The long-term vision for a modern pulp mill will see the fiberline and bleach plant in a “pressurized pipe” with bulk and oxygen delignification


By MARTIN MACLEOD

Tony Johnson, who will talk about “21st Century Fibrelines,” a keynote presentation at the 2008 International Pulp Bleaching Conference June 2-5 in Quebec, QC, has been immersed in kraft mill fibreline design and operation for two centuries. Okay, so really the last two decades of the 20th Century; plus the present one. Based in New Zealand, his global professional practice has put his engineering knowledge to work at dozens of mill sites, new and renovated. He continually tracks new developments in the kraft pulp sector, giving him a global perspective of the latest facts and trends in mill design.

P&P: What are the newest bleached kraft pulp mills all run on eucalyptus? Can you begin by characterizing them in terms of production rate, fibreline design, and overall capital cost?

Johnson: The first word that comes to mind is BIG! World-class scale is at least 2,000 tonnes/day, but really up to and exceeding 3,000 tonnes/day, such as the APP Hainan Jinhaii mill in China.

Among the main factors you have to consider when planning a billion-dollar-plus mill are the wood supply and its scale, environmental impact and how that can be mitigated, energy efficiency (increasingly a major factor), operating and capital costs, people and product quality relative to the markets the mill will serve.

With eucalyptus and acacia, wood grows at 40–65 m3/ha/yr with rotations of five to seven years. It’s all plantation wood. The best economies are where a mill sits in the middle of the forest, or in a half circle on a sea coast, like Araucura. Locating a mill close to the wood supply, a port and a fresh water supply are all essential ingredients. Proximity to a city or town with access to good labor to operate the mill is important too.

In capacity, world scale in the 1980s meant 500 tonnes/day. By the 1980s, that figure had roughly doubled. In the boom in the late 80s and early 90s, it had climbed to about 1,500 tonnes/day. A decade and a half later, we’re at a new benchmark of 3,000 tonnes/day.

I’m not sure it’s the optimum size. That depends on what you get once you’ve analyzed all the inputs, including wood supply, water supply, enough wood waste to be energy self-sufficient and so forth. A lot goes into making the business decision, so it doesn’t necessarily come exactly to 3,000 tonnes/day. Arauco’s Valdivia mill in Chile, for example, was designed for 2,000 tonnes/day, the optimized capacity for its situation.

P&P: What about environmental considerations?

Johnson: These mills use modern, best-available technology that is technically effective and economically viable, minimizing any discharge of pollutants. They minimize water use, air emissions and solid waste discharges, use closure wherever possible, are energy efficient — all the things we consider part of good environmental stewardship. This applies no matter where in the world they’re installed.

There continues to be pressure to minimize environmental impact, particularly with ECF bleaching. Lobby groups keep pushing for the elimination of chlorine-containing reagents from bleaching. The Gunns mill proposal in Australia is experiencing that right now. Mills will recycle and reuse a lot more water than in the past.

Being energy efficient flows on from environmental impact. Targeting a mill’s maximum power-to-heat ratio is important, to go beyond energy self-sufficiency in order to export electricity, contributing to the area in which it operates. Unlike the past, new kraft mills can do this routinely. Their heat use is in the range 10–11 GJ/tonne, power at around 600 kWh/tonne, and they make efficient use of secondary heat. That’s a key platform for a world-class bleached kraft mill, softwood or hardwood.
Vercel needs about 70 MW and can generate about 110 MW. So it can export power to the chemical island, which is operated by a different company in an over-the-fence arrangement. It’s an interesting synergy. Arauco Valdivia is also set up to export electrical power.

P&P: Is pulp uniformity a “given” because of designer trees from well-managed industrial plantations?

Johnson: Yes, it comes with the territory. This starts in the forest, with individual species, predictable wood density, age control and so forth. Then the wood handling system and the fiberline on a millsite are designed to provide a uniform final pulp product.

Really, the key product quality issue is uniformity – paper-making customers want this more than anything, for predictability. High brightness is also important, and so is good tensile strength.

P&P: We commonly lump people under “labor,” but what are the real needs in human skills for these mills?

