Powder Forming Using Dynamic Magnetic Compaction

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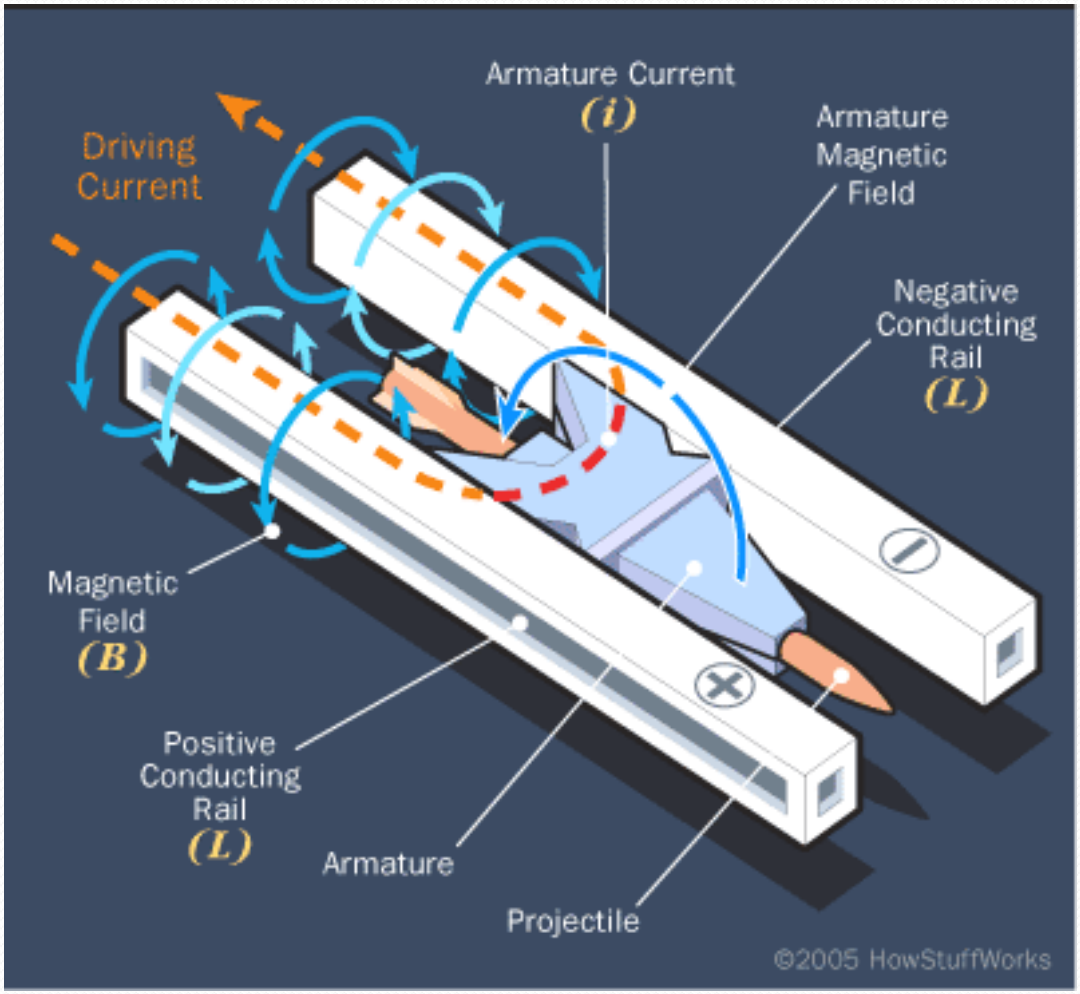
IAP Research, Inc.

