Pulp and Paper Industry

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** The pulp and paper industry (PPI) produces pulp, paper, board and other cellulose-based products. The main steps of the process are pulping, papermaking and paper finishing. Pulping can be based on mechanical, semi-chemical or fully chemical methods. Wood used to make pulp contains three main components: cellulose fibers (desired for papermaking), lignin and hemicelluloses. In pulping, the bulk structure of the fiber source is broken down into the constituent fibers. In chemical pulping, this is accomplished by degrading the lignin and hemicellulose into small, water-soluble molecules which are washed away from the cellulose fibers. Mechanical pulping methods physically tear the cellulose fibers apart. Chemical pulping is the dominating pulping method and accounts for 70% of today's global pulp production. Paper-making involves several steps including making a pulp slurry, pressing and drying. The appearance and properties of the final products are supplemented and enhanced by finishing treatments, which can be simple processes where the reel are cut into sheets or more complex processes, such as coating or super-calendering. North America, Asia and Europe are the dominating world regions for PPI, and accounted for 37, 24 and 25%, respectively, of the global pulp production in 2010.

■ **PERFORMANCE AND COSTS –** The PPI is a highly energy and capital-intensive industry. Comparing chemical/kraft mills, mechanical mills, and paper mills (without virgin pulp production), chemical/kraft mills generally have the largest on-site fuel use, which is mainly biomass-based. However, a mechanical mill uses large amounts of electricity, implying that the primary energy use of the mechanical pulp mill may be significantly higher than its final use. A paper mill using imported pulp and/or de-inked paper has a lower energy use than mechanical or chemical pulping. In regard to feedstock use, the pulp yield in chemical processes is about half compared to the production of mechanical pulp from the same amount of pulpwood. A large-scale chemical pulp mill with an annual pulp production of around 1.4 million tons has an investment cost of about 2.5 billion USD if built from the ground up. The specific investment costs (investment cost per production capacity) are around 1500-2000 USD/(ton/year). As for many capital-intensive industries, economies of scale apply, giving lower specific investment costs for larger mills. Generally, the largest capital cost in a chemical pulp mill is linked to the power generation and chemical recovery part of the mill, which could account for about a third of the capital cost.

■ **POTENTIAL AND BARRIERS –** The PPI is a globalized industry sector where several countries that were strong producers in the past now face growing competition from new producers. On national level, cost-efficient production is crucial for the survival of the industry. A future increase in competition for biomass resources from the energy sector implies further challenges. In meeting climate targets, biomass resources, including pulpwood, will likely become a sought after resource for energy products. However, measures and new technologies for increased cost-efficiency and competitiveness exist and include option for increased energy efficiency and diversification of products. An increased societal demand for "green", high-value energy products can therefore be turned into an opportunity for the PPI, which has well-established biomass supply-chains and plants that can be converted to efficient energy combines with multiple outputs. In relevant countries, this could make the PPI a key actor in a future "greener" energy system. The chemical/kraft PPI has the largest potential for implementation of new technologies for production of biomass-based, high-value energy products (electricity, motor fuels) in addition to the pulp and paper. In this respect, integrated black-liquor gasification systems can become a key technology.

PROCESS

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■ **Pulping** – Pulp, the main raw material for paper-making, is a ligno-cellulosic fibrous material, which is produced from separation of the cellulose fibers in wood, fiber crops and waste paper. The pulp-making process can be divided in timber and debarking, chipping, pulping, cleaning, bleaching, and washing and drying. Timber utilized for pulping is denoted pulpwood. Examples of wood types that is often used for pulp making include softwoods such as spruce, pine, fir, larch and hemlock, and hardwoods such as eucalyptus, aspen and birch.

Wood and other plant materials used to make pulp contain the following main components: (1) cellulose fibers, which are desired for papermaking, (2) lignin, which is a polymer of aromatic alcohols which binds the cellulose fibers, and (3) hemicelluloses, which is a shorter branched carbohydrate polymer. The purpose of pulping is to break down the structure of the fiber feedstock into its constituent fibers.

In **chemical pulping,** the lignin and hemicellulose are degraded into small, water-soluble molecules which can

Please send comments to Martin Hagberg Börjesson and Erik O. Ahlgren (erik.ahlgren@chalmers.se, Authors), and to Giorgio.Simbolotti@enea.it and Giancarlo Tosato (gct@etsap.org), Project Coordinators