

Precision in Production: Case Studies on Testing Techniques and Manufacturing Applications

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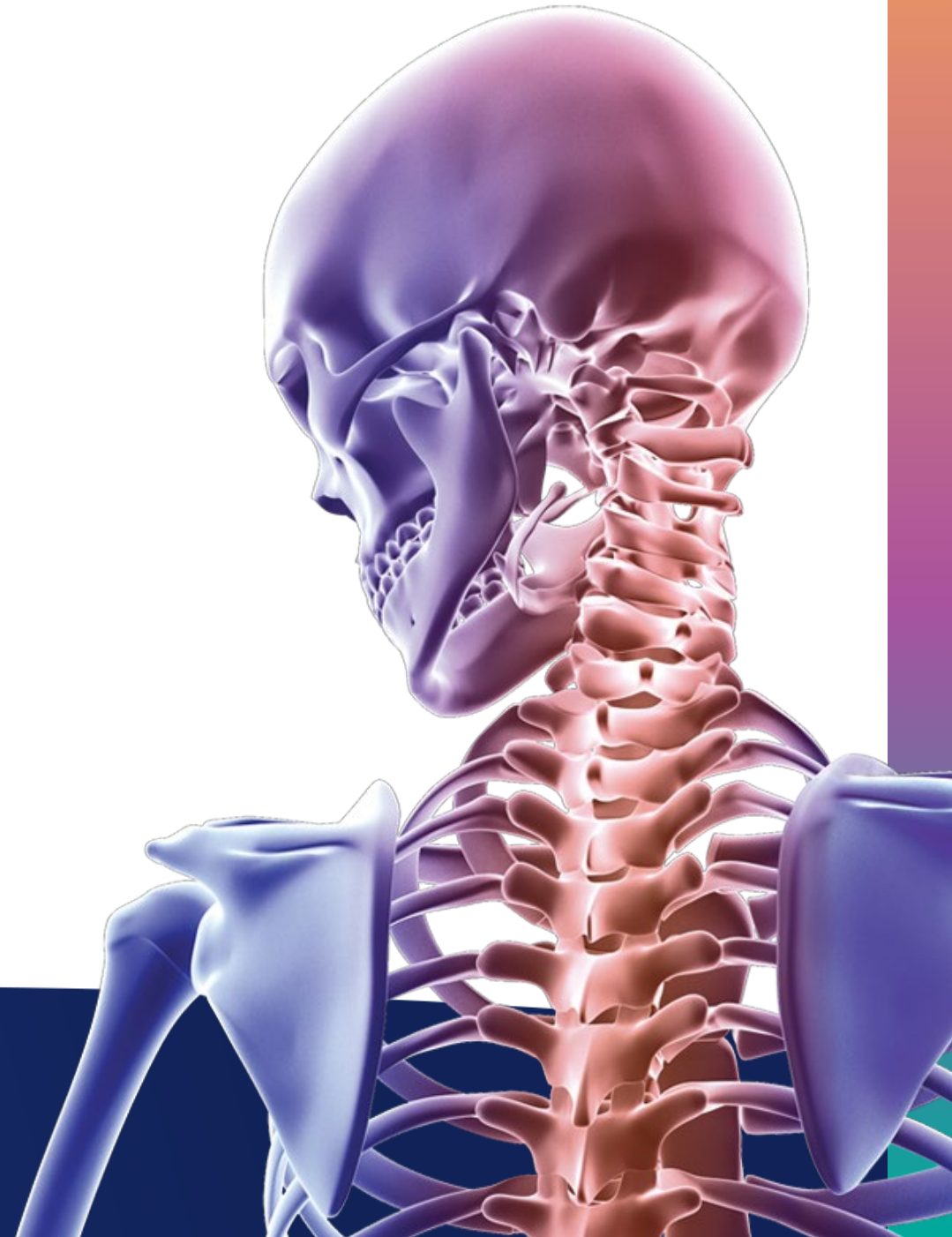
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Characterization of Particles Released from Implants

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Particle Characterization Matters

- Effect of particles released from orthopedic implants (e.g. wear debris) are well understood
- Cause inflammation, tissue damage, and implant failure leading to surgical revision
- Particle shedding also a concern for additive manufacturing (AM)
 - Structures can trap unfused powder, released post-implantation
- Need robust analytical techniques to assess safety and regulatory compliance

Particle Types and Sources

- Size range: 0.1–1000 μm
- Sources:
 - Traditional wear (metal-on-polymer, metal-on-metal, ceramic-on-polymer)
 - Unfused AM powder
 - Manufacturing contaminants (machining, packaging, cleaning residuals)
- Types: metallic, fibres, organic

