XXI

PULP AND PAPER INDUSTRY IN FINLAND

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1. Finland: The most forested land in Europe

Located in Northern Europe, The Republic of Finland is the most forested area in the whole Europe (see Figure 1).

The total volume of timber of forest in Finland is 2,189 million cubic metres and for a few years now, the Finnish forest annual growth has already exceeded one hundred cubic metres. Due to extreme climatic conditions, Finnish trees grow only over the growing season, which in Finland is about 80 days.

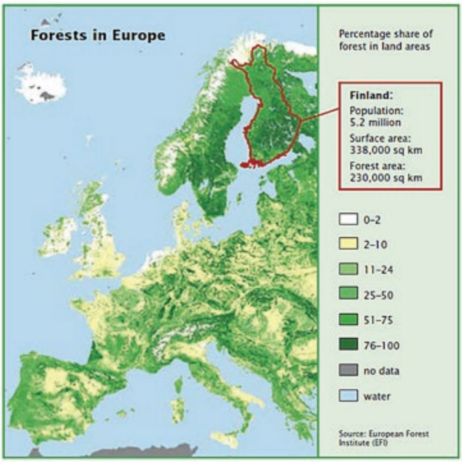

Figure 1. Percentage share of forest in land areas.

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Even though large areas of Finnish territory were surrendered to the Soviet Union at the end of the Second World War in the 40's, the Finnish timber resources increased by 60% since the beginning of the 20th century. Presently there is 111 cubic metres of timber per hectare of forest land, while in the 70's there were only 75 cubic metres.

75% of the Finnish land (338,424 km^2) is covered by forests, and with a population of 5,4 Millions, there is about 4 hectares of forest for every Finn. Figure 2 shows the distribution of the Finnish land, which is classified depending on its use, 86 percent of land area is forestry land (the rest is agricultural land, built-up areas etc.) which according to the yearly increment is divided in the following categories:

a) Productive forest land with an increment of over one cubic metre per year per hectare
b) Low productive forest land with an increment between 0.1 and 1 cubic metre per hectare per year
c) Other forest land with an increment of less one cubic metre per year per hectare

Finnish productive forest land accounts for 20.3 million hectares, of which 34% consists of mires. An increase of forest land between 50's and 80's is due to the draining of mires, which resulted in lands with higher productivity per hectare (Ministry of Agriculture and Forestry, Finnish Forest Research Institute).

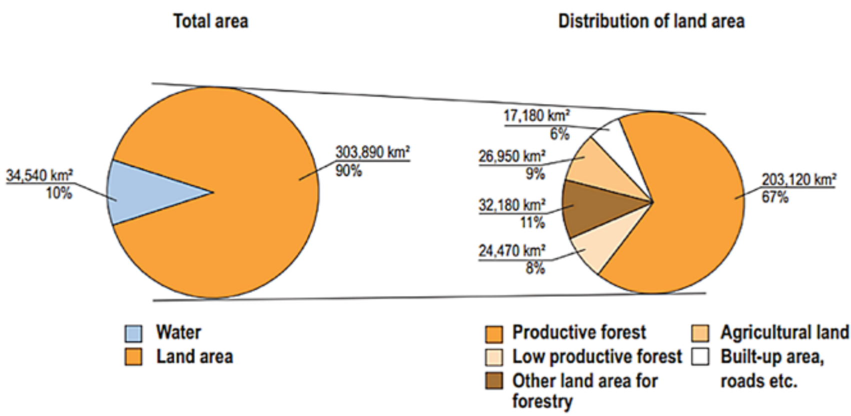

Figure 2. Distribution of the Finnish land (Source: Statistical Yearbook of Forestry 2013, Finnish Forest Research Institute; Statistics Finland 2013)

From the total of 20.3 million hectares is available for wood production, 60 per cent of this is privately owned, accounting for 740,000 individual forest owners (14% of the total population). 26% of the Finnish forestry land is state-owned (mainly located in the north of the country), 9% is privately owned and other parties own 5%. 13% of the Finnish forest area is strictly protected of the state-owned forest is strictly protected or under restricted use, representing the biggest protected area in the whole Europe (See Figure 3). (Ministry of Agriculture and Forestry, Finnish Forest Research Institute)

