The Grinding Media Depot

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HOW TO CHOOSE THE CORRECT GRINDING MEDIA

WHICH MILLS USE GRINDING MEDIA?




Horizontal Mills - Ball Mills - Jar Mills - Shaker Mills
Vibratory Mills - Sand Mills - Vertical Mills - Immersion Mills
Basket Mills -Attritor Mills - Recirculation Mills





THIS PRESENTATION WILL COVER:

- **What is milling?**
- **What is media?**
- **What do I need to consider when selecting media?**
- **What types of media are available?**
- **What size, shape, material, amount do I need?**

You will learn which questions to ask when evaluating a process.

DIFFERENT MILLS REQUIRE DIFFERENT MEDIA

Ball Mills:	large balls, cylinders, satellites, pebbles, naturals
Vibratory Mills:	cylinders
Small Media Mills:	small beads
Hi Flow Mills:	tough beads
Recirculation Mills:	tough beads
Immersion Mills:	tough beads

MEDIA MILLING CAN BE DESCRIBED AS BOTH AN ENERGY AND A FILTRATION PROCESS:

Energy:

- **Force = Mass x Acceleration**
- **Mass = bead size & bead density**
- **Acceleration = agitator speed**

Filtration:

- **PSD/particle size distribution is controlled by bead spacing which is determined by bead size, bead distribution and % media charge.**

GRINDING FORCES IN MILL

WHAT IS HAPPENING DURING THE MILLING PROCESS?

- **Shear: material and media move past each other reducing particle size with velocity**
- **Impact: media pounds the material between media/media and media/chamber**
- **Impingement: material pinches between media.**
- **Autogenous: tearing and smashing itself apart**
- **Vaccuum: removing air for faster and easier wet out; internal particle air helping to break agglomerates from the inside out**
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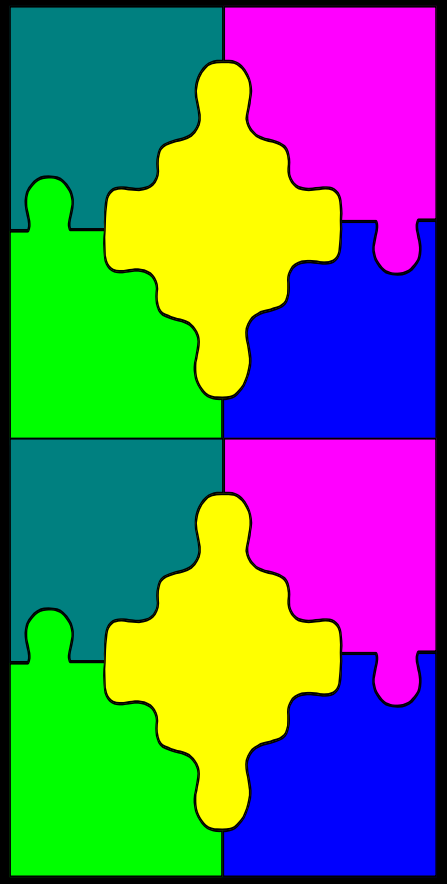


DON'T UNDERESTIMATE PRE-GRINDING

Always know the size of the feed going into the mill

- The mill is the most expensive piece of equipment in the plant; only use it for what it is designed to do – Grind Beyond the Disperser
- Pre-Grinding helps optimize the use of the mill
- Pre-Grinding assures that the product feed is consiste
- Pre-Grinding opens up the door to using smaller medi thereby producing finer grinds faster
- Always use the optimum blade fo pre-grinding that ha been determined through testing, not guessing
- or "always been done this way"

CONSIDERATIONS FOR USING MEDIA

- Initial particle size determines size of media
- Viscosity of slurry determines density of media
- Final particle size determines media charge, filtration effect

NEED CORRECT AMOUNT OF MEDIA IN THE MILL:

