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EXPANSION OF TMP/CTMP IN THE UNITED STATES — IS THERE ENOUGH ELECTRICAL POWER?

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ABSTRACT

The ability of the electric utilities in the United States to accommodate a significant increase in TMP/CTMP production is examined. The energy consumption in mechanical pulping processes is reviewed to establish the power required for expansion of this pulping process. Next, the capacity margins of the electric utilities in the United States are examined. Generally, it appears that there is sufficient power to accommodate a major increase in TMP/CTMP in the United States, although individual utilities in certain regions may be less able to accommodate such growth in electrical demand. The mutual benefits — to the pulp mill and the electric utility — of a cooperative program allowing occasional curtailment of pulp production during periods of peak power demand are discussed.

INTRODUCTION

TMP (i.e., thermomechanical pulping) and other related types of mechanical pulping have several advantages and disadvantages compared to chemical pulping processes (1-2). Mechanical pulping processes are generally much simpler than chemical pulping processes, and the capital costs for installation of additional pulping capacity are usually lower than an equivalent expansion in chemical pulping capacity. Mechanical pulping may also exhibit fewer environmental concerns, and these high yield processes convert more of the raw material into a salable product. However, the brightness and strength of mechanical pulps are lower than those of chemical pulps, which currently restricts their use to products such as newsprint and similar grades. In spite of these disadvantages, there is renewed interest in substituting mechanical pulps for chemical pulps in certain products, including diapers, tissue, toweling grades, and others.

A concern in most mechanical pulping processes is the relatively large amount of electrical power required to produce a ton of pulp. In general, the release of fibers from the incoming wood chips occurs as a result of forces applied to pre-steamed chips in one or more refining stages. The refiners are driven by large electrical motors that drive the rotation of one or more serrated refiner plates in contact with wood chips that have been forced into the gap between the plates. This abrasive process separates individual fibers and produces a wood pulp that is stronger than other traditional pulps such as groundwood pulp. Refiner motors are quite large, often 10,000 horsepower or more, and the electrical power consumed by the large motors is a large fraction of the production costs for mechanical pulps. Because of the costs of electrical power, TMP and CTMP (i.e., chemithermo-mechanical pulping) processes have been particularly attractive in those countries with relatively inexpensive hydroelectric power.

Given the current interest in expanding the use of mechanical pulping processes in the United States, a natural question that must be addressed is — "Is there sufficient electrical power generating capacity in the United States to accommodate an increase in the use of TMP and CTMP pulping processes?". The answer to this question is not simple, since utility reserve margin requirements vary across the country. Furthermore, pulp mills may implement strategies that can reduce the peak power demand, provided that economic incentives are present. These incentives, in turn, are affected by power usage rates charged by individual utilities that are responding to their own situations in terms of generating capacities, regulatory pressures and power generation costs. These issues are addressed in the following sections.

POWER REQUIREMENTS FOR MECHANICAL PULPING PROCESSES

In the earliest manifestation — using a process known as stone groundwood — mechanical pulps were produced by stone grinding processes, in which logs were forced into contact with large rotating stones that were often driven by water power. The discovery that the quality and strength of mechanical pulps could be improved by fiber separation in chip refiners, and the need for process control that could only be achieved by electrical motors, led to the widespread replacement of water power by electrical power in the prime movers that produce mechanical pulps.

There is no doubt that mechanical pulping is an energy-intensive process. The electrical motors that drive chip refiners are some of the largest in industrial usage today. Motors rated at 10,000 to 20,000 horsepower are commonplace in the industry. Since the efficiency of the process and the quality of the pulp increase with refiner plate diameter, there is a trend toward larger diameter refiners requiring larger motors. Refiners with electrical motors rated at 40,000 hp are on the drawing boards and will likely be commercialized in this decade (3). A 40,000 horsepower motor will draw approximately 30 megawatts from the grid.

Since most TMP processes involve two or more refining stages and multiple lines, a typical TMP mill will have several of these large motors in operation at any time. A 100 MW electrical load is not uncommon for a large TMP mill, and such mills are often the largest single customer of an electrical utility. The cost of the electrical power, and the impact of such large systems on demand experienced by the electrical utility, necessitate careful attention to the interactions of the pulp mill and the electric utility that supplies the mill with power.

