Soy Excellence Center
SEC Feed Manufacturing Track – Basic Level

SOY EXCELLENCE CENTER
A USSOY program

Particle Size Reduction

Patrick Clark, PhD

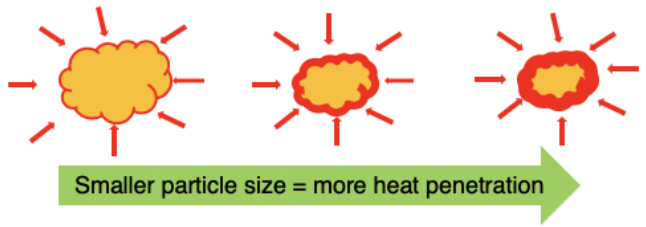
Particle Size Reduction

- The majority of the ingredients used in livestock feeds require some type of grinding

Grinding

Objective:

- Reduce particle size of ingredients
- Increase the amount of materials exposed to the animal's digestive system
  - Better digestion and feed efficiency
- Improves pellet quality
  - Greater heat and moisture penetration during conditioning



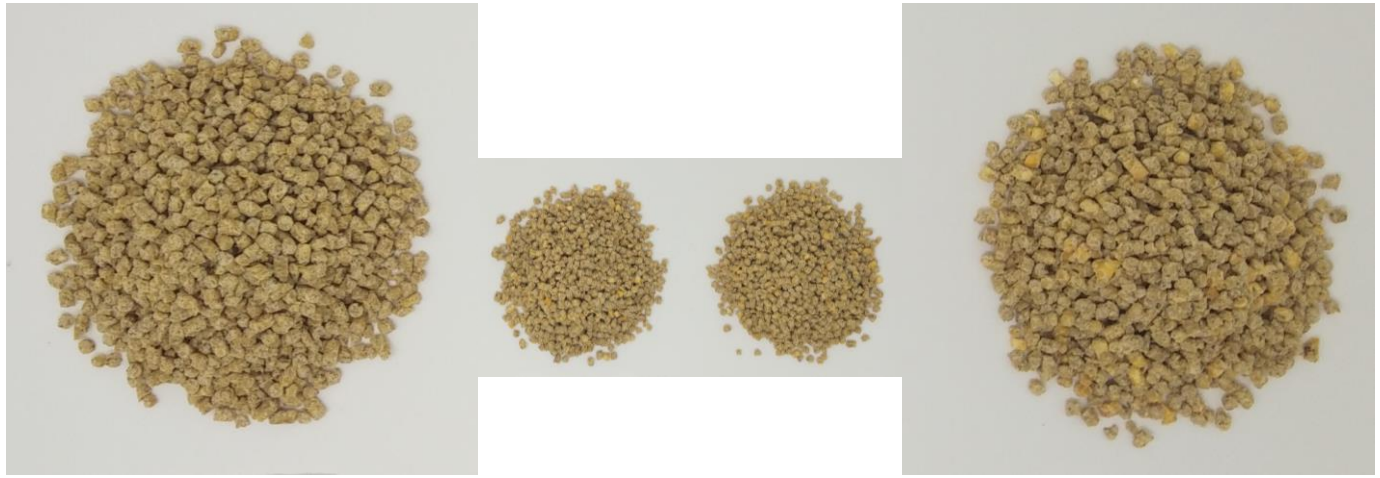
  - Soybean meal is ground to improve pellet quality - **No Recommended!!**

Grinding and Pellet Durability

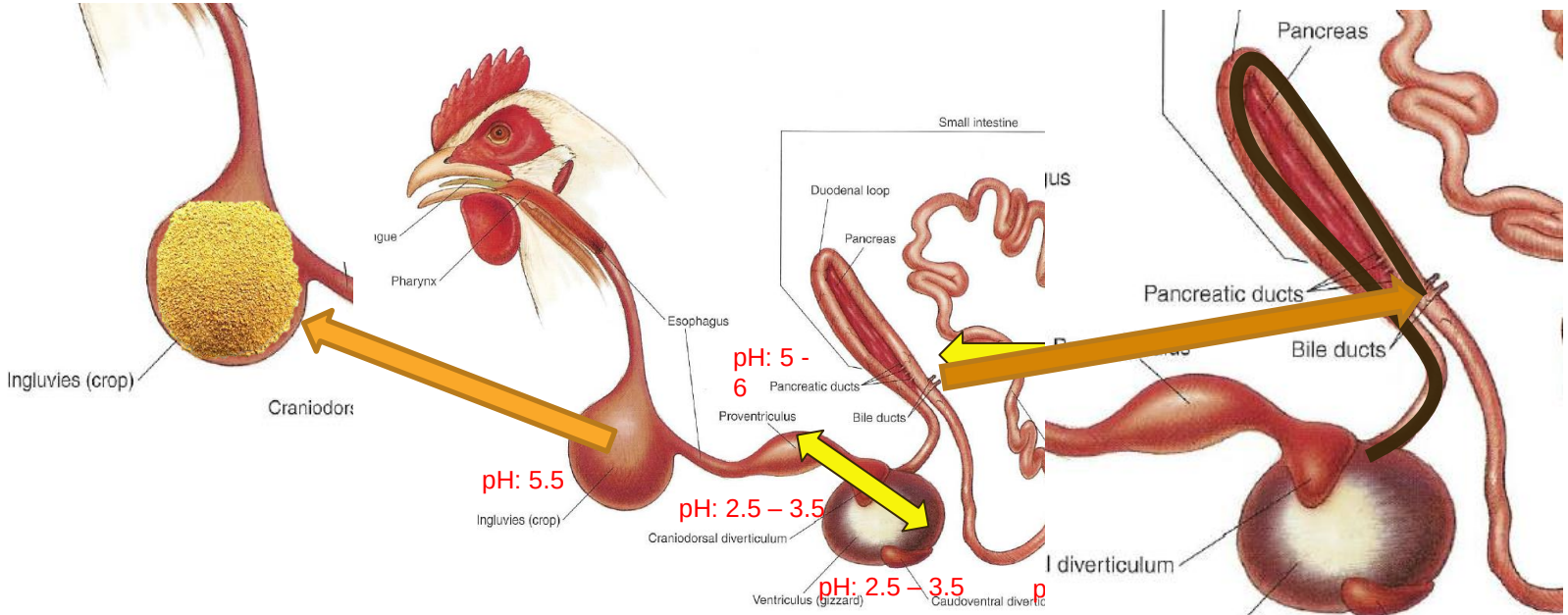
"The main reason for fine grinding is to improve pellet quality"

But remember: We need to focus not only in the macro structure,

but also in the micro structure!



