Grinding Improvements and Analysis

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Patrick Clark, Ph.D.

patrick@c6advantage.com

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WHY DO WE GRIND?

IS GRINDING IMPORTANT?

WHY?

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HISTORY

Headley and Pfost

- **1971**
  - ❖Detailed a Comminution Equation Relating Energy to Surface Area by the Log Probability Model
  - ❖Derived from over 20 Equations
  - ❖These Grinding tests were performed with the energy and particle size distribution through sieving.

Hammermills

Hammer Mill Analysis

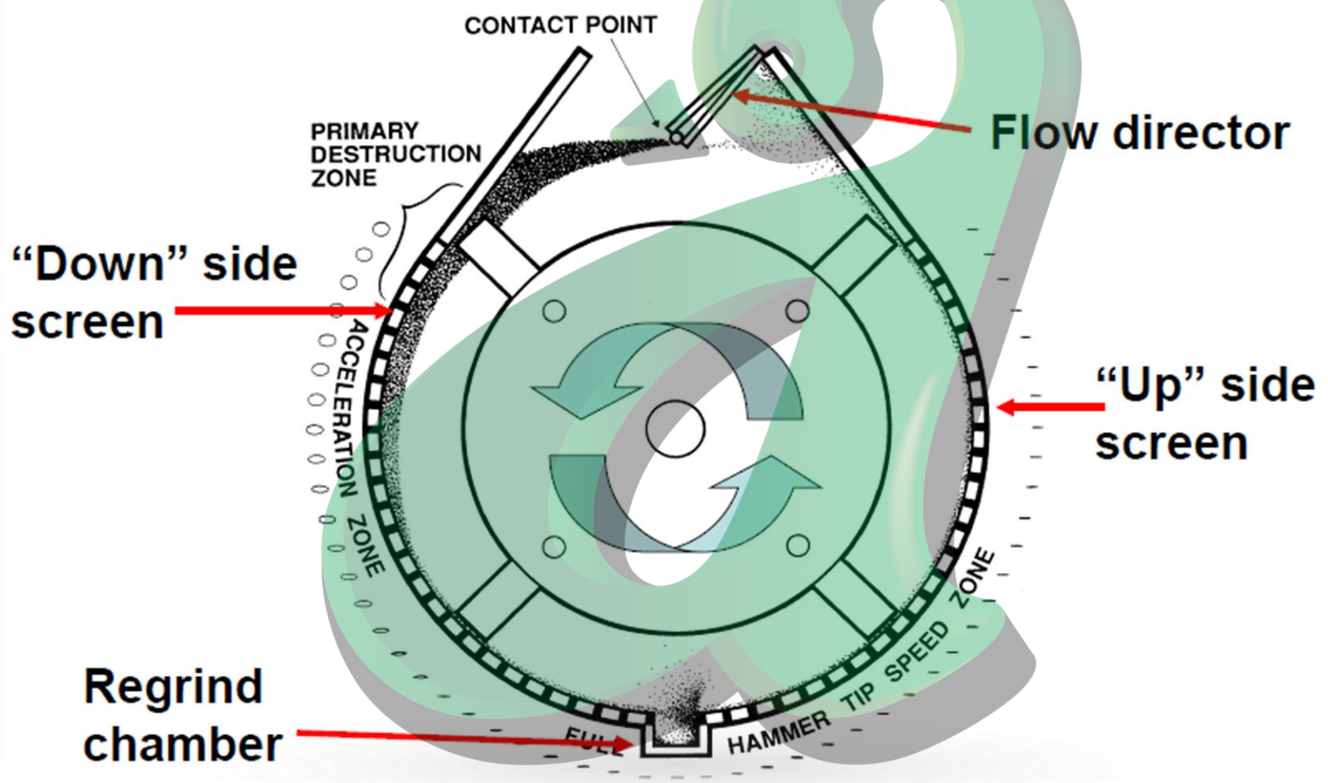
Advantages

- Ability to grind a wide variety of materials
- Ease of maintenance, less maintenance cost
- Versatility
- Less complicated to operate
- Less initial cost

Disadvantages

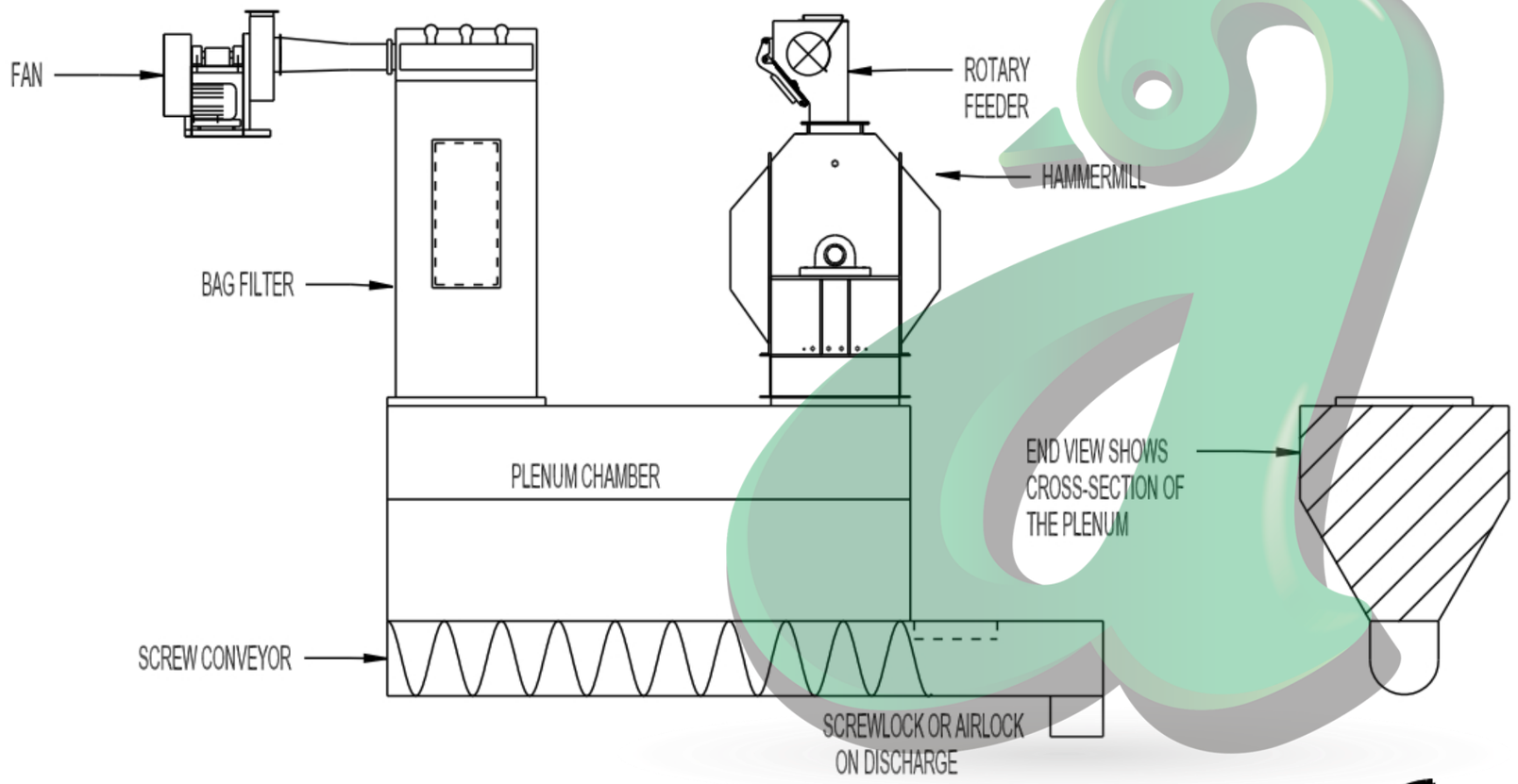
- Energy consumption
- Produces a greater Sgw
- Noise and dust pollution
- Heat generation and moisture loss

Hammermill Terminology



Source: CPM

Hammermill System



HAMMERMILL AIR RELIEF SYSTEM

AIR ASSIST WITH BAG FILTER

BLISS INDUSTRIES LLC
900 East Oakland, PONCA CITY OK 74601
PH: (580) 765-7787 FAX: (580) 762-0111
www.bliss-industries.com

BLISS ENGINEERING

- Air assisted grinding systems will out produce non-assisted systems by 15-40%.