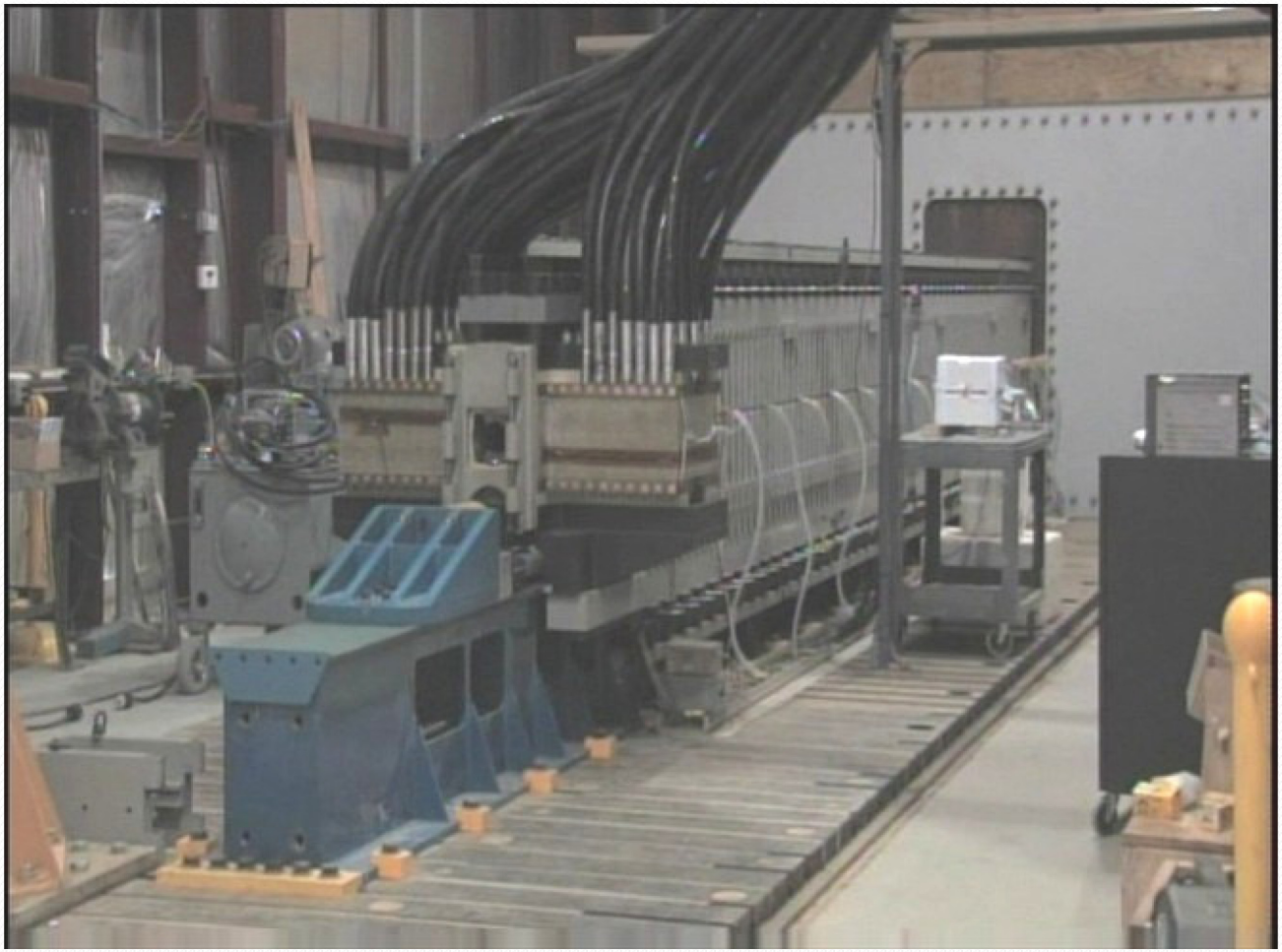
www.iap.com

International Conference on High Speed Forming 2010

Railguns - Magnetics at Work



28 Years of Development at IAP



The Big Bang – a Record Test

Test conducted January 31, 2008

Business Thrusts

- **Railguns**
  - Support the Navy and Army thrust to field a system
- **Power Electronics**
  - Technology development for high power density
  - Product development for Navy applications
  - Product development for commercial applications
- **Advanced Materials and Processes**
  - Nano composite materials – magnetics, bearings, medical
  - Advanced FRP for railgun application
  - Rail materials and coatings
  - Armature advanced materials and designs
  - Magnetic pressing of powder materials and metals

IAP

Presentation Outline

- **Powder material processing basics**
- **Dynamic Magnetic Compaction (DMC) process**

All Powder Processes Have The Same Steps

Powder

Load Tooling

Compact

Part Removal

Sinter/Cure

Finish Machining

Ship

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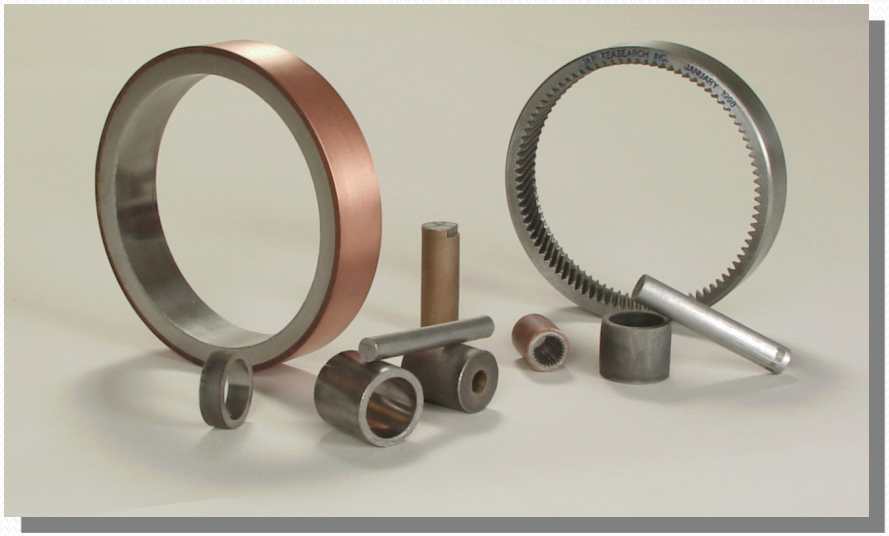