Grinding and Reverse Peristalsis

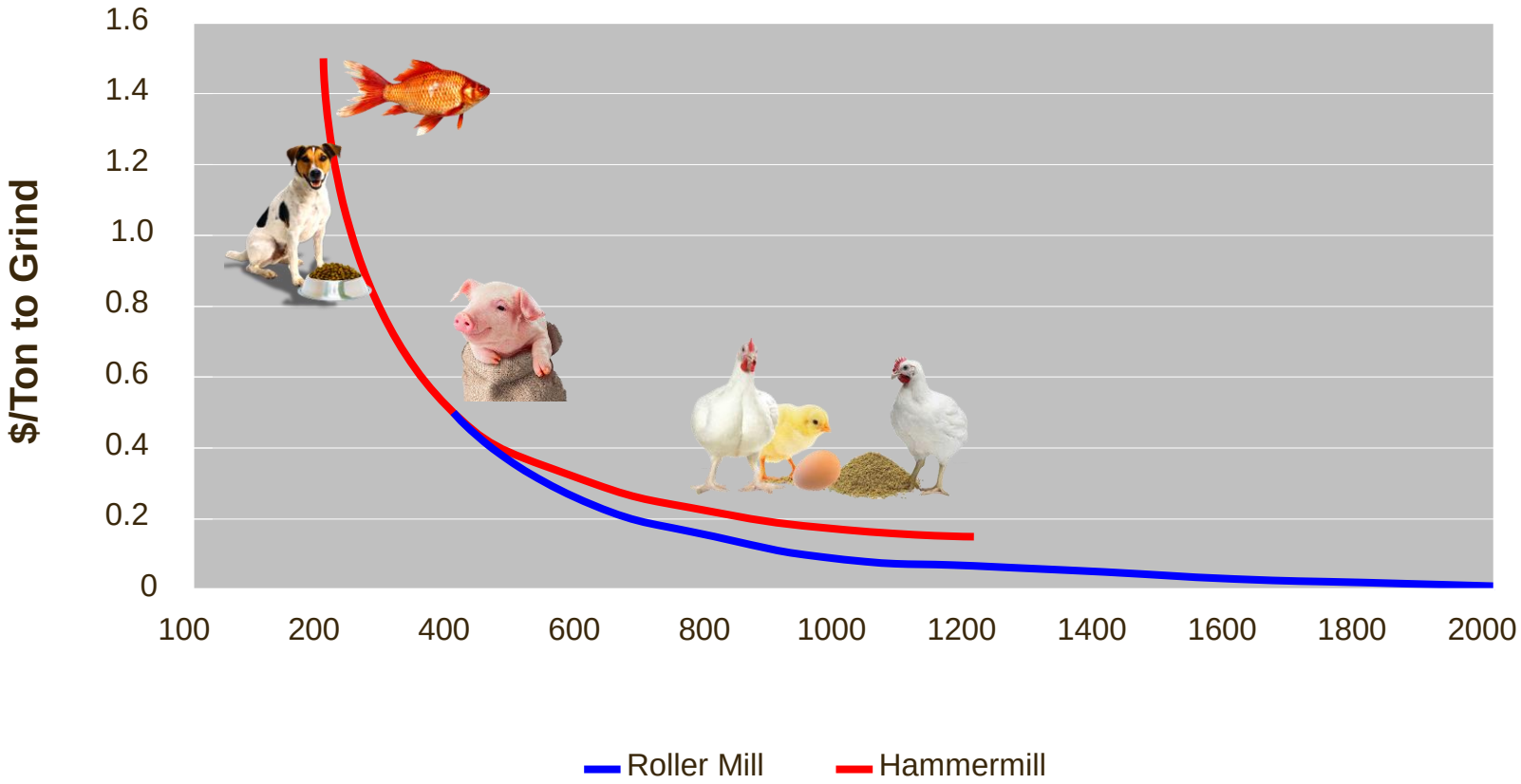


Gastric: Peptic digestion, fat emulsification

Reverse peristalsis transports these secretions to the gizzard and proventriculus

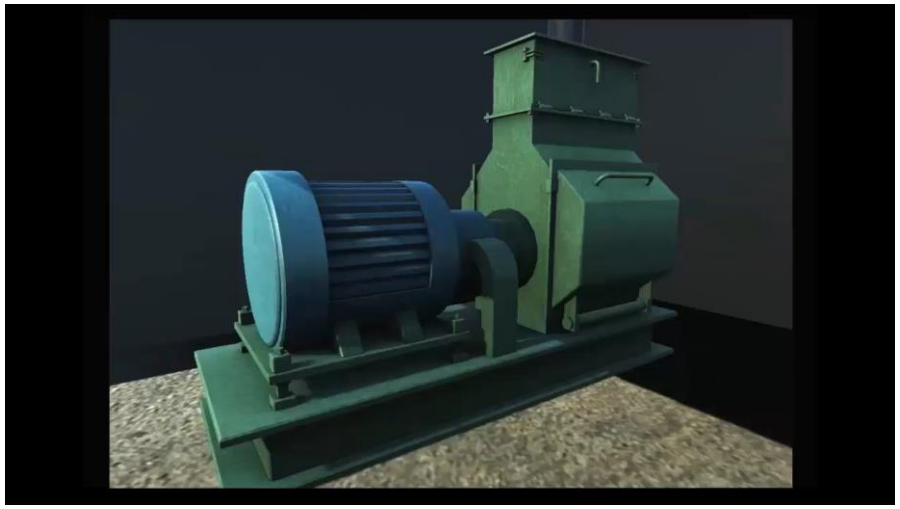
Grinding Costs

- As particle size decrease, grinding costs increase



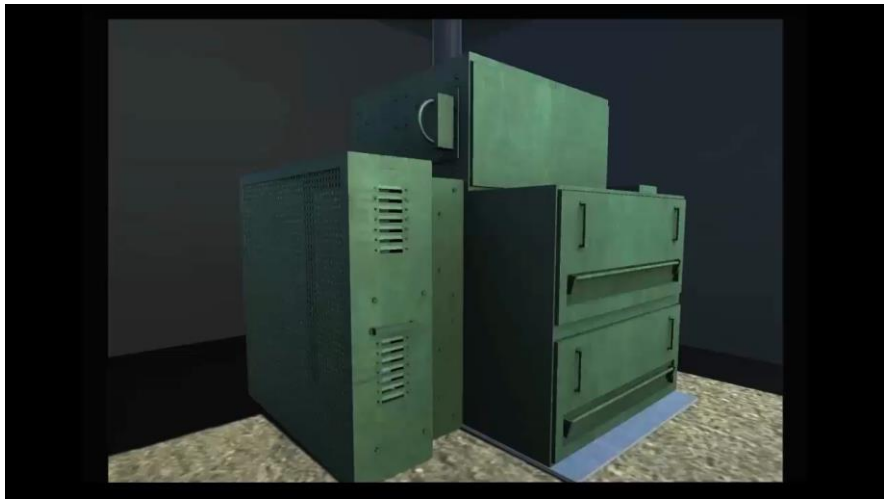
Adapted from Kitch, 2018

Grinding Equipment



Hammermill

- Commonly used in pelleted diets
- Particle size reduction occurs by impacting an slow moving target (whole grains) with a rapidly moving hammer



Roller Mill

- Commonly used in the feed industry when diets are fed in mash form

Roller Mill or Hammermill?