The cost of electrical power is a significant fraction of the total cost of production of mechanical pulps. In a typical TMP process, the electrical power consumed to produce a ton of pulp is in the range, 1800-3600 kW-hr. Using 5¢/kW-hr as a rough approximation of power costs, the cost of power is approximately $100 - 200 per ton, for products whose market price is on the order of $600/ton.

In recent years, efforts have been made to reduce the energy costs associated with TMP pulp production. At the newest installations, some of the energy involved in mechanical pulping has been recaptured in the steam produced in the TMP process, which is then used for chip pre-steaming and other uses. Other approaches to reduce the energy requirement have also been used, including optimization of the pre-steaming conditions, and the use of modest amounts of chemicals to render the wood more susceptible to fiber separation.

Nonetheless, the process is inherently energy-intensive and installation of a sizeable TMP mill will have ramifications for the electric utility that will supply the energy. Approximately 3,500,000 tons of TMP pulp are produced in the United States at the present time, out of a total pulp production of approximately 65,000,000 tons (4). The rate of growth has averaged approximately 6% per year, which would result in a doubling of mechanical pulping capacity in 12 years. The additional electrical generating capacity needed to accommodate this doubling of TMP production would be on the order of 1,000 MW, considering pulping requirements alone.

GENERATING CAPACITY IN THE UNITED STATES

The capacity of the electric utilities to produce power is measured in different ways. One measure is the rated capacity of all of the electric generators installed in the United States — i.e., the nameplate capacity. Another, more conservative and perhaps more realistic, measure of the capacity takes into account the ability of the electric utility industry to deliver power. Power delivery capacity takes into account averages of reduced availability due to factors such as weather, nuclear refueling, maintenance and repair, unanticipated shutdowns, etc. The generating capacity is approximately 90% of the nameplate capacity. Statistics of generating capacity and consumption are maintained by the Edison Electric Institute and by the North American Electrical Reliability Council (NERC).

Regardless of how it is measured, the generating capacity of the electric power utilities in the United Sates is vast, compared with the demand for mechanical pulping, now and in the future. In 1988, the generating capacity in the United States was approximately 650,000 MW(5). The entire pulp and paper industry usage of electrical power in 1987 was 4.7 x 10^9 kW-hr — which is only approximately 2% of the total electrical power consumed in that year.

The ability of the electric utilities to provide incremental power is reported as the margin, defined since 1983 as:

Capacity Margin = [Capacity – Peak Demand] ÷ Capacity.

In the United States, the Capacity Margin has been in the range, 23-29%, throughout the 1980's, based on summer peak load. Utilities require a certain level of this Capacity Margin, typically about 20% (called Reserve Margin), to account for equipment maintenance, weather, and emergency conditions, and to ensure reliable service. This indicates that, on average, three to nine per cent of additional generating capacity was available at periods of peak load throughout this decade. By comparison, a large, 100 MW TMP mill would be a relatively small incremental load.

This does not imply that all electric utilities would welcome the additional demand, since the generating capacity and the margins vary significantly from area to area. The NERC divides the generating capacity of the United States into nine regions, as shown in Table 1 (6). The capacity, peak load, and margins of each of these regions are shown in Figure 1 for 1988. In the Far West, for example, the capacity margin is nearly 27% and thus 7% is available. In New York and New England (the NPCC region), however, the margins are only 16% and, on average, many utilities in these areas may be more concerned about managing the electrical demand in their districts.

The future growth of utility generating capacity is difficult to predict with any certainty, particularly in a climate where some public service commissions are questioning the extent of, or need for, further growth in capacity at the rates experienced in recent decades. However, utilities with generating capacity in excess of the required reserve margin may have additional capacity and would welcome the TMP as a relatively steady base-load customer. Other utilities, with less peak load margin but ample base load capability, may be able to accommodate additional customers under power curtailment options. Other utilities may be unable to accommodate large incremental demand, perhaps in response to regulatory encouragement to limit growth. The response of an individual utility to overtures regarding incremental load due to TMP and CTMP installations must be plumbed on a case by case basis. However, it is clear that the United States has substantial reserve margins in power generation, and a substantial growth in mechanical pulping could be accommodated, although some compromise in location may be necessary.