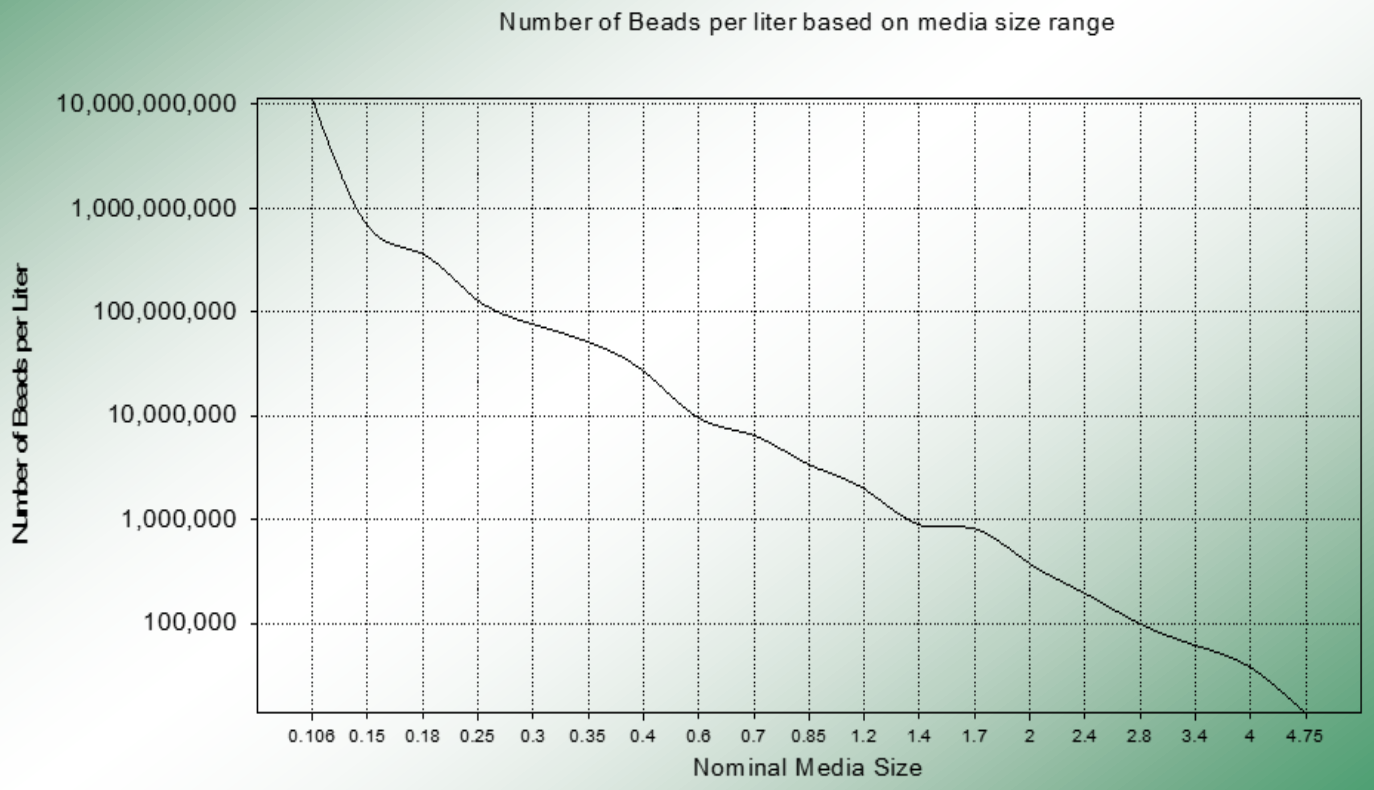
GRINDING MEDIA PROPERLY.
WILL ONLY WORK IF THE MILL IS CHARGED
YOU ARE NOT SAVING MONEY BY UNDERCHARGING A MILL.

EACH TYPE OF MILL
IS CALCULATED DIFFERENTLY.

BEAD CHARGE EFFECTS GRIND TIME, HEAT, NUMBER OF CONTACT POINTS

- # of beads increases exponentially as bead size decreases. ↑ beads =
  - smaller spaces between beads making a tighter filter giving higher efficiencies in grinding
  - higher pressure due to more resistance to flow
  - higher temperatures due to increased shear and grinding

Beads Per Liter



1.5 mm beads = 970,000/liter

2.0 mm beads = 600,000/liter

1.0 mm beads = 3,000,000/liter

.85 mm beads = 5,300,000/liter

0.6 mm beads = 10,000,000/liter

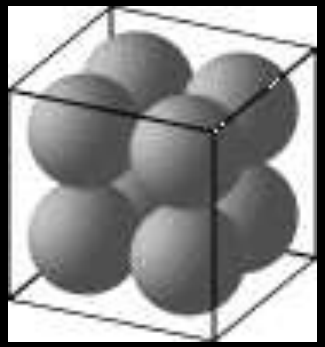
0.4 mm beads = 50,000,000/liter

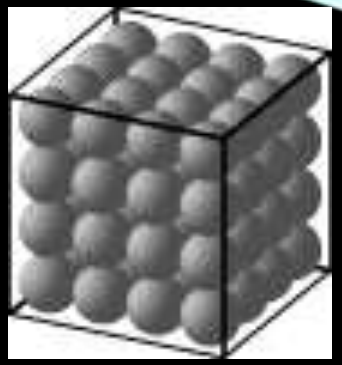
DIFFERENT MILLS REQUIRE DIFFERENT AMOUNTS OF MEDIA

- **BASED UPON WORKING VOLUME OR TOTAL VOLUME**
- **Mills such as the Immersion Mill have a fixed amount determined by size of the basket**