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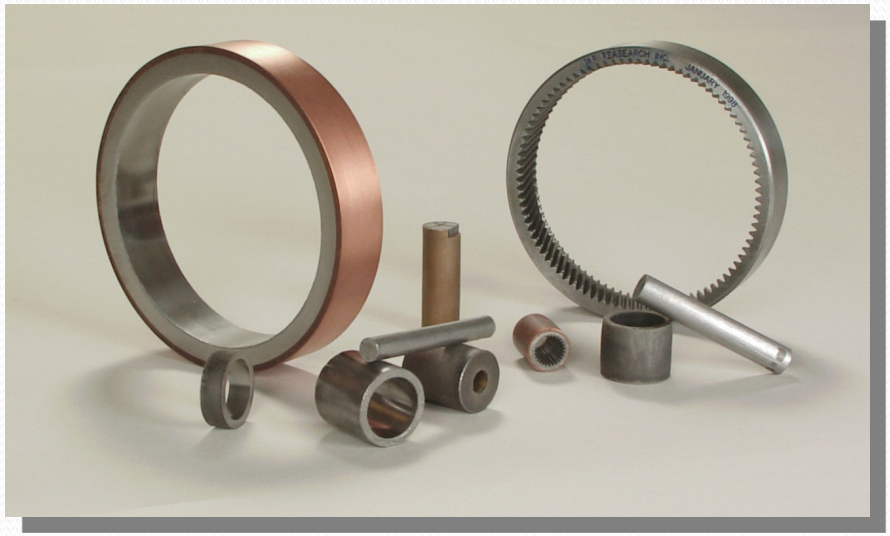

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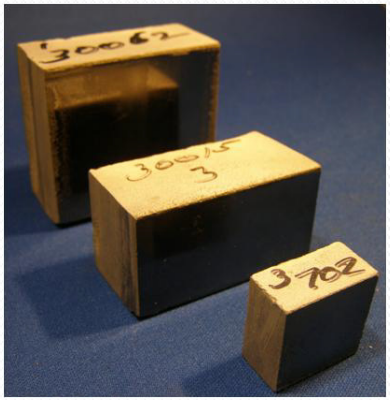

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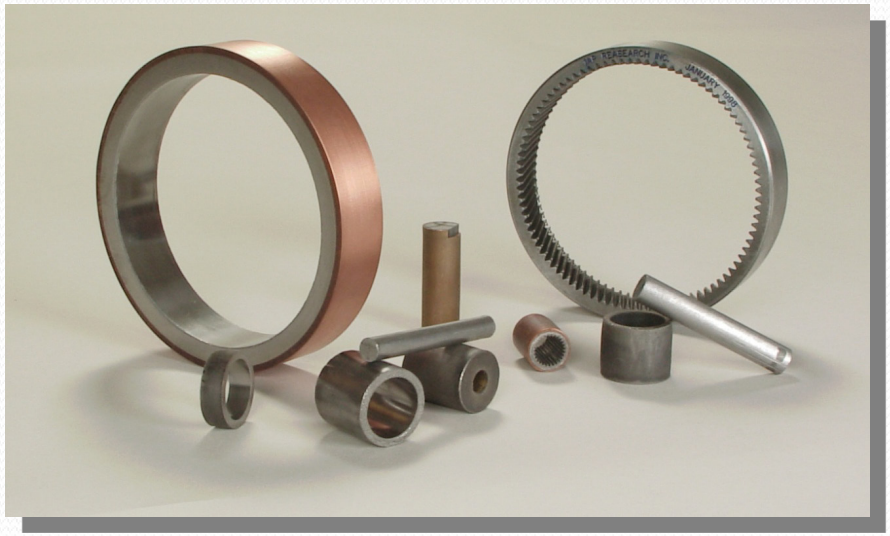

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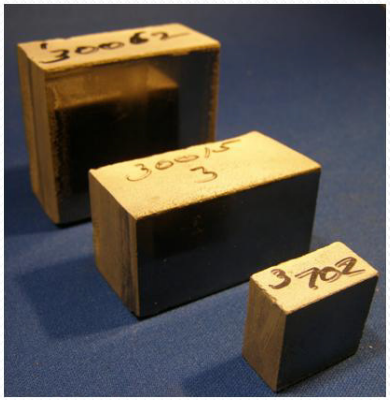

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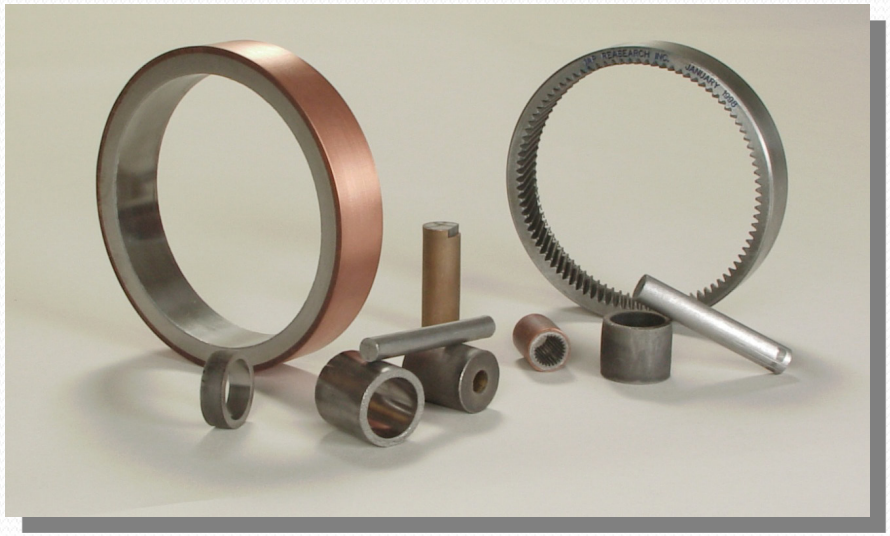

