

JULY/AUGUST 2019

Biomass Magazine's

Pellet Mill

MAGAZINE

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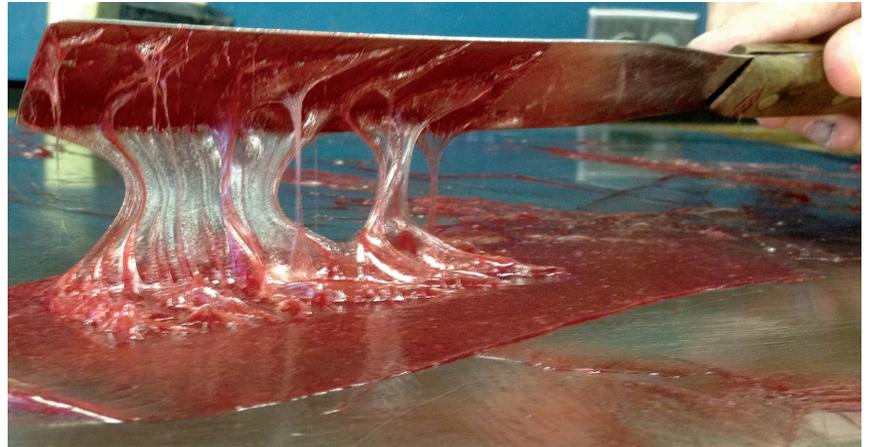
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Anna Simet
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All in the Same Boat

Last month, I had the pleasure of taking a quick trip to Hershey, Pennsylvania, to the annual Pellet Fuels Institute conference. Not only was I presented with chocolate at every turn, but I walked away from the event with new ideas, knowledge and much enthusiasm for our (relatively) small but growing industry. You can read a summary of what I learned on page 12, in our event review “A Rising Tide Lifts all Boats.” I drew the title from comments made by Charlie Niebling, a wood pellet industry veteran and former general manager of New England Wood Pellet. Several times during the conference, Niebling emphasized how essential it is to work together and be transparent when it comes to sharing information that will benefit the industry as a whole, one example being (uninflated) production capacity numbers. While both *Pellet Mill Magazine* and the U.S. EIA tracks this data to share with the industry, we occasionally run into skepticism and frustration from some producers who believe the numbers being reported are inaccurate. Niebling also underscored the value in working with other renewable heating groups trying to convince our officials on Capitol Hill that our industry is deserving of an even playing field with other energy sources. We have a common goal, so why not be stronger and louder together?

This mantra of being in it together is just as true when it comes to the theme of this edition, which is focused on plant safety—fire and explosion protection, and dust management. In my decade-plus stint at this magazine, I have heard many times that the impact of one bad incident can spread far beyond that one plant.

Early in this issue, you’ll find some tips on conducting a dust hazard analysis (DHA), a column written by Brian Edwards of Conversion Technology. Not only are DHAs incredibly valuable when it comes to understanding and correcting the risks at your unique facility but, by September 2020, all pellet plants will have to have one done. The time to think about it is now.

And perhaps a lesser-discussed but relevant topic, in his page-18 feature “The High Cost of Low-Grade Grease,” Senior Editor Ron Kotrba discusses the benefits and risks of using higher- and lower-grade greases. In regard to how that relates to safety or incidents, bearing failures—often preventable ignition sources at pellet mills—are typically caused by breakdown of the grease.

Though there is much more in these pages, the final story I will highlight is “Safety Front and Center,” on page 26, authored by Gordon Murray, executive director of the Wood Pellet Association of Canada. Murray heads up WPAC’s Safety Committee, and in the piece outlines the committee’s most pressing safety objectives. If you visit the committee’s website, you’ll see a member responsibility bullet point that drives home the basis of this column—“...be aware that each company’s individual safety performance reflects on the reputation of the entire industry.”

In other words, we’re all in the same boat.

A handwritten signature in black ink that reads "Anna Simet".

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Five Keys to a Successful Dust Hazard Analysis

BY BRIAN EDWARDS

Combustible dust fires and explosions affect many industries, but they are particularly troubling at pellet and biomass facilities. In order to minimize the risks to your people and business, it is critical to understand the hazards specific to your process, equipment and buildings. The National Fire Protection Association provides basic guidance on how to conduct a dust hazard analysis, or DHA. The most important goal is to systematically identify where fire, flash-fire, and explosion hazards exist, and to provide recommendations for safeguards to protect against these events. The following are key factors that will ensure that your DHA is done correctly, and that your pellet plant is safer.

Conduct the DHA at the right time. NFPA 652, Standard on the Fundamentals of Combustible Dust, requires that existing facilities complete their DHAs by Sept. 7, 2020. It also requires that DHAs be completed concurrently with new processes and buildings. For future projects, DHAs should be conducted early in the design process, so that the required fire and explosion protection systems are identified early. You don't want to realize a silo needs explosion venting a week before the plant is set for commissioning.

Assemble the right team. The DHA must be led by a qualified person who understands the science of dust fires and explosions, but also needed is input from people with direct knowledge of the materials, processes and equipment being reviewed. Team members often include people from engineering, operations, safety and maintenance. When conducting the DHA, not only is the intended operating process reviewed, but there must be an understanding of what can and does go wrong. Most major incidents don't occur when plants are running perfectly; having diverse perspectives is critical to understand possible upset conditions.

Establish the right goals. At the highest level, the goal of a DHA is to reduce risk. The level of risk an operation is willing to accept changes from facility to facility, and so it is important to openly discuss the goal of the DHA. Should we focus on preventing human injury? Should we have a goal to prevent process downtime of over one week? Do we want to

only focus on preventing catastrophic events? If your goals are undefined or unclear, you can end up with a DHA that has a long list of recommendations that are unfocused, unnecessary, or do not match your business goals.

Use the right method. There are different methods for conducting a DHA. Several are based on process hazard analysis methods used in the chemical industry, such as hazard and operability (HAZOP) studies, what-if, checklist, etc. Other methods have been developed more specific to dust hazards—for example, Conversion Technology uses its own method based on likelihood of a dust cloud, likelihood of an ignition source, and severity. At its heart, though, the purpose of a DHA is to identify what can happen, how likely is it, and the consequences. Some methods, like a HAZOP, can be overly complex and time-consuming, with little value added for the extra work. Others, such as a checklist DHA, may be too generic and lack the detail needed for a complex manufacturing process. It is important that the DHA method aligns with the established goals and the complexity of the process being analyzed.

Manage the findings in the right way. When the DHA is complete, you will have a document that lists existing safety controls and procedures, and often, there will be a list of recommendations for additional safeguards. It is important to prioritize the list based on which recommendations will have the greatest impact on reducing risks in your operation. No one has unlimited money to spend on protection, so using the DHA to understand where to most efficiently direct those funds is important. You shouldn't look at a DHA as just another regulatory requirement; it is a powerful tool to ensure you protect your people and process in a cost-effective way.

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Contemplating Conveyor Safety

BY HOLGER STREETZ

In this month's column, I'm going to focus on drag technologies, and improvements available for the hundreds-of-years-old principle. Many conveyors still look as they did in the 1800s—they consist of little more than a chain pulling paddles through a metal box. Energy that should move material is instead used to overcome friction of the chains and steel paddles as they run over the bottom panels. Furthermore, the steel-on-steel contact wears on the components and bottom panels as they move through the conveyor. More importantly, they increase the risk of sparks, especially in tight places. When the distance between the cover and the outer wall is very narrow, woodchips and sawdust can agglomerate there. Also, when a conveyor belt slides sideways and up against the drive roller's cover, the heat from the increased friction can ignite woody material.