• **Steel Ball Mill**	**33.3%**
• **Open Head Sand Mill**	**35-45%**
• **Ceramic & Pebble Ball Mill**	**50%**
• **Dry Grind Batch Attritor**	**45-60%**
• **Wet Grind Batch Attritor**	**38-45%**
• **Continuous Attritor**	**78-92%**
• **Circulation Attritor**	**85-92%**
• **Straight Side Vertical Mill**	**50-55%**
• **SW Vertical Mill**	**40-45%**
• **Fryma Vertical Mill**	**55-70%**
• **Horizontal Disk Mill**	**70-85%**
• **Recirculation Mill**	**80-100%**
• **Basket Mill**	**100%**

MEDIA CHARGE: EFFECT ON SPACING & GRINDING

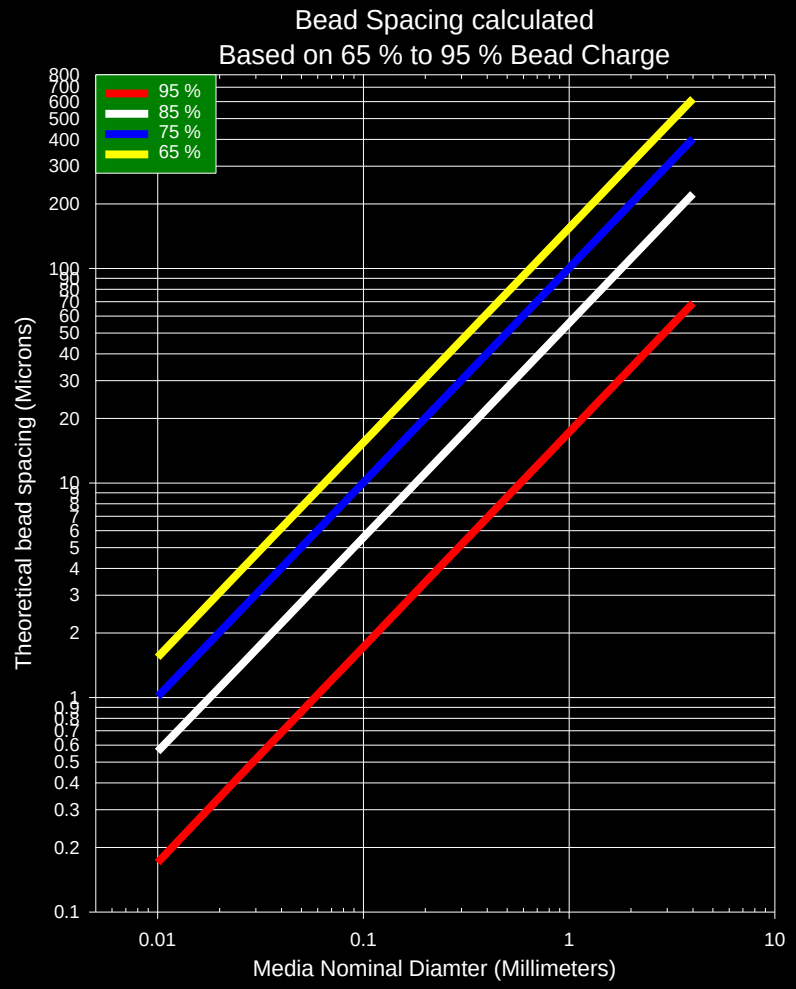




Theoretical space between grinding media based on random packing

- **Solids in slurry to be processed decrease gap between beads**

- **Increasing bead charge**
  - **Increases compression**
  - **Increases power input**
  - **Increases shear rate**
  - **Tighter bead spacing results in higher filtration and finer grinding**



HOW OFTEN SHOULD MEDIA BE CHANGED?

- Topping Off: beads can be added for a period of time when media gets low due to wear and spillage; should be done regularly
- Media Replacement: beads should be completely replaced when the average bead size is 70% that of the original size;
- If the mill has been running for a long time with smaller beads, consider using smaller sized beads for the fresh charge.

CHECKING MEDIA CHARGE

- ***Best Way*:** check and note the power draw on a high volume product. If power draw decreases gradually it's probably due to media wear. Recharge with media until the original power draw is restored.
- ***Acceptable Way*:** measure the initial media level with a stick or mark somewhere visible. Check the level periodically and fill when needed.
- ***Alternative Way*:** passive maintenance: wait until the screen starts to block.
- ***Worst Way*:** wait until product doesn't meet QC standards

SIZE MATTERS

- Use the smallest bead possible determined by the feed size, not the desired final size;
- Use the largest opening possible for the best flow without causing bead plug;
- Standard media should be 3x the opening size;
- Long wearing media can be 2x the opening size but this can vary with mill type