Cracking, Crimping, Minimum Fines, Dust

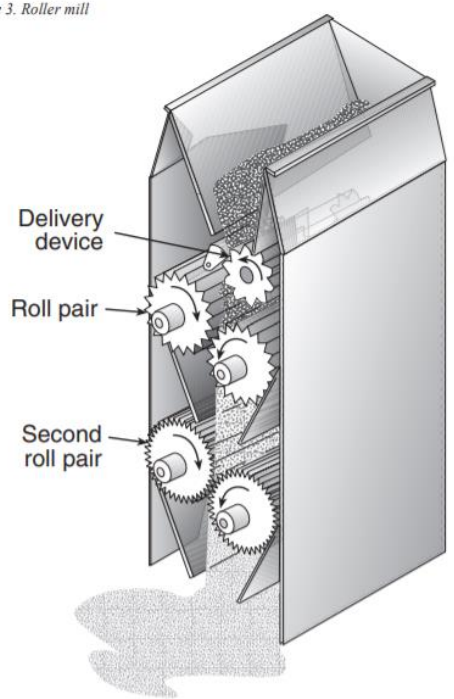
Coarse Grinding, Textured Feeds

Grinding for Pelleting
Corn, Wheat, Milo

Grinding for Pelleting
Oats, Barley, Fiber

Grinding < 300 µm
Pet food/Aqua

Figure 3. Roller mill



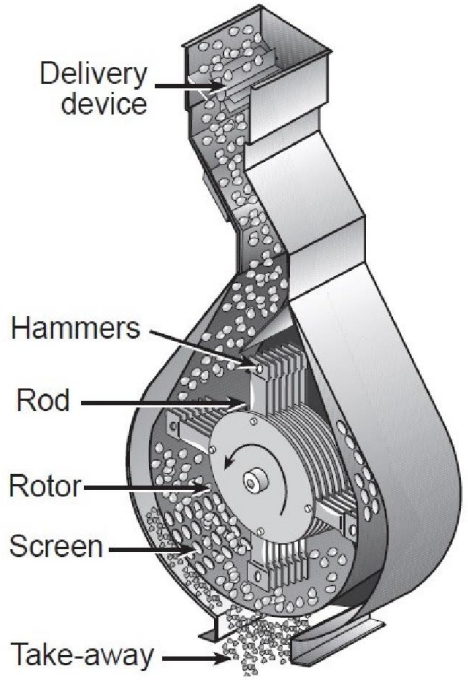


Fig. 9. Hammer Mill. (Koch, 1996)

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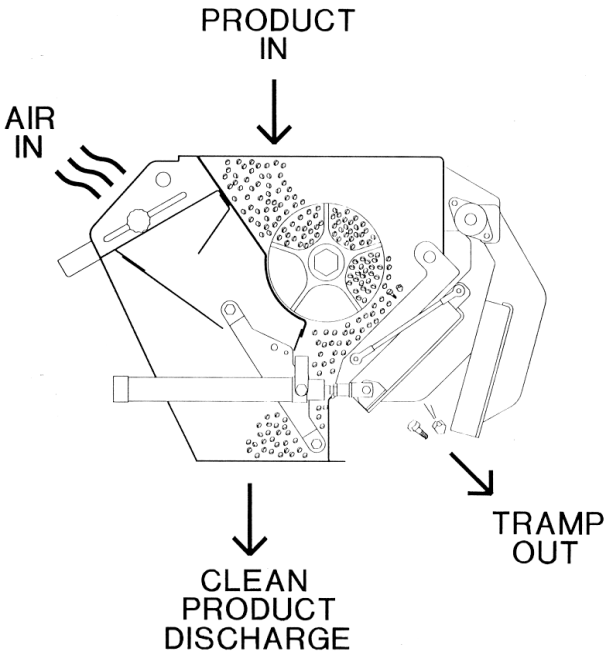
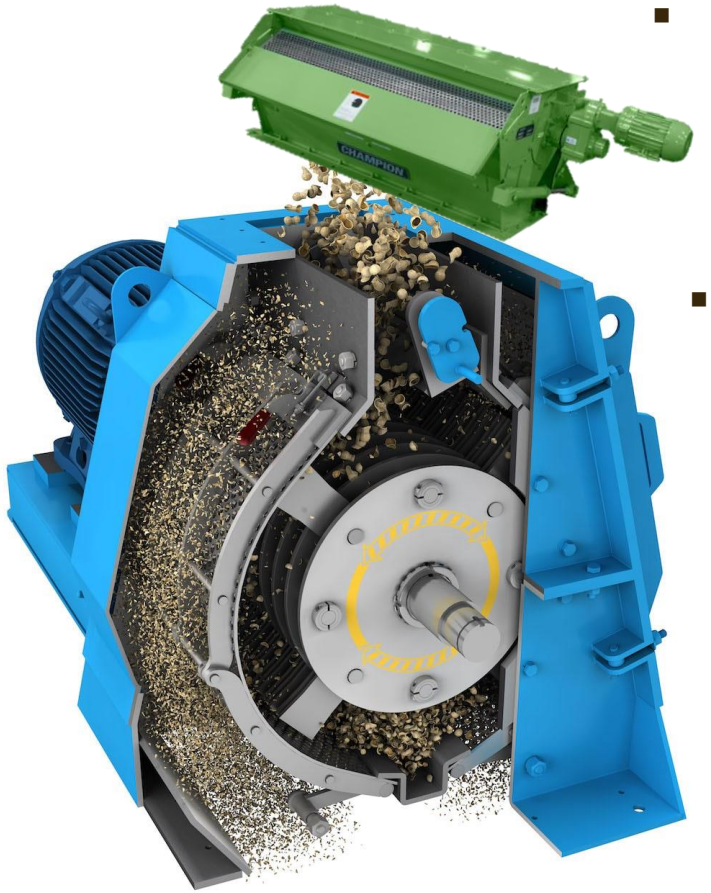
Adapted from Kitch, 2018

Factors to Consider

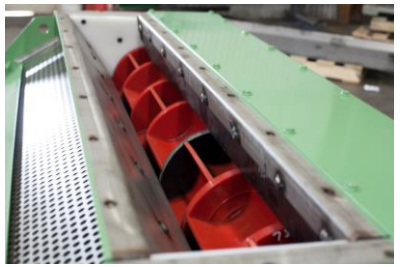
- **Target particle size**
  - Coarse (mash diets) – Roller mill
  - Fine (pellet diets) – Hammermills
- **Energy consumption**
  - Roller mills use less electric energy, but less efficient at lower particle size than hammermills
- **Maintenance cost**
  - Roller mill – Re-corrugation, routine gap adjustments, daily particle size analysis
  - Hammermill – Screen and hammers replacement, rotation
- **Environment and safety**
  - Roller mill – Lower noise and less dust
  - Hammermill – Requires dust control, high noise, risk of fire explosion

Hammermills





- **Rotary pocket feeder**
  - Even feeding across mill width
  - Easy to automate
  - Available with self cleaning magnet
- **Considerations**
  - Make sure that feeders are not broken and leaking product
    - Important if you change from grinding corn to wheat
      - Smaller grain



