP-O as open) the belt was more alike to press felts as it was not short (in MD) tube-like sleeve but rather long open-sided loop run through guide and stretch rolls. Oil seals were placed to keep the oil inside the belt, but where rather ineffective. Even with the continuous oil leakage considered, the ENP-press was effective enough performance-wise to courage others and Beloit to further develop the press. (Jermo. 1999, 6.)

To solve the oil-leakage problem, and to lesser extent make the press possibly to be run inverted i.e. in top position, a closed, modern shoe press as explained before was developed. The closed structure provided a more reliable (and clean) operation of the shoe,

while also making the structure more compact, because all devices like loading elements are centrally located in one package inside the shoe press.
German company Voith with their FlexoNip-press was the first one to introduce this closed variant of the press in 1984, closely followed by Escher-Wyss (Intensa-S, 1985) and Valmet (Symbelt-S, 1990). Also Beloit introduced a closed version, appropriately named ENP-C (as closed). (Jermo. 1999, 7)

In the early stages of the shoe press production it had been marketed as alternative retrofit to existing board machines to improve machine capacity. It wasn't until the mid-90s when the paper manufacturers started to see the advantages in paper machines too, when conventional press section solutions started to show limitations in increasing machine speeds. (Seppo et al. 1979; Moser, 1995, 22-25.)

6 MANUFACTURERS

As usual in the business world nowadays, the field of paper machine manufacturers and shoe press technology suppliers is under constant change. In the machine supplier markets the key players have maintained their position, as the biggest paper machine suppliers, Voith and Valmet both hold a significant proportion of the worlds shoe press installations and re-builds. Like in so many other industries, market centralization in paper machinery has happened through company acquisitions and bankruptcies, like previously mentioned Voith's purchase over Escher-Wyss or Beloit ending up selling its services and through Mitsubishi Heavy Industries also machinery to Valmet (known then as Metso). More detailed look is taken in the following pages.

6.1 Valmet

The Finnish Valmet Corporation could be the oldest company still operating in the same field of business as where it started over 200 years ago, at least when some corners are cut. Even though the modern Valmet was founded back in 2013 after Metso Corporation demerger, the companies that were fused into Metso / Valmet concierge over the decades date back a lot further. Valmet's history, which nowadays supplies services, technology and automation systems to pulp, paper and energy industries, could have said to began back in the 1750s when a small shipyard was established in Sveaborg (Suomenlinna) fortress. Shipyard business was sold in 1986, so as far as the modern day Valmet core business is considered a part of Valmet's service business line, company manufacturing technical textiles known as Tampereen Verkatehdas (later Tamfelt), was founded in 1797. Valmet entered into paper machine business in the early 1950s after converting its (then government owned) artillery works into paper machine manufacturing, and strengthened its paper machine portfolio after acquisitions of paper machine businesses from other Finnish companies Wärtsilä (1986) and Tampella (1992). (Valmet. n.d. a)

Valmet, alongside Voith, supplies both the machinery and paper machine textiles in-house. Valmet shoe press development was actually a combination of three different companies later acquired by Valmet: Finnish Tampella, Swedish KMW and Valmet itself. The first press was installed in Sweden back in 1990. (Jermo. 1999, 15.)

Valmet's shoe press portfolio consists SymBelt-line for paper and board machines, as well as the Advantage ViscoNip-series for tissue machines. As a part of the OptiPress-family, there are multiple different configurations, retrofit options and shoe sizes to choose in SymBelt-S.

Valmet's SymBelt-S originally differed a bit from some other closed shoe press designs when the oil feeding system was concerned, by introducing the so called hydrostatic shoe. In SymBelt-S the pressurized oil is fed directly to "oil pockets" in the shoe area, but in terms of design the shoe consists both hydrostatic and hydrodynamic elements as the oil circulating in the system is also carried by the belts inner surface to the shoe. It is said that the forced oil feed makes the press easier to start and run, as the oil feed starts instantly to the shoe area.

The belt fixation system in SymBelt-S is done via squeezing an elastic clamping ring between two rigid metal ones in the round end plates of the shoe, after which the installation tabs could be removed. The elastic fastening systems makes the Symbelt a little more flexible conserning belt diameter, however within tolerance requirements. (Jermo. 1999, 15-17.)

