Mechanical Conversions

Lecture 10 – Oil Extractions & Size Reduction

When you have a chance please visit the attached link to an article about a robot designed in NZ to log trees. Logging has become very automated to make it safer and faster, and as this development continues it is only natural to think that the majority of logging may someday be done by robots instead of people. Robot logging is a prime example of a mechanical conversion from tree to log.

http://www.stuff.co.nz/national/education/9859457/Tree-felling-robot-nabs-design-award

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.

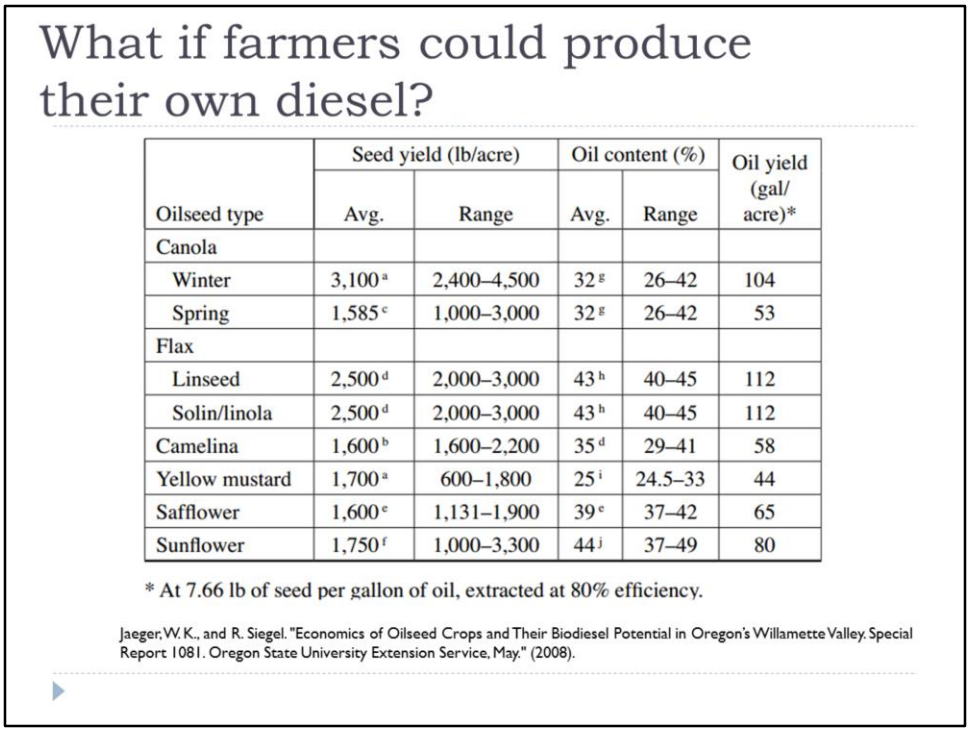
Biomass Conversion Pathways

- Mechanical Conversions – normal everyday conditions
  - Crushing oil seeds and algae
  - Densification
  - Chipping and grinding
- Thermal Conversions – over 400 ˚C
  - Combustion (excess oxygen produces excess heat)
  - Gasification (heat with some oxygen)
  - Pyrolysis (heat with no oxygen)
- Chemical Conversions – under 400 ˚C
  - Biomass breakdown to components (acid, base, solvent, enzyme)
  - Biomass components to fuels & chemicals (endless possibilities)
  - Oil Conversions
- Biological Conversions – mild, wet conditions
  - Fermentations (microbes without oxygen)
  - Photosynthetic organisms and animals

Crushing/Pressing Oily Biomass

Humans have been doing this since ancient Greece (we are better at it now). Can be done with grind-stones, screws, rams, plates, etc.

Crushing oil plants and oilseeds to make oil has been done for a very long time. This is not a complicated process which is great because it means it can be done easily. However, unless the process is made to be a little more complicated it is not always super efficient, so there are tradeoffs. At its most basic you literally just squeeze the oil out of the biomass. If you want to get every last drop of oil, you increase the intensity and the number of steps.



What if farmers could produce their own diesel?