Hammermills

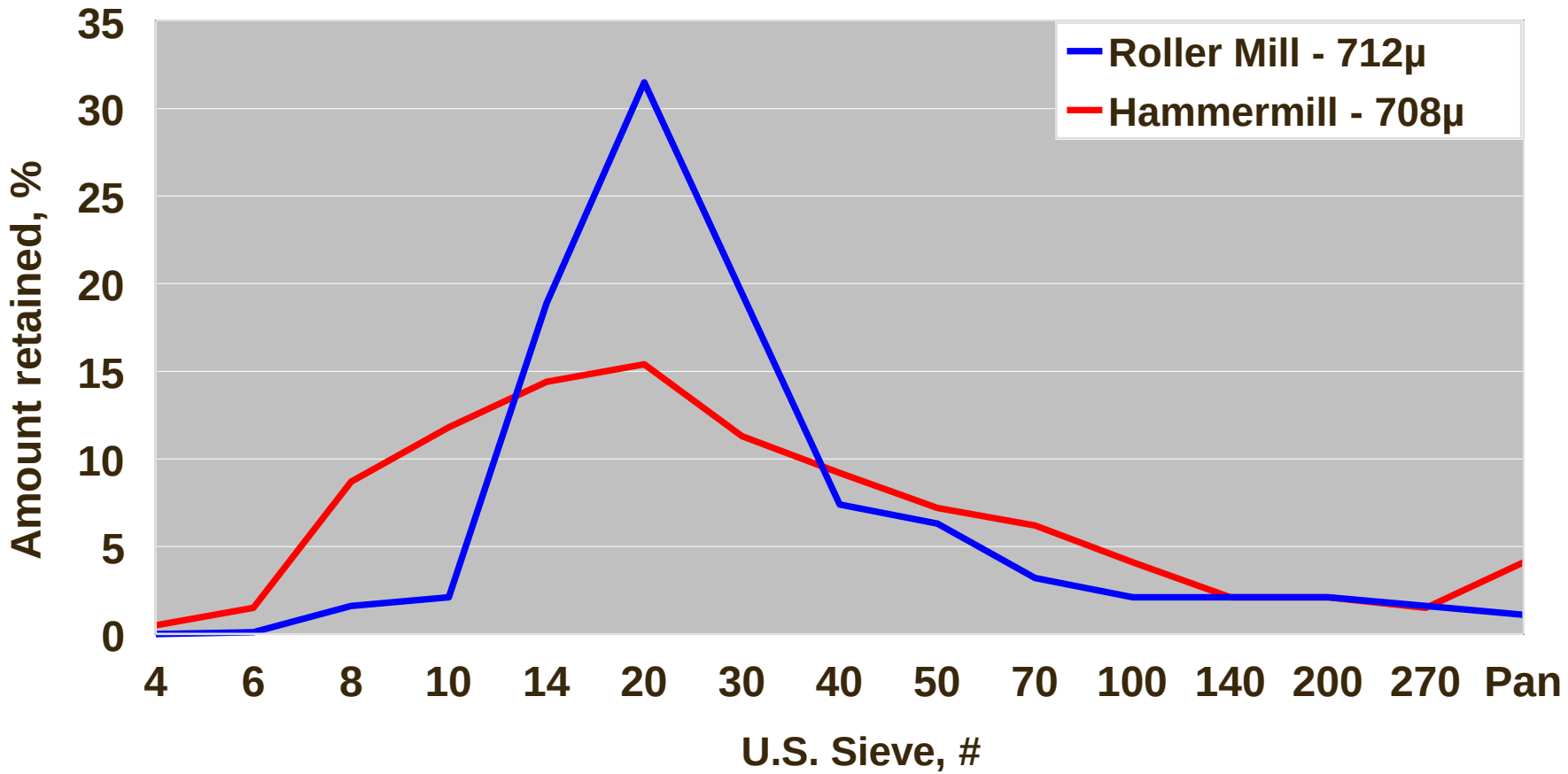
Advantages

- Process a wide range of materials
- Lower initial cost
- Minimal maintenance
- Easy operation
  - Select Screen Size
  - Turn it on

Disadvantages

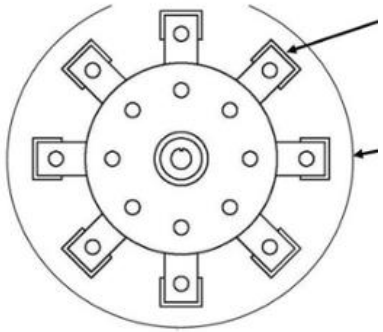
- Less uniform particle size
- Higher energy costs
- Noise and dust pollution
- Generates more heat (shrink)

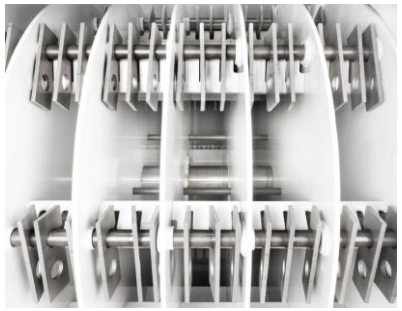
Hammermills



Particle Size Controlled By:

- **Screen Size**
  - **Small:** Fine grinding
  - **Large:** Coarse grinding
- **Hammer Tip Speed, FPM**
  - <13,000 Coarse
  - 13,000 to 18,000 Medium
  - >18,000 Fine

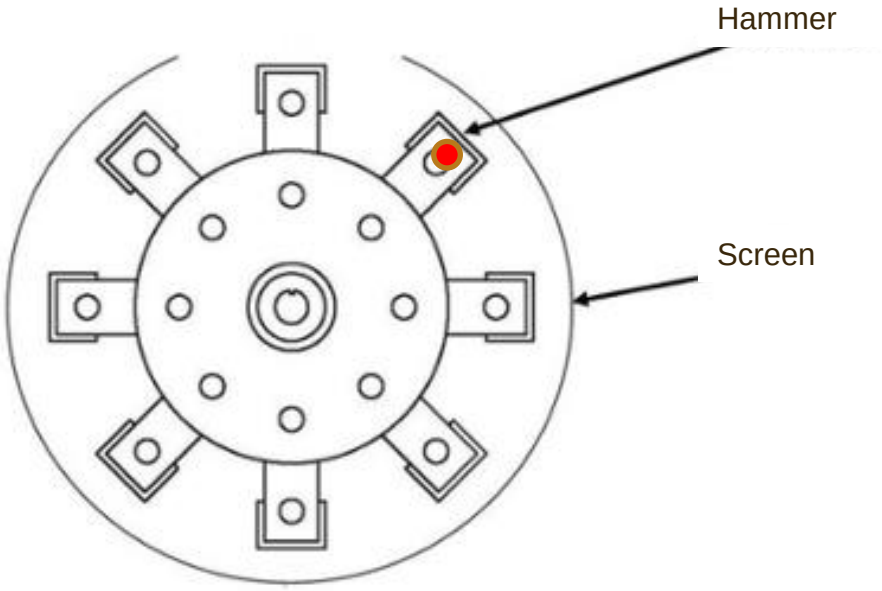




- **Hammer setting**
  - Coarse 3/8 to 1/2 inch gap from hammer tip to screen
  - Fine 3/16 to 1/4 inch gap from hammer tip to screen
- **Hammer Pattern**
  - Heavy – Lower ratio of HP/Hammer Number
    - 2 HP/Hammer
  - Medium – Higher ratio of HP/Hammer Number
    - 2.5 -3.0 HP/Hammer