6.1.1 Advantage ViscoNip

ViscoNip is a quite new shoe press designed specifically for tissue machines to be used against the large Yankee dryer cylinder. In ViscoNip the metal shoe is replaced with a liquid-filled press body, which adapts to Yankee surface, which quarantees a uniform nip load in cross-machine direction and the load change is possible without crowning issues with the Yankee. It can also be operated with comparatively low linear loads with high quality, soft and bulky but quite sensitive tissue papers. (Valmet. 2015.)

6.2 Voith

Like Valmet a German paper machine supplier Voith Paper, a part of the family-owned Voith group, has been in the paper industry since the existence of the industry field itself.

Voith GmbH's history started as a small craftsman's shop in 1825 in modern day Germany, former Kingdom of Wurttenberg. Road towards paper machine production began in 1848 when Johann Matthäus Voith started working with Heinrich Voelter to mass-produce paper. With the co-operation born the first wood pulp refiner in 1859, and after research and patent applications Voith delivered the first complete paper making machine in 1881. During the coming century Voith also became more and more involved in hydro power and turbines, automotive industry and various other fields, without forgetting the paper machinery. (Voith. n.d. a) As mentioned, Voith was the first company to introduce the closed variant of the shoe press, FlexoNip, and the company was also a pioneer in double shoe press sections, so called tandem or duo presses. FlexoNip had a single row of loading elements and lubrication had no direct oil feed to the shoe are making it hydrodynamic. (Jermo. 1999, 12-13.)

6.2.1 NipcoFlex

Voith bought Escher-Wyss along with the exiting Intensa-S shoe press design to form the Voith-Sulzer Papertech (nowadays just Voith Paper). Soon after the deal, NipcoFlex-press was introduced which has been called a combination of the best features of the both Intensa-S and FlexoNip. It originally retained the hydrodynamic oil feed of the both Intensa-S and FlexoNip, with an developed shoe design and a single row of hydraulic piston shoe loading elements. Manufacturer claims that the hydrodynamic design with no need for oil pockets in the shoe gives a more uniform pressure profile with no flat areas, though Voith too offers the NipcoFlex with the direct, hydrostatic oil feed to be used in the more demanding machines with high speeds and linear loads. Deflection compensated backing roll, called as Nipco-P roll, is similar to Valmet's. Fastening the belt to the shoe is done via tabs with holes at the each end of the belt: the holes are pulled to the dedicated numbered studs and the belt is bolted in place with a clamping ring. Fastening mechanism is quite easy, although to get the belt evenly on the shoe requires the end plates to be carefully rotated to get the fastening studs line up. (Jermo. 1999, 19-20.)

Miniature version of the NipcoFlex, conveniently named as Mini-NipcoFlex with a diameter of just 770mm is offered to provide an easy, capital-expenditure saving solution for rebuilds for machine where the existing space is limited. (Voith. n.d. b)

Voith also offers a shoe press dedicated for tissue machines, NipcoFlex-T: instead of hydraulic pistons, there is a rubber elements loading the flexible shoe element to adapt to the deflections of the Yankee cylinder. (Rothenberg. 2014.)

6.3 Andritz

Austrian-based company operates in hydropower, recycling and metal industry among its pulp and paper-wing by supplying machinery, services and automation for the customers. Company's shoe press family includes PrimePress X and XT (T for tissue respectively), and the company offers a small, rebuil-friendly shoe with a diameter of 700mm like Voith. PrimePress X is engineered with nip lengths between 120 and 350mm depending on the paper or board grade produced. As with the competitors, XT tissue shoe press is equipped with a flexible shoe element to adapt to Yankee cylinder. (Andritz. n.d.)

6.4 Others

Even though developing a shoe press from scratch is an expensive effort, over the years it has basically became essential for new paper and board machines in almost every thinkable application, so apparent are the benefits compared to more traditional press section solutions. After the initial success of shoe presses many smaller machinery companies developed their own, and while the mentioned market centralization has made some of them a part of their larger rivals, some have also hold their own.