Source: Bliss

Grinding Efficiency Variables

- Tip speed
- Screen (hole) size and open area
- Screen area / horsepower ratio
- Hammer pattern (number of hammers)
- Hammer position (coarse or fine)
- Feed distribution (uniformity)
- Air assist (properly designed and functioning)

❖ **Quality and type of the material(s) being processed**

Hammermill Tip Speed

- Particle size reduction is caused by impacting a slow moving target (grain) with a rapidly moving hammer

- Hammer Tip speed = 2∏r x motor RPM
- r=radius (in feet)
- ∏=3.14

- Hammer Tip speed = 10,000 to 25,000 ft./min. (50 to 127 m/s)

Hammermill Tip Speed

- A function of diameter and motor rpm $(2 \pi r)/(12 \times rpm)$
- Hammer mill tip speed can range from 10,000 to 25,000 ft/Min
- High tip speeds (>18,000 ft/min (91 m/s)) are best for fibrous materials and fine grinding
- Low tip speeds (<13,000 ft/min (66 m/s)) are more suitable for friable materials and for coarser grinding
- Feed Ingredient conditions change throughout the year which can impact grinding efficiency

Horsepower / Hammer Ratios

Hammer Size	Easy to Grind	Tough to Grind
6-8"	1 to 1.5 H.P./Hammer	.5 to 1 H.P./Hammer
8-10"	2.5 to 3.5 H.P./Hammer	1 to 2 H.P./Hammer

Hammermill Selection

Rotor Diameter in (mm)	Screen Area in^2 ($meters^2$)	RPM	Tip Speeds ft/min (meters/sec)	HP Range	Aspiration Requirements (CFM)
38 (965)	1,296–6,048 (0.84–3.90)	1,800/1,500	17,898 (91)/ 14,915 (76)	75-500	1,620–7,560
44 (1,118)	1,440–6,270 (0.93–4.05)	1,800/1,500	20,724 (105)/ 17,270 (88)	75-500	1,800–7,840
54 (1,372)	1,776–8,288 (1.15–5.35)	1,800/1,500	25,434 (129)/ 21,195 (108)	100-600	1,420–10,300

Source: CPM

Rotor Design

Hammer pattern

- Heavy – Low ratio of HP/Hammer Number

2 HP/Hammer

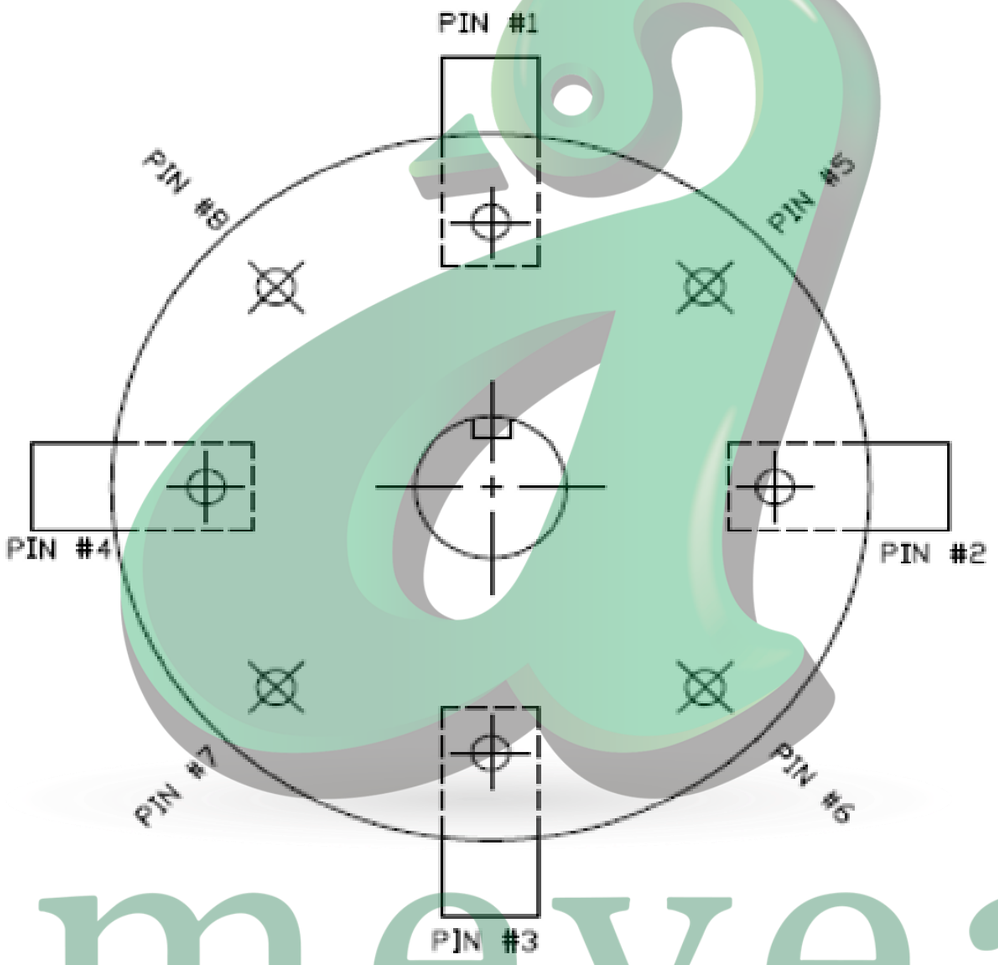
- Medium – High ratio of HP/Hammer Number

2.5 -3.0 HP/Hammer

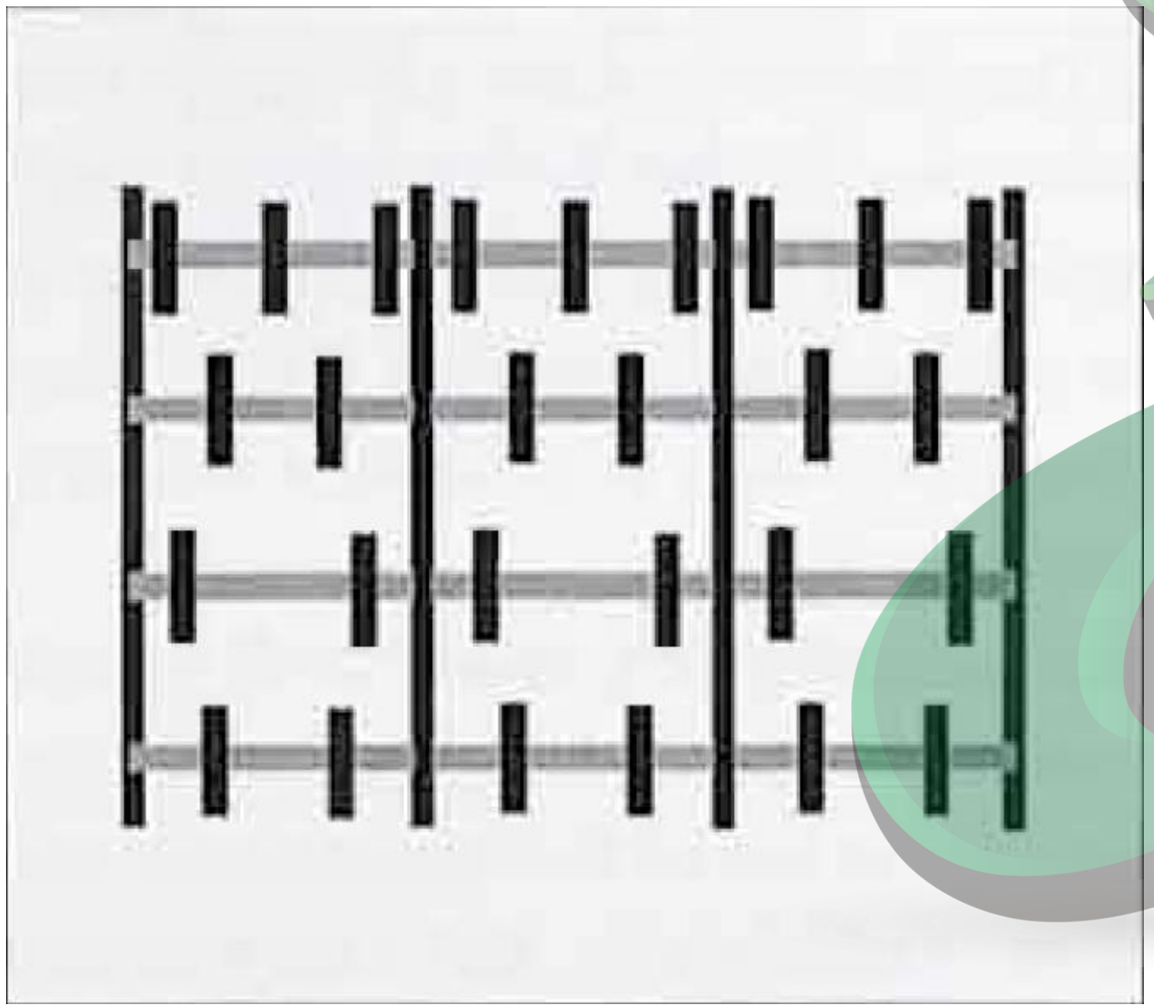
Hammer setting

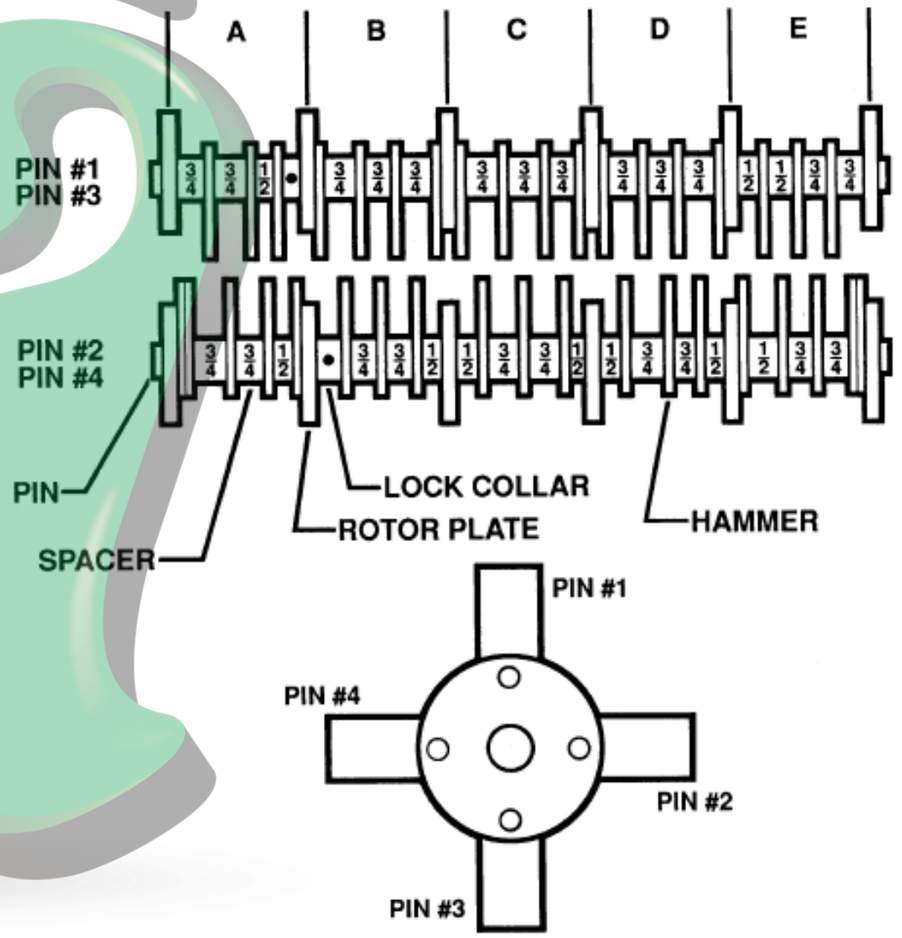
- Coarse 3/8” to ½” (9.5 - 12.7mm) gap from hammer tip to screen
- Fine 3/16 to ¼” (4.76 - 6.35mm) gap from hammer tip to screen

