



THE WONDER CERAMIC MICRO-MACRO MILLING MEDIA

Ceria Stabilized Zirconium Oxide
High Density ($\geq 6.20 \text{ g/cm}^3$)
Milling High / Medium
Viscous Formulations
Long Lasting



VERSATILE INDUSTRIAL APPLICATIONS



PRINTING INK



GOLD



AUTOMOTIVE PAINT



CHOCOLATE



PHARMA



THE WONDER CERAMIC MICRO-MACRO MILLING MEDIA

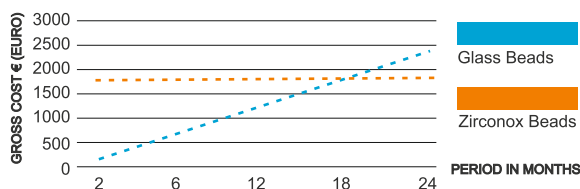
Jyoti Ceramic is the proud manufacturer of Zirconox milling media, exporting 70% of its production to 55 countries for over three decades. Zirconox milling media has proved to be the most efficient, cost effective milling media in varied industries.

Zirconox was formulated in 1990's from micro fine monoclinic zirconia powder stabilized with rare earth Cerium Oxide transformed to tetragonal polycrystals.

Due to its unique features Zirconox has become synonymous with milling beads and today is considered as the wonder ceramic milling beads.

Benefits of Zirconox micro beads are as below.

- Zirconox micro beads have a density of 6.20 g/cm³ and bulk density of 3.85 kg/ltr. With combination of high density & hardness, desired particle size of pigment or slurry will be achieved faster, resulting in better material yield in reduced milling time.
- Zirconox micro beads are the most cost effective for speedy dispersion and micro fine milling of high viscous (15,000-50,000 cP) hard & soft substances with insignificant contamination from media wear.
- Zirconox beads are free from pin holes, cracks, bead fused with other bead resulting in reduced downtime, and greater process safety.
- Zirconox micro beads have a dense, homogeneous internal micro structure. Due to this property beads maintain glossy satin smooth surface finish and do not crack or shatter easily. As the hours of milling progresses, wear rate of Zirconox micro beads reduces further and surface finish of beads appear more glossy.
- Zirconox micro beads are extremely gentle to expensive mill parts. With usage of Zirconox beads wear of mill parts is extremely low.
- Zirconox 90% micro beads maintain sphericity ≥ 0.95 . With enhanced sphericity & satin smooth surfaces media flow improves and reduces abrasion resulting in Zirconox beads lasting approximately 300-350 times longer than glass beads, 25-30 times more than MgO stabilized beads, 20-30 times more than Zirconium Silicate beads.



TEST CONDUCTED BY

TECHNOPLAN FABRITECHNIK
GMBH & CO. KG GERMANY.

Practical Wear test with Zirconox -
milling media (1.7-2.4 mm)
In comparison to actually used
glass beads.

IN REFERENCE TO THE GRAPH

Initially the cost of Zirconox may be
higher by about 17 times than the
glass beads

In the course of usage of the mill for
about 18 month, it is realized that
the amount spent on both types of micro
media is the same.

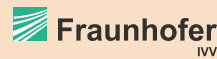
At the end of 24 months it is observed
that the cost of glass beads is higher
by about 40% than Zirconox.

COMMENTS:

The above trend is mainly due to
exorbitantly high wear of glass beads
in comparison to Zirconox beads.

Figures from the graph indicate that
the glass beads wear is about 300
times more than that of Zirconox.

CERTIFICATE



Food regulatory assessment of Zirconox® mill beads
Client : JYOTI Ceramic GmbH, 90429 Nurnberg
Order : PA/4325/18
Sample : Zirconox Micro Beads, dia. 0.4 -0.6 mm

The investigated zirconox-cerium-material is used as mill beads (repeated contact) in mills to grind food. Thereby various sizes of beads are available. Beads with a diameter of 0.4-0.6 mm were used for the analysis. The results can be transferred to beads with a larger diameter. The receipt of the beads was disclosed to Fraunhofer IWV.