Oilseed type	Seed yield (lb/acre) Avg.	Seed yield (lb/acre) Range	Oil content (%) Avg.	Oil content (%) Range	Oil yield (gal/ acre)*
Canola					
Winter	3,100 [a]	2,400–4,500	32 [g]	26–42	104
Spring	1,585 [c]	1,000–3,000	32 [g]	26–42	53
Flax					
Linseed	2,500 [d]	2,000–3,000	43 [h]	40–45	112
Solin/linola	2,500 [d]	2,000–3,000	43 [h]	40–45	112
Camelina	1,600 [b]	1,600–2,200	35 [d]	29–41	58
Yellow mustard	1,700 [a]	600–1,800	25 [i]	24.5–33	44
Safflower	1,600 [e]	1,131–1,900	39 [e]	37–42	65
Sunflower	1,750 [f]	1,000–3,300	44 [j]	37–49	80

* At 7.66 lb of seed per gallon of oil, extracted at 80% efficiency.

Jaeger, W. K., and R. Siegel. "Economics of Oilseed Crops and Their Biodiesel Potential in Oregon's Willamette Valley. Special Report 1081. Oregon State University Extension Service, May." (2008).

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What if … This chart makes it pretty clear that canola and flax are the most compelling. There are a lot of people that believe biofuels make the most sense on the farm and maybe they are correct. A suburban homeowner or an urban resident in a highrise can't grow enough canola to fuel their car for a year, but a farmer might be able to if they set aside 10 acres to cultivate strictly for their own fuel use. Its worth thinking about.

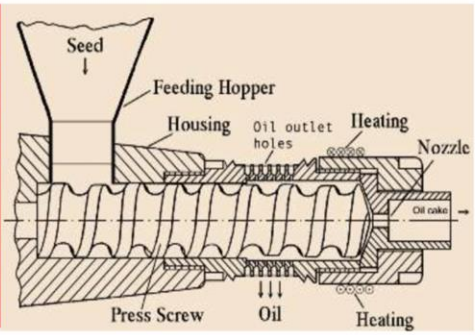
Extracting oil from oilseeds is globally important for rural bioenergy

Oil Extractor	% Oil Extracted
Industrial Screw Expeller	80 - 90
Mid Size Screw Expeller	70 - 80
Manual Screw Expeller	50 - 60
Ram Press / Piston	40 - 60
Ghani (Mortar & Pestle)	20 - 30

Shankar Haldar; Expellers in India and Expelling Operations, Inspire Network for Environment, Dept of Science and Technology Govt of India; June 2012

These are the different types of mechanical oil extractors. They can all be manual or automated. Sometimes the simplest solution is the best in rural areas and rural areas often have the greatest need for what bioenergy offers.

Screw Expeller

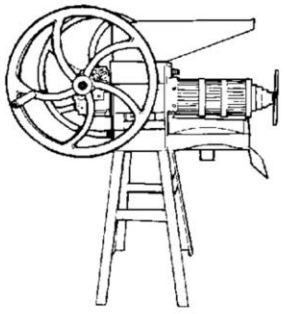


Shankar Haldar; Expellers in India and Expelling Operations, Inspire Network for Environment, Dept Science and Technology Govt of India June 2012

Read slide

Most efficient mechanical extractor with 50-90% oil recovery depending on level of complexity.
A screw press that moves the oily material forward and crushes it against a grate or side wall. Heat, pressure and RPMs all contribute to efficiency.

Ram Press or Piston



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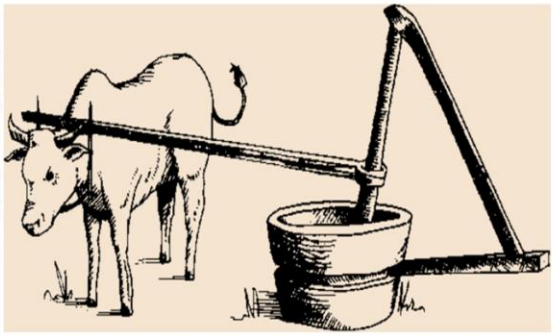
Second most efficient mechanical extractor with 40-60% oil recovery depending on level of complexity.

A ram or piston or plate press crushes the oily material into a small hole with an oil drain port. Heat and pressure contribute to efficiency.

Ghani (mortar & pestle) – state of the art in some places



Shankar Haldar; Expellers in India and Expelling Operations, Inspire Network for Environment, Dept Science and Technology Govt of India June 2012

Lowest efficiency mechanical extractor with 20-30% oil recovery depending on level of complexity.
Easiest to implement if you don't have a lot to work with.

