Mechanical Conversions

Lecture 11 – Drying, & Densification

When you have a chance please visit the attached link on the largest biomass energy plant in the world. It is located in Poland and is rated at 205 MW. It will utilize over 1 million tons biomass every year, 80% of which should come from purpose grown tree farms.

http://biomassmagazine.com/articles/9072/gdf-suez-inaugurates-205-mw-biomass-plant

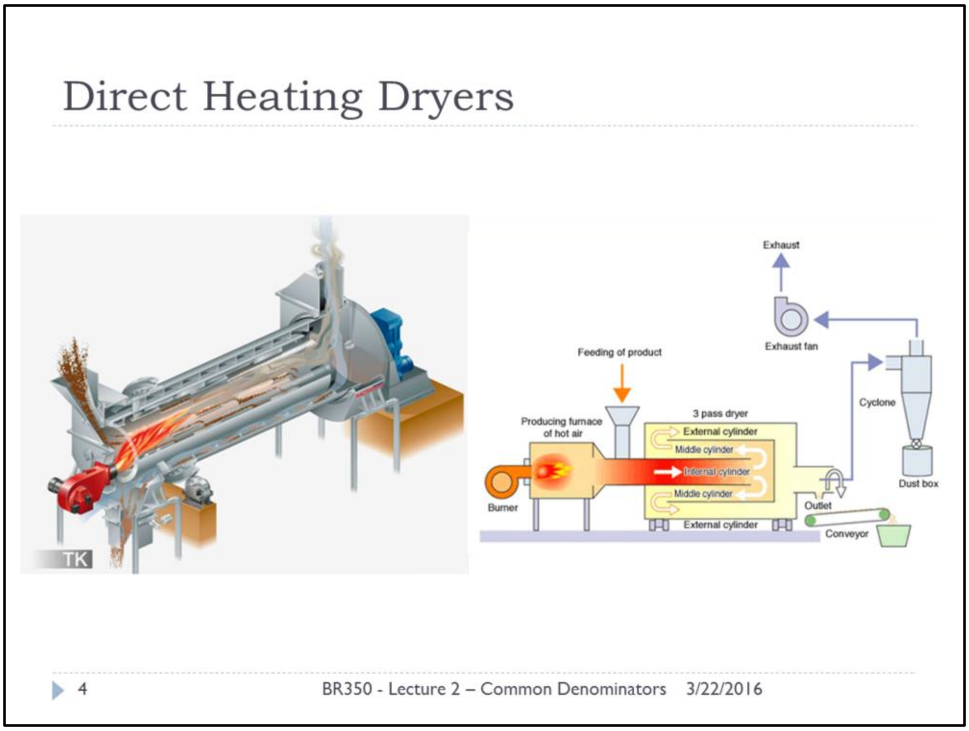
Week 4 – Mechanical Conversions

-Learning Objectives-

- Explain the mechanical conversion of biomass.
- Identify things in your day to day life that use mechanical conversions of biomass.

Drying

Biomass is almost always wet and often at least some of this water has to be removed before it can be used/processed. Drying is a very expensive and often overlooked step in using biomass.

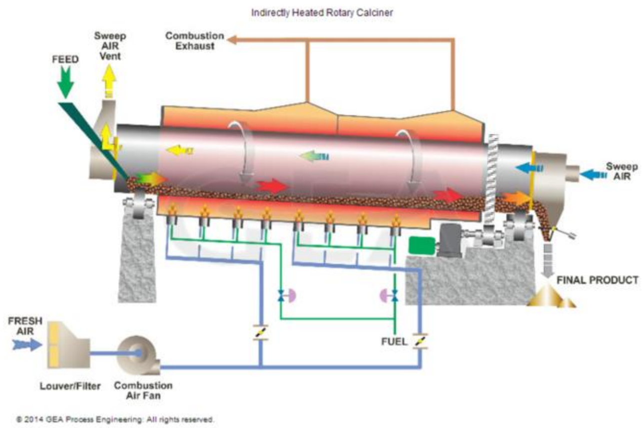


http://www.almoprocess.com/content/drying-and-cooling-drum-dryer

http://www.arakawa-mfg.co.jp/english/products_rotarydryer.html

The cheapest way of drying is called direct heating. These dryers blow hot combustion air directly on the feed that needs to be dried. While this is cheaper and easier, it is also harsher and much easier to damage the biomass.