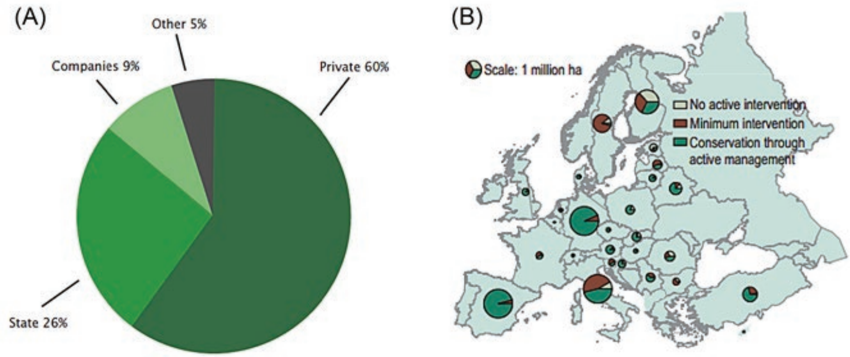

Figure 3. Ownership of Finnish forest land (A) Source: Forest and Forestry in Finland report. Ministry of Agriculture and Forestry; Location of protected land forest in Europe (B) Source: State of Finland's Forests 2011 report. Ministry of Agriculture and Forestry

2. Trees species

Finland is located in the boreal coniferous zone, with rather poor and acid soils, which allow very few tree species to grow. Nearly half of the Finnish timber stock consists of pine (*Pinus sylvestris*), followed by spruce (*Picea abies*) downy birch (*Betula pubescens*) and silver birch (*Betula pendula*). These species constitute 97% of total timber volume in Finland. Most of Finnish forests are formed by more than one species (Statistical Yearbook of Forestry 2013, Finnish Forest Research Institute). Figure 4 shows the distribution of trees species in the year 2012.

Figure 4. Distribution of trees by species in the year 2012 (Source: Statistical Yearbook of Forestry 2013, Finnish Forest Research Institute).

3. The Finnish forest industry and its impact in Finland's economy in a nutshell

The forest sector is one of the main pillars of the Finnish economy, employing directly nearly 48,000 people in Finland, from which 46% works in the paper industry, and the rest in wood products industry including furniture production (Statistics Finland, National Accounts 2012, Finnish forest industry federation). Naturally, indirect employment derived from it is much larger. 18% of the Finnish industrial output value and nearly 15% of the industrial jobs corresponds to the Finnish forest industry (Statistics Finland, Regional and industrial statistics on manufacturing, National Accounts, Finnish forest industry federation). Finnish forest industry impacts also global economy, giving employment to nearly 46,000 people in other countries, mainly in Europe (Statistics Finland, Subsidiaries Abroad, Finnish forest industry federation).

In 2012, the forest industry production accounted for 19.4 billion euros, including wood products (6.8 millions) and pulp and paper industry (12.6 millions) (Statistics Finland, Regional and industrial statistics on manufacturing, 2012 preliminary, Finnish forest industry federation).). Even though it was 2.7% lower than the previous year, the Finnish forest industry exports accounted for 11 billion euros in 2013 (20% of total exports) (National Board of Customs, Finnish forest industry federation).

4. The pulp and paper industry

4.1. Historical evolution of Finnish pulp and paper industry

Finland is a forested country. This is of course the main reason that our country so far has been, in a way or another, dependent on the forest and its resources. However, there is at least one more prerequisite of successful forest utilisation, and that is the thousands of lakes and water streams in Finland, that have made it possible to transport tree logs to the pulp mills, or for example tar barrels to the export harbours. Oulu River, Kokemäki River and Kymi River are the largest rivers flowing into the Baltic, but there are a number of smaller streams that attracted pulp and paper mills as well. Nowadays the water transport of logs has been replaced for fast truck transportation, but the lakes and streams are still providing fresh water for the pulping and papermaking processes.

The Finnish forest has always provided shelter, energy and pleasure for the inhabitants. Houses were and are still built of logs and board. Wood can be burnt for heating purposes, for example for a hot sauna bath. And the forest has always been a place for various physical activities and mental rest. Also, the forest provides young birch trees for the Midsummer celebration and spruce trees for Christmas. - These are just some examples of possibilities that the northern forests may provide.

The main utilisation of the forest trees is due to their fibrous composition. Tree logs may be converted to pulp by liberating the fibres by mechanical or chemical means. The pulps are the basis for a number of various paper grades, from cheap printing papers, aimed for daily newspapers, to high-quality printing papers including bank note papers. These products, along with various boards, have been the backbone of the Finnish national economy. And they still are very important, although their share of the export income has decreased significantly. Presently, the printing papers are slowly declining, but on the other hand packaging papers and board are growing, which most probably increases investments in kraft pulping.

4.2. Forest products

Before pulping and papermaking were introduced in Finland, the forest was a source for charcoal and tar, which were useful stuff, and later important export products. The early iron and steel production, both in Finland and elsewhere in Europe, was dependent on charcoal, which guaranteed high-quality steel products. Tar again was utilised for painting the wooden board on houses and, the thick tar pitch remaining after distillation for turpentine, was utilised particularly for impregnation of house roofs. In fact, every item that needed to be protected was treated by tar, for example boats and rope.