Rotor Design



Hammer Location





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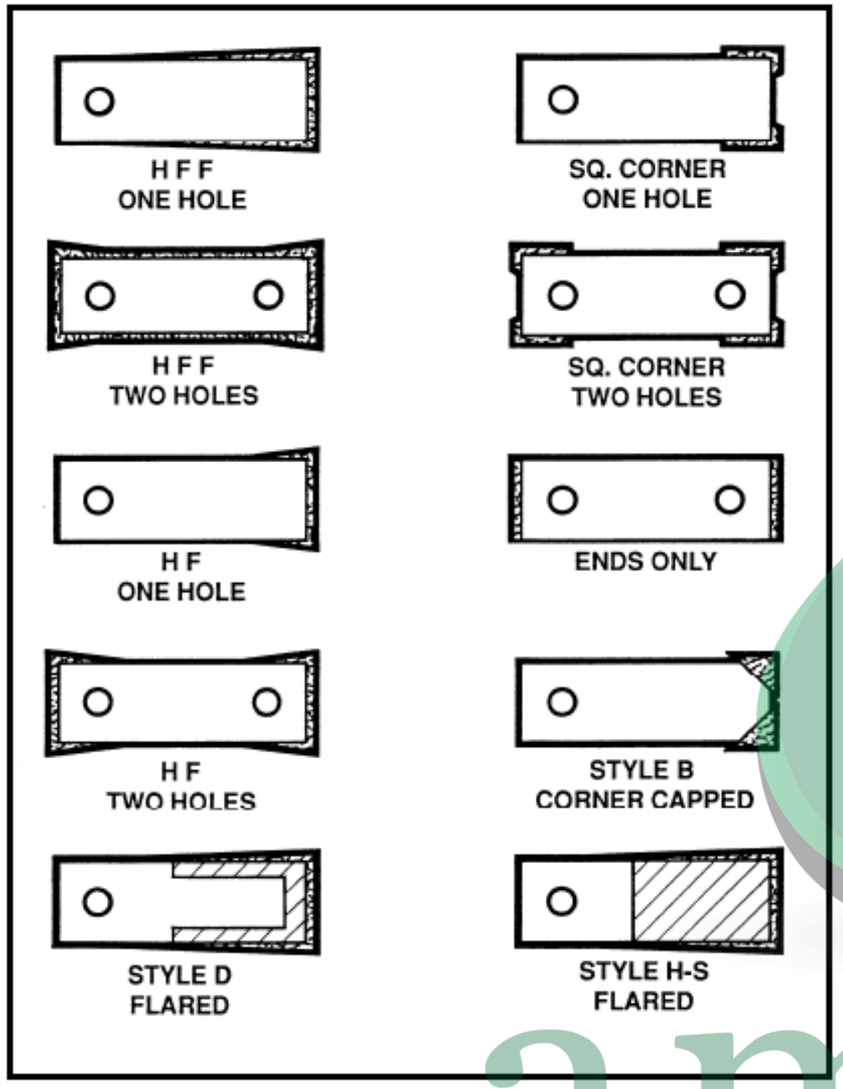
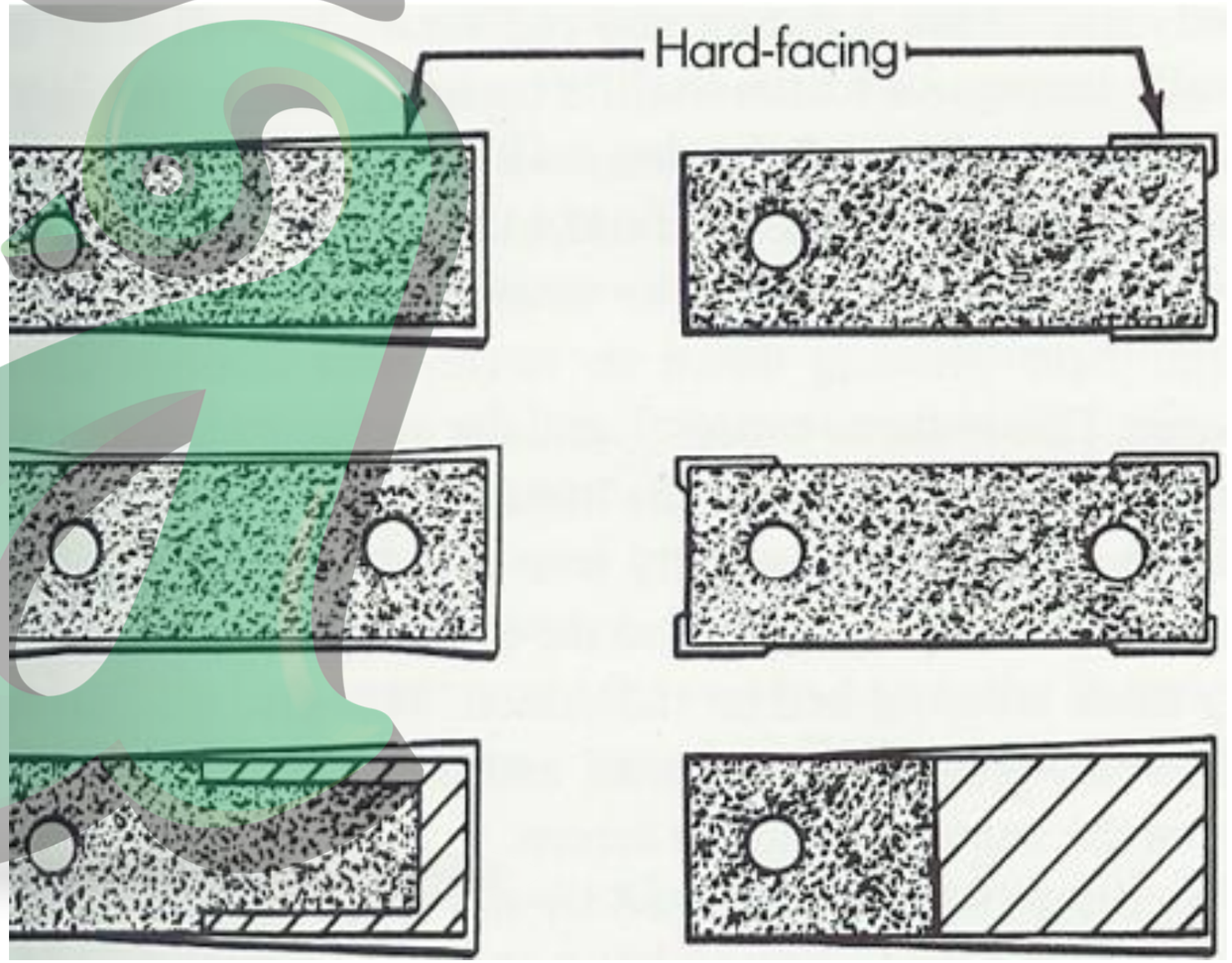
Hammers