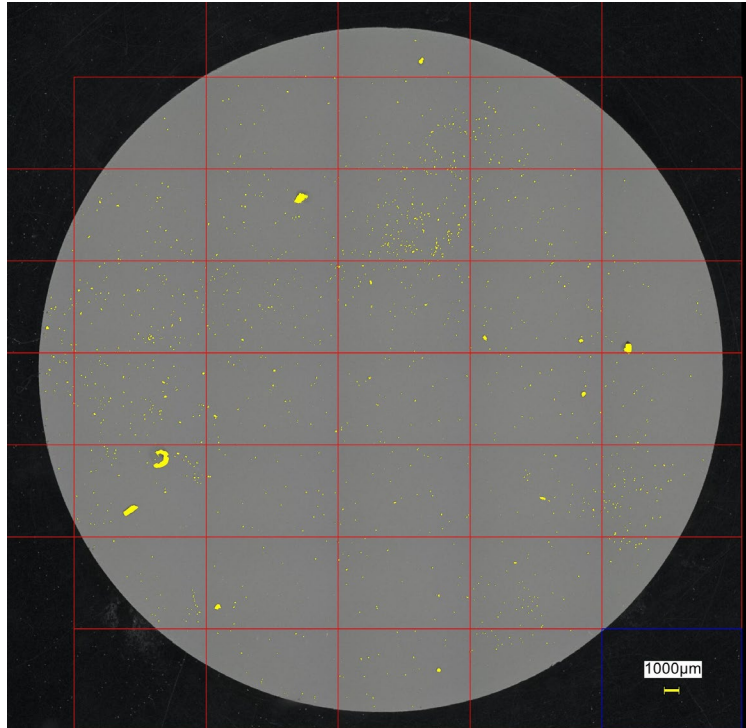


Particle Extraction & Collection

- Particles extracted from sample via sonification in water bath
- Collection on filter membranes or carbon tabs
- Gravimetric analysis for mass loss
- Particles analyzed for:
 - Quantity
 - Size
 - Morphology
 - Quantification
 - Chemical composition

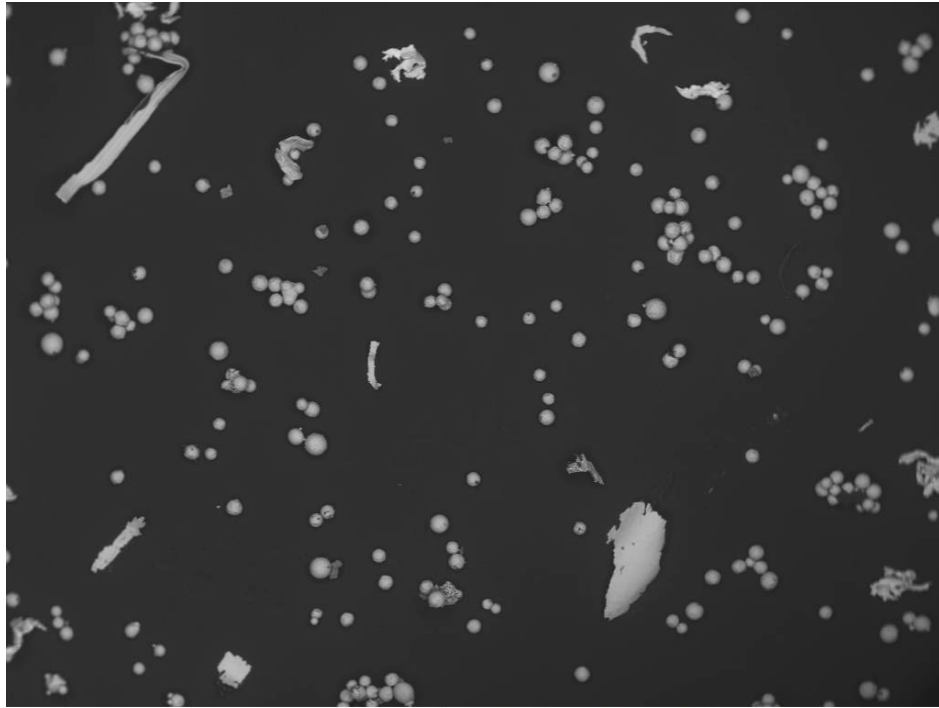


Counting & Sizing Using Optical Microscopy



- Used for larger, coarser particles
- Optical microscopy used to determine particle size and distribution
- Examine entire filter (47mm diameter)
- Stitch together ~50 images
- Software colors the particles
- Then determines sizes & counts