ACCOMMODATING SPECIAL POWER AVAILABILITY SITUATIONS

Special accommodations in the pulp mill may permit a paper company to install new or incremental TMP pulping capabilities, even in those regions where the margins at peak load are small, or where the utility seeks to manage its power demand for other reasons. In some cases, economics will dictate special accommodations in pulp mill operations, to take advantage of special rates provided by the utilities in response to their own costs of power generation. In these cases, the pulp mill may find it advantageous to implement operations that will allow temporary suspension of pulping operations at times of peak power demand.

Depending on its own cost of generating or purchasing electric power, the utility may offer its largest industrial customers alternative rates that provide mutual benefits to both the utility and the customer. These rates are designed to minimize system peak demand and thereby reduce the cost of new peaking generation equipment. In addition to the normal rates for nominally uninterrupted service, utilities may also offer special, lower rates for curtailable service and for interruptible service. Interruptible service is seldom attractive to pulp mills because it allows the utility to interrupt power without prior warning; few pulp mills can be profitable when such interruptions occur. With curtailable rates, the customer agrees to suspend temporarily the use of selected energy-intensive equipment during times of system peak load. Usually, the curtailment occurs only for the duration of the peak demand, such as the summer peak in the late afternoon and early evening, or the winter peak at the start of the day. The utility and its customer negotiate the number and duration of interruptions that the utility may request in a given year.

Other utilities offer rates that provide similar incentives for temporary curtailment of energy-intensive applications such as mechanical pulping. In some cases, the rates charged during periods of peak power are substantially higher than the discounted rates charged during off-peak times. This rate structure encourages large users to suspend operations during those periods when peak demand is experienced by the utility.

One Eastern TMP mill has arranged a mutually beneficial curtailment credit with the electric utility that supplies power to the mill. This electric utility purchases its power from another utility that delivers it through the grid. The monthly cost rate to the utility for this purchased power depends strongly on the peak usage each month. Therefore, the utility that purchases this power from the generator, and the pulp mill that ultimately consumes the power, both benefit if power usage is temporarily curtailed when the monthly peak in usage appears imminent. Such an arrangement has been established with the pulp mill.

In this instance, the mill continuously monitors the electrical load experienced by the utility and will curtail operations of the pulp mill if it appears that a demand peak will occur. In the winter months, a sharp peak occurs early in the morning as residential customers prepare to leave for work and school. The mill will curtail approximately 60 MW of its normal 90 MW load for an hour or so, until the peak demand has passed and pulping operations can be resumed. The papermaking operation is not interrupted during this time. In the summer months, when a broader peak occurs in the late afternoon and early evening, the pulping operations may be curtailed for two to six hours, until the restoration of mechanical pulping operation will not cause a new peak in power use.

This curtailment is beneficial to both the utility and the pulp mill. The utility and its other customers benefit because of a reduced rate which is charged by the utility for purchased electric power. The paper mill obtains a substantial credit against its monthly utility bill for each kilowatt of peak load that is removed from service. In the summer months when demand is highest, this credit is on the order of $10-12/kW, for a monthly benefit on the order of $700,000. In the winter, when demand is proportionately smaller, the credits may drop to $5-6/kW for reductions in peak power utilization. When it appears that a peak in demand may occur, the mill begins to build pulp inventory in anticipation of a temporary shutdown. Refiners are taken off-line to avoid a peak in power consumption experienced by the utility. When the peak from other sources has passed and the mechanical pulping operations can be restored without introducing a new peak, the mill resumes its pulping operations.

Of course, the pulp mill experiences additional capital costs and certain operating challenges as a result of its agreement to curtail its mechanical pulping operations. For example, the refining capacity must be higher than required for continuous operations, since some pulping capacity must be available to build inventory in anticipation of a curtailment event. Furthermore, the mill must install storage facilities to hold as much as six hours of pulp inventory, to ensure uninterrupted operation of the paper machine during curtailment of mechanical pulping.

While the return on the investment in capital equipment for incremental pulping capacity and pulp storage is relatively rapid due to the substantial load-reduction credits awarded by the utility, the problems arising from interruptions in operating routine were of greater concern. However, as a result of experience gained over several years of operating in this fashion, the mill is able to suspend and restore its pulping operations without affecting the quality of the pulp. The additional storage time experienced by the pulp during curtailment of pulping operations does not affect the quality of the paper being produced.