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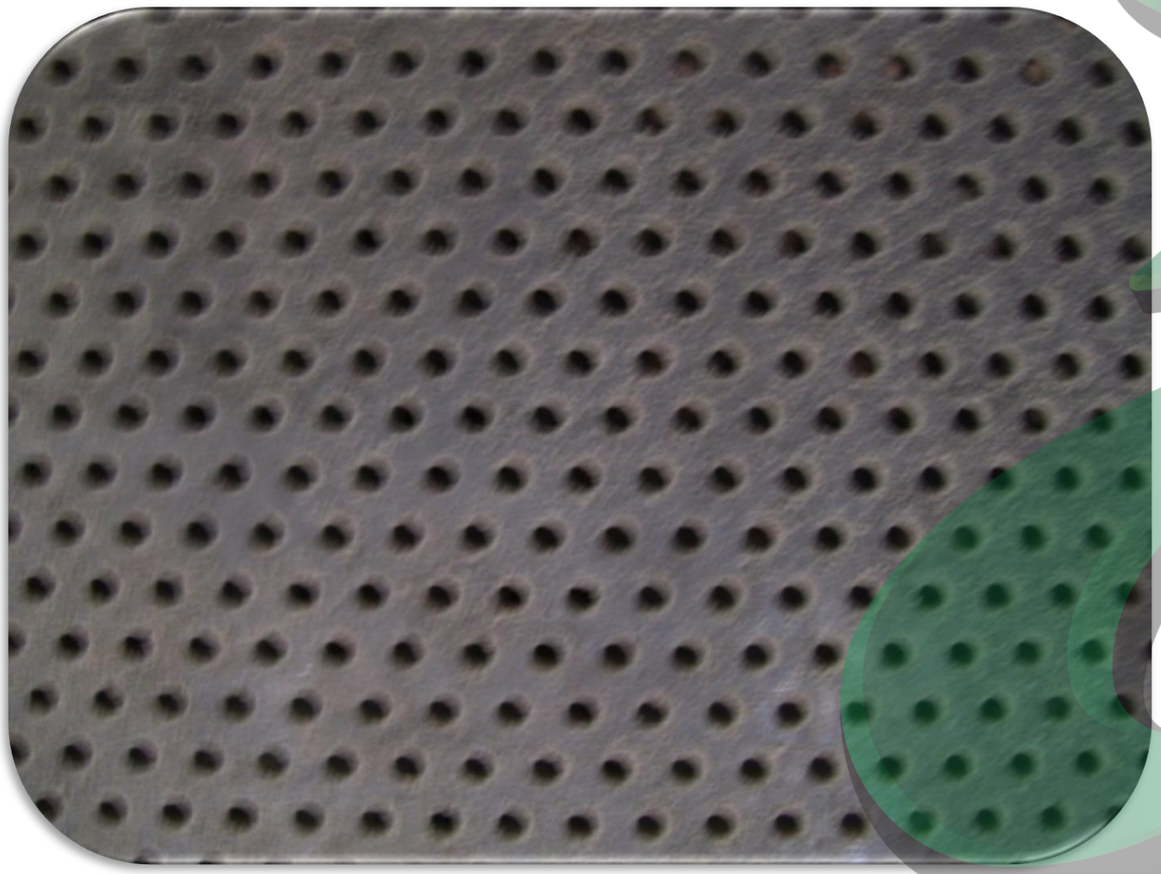
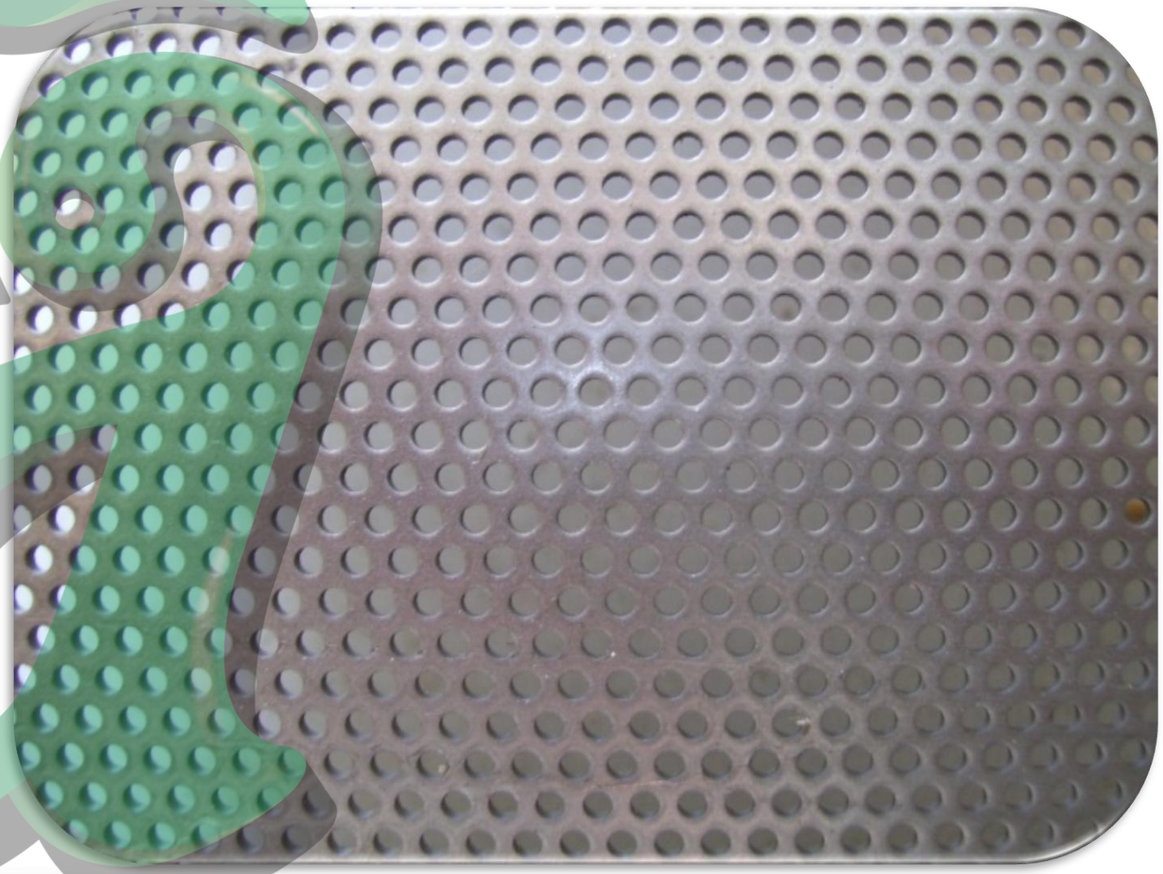
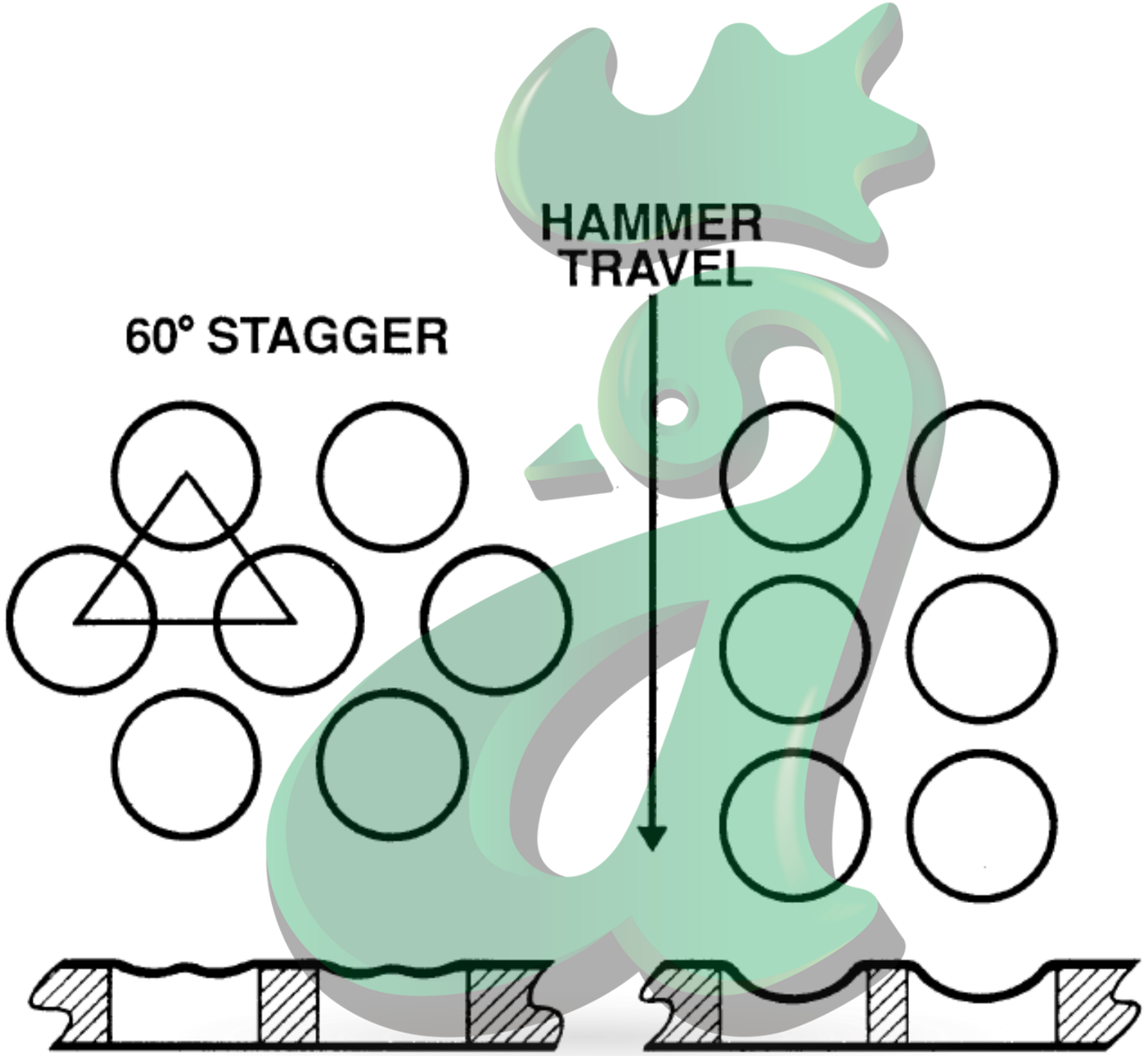
Screen Design