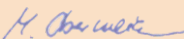
Since the mill beads are used as repeated use articles, the migration contact was repeated two times with fresh simulant (3 % acetic acid) at the test conditions 2 h / 70 °C following the rules for migration testing of the European Regulation (EU) No 10/2011 (Fraunhofer IWV test report PA/4157/18). For the assessment of the possible migration of the investigated metals zirconium, cerium, lead, cadmium, chromium, mercury, arsenic, nickel and tin the European Resolution AP(2) of the Council of Europe for aids to polymerisation and technological coadjuvants is being used.

The migration of the investigated metals zirconium, cerium, lead, cadmium, chromium, mercury, arsenic, nickel and tin is in compliance with the requirements of the European Resolution AP 92 (2) of the Council of Europe for aids to polymerisation and technological coadjuvants for repeated use at the chosen test conditions. Because of the good solubility of the components in the simulant 3 % acetic acid, the results can be transferred to the assessment for all types of food. In conclusion, there is no safety concern related to the use of the zirconox-cerium based mill beads for the grinding of food.

Fraunhofer Institute Process
Engineering and Packaging

Freising, 18.04.2018


Dr. Diana Kemmer
(Dep. Head of Migration Laboratory)


Maria Obermeier
(Scientist in Charge)

Fraunhofer Institut für Verfahrenstechnik und Verpackung, Glöcknerstr. 35, D-85354 Freising

Fraunhofer Institute, Freising, Germany has approved Zirconox micro media for milling of food stuff in accordance with the regulations of the European Community.

National Radiological Protection Board (NRPB), Great Britain has confirmed that the radio activity of Zirconox is within the regulations established by the European Community.

- Zirconox milling media are :
- Non-contaminative
 - Non-toxic
 - Non-radioactive
 - Non-magnetic
 - Chemically inert
 - Resistant to all acids and alkalis except hydrofluoric acid

PHYSICAL PROPERTIES

| | |
|--------------------------------------------------|--------------------------------|
| Colour | : Golden brown |
| Surface Finish | : Glossy, Satin Smooth |
| Density | : 6.20 ±0.05 g/cm ³ |
| Bulk Density | : 3.85 ±0.15 kg/ltr |
| Porosity | : Nil |
| Water absorption | : Nil |
| Hardness on Moh's scale | : 9 |
| Hardness on Vicker's scale (Hv _{0.05}) | : 1250-1300 |
| Crushing strength (Ø 1.5mm bead) | : 215 kgf |
| Bead Sphericity 90% | : ≥ 0.95 |

% CUMULATIVE WEIGHT LOSS / HR

| | |
|---------------|----------|
| After 24 hrs. | : 0.0015 |
| After 96 hrs. | : 0.0010 |

(wear test conducted with water)

APPLICATION OF ZIRCONOX MICRO BEADS

Zirconox micro beads are being used in varied industries for micro fine milling & dispersion of :

Agro chemicals : Fungicides, Herbicides pesticides.

Adhesive, Sealants & Glues. Ceramic : Ceramic Inks, Engobes, Glazes, Frits, Enamels, Pigments. **Cosmetics.**

Dyestuff : Textile dyes, Textile Inks. **Electronic materials** :

Lithium Iron Phosphate battery. **Food Stuff. Inks** : Printing inks, Inkjet - Magnetic inks, Tattoo inks. **Minerals** : Calcium Carbonate. **Metal** : Gold, Silver, Platinum. **Oxides** : Titanium Dioxide, Zirconium Oxide. **Paints & Varnishes** : Auto & allied paints, Decorative & Marine paints. **Pharmaceuticals.**

Zirconox beads are also used for shot peening treatment on metal surfaces, metal polishing, contact eye lenses polishing and a host of many other applications.