Prevention measurements include fire-resistant rubber conveyor belts, cleaning routines, fire alarms and sprinklers, or dual chains, one example being SMART conveyors by BE&E. The dual chains run in ultra-high, molecular-weight-(UHMW) lined channels outside the material path. This type of polyethylene has very long chains for more effective load transfer. Running the chains on UHMW decreases internal friction of the conveyor; the only metal-on-metal contact is at the sprockets. Using two chains instead of one increases the chain life, as it reduces the load on each chain. It also decreases the chains' exposure to mechanical and acidic wear. Using one chain, that one component endures all the stress of the load. Chains in the one-chain set up are thus the most maintenance-heavy part of these machines.

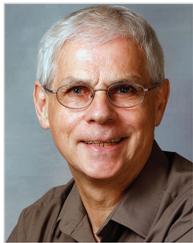
Safety First

Although many features have been added to improve conveyor safety, there are still lethal accidents. One such accident occurred in Europe during a maintenance shutdown,

when a contractor was working on a conveyor when someone turned on the equipment. An easy way to prevent someone from starting equipment while another person is working on it is the lockout procedure. This best practice is part of the safety indoctrination at Pinnacle Renewable Energy and many other Northern American pellet plants.

To improve maintenance and prevent fires from happening, it is crucial to have enough space between the belt and the wall so that maintenance teams can easily clean the gaps. Post-maintenance checks improve the safety further, as well as the two-man rule (actions require the presence of two individuals at all times). Further improving reliability are sensors that detect conveyor belt sliding, and automatically set off an alarm to stop the conveyor. Using high-performance lubricants with long-life and emergency operating features help increase the lubrication intervals; alternatively, automated lubrication systems decrease manual work to a minimum. Using a paddle design that allows wood to wedge between "fingers" in the paddles rather than beneath them not only prevent the material from wedging in the gap beneath the paddles, but also provides an initial fail point in the event an obstruction occurs in the conveyor. Therefore, instead of the obstruction damaging the chain or sprocket, a smaller (and less costly) component breaks first.

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Early Detection of Spontaneous Combustion in Pellet Mills

BY DEREK STUART

Wood pellets are increasingly being adopted as a fuel for both domestic and industrial applications at all scales, from small space heating to a 600-MW power plant. Pellets are considered a renewable fuel, provided the wood comes from sustainably managed forests. Using them instead of fossil fuels such as coal helps reduce emissions of carbon dioxide, which contributes to climate change.

Wood pellets are by their very nature combustible and can be ignited by a range of sources. Stored bulk piles of wood pellets tend to oxidize, which leads to self-heating and, potentially, spontaneous combustion. Additionally, the dust associated with the pellets, when dispersed and ignited, can give rise to a dust explosion under appropriate conditions of containment.

Fortunately, there are techniques to detect the early stages of spontaneous heating and combustion, allowing operators the chance to prevent the problem and avoid costly damages.

Gas Detection

Carbon monoxide (CO) monitoring is the most effective method of detecting the presence of spontaneous heating or combustion in an enclosed space, such as a silo or pulverizer. CO detection gives a fast and unambiguous indication that spontaneous combustion is taking place.

The concentration of CO in ambient air is very low, and a lot of this gas is produced as spontaneous combustion begins, so a rapid increase in CO concentration is a sure sign that action is needed. Measurement of CO in pulverizers is especially important. Along with the risk that burning material could be introduced, the mill performs a great deal of mechanical work in crushing the fuel that can lead to a fire or explosion.

The risk is small when the mill is in operation because the particle concentration is above the upper explosive limit. However, whenever the mill is started or stopped, the concentration inevitably passes through the explosive range and, if burning material is present, a potentially serious incident is extremely likely.

Temperature Measurement

The actions of bacteria and fungi cause an increase in the temperature of a storage pile, whether open or enclosed. Temperature measurement is the most effective option for outdoor locations.

The simplest method for scanning a storage pile is use of a handheld thermal imager. Such devices are relatively inexpensive, but the intermittent measurement means that spontaneous heating can go undetected. A fixed imaging system is preferable, since it allows operators to store and compare images over time. Additionally, image processing software measures the temperature over different zones of the storage pile and can also exclude short-term fluctuations, such as a vehicle passing through the field of view.

Temperature measurements can be taken on a conveyor using a line-scanning infrared pyrometer that uses a single detector with a high-speed scanning mirror to make up to 1,000 discrete readings across the width of the conveyor. The movement of the conveyor allows the scanner software to build up a two-dimensional image of the material on the belt and show any hot spots associated with burning material.

Two instruments from Ametek Land enable the monitoring of gas and the measurement of temperature—the Silowatch extractive CO monitors, which are widely used in pellet silos at one of the largest biomass electrical generating facilities in the United Kingdom—and the HotSpotIR infrared line scanner, which have become the industry standard for a variety of conveyors from wood pellets to petcoke. In all cases, the analyzers, which all have variants approved for use in hazardous area locations, have provided valuable information to the plant operator while maintaining high levels of reliability and safety at industrial sites. This allows the plant to provide evidence of automated detection systems if needed in insurance situations.

Spontaneous heating and spontaneous combustion pose risks in any location that handles and processes woody biomass. Choosing the right detection method can significantly improve site safety by reducing fire risks.

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- 3** The Quality Mark will make your product stand out on shelves. Customers and retailers are increasingly looking for easy ways to identify top-quality pellets.
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Business Briefs

PEOPLE, PRODUCTS & PARTNERSHIPS

Pinnacle's Bax assumes role of chief operating officer

Effective July 2, Pinnacle Renewable Energy's President and Chief Operating Officer Leroy Reitsma began transitioning from his current role to focus solely on Pinnacle's U.S. development projects, the company announced in late June. Reitsma joined Pinnacle in 2007 and was appointed president and chief operating officer in 2011. In recognition of his accomplishments and increasing responsibilities in the organization, Scott Bax, current senior vice president of operations, will succeed Reitsma in the role of chief operating officer, reporting to CEO Rob McCurdy.

Bax joined Pinnacle in 2013 and has been instrumental in the safe and cost-effective production of quality wood pellets from Pinnacle's facilities. Prior to joining Pinnacle, Bax acquired more than 20 years of forestry experience in various logging and wood manufacturing operations throughout Canada and the United States. Bax holds a master's degree in business administration as well as a master of forestry from the University of Alberta, and a bachelor of science (environment) from the University of Guelph.



Bax

FuelCell Energy, Drax announce new carbon capture project

FuelCell Energy Inc. announced it has entered into a contract with Drax Power Station for an application of its carbon capture solution.

Under the contract, FuelCell Energy will support Drax with a front-end engineering and design study evaluating the use of its proprietary carbonate fuel cells to capture carbon dioxide emissions from Drax's biomass boilers. FuelCell Energy said its carbon capture technology is based on its proprietary carbonate fuel cell power plants, which are able to concentrate carbon dioxide from dilute flue gas streams as a side reaction during power generation. The concentrated carbon dioxide is then available for sequestration or utilization.

The initial FEED study is scheduled to be complete in late 2019 and will include a detailed design and cost estimate for the demonstration. Completion of the FEED study may lead to the construction and operation of the demonstration system in a subsequent project.

The U.K. Department of Business, Energy and Industrial Strategy awarded £500,000 (\$633,500) toward the £1 million fuel cell biogenic carbon capture demonstration project.

