Are We Missing the Point on Biomass Fuel for US Utilities?

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INTRODUCTION

US utilities are interested in adding biomass to their fuel mix due to mandated renewable portfolio standards, and also to enable them to sell "Green Power" to their customers. There are three routes to doing so:

- New boilers designed for firing biomass,
- extensive rebuilding of old coal boilers to burn wet wood, or
- mixing coal and wood in existing coal boilers.

Thus far, much of the coal/wood mix tests aimed at 20% biomass firing utilized wood pellets. While expedient for testing, this is an expensive means to an end, and it violates a basic premise in solid fuel preparation – *do only as much as the application requires*. So why take all the effort to make a pellet? The reasons are that they are a standard commodity, are low in moisture, have good flow properties, and are higher in bulk density than raw wood. But they also can be costly, are prone to dusting and crushing, turn to mush when they get wet, and generate carbon monoxide (CO) while in storage. Are pellets the only way to get the job done? Is there a superior, lower cost, greener fuel available with a smaller carbon footprint? One that fits this profile is DMC Fuel™ (dry micro chip fuel). This is created by a new generation of in-forest chippers[1] which produce a nominal ¼" long by 1/16" thick chip. When dried, micro chip fuel has all of the positive properties desired for combustion: low moisture, good handling, near zero dust, little breakage when handling, and based on preliminary tests, no detectable CO generation in storage. Fuel can be stored in simple, lower-cost, roofed buildings instead of traditional silos used for pellets. Capital cost and electricity are reduced by eliminating the fine grinding and pelletizing process, thereby reducing delivered price and CO_2 footprint. Finally, chip size can be tailored to suit a particular boiler's requirements.

WHAT BOILERS LIKE AND DON'T LIKE…

Combustion Issues

Burning wet wood (typically 50% moisture) in a coal boiler cuts flame temperature and heat transfer, and significantly raises the flue gas volume. These factors reduce fuel-to-steam efficiency and reduce boiler output. However, if wood is dried to a nominal 10%, there is little difference in combustion between burning dry micro chip fuel and coal, keeping in mind that coal also contains moisture.

Solids handling

Tests using coal pulverizers for wood fuels have proved to be failures or marginal successes and had drawbacks when grinding either wood pellets or raw wood fuel. Example test programs include the Nanticoke and Atikokan generating stations in Canada. In short, if size reduction is required for wood fuel, the right tool is a hammer mill, not a coal pulverizer. In

discussions with utility engineers, and based on our experience, we expect dry micro chip fuels to burn well in virtually all coal boilers, as the wood rapidly loses water, then volatizes (wood is about 80% volatiles, 20% fixed carbon by weight) and loses strength as it quickly chars. The task then is to choose the right nominal chip size (e.g., 1/8", ¼", 3/8") for a particular coal combustion system, and *if and only if* required, use a hammer mill just upstream of the final feed system for final size reduction.

Full Scale Testing and Operation

Onsite-produced wood waste equivalent to dry microchip fuel and other dry wood byproducts is used at multiple forest products plants. The author has experience with such fuel being burned in fluid beds, and in water wall power boilers. Outside the forest products industry, at least limited testing has been done on dry micro chip fuel. The UNC (University of North Carolina at Chapel Hill) campus-wide steam and power system has a 32 MW coal fired cogeneration facility. They tested ¼" dry wood bedding, similar in concept to dry micro chip fuel, as a candidate for future co-firing and biomass conversion fuel. The limited test showed that it was compatible with the solids handing system. A longer scale test is contemplated to assure that it is compatible with the dual fluid bed combustors.

COMPARING PELLETS AND DRY MICRO CHIP FUEL

"Engineered Fuels"[2] are those that undergo one or more beneficiation steps. For biomass, this would start with the base fuel of whole tree chips or "hog" fuel. Beneficiation steps could include size reduction, drying, pelletizing, briquetting and torrefaction. Each step has its own costs and benefits. This paper focuses on DMC Fuel™ (dry micro chip fuel) and its comparison to pellets.

DMC Fuel™ is a new biomass product aimed primarily at the utility and industrial export market and US utility use, and secondarily at the national market for residential and commercial wood heating. DMC Fuel™ is trademarked by TMTS Associates, Inc, an engineering consulting firm focusing on biomass projects.

Figure 1 shows both dry micro chip fuel (at left) and conventional wood pellets (at right). Conventional pellets are about 3/8" diameter by ½" long. Dry micro chip fuel's smaller size makes drying much easier and faster, when compared to the old standard 2"x2"x1/4" whole tree chips, or 2" hog fuel, getting the job done with shorter dryer residence time and smaller, dryer shells.

Figure 1. Dry Micro Chip Fuel and Wood Pellets

Table 1 lists the good and bad features of wood pellets and DMC fuels.