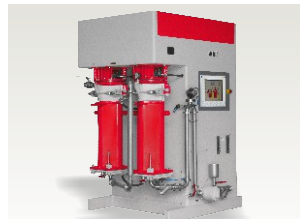
WAB BEAD MILL



NEIHMAN BASKET MILL



GETZMANN BEAD MILL



VOLLRATH BEAD MILL



CHEMFILT BEAD MILL



HCP IMMERSION MILL

CHEMICAL PROPERTIES

| | |
|------------------|-------|
| ZrO ₂ | : 83% |
| CeO ₂ | : 17% |

CHEMICAL RESISTANCE DATA OF ZIRCONOX MICRO BEADS AT 25°C TEST TIME 24 HRS.

| Chemical Medium | Concentration | % Weight Loss per hour |
|---------------------------------------------------|---------------|------------------------|
| Acetic Acid (CH ₃ COOH) | 50% | 0.00 |
| Chromic Acid (H ₂ CrO ₄) | 25% | 0.00 |
| Formic Acid (CH ₂ O ₂) | 25% | 0.00 |
| Hydrochloric Acid (HCl) | 18% | 0.00 |
| Hydrofluoric Acid (HF) | 24% | 0.01 |
| Nitric Acid (HNO ₃) | 35% | 0.00 |
| Perchloric Acid (HClO ₄) | 25% | 0.00 |
| Phosphoric Acid (H ₃ PO ₄) | 25% | 0.00 |
| Sulphuric Acid (H ₂ SO ₄) | 50% | 0.00 |
| Saturated Sodium Hydroxide Acid (NaOH) | 50% | 0.00 |

** With the exception of Hydrofluoric acid Zirconox beads did not lose it's gloss or colour*

VARIOUS MILLS SUITABLE FOR ZIRCONOX BEADS



SUPERMILL PLUS 45 BEAD MILL



IEC BASKET MILL



SUPERMILL PLUS 45 BEAD MILL



IEC HE30 BEAD MILL

GUIDELINES FOR USING ZIRCONOX MICRO MILLING BEADS

The density of Zirconox beads is $> 6.20 \text{ g/cm}^3$ which is about 3 times greater than the glass beads, 1.6 times $>$ than Zirconium Silicate beads and 1.1 times than the MgO PSZ beads.

As Zirconox beads possess higher density as compared to any other ceramic micro milling beads, it can generate considerable heat during milling process, which may affect physical properties of ingredients being milled. Therefore, it is strongly recommended to provide suitable cooling system to the mill chamber, to monitor dissipation of heat generated during the milling process.

Due to higher density of Zirconox milling beads, it is strongly recommended

- In the use of High Viscous Formulations.
- To avoid passage of beads in the slurry, ensure that the size of strainer aperture is minimum 2 times smaller than the average size of beads.
- To avoid fracture, shearing of beads or flattened plate shaped beads, ensure that the gap between walls & bottom of mill vessel to the stator/agitating arm is maintained minimum 3 to 5 times larger than the average bead size.
- Smaller the media size larger the number of contact points resulting in reduced milling time enhanced productivity and intensity of the pigment colour
- Before charging the mill with Zirconox beads, it is strongly recommended to check thoroughly the capacity & volume of the bead mill chamber and to assess the quantity of Zirconox beads required for the mill (i.e. 60 to 85% volume of mill \times Bulk Density of Zirconox beads = Quantity).

ZIRCONOX BEADS BULK DENSITY

| Dia (mm) | kg/ltr |
|------------------|--------------------|
| Ø 0.40 - 0.70 mm | 3.75 ± 0.05 kg/ltr |
| Ø 0.70 - 1.20 mm | 3.75 ± 0.05 kg/ltr |
| Ø 1.20 - 1.70 mm | 3.85 ± 0.05 kg/ltr |
| Ø 1.70 - 2.40 mm | 3.85 ± 0.05 kg/ltr |
| Ø 2.40 - 2.80 mm | 3.95 ± 0.05 kg/ltr |
| Ø 2.80 - 3.30 mm | 3.95 ± 0.05 kg/ltr |