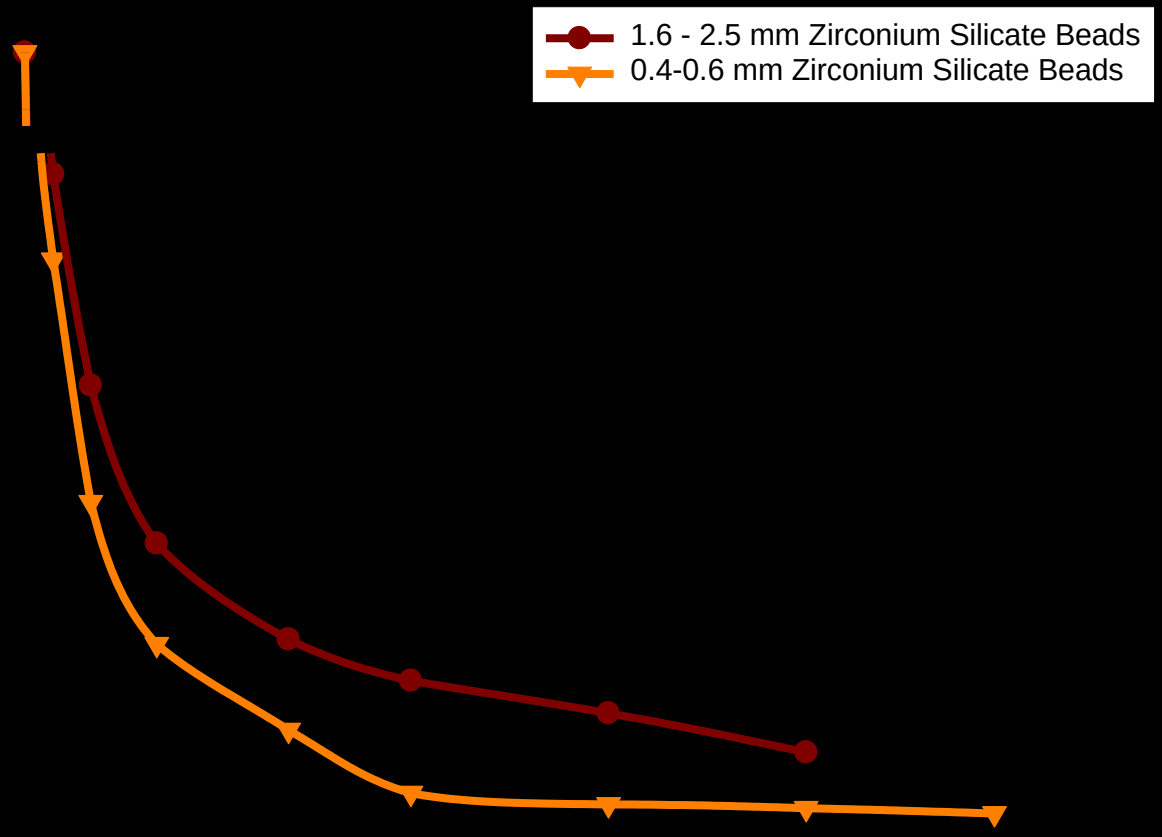
BEAD SIZE DETERMINES FINAL PARTICLE SIZE BUT SHOUBLE BE BASED UPON *STARTING PARTICLE SIZE*:

- **General rule #1:** Feed particle size should be 90% < 10x bead size. Example: 2.0 mm bead will have a feed size of 90% < 200 micron

- **General rule #2:** final particle size will be 1/1000th of media size. Example: 2.0 mm bead will give a D50 of 2.0 microns

- ***The bead has to be large enough to grind the largest particles but small enough to produce the desired final grind.***

Fine Grinding & Media Size



Resulting median particle size is 1/1000th median bead size

MIXING DIFFERENT SIZES

- In general, small media with tight distributions result in more efficient grinding than wide distributions or mono sized beads
- Mono sized beads retard wear and extend the life of the media
- Broad distributions or mixing sizes creates accelerated wear as the large beads grind the small beads

WHAT HAPPENS TO THE MEDIA WHEN IT WEARS?

IT GOES INTO YOUR PRODUCT!

MEDIA CAN BE A MAJOR CONTAMINANT IF THE PRODUCT IS NOT FORMULATED TO USE THE MEDIA AS A RAW MATERIAL.

steel media will cause graying or rust
glass media can change the refractory index

MEDIA SHOULD WEAR, NOT THE MACHINE

Media should be chosen to be the major wearing part of the mill OR the least destructive to the mill ***because it's cheaper to replace media than mill parts.***

Low Viscosity

can also lead to mill wear.

FORMULATION TIP

Mills are expensive. There is no reason to mill products like resin and solvent. These types of products should only be added for flowability.

If possible, it is best to make a high solids concentrate. This will reduce grind times and also the required mill size.

MATERIALS OF CONSTRUCTION

- Media hardness should match liner hardness to prevent excessive wear.
- High density media can cause high wear of stainless or alumina parts; Use 440 stainless if possible.
- High heat can destroy polymer parts.
- Mills are available in various steels, polymers and ceramics.
- Be aware that alternative liner materials can reduce heat transfer. A compromise is to make the parts from alternative materials and the keep the liner as some time type of metal.