Counting & Sizing Using SEM

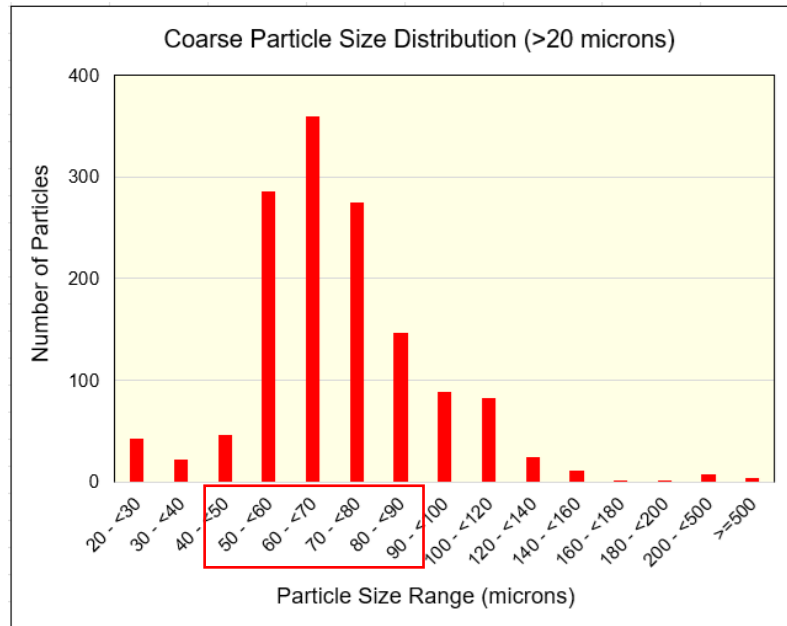


2mm

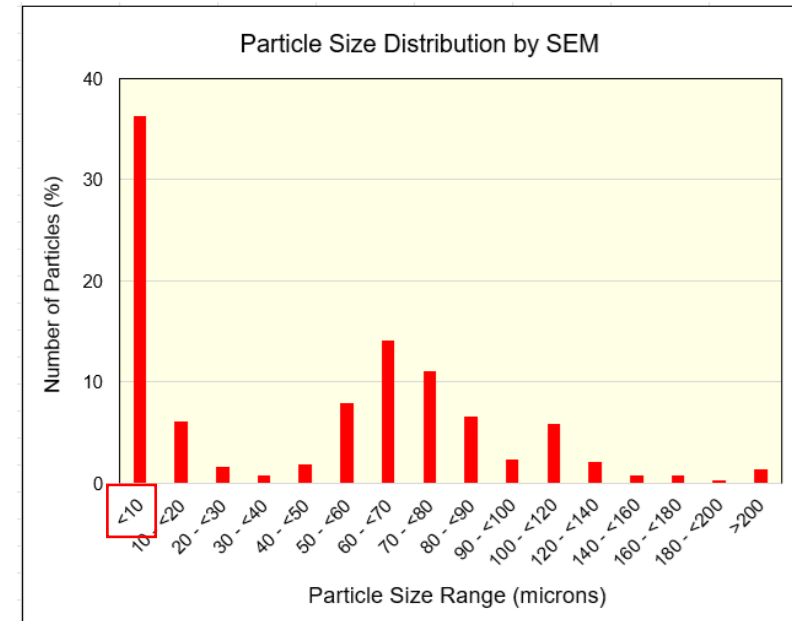
Metallic Particles SEM Image 3

- Used for finer particles
- SEM used to determine particle size and distribution
- Can scan large areas by automated stitching together individual SEM images
- Particle size used to determine particulate origin