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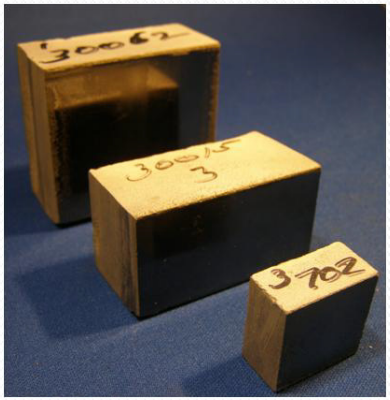
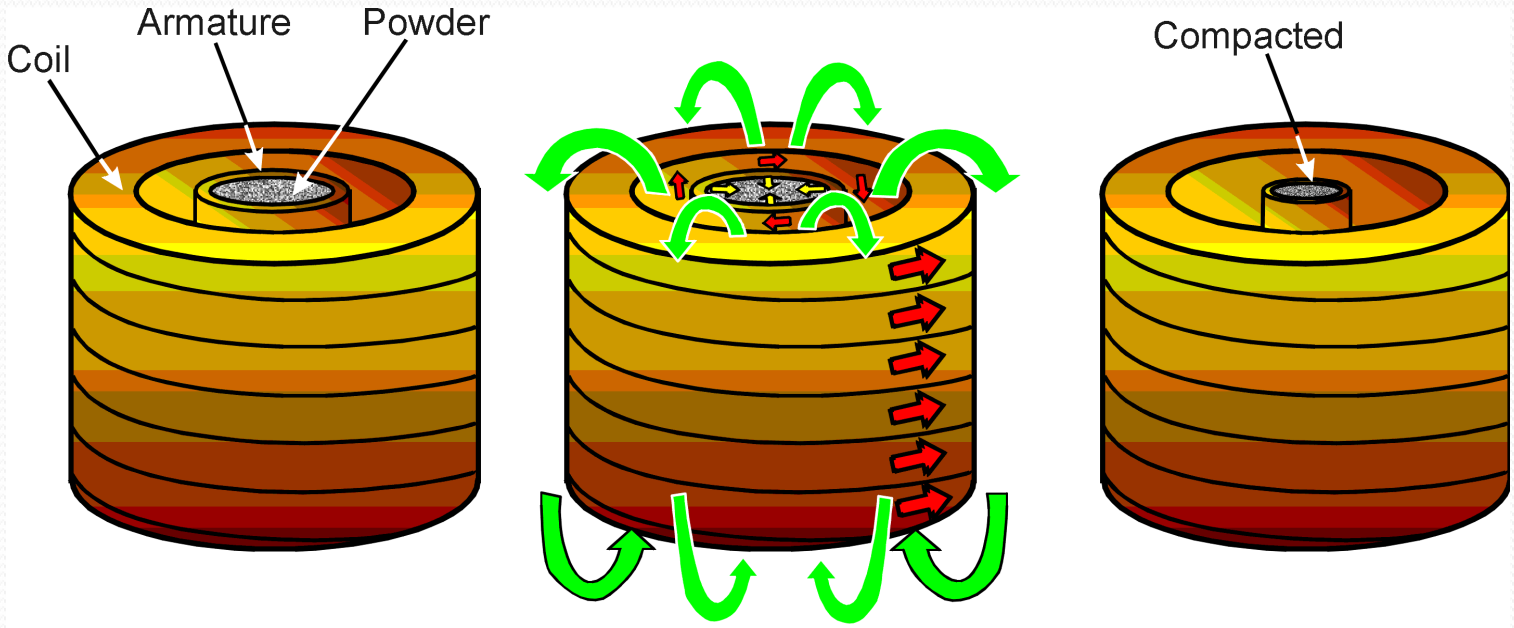