CONSIDER TEMPERATURE

THE MILLING PROCESS IS AN ENERGY PROCESS CREATING HEAT AS A BY-PRODUCT.

↑ density, ↑bead charge,
↑ viscosity; ↓ bead size,
↓ batch size = MORE HEAT

WEAR PROPERTIES OF MEDIA CAN VARY GREATLY. CHOOSE WISELY.

Cheap can be expensive.

Look at VALUE rather than price.

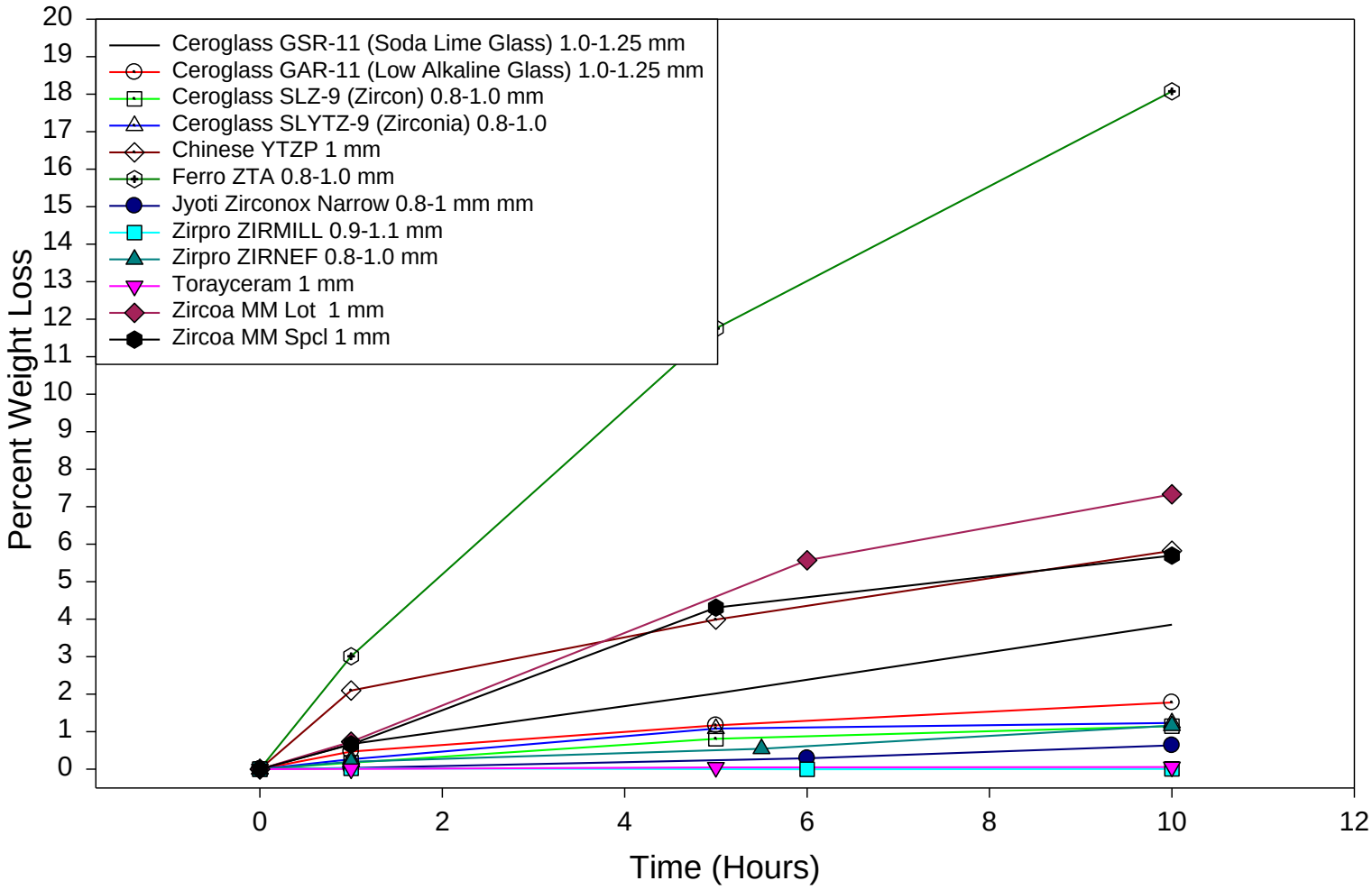
More wear =

- more contamination
- more time to recharge the mill
- less efficient grinding with time

Not always less wear on mill parts

MEDIA WEAR RATES

Media Wear Comparison
All beads 1 mm range
Tested on Minizeta with Polyamide shaft
Water circulated



BEAD SPHERICITY (ROUNDNESS) EFFECTS BEAD WEAR AND MILL WEAR

- ***Round:*** **uniform in shape, will roll and move through the mill making consistent contact. The smooth rolling action causes less wear on the mill.**
- ***Oblong:*** **or other non-round shapes such as pyramids or flats will not roll smoothly causing erratic flow, inefficient mill wear and premature mill wear**
- ***Starting Shape*** **influences *wear shape*** **which effects media life and mill wear**