Over the recent years Papcel, a Czech company has added former shoe press developers Gorostidi, PMT Italia and GapCon Tissue to its portfolio. GapCon's roll and calendar production is owned by German Bellmer Group, which also acquired a Finnish shoe press developer Vaahto and its Turbo shoe press concept back in 2013. Also a small, still independent Italian firm Toscotec has a shoe press machinery in its product portfolio, for both paper and board called Xpress and for tissue, called NextPress. (Belmer. n.d; Papcel. n.d; Toscotec. n.d.)

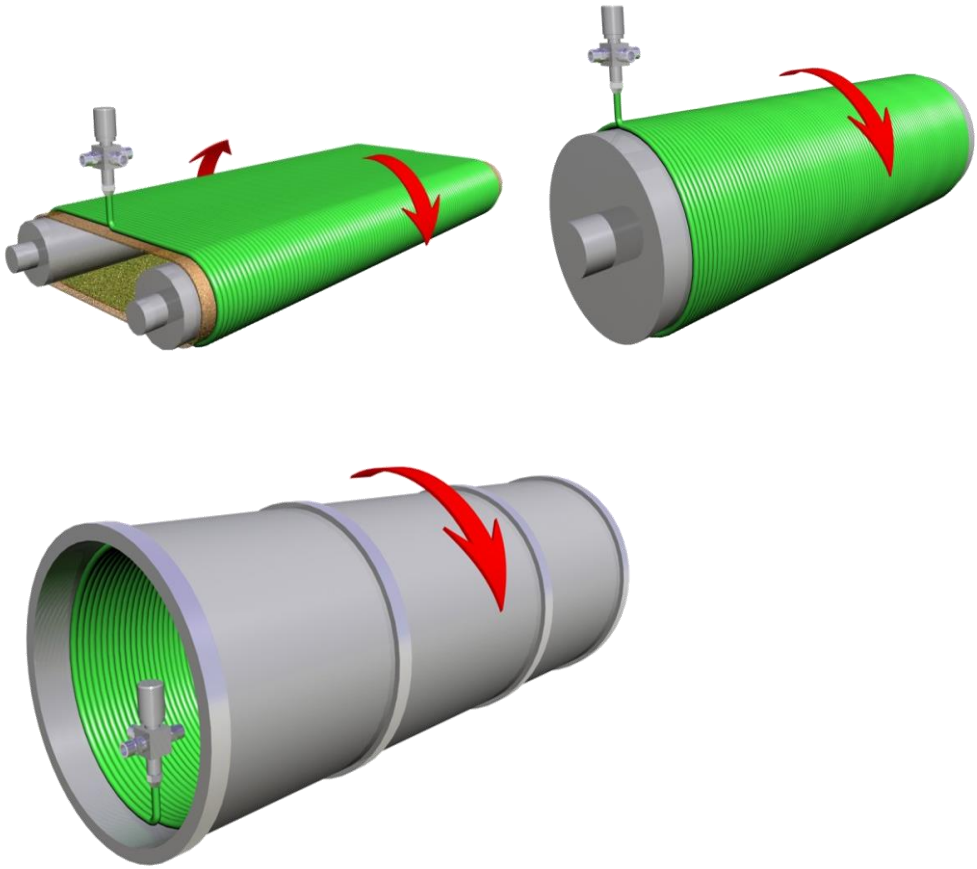
7 BELTS

As discussed earlier, a shoe press requires a new, additional piece of paper machine fabric to be able to run. Shoe press belt, or sleeve, is a polyurethane endless loop or "tube" designed to withstand the elements in the shoe press.

As the requirements for the shoe press belt are quite complex, so is the belt itself. Primary material, ether-polyurethane, is chosen because of its high ability to withstand mechanical wear and hydrolysis (breakage of chemical bonds in the presence of water). Due to the structure of the shoe press, as the outer surface of the belt has to deal with the excess water removed from paper web in the nip, the inner surface needs to be oilproof because of the lubrication requirements.