Indirect Heating Dryers



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http://www.barr-rosin.com/technologies/rotary_drying_cooling_calcining.asp

These dryers contact the feed that needs to be dried with some kind of metallic heat exchanger. Indirect heating is more expensive, but much more controllable than direct heating. Indirectly heating of biomass is more common these days since it safer and often more manageable.

Wood Dryer Efficiencies

- Wood Kilns for drying lumber require 1800-4000 BTU/lb water evaporated
- Veneer dryers for drying the veneer in plywood require 1500-2000 BTU/lb water evaporated
- Particle dryers for drying sawdust require 2000-3000 BTU/lb water evaporated
- Paper dryers for drying paper require 1300-1600 BTU/lb water evaporated

Efficiency = (1000 BTU/lb) / (energy used)

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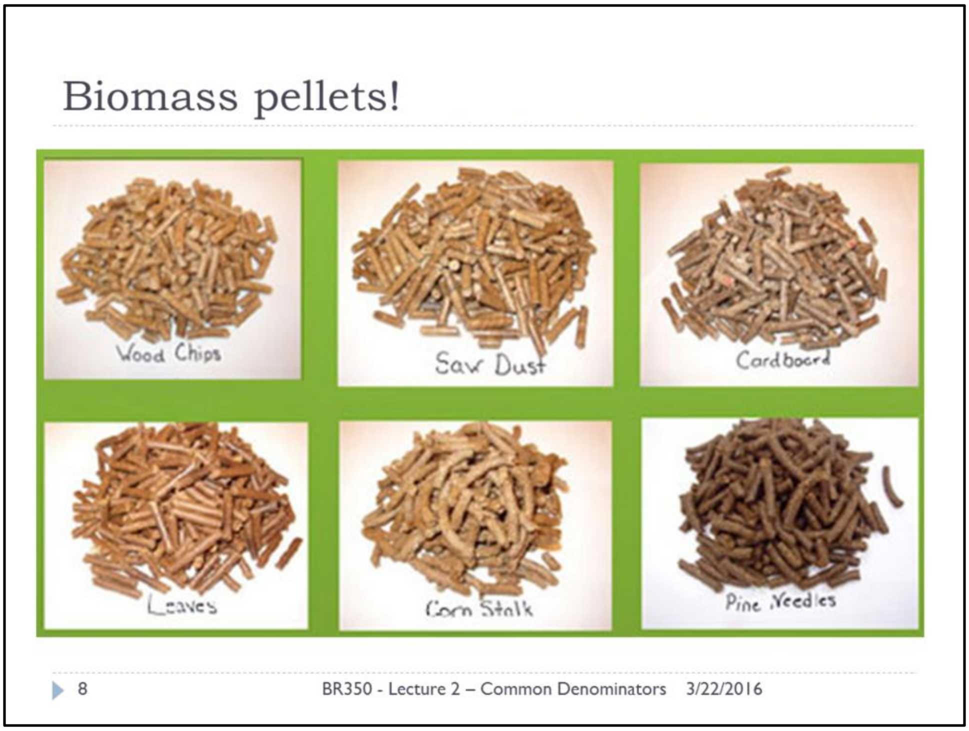
It is clear that drying wood is expensive. A BTU measures how much energy is needed to heat one pound of water by one degree. A gallon of water weighs 8 lbs., so it should take about 350 BTU to evaporate if it is sitting in a pot and being heated with perfect efficiency. Sadly, in the real world of thermodynamics perfect is not an achievable thing. Biomass drying requires a massive source of energy because removing water from biomass is harder than getting it to boil out of a pot. Wood dryers are not all that efficient because its hard to heat awkward solids like biomass. As a result we end up requiring a lot of energy to dry biomass.