Tar and turpentine were even used in early medicine. In the nineteenth century, a very famous "doctor" in Snappertuna, Raseborg, Finland, was called to S:t Petersburg to cure the tsar who suffered from constipation. When "Sandsundarn" Karl Gustav Knopman entered the palace, he asked for warm water and turpentine (Jansén 2014).- A Finnish saying concludes that "if not sauna, alcohol and tar help, your disease is deadly".

Charcoal and tar were initially produced in traditional charcoal stacks or tar pits. Pine wood contains more pitch than spruce and was thus preferred as raw material. The logs were stacked leaning on each other, and on top spruce branches and moss were put to isolate the stack from the surrounding air. The smoke gases containing water steam, carbon monoxide/dioxide and hydrogen were lost in the air. But charcoal was yielded, and initially acetic acid, and finally turpentine and tar etc., were collected from the pit (Talvitie 1947).

4.3 Mechanical pulping

4.3.1. Grinding

The early mechanical pulp mills had to be located at water rapids, where a water wheel was rotating the grindstone. The short wood logs were compressed against a stone surface, which applied shearing forces on the wood surface. Compression of the wood logs in combination with the shearing caused frictional heat. This complex fibre liberation mechanism produced long, well fiberized or broken, woody fibres, and dependent on the conditions in the thin wood layer next to the stone surface. The "groundwood" was mixed with rags for early papermaking. Wood grinding is still a useful method, and it has been developed continuously for almost two centuries. Nowadays, however, it is mixed typically with bleached kraft pulp to provide, dependent on its proportion, newspaper or various printing paper grades.

Wood grinding was described by J. C. Schäffer, Germany, already in the 18th century. But he ground sawdust as to be used in paper, and his idea was never employed commercially. One century later, the wood grinding process was further developed independently by F. G. Keller, Germany, and C. Fenerty, Nova Scotia, Canada, in 1843 - 1844. Fenerty had started experimental grinding of wood billets about ten years earlier, but he failed to develop an industrial process. However, Keller was successful in producing – assisted by his wife - one hundred kilograms of groundwood by a hand-driven grinder. This groundwood was mixed with rags and made to paper for some copies of the Frankenberg weekly paper in 1845, which year Keller also got his invention patented. The following year he sold the patent rights to H. Voelter, Germany. Voelter developed the grinding equipment together with J. M. Voith at Voith´s engineering works in Heidenheim, Germany. They installed their two first grinders at Voelter´s papermill in 1852, and two years later they sold their first multipress grinders to a Swiss papermill. The grinder was also presented at the 1855 World Fair in Paris, after which more than twenty grinders were sold by 1860 (Sundholm 2009).

C. J. Jansson, born in 1846 in Turinge, Sweden (picture presented by PI/ Finnish Paper Engineer´s Association, Helsinki), was referred to in Das Papier by E. Kirchner, Germany, concerning wood grinding. I. Sourander, Nokia, Finland, started discovering the background, and found Janssons booklet published in 1878, and thus he published a second issue in 1925. Jansson had his practical education at the Nykvarn paper mill, Sweden, but moved to Funnefos, Norway, where he successfully developed the groundwood quality. Jansson introduced heating of the wood logs by hot water or steam prior to grinding, and he also improved the collergang process including control of the clearance. Subsequently, Funnefos received first prize at the 1876 World Exhibition in Philadelphia, U.S.A., for its "paper products that were the strongest and best of all exhibited wood papers produced by mechanical means". During his time in Finland, Nokia (1878 - 1880) and later Tammerfors/Tampere (1884 - 1896), Jansson helped the companies to improve the pulp and board quality to a commercially successful level. In Nokia, Jansson increased the stone revolution speed, but simultaneously decreased the feeding pressure. And he also introduced a stone sharpening tool, modified the refiner-stone grooves and the shaking sorters for a better pulp and paper strength. At the Roofing-Felt Co., Tammerfors, he started to heat the logs prior to grinding, and that way high-quality cartridge board could be produced (Jansson 1925; Lönnberg 2013).

It seems that Jansson was one of the first to understand the grinding mechanisms, although he had no education except a three-year model carpentry school, which carpentry he was practising for some time at Nykvarn. In fact, he applied all modern methods, i.e. stone grooving and sharpening, a best combination of stone speed and wood compression against the stone, as well as heating of the wood logs.

The grinder and grinding process were further developed. As the initial groundwood contained too many shives to fit directly into paper, the shives had to be screened off and this reject had to be properly refined. Consequently, Voith introduced the first "raffineur" in 1859, which may be considered a start of the refining technology (Sundholm 2009).

The natural grindstones were of variable quality, so they were little by little replaced for man-made grindstones made of quartz sand and cement since the

1870´s by Hercules, Germany, and Norröna, Norway. The synthetic ceramic grindstones were developed in the 1920´s in North America by Norton and Carborundum. The grinders were simultaneously developed, and Voith installed the first chain grinder in 1922 for one metre logs in Schongau. And the first hydraulic Great Northern grinder was installed in East Millinocket in 1926. Tampella, Finland, built the first grinder for the domestic Anjala paper mill in 1937, under licence by Great Norhern-Waterous (Sundholm 2009).