In addition to the mechanical wear in the nip the material has to be elastic enough to be able to, as mentioned earlier, bend from concave-shaped shoe to round end plates (cross-machine direction) in the nip edge area and body (machine direction) of the press and back again without cracking. This amount of needed elasticity combined with the requirements for the dimensional stability and minimal stretch is quite hard to achieve with the polyurethane alone, so inside the belt there is a reinforcement structure formed by machine and cross-machine direction yarns or a specific woven reinforcement base fabric. (Jermo. 1999, 21-23.)

Although the belt has to meet all the requirements to be successfully run in the shoe press, there are a few different ways to manufacture it. When simplified, the polyurethane which is formed by combining isocyanate (organic compounds containing functional group R–N=C=O) and polymeric polyol (compounds with multiple hydroxyl functional groups) (Junnila. 2013, 11-13.) is casted into a mold or on top of a woven base fabric. In the mold casting, the reinforcement yarns are added between the polyurethane layers. After casting the belt blank can be heat treated to finalize the chemical reactions (bonding) in polyurethane, and finally the belt is finished with desired paper web side grooves or blind drillings, installing tabs and cut to correct width.



Kuva 10: different casting methods; on top of the base fabric, on-mold (ribbon) or in-mold (centrifugal) casting. (Valmet. 2017.)

Nowadays most of the installed belts are grooved ones to counteract the lack of space for water in the nip and enhance the water removal effiency. Discontinuously grooved belts were introduced to limit the web rewetting in the nip, as by simply pressing the web some of the water always flows backwards in machine direction. To remove the marking problem in fine papers, thing grooved belts are also available. (Valmet. 2014.)

8 MARKET STUDY

8.1 Background

Over the years, the shoe press has proven its efficiency across the paper and board industry, from tissue making to pulp drying machines. Clear advantages in a wide variety of occasions, relatively easy retrofits and basically a must-have status on new machines being built have meant that the amount of operating shoe presses all over the world has increased rapidly during the past decade. As the running hours and machine numbers of the shoe presses went up, so did the demand for the shoe press belts, the specific paper machine clothing for shoe press.

For a better part of the past decades, time during the paper machines have been equipped with shoe presses, the different manufacturing methods for shoe press belts were heavily guarded with patent-shielded applications and getting into the belt market was not an easy task. The relatively long running time, a complex manufacturing process and small number of existing suppliers kept the price competition limited. This have been the case up until recently. As the old patents have started to expire and the growth of the shoe press markets have increased the demand for belts, a shoe press belt have become a more easily developed and a somewhat essential part of the paper machine clothing supplier's portfolio.

Demand creates competition, and new belt suppliers have emerged to create some pressure to a market that has been quite static for a while. The more "traditional" suppliers have found themselves facing new challenges as the production capacity on the shoe press belt markets have increased.

8.2 The study and how it was conducted

As mentioned earlier, increased competition has had an effect on the shoe press belt markets, and even though new shoe presses are being installed around the world the market prices have dropped over the years. To compensate for the "lost" revenue due to lower market prices of belts, paper machine clothing manufacturers have a need to increase sales volumes, trouble being the customers justified expectancy of the belt life on a paper machine to be as long as possible.

In a highly price-oriented competitive market having a superb product doesn't necessarily guarantee great sales figures. For example, even though the requirements for belt in high-quality printing papers are quite high, the same belt could be "too good" for pulp-drying. In a age of optimization this can be challenging for belt manufacturers.

One way for belt manufacturers to tackle the problem of decreasing market prices is to expand customer base. Growing field of paper machines around the world utilizing shoe presses eases the task a bit, but also keeping up with the ever-changing paper industry could prove to be quite tedious even for the bigger companies, as the situation especially in the emerging markets in Asia and South America transform quite rapidly.

The task of this study was to map the existing shoe presses currently in use in the industry and look for potential new customers, to be used as aid and baseline for shoe press belt manufacturer (hence referred as the company) in investment and sales planning. The company had its own databases for existing customers, and information of the worlds running paper machines were obtained through international consulting offices like Pöyry and Fischer, from company's own sales offices and sales personnel, shoe press installment press releases etc.

The results of the study have been classified by the request of the company, due to nature of the sources and information.

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