Densification/pellets

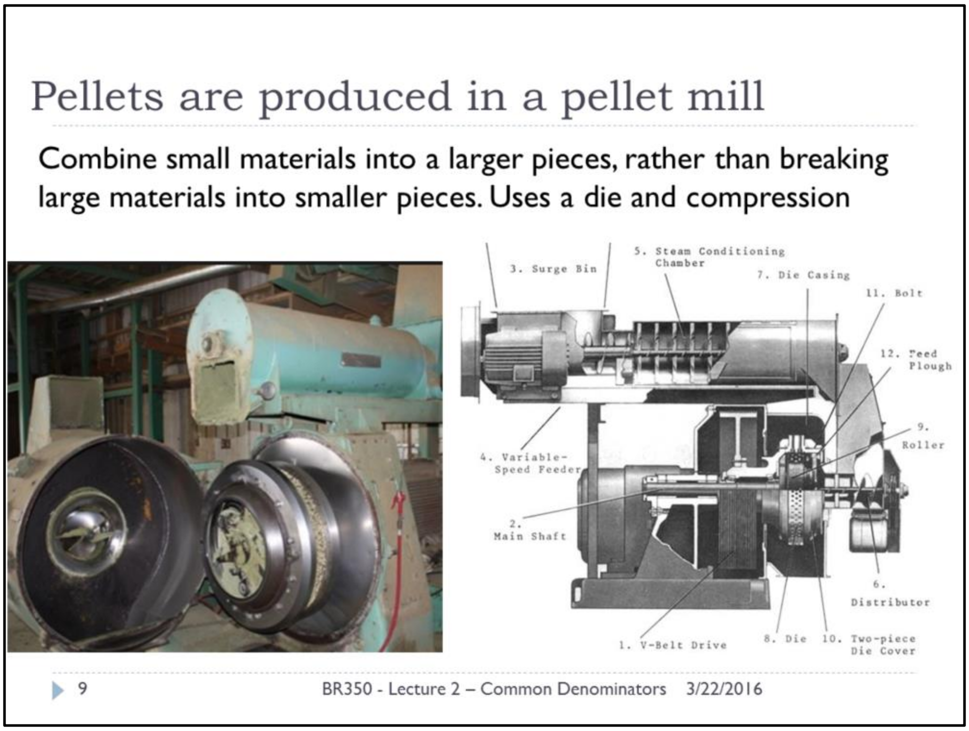
As a non-compressed solid, natural biomass is not very energy dense compared to oils and coal. Pellets are ~ double the energy content of wood chips.

In a lot of ways pelts are looking like the future of small scale biomass combustion. They are much easier to handle than firewood and like was previously mentioned, they are an engineered fuel. They can be used in a precisely engineered manner, which increased efficiency and uptime. Pellet plants are operating all over the nation and in many states have taken over plants that ere previously used to produce particle board and fiber board. New designs for better utilization of pellets are happening all the time and this area of bioenergy promises to be interesting area of development for years to come.



http://www.pellet-press.com/News/biomass-pellet-machines.html

Pellets are an excellent way to take loose biomass and make it uniform and high density. You can make pellets from any solid you can get to flow. Its amazing to look at pellets and think about how different all those sources are, yet the pellets look similar and would probably work in similar systems. This would be like being able to put gasoline or diesel into an engine and have it work just fine. Being able to make pellets from anything is a big deal.



http://en.wikipedia.org/wiki/Pellet_mill

http://www.fao.org/docrep/x5738e/x5738e0j.htm#4. pelleting

The pellet mill is almost the opposite idea of the grinder or chipper. The goal of the pellet mill is to ….

As this happens quite a bit of heat is generated from all the friction. This heat tends to melt some of the lignin on the outside of the pellet and it gives it a harder surface. When you hold a wood pellet and notice that it’s a hard on the outside and a little shiny, that’s because of this lignin melting and reforming process. Pelletizing doesn't work well with all forms of carbon, but it works very well with biomass.