Low Open Area

High Open Area



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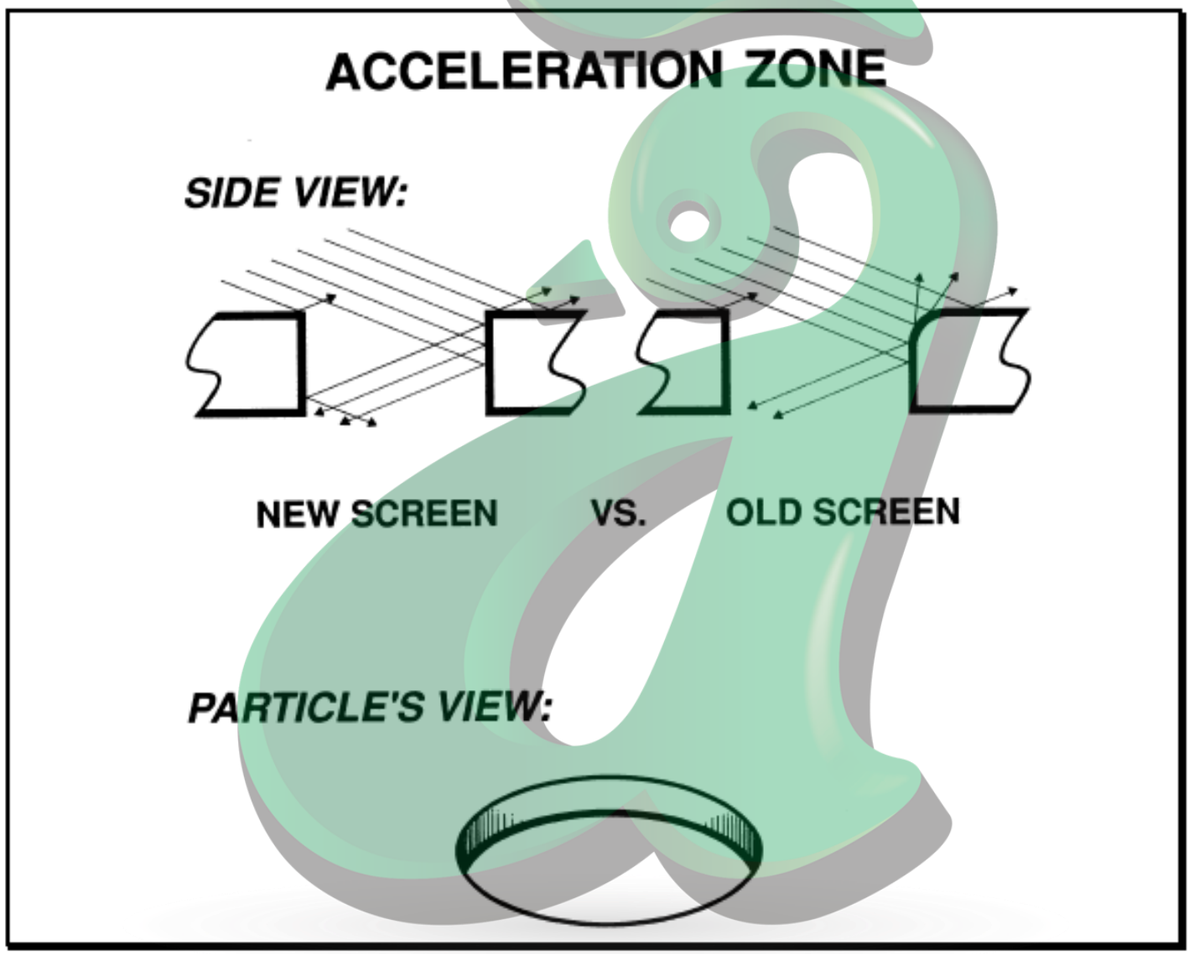

Source:
CPM

ANSI/ASAE S319.4 FEB2008
Method of Determining and Expressing Fineness of Feed Materials by Sieving

American Society of
Agricultural and Biological Engineers

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ANSI/ASAE S319.4 FEB2008 (R2012) Method of Determining and Expressing Fineness of Feed Materials by Sieving

American Society of
Agricultural and Biological Engineers

Table 1 – Aperture sizes for test sieves

ISO 3310-1 Supplementary Sizes R40/3	US Sieve No.	US Sieve Opening		Tyler Designation
mm		mm	in.	
4.75	4	4.76	0.187	4
3.35	6	3.36	0.132	6
2.36	8	2.38	0.0937	8
1.70	12	1.68	0.0661	10
1.18	16	1.19	0.0469	14
µm		µm		
850	20	841	0.0331	20
600	30	595	0.0234	28
425	40	420	0.0165	35
300	50	297	0.0117	48
212	70	210	0.0083	65
150	100	149	0.0059	100
106	140	105	0.0041	150
75	200	74	0.0029	200
53	270	53	0.0021	270
Pan				

Particle Size Analysis - Calculated

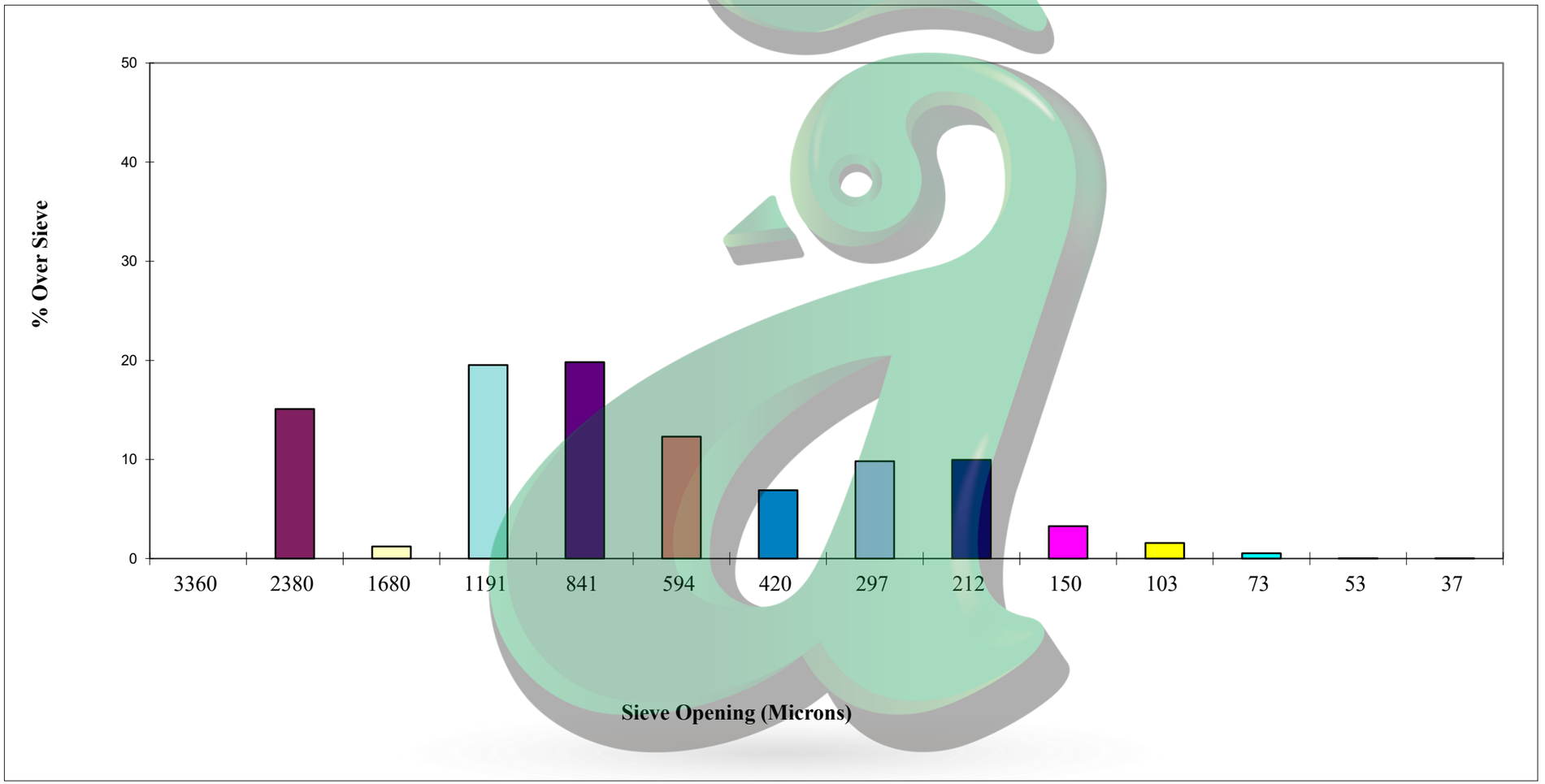
Particle Size Analysis

Material: Corn
07/21/2026

U.S Sieve	Micron Size	Wt grams	%	% less than	log dia	wt * log dia	log dia - log Dgw	wt(log dia - log Dgw)^2
6	3360	0.00	0.00	100.00	3.60	0.00	0.82	0.00
8	2380	0.14	0.14	99.86	3.45	0.48	0.67	0.06
12	1680	1.21	1.22	98.64	3.30	3.99	0.52	0.32
16	1191	19.41	19.50	79.15	3.15	61.15	0.37	2.59
20	841	19.70	19.79	59.36	3.00	59.11	0.21	0.91
30	594	17.23	17.31	42.06	2.85	49.09	0.06	0.07
40	420	11.85	11.90	30.15	2.70	31.98	-0.09	0.09
50	297	9.76	9.80	20.35	2.55	24.87	-0.24	0.55
70	212	9.90	9.94	10.41	2.40	23.76	-0.39	1.48
100	150	8.25	8.29	2.12	2.25	18.57	-0.53	2.36
140	103	1.56	1.57	0.55	2.09	3.27	-0.69	0.75
200	73	0.53	0.53	0.02	1.94	1.03	-0.85	0.38
270	53	0.01	0.01	0.01	1.79	0.02	-0.99	0.01
Pan	37	0.01	0.01	0.00	1.65	0.02	-1.14	0.01
Summation		99.56	100.00			277.33		9.57