F. Powell, F. Luhde and K. Logan, Canada, tested pressurised wood grinding on a laboratory scale in the early 1960´s, but they concluded that pressurisation rather would fit into the chip refining process. Anyhow, A. Lindahl, Sweden, suggested to M. Aario and P. Haikkala of Tampella that pressurised log grinding should be developed. Accordingly, mill scale tests were conducted at MoDo´s Bure mill in Sweden, which in 1979 made it possible to install the first pressurised grinders of a completely new design, in both Bure and Anjala. By the mid 1980´s the pressurised groundwood (PGW) had been developed to a major wood grinding process under the leadership of A. Kärnä, Tampella (Sundholm 2009).

4.3.2. Refining

The wood grinding equipment was initially applied on sawdust and later perhaps on chips, too, but in the long run the disc refining of sawdust and particularly chips was successful. Refining of wood chips in the gap between rotating stones and later metal discs is somehow an application of the old grainmill driven by a water wheel or wind mill. The stone discs were also grooved as to let the flour/fibres exit from the gap. The conical refiner used for beating of fibre pulps, to decrease their shive content and improve their fibrillation degree and flexibility, or for refining of shives, may be considered a combination of the grinder and disc refiner.

The early "brown groundwood" that was developed by Rasch and Kirchner, Germany, in the beginning of the 1880´s was the first technique for mechanical pulp production without the application of grindstones. They steamed the wood logs before chipping, and crushed the chips in a Kollergang before beating in a Holländer. - The modern refining of chips for papermaking had its forerunners in the groundwood-shive raffineurs, the neutral-sulphite semichemical (NSSC) refining process and the Asplund hardboard process (Sundholm 2009).

The chip refining techniques were developed in the U.S.A. in the 1920´s. Bauer Brothers Company built their double-disc refiners for production of pulp for Insulite fibreboard, and W. H. Mason had his own "explosion" technique for masonite fibreboard. - A. Asplund, Sweden, worked for Mason, and supervised the construction of a masonite mill in his native country. Inspired by this, he developed together with KMW the continuous Asplund Defibrator that was installed in 1934 in the Ljusne hardboard mill in Sweden. The method was a basis for the modern continuous thermomechanical pulping (TMP) process and the Kamyr continuous cooking process as well, regarding the chip feeding and pulp discharging technology (Sundholm 2009).

The refiner technology was developed all over the word, and under variable ideas leading to RMP (refiner-mechanical), TMP (thermo-mechanical) and CTMP (chemi-thermo-mechanical pulps). In this context spanning over a time period from about 1930 to 1990, it is only possible to mention the important companies: Bauer, Norton, Sprout Waldron, Defibrator, Sunds (Bauer license), Enso (Bauer license), Jylhävaara and Andritz. However, it is worth to mention the 1973 International Mechanical Pulping Conference of Stockholm, because after this the TMP had its break-through. TMP was a stronger pulp and contained less shives than RMP, but required a lot more fiberising energy, although some papers of that conference argued for the opposite (Sundholm 2009).

4.4 Chemical pulping

4.4.1 Alkaline pulping

4.4.1.1. Soda cooking

The first known soda process was used in the ancient China, where bast fibres of mullberry trees were cooked in open vessels by application of wood ash solutions. - Much later, in 1800, Koops, England, was able to fiberize straw by soda cooking in open vessels, but failed to fiberize wood materials. Wood contains more lignin than straw and would hence require higher temperatures as would be the case in pressurised cooking vessels (Virkola 1983).

In 1844, also F. Keller, Germany, made wood cooking experiments by application of sodium hydroxide in open vessels, but was not successful in fiberizing wood. In 1854, however, Mellier, France, C. Watt, England and H. Burgess, U.S.A., introduced coincidentally pressurised cooking, and hence succeeded in fiberizing wood chips. As sodium carbonate - make up for lost chemicals - was expensive, Burgess and Keen developed an incineration method that significantly improved the alkali recovery to 85 %. Thus, the first soda pulp mill could be started in 1860 in U.S.A. In Finland, the first soda pulping process started in 1875 in Nurmi, but had to shut down half a decade later. Fortunately, there was another soda pulp mill established in Valkeakoski in 1880 (Virkola 1983; Gustafsson 2011; Häggblom 1966).

4.4.1.2. Kraft cooking

Stratchan, England, found early in the nineteenth century (the Napoleon wars), that soda cooking of straw could be improved by adding sulphur and sulphide into the cooking liquor. However, it took until 1871 before the idea with added sulphide was applied in chemical wood fiberizing, when Eaton, U.S.A., was granted a patent (Gustafsson 2011).