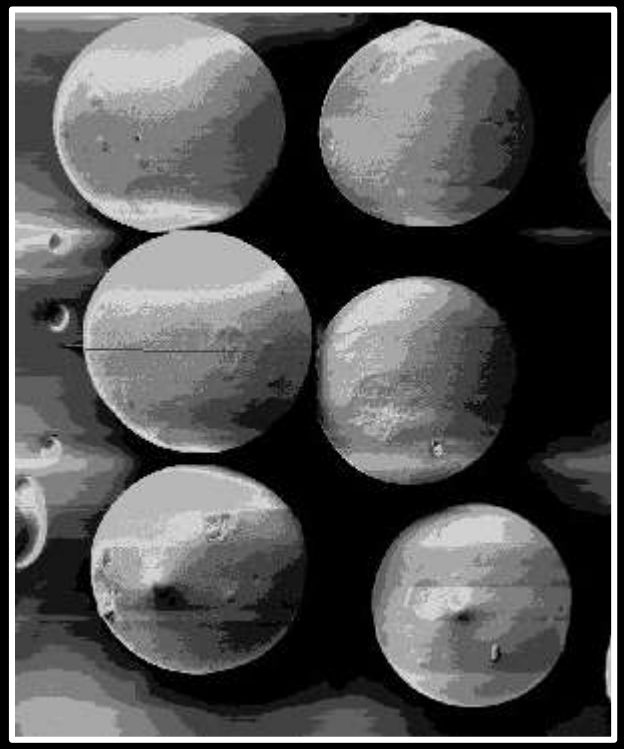
MEDIA WEAR PHOTOS

Cerium Brand, New

Yttria Brand, New

24 hours of grinding

BEAD WEAR PATTERNS



Before

After Horizontal Mill

Flats & Misshapen

This is an example of an expensive high density bead which lasts a long time but can cause excessive wear on the mill due to its initial shape which effects the wear pattern.

CAN CRUSH STRENGTH PREDICT MEDIA WEAR?

- This test can be misleading due to the difficulty in obtaining good alignment of the same point on a sphere with the compressive axis.
- **Vickers Microhardness test on the mirror-finished surface of the media is a more reliable indicator about wear performance of media.**
- The higher the Vickers Number, the higher the crush strength, the higher the wear resistance.
- **Example: Yttria ZirOx might be 1300; Cerium ZirOx 1150; & Zirconia Silicate 800.**

CHEMISTRY COUNTS

- How will heat effect the mill and the formulation?
- Does the media density match the viscosity?
- Can the product tolerate metal contamination or rust?
- Can all traces of the media be removed from the product?
- Will media wear effect the performance of the final product?

BEAD DENSITY MATTERS

The bead should be heavier than the product which is being milled, especially in a vertical mill, to prevent "media float."

- higher viscosity ↑ density
- higher solids ↑ density
- faster grind time ↑ density
- lower temperature ↓ density
- shear sensitive ↓ density
- deagglomeration ↓ density

BEAD DENSITY

THERE IS A CORRECT BEAD FOR EVERY APPLICATION

- Polymers: 1.0-1.6
- Silica: 2.5-2.6
- Pebbles: 2.6
- Steatite: 2.6
- Mullite: 2.8-3.3
- Alumina: 3.0-4.2
  - 70% 3.0 /3.2
  - 87% 3.40
  - 90% 3.50
  - 92% 3.58
  - 94% 3.62
  - 99.5% 3.88
  - 99.9% 3.90
  - ZTA 4.20
- Zirconia 3.8-6.2
  - Silica 3.8
  - Silicate 4.0
  - ZirSil HD 4.4
  - ATZ 4.7
  - Mag ZirOx 5.5
  - Yttria ZirOx 6.0
  - Cerium ZirOx 6.25
- Steel 7.6
- Tungsten Car 15

DENSITY & MILL WEAR

- High Density Media is best used in standard mills if viscosity is 1500+ cps;
- In Ceramic, Urethane, Rubber lined mills viscosity isn't as much a wear issue as it is a heat transfer issue;
- The crystalline structure of the media has a greater impact on abrasiveness than density;
  - For example, YTZ media is dramatically LESS abrasive than Alumina or Zirconia Silica which are lower in density. It's not just HARDER, it's TOUGHER.

DETERMINING HOW MUCH YOU NEED IN A VERTICAL OR HORIZONTAL MILL

Void Volume of Mill ***multiplied by***
% Charge for the Mill ***multiplied by***
kg/liter, kg/gal, #/liter, #/gal of grinding media

40% of the media volume is open space

DON'T MIX MEDIAS
UNLESS RECOMMENDED BY AN EXPERT

- Never ever mix different types of media.
- Always put in a fresh charge when making a media change. This includes same type/same size but different manufacturer.
- In most cases, if mixed, both medias will wear prematurely due to differences in hardness, toughness, surface finish, size distribution, and density
- There is a simple method for transitioning to a new media by removing the media from 1 mill, screen it, use the on-size media to replenish the other mills. When the replenishment is used up, move on to emptying the next mill and repeat the same procedure until there is only one mill remaining.