Counting & Sizing - Optical vs SEM



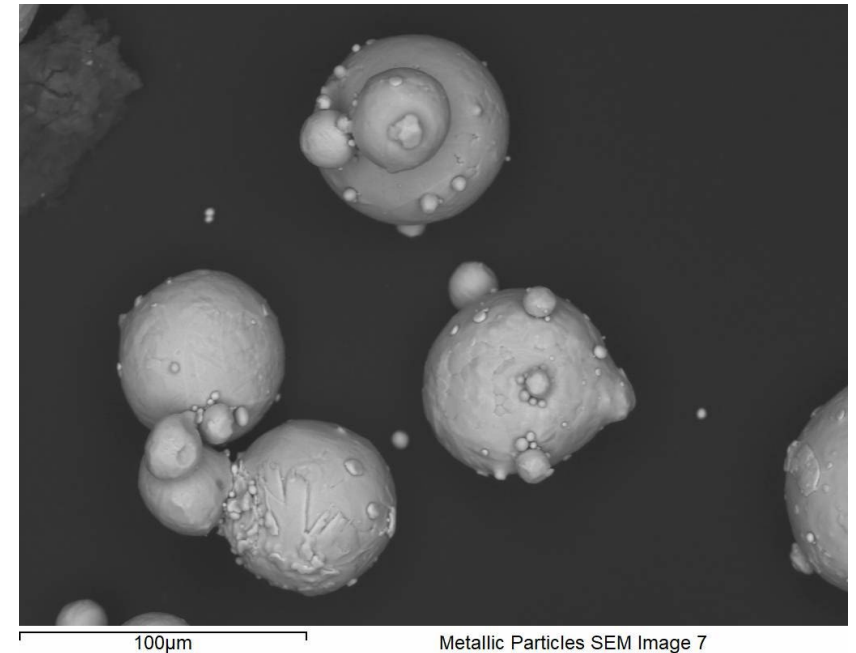
Optical Microscopy



SEM

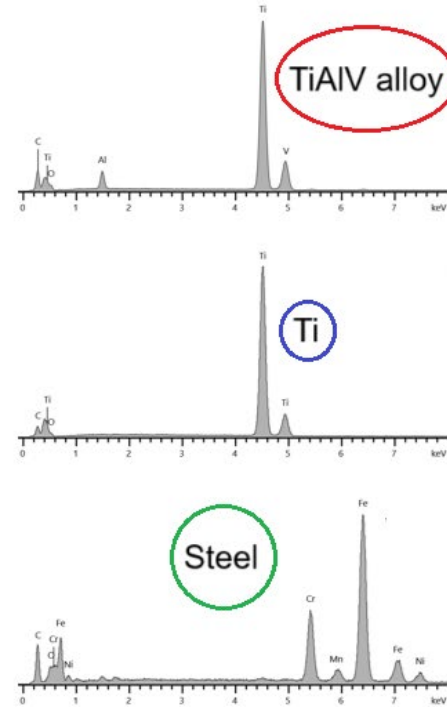
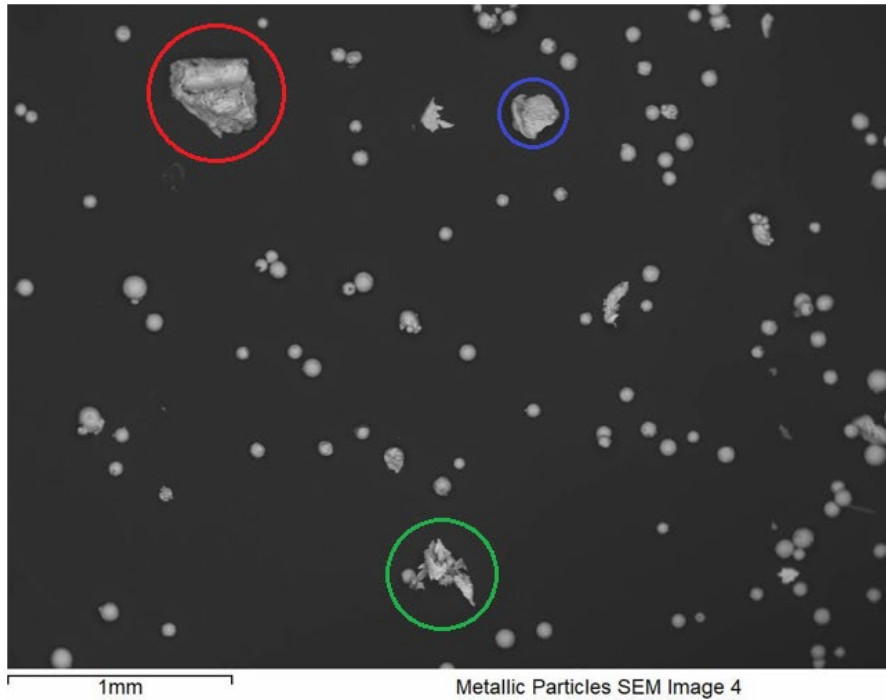
SEM Visualization & Morphology

- SEM (Scanning Electron Microscope) used to classify particle shapes
- ASTM standard descriptions:
 - Spheroids
 - Fused clusters
 - Granules
 - Irregular
- Morphology helps determine particulate origin



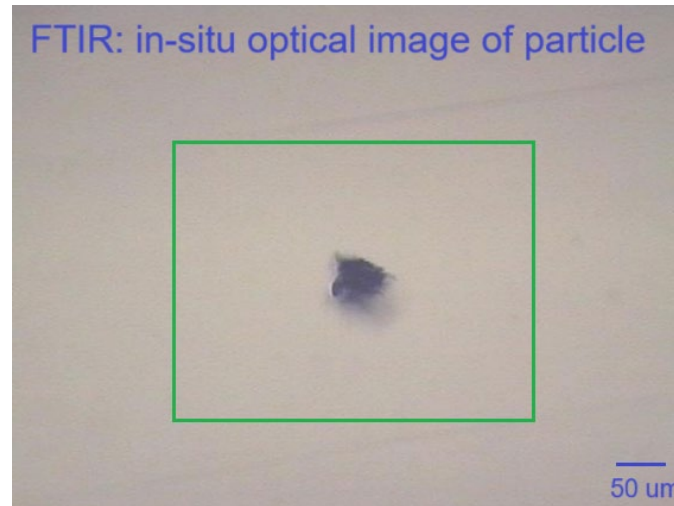
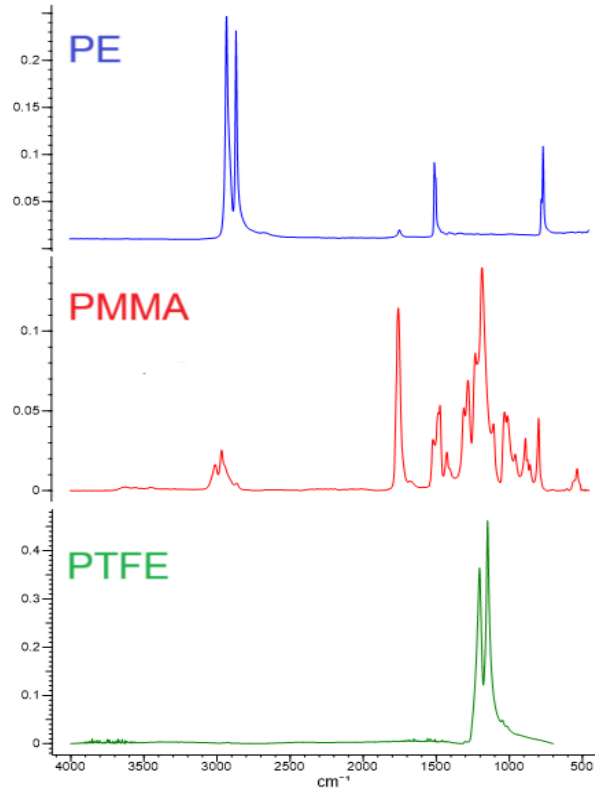
SEM image capturing multiple particle sizes and morphologies