In 1879, C. Dahl, Germany, discovered that sodium carbonate (soda) as make-up could be replaced for cheaper sodium sulphate (glauber salt). Reducing conditions in the incineration led to a cooking liquor that contained both sodium hydroxide and sodium sulphide as active chemicals. Dahl is accordingly considered being father of this "sulphate" or later "kraft" pulping process. In Sweden, the first sulphate pulp mill was started in Jönköping in 1885, and in Finland the Valkeakoski soda pulp mill was changed to a sulphate mill in 1886. The following sulphate pulp mills in Finland were built as late as in the beginning of the 20th century (Virkola 1983, Gustafsson 2011; Häggblom 1966).

Since then the kraft process has developed tremendously both in capacity, quality and technology. The new recovery system developed by G. Tomlinson, U.S.A., in the 1920´s should be mentioned, as it was a continuous process, which later made it possible to improve the heat economy and the chemical balance (Virkola 1983).

4.4.2. Acidic pulping

4.4.2.1 Acidic bisulphite cooking

P. Clausen, England, received an American patent in 1851 for his straw pulping method that started with an alkali impregnation and continued with a sulphurous acid or sulphur dioxide treatment. However, the invention was obviously not applied to any larger extent (Gustafsson 2011).

B. Tilghman, U.S.A., observed when treating fats by hydrobisulphites, that the wooden plugs in the reaction tanks slowly softened to a pulp. Accordingly inspired, he and his brother started experimenting with sodium, magnesium and calcium bisulphites on wood. Their first successful cooks on a laboratory scale were made in 1865 by using Ca- bisulphite and sulphurous acid. This method was patented the next year in England, and in 1867 in Germany and the U.S.A. Tilghman also planned to start a bisulhite pulp mill, but as the soda price decreased, he considered that his process could not economically compete with the alkaline soda pulping (Gustafsson 2011; Häggblom 1966; Alhoniemi 1983; Talvitie 1948).

The first Finnish bisulphite pulp mills were started in the mid 1880´s at Kymi, Kuusankoski and Nokia. They were all Ca-bisulphite based mills. Some years later two more mills started up at. Kymintehdas and Jämsänkoski. For example in 1918, when Finland got politically independent, its production of sulphite pulp was 20 000 tons. Twenty years later it had grown to about 1 million tons, and two thirds of the sulphite pulp had been bleached. In addition, Finland produced annually almost half a million tons of kraft pulp, and was ranking third in the total pulp production including sulphite and kraft pulps. U.S.A. was ranking number one with 31 % of the entire world production, and Sweden second with correspondingly 18 % (Häggblom 1966; Talvitie 1948).

Later, the acidic calcium bisulphite pulping process lost its markets to the kraft pulp, and initially also to other sulphite pulping alternatives, i.e. the so-called soluble-base processes with magnesium or sodium as cation. Finally, the sulphite processes lost their economic position due to their narrow wood raw material base, which required long fibres and a low pitch content. In the Nordic countries practically only spruce fulfilled these properties. Moreover, the kraft process fit very well to pine with its high pitch content and short-fibered birch as well. Further, the kraft pulp has good paper strength, and the process has a well-working chemical recovery. The problems, if any, are the relatively low pulping yield and the low unbleached pulp brightness. The kraft pulp must be fully bleached to fit modern printing papers, but it can be used also in an unbleached form in packaging papers and paper boards. Currently, kraft pulping is the most important chemical pulping process applied on wood.

4.4.3. Neutral or alkaline sulphite cooking

The drawback of the acidic calcium bisulphite pulping process is its sensitivity to the wood and its impurities. As long as the chemical recovery was not a crucial factor, it was a useful process producing a bright pulp with a pulp yield exceeding 50 %, but with a paper strength far below that of kraft. In fact, the sodium NSSC (neutral-sulphite semi-chemical) pulping process applied on hardwood (birch) is one of the few soluble-base sulphite processes. It produces high-yield pulps after mechanical refining of the cooked chips. Alkaline sodium sulphite would perhaps be a chemical pulping process, provided that some catalytic agent, for example anthraquinone, is applied.

4.5. Papermaking

4.5.1. Papyrus and parchment

History confirms that there has always been a need for communication. Cave paintings, the Assyrian clay tablets, Egyptian papyrus rolls, the Chinese mulberry tree bast fibre papers and parchment were forerunners to modern papers made of wood fibres. The development of modern papers required five millenia. The papyrus paper made of Cyperus papyrus – a tall reed of the Mediterranean region – was able to store a lot of information in rolls that were light, but had a limited area. Although papyrus has given its name to paper, it was not made of separate fibres like modern papers are, but of longitudinally cut strips of the papyrus stem pith. After some putrefaction in water, the strips were cross-wise organised into sheets that were hammered to achieve suitable bonding of the strips and thus good strength and a smooth surface. The sheets were finally sun-dried. For extra good writing on papyrus, it was polished with a smooth stone or shell (Lindberg 2008).