How Dynamic Magnetic Compaction (DMC) Works

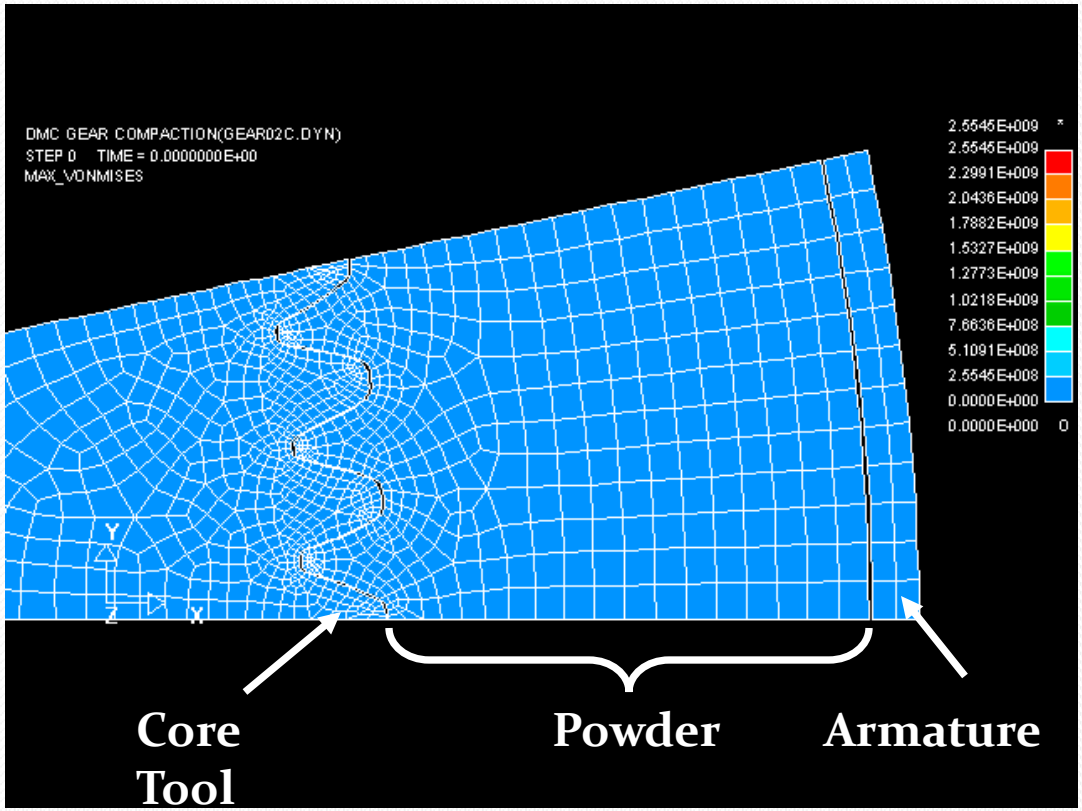


Ductile and brittle powder materials can be compacted

DMC Can Made Precise Parts

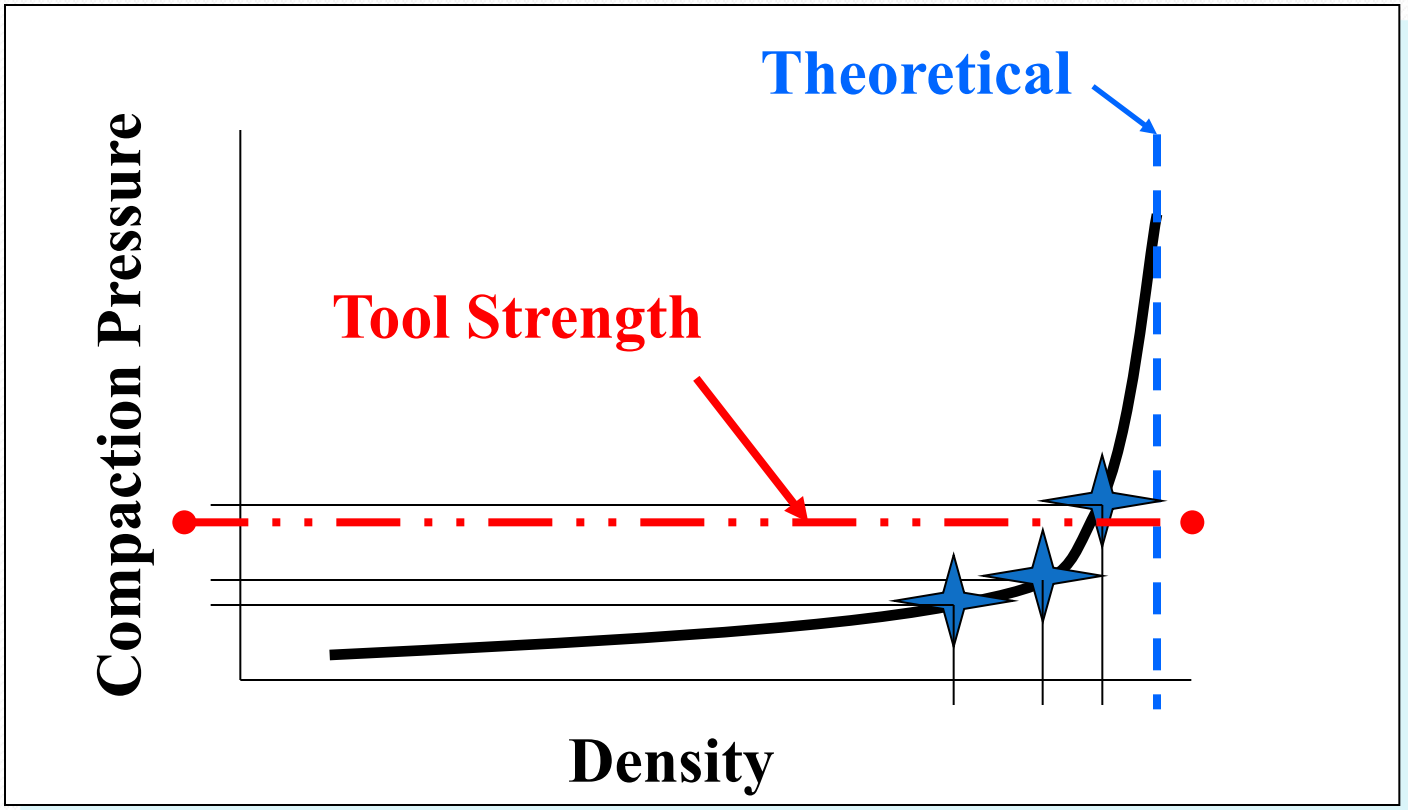
- AGMA 9 rating
- Conventional process machines forged blanks