Calculating Tip Speed

Diameter, Inch	Width	RPM	Tip Speed, FPM	HP Range
38	48	1800	17,898	300 – 350
44	48	1800	20,730	300 – 450
54	48	1800	25,434	350 - 500

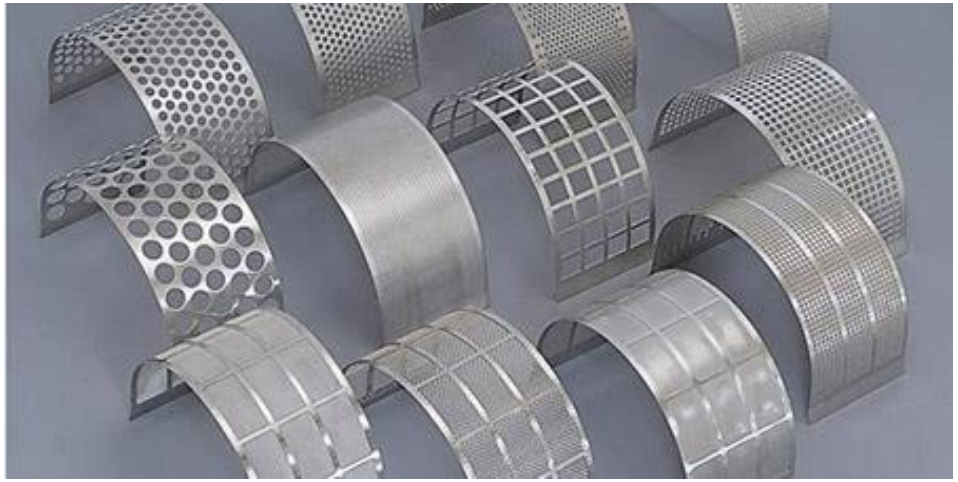


P = 2 π r = πD
P = 3.1416 x D
P = 3.1416 x **38”**/12
P = 3.1416 x 3.167 feet
P = 9.94 feet