Compositional Analysis by X-ray Spectra



- X-rays produced during SEM analyzed
- SEM-EDX (Energy Dispersive X-ray analysis)
- Determine origin of particles
- Understand potential risk of particulates

Compositional Analysis by Infrared Microscopy



- FTIR used to determine composition of organic compounds
- Matched to library of compounds
- Origin detection
- ToFSIMS also used for compositional analysis

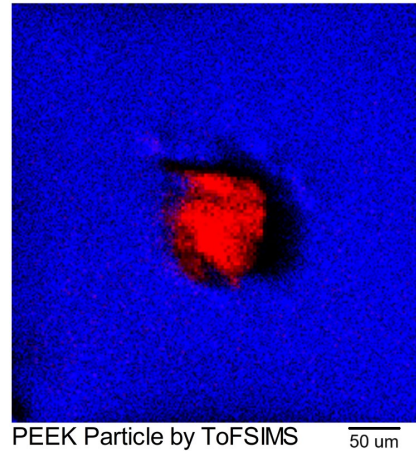
Particle Characterization Process



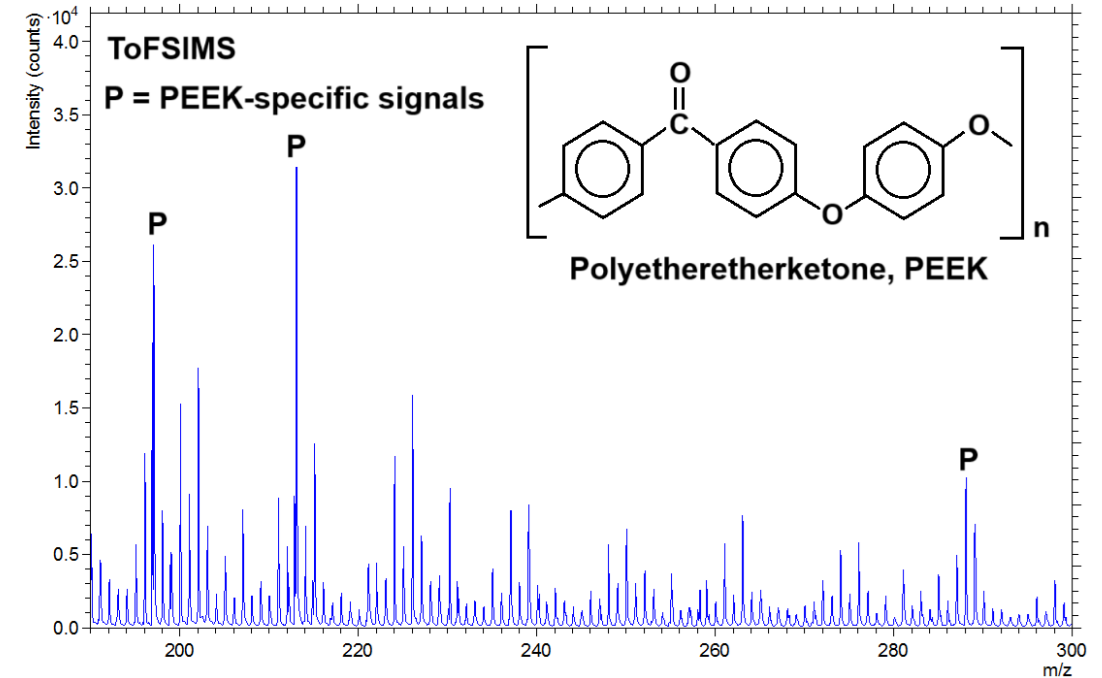
- 1) Extraction
- 2) Filtration
- 3) Filter Weighing
- 4) Optical microscopy – counting & sizing
- 5) SEM – counting & sizing, morphology
- 6) Chemical analysis (EDX, FTIR, ToFSIMS)
- 7) Reporting