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Morbark's Burkholder retires

Larry Burkholder, industrial sales representative for Morbark LLC, has retired after nearly 57 years with the company, the company announced June 27.

While Burkholder's contributions have been mainly with the sales team, he served in a wide range of roles within Morbark during his career, from accounting to marketing. He joined Morbark on Oct. 7, 1962, as a bookkeeper and acting as a sales assistant to Ralph Morey, the brother of company founder Norval Morey, and has held the positions of marketing manager, manager of Recycling Systems Inc., a division of Morbark; and vice president and general manager of Morbark of the Lake States Inc., a franchised dealer based in Tomahawk, Wisconsin.

Burkholder excelled at sales at Morbark, helping his sales region earn the highest annual revenue for the company. He actively participated in the industry and community throughout his career, having served as president of the National Wood Energy Association during its formative years in the 1980s, and on the boards or as a member of several industry associations, including the American Loggers Council, Michigan Forest Products Committee and the Forest Resources Association.

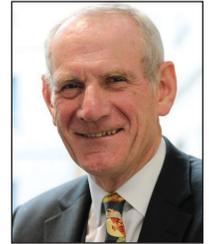


Burkholder

Schulz elected to Bühler Group board

At its general shareholders' meeting on June 21, Bühler added a new member to its board of directors with the nomination of Rainer Schulz. After obtaining a degree in production technology, for which he was awarded the promotion prize of the Association of German Engineers VDI, Schulz held various materials management and production supply chain positions in the electronics and mechanical engineering industries.

Since 1995, Schulz has acted as head of production and later as general head of purchasing in charge of global procurement at the jet engine builder BMW Rolls-Royce AeroEngines. In 2001, he moved on to the global REHAU Group. As chief operating officer, he was in charge within the context of the company management of the engineering, production, and materials management functions. In 2010, Schulz was appointed CEO of the REHAU Group, a position he held until mid-2018.



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A RISING TIDE LIFTS ALL BOATS

Consumer awareness, quality and collaboration were the buzzwords at the 2019 Pellet Fuels Institute Annual Conference.

BY ANNA SIMET
PHOTOS BY SYMMETRY CO. PHOTOGRAPHY

As it was last year, fostering growth of the retail pellet appliance market is a key initiative for the domestic U.S. wood pellet industry in 2019. The Pellet Fuels Institute Annual Conference offered fresh perspectives during its discussions this year, featuring panels with a near-split on representatives from the pellet production and pellet appliance manufacturing/retail segments, with much of the content centered on how producers and retailers can work together to increase consumer awareness and satisfaction, and grow the market.

Kicking off the conference with a thorough discussion of the U.S. EIA's Monthly Densified Fuel Report, Lead Survey Statistician Connor Murphy discussed fiber prices, production and inventory levels, sales and data trends since the agency began collecting the data in 2015. While fiber costs have risen in 2019 as a result of last year's historically wet weather and constraints driven by the China

trade war, U.S. inventory levels were below 20,000 tons at the end of 2018, according to Murphy, and reported sales for 2018 were the highest they have been since 2015. In February alone, sales were up by nearly 30,000 tons compared to February 2018, and up 53,000 tons from February 2017.

Murphy said the EIA, which publishes each report about four months retroactively, is looking to improve the way it presents the data. Feedback from producers and industry is welcome, he added, and reminded producers that all manufacturers of densified biomass fuel products—operating and those planning to begin operating within a year—are required to report. Those with capacities of 10,000 tons or greater must report monthly, and those under 10,000 tons on a quarterly basis.

When asked about releasing regional feedstock pricing data, as each U.S. region experiences significant variations, Murphy said that due to a low number of large-scale pro-



ducers in the Southeast region, EIA could not share at this time, due to confidentiality issues. Other attendee suggestions to improve the data included redefining the geographical regions to more accurately depict the domestic wood pellet industry.

Eyes on Appliances

For pellet appliance shipments in the U.S. and Canada, 2017 and 2018 were both strong years, according to John Shimek, vice



The 2019 Pellet Fuels Institute Annual Conference was held in Hershey, Pennsylvania, June 5-7, attended by a mix of wood pellet producers, appliance and equipment manufacturers, government officials and other stakeholders.

PHOTO: SYMMETRY CO. PHOTOGRAPHY

president of marketing at Hearth & Home Technologies. Shimek said 2018 saw double digit growth, and that he expects another solid year of double digit growth in North America in 2019. He estimated that around 70,000 to 80,000 appliances were sold in the U.S. and Canada last year.

Whether the upcoming U.S. EPA New Source Performance Standard requirements would affect sales, Shimek said he is confident there will not be a sell-through provision and

as a result, dealers will only be purchasing 2020 compliant appliances. “90 percent are already compliant, so this forces dealers to look at other inventory...there may be discounting of noncompliant appliances.”

Although cheaper wood appliances won't likely sway consumers from compliant pellet appliances, Shimek said, it will make for choppy inventory levels going into 2020. On the topic of consumers, Shimek said they are changing the way they shop and becom-

ing more involved in the process, and desire to start buying everything the way they want, such as online. “We may have to change how we do things, or figure out how to address that,” he said, adding that along with buying ease, customers want ease of use, one example being having to feed an appliance less. “People like to travel, and they can't be there feeding the appliance on a regular basis,” he said. “We need ease of use.” He said Hearth & Home Technologies plans to launch a product this fall



Tim Portz, executive director of PFI, interviews Tom Swan, Black Swan Fireside Hearth & Home; Rick Soccio, AES Hearth & Patio; Adam Martin, Martin Sales & Service; and Dean Michanczyk, Dean's Stove & Spa, during a panel featuring appliance retailer perspectives on consumer purchasing habits and trends.
PHOTO: SYMMETRY CO. PHOTOGRAPHY

that can go three or four days without being fed.

The biggest challenge the industry faces is awareness, according to Shimek. “If we can team (with producers) and drive one thing, it should be awareness...it all starts with the consumer.”

One way of doing that is increasing the use of digital advertising technology, Shimek said, adding that this year, Hearth & Home invested \$750,000. “It’s not going away; we’re investing heavily to get consumers into our facility,” he said. “It’s a process, a system we’re putting into our business—we’re going after it.

« Event

Continuing the theme of appliance sales, the next panel featured the perspectives of four stove retailer representatives. All agreed that while 2016-‘17 were down years, the past two years have been up by 25 percent or more.

But while appliance sales have been on the rise, pellet sales have not, said Adam Martin, owner of Martin Sales & Service. “This is the big problem—that pellet sales aren’t going up, and we’re doing nowhere near where we should be,” he said. The panelists attributed stagnant pellet sales to big box retailers selling lower-priced pellets, and suggested finding ways pellet producers and appliance retailers could work together to incentivize consumers to purchase their pellets where they buy their appliances. Ideas included using a different bag type or carrying a higher quality of pellet that can’t be bought at big box stores.

Strategy aside, some customers will always go for the lowest price, emphasized Tom Swan of Black Swan Fireside Hearth & Home. “I tell my customers that they should buy pellets from me for two reasons—I sell high quality pellets, and if you burn them in our stove, I

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will have less service calls,” he said. “I lay that out up front and plant those doubts, and tell them that if they don’t, it will come back to haunt us both.”

On service calls, Dean Michanczyk, owner of Dean’s Stove & Spa, said the online shopping experience has actually made things more difficult for both consumers and dealers. “Half of our service calls come from people who didn’t buy from us—the dealer gets a bad name when people can’t get service when they have made online purchases.”

The consensus of all panelists was that online sales won’t work well for appliances. “I don’t believe appliances could be sold successfully online—they need service,” said Martin. “It creates a lot of backlash.”