Particle Size, Dgw	610	Surface Area (cm^2) / gram	96.1
Standard Dev., Sgw	2.04	Particles / gram	33,000

Particle Size Analysis - Graphical



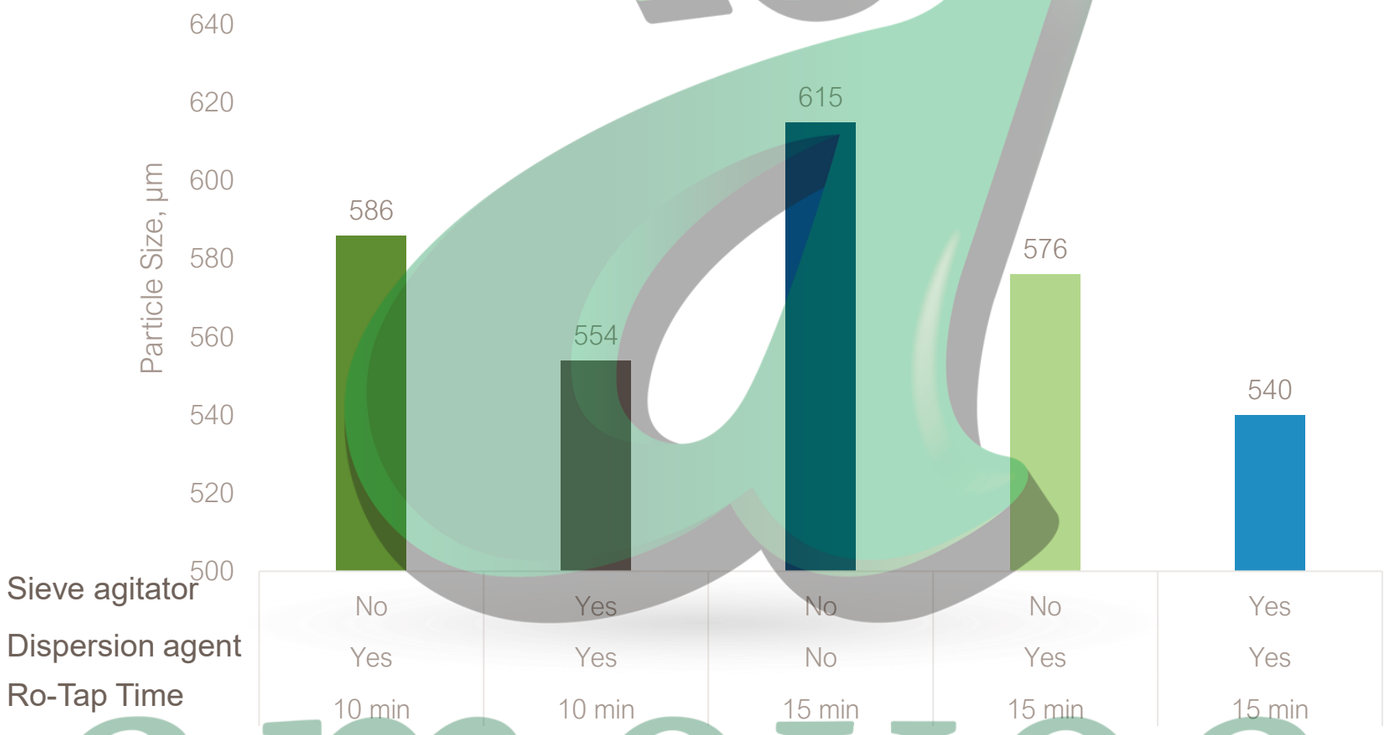
Estimating Particle Size (Microns, µm)

Particle Size	% Passing 14 Mesh (Tyler) Screen
500 Microns	90 -95%
600 Microns	80-90%
700 Microns	70-80%
800 Microns	65-75%
900 Microns	60-70%
1000 Microns	50-60%

For estimating ground corn, sorghum, wheat, soybean meal, and similar materials. Weigh out 50 to 100g, sieve over a Tyler #14 sieve(opening 1.191 mm) and measure the 2 separated fractions

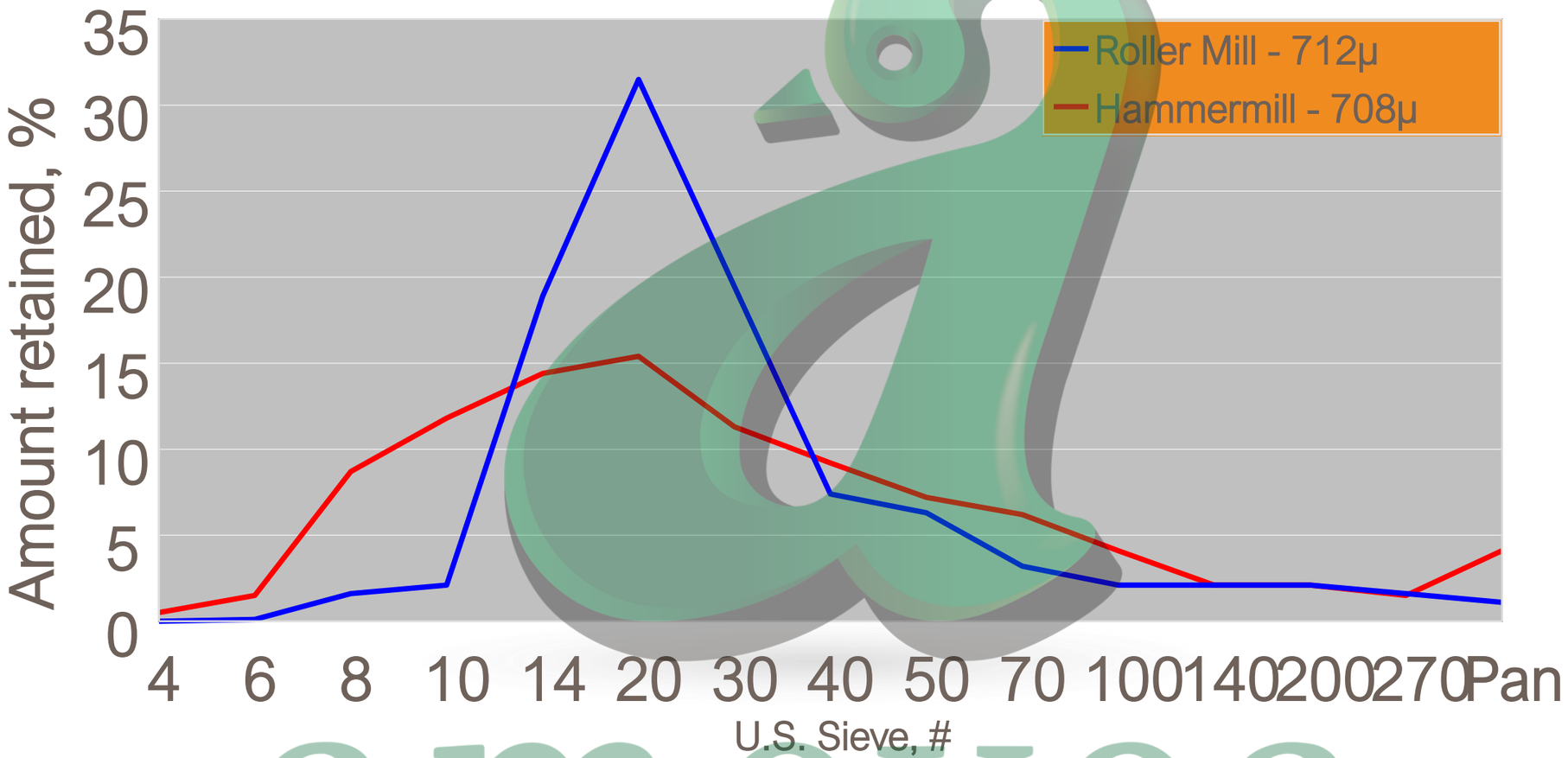
Particle Size Analysis – ASABE S319.4

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

Hammermill versus Rollermill



AUDIENCE QUIZ

IS THERE AN ISSUE?

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Particle Size Analysis - Calculated