Armature Kinetic Energy Compacts The Powder

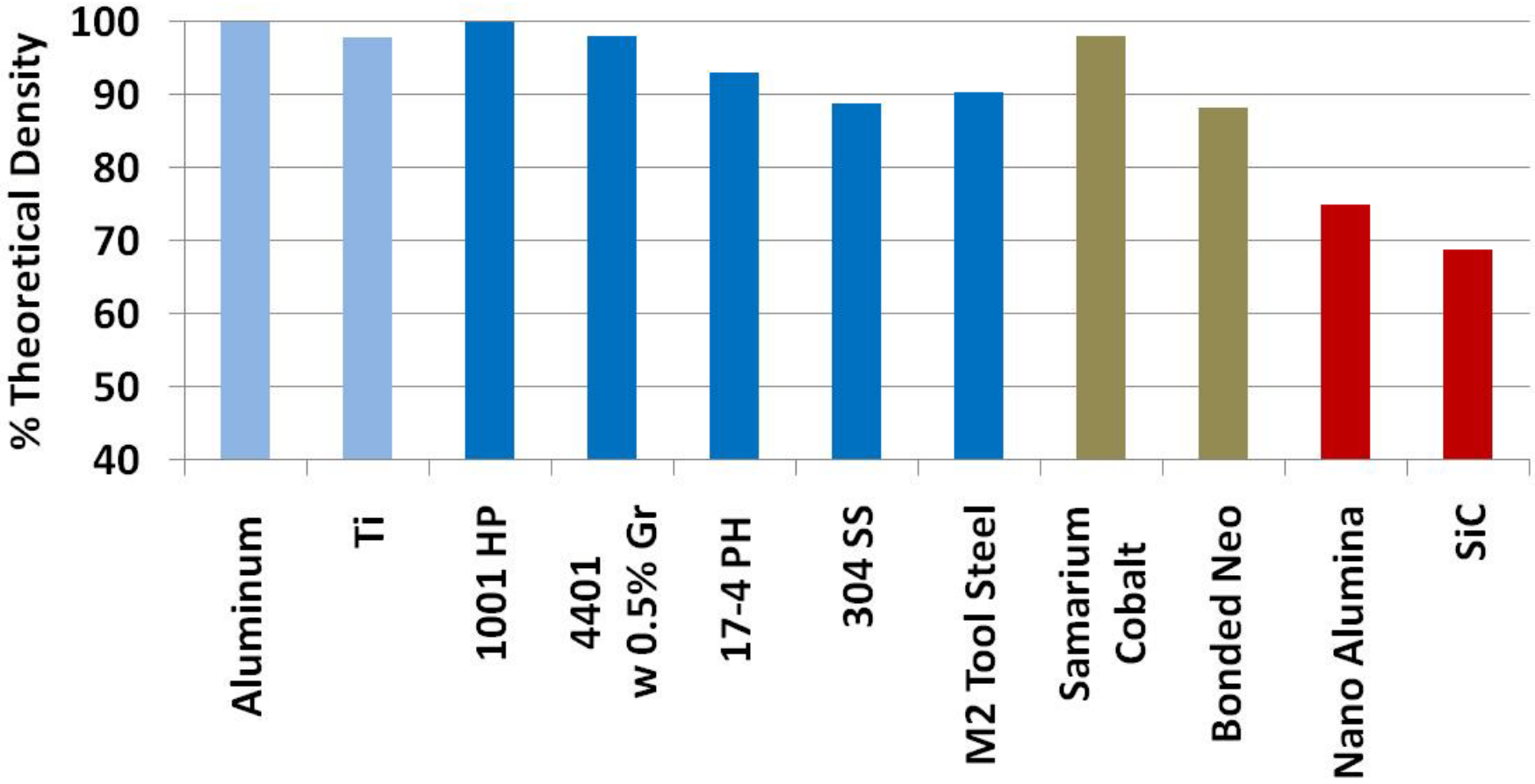


- Magnetic pressure launches armature
- Powder and core tool stop armature

High Pressures Give High Density

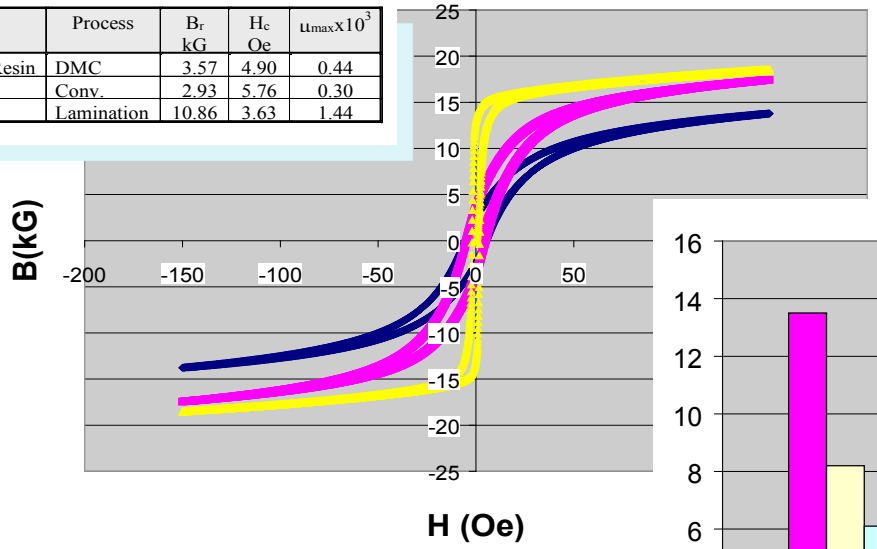


DMC Creates High Density Green Parts

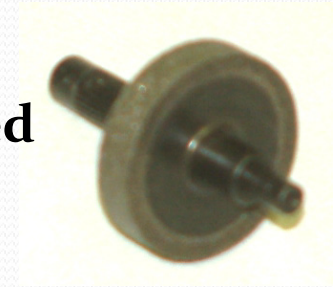


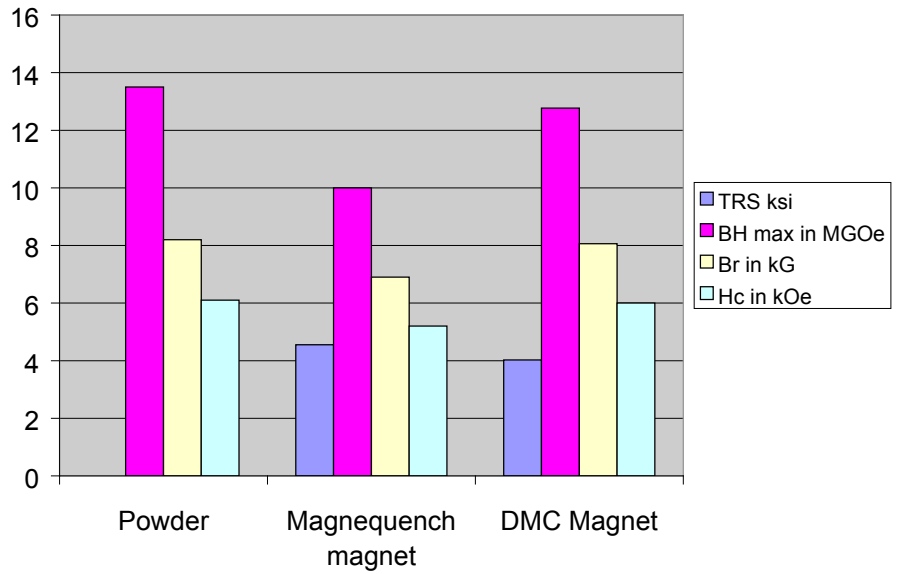
Density Improves Magnetic Properties

Material	Process	B_r kG	H_c Oe	$\mu_{max} \times 10^3$
Powder Iron w/Resin	DMC	3.57	4.90	0.44
EMI Resin	Conv.	2.93	5.76	0.30
1008 Steel	Lamination	10.86	3.63	1.44