ZIRCONOX BEADS ARE AVAILABLE IN FOLLOWING FRACTION SIZES

| Broad Fraction Size | |
|---------------------|----------------|
| Ø 0.4 - 0.7 mm | Ø 0.7 - 1.2 mm |
| Ø 1.2 - 1.7 mm | Ø 1.7 - 2.4 mm |
| Ø 2.4 - 2.8 mm | Ø 2.8 - 3.3 mm |

| Narrow Fraction Size | |
|----------------------|----------------|
| Ø 0.2 - 0.4 mm | Ø 0.4 - 0.6 mm |
| Ø 0.6 - 0.8 mm | Ø 0.8 - 1.0 mm |
| Ø 1.0 - 1.2 mm | Ø 1.2 - 1.4 mm |
| Ø 1.4 - 1.7 mm | Ø 1.6 - 2.0 mm |
| Ø 1.7 - 2.0 mm | Ø 2.0 - 2.4 mm |

* We also offer custom fraction size beads, if found feasible for production.

CALCULATION OF MEDIA LOAD

| Type of Media Load | Bead Charge |
|--------------------|---------------------|
| Closed Horizontal | 75% - 85% of Volume |
| Closed Vertical | 70% - 80% of Volume |
| Open Vertical | 60% - 70% of Volume |

E.g. : Bead mill net volume capacity is 50 ltr. Charging with Ø 1.2 - 1.7 mm bead. For vertical closed type mill it works out to = 35 ltr (70% of mill vol.) \times 3.85 kg/ltr (Bulk Density of Zirconox beads) that is 135 kg. of Zirconox micro beads charge required for a 50 ltr capacity closed vertical mill.

Considering Bead Ø 1.2 - 1.7 mm & bead charge of 75-85% of volume of grinding chamber for closed horizontal mill, 70-80% of volume for closed vertical mill & 60-70% of volume for open vertical mill.

ZIRCONOX BEAD CHARGE WEIGHT SUGGESTED FOR DIFFERENT CAPACITY MILLS

| VOLUME OF GRINDING CHAMBER (LTR) | QTY. OF ZIRCONOX MICRO BEADS (KGS) | | |
|----------------------------------|------------------------------------|----------------------|--------------------|
| | CLOSED HORIZONTAL MILL | CLOSED VERTICAL MILL | OPEN VERTICAL MILL |
| 8.0 | 23 - 26 | 22 - 25 | 18 - 22 |
| 15.0 | 43 - 49 | 40 - 46 | 35 - 40 |
| 30.0 | 87 - 98 | 81 - 92 | 69 - 81 |
| 45.0 | 130 - 147 | 121 - 139 | 104 - 121 |
| 60.0 | 173 - 196 | 162 - 185 | 139 - 162 |
| 115.0 | 332 - 376 | 310 - 354 | 266 - 310 |
| 225.0 | 650 - 736 | 606 - 693 | 520 - 606 |

DETAILS OF BEAD MILL USED FOR CONDUCTING THE WEAR TEST

| | | | |
|----------------------|--------------------------|---------------------|------------------|
| Mill Type | Horizontal Lab Bead Mill | Make | NETZSCH, Germany |
| Model | LME - 1 | Mill Container | Polyurethane |
| Mill Capacity | 0.61 Ltr | Mill Agitator Speed | 3000 RPM |
| Ceramic Media (Qty.) | 2.35 kgs. | Media (Milled with) | Water |

After milling for 24 & 96 hours at 3000 RPM (10.0 m/s), beads were collected, washed and dried thoroughly, weighed on sensitive electronic balance (Resolution : 100 mg) & the percentage weight loss was calculated as.

$$P = \frac{W1 - W2}{W1} \times 100\%$$

Where
P = Percentage Weight Loss
W1 = Initial Weight of Beads
W2 = Final Weight of Beads

The weight loss of Zirconox micro beads was found insignificant as well as caused lowest wear on mill contact parts. The percentage cumulative weight loss of Zirconox beads was observed to be 0.0015% per hour in the 24 hour test. The percentage cumulative weight loss came down to 0.0010% per hour in the 96 hour test.