Particle Size Analysis

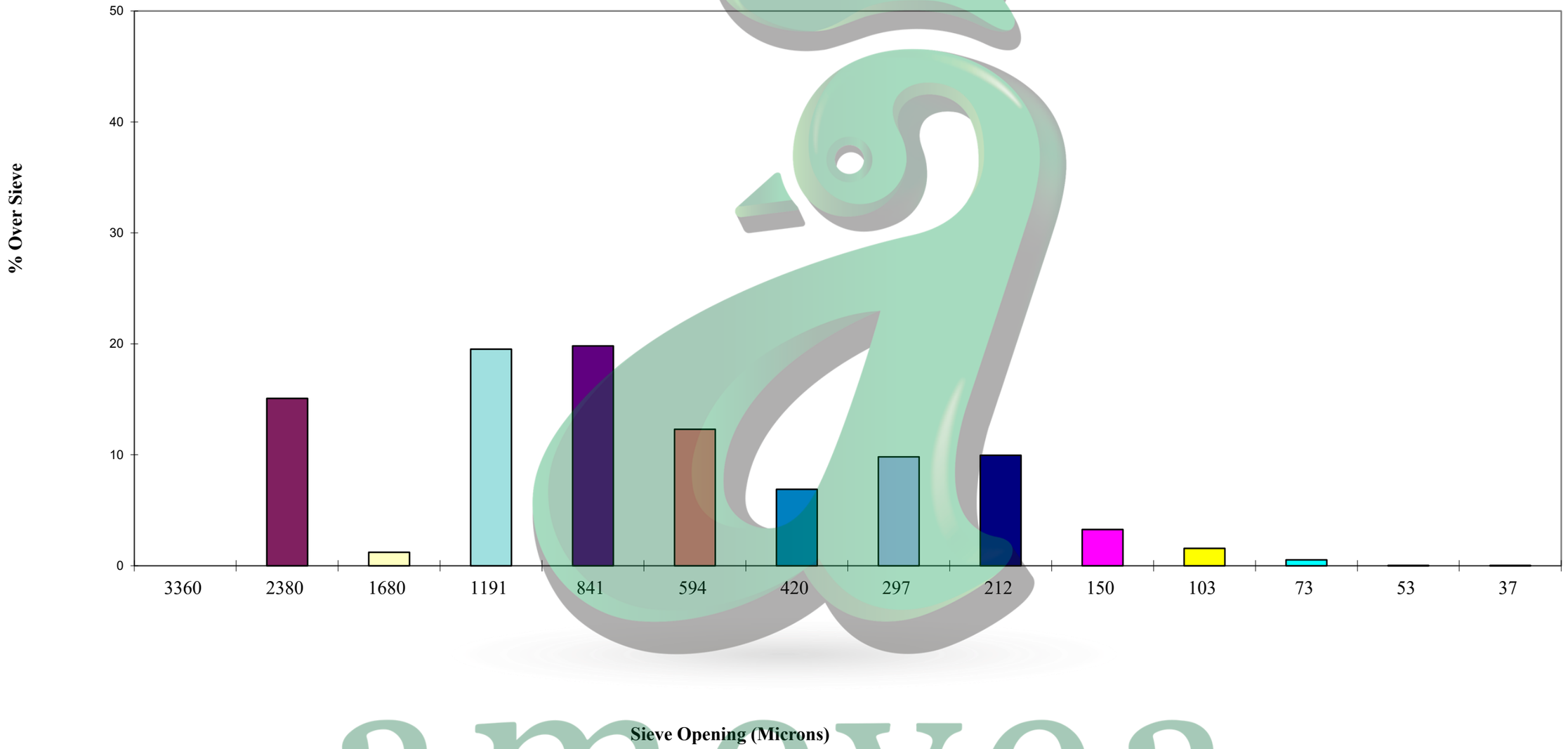
Material: Corn

07/21/2026

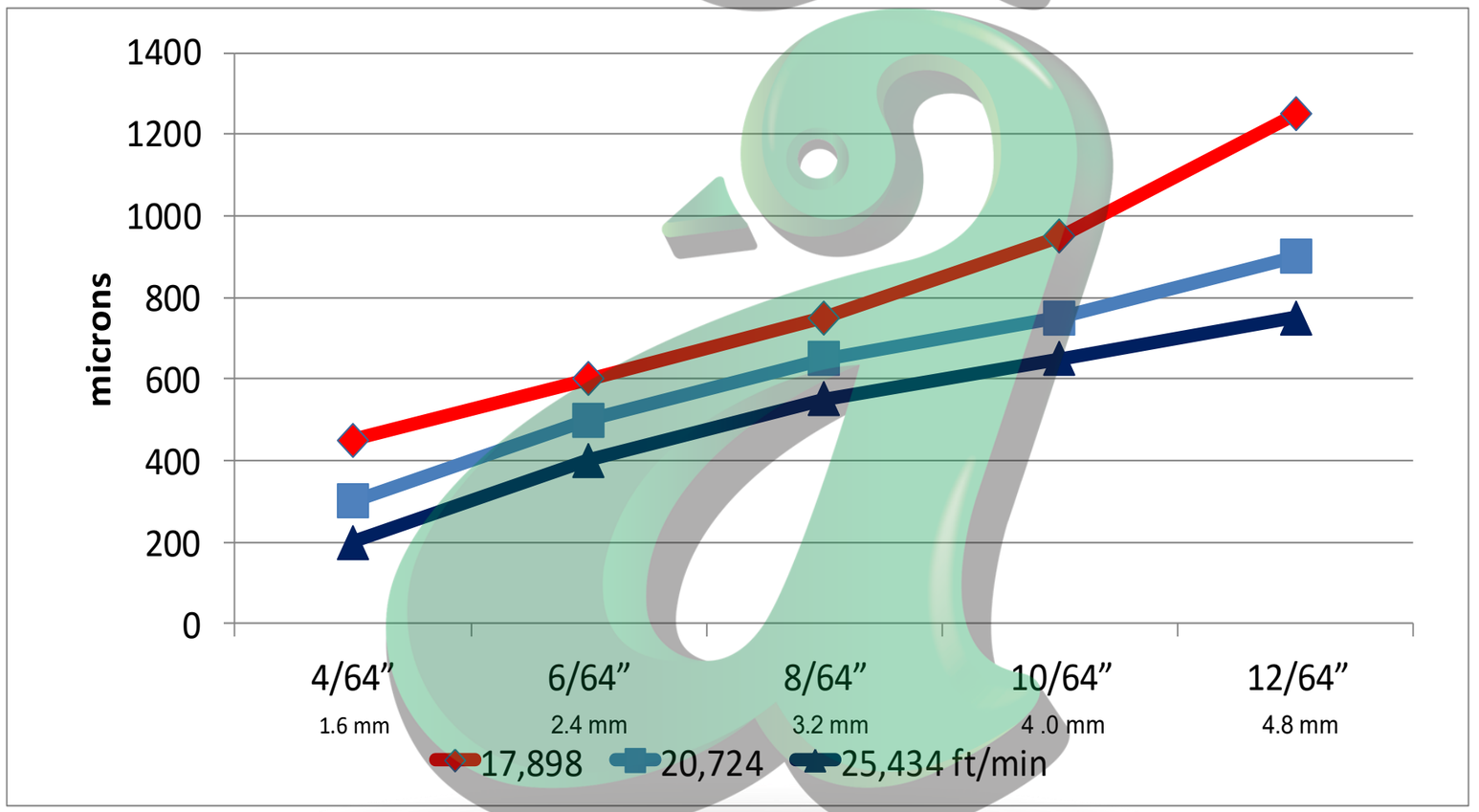
U.S Sieve	Micron Size	Wt grams	%	% less than	log dia	wt * log dia	log dia - log Dgw	wt(log dia - log Dgw)^2
6	3360	0.00	0.00	100.00	3.60	0.00	0.69	0.00
8	2380	15.00	15.09	84.91	3.45	51.77	0.54	4.35
12	1680	1.21	1.22	83.70	3.30	3.99	0.39	0.18
16	1191	19.41	19.52	64.17	3.15	61.15	0.24	1.09
20	841	19.70	19.81	44.36	3.00	59.11	0.09	0.15
30	594	12.23	12.30	32.06	2.85	34.85	-0.06	0.05
40	420	6.85	6.89	25.17	2.70	18.48	-0.21	0.32
50	297	9.76	9.82	15.35	2.55	24.87	-0.37	1.30
70	212	9.90	9.96	5.39	2.40	23.76	-0.51	2.61
100	150	3.25	3.27	2.12	2.25	7.32	-0.66	1.42
140	103	1.56	1.57	0.55	2.09	3.27	-0.82	1.05
200	73	0.53	0.53	0.02	1.94	1.03	-0.98	0.50
270	53	0.01	0.01	0.01	1.79	0.02	-1.12	0.01
Pan	37	0.01	0.01	0.00	1.65	0.02	-1.27	0.02
Summation		99.42	100.00			289.63		13.05

Particle Size, Dgw	819	Surface Area (cm^2) / gram	78.6
Standard Dev., Sgw	2.30	Particles / gram	31,647

Particle Size Analysis - Graphical



Effects of Screen Size and Hammer Speed on Particle Size



Hammermill Power Consumption Guide

Pounds per horsepower per hour

Converting to kg/kW factor **0.608277**

Screen opening size (64")	3	4	5	6	7	8	10	12	16	20
Screen opening (fractional)	3/64	1/16	5/64	3/32	7/64	1/8	5/32	3/16	1/4	5/16
Screen opening in (decimal)	0.0469	0.0625	0.0781	0.0938	0.1094	0.1250	0.1563	0.1875	0.2500	0.3125
screen opening in (mm)	1.1906	1.5875	1.9844	2.3813	2.7781	3.1750	3.9688	4.7625	6.3500	7.9375
Aquaculture Feeds										
US Standard (lbs)	120	170	210	250	265	280	320	360	450	510
Metric (kg)	73	103	128	152	161	170	195	219	274	310

Options

"DOUBLE GRINDING" SYSTEMS

✓ **Single hammermill**

- Process the entire batch through hammermill (typically 1 to 3 mm)
- Change screen (typically 0.4 to 1 mm) to improve the fineness of grind
- Rerun the same batch back through the same hammermill

✓ **Two hammermills in series**

- Grind through a larger screen first (typically 1 to 3 mm)
- Regrind entire batch through a second hammermill with smaller screens (typically 0.4 to 1 mm).

✓ **Hammermill for preliminary grind then through an air swept pulverizer for the finished particle sizing.**

❖ Double grinding offers improved efficiency over single grinding operations with a finer, more uniform finished ground product however, much more expensive.

Options

"DOUBLE GRINDING" SYSTEMS

- ✓ **Rollermill for preliminary grind then through Hammermill for the finished particle sizing.**

- ❖ Double grinding offers improved efficiency over single grinding operations with a finer, more uniform finished ground product however, much more expensive.