Cogeneration may also be a viable alternative for pulp mills seeking to insure the availability of electrical power for mechanical pulping installations. Many electric utilities encourage the installation of cogeneration equipment within their regions, and welcome the opportunity to purchase excess power for the grid from industrial cogenerators. Perhaps the most interesting example of an innovative cogeneration arrangement is the recent start-up of the Lake Superior Paper Company as a joint venture of subsidiaries of Minnesota Power and Pentair, Inc. (7). This mill produces 600 tons per day of supercalendered (SCA) groundwood paper, using power provided by the Hibbard Power Plant — a plant that had previously been mothballed by Minnesota Power, and which was retrofitted specifically to provide the power for the new paper mill.

A resource for the paper industry seeking a site for installation of a mechanical pulping facility is the EPRI Pulp and Paper Office, which has been established recently at the Institute of Paper Science and Technology. The Office serves as an information resource for both the utility and paper industries, regarding the use of electrotechnologies in the pulp and paper industry. This Office will be a clearinghouse for information on generating capacity throughout the United States, as well as other information.

Thus, through innovative rates and cooperation between the utility and its paper industry customer, it is possible to reduce the costs of electrical power for mechanical pulping, and to minimize the impact of incremental electrical load on the utility.

CONCLUSIONS

Although the manufacture of mechanical pulps via TMP or CTMP is an energy-intensive process, it appears that the capacity margins within the electrical utilities are adequate for a substantial increase in mechanical pulping by the U.S. paper industry. Furthermore, if the recent trends continue, margins in excess of the reserve margins will be available, at least for the next several years, permitting incremental TMP production in many locations. Regional differences in capacity margin exist, with the largest margins available in the Northwest and the smallest in the New England states. However, differences in capacity margins among individual utilities far outweigh these regional trends. The situation at each individual utility must be explored when selecting a site for incremental TMP production. Utilities seeking to manage their electrical demand will welcome the addition of a large, stable user of electrical power, particularly if the mill will entertain options that will remove the electrical load during periods of peak use.

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TABLE 1

NORTH AMERICAN ELECTRICAL RELIABILITY COUNCIL REGIONS

ECAR	Eastern Central Area Reliability Agreement	MI, IN, KY, OH, WV, VA
ERCOT	Electrical Reliability Council of Texas	Eastern TX
MAAC	Mid-Atlantic Area Council	MD, DE, PA, NJ
MAIN	Mid-American Interpool Network	MO, IL, WI
MAPP	Mid-Continent Area Power Pool	MN, NE, IA, ND, SD
NPCC	Northeast Power Load Council	NY, CT, RI, NH, MA, ME, VT
SERC	Southern Electric Reliability Council	MS, TN, NC, SC, GA, FL, AL
SPP	Southwest Power Pool	Western TX, NM, OK, AR, MO, KS, LA
WSCC	Western Systems Coordinating Council	WA, OR, MN, ID, WY, CA, UT, NV, CO, AZ, NM, MT

TABLE 2

CAPACITIES, PEAK LOADS, AND MARGINS*
- U.S. ELECTRIC UTILITIES -

YEAR	SUMMER CAPACITY	SUMMER PEAK LOAD	SUMMER MARGIN
1970	327 MW	274 MW	16%
1975	479	356	26%
1980	558	427	24%
1981	572	428	25%
1982	586	414	29%
1983	596	447	25%
1984	604	451	25%
1985	621	460	26%
1986	633	476	25%
1987	647	493	24%

*Reference 5.