Rick Soccia, owner of AES Hearth & Patio, said he tells his customers if they buy from his dealerships, they will provide the best pellets and won’t run out, and that they will provide service when it’s needed.

All agreed that on top of treating existing customers well, thus bringing in new customers from word-of-mouth, cost-effective so-



Portz discusses the past heating season’s successes, upcoming challenges and industry priorities with pellet producer representatives Brett Jordan, CEO, Lignetics; Don Wagner, general manager, Appalachian Wood Pellets; Everett Follett, pellet sales manager, Spearfish Pellet Co.; Stan Elliot, vice president of sales and marketing, Pacific Coast Fiber Fuels; and Mike Sayers, CFO, BioMaxx.

PHOTO: SYMMETRY CO. PHOTOGRAPHY

cial media will be key in spreading consumer awareness.

Policy and Relationships

Representatives of the pellet manufacturing sector took the stage in the afternoon to discuss the current policy and regulatory landscape, bright spots and challenges. Innovative

Natural Resource Solution’s Charlie Niebling said NSPS aside, a main focus is still on the BTU Act and getting it over the line, as well as getting funding for bioenergy programs authorized in the Farm Bill.

Niebling emphasized the significance of fostering relationships with officials on all levels. “If you aren’t on Capitol Hill, you don’t ex-

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Unlike the U.S. Northeast and Midwest regions, the Pacific Northwest has a very tight pellet supply and demand, and can't weather a lot of variations with such a close balance, explains Elliot.

ist," he said. "It can seem pointless sometimes, but making relationships slowly, over time, has made a difference. They need to know who you are, so call and invite them to your plant. Get to know them before you need a favor or big ask. Two or three people in a room understanding your perspective makes a huge difference."

Stephen Fachner, president and CEO of American Wood Fibers, said the industry has been challenged since the beginning to be relevant or counted, so the EIA tracking the industry with its densified fuel report is "a

massive accomplishment. A lot of effort is spent [on policy and regulatory issues], and it sometimes feels like pushing a boulder uphill. It's why the PFI is important."

There is opportunity in strategizing and partnering with new environmental groups that understand the value in using low-grade wood for energy to replace fossil fuels, Niebling stressed, as well as working much closer with other renewable groups toward a common goal. "A rising tide lifts all boats," he said. "Let's all be for renewable thermal, rather than all against something."

He also reminded audience members of the importance of sharing accurate data in instances such as the EIA report—particularly, installed capacity data. "Our industry needs to come to terms with the value that could be derived from reporting that accuracy," he said.

BBQ Pellets

Growth of the barbecue pellet industry during the past two years has been "miraculous," according to Jeff Thiessen, president of Danson's Inc. His company's brand Pit Boss experienced 300 percent growth, he said. "We've seen massive growth, and not just with Pit Boss, but other specialty pellets as well. Year to date, we're up 40 percent, so it's pretty exciting...the market is phenomenal."

Thiessen said he believes that in the next decade, pellet grills will be as common as gas grills. "It's the flavor and convenience—once you use grill pellets, you don't go back."

Bryan Traeger, divisional sales manager at Danson's, said that reviewing the past 20 years, he can't think of any person who complained to him about a bad pellet grilling experience. "It's still a small percent of the overall market, but it's definitely here," he said.

Building on that momentum, EnergeX is soon opening at Atlanta-based grilling pellet division, said Kenny Lisle, sales and marketing manager. Lisle said having a grilling pellet side helps alleviate off years for fuel pellets. "We know people will barbecue, and it isn't depen-

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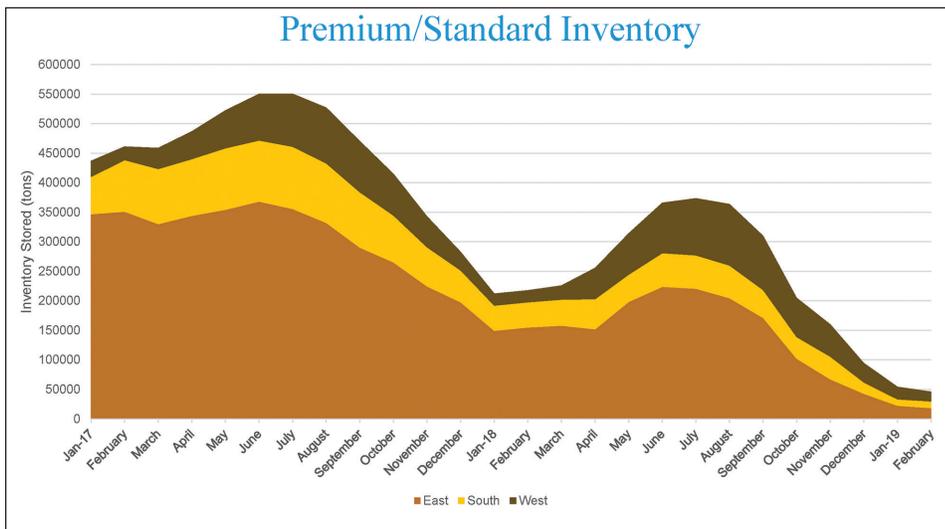
dent on the market forces that heating pellets are...it's a national market, and not regional. We're reaching out to retailers that we never would for heating pellets—it's been a unique challenge, going outside of our normal market. The freight angle is the battle."

Lisle highlighted the value of social media, particularly platforms like Instagram that uses hashtags, when it comes to grilling pellets. "It's all about the picture, everyone wants to see what everyone else is doing, and try new things."

Panelists also discussed fiber sourcing for grilling pellets. All agreed that while being open to smaller fiber suppliers could be advantageous, caution should be taken to avoid using any questionable fuel, though it is unlikely anyone would risk the liability. Additionally, all agreed that pellet standards, such as the PFI program in place for heating pellets, wouldn't serve the same purpose or offer much value for grilling pellet consumers.

"There is a lot of room for innovation in this space—the fun part is trying new things," Lisle concluded. "Ten years ago, we were barely talking about this. It's been a thrill watching it evolve."

Rounding out the day's discussion, pellet plant representatives reported on their perspective years, and shined some light on what might lie ahead. "We're looking at a strong 2019—the pipeline is clean from the manufacturer to the consumer," said Don Wagner of



As presented by the U.S. EIA's Connor Murphy while discussing the Monthly Densified Fuel Report and reiterated by several producer panelists, U.S. wood pellet inventory is the lowest it has been since 2015, which may lead to a strong 2019-'20 heating season for many manufacturers.

Appalachian Wood Pellet. "There is no inventory sitting around."

Everett Follett, pellet sales manager at Spearfish Pellet Co, said a colder-than-average February made a big difference, as extra orders came in. "We were down to 2,000 tons in the yard at one point," he said. "We're very optimistic for the upcoming year—we're already sold out. We are asking for orders a year in advance, which can be difficult for customers—some get upset when they can't get orders on demand."

On issues surrounding fiber constraints, BioMaxx has gotten creative and is looking deeper, but continues to try to determine what could be done differently," said Mike Sayers, chief financial officer. "I don't know if we have the answer yet—we're still trying to figure out how to better prepare for next time," he said.

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THE HIGH COST OF LOW-GRADE GREASE

Total cost of ownership, not just price per pound, should be the gauge by which pellet mill grease is measured.

BY RON KOTRBA

Lubrication Engineers provides an engineered grease that is made in a batch process to ensure quality and consistency.
PHOTO: LUBRICATION ENGINEERS INC.