Papyrus sheets were glued together, for example twenty sheets in a row that could be rolled for storage. The oldest Egyptian papyrus document was found in a tomb, and it is representing the First Dynasti (about 3000 B.C.). The youngest is from the 11th century papal office. Papyrus Ebers, after a German egyptolog, is one of the famous papyrus rolls dating back to the second millenium B.C. The roll is 20 m long with more than 100 pages of medical notes concerning for example the heart and vessels, and with a large number of recipes (Stora Focus 1989).

However, parchments made of sheep, goat or calf skins became soon more effective, as it was easier to write on them, and on both sides. The skins were washed, soaked in limewater and finally stretched for scraping and smoothening. By tradition, the invention of the parchment has been attributed to Eumenes II of Pergamum in Asia Minor, although it had been practiced long before that. Parchment became the most common writing material by the third century A.D., and finally paper did the same by the late Middle Ages (Lindberg 2008; Stora Focus 1989).

4.5.2. Early papermaking

Tapa is an early paper-like material that was prepared from bast of mulberry, fig and bread-fruit trees. Tapa has been produced for thousands of years in the temperate zones of the globe. However, it was not used for writing, but mainly for clothing and wall covering. Its preparation resembles the Far East technology applied in ancient papermaking. - Felt has also been produced long before the ancient papers. Wool and other hair fibres were moistured and mechanically treated, which procedures resulted in felted mats (Lindberg 2008)

The true papermaking is considered being introduced by Cai Lun in China in 105 A.D., although paper had been produced long before. Typical for papermaking is that the vegetable fibres used are at least mechanically treated to create fibrils. These contain hydrogen bonds that enable effective inter-fibre bonding and accordingly good paper strength and a smooth surface (Gustafsson 2011; Lindberg 2008).

The papermaking spread westwards by Chinese papermakers that were taken prisoners by the Arabs in the Samarkand battle in 751 A.D. The Mediterranean region was under influence of the Muslim domain, and in Spain the first European paper mill was founded in 1144 in Xativa, currently the Valencia region. However, the papermaking reached central and northern Europe independently of Spain. Some of the oldest paper documents in Europe are:

- Portugal 1288
- Sweden 1345
- Finland 1350

And some of the oldest paper mills were:

- Spain, Xativa 1144
- Portugal, Leiria 1441
- Sweden, Stockholm 1565
- Finland, Tomasböle 1667

According to Encyclopedia Americana, the first American paper mill was founded by the Spaniards in 1575 in Culhuazan close to Mexico City (Lindberg 2008).

The hand-made papermaking remained unchanged for centuries including stamping the fibres to achieve fibrillation, sheet making, pressing the wet sheets to remove water and finally drying them. One must mention the technical improvement introduced by N.-L. Robert, France, meaning that paper formation went continuous. His first trials were made in 1793, and in 1798 he introduced his wooden construction that continuously could produce an endless paper web, 64 cm in width. The patent was granted one year later. To make a long story short, Didot acquired the patent rights and introduced the new idea to Henry Fourdrinier and his brother. They decided to take part in the development and its financing, and they patented the device in England in 1801. Later paper machines with continuous wire belts have been called "fourdrinier" machines. The belt machine was a lucrative business for England, but not for the Fourdrinier brothers who went bankrupt in 1810. Brian Donkin had built 42 machines by 1822, at the time when the volume of machine-made paper exceeded that of hand-made paper (Lindberg 2008). This was long before the big inventions of wood grinding and chemical pulping.

The Tomasböle mill in Pojo, currently Raseborg, Finland, was founded by bishop J. Gezelius the Elder in cooperation with a German paper maker. It served mainly the old Åbo Akademi university that had been established in 1640. However, Tomasböle was laid down already in 1713 due to wartime, and it took until the 1760´s before the following paper mill was established, and now close to Turku/Åbo. Shortly several paper mills were established in Finland, but particularly the Tampere/Tammerfors paper mill that started in 1785 was important, because it got in1841, during the masterprinter J. C. Frenckell´s ownership, the first paper machine (On the internet: www.uppslagsverket.fi/bin/view/Uppslagsverket/Pappersindustri).