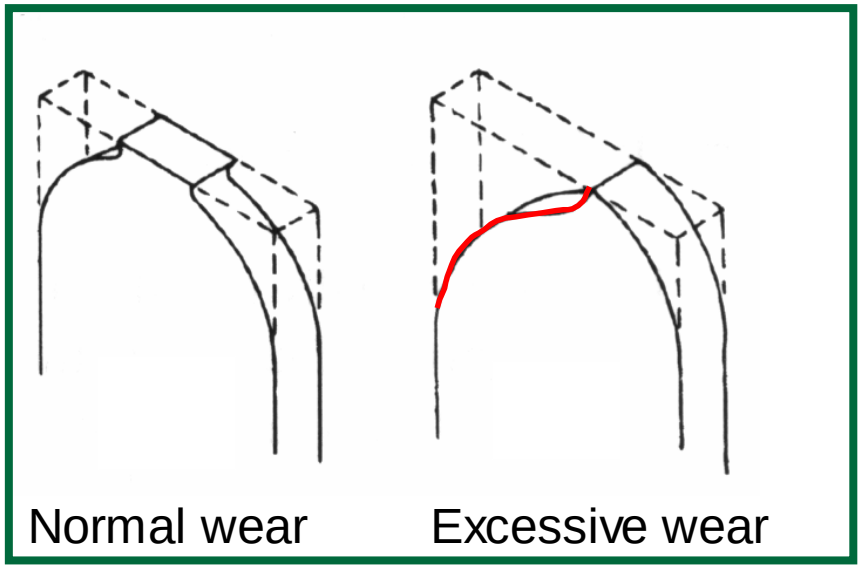
Motor = **1800 rpm x 9.94 feet**

Feet/min = 17,898
Miles/hr = 203

Hammers and Screens

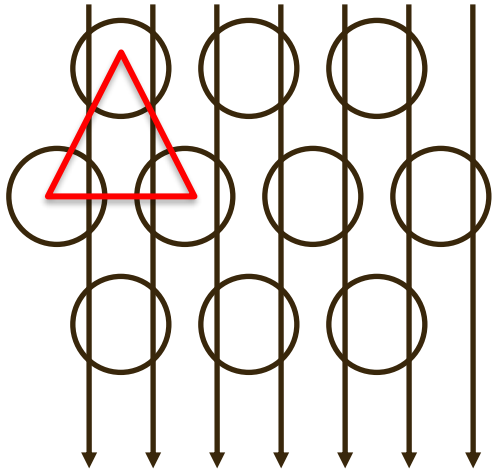


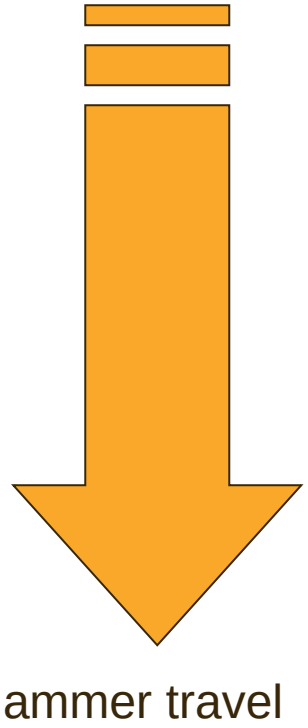
Hammers and Screens



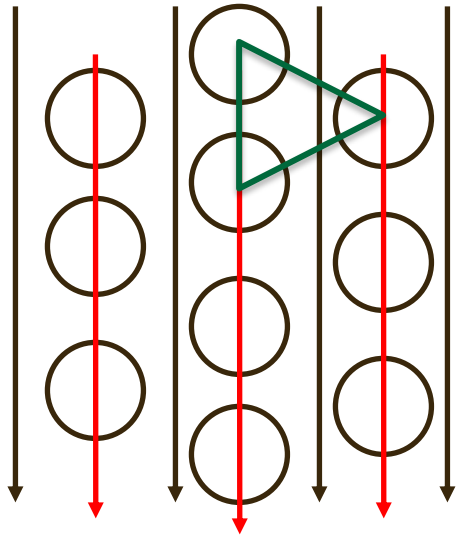
- **Hole Stagger**

Correct





Incorrect



Grinding Cost

	Poor	Good
Maintenance	0.02	0.05
Electrical	0.38	0.29

$/ton

Grinding Cost

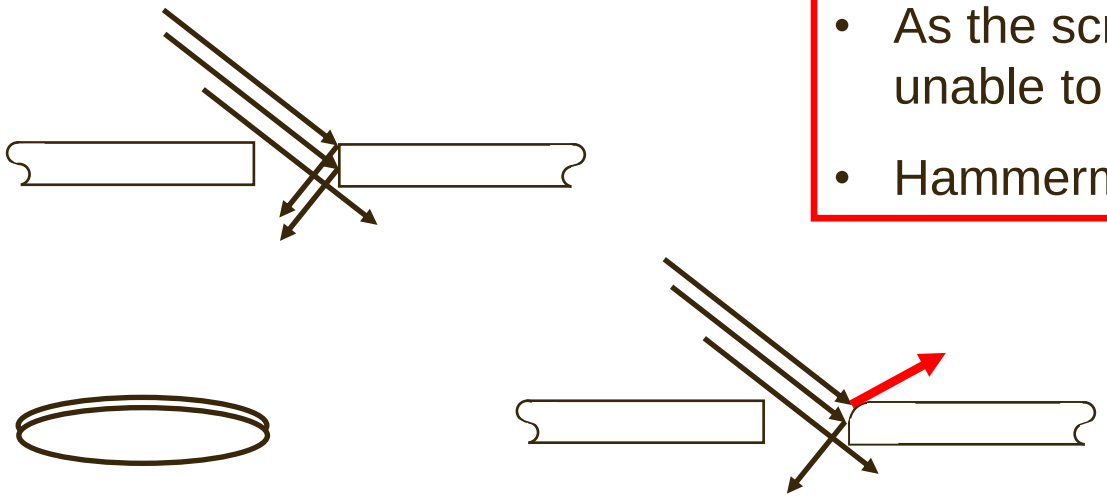
- **Based on the previous example, a good maintenance program can produce:**

Energy Savings: $ 0.06/ton of grinding

With an average of 65% corn in the diets, a feed mill producing 10,000 tons/week or grinding 6,500 tons of corn/week will save approximately $20,280/year in grinding costs

Maintenance	Grinding Costs/ton	Tons/year	Grinding Costs/year
Poor	0.40	6500 x 52 = 338,000	$135,200
Good	0.34		$114,920
Savings			**$20,280**

Grinding Cost

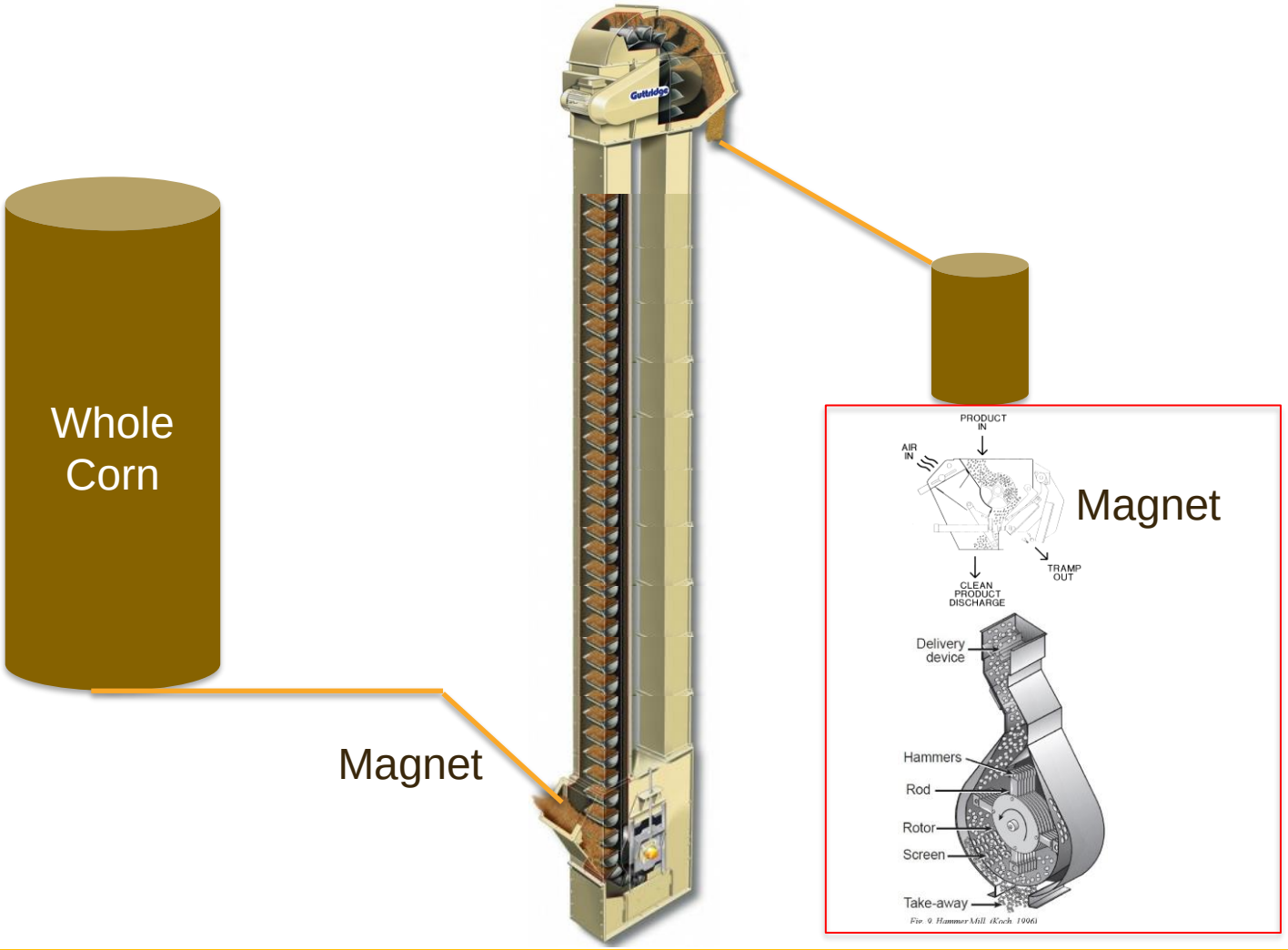


- As the screens wear, material is deflected and unable to pass through the screen
- Hammermill capacity and efficiency decreases

- Feed mill managers and maintenance personnel should determine when the increased energy cost per ton of material exceeds the replacement cost of the screens and hammers
  - Solution: record amps and production rate with new hammers and new screens and then monitor the decrease in production rate as the hammers and screens wear