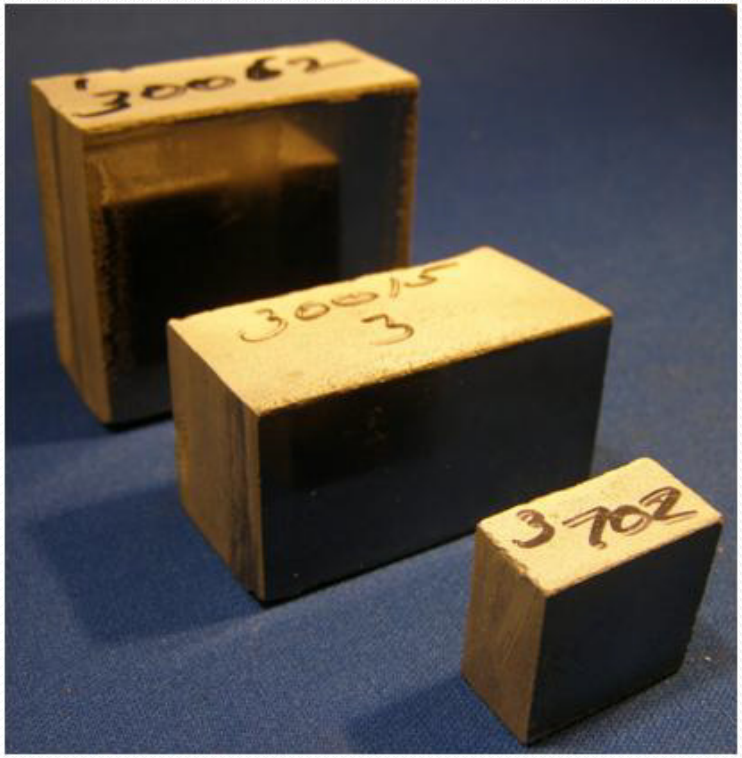


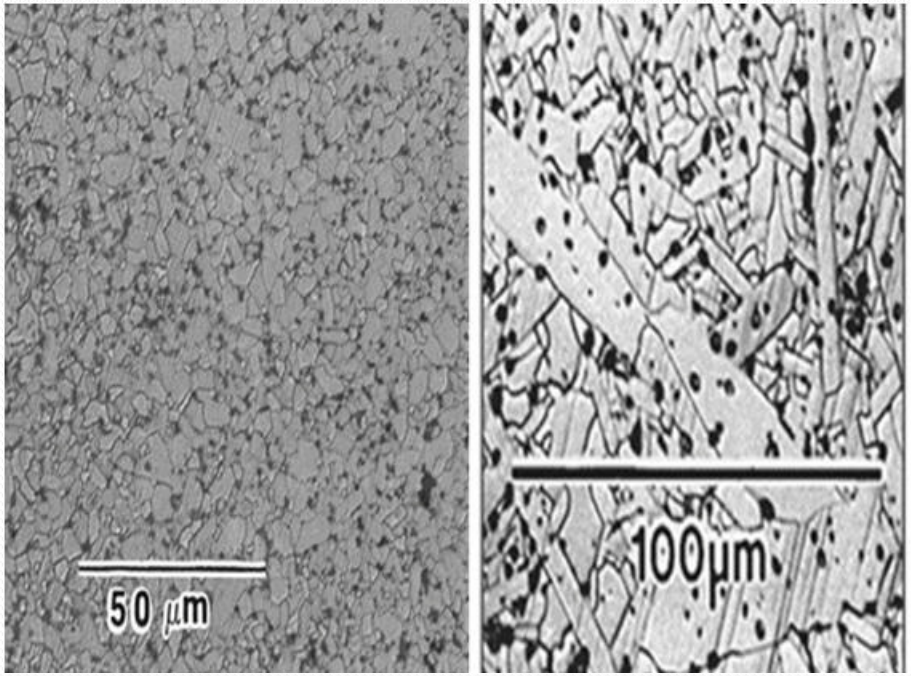
Doubled rotational speed capability





Dynamic Compaction For Ceramics





a) DMC & PS b) CONV & PS

Successful tile size scaled-up through process development

- **DMC delivers high density compacts**
- **Fine microstructures**

DMC Pressing Feature Summary

- DMC compactions deliver high density