Wood pellet production facilities consume significant quantities of grease daily. The equipment at the heart of operations, the pellet mill, consistently runs so hot and hard that the larger plants can spend hundreds of thousands of dollars per year on this consumable component essential to their operations. According to Harish Doshi, a lubrication reliability consultant with Lubrication Engineers Inc., a plant manufacturing 2,040 tons of pellets a day consumes on average more than 130 pounds of grease in that time. Holger Streetz, the director of international business development for Bathen, a Switzerland-based lubricant supplier, says North American pellet plants consume twice as much grease as their European counterparts, on average roughly 800 pounds per month. He says there are three reasons for this.

“The wood is different,” Streetz says. “Pelletting hardwood is challenging due to the much higher load. The Southern Yellow Pine is a great tree for biomass, but it is challenging for the equipment due to its relatively high hardness compared to other softwood, and it is rich in resin.” He also says in Europe many producers add starch as a lubricant, thus extending the life of their grease. Third, Streetz says the different type of mills used in Europe vs. North America plays a role in the disparate grease consumption rates between the two continents. Max Jaworski, North American market manager for the wood industry with Klüber Lubrication, says factors that influence the frequency and amount of relubrication include raw materials, facility climate and operation schedules.

With such high consumption volumes of what many consider a commodity, the natural approach for bean counters crunching numbers in the accounting department

might be to buy the lowest cost product to shave tens of thousands of dollars per year from expenditures. “Selection of grease for a pellet mill operation must be an engineered solution—certainly not a commodity product,” Doshi says. “Pellet mill grease must be treated as an asset.” As is often the case, the cheap comes out expensive when only one metric—price—is considered. But when the total cost of ownership is factored in, a premium grease should improve the bottom line of a pellet mill operation.

Basic Considerations

Grease is a vital component in many aspects of wood pelleting. Depending on the setup of the plant and whether the pellet manufacturing facility is adjoined with a sawmill or raw material flow, grease is essential from start to finish. “Everything from the green end including wire ropes on overhead cranes, take-up rolls on conveyor systems to transport raw materials, trun-



nion bearings on dryers to remove moisture from the raw material, and the heart of pellet production facilities—the pellet mills,” Jaworski says. If a pellet facility is directly connected to a sawmill, then the sawmill itself can rival pellet mills in grease consumption, Streetz says. Naturally, the pellet mills are where a great deal of grease is consumed in the pelleting process. “Especially the roller bearings,” Streetz says. “Depending on the type of equipment, the main shaft and jackshaft of the pellet mill consume grease too. Besides that, hammer mills need regular relubrication as well as conveying equipment.” Jaworski adds that high temperatures, loads and moisture of pellet mills, along with constant operation, require suitable lubricants to ensure efficiency and reliability of operations.

The type of grease best for the mill is typically determined or specified by the mill OEM, according to Doshi, but Streetz advises it is not a binding obligation to use the

recommended lubricants to maintain the manufacturer’s warranty. “However,” he says, “it makes sense to choose a lubricant that matches the recommended lubricants in terms of viscosity, temperature range and additives, especially extreme pressure additives.” Doshi says the basic type of proper grease for pellet mills is usually an NLGI 2 high-temperature grease with additives for wear protection. “Generally, OEMs will allow the use of alternative greases not listed in the OEM specification,” Doshi says, “but they usually require the alternative grease of interest to be submitted for OEM approval prior to use in their equipment to preserve the warranty.”

Grease consists of two main components—base oil and thickener—plus per-



Streetz

formance-enhancing additives. “The base oil is either mineral oil or synthetic oil,” Streetz says. “Thickeners range from aluminum, calcium or lithium, to complexes of those thickeners and perhaps bentonite for food-grade applications.” He adds that, for pellet production, grease must have extreme pressure additives to withstand the loads. “The temperature range should be between negative 20 and 360 degrees Fahrenheit because the bearings in a wood pellet mill can get very hot,” Streetz says. “The temperature range depends on the base oil, the viscosity and additives.”

Thermal stress is typically the reason grease fails in pellet applications. “A rule of thumb with lubricants is the 15-degree rule,” Jaworski says. “What this means is for every 15 degrees of temperature increase, the life of the lubricant is effectively halved.” When vibration is coupled with high temperatures, the grease breaks down from both oxidation and oil separation, ac-

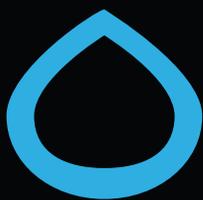
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Klüber Lubrication says a customer-focused support structure, including engineering, continuous product development and tribological testing, defines a superior lubricant brand.

PHOTO: KLÜBER LUBRICATION

According to Doshi. “Contamination from dirt and process materials can also become a concern when trying to extend bearing life,” he says. “These issues can typically be avoided by using a high-quality grease that does not separate under these conditions, as well as by relubricating with sufficient quantities of grease at the appropriate intervals to adequately purge harmful, abrasive contaminants from lubricated points.”

Streetz says provided the right grease for the application was chosen, a well-performing grease is stable and does not decompose within the given temperature range. “The lubrication abilities do not decrease too much over time and ideally provide some emergency features,” he says. “However, the best grease is for nothing if the wrong amount of grease is used. Over-greasing leads to self-friction of the grease shown by increasing temperatures when the bearing is still intact. Under-greasing leads to lack of lubrication. The bearings run dry and overheat with the potential threat of a fire. Additionally, the lubrication system needs to be checked on a regular basis to ensure functionality.” Thus, Doshi suggests

that for pellet mill applications, the most vital properties of a grease are resistance to oil separation in the presence of high temperature and vibration, good oxidation resistance, good pumpability where automatic lubrication systems are employed, and appropriate base oil viscosity to provide adequate film thickness for specific operating conditions.

Jaworski explains that grease quality can be judged in part by tribological testing, including industry test methods such as FAG FE-8, 4-ball wear and EMCOR corrosion testing, but Streetz says performance is often subjective and based on personal experiences. “I often hear, ‘The red grease is better than the white,’ or, ‘The beige better than the blue.’ Besides these soft factors, the additive package differs from supplier to supplier. There are only a few grease producers that mix base oils with thickeners and additives. The biggest difference in the greases is the additive package. Expensive lubricants tend to have more additives and therefore perform longer or better.”

Raw materials and the manufacturing process employed in grease production

largely influence the quality of lubricants, according to Jaworski. “For example,” he says, “a synthetic oil isn’t just a synthetic oil. There are numerous different grades and methods of achieving the end product, including the addition of viscosity improvers to achieve the desired viscosity. These additives have the tendency to break down from shear stress in applications, greatly reducing both the viscosity and the usable life of the lubricant.”



Jaworski

Synthetics revolutionized the automotive engine oil industry, and while Jaworski says synthetics have certainly influenced grease development, the consumable nature of grease in pellet applications has produced a more marginal impact. “The performance improvement most likely does not justify the costs,” Streetz says. Doshi says in his experience, greases with synthetic base oils are not as popular in the pelleting industry. “The vital properties needed in the pelleting industry can generally be provided by high-quality, petroleum-based greases, making it difficult to justify the additional cost of using a synthetic grease,” he says.

Jaworski says synthetic greases make up roughly half the greases used in the pellet industry. “The ability to improve the viscosity-to-temperature relationship, increase relubrication intervals and increase upper service temperature are all benefits,” he says. “In addition to improvements in base oils, greases have benefited from the development of new thickening agents. Complex soaps and synthetic thickeners have helped improve on older, simple soap technology. Synthetic thickeners boast many of the same benefits as synthetic base oils with improved viscosity-to-temperature relationships, increased relubrication intervals and increased upper service temperatures.”