Stark et al., 2017; Kitch, 2018

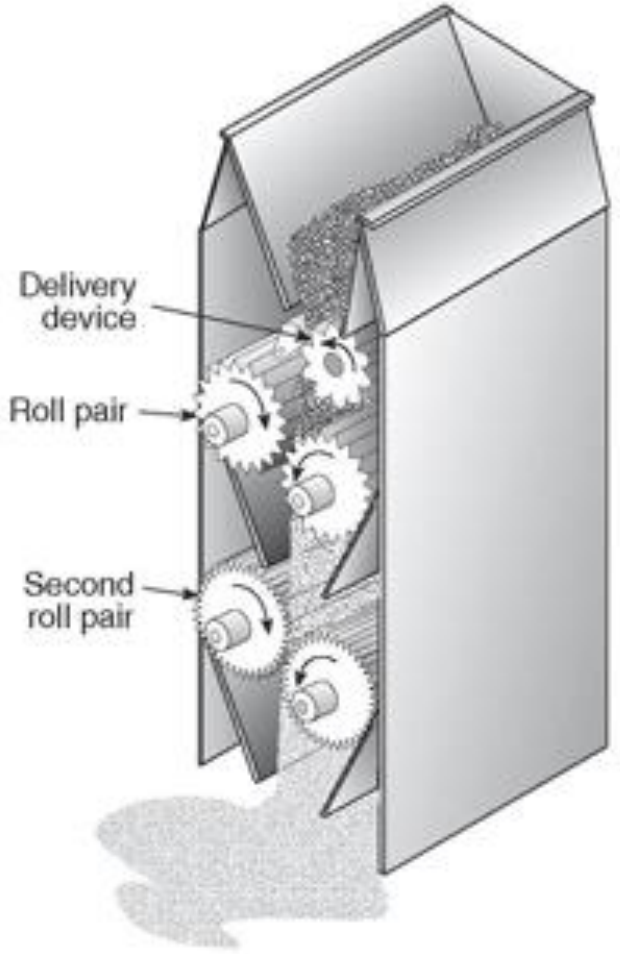
Protect Your Grinding Equipment



- Grinding area is typically located adjacent to the feed mill
- Having explosion panel is common

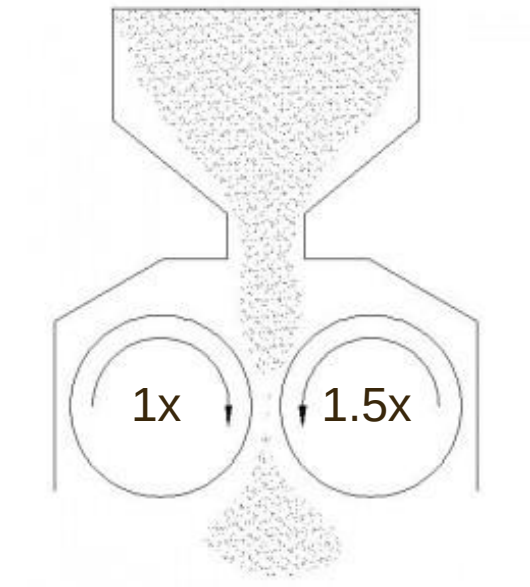
Roller Mills

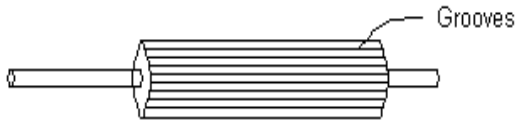
- Commonly used in the feed industry when diets are fed in a mash form



Particle Size Controlled By:

- **Number of roll pairs**
  - Three pairs: fine grinding
  - Two pairs: coarse grinding
- **Roller gap**
  - Narrow gap= fine grinding
  - Wide gap: coarse grinding
- **Number of corrugations**
  - Top pair = 4-6 grooves/in
  - Bottom pair = 10-14 grooves/in





Roller Mills

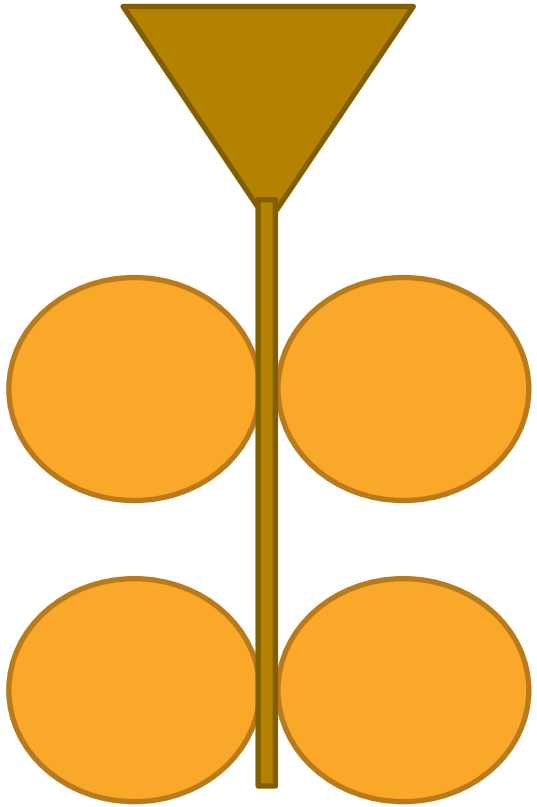
Advantages

- Low noise operation
- Less heat increase and moisture loss
  - 0 – 3°F vs. Up to 10°F
- Uniform particle size
  - Less fines and oversized particles
- Energy savings
  - >15%
- Less Moisture losses
  - <0.5% vs. 1-3%

Disadvantages

- High initial investment
- More complicated to maintain
  - Roll adjustments and more frequent particle size analysis
- Does not grind fibrous materials (barley, oats), high moisture grain

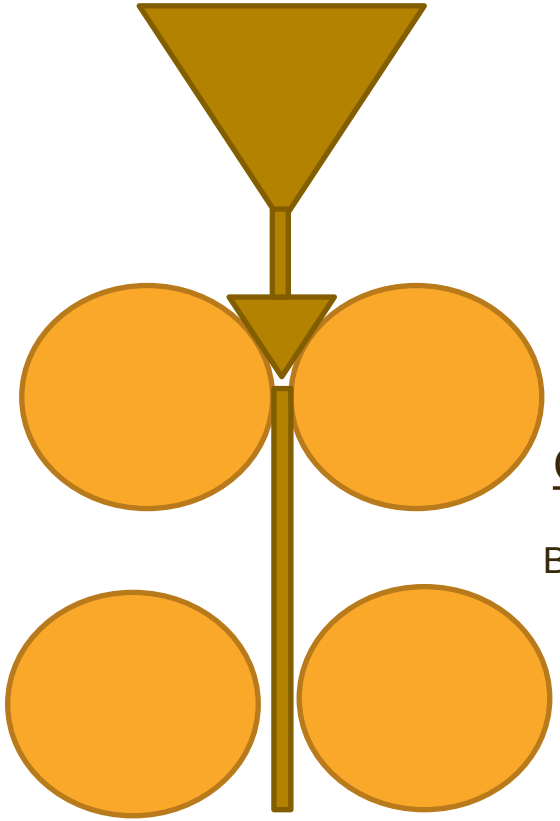
Roller Mills



Normal Operation

Work divided evenly

Bottom pair slightly tighter



Condition to Avoid

Top rolls too close

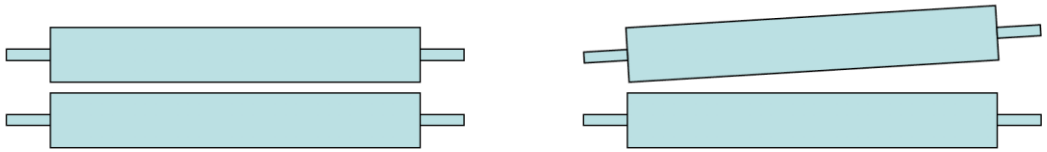
Bottom rolls too far open

Material build up

Adapted from Kitch, 2018

Roller Mills

Roll Gap
(looking down from above)