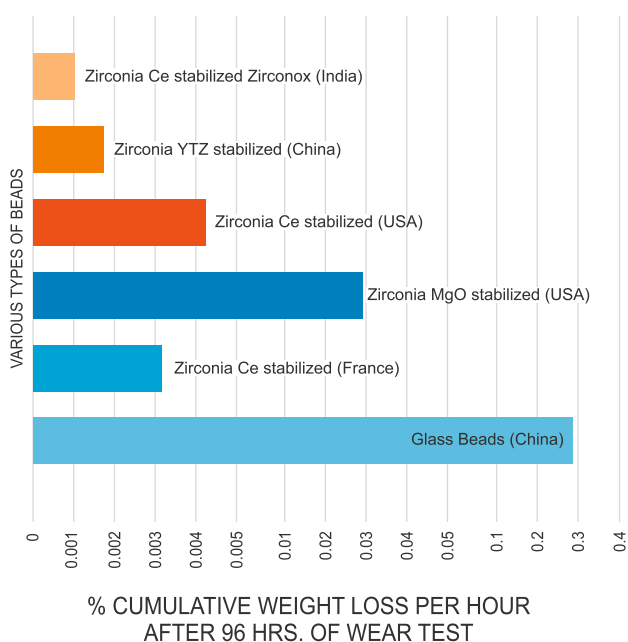


High Speed Bead Mill for Wear Test

COMPARATIVE TYPICAL PROPERTY AND WEAR RATE CHART

| CHARACTERISTICS | UNITS | Ce STABILIZED ZIRCONOX (INDIA) | YTTRIA STABILIZED ZIRCONIA (CHINA) | Ce STABILIZED ZIRCONIA BEADS (USA) | MgO STABILIZED ZIRCONIA BEADS (USA) | Ce STABILIZED ZIRCONIA (FRANCE) | Glass Beads (CHINA) |
|---------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------|---------------------------------|------------------------------|
| Colour Shade | -- | Golden Brown | White | Brown | Golden Yellow | Black | Transparent |
| Density | g/cm ³ | ≥ 6.20 | 6.0 | 6.17 | 5.73 | 6.2 | 2.24 |
| Bulk Density | kg/ltr | 3.85 ± 0.15 | 3.81 | 3.60 | 3.59 | 3.81 | 1.55 |
| Porosity | % | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water Absorption | % | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hardness on Moh's scale | Moh's scale | 9 | 9 | 9 | 8 | 9 | 5.5 |
| Hardness of Vicker's Scale | Hv ₅ | 1310 | 1350 | 1150-1200 | 900-950 | 1250 | 500-550 |
| Average Bead size taken for crushing strength | mm | Ø 1.496 | Ø 1.615 | Ø 1.44 | Ø 1.55 | Ø 1.52 | Ø 1.66 |
| Crushing Load | Kgf | 215.50 | 233.82 | 200.00 | 81.00 | 159.57 | 45.00 |
| Sphericity for 90% of the beads | -- | > 0.96 | 0.98 | 0.90 | > 0.95 | 0.96 | 0.95 |
| % Cumulative Weight Loss Per Hour of Wear Test (Wear Test conducted with Water) | After 24 Hrs. | 0.0015 | 0.00213 | 0.00233 | 0.0236 | 0.00329 | 0.2724 |
| | After 96 Hrs. | 0.0010 | 0.00175 | 0.00418 | 0.0273 | 0.00309 | 0.2982 |
| Surface Condition of Beads observed after 96 Hrs. of Wear Test in water | -- | Glossy Satin smooth surface, free from pin holes & no broken beads | Glossy Satin smooth surface, few beads with pin holes & few broken beads observed | Satin smooth few beads with pin holes & few broken beads observed | Satin smooth surface, few broken beads observed | Dull surface finish observed | Dull surface finish observed |

GRAPHICAL REPRESENTATION OF WEAR TEST RESULTS



| MEDIA TYPE | % CUMULATIVE WEIGHT LOSS / HR | |
|-----------------------------------------|-------------------------------|---------------|
| | AFTER 24 HRS. | AFTER 96 HRS. |
| Zirconia Ce stabilized Zirconox (India) | 0.0015 | 0.0010 |
| Zirconia YTZ stabilized (China) | 0.00213 | 0.00175 |
| Zirconia Ce stabilized (USA) | 0.00233 | 0.00418 |
| Zirconia MgO stabilized (USA) | 0.0236 | 0.0273 |
| Zirconia Ce stabilized (France) | 0.00329 | 0.00309 |
| Glass Beads (China) | 0.2724 | 0.298 |