When changing lubricant types or brands, Jaworski says it’s always important to consider compatibility, including compatibility between the thickening agents and base oils and whether the recommended grease provides benefits to the

user. Doshi adds, “The main consideration when changing products is the thickener compatibility of the two products. There are industrywide standards on what types of thickeners are compatible or incompatible. A thorough purge of the application or lube lines, if an auto-lube system is being used, is recommended when changing products to realize the full benefit of the new grease.” Streetz says some thickeners do not mix well, therefore it is important to verify the miscibility of lubricants or purge the lubrication system well.

Other considerations in lubricant selection beyond the manufacturer’s recommendations, according to Jaworski, include the customer’s specific needs. “This can include increased service intervals, reduced wear and cost reduction,” he says. “All are influenced by differences in the production process and must be addressed individually.”

Operating temperatures and environmental conditions should also be taken into account, Doshi says. “In addition,” he adds, “grease with the correct base oil viscosity should be selected to provide adequate film thickness under specific operating conditions—bearing size, and operating temperature and speed.”

Grease quality and consistency are two of the main variables between suppliers, Doshi says. “A grease can typically be broken down into thickener type, base oil type or viscosity, and additives, but there are countless variations in the quality of the raw material options, as well as in manufacturing processes.”

“All pellet producers I talked to have tested several lubricants in their plants,” Streetz says. “Most greases do not differ from another, because the base oil, thickener and additive packages are similar. Therefore, the price has become a major decisional parameter.”

Price vs. Cost

The per-pound price of grease is one way to look at costs, but the better, more preferred method is cost per ton of pellets produced. “We show our customers that the price per pound is not the key indicator for the performance of a lubricant,” Streetz says. Rightly or wrongly, price per pound can influence purchasing decisions.

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Pellet Mill Grease							
	Daily Pellet Production (MT)	Daily Grease Consumption (lbs)	Grease Cost (per MT)	Annual Pellet Production (MT)	Annual Grease Consumption (lbs)	Grease Cost (per lb)	Annual Grease Cost
Current Grease	2,040	140	\$0.34	701,760	48,160	\$4.95	\$238,392.00
Engineered Grease	2,040	98	\$0.27	701,760	33,712	\$5.70	\$192,293.25
						Annual Savings	\$46,098.75

TABLE 1: Cost of Grease per Metric Ton of Pellet Production

Pellet Mill Roller Bearing Life Extension													
	Bearing Life (hrs)	Hourly Production (MT)	Cost per Minute	# of Roll Bearings Per Plant	# of Unexpected Downtime Events Per Year	Cost of Bearings	Replacement Labor (per hr)	Replacement Labor (hrs per failure)	Downtime (hrs per failure)	Annual Labor Cost	Annual Loss of Production	Annual Cost of Bearing Replacement	
Current Grease	1,000	85	\$190.00	120	8.3	\$270.00	\$65.00	4	4	\$2,146.56	\$533,337.60	\$267,494.40	
Engineered Grease	3,300	85	\$190.00	120	2.5	\$270.00	\$65.00	4	4	\$650.47	\$161,617.45	\$81,058.91	
										Annual Savings	\$1,496.09	\$371,720.15	\$186,435.49

TABLE 2: Bearing Life Extension

In concert with Daniel Roberts, technical service manager for Lubrication Engineers, Doshi has developed these metrics to evaluate current and engineered grease costs and bearing life extension.

SOURCE: LUBRICATION ENGINEERS INC.

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“Unfortunately,” Doshi says, “it can be a large obstacle for customers who look at grease as price per pound instead of from a perspective of total cost of ownership. The use of a premium lubricant at a higher price per pound to reduce downtime, increase production capacity and reduce maintenance costs can usually negate the higher price of a premium lubricant. The use of a premium lubricant may also allow for these benefits to be obtained while reducing consumption, which can help close that gap even further.” In addition, Doshi says pellet producers can invest in a high-quality lubrication system to further increase the longevity of their grease and, in turn, their equipment. “By providing the right type and the right quantity of grease at the right time, a large portion of equipment failures can be avoided,” he says.

Pellet mills are high-value capital assets, and grease provides protection to the wearable components of these investments, Doshi says. The four criteria Doshi suggests for grease selection in pellet applications—resistance to separation, strong

oxidation-resistant chemistry, good pumpability, and appropriate base oil thickness—have a weighted average of greater than 80 percent, he says.

When considering changing greases, Doshi says performance evaluations from a business and profitability standpoint should yield significant improvements over current lubrications, including bearing life extension of three to four times over current practice, at least a 30 percent reduction in downtime and up to a 40 percent reduction in grease consumption—all at a cost of 34 cents per ton of pellets produced.

“Cost of operation is of the utmost importance to our customers,” Jaworski says. “Operating costs are affected by facility uptime, bearing life, grease consumption and preventative maintenance. We understand that grease is a large investment for pellet producers—and choosing a grease that reduces overall cost of operation is crucial.” As overall operating costs are influenced by grease costs, he adds, it is specific to each facility. “Typical grease costs are estimated to be between 35 and 50 cents

per metric ton of pellets produced,” Jaworski says. “To properly estimate this, the tons per hour produced by each mill combined with grease relubrication quantities are required.”

Streetz says Bathan lubricants have base oils and thickeners similar to its competitors, but the difference is with the additive package. “It contains ceramic particles that smoothen metal surfaces, thus reducing friction and wear,” he says. “The operating temperature drop of 8 to 10 percent is an indicator of the friction modification effect. Our unique performance proposition is a reduction of grease consumption by 95 percent. This reduces logistics to a minimum and often reduces the lubricant costs per ton.” Streetz says one of its U.S. customers with a production capacity of 150,000 tons per year is saving \$50,000 annually on lubricant costs alone by using Bathan grease. “Besides the environmentally friendly and often financially beneficial aspect of lower grease consumption, bearing life is extended by up to a factor of 10, thus saving substantial spare parts costs,” he

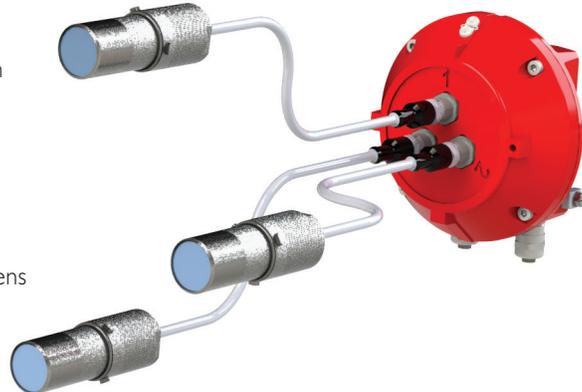
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says. “In Europe, some of our customers detect 8 percent lower energy consumption, which corresponds with the lower operating temperatures.”

With regular grease, the price is the most important indicator, according to Streetz. “With volumes and performance being similar, the price is the only adjusting screw for financial performance improvements,” he says. “With our grease, customers have the chance to outperform.” Jaworski says that in addition to the products, a customer-focused support structure—including engineering, continuous product development and tribological testing—defines a superior lubricant brand. Doshi says Lubrication Engineers utilizes a batch manufacturing process, which ensures quality and consistency of each batch prior to packaging.

Some have gone so far as to suggest that OEMs do not always specifically recommend the highest quality grease because they make their money on spare parts.