Pellets increase the energy available in a given volume

Must remember the differences between energy/mass and energy/volume!

Pellets are approximately double the energy/volume compared to starting biomass

Feedstock	Bulk Density (kg/m3)	Energy Content (MJ/Kg)	Energy per Gallon (MJ)	Approx Pellet Density (kg/m3)	Energy per Gallon Pellets (MJ)
Sawdust	606	20.1	46.10	1231	93.65
Bark	676	20.1	51.43	1248	94.95
Logging Leftovers	552	20.8	43.46	1222	96.21
Switchgrass	445	19.2	32.34	1113	80.85
Wheat Straw	475	16	28.77	1188	71.92
Barley Straw	430	17.6	28.64	1075	71.61
Corn Stover	550	17.8	37.06	1375	92.64

Lehtikangas, Päivi. "Quality properties of pelletised sawdust, logging residues and bark." *Biomass and Bioenergy* 20.5 (2001): 351-360.

Pellets do not change the chemical composition of the biomass, they just change the form the biomass is packaged in and by doing so noticeably increase the energy per unit volume. So, you get way more biomass energy per gallon than you would if it wasn’t pelletized. This does different things for different sources of biomass – corn stover for example goes from being a poor fuel as a loose biomass to being as compelling as something like sawdust after its turned into a pellet.

Compared to conversions that increase energy available in a given mass

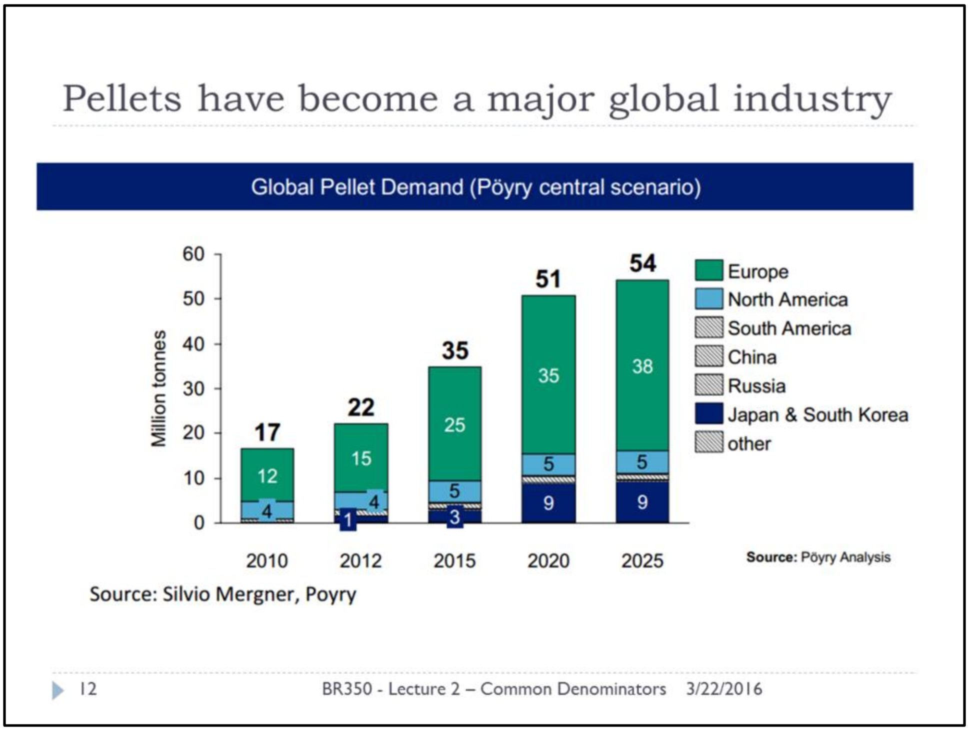
Must remember the differences between energy/mass and energy/volume!