JOG THE MILL WHEN MEDIA IS WASHED

- Never run a mill dry or continuously with beads in wash water or solvent.
- Both will deteriorate the mill rapidly.
- One option is to make a resin rinse before a final cleaning.

MEDIA TRENDS

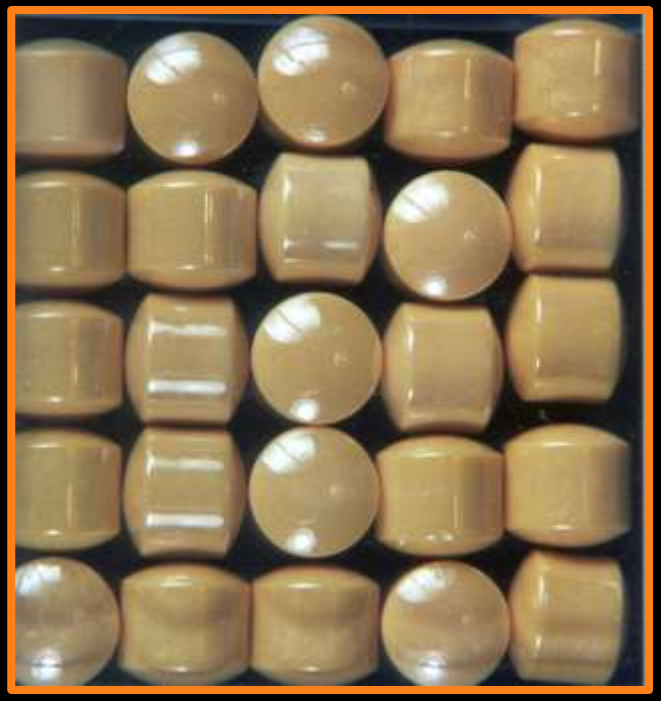
- Glass, Alumina & Zirconia Silicate is still used due to the low cost especially in the older mills;
- Steel medias are still the best value due to the high density and low cost if using steel shot and high sphericity if using steel balls. Removable with magnets. However, many customers cannot use this due to graying and/or rusting;
- Zirconia Oxides are growing the fastest due to the long life and lower abrasion. The value of paying extra to buy less, lower maintenance, higher operating efficiencies are paying off;
- Very high quality media has been developed for the mining industries at much lower costs due to the high volume. These lower cost high value medias are now available to the coatings industry;

Zirconium Oxide

- Magnesium stabilized
- Cerium stabilized
- Yttria stabilized

MAGNESIUM STABILIZED ZIRCONIA OXIDE 5.4 GM/CC

- High density with reasonable $
- Small beads are extremely abrasive
- Very popular in jar and ball mills
- Not a viable option for small media mills



ALUMINA TOUGHENED ZIRCONIA OXIDE 5.1 GM/CC

- Spherical
- 73% ZrO, 25% AlO
- High density with reasonable $
- 1.0 mm-1.7 mm
- Very Hard/Tough
- Vickers 1300
- Excellent wear rates
- Mining, Minerals, Inorganics
- Not abrasive

CERIUM STABILIZED ZIRCONIA OXIDE 6.0-6.25 GM/CC

- High density - reasonable price
- Low wear rate, 1200 HV
- Less abrasive than Mg but more than Yt
- High viscosity or lined mill is needed, 1500 cps
- Widely used for fast grinding
- 2 High Value Suppliers; 2 Very Good Value Suppliers; 1 Average Value Supplier
- A new and better yttria bead may replace cerium zir ox in the future