4.6. The Finnish pulp and paper industry today

A great lot of improvement had the Finnish pulp and paper industry had gone through since then and today is among the main players worldwide. According to CEPI (Confederation of European Paper Industries), in 2013 Finland ranked second as pulp producer in Europe with 28.2% of the total pulp production (37.3 Million Tonnes) (CEPI Key Statistics, 2013) Additionally, Finland was the third pulp, paper and board largest European producer in 2013 (CEPI Key Statistics, 2013) (see Figure 5)

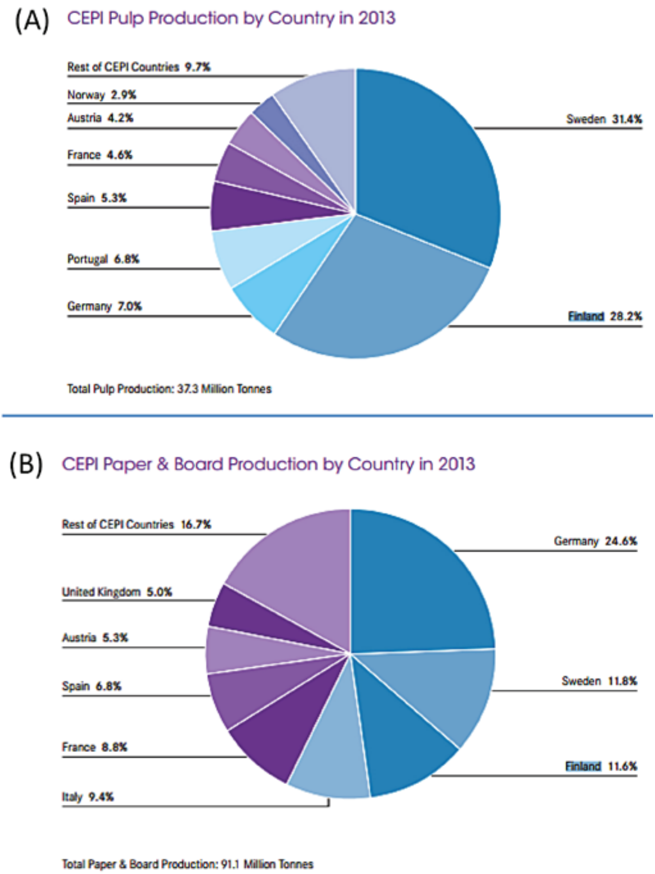

Figure 5. CEPI Pulp production (A) and CEPI Paper and board production by country in 2013. Source: (CEPI Key Statistics, 2013)

In 2013, pulp production in Finland was 7.1 million tonnes, accounting for 40% of the share of exports. (See Figure 6 (A)). Additionally, 10.6 million tonnes of paper and cardboard were produced, including printing and writing (6.3 million tonnes), paperboard (2.9 million tonnes) and other paper. Figure 6 (A) shows the evolution of paper production, separated in categories since 1960.

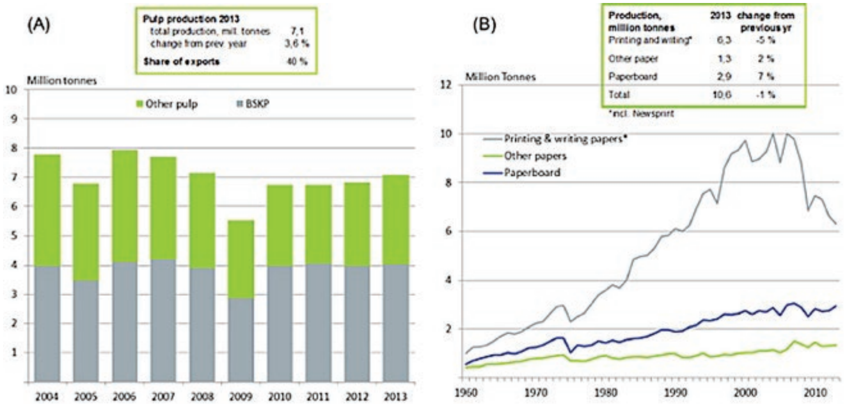

Figure 6. Paper and paperboard production in Finland. Source: Finnish Forest Industry Federation

Not alien to the global recession, the production of the pulp and paper sector has been forecasted to decrease to a third in the period from 2007 to 2020. Similarly, forecasts show that wood processing production will be reduced in fifth. (See table 1)

Table 1. Finnish Forest Industry Production in 2007 and forecast for years 2015 and 2020 (in millions of tons and millions m3) Source: Hetemäki 2009

	2007	2015	2020	Change 2007-2020	
				Quantity	%
Pulp and paperboard	14.3	10.8	9.4	4.9	-34
Pulp	12.9	9.0	7.5	5.4	-38
Wood products	14.3	11.8	11.9	2.4	-17

The decrease in the national main exports, as well as the increased competitiveness of competing countries (Asia, Sweden, West Europe) reflects on such recession in production. The flagging of export markets is strongly influenced by the global economic decline affecting prices and product demand, the increasing use of electronic media leading to an important decrease in demand and price of communication paper such as newsprint and printing papers, and finally the overloading increasing offer of paper products from Asian and Western markets (Hetemäki 2009).