Charcoal has approximately 20-30% greater energy/mass compared to starting biomass

Feedstock	Energy Content (BTU/lb)
Wood	8500
Wood Pellets	8500
Torrefied Wood	10,500
Coal	15,000

http://torrproc.com/torrefied-wood/torrefied-wood-vs-wood-pellets-vs-coal/

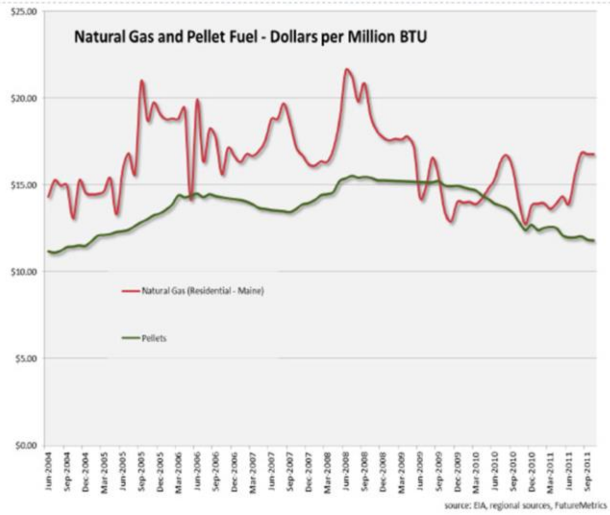
It is important that we are clear about pellets increasing energy per unit volume compared to energy per unit mass. Once more, pellets increase energy per unit volume. If you want to increase energy per unit mass the most desirable conversion is thermal to make charcoal, not mechanical to make pellets. Making charcoal changes the chemical composition of the biomass and increased its energy per unit mass. So, something that is 10 BTU/lb. can become 13 BTU/lb. The table tries to make this comparison between wood, wood pellets and charcoal.



http://www.pellet.org/about/publications

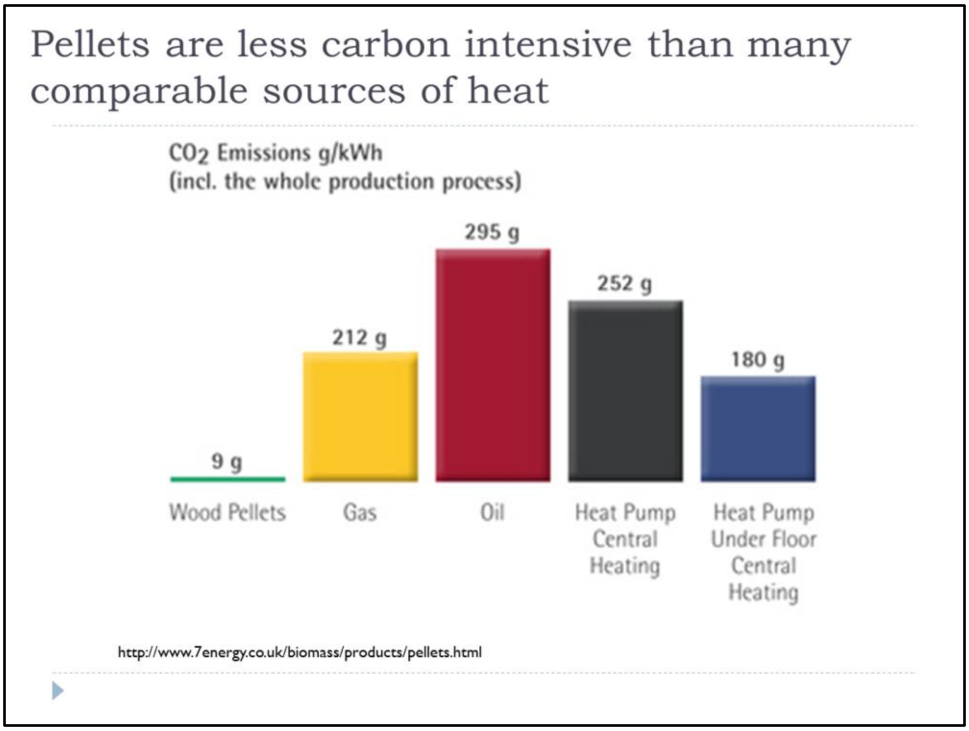
It's hard to imagine using 54 million tons of wood pellets. Pellets sell for around \$250-300/ton, so that a lot of money in pellets. Only a few parts of the world grow enough wood to support that level of demand and NA is one of them, so this is a growth area worth paying attention to.

