

# Paper

## An Indispensable Material for 2000 Years

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**SULZER PUMPS**

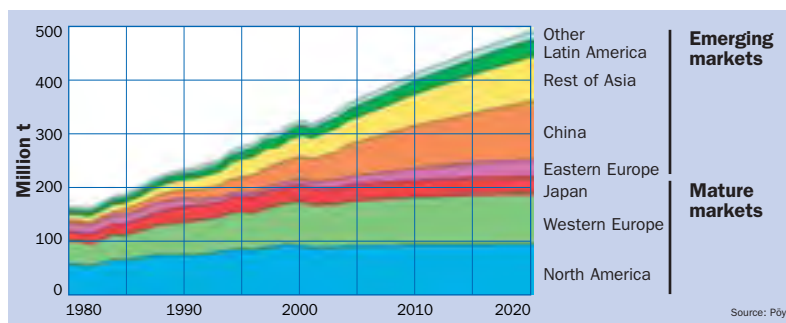
The basic method of papermaking has not changed since it was invented in China around 2000 years ago. The 4 basic steps of pulping, sheet forming, pressing, and drying are still the core processes used today. However, industrial methods of paper production have little in common with traditional papermaking using a deckle frame. In modern pulp and paper mills, sophisticated machines and complex procedures transform the raw material into a variety of products, including graphic paper, newsprint, tissue, and board, as well as printing, writing, and specialty papers. A variety of products and services offered by all Sulzer divisions contribute significantly to the modern, sustainable production of high-quality paper and board.

Today, it would be difficult to live without paper, paperboard, and other paper-based products. Levels of paper consumption are also a reflection of relative wealth, as there is a clear correlation between gross domestic product and per capita paper consumption. In many developing countries, per capita paper consumption amounts to only a few kilogram. The largest consumers are the USA, Canada, many Western European countries, and Japan, with well in excess of 200 kg per person, compared with the global average of 56 kg per person.

### Growing Market

The global demand for paper and board has continued to grow steadily since 1980 (Fig. 1). North America and Western Europe dominated the growth in consumption up until the beginning of 2000, while China and other Asian countries saw demand increase strongly from the 1990s. The markets in North America, Western Europe, and Japan are maturing, but are continuing to grow and remain important due to their considerable size. Demand in these regions is expected to increase at an annual rate of 0.5% up until 2020. It is also anticipated that the demand in the emerging markets, China and other Asian countries, as well as in Latin America and Eastern Europe, will continue to grow at a strong annual rate of over 4% until 2020.

In 2005, almost 4000 pulp mills and around 7700 paper and board mills worldwide produced 189 million t of pulp and 367 million t of paper and paperboard (Fig. 2). Around half of the raw materials used in the manufacturing of pa-



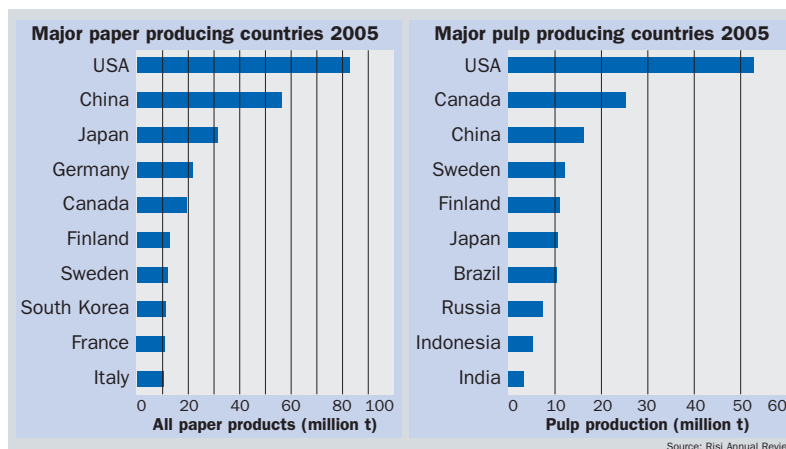
per and paperboard are recycled. However, recycling has its limits. As the fiber can only be recycled a limited number of times, the industry's raw material requirements have to be met using pulp—also referred to as virgin fiber. The raw material used to produce pulp is wood. Large pulp mills are being built in areas with a strong supply of wood and high levels of photosynthetic activity—such as Latin America, with its abundance of fast growing eucalyptus trees (Fig. 3). Pulp is traded as a commodity and shipped to the paper mills, which are usually located close to consumers (Fig. 4).

### Transforming Wood into Pulp

In the first stage of pulp making, the logs are debarked, cut, and chipped. The wood is transformed into pulp by means of chemical or

mechanical processes. In the chemical pulping process, the fibers are separated using chemicals and heat. Wood chips—made mainly from eucalyptus or pine—are cooked in a solution containing sodium hydroxide (lye) and sodium sulphide. The high temperatures and pressure cause the lignin, which binds the wood fibers together, to dissolve into the cooking liquor, and the fibers subsequently separate. The lignin is drained from the pulp, as it would make the paper brittle and yellowish in color. Once the cooking process has been completed, the pulp is bleached to remove the brown lignin stains (Fig. 5).

The dark cooking solution, which is called black liquor and contains a number of wood-derived substances, is put to good use. It is first concentrated in an evapora-



**1** The anticipated growth in demand for paper and paperboard up to 2020. Production grew by more than 2% (7.5 million t) in 2005. Many machines used in the production of pulp and paper worldwide rely on Sulzer technology to perform essential steps in the process.

**2** An increasing volume of paper and paperboard will be produced in the areas in which consumption is growing. Today, most paper and board machines are built in Asia.