“Equipment manufacturers profit from the aftermarket selling of spare parts and services,” Streetz says. “Many pellet producers learned the hard way not to buy cheap. Since uptime is a key factor in pellet production, improving wear protection pays off.”

Ultimately, Doshi says an engineered grease product for pellet mill applications should yield an internal rate of return of more than 40 percent over any other candidate product or the current grease being used.

New Developments

Like any industry, there are many new developments going on in the world of grease. “Many of the changes are being driven by the growth of electrically powered vehicles coming in the future,” Doshi says. “Current research is being focused toward alternate thickener technologies instead of lithium—the most common thickener type—due to competition for use of the raw material lithium hydroxide for produc-

tion of batteries. Along with that, there are anticipations that increased electrification could put new requirements on conductivity testing for greases.” He says these requirements could affect additive selection, depending upon whether a grease needs to be conductive or insulatory. “Of course, efforts continue toward greases with an environmental slant,” Doshi adds. “For quite a few years now, efforts have been continuing to formulate ecofriendly—meaning nontoxic, nonbioaccumulative, biodegradable—greases. Much of this is now driven by the marine industry, but other industries are now also wanting those greases.” He says the other environmental option is energy savings. “This is very difficult to prove with greases, yet grease grading, thickener type, base oil selection and additive selection are all things that are hypothesized to play a role,” Doshi says. “The challenge is developing tests or capturing data from applications that can differentiate grease performance.”

Klüber Lubrication has created the first-ever hydro-based lubricants for gears, Jaworski says. “This is a product that utilizes the enhanced lubricity of water, reducing friction by up to 90 percent compared to oil lubricants,” he says. “All this is achieved without reducing load-carrying capability, netting scuffing loads similar to that of a polyglycol gear oil.”

Streetz says groundbreaking discoveries in grease technologies are rare. “We are glad to have our ceramic technology, which we formulate with more and more lubricants, ranging from sea-waterproof to H1-certified food grade,” he says. “With our food-grade greases we already have a cutting-edge technology setting a new standard according to FDA regulations. New levels of lubrication can be achieved in cooperation with equipment manufacturers and suppliers. There are approaches to a once only lubrication of roller bearings and new concepts of distribution, where uptime is sold rather than spare parts.”

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SAFETY FRONT AND CENTER

The Wood Pellet Association of Canada's Safety Committee is striving to eliminate incidents in the wood pellet industry.

BY GORDON MURRAY

Regular crew meetings are vital for developing and maintaining a positive safety culture.

PHOTO: PINNACLE RENEWABLE ENERGY

In Canada, British Columbia's sawmill industry experienced two horrific incidents in 2012. Explosions occurred at the Babine Forest Products sawmill in Burns Lake, and at the Lakeland Mills sawmill in Prince George, killing four workers and injuring 42 others. In both cases, the provincial safety regulator WorkSafeBC concluded that the explosions were caused by combustible wood dust.

In response to these two incidents, WorkSafeBC put an intense emphasis on enforcing effective combustible dust management in the sawmill industry in order to prevent similar tragedies. By mid-2014, WorkSafeBC concluded that the wood pellet sector had not responded adequately and was an especially poor performer in minimizing the risk of fires and explosions from combustible dust. The agency threatened to increase safety-related stop worker orders, fines and even shut down our entire industry if we could not show significant improvement.

Members of the Wood Pellet Association of Canada realized that WorkSafeBC was correct in its assessment. WPAC's mandate—originally limited to commercial aspects of the wood pellet trade—was expanded to

include safety. WPAC formed a safety committee, made up initially of British Columbia-based members focused on combustible dust management, and soon expanded to members from across Canada focusing on all aspects of wood pellet safety. Committee members, backed up in writing by their company CEOs, made two significant commitments: There will be no competition amongst WPAC members related to safety, with all safety resources being shared openly; and the committee would adopt a culture of openness with WorkSafeBC and other safety regulators.

On the issue of combustible dust management, the committee's work consisted of: researching and documenting best practices; understanding regulatory requirements; preparing and publishing a combustible dust audit tool and auditor workbooks; holding training workshops; and individual committee members holding themselves accountable in reporting back to the group at large on progress in improving dust collection systems, housekeeping and audit completion.

As the committee's focus expanded to safety issues beyond combustible dust, we began preparing and publishing an annual safety work plan and meeting with WorkSafeBC

twice a year to review the committee's progress against the work plan. The committee's purpose for publishing the work plan is to hold ourselves publicly accountable for our commitment to safety. The committee manages the work plan by sharing work amongst all committee members, and then reporting back via a monthly conference call.

The committee publicly released its 2019 Work Plan on Jan. 18. Current year focus areas include the following:

Process safety management. Process safety management is an analytical tool focused on preventing the frequency and severity of major catastrophic Events. The committee has been focusing on PSM for several years and holds annual training workshops. This year, we are planning a workshop on Bowtie Analysis, a risk method for analyzing and demonstrating causal relationships in high-risk scenarios. We will be identifying potential major unwanted incidents common to all operators in the wood pellet sector, and creating bowties for controlling each incident. The method takes its name from the shape of the diagram that's created for each potential incident, which looks like a men's bowtie.

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Silo fires: risk assessment and response. In February, the committee held a workshop on silo fire management that was attended by nearly 100 wood pellet plant operators, maintenance personnel and municipal fire department personnel. The top takeaways included: Do not open a silo to allow oxygen to reach the fire so as to prevent an explosion; use proper protective clothing, breathing apparatus, and a personal gas monitoring devices; do not use water for fire suppression; create an emergency response plan to have on hand in case of a silo fire and hold drills; use nitrogen for fire suppression.

WPAC's next step is to develop a centralized liquid nitrogen storage facility for rapid fire response in Northern British Columbia.

Plant operator training and use of alarms. The committee is working with a facilitator and plant operators to develop a list of core competencies and a web-based training program to be used by plant operators across the wood pellet industry. We are also planning a fall workshop on human-computer interface design, display levels, visual clutter, situation awareness, alarms, etc.

Combustible dust management: raw product storage areas, general training and combustible dust hazard analysis. The committee has developed best practices for managing combustible dust in raw products storage areas, including a comprehensive list of potential ignition sources and mitigating measures.

Combustible gas and confined space entry. The committee has developed best practices for combustible gas awareness and risk mitigation. We have developed a list of hazards and have documented mitigating measures for each hazard. We are working with WorkSafeBC to embed our best practices into the B.C. provincial regulatory framework.

In June, we held a combustible gas training workshop during the Wood Products Safety Summit in Prince George, B.C.

Training and supervision of workers. We have already held two safety events in 2019, including the February silo fire workshop and the Wood Products Safety Summit held in June, in Prince George. We are planning two more workshops in the fall on the subjects of process safety management and human-computer Interface, and will be holding a safety session at the WPAC annual conference in Ottawa in September. We are also working on an operator training program.

Incident reporting—review and trend analysis. We held a November 2018 workshop on incident reporting. The committee has developed a central database to record incidents and near misses. When we have accumulated sufficient data, we will use the findings to guide future safety focus areas for the committee.

Communications: We will develop a clear plan to support safety improvements across all members.

In keeping with past practice, the committee has released its 2019 Work Plan, and created a safety website as a central repository of all its work and minutes of meetings and conference calls. We continue to encourage member participation. We have also reached out to other international pellet organizations to share knowledge. We successfully formed a cooperation with the European Pellet Council, and for the past two years, we have participated in joint safety sessions at various meetings of the European Pellet Council. Disappointingly, we haven't had the same degree of success with our American colleagues.