Compositional Analysis by ToFSIMS

- Time-of-Flight Secondary Ion Mass Spectrometry
- Generate a mass spectrum from a selected area

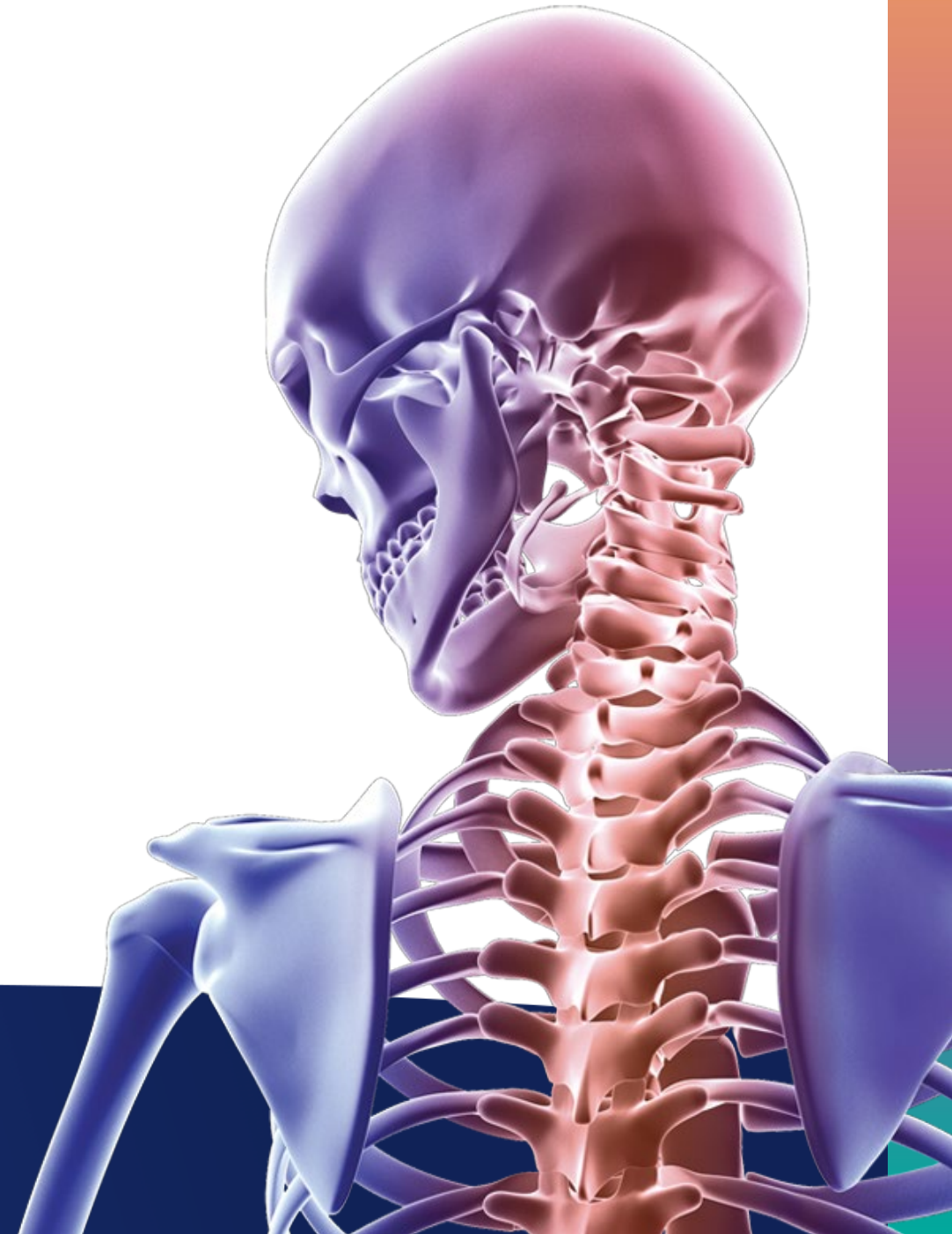


Red particle = sum of PEEK-specific signals in the mass spectrum.