5. Pulp and Paper production sites and research centres in Finland

Nowadays, there are 22 paper mills, 12 paperboard mills, 14 chemical pulp mills and 2 BCTMP (bleached chemithermochemical pulp) mills in Finland (Finnish Forest Industry Federation). Figure 7 shows the distribution accross the country of the paper-, paperboard-, chemical pulp- , BCTMP-mills and companies (A) as well as the paper and paperboard converting plants in Finland Members of the Finnish Forest Industries Federation (B) updated to 2014.

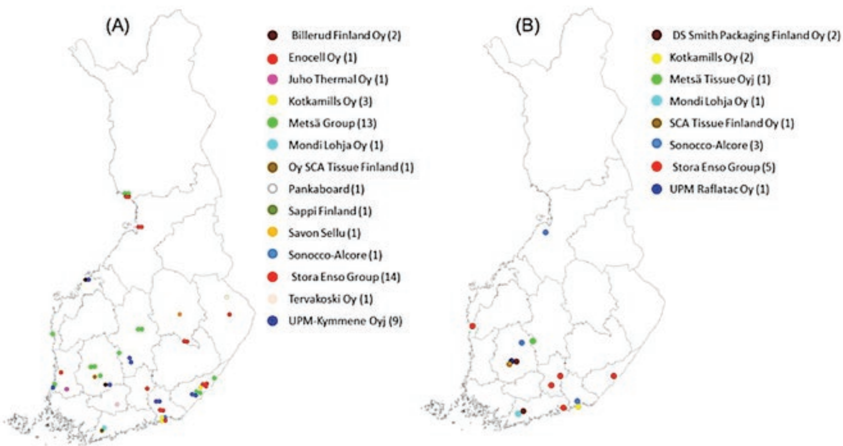

Figure 7. Paper-, paperboard-, chemical pulp- and BCTMP-mills in Finland, companies (A); Paper and paperboard converting plants in Finland Members of the Finnish Forest Industries Federation (B) Source: Finnish Forest Industries Federation

5.1. List of Paper-, paperboard-, chemical pulp-, BCTMP-mills and companies in Finland and their specific locations:

- BillerudKorsnäs Finland Oy: Pietarsaari and Tervasaari
- Enocell Oy: Uimaharju
- Juho Thermal Oy: Kauttua
- Kotkamills Oy: Kotka and Tainionkoski
- Metsä Group:
    - Metsä Board Kemi Oy: Kemi
    - Metsä Board Oyj: Joutseno, Kaskinen, Kyro, Simpele, Tako, Äänekoski
    - Metsä Fibre Oy: Joutseno, Kemi, Rauma, Äänekoski
    - Metsä Tissue Oyj: Mänttä
- Mondi Lohja Oy: Lohja
- Oy SCA Hygiene Products Ab: Nokia
- Sonoco-Alcore Oy: Kotka
- Stora Enso Group:
    - Stora Enso Ingerois Oy: Inkeroinen
    - Stora Enso Oyj, Fine Paper: Oulu
    - Stora Enso Oyj: Heinola, Imatra, Oulu, Sunila, Veitsiluoto
    - Stora Enso Oyj, Publication Paper: Veitsiluoto,
    - Stora Enso Publication Papers Oy Ltd.: Anjala, Varkaus
    - Stora Enso, Corenso United Oy Ltd
- Tervakoski Oy: Tervakoski
- UPM-Kymmene Oyj: Jämsänkoski, Kaipola, Jämsä, Kaukas, Lappeenranta, Kymi, Kuusankoski, Pietarsaari, Rauma, Tervesaari

5.2. List of Paper and paperboard converting plants in Finland Members of the Finnish Forest Industries Federation their specific locations:

- DS Smith Packaging Finland Oy: Nummela, Tampere
- Kotkamills Oy: Kotka
- Metsä Tissue Oyj.: Mänttä
- Mondi Lohja Oy: Lohja
- SCA Tissue Finland Oyj: Nokia
- Sonoco-Alcore Oy: Karhula, Ruovesi, Ruukki
- Stora Enso Group:
    - Stora Enso Packaging Oy: Heinola, Lahti, Tiukka
    - Stora Enso, Corenso United Oy Ltd: Imatra, Loviisa
    - UPM Raflatac Oy: Tampere

5.3. List of Research units dealing with studies on pulp and paper:

- VTT Technical Research Centre of Finland – Fibers and Biobased materials units: Espoo and Jyväskylä
- KCL – Pilot services for the paper industry: Espoo
- METLA – Finnish Forest Research Institute: Vantaa, Tuusula, Läyliäinen
- Aalto University, School of Chemical Technology, Department of Forest Products Technology: Espoo
- Åbo Akademi University, Department of Chemical Engineering: Turku
- Lappeenranta University of Technology, LUT Chemtech: Lappeenranta
- Tampere University of Technology, Department of Materials Science: Tampere
- University of Jyväskylä, Department of Chemistry: Jyväskylä
- University of Oulu, Faculty of Technology, Process and Environmental Engineering: Oulu

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