Troubleshooting

Troubleshoot the grinding process on a regular basis to make sure the system is operating properly. One way to accomplish this is by using the following checklist:

- Confirm capacity
- Check hammers and screens
- Check temperature of the grinding chamber
- Check the air volume
- Check the feeding device
- Check for possible discharge obstructions
- Make sure you're not using excessive horsepower

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Troubleshooting

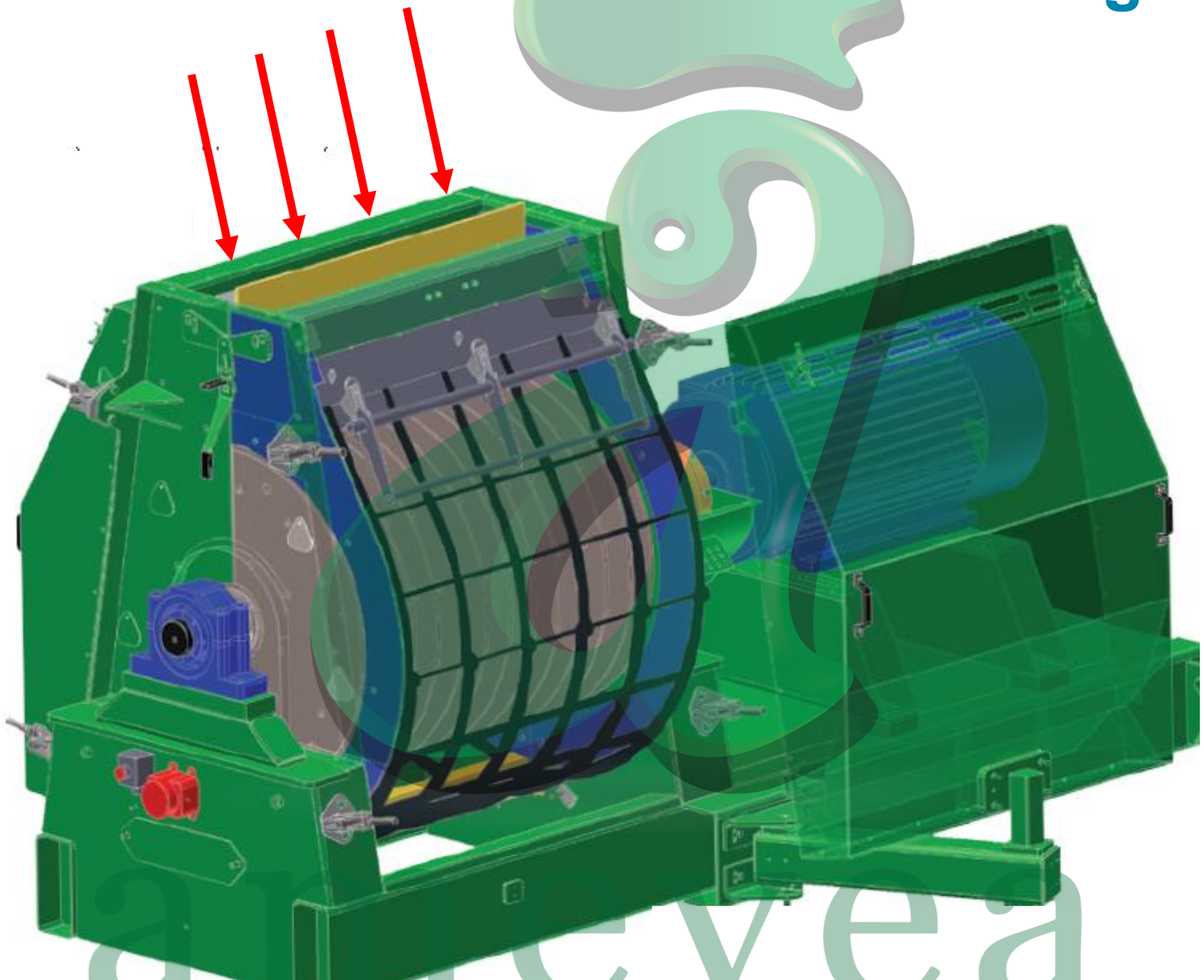
• Reverse the rotation of the hammermill rotor on at least a weekly basis, if not daily. Doing this will increase the life of both the hammers and screens.

• Make sure product is being fed uniformly into the mill.

• Too little air flow will cause premature wear on the main rotor plates and force you to change hammers and screens before they normally would need to be changed.

• Make sure adequate air volume is used. Air flow will help uniform feeding and grinding.

Even Feeding



Source:
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Rule of Thumb

Rules of thumb apply to hammermill screens in relation to applied horsepower:

1. Never have less than 14 in^2 (9,032 mm^2) of screen area per horsepower (more is always better).

2. Never have less than 4 in^2 (2,580 mm^2) of open area per horsepower.

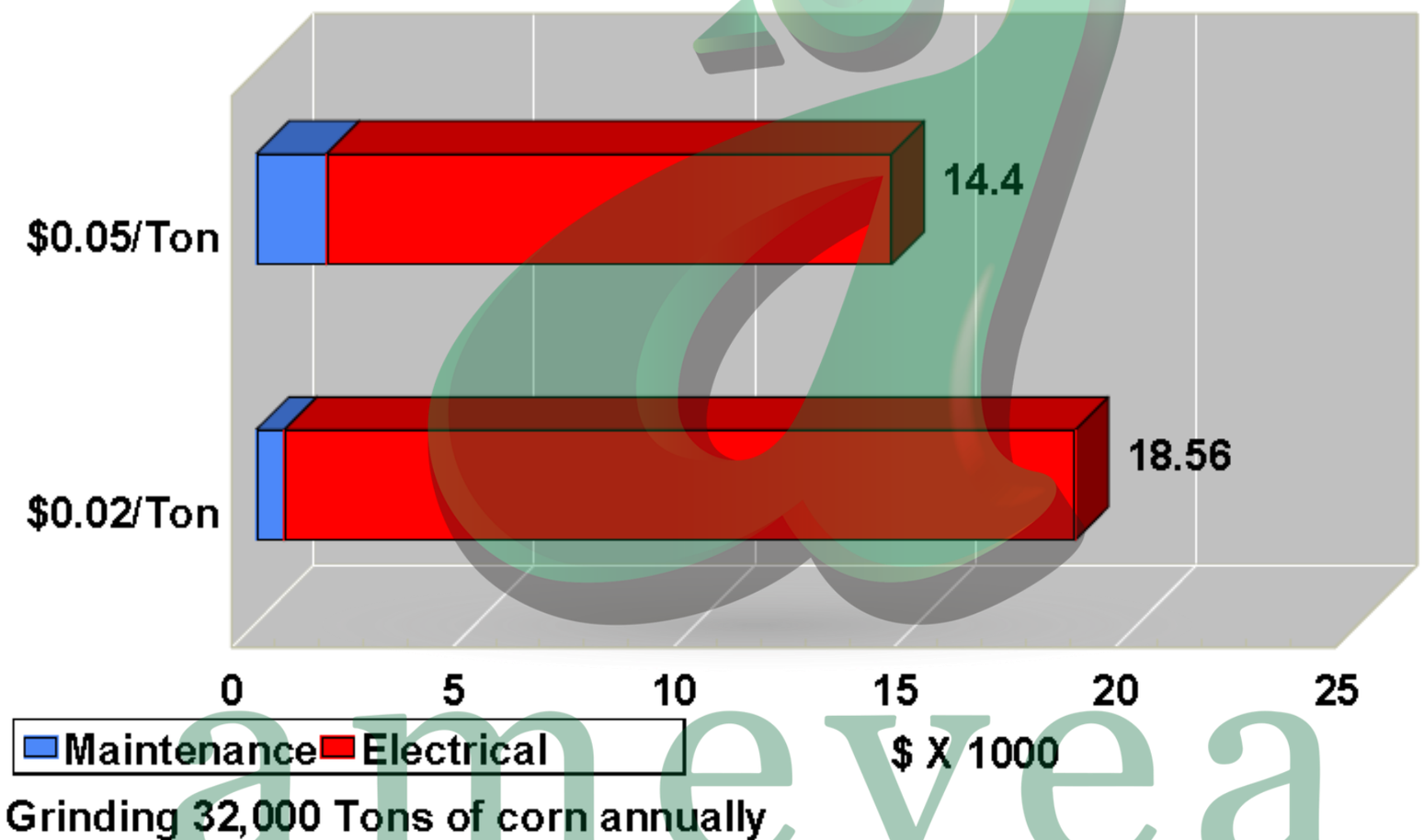
3. If there is a temperature rise of 10 F (5.56 C) something is wrong.

Rule of Thumb

Rule of thumb for the amount of air required to assist product and control dusting is

1. 1.25-1.50 CFM/in^2 of screen area. (0.035 – 0.042 CMM/645 mm^2)
2. Pressure drop across the mill may range from 2-5“ W.C.

Annual Operating Costs Hammermill -Good vs. Poor Maintenance Grinding



Feed Mill Key Performance Indicators

- Productivity
  - Tons/man hour
  - Changeovers
  - Energy per ton
    - Electrical

- Productivity
  - Actual vs. scheduled hours
  - Downtime
    - Unplanned vs. planned
  - Transportation efficiency

Tons/Man Hours - Example

- Tons Produced per Hour or Week
- Man Hours
  - Management
  - Staff
  - Operators
  - Maintenance
  - Sanitation

FUTURE / FINAL THOUGHTS

- CONTINUED RESEARCH WITH PARTICLE SIZE AND THE EFFECTS ON ANIMAL PERFORMANCE
- NEXT TECHNOLOGICAL ADVANCEMENT?
- UTILIZE kWh/Ton AS A METRIC?
- ARTIFICIAL INTELLIGENCE (AI) - USE IN PARTICLE SIZE DETERMINATION?