Isotropic Surface Finishing with MFI

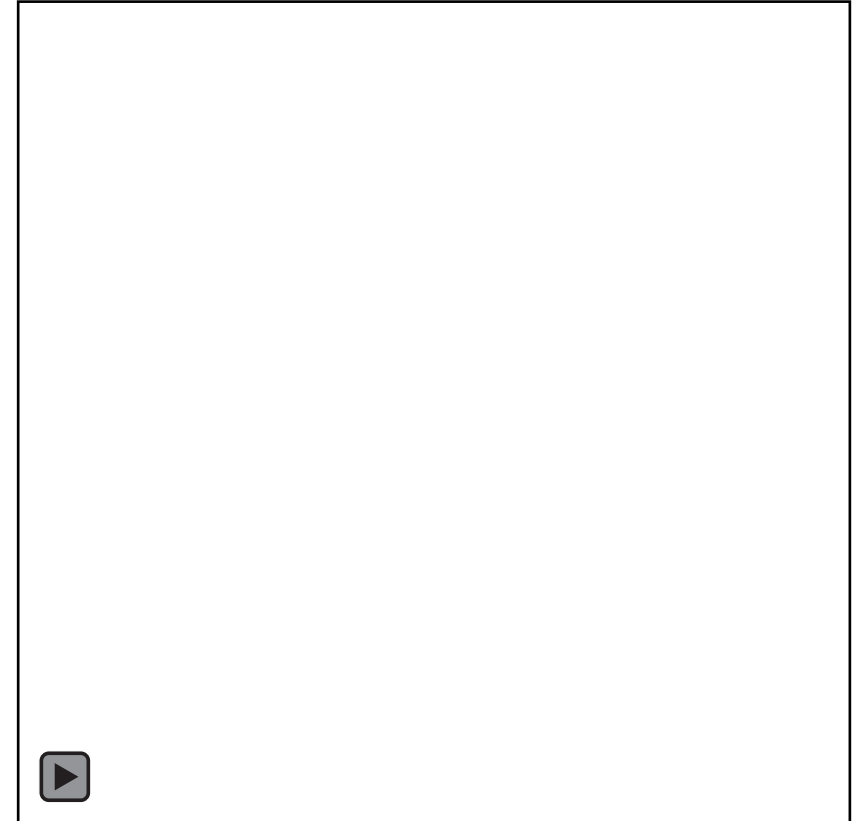
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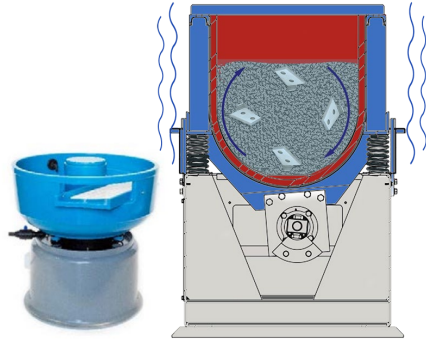
Tumbling Basics

Tumble Finishing – The use of a machine to create a tumbling action in conjunction with abrasive or non-abrasive media to smooth rough surfaces of parts.

Isotropic Surface – Having the physical property which has the same value when measured in different directions



Tumbling Equipment



**Vibratory
Tub/Bowl**

1-1.5 g



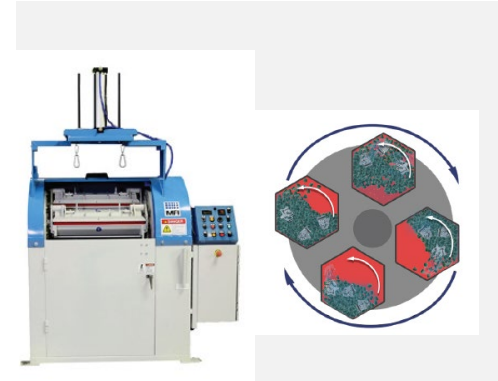
**Centrifugal
Disc**

6-8 g



**Drag or
Spindle**










4-7 g



**Centrifugal
Barrel**

11-13 g

HZ-Series Centrifugal Barrel Tumblers

	COMPACT		HIGH EFFICIENCY			WIDE DIAMETER		HIGH CAPACITY	
	HZ-12	HZ-40	HZ-60	HZ-85	HZ-175	HZ-120	HZ-160	HZ-220	HZ-330
MODELS									
Main Motor HP	1	3	5	7.5	15	10	15	15	30
Voltage	110v	230-460v	230-460v	230-460v	230-460v	230-460v	230-460v	230-460v	230-460v
Total Capacity	0.4 Cu.Ft.	1.4 Cu.Ft.	2 Cu.Ft.	3 Cu.Ft.	6 Cu.Ft.	4.7 Cu.Ft.	7.1 Cu.Ft.	8 Cu.Ft.	12.8 Cu.Ft.
Shipping Weight	700 lbs.	1280 lbs.	3000 lbs.	3300 lbs.	7000 lbs.	2900 lbs.	3500 lbs.	5200 lbs.	6800 lbs.
Dimensions LxWxH	34"x34"x55"	47"x38"x49"	68"x39"x94"	77"x39"x94"	102"x57"x86"	71"x57"x106"	74"x57"x75"	86"x57"x106"	101"x65"x123"
Barrel Dimensions	8.375"L x 5"D	12.5"L x 6.75"D	25.75"L x 5.8"D	33.5"L x 5.8"D	48"L x 8"D	17"L x 10.25"D	20.625"L x 11.8"D	27.375"L x 11"D	41.4"L x 11.9"D
Max Part Size	8"L x 4.5"D	11"L x 5.5"D	25.25"L x 5.25"D	33"L x 5.25"D	47"L x 7"D	16"L x 9.5"D	20"L x 11"D	26.5"L x 10"D	40.75"L x 11"D
Max RPM	250	225	225	225	150	150	150	135	115