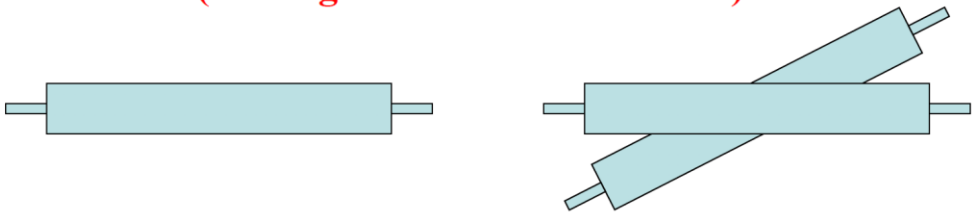


Correct
(Uniform Spacing)

Incorrect
(Varied Spacing)

Rolls Must Be Parallel

Roll Tram
(looking from front of machine)



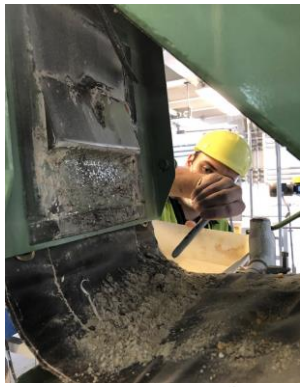
Correct
(Rolls Aligned)

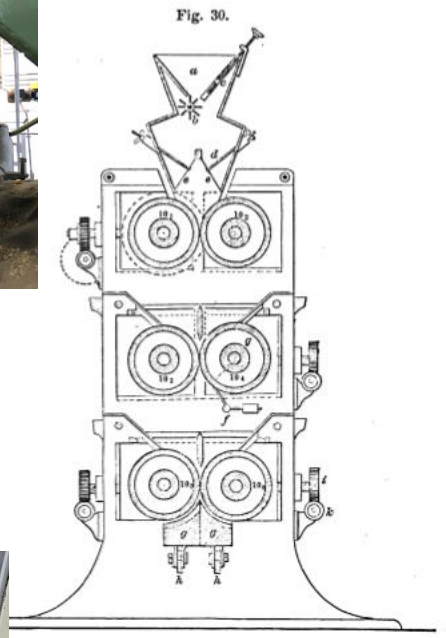
Incorrect
(Rolls Not Aligned)

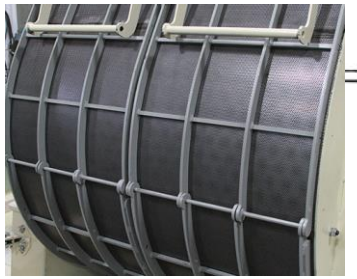
Rolls Must Be In Alignment (Tram)

Process Control

- **Equipment**
  - Maintain equipment according to manufacturers recommendations
  - Clean magnets daily
  - Inspect screens and hammers weekly
  - Adjust roll gaps daily; check roll parallel monthly
- **Visual inspection**
  - Check appearance of ground grain
  - Check screens for holes



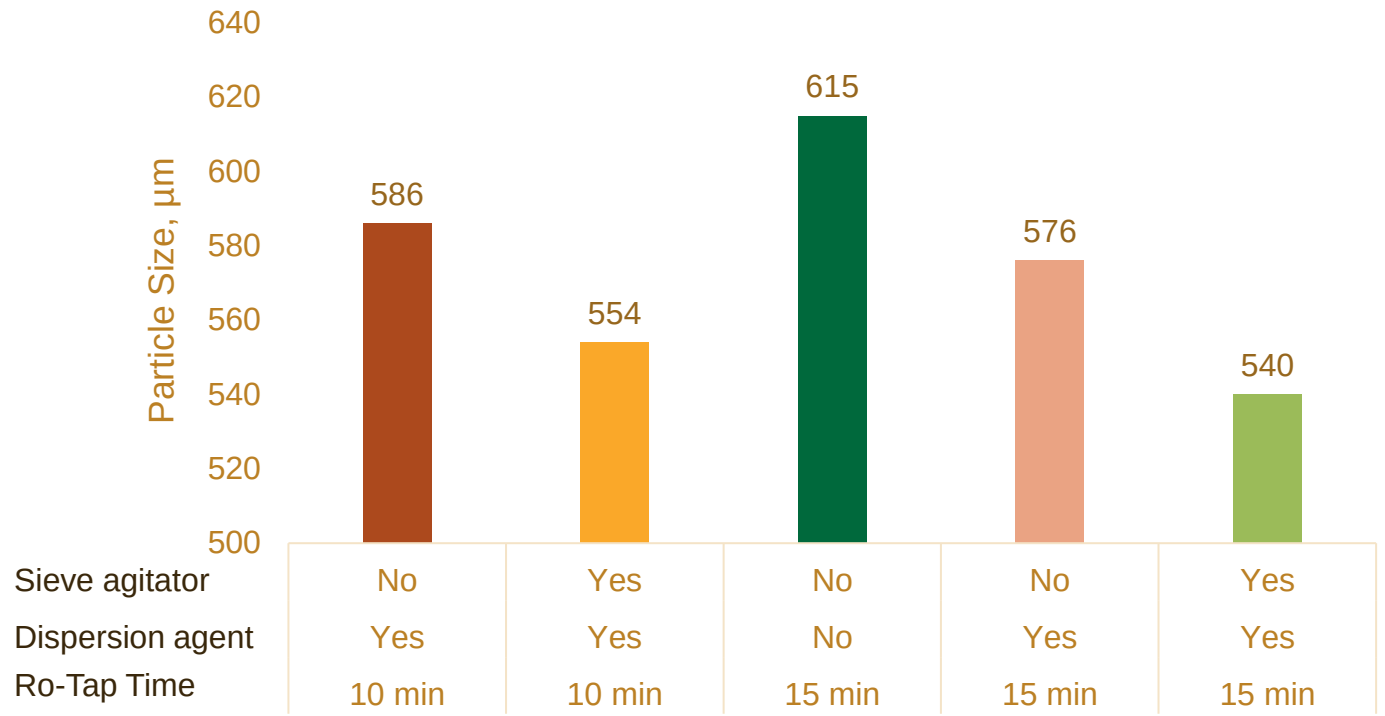




Particle Size Analysis

Particle Size Analysis – ASABE S319.4

The methodology of particle size analysis can significantly impact the final results
It is important to understand how the test is being conducted at the laboratory to ensure the results are interpreted correctly



Kalivoda and Stark, 2016

Conclusions

- Particle size of feed ingredients influences on grinding cost and animal performance
- Develop particle size targets based on:
  - Farm bin design, feed form, ingredients
- Correct sampling and particle size analysis should be performed at least weekly, after performing any preventive and/or corrective maintenance such as changing screens, hammers, or changing rotation as well as when the characteristics of corn change (e.g. new crop corn).

Thank You!

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