Pellets contain quite a bit of energy considering their price

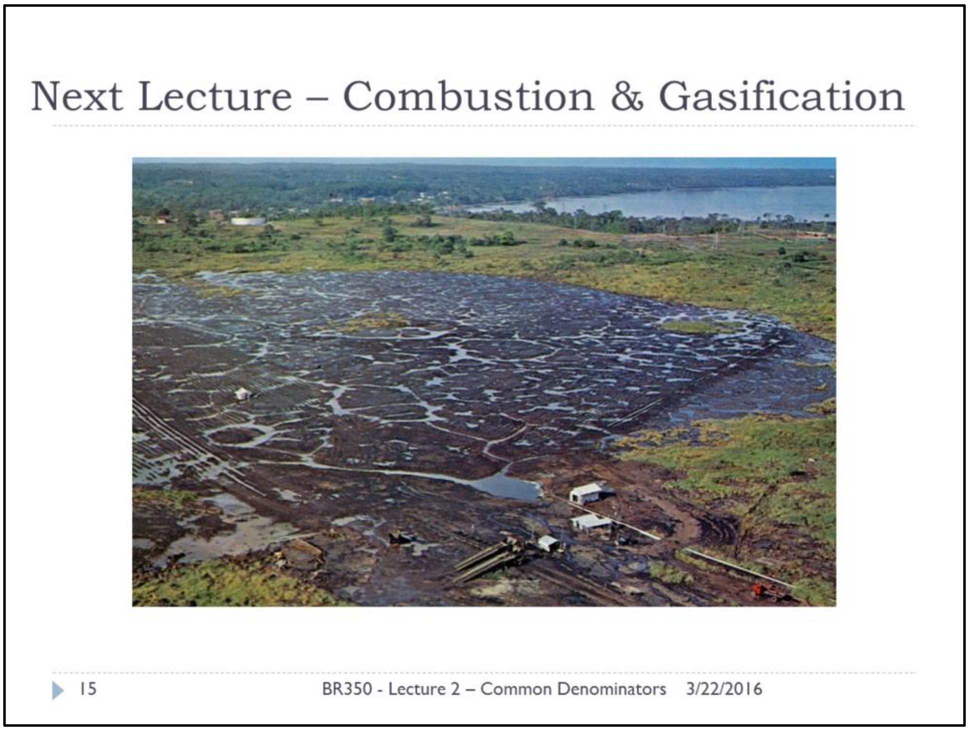


http://thepelletco.com/heat-sale/heat-sale-frequently-answered-questions/

Pellets sound a little silly in our current world of natural gas until you consider availability and market conditions. Pellets are easy to store and easy to produce when needed, so they don’t require expensive LNG facilities and they aren’t subject to the same market fluctuations because they are more distributed than centralized. This is very clear when looking at natural gas and pelt price fluctuations. There are some very good reasons to consider pellet heating.



On the whole, because they are produced by a renewable resource, pellets have a lot going for them. They are also not nearly as carbon intensive to produce as liquid fuels, so they are much more sustainable than biofuels as well. A car that efficiently ran on pellets would be quite a thing.



http://www.amusingplanet.com/2012/10/pitch-lake-trinidad-largest-natural.html

The article in the attached link is about a tar lake in Trinidad. As the world fights over oil, it is always interesting to think about how there are still lakes of oil all over the world that aren’t considered for production. They aren’t considered because the oil is low quality compared to what we use today, but that is becoming a silly idea as we watch the tar sands of Canada and shale oil production continue to become more commonplace. I don’t know how long it will be before we considering trying to produce oil from these tar lakes and tar reservoirs, but it certainly casts light on the complexity of what technically recoverable reserves mean and what the future of hydrocarbon on earth looks like.