Tumbling Media

Ceramic – Hard Metals
Deburr Smooth



Plastic – Aluminum/Magnesium
Deburr and Smooth



High Density – Polish



Porcelain – Polish



Corn Cob – Polish



Tumbling Basics



2.5 Hours of Processing
+ 40 min. Cool/Load/Unload



40 Min. of Processing
+ 15 min. Load/Unload



Six Parts per barrel x Four Barrels = 24 Parts Each Load



MFI
MASS FINISHING, INC.

HZ-60
CENTRIFUGAL BARREL FINISHER

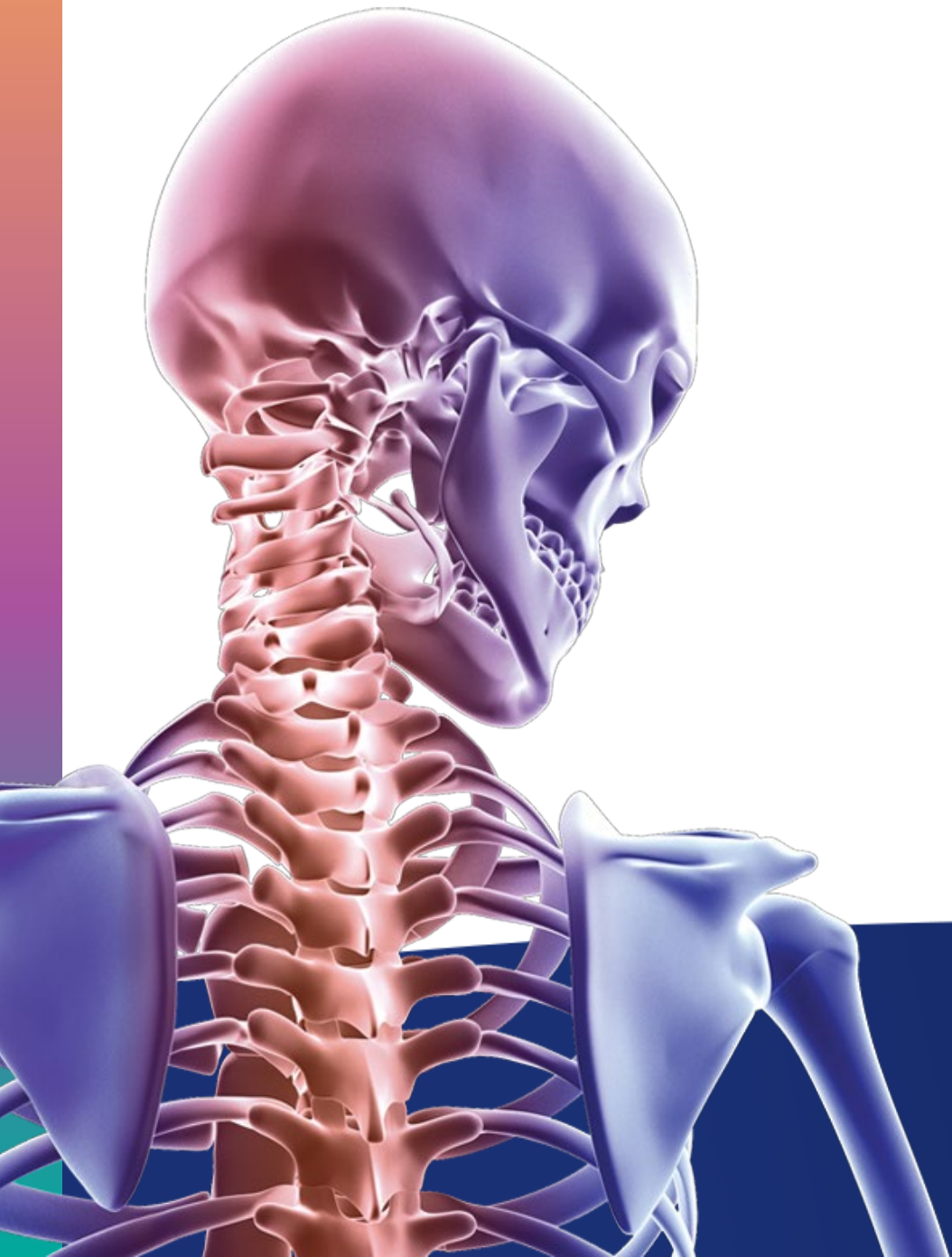




Key Takeaways

1. **Eliminate hand sanding, deburring and polishing**
2. **Achieve an isotropic, even surface finish**
3. **Repeatable and consistent sub 2 μ Ra results**





Thank You

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