CERIUM STABILIZED ZIRCONIA OXIDE 6.1-6.25 GM/CC

1. Japan
2. France
3. India
4. US
5. Korea
6. China






1-May-20	COMPARISON OF CERIUM ZIRCONIA OXIDE BEADS					
Name	ZirCe	CerZO	CNCZ-GB	CeNor	MilCe	CeTZP
Type	Cerium	Cerium	Cerium	Cerium	Cerium	Cerium
Country of Origin	France	Japan	India	Korea	US	China
Chemistry	82 ZrO/16 CeO	80 ZrO/20 CeO	83 ZrO/17 CeO	79 ZrO/21 CeO	ZrO/CeO	80 ZrO/18 CeO
Density: gm/cc	6.2	6.1	6.15-6.25	6.1-6.15	6.25	6
Bulk Density: kg/l	3.8	3.7-3.75	3.75-4.05	3.7	3.78-4.06	3.6
Crush Kgf	>150		205-215		200	
Color	polish black	light toffee	golden brown	dark brown	dark gray	marigold
Polish	hi gloss smooth	glossy smooth	glossy smooth	hi gloss smooth	satin smooth	glossy smooth
Shape	very round	very round	egg-round	round, some egg	egg-round	round, some flats
Sphericity	95%>0.8	0.98	90%>0.95	0.92	0.96	not published
HV Hardness	1180	1200	1200	1100	1130	1100
Packaging	20 kg	15 kg	25 kg	20 kg, 25 kg	22.7 kg	25 kg
Norstone Rating	A+	A+	A+	B	B-	C
Price Low to High	4	1	5	3	6	2
Lead Time	usually in stock	3-4 months if not in stock	usually in stock	usually in stock	usually in stock	3-4 months if not in stock
Comments	better in med-high viscosity	long lead time	can flatten and pyr	on the small side	flattens, abrasive	higher wear rate
Best Value	**	***				

YTTRIA STABILIZED ZIRCONIA OXIDE 6.0 GM/CC

- Used to be the most expensive but now not necessarily
- Longest Life with some exceptions in high temp water based products with extreme pH
- Most brands offer high sphericity
- Tight sizing
- Not abrasive
- **Not all are equal!** beware of poor quality
- 1 top producer, 2 excellent, 2 good, many poor
- .03 mm - 60 mm

YTTRIA STABILIZED ZIRCONIA OXIDE 6.0 GM/CC

1. Japan
2. France
3. Japan
4. Korea
5. France
6. China






NEW ALTERNATIVE TO CERIUM: LOWER COST YTTRIA WITH HIGH QUALITY

- COMPARISON TO EXPENSIVE YTTRIAs:
- 93% ZirOx; 5% Yttria
- Density 6.0
- Sizes 0.6 – 2.0 mm
- Narrow size distribution
- Fine microcrystalline structure
- Polished
- Cream color
- Slightly broader distribution
- Not quite a spherical
- Vickers 1150

1-May-20	COMPARISON OF YTTRIA ZIRCONIA OXIDE BEADS					
Name	Tosoh YTZ	CYZ	Zirmil-Y	Zirmil TZP	SLYTZ	YZP
Type	Yttria	Yttria	Yttria	Yttria	Yttria	Yttria
Country of Origin	Japan	Japan	France	France	Korea	China
Chemistry	95 ZrO/5 YO	94.75 ZrO/4.9 YO	93 ZrO/5 YO	93 ZrO/5 YO	99.7 ZrYO?	94.8 ZrO/5.2 YO
Density: gm/cc	6.1	6.1	6.1	6.0	5.9	5.9
Bulk Density: kg/l	3.7	3.7	3.7	3.65	3.6	3.55
Color	iridescent white	polished white	polished white	polished cream	off white	white
Polish	hi gloss smooth	glossy smooth	glossy smooth	low gloss smooth	satin smooth	polished smooth
Shape	very round	very round	round	round	round, undulates	round, undulates
HV Hardness	1300	1250	1250	1150	1100-1400	1020
Packaging	1 or 10 kg	15 kg	20 kg	20 kg	22.7 kg	25 kg
Norstone Rating	A+	A+	A+	A	B	B
Price Low to High	6	5	4	1	3	2
Lead Time	usually in stock	3-4 months	usually in stock	new, stock as needed	usually in stock	3-4 months
Comments	best in the world	on the smaller side	excellent	best value for most	wears fast	100% prepay
Best Value	**	***	*	*		

New Medias

Many Developed for the Mining Industries

- Beads are Alumina, Zirconia, Silica and a combination of the three
- Density ranges from 2.6 – 6.0
- Vickers Hardness ranges from 742 – 1431
- Size ranges from .4-.6 mm up to 8.0 mm
- Used for minerals & mining in stirred ball mills, verticlal mills, small media mills. Also used for armor, surface treatments, fillers, etc.

MEDIA RECOVERY

- Newer Medias are far more expensive than in prior decades.
- We now offer special screening services to recover media if you can't do this in house.
- Keeping the distribution narrow will extend the life of the media and make grinding more efficient.
- Screening will save a lot of money since only enough media for top off needs to be purchased.

UNDERSTAND THE PERSONALITY OF THE PLANT & NATURE OF THE PRODUCT

B E C A U S E

- **It doesn't matter if the media lasts a long time if …**
- **Common practice is to find a lot of it on the floor or down the drain;**
- **The product wears down the media so fast that the value of long wearing media can't be realized**

TRAINING SAVES MONEY

- **Tell the people who are working with the media how much it costs. They will treat it with more respect.**
- **Train the operators in proper handling and charging of the media.**
- **Put the cost of the media on the mill along with the correct per cent charge for the mill. Operators will respect it more.**

GRINDING MEDIA DEPOT

We are always available to assist with choosing the right grinding media, educating users on what is new and helping in any areas of need.

We represent all medias and have exclusivity with none so that we can better help you choose the best vale option.

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