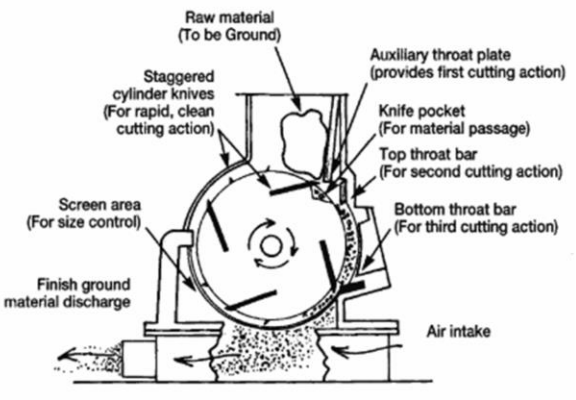
Chipping & Grinding Biomass

Logs and bales have to be turned into something easier to transport and feed into processes. This is often referred to as size reduction.

Chipping and grinding biomass is an absolute requirement for using it many cases. However, it also time consuming, energy consuming, and expensive.

An easy way to think about is that the tree or plant spent a lot of time and energy from the sun creating a large solid. So, to turn that large solid back into small solids we have to undo all that work and that costs a lot of energy. Every time you make it smaller, you have to spend energy and time … kind of like chewing. Chewing your food 200x before swallowing would take time and it would probably make your jaw tired from expensing so much energy.

Hog mills are a common way of grinding biomass very roughly

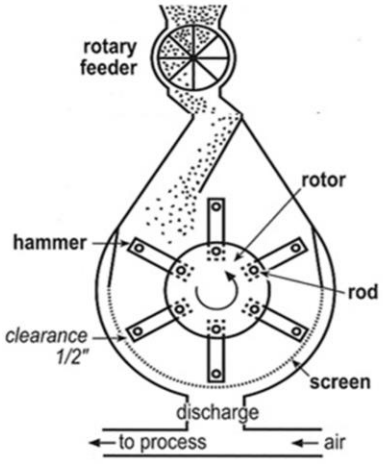


http://www.jordanreductionsolutions.com/product-grinder.html

http://www.coemfg.com/prod/img/hog_600.jpg

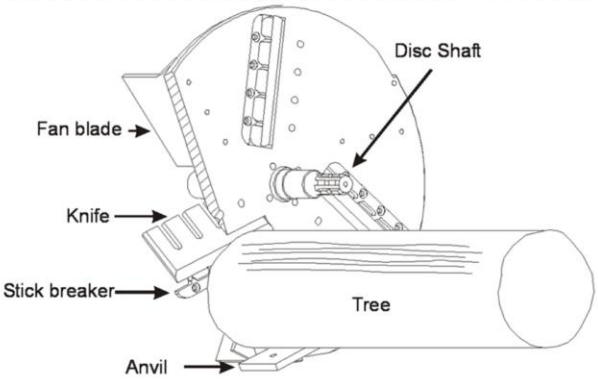
A sharp, heavy fixed hammer forces biomass material through a large grate, grinding it into a chunk or rough chip.

Hammermills are a common way of grinding biomass very fine



A sharp, heavy swinging hammer forces biomass material through a small grate, grinding it into a sawdust or wood flour type product.

Chipping is different than grinding because it is more precise



http://www.woodproductsonlineexpo.com/content.php/12/2111/brunette_industries_drum_chipper.html

http://www.woodenergy.ie/woodharvestingequipment/

A chipper uses sharp knives and specific geometry to produce a very consistent chip type that meets process needs. There are several kinds of chippers (gravity/disk, horizontal feed, drum/disk, etc.).

Because we need to be able to easily move it around trucks, trains, ships and processing facilities. This has to be done with conveyors (belt, screw, pneumatic, etc.).

You chew your food so that it can be conveyed by your throat down into your stomach. If you don't chew your food you might choke, same idea here. The biomass needs to be reduced in size that it can be conveyed easily.

Next Lecture – Drying & Densification/Pellets

15 BR350 - Lecture 2 – Common Denominators 3/22/2016

When you have a chance please visit the attached link in wastewater sludge pellets. Wastewater sludge is very hard to use because it is so wet and often so hazardous. However, some innovative people are working around that by using a mechanical conversion and pelletizing it. Take a look and think about ways you might use a wastewater sludge pellet.

http://grist.org/article/2009-05-06-sludge-energy-business/

http://www.kitv.com/news/hawaii/fertilizer-made-from-human-waste-used-at-city-parks/24675304#!bwVcSj