Photo: Andritz

**3** The Veracel pulp mill in Eunapolis, Bahia state, Brazil, is owned by Stora Enso and Aracruz Celulose. The mill commenced operations in 2005. Its production capacity is 900,000 t of eucalyptus pulp p.a. Sulzer pumps and mixers are used in the mill.

tion plant and then burned in a recovery boiler to generate energy. At the same time, the inorganic cooking chemicals in the cooking solution are recovered for re-use. A variety of compounds—such as turpentine, tall oil, or the cholesterol-lowering steroid Phytosterol—can be extracted from the solution as by-products (see STR 1/2006, p.4).

**4** The UPM-Kymmene Schongau mill on the River Lech in Schongau, Germany. It produces newsprint and other special paper products and has an annual capacity of 730,000 t. It already began producing newsprint from 100% recovered paper in 1991.



Photo: UPM-Kymmene

## Grinding Wood

Mechanical pulping involves separating the wood fibers using grinding or refining processes. The friction which this generates softens the lignin and causes the bonds between the fibers to break. In the grinding process, debarked blocks of wood (fresh spruce) are pressed against a rotating stone. In the refining process, spruce chips are ground between rotating discs. Heat and steam accelerate the pulping process.

The mechanical stress separates the wood fibers, but also cuts them into shorter lengths. Shorter fibers reduce the strength of the paper, thus limiting the range of uses of mechanical pulp: it is ideal for making newsprint, but is not suitable for products such as bag paper.

## Reusing Paper

Deinking is a multi-stage sorting and cleaning process that is used to separate printing ink and other unwanted materials from the fibers of recovered paper. In the first stage of the process, the recovered paper is broken up in water, and the printing ink is removed by foaming in various flotation stages.

The remaining impurities—such as staples and plastic—are subsequently removed from the stock. Most of the deinking sludge and screened waste is used as fuel in the facility's power plant.

## From Pulp to Paper

Paper machines produce paper from a liquid with a dry-matter content of only 1% (99% water and 1% pulp), which is produced by mixing different kinds of pulps and additives—the composition



Photo: ZPK (Schweizer Verband der Zellstoff-, Papier- und Kartonindustrie)

**5** Bleached pulp: half of the lignin remaining in the fibers can be removed using oxygen and lye. Final bleaching without the use of chlorine compounds (TCF bleaching) is performed using oxygen, hydrogen peroxide, ozone, and enzymes.

of which depends on the paper quality—in the stock preparation (Fig.6).

The paper machines, which can be more than 100m in length, increase the dry matter content in different stages (Fig.7). Papermaking begins at the wet end of the paper machine, where the combination of different pulps is diluted with water to form a thin broth known as paper stock. From the headbox at the wet end, the mixture is spread onto a moving belt of plastic mesh—referred to as wire—which allows the water to drain through. When water is removed from the paper stock, the fibers adhere to each other and form a web of paper on the wire. At the far end of the wire section, the dry matter content rises to around 20%, and the paper web is then removed from the wire. In the next stage of the process, the paper web enters a section of the machine where it is pressed between felt and metal rollers, increasing the dry matter content to 45%. In the drying section, the web is pressed against hot cylinders or drying felts. By the time it leaves

the drying section, the paper web's dry matter content has risen to 90–95%.

### Finishing to Enhance Quality

The quality and properties of paper can be tailored to various uses by glazing and coating, during which a smoothness-enhancing coating containing substances such as kaolin, calcium carbonate, or talc is applied to the surface of the paper. The surface quality of the paper is subsequently improved by passing it through a mangle-like series of rolls known as a calender. The surfaces of the calender rolls are coated using wear-resistant materials. At the end of the papermaking process, the paper is wound into a machine roll weighing up to 30 t.

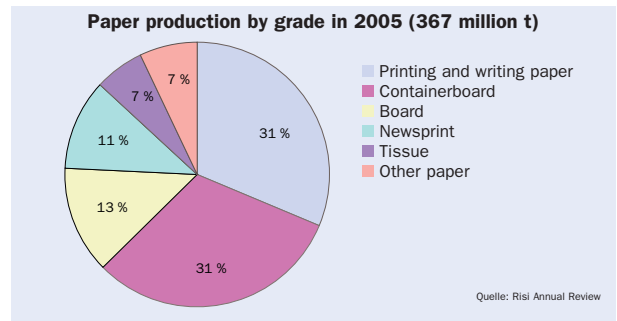
Finally, the paper is shipped to the consumers or to sites such as printing shops for further processing. Common printing methods include offset lithography, which is used for books and newspapers, and flexography—also referred to as surface printing—which is most commonly used for packaging.

The printing quality achieved using flexography was originally very low, but has improved due, in part, to the use of direct laser engraved anilox rolls. Sulzer Metco coats anilox rolls with high-quality ceramics that are essential to achieve high-quality printing (see article p. 8).

### A Paperless Society?

The invention of paper can easily be described as one of the greatest revolutions in communication. Even though paper has been around for thousands of years, it will continue to play an important role in our lives, and new technologies for the production and processing of paper will evolve. The widespread use of computers may eventually lead to a paperless office—even though this has yet to occur—but is unlikely to ever result in a paperless society. ◀

The foldout on pages 14–16 provides details of papermaking and of Sulzer's contribution to this process.



6 Different qualities of paper can be made using a certain proportion of recycled fiber. Some grades, e.g. newsprint, are often composed almost entirely of post-consumer recycled paper.

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7 The paper machine PM4 at Perlen Papier AG (CH) produces, coats, and calenders light-weight coated (LWC) paper in one single operation process (left). The PM12 paper machine at Stora Enso in Kvarnsweden, Sweden, produces 400,000 t of supercalendered (SC) paper p.a. The machine has a wire width of 11.3 m and a design speed of 2000 m/min (120 km/h).