Johnson: Well, you need pretty clever people to maintain all that equipment, especially good control systems. In really remote locations, such as the Jari mill in Brazil, that was a serious problem years ago – just trying to maintain the instrumentation and control system was a continual challenge. So attracting competent control systems engineers is a necessity.

Training and development is top class these days. Interactive 3D training and sophisticated simulators are now available to train new operators and engineers, based on the dynamic mass balances of their own mills. The simulator output is fed through the actual distributed control system (DCS), so everything looks just like the real process.

I think Arauco does a fabulous job in that regard. Vercel too. The evidence of how well the training is done is reflected in a mill’s startup curve, and there are some really good ones now. Reaching the intended production rate is now measured in weeks rather than months.

P&P: What special factors attach to a big new softwood mill?

Johnson: Arauco’s Valdivia swing mill in Chile is a good example. It’s located in an area of fast-growing wood (25-28 m²/ha/yr for radiata pine), and it chose liquor displacement batch cooking for superior pulp strength. Apart from pulping, there are very few differences in the configurations of modern hardwood and softwood mills. Some extra recovery boiler capacity is required for softwood, but that also means that you can run at about 10% higher production rate on eucalyptus than pine if it’s a swing mill. There may also be a minor difference at the front end of the bleach plant. You can switch between the wood supplies quite easily, and have even more flexibility if there are two fiberlines, such as at Arauco’s Nuevo Aldea twin mill.

P&P: Are capital costs higher than in the past?

Johnson: Capital cost is directly related to the scale of the mill, so as size increases, capital cost per ton comes down. In dollars per annual tonne of capacity, mills in the early 1990s (e.g., in Canada, Chile) stood at $1,700-2,200/tonne. Today the figure is around $1,000/tonne ± 10%. Some special cases, such as Mill C at Arauco, can be significantly lower because a lot of infrastructure is already there on a brownfield expansion site, decreasing the capital cost to perhaps $700/tonne.

Investment money from banks is just one more raw material input. If you like, comparable to wood, energy, water, chemicals, labor, and so forth. And good business means being a low-cost producer so that you can make a buck.

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Bleaching over the decades

Remember when chlorine dioxide was not used to bleach kraft pulp? No! Nor does anyone else. From a promising new reagent around 1950 to the backbone of today’s almost universal ECF bleaching, ClO₂ powers the pulp bleaching world. Across the same half century, only a very few other developments have had anywhere near the impact as they advanced from ideas to standard industrial practice:

- Medium consistency technology in the 1970s, leading to MC oxygen bleaching and oxygen-reinforced first extraction stages.
- Counter-current filtrate recycle, reducing fresh water use in bleach plants by half or more and encouraging the development of closed system thinking.
- Reliable on-line sensors for brightness, chemical residuals and kappa number, feeding ever more sophisticated distributed control systems for process control.

All the other things – hydrogen peroxide, ozone, enzymes, displacement bleaching, system closure – have been supporting actors rather than the stars in the show we know as bleaching.
P&P: What’s important when comparing modern batch and continuous digester systems?

Johnson: Continuous digesters have evolved into simpler systems, so control loops, piping and chip feeding are all less expensive than before. If for a continuous digester you have about 30 main control loops, a liquor-displacement batch system may have 200. Modern batch technology is more expensive, but you really have to put that into the perspective of the whole mill, not just the digester system. A cooking plant might be only 5% of the total bill.

Looking at only one part of a mill isn’t too helpful on its own. And saving $5 million somewhere is a marginal thing if the project is $1 billion. On the other hand, choosing a particular technology to gain a preferred position in the marketplace can be a very strong argument. Arauco’s Valdivia mill chose SuperBatch K technology for superior pulp strength over other softwood producers.

P&P: Post a digester system, can one simply assume that there will be tightly-coupled brownstock screening, a two-stage oxygen delignification system with reactors of different sizes and a three-stage ECF bleach plant?

Johnson: That last part isn’t quite right. The newest mills for eucalyptus have more than three stages of bleaching. Veracel, for example, was designed for DExoDD. In a market mill, pulp has to be produced on a reliable basis at 90%+ brightness 24 hours a day and 365 days a year, so that last D stage is considered worth the money by ensuring that high brightness targets can always be met. Arauco Valdivia is DExoDD. Jinhai is DExoDD. All of the new mills are ECF.