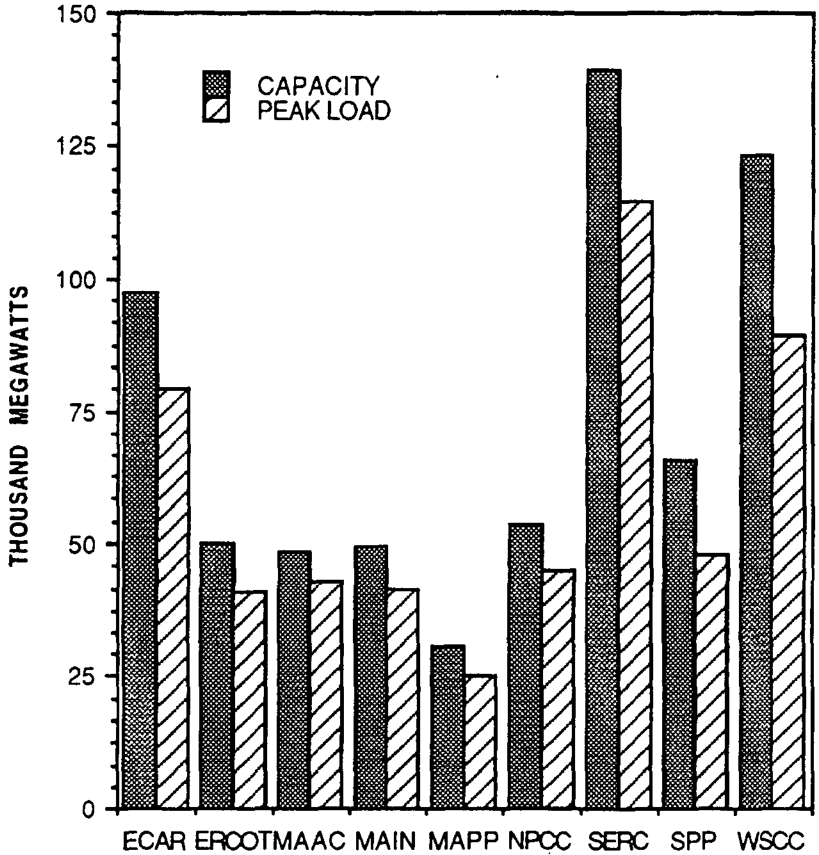

Figure 1. Capacity and Peak Load Data for Nine Regional Electric Reliability Areas for 1988. From Reference 6.

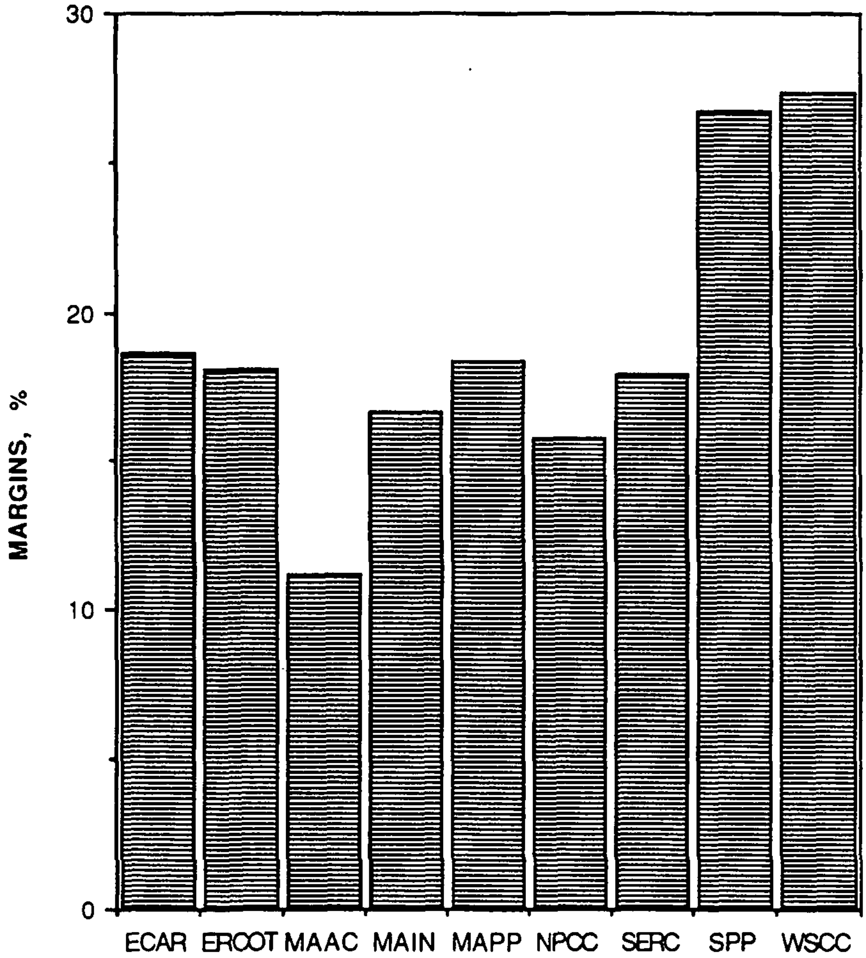

Figure 2. Margins for each of Nine Regional Reliability Areas, as a Percentage of Capacity, in 1988. Source: Reference 6.