ZIRCONOX MACRO MILLING MEDIA

Zirconox macro milling media are manufactured from micro fine Zirconia powder stabilized with rare earth Cerium Oxide, transformed to tetragonal polycrystals. Zirconox macro media have a density of 6.1 g/cm³, are tough sapphire hard and have a glossy, satin smooth surface finish. After Tungsten Carbide, Zirconox macro milling media are considered to have the highest density among the ceramic materials and the lowest in coefficient of friction. Due to its unique features, Zirconox milling media mills hard and soft high viscous substances faster and produces insignificant contamination from its wear.

Zirconox macro milling media are ideal for particle size reduction, dispersion of hard and soft substances in Attritor mills, Jar mills, lab scale and bulk production Ball mills and Vibro Energy Mills.





For Jar mills, satellite type or iso pressed dia 12.5, 15 & 20 mm balls are ideal, for ball mills dia 20 to 30 mm Iso pressed balls are recommended. For Vibro energy mills 6, 10, 12.5, 15 mm dia radius corner / radius end cylinders are recommended. For low and medium speed attritor mills 6, 8 and 10 mm dia satellite type balls are recommended.

Smaller the size of milling media, larger the number of contact points, resulting in reduced milling time. Zirconox macro milling media lasts longer due to its dense, homogeneous internal micro structure, higher toughness and micro fine grain size. Zirconox media are very gentle on mill contact parts.

APPLICATION OF ZIRCONOX MACRO MILLING MEDIA

Zirconox macro milling media are excellent for milling and dispersion of high viscous formulations, wet and dry grinding of hard and soft substances, such as auto and allied paints, printing inks, colors, pigments, chemicals, Calcium Carbonate, minerals, enamels, glazes, frits, graphite, advanced ceramic materials, dielectric and piezoelectric formulations, cosmetics, batteries, pharmaceuticals, food and a host of many other applications requiring contamination free, speedy micro fine milling or dispersion of formulations.

ZIRCONOX MACRO MEDIA ARE AVAILABLE IN FOLLOWING SIZES

| Type of Zirconox Macro Milling Media | Available Sizes (In mm) | Shapes |
|-----------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------|
| Uniaxial pressed sphere with ridge / band at centre | Dia 6, 8, 10, 12.5 |  |
| Iso pressed sphere with ring at top | Dia 16, 21, 26, 31 |  |
| Radius end Cylinder (REC) | Dia 6, 8, 10, 12.5 |  |
| Radius end Corner Cylinder (RCC) | Dia 6, 8, 10, 12.5, 15, 20, 25 |  |

CHEMICAL PROPERTIES

| | |
|------------------|-------|
| ZrO ₂ | : 83% |
| CeO ₂ | : 17% |

PHYSICAL PROPERTIES

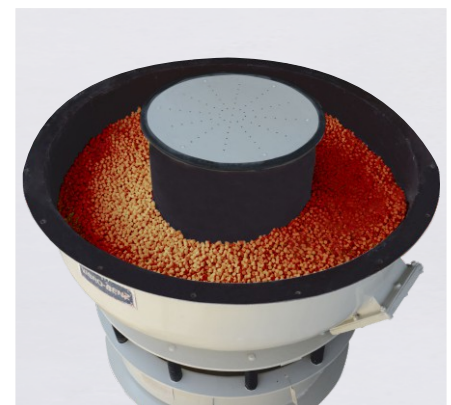
| | |
|----------------------------------------------|-------------------------------|
| Colour | : Golden brown |
| Surface Finish | : Glossy, Satin Smooth |
| Density | : 6.1 ±0.05 g/cm ³ |
| Bulk Density | : 3.95 ±0.05 kg/ltr |
| Water absorption | : Nil |
| Hardness on Moh's scale | : 9 |
| Hardness on Vicker's scale (H _v) | : 1100 |
| Flexural strength at Room Temp | : 5000 kg/cm ² |



Attritor Mill



Jar Mill



Vibro Mill



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