EFFECTS OF DECREASED RELEASE OF CHLORINATED COMPOUNDS ON ENERGY USE

Energy Consumption for Different Bleaching Configurations

Energy consumption within these various general configurations is a function of

1. the extent to which unbleached pulp is delignified prior to bleaching;
2. the chemical configuration of the subsequent bleaching sequence;
3. the magnitude of bleaching sequence-related chemical requirements;
4. process heat requirements;
5. electricity required for pumping and mixing among and within the various bleaching stages; and
6. electrical energy required for the production of bleaching chemicals.

The latter two items, when combined, are particularly prominent. Taken together, they represent from one-third to one-half of a mill's total electrical requirements. Considering the bleach plant alone, elemental chlorine free (ECF) bleaching sequences applied to similar unbleached pulps tend to be more attractive than totally chlorine free (TCF), when considering total electricity requirements for chemical manufacture and bleach plant operation. Differences as great as 50% have been estimated. Such comparisons, however, are highly sensitive to the estimates of electricity required for the manufacture of the major bleaching chemicals used. From an electrical energy standpoint, ECF sequences are typically more efficient than TCF sequences for delignifying pulps in the bleach plant.

Energy requirements among the various categories of bleaching are seldom compared in isolation from considering the extent to which pulps are delignified prior to bleaching. In their appraisal of bleached kraft manufacturing technologies, the Paper Task Force (1995) tabulated information comparing the energy profiles of alternative bleach sequences, presented in Table C3 below.

Factors that dominate the energy footprint are a) the extent to which unbleached pulps are delignified prior to bleaching, and b) the chemical agents chosen for the bleaching sequence.

In their analysis, the Paper Task Force (1995) concludes that enhanced ECF bleaching processes require significantly less total energy input than either conventional bleaching or traditional ECF processes. Taking into account potential energy credits, enhanced ECF bleaching consumes 36% less energy than conventional chlorine bleaching and 47% less than the traditional ECF sequence. The lowest energy inputs are associated with the low effluent ECF and TCF processes. However, relative to an enhanced ECF sequence, energy input varies less than 10% for filtrate recovery enabled by either a low effluent ozone ECF process, a low effluent ozone TCF process, or an enhanced ECF process with chloride purge (BFR). Folke et al. (1996) offer a broader perspective:

> *"The progression from the highest to the lowest energy-consuming sequences is not smooth, reflecting the variations from mill to mill. In practice there is considerable variation between bleach plants using identical bleaching sequences. The authors have seen data where consumption of bleaching chemicals differed by well over 25% in substantially identical bleach plants producing competitive products from similar wood using identical bleaching sequences. The reasons are primarily differences in operating skills, which in turn depend heavily upon management equipment, the quality of training and the supervision of process operators, and the skills of maintenance personnel. In many cases, these differences outweigh the advantage of one bleach sequence over the other with respect to energy efficiency and effluent quality."*

They go on to say:

> *"Bleaching sequences based on peroxide generally result in lower energy demand than those based on ozone, which are in turn more energy efficient than those based on chlorine dioxide. However, mill operating conditions, product specifications and operator skills can have just as much an effect on energy consumption. The agenda is thus not whether to use ECF or TCF as the choice of bleaching sequence, but rather to modernize the pulping operation itself."*

Table C3. Estimates of Energy Usage and Savings for Different Pulping Processes for 90 GE Brightness Softwood Pulp (millions of Btu/air-dried metric ton of pulp) (Source: Paper Task Force 2005)

	Bleaching Process	$C_{50}D_{50}$EDED	D(EO)DED	OD(EO)D	OZ(EO)DD	OZQPZP	OD(EO)D + BFR
Energy Input	Energy to manufacture chemicals[1]	7.6	10.2	5.0	5.0	3.6	5.4
	Direct equipment power[2]	0.9	0.9	1.3	1.5	2.2	1.3
	Process steam[3]	4.4	4.4	3.8	3.1	3.8	3.8
Energy Credit	Recovery steam credit[4]	0.0	0.0	-1.6	-2.7	-2.7	-2.7
	Water supply credit[5]	0.0	0.0	-0.3	-0.3	-0.3	-0.3
	Effluent treatment credit[6]	0.0	0.0	-0.1	-0.2	-0.2	-0.2
Energy Balance	**TOTAL ENERGY INPUT**	12.9	15.5	10.2	9.6	9.6	10.6
	TOTAL ENERGY CREDITS	0.0	0.0	-2.0	-3.1	-3.1	-3.1
	NET ENERGY REQUIRED	12.9	15.5	8.2	6.5	6.5	7.5

NOTE: The energy data include the transmission losses associated with generating electricity at a utility; thus 1 kilowatt hour of electricity equals 10,500 Btu of energy.
[1] Energy required to make the bleaching chemical.
[2] Running power consumed by the bleach plant equipment.
[3] Process steam energy required (converted into kWh/metric ton).
[4] Credit for recovery boiler steam used (assuming that O-stage solids are recovered for O(CD)ED and ODED cases, and O-, Z- and E-stage solids are recovered for the OZQPZP case).
[5] Water supply energy credit based on reduced deep well pumping.
[6] Effluent treatment energy credit based on reduced BOD treatment requirements in an aerated lagoon.

References

Folke, J., Renberg, L., and McCubbin, N. 1996. Environmental aspects of ECF vs. TCF pulp bleaching. In *Environmental fate and effects of pulp and paper mill effluents*, 681-691. Boca Raton: St. Lucie Press.

Paper Task Force. 1995. White Paper No. 5. *Environmental comparison of bleached kraft pulp manufacturing thechnologies*. http://c.environmentalpaper.org/documents/1626_WP5.pdf