Table 1. Pros and Cons of Wood Pellets and Dry Micro Chip Fuel

Wood Pellets	
Pros	**Cons**
Well-established commodity	Dusting and crushing in transport and handling
High bulk density	Loss of integrity upon wetting; protection from weather required
Low moisture content	The need for hammer milling/grinding to less than 1/16" particle size before pelletizing
	High energy and maintenance pelletizing step
	High cost and power consumption in manufacture
	Need for pellet coolers
	Carbon monoxide generated in storage (Reference 2: CO levels have been found that are many times the NIOSH IDLH (Immediately Dangerous to Life and Health) level of 1,200 ppm, with CO concentrations of 1,460 to 14,600 ppm in cargo holds for ocean shipped pellets)[3]
Dry Micro Chip Fuel	
Pros	**Cons**
Lower capital costs	Lower bulk density
Lower power, labor and maintenance cost	Higher ocean transport cost
Lower cost per ton	
Greener fuel due to lower power per ton in manufacture	
No grinder/hammer mill	
No pellet mill	
No pellet cooler	
Smaller dryer shell	

The properties of micro chip fuel vary little with type of wood, with the exception of slightly higher heat content and volatile fraction for softwoods as compared to hardwoods, as would also be the case with pellets.

Micro chip fuel ash content will vary with feed stock, and, if sand and fines are excessive, screening to remove sand and fines can be done as part of the production process after drying. As an additional benefit, any resultant wood fines can be used as dryer fuel. Another green route for drying would be to use landfill gas (LFG) as the fuel, with synergistic mating of micro chipping of storm damage, pruning, tree clearing and development related biomass, and use of LFG, which must be flared if not otherwise used at the receiving landfill. With the low price of natural gas, it is tempting also to use it as a dryer fuel, however, that would increase the fuels CO2 footprint.

Pellet bulk density is in the range of 45 lb/ft^3 (720 kg/m^3), while dry micro chip fuel is about 15 lb/ft^3 (240 kg/m^3). Cost for truck shipping differs little between the two fuels, as both can make a full truckload weight, and a standard 48' chip van can transport a full truckload (20 short tons) of dry (or wet) micro chip fuel.

An additional advantage of micro chip fuel is the potential for outsourcing the drying step to existing tolling facilities. This will enable low risk and fast startup of production, and will bypass the need to expend capital and time on equipment, permitting and construction. In addition to offsite drying, drying could be done at the utilities, with potential for use of their waste heat.

Capital and Operating Cost

Producing dry micro chip fuel eliminates equipment from the flow sheet (e.g., hammer mill, multiple pellet mills, pellet cooler, interconnecting conveyors, etc.), cutting capital cost of equipment 57%. Total savings for power, maintenance, labor, reduced amortized cost of capital is in the range of $30-$35/ton of dry product, with an expected price tag in the range of $90-$100/ton for dry micro chip fuel. In comparison, wet whole tree chips are in the range of about $30/wet ton ($60 per bone dry ton). The price difference shrinks between DMC Fuel™ and wet whole tree chips when higher fuel to steam efficiency is figured in for dry fuel, the moisture is taken into account, and the reduced boiler plant capital cost and smaller air pollution control system for burning lower moisture fuels is considered.

PRODUCT REGULATION AND SPECIFICATIONS

In addition to grading by industry standards for industrial (higher ash) and residential (lower ash) markets, the following multiple parameters are tested on wood pellets:

- fines content, bulk density, diameter, length
- heating value, chloride, moisture content
- pellet durability index
- ash content

Comparatively, micro chip fuel requires only moisture content, particle size range, ash content and heating value tests. Table 3 shows general specifications for dry micro chip fuel:

Table 3. DMC Fuel Specifications

Parameter	Value	Comment
Size	Nominal top size, e.g., 1/4"	This can be fine-tuned for end use
Moisture content	10%	8-12% typical, wet basis
Heating value	+/-7650 Btu/lb (18 kJ/kg)	Varies with hardwood (less), softwood (more)
Bulk density	15 lb/ft^3 (240 kg/m^3)	Approximate
Ash	0.5% to 2%	Varies with source; can be reduced by screening

While not an issue in the US, moisture content is an issue for export. Wet wood is generally banned from shipment due to the potential for transporting parasites, such as PWN (pine wood nematode). PWN treatment per the "56/30" rule requires a core temperature of at least 56°C for 30 minutes for wood chips. Hence, the drying step is mandated for overseas shipment.

Wet wood chips tend to pack in storage, leading to arching and bridging in storage and handling systems; dry wood is freer flowing, and is stronger and less prone to jams and hang-ups.

SUMMARY

As the utility industry moves forward in adding biomass to their fuel mix, dry micro chip fuel has potential to lower total cost of delivered power, maintaining boiler and generator output, simplifying hardware additions and alterations and the time require to carry them out, and reducing the carbon footprint delivered kilowatts.

References:

1. Example micro chipper manufacturers: Peterson: http://tinyurl.com/ChipPeterson Vermeer: http://tinyurl.com/ChipVermeer.
2. McGowan, Thomas F., Sizing, Drying, Torrefaction and Pelletization, IT3, Jacksonville, FL, May 11, 2011.
3. Urban Svedberg, Jerker Samuelsson, Staffan Melin, Ann. Occup. Hyg., Vol. 52, No. 4, pp. 259–266, 2008, Hazardous Off-Gassing of Carbon Monoxide and Oxygen Depletion during Ocean Transportation of Wood.