P&P: Will they operate the last D stage all the time?

Johnson: Yes, but there’s the possibility of using it as a P stage instead, as Veracel is already doing. The driver is brightness stability.

P&P: How about choosing an A stage versus a hot first ClO₂ stage for eucalyptus mills?

Johnson: Of the mills we’ve been discussing, only Veracel was designed with an A stage. In fact, it converted fairly quickly to DExoDD. So the consensus seems to be tilting to hot ClO₂.

P&P: Operating costs for bleaching: are they decreasing?

Johnson: Yes. An overriding factor in modern mills is that they’re at medium consistency all along the fiberline. In bleach plants, that means
misters, pumps, towers and washers. So less steam is needed to heat the pulp, less water is used, and the pumps and pipes can be smaller, with the overall effect of reducing energy requirements and operating costs.

**P&P: Is there any significant step forward in terms of chemical efficiency across truly modern washers?**

**Johnson:** They’re certainly more efficient than the vacuum drum washers of the past, but they all tend to operate at displacement ratios in the 0.90–0.95 range. The Andritz DD washers can have an advantage if they are multi-stage units.

**P&P: What about reducing total chlorine dioxide use?**

**Johnson:** All things considered – mixing, process control, washing – the modern bleach plants are probably better than those of a decade ago. But there hasn’t been a huge stepwise change. Two-stage oxygen delignification has become the norm, delivering softwood pulps with kappa numbers as low as 12. The equipment is capable of doing more, to 9–10 on eucalyptus. The floor-level kappa out of oxygen delignification appears to be 9–10 whether hardwood or softwood, so the ClO₂ consumption in bleaching is essentially fixed. Yield considerations may keep kappas slightly higher in some softwood mills. Overall chlorine dioxide consumption doesn’t appear to have changed significantly in the past ten years in new mills.

Technologies that might get around this barrier are catalysts which selectively seek out the residual lignin and modify it, activators that transform the substrate so that it’s more receptive to the chemical being applied and maybe the use of chelants to trap transition metal ions. Of course, there are costs associated with all of these.

**P&P: What about process control improvements? Are there any significant benefits relative to 10 or 15 years ago?**

**Johnson:** It’s the norm that you have a higher level of control in bleach plants now. The on-line sensors are very good for brightness and residual chemicals. Well-tuned process control systems are essential.

**P&P: Do you see anything clearly missing that would provide useful on-line information to a DC? What about a sensor for the hexeneuronic acid content of pulp?**

**Johnson:** Something like that would be quite handy. Beyond the traditional temperature, pressure, pH, etc., on-line analysis of fiber surfaces and more optical properties will be possible, I think.

The lower limits of process water use per ton may be determined by issues of scaling on inside equipment. So sensors to measure the ions of concern, especially calcium, will be required to stay out of operational danger zones. And very specific purges will remove streams you don’t want, perhaps taking them to a “kidney” device for processing. Ion sensors will increase in importance.

**P&P: A new mill built in 2020 – will it just be a bigger version of today?**

**Johnson:** Actually, my long-term vision is that the whole fiberline and bleach plant will be in a pressurized pipe in which there will be the bulk delignification and oxygen delignification and you’ll recognize some bleaching. There has been some very clever research by Geoff Duffy (University of Auckland), diffusing chemicals through a moving slug of pulp, extracting it again, and using steam to heat up the suspension. Kind of like displacement on the deck of a drum washer, but in a pipeline.

In 2020, mills will certainly use less energy, and there will be new “kidneys” for removing unwanted chemicals such as transition metal ions. Washers – they’re very efficient now; so there’s not much room for further improvement there.

**P&P: How big?**

**Johnson:** A graph of Kraft mill size over the decades looks exponential – suggesting perhaps 5,000 tonnes/day in one fiberline by 2020. The washing equipment is probably the greatest restriction at the moment, but paralleling washers at critical locations is already being done.

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**MARTIN MACLEOD** is a freelance writer, teacher, and technical consultant to the forest products industry. Appropriately, he lives at 150 Sauvage Private, Ottawa. ON. K1V 2E1 and can be contacted at the.macleods@sympatico.ca

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