Scott Bax, chief operating officer of Pinnacle Renewable Energy, is the chair of our

committee. He often presents on the topic of safety. One of his favorite quotes is attributed to the late management guru Peter Drucker: "Culture eats strategy for breakfast." This statement is an acknowledgement that no matter how sophisticated an organization's mission statements, visions and strategies may be, nothing will ever be accomplished if people don't share common beliefs and have the willingness to embrace those beliefs together. In our experience, it takes a serious, continuous sustained effort and support from the industry's top management for us to achieve our safety goals. And despite our best efforts, we have continued to experience a small number of safety incidents in Canada. We will continue our focus on improving, striving to reach a state where our industry no longer experiences any safety incidents and we send all our people home safely every day.

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WHY HASN'T TORREFACTION TAKEN OFF?

BY THOMAS P. CAUSER

For well over a decade, numerous academic institutions, research institutions, governmental agencies, and private industries have focused on torrefaction technology, with a goal of bringing it to viable commercial status. Upon commercialization, torrefaction will play a crucial role in transitioning our society to a circular economy, where carbon-containing materials will be recycled, lowering overall carbon emissions and combating climate change.

Torrefaction has long been envisioned as the next logical step in the production of an engineered fuel from biomass which, because of its advanced characteristics, could ultimately replace white wood pellets. When compared to white wood pellets, the superior characteristics of densified, torrefied biomass include lower moisture content, higher energy density, greater bulk density, hydrophobicity, resistance to biological activity, improved grindability, and a relatively uniform particle size distribution. These characteristics translate into lower transportation costs, much higher cofiring rates, and lower cost-of-use for the customer. It is for these reasons that torrefaction has received so much attention.

Countless press releases and announcements have heralded supposed torrefaction successes only to be followed by deafening silence, with the exception of occasional news reports of fires, explosions and failed ventures. Many

millions of dollars have been spent without a single example of large-scale, ongoing commercial success. Investors have become disillusioned, and many potential customers have all but given up on the idea that torrefaction will ever be commercialized. This inevitably leads to the question, “With torrefied biomass holding such promise, what is holding it back from commercial success?”

This article discusses the underlying issues hindering the commercialization of torrefaction, and then proposes a change in system design that resolves these problems. But first, it is helpful to understand the issues not barring the commercialization of torrefaction. It's not high capital costs, which are approximately the same as the capital costs associated with white wood pellets on an energy basis. It's not high operating costs, as are approximately the same as those associated with white wood pellets (again, on an energy basis). It's also not feedstock costs—the torrefaction process can economically use the same feedstocks as used in the manufacture of white wood pellets, plus additional feedstocks such as forest slash that are generally not usable by white wood pellet manufacturers, and these lower-quality feedstocks are generally available at a lower cost.

So what has prevented the commercialization of torrefaction despite so much effort over so much time? The answer to that question centers around one root technological problem,

and the failure to properly address that problem results in issues with process stability, system reliability and safety.

The Real Issues

Torrefaction is a low-temperature thermochemical conversion technology that results in the chemical decomposition of carbon-based materials through the application of heat, resulting in a devolatilized, hydrophobic, easily grindable, solid, high-carbon product.

Devolatilization yields torrefaction gases that include both carbon dioxide and carbon monoxide, in addition to a variety of condensable components such as acetic acid, formic acid, methanol, lactic acid, furfural, hydroxyacetone and water. These torrefaction gases contain a tremendous amount of energy. For an economically viable torrefaction system, it is critically important that this energy be utilized efficiently in the system. But these gases are also highly reactive and can rapidly polymerize into heavy molecular weight bio-oils. Current torrefaction gas handling systems are based on traditional thermal oxidation technologies—burning the concentrated torrefaction gases to produce heat in the form of a hot flue gas. Although this traditional approach seems like an obvious choice, actual operations have revealed major shortcomings, predominantly because the oxygen content of that flue gas is too high to be used in direct contact with the biomass.

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Process design efforts undertaken to overcome this shortcoming result in unacceptably high concentrations of volatile gases in the system, and that is the root cause triggering the problems preventing commercial-scale torrefaction.

In general terms, here is what's happening: Because of the high reactivity and concentration of the torrefaction gases, it is difficult to handle them safely and effectively. To make matters worse, the gas pressure can fluctuate, resulting in unstable flow and subsequent process control issues. This is true whether a directly heated torrefaction reactor technology or an indirectly heated torrefaction reactor technology is employed. Traditional thermal oxidation technologies must adjust for these conditions by using excess combustion air, and that produces an oxygen-rich flue gas that cannot be used in direct contact with the biomass. This severely limits the efficient use of this energy source inside the torrefaction reactor, and in other system applications such as cooling. Directly heated reactor designs attempt to deal with this situation by continuously recycling the concentrated torrefaction gases, via a heat exchanger, as outlined several years ago by torrefaction technology company ECN. Indirectly heated reactor designs allow the gases to concentrate inside the reactor and basically reside there for an extended period of time before being expelled from the reactor simply by the buildup of internal gas pressure. As a result, in both cases, these volatile gases are present in high concentrations. This situation leads to process stability issues and can result in condensation of the gases into pyrolysis oils and tars, which then build up relatively quickly on equipment, in piping, and on process monitoring instrumentation. Formation of these pyrolysis oils and tars not only creates a dangerous environment, but it also disrupts operations requiring frequent shutdowns for cleaning. Even minor leaks of concentrated torrefaction gases create an unacceptable workplace environment and safety hazard. In addition, torrefaction gases continue to diffuse from the solids upon exiting the reactor. This situation can create both environmental and safety issues.

Finally, torrefaction involves heating biomass to well beyond its auto-ignition temperature. If the torrefied biomass is exposed to air prior to cooling down, it will burst into flames, potentially causing catastrophic loss.

In all cases, process interruptions can and often do occur. A commercially viable process must be capable of operating 24/7, without interruption, for months at a time. Achieving uninterrupted operations without effective handling of the torrefaction gases is not possible.

Handling Gases

What is needed to effectively handle torrefaction gases? The logical solution is to adopt a torrefaction system design that uses a very large and continuously available quantity of inert gas. The torrefaction reactor must be continuously flushed (purged) with a hot inert gas stream at torrefaction temperature, diluting the torrefaction gases and quickly removing them from the reactor, away from the torrefied solids.

An inert purge gas will reduce the concentration of the torrefaction gases to a very dilute, small fraction of its original concentration; stabilize gas flows from the reactor; and significantly shorten the lifespan of the torrefaction gas components, thereby greatly reducing the opportunity for creation of pyrolysis oils and tars.

A secondary benefit of this purge and dilution strategy is a dramatic reduction in the possibility that the volatile gases will condense onto the surface of the torrefied solids at the point in the process where the solids are about to exit the reactor. Condensation onto torrefied biomass has been observed by multiple technology developers and is detrimental to

product quality and environmental compliance downstream of the reactor.

The need for a large and continuously available quantity of inert gas begs the question, "Where does it come from?" Purchasing or generating (and heating) that much inert gas is likely to be cost prohibitive. Thus, an alternative approach is necessary. The solution is a torrefaction gas handling system that uses an oxidation catalyst instead of a thermal oxidizer. Oxidation catalysts have a long and successful history of use in industrial and environmental applications. They very effectively oxidize a wide range of volatile organic compounds such as those contained in the torrefaction gases, and in the process can create a large volume of hot, essentially inert flue gas as a no-cost by-product of the oxidation. Use of this free inert gas throughout the torrefaction system will address and resolve the process stability, system reliability, and safety issues currently preventing commercial-scale torrefaction.

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