  - Kinetic process => High compaction pressure
  - Metal material properties like wrought
  - Promotes a fine grain structure
- DMC a natural for radial pressing
  - High L/D part shapes
  - Net shaped parts
- DMC can produce flat (non round) part shapes

Questions?

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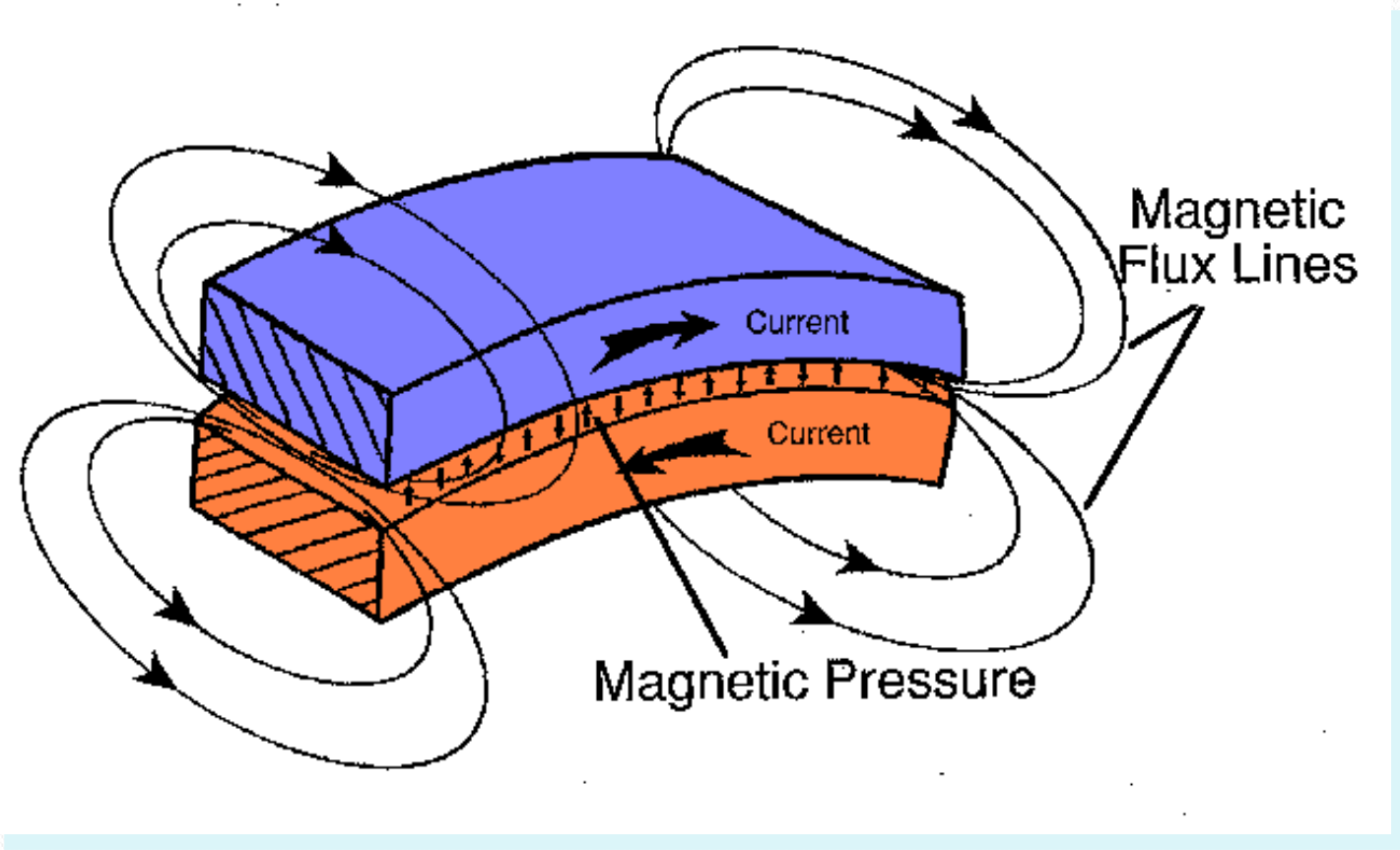
Supplemental Charts

Opposing Currents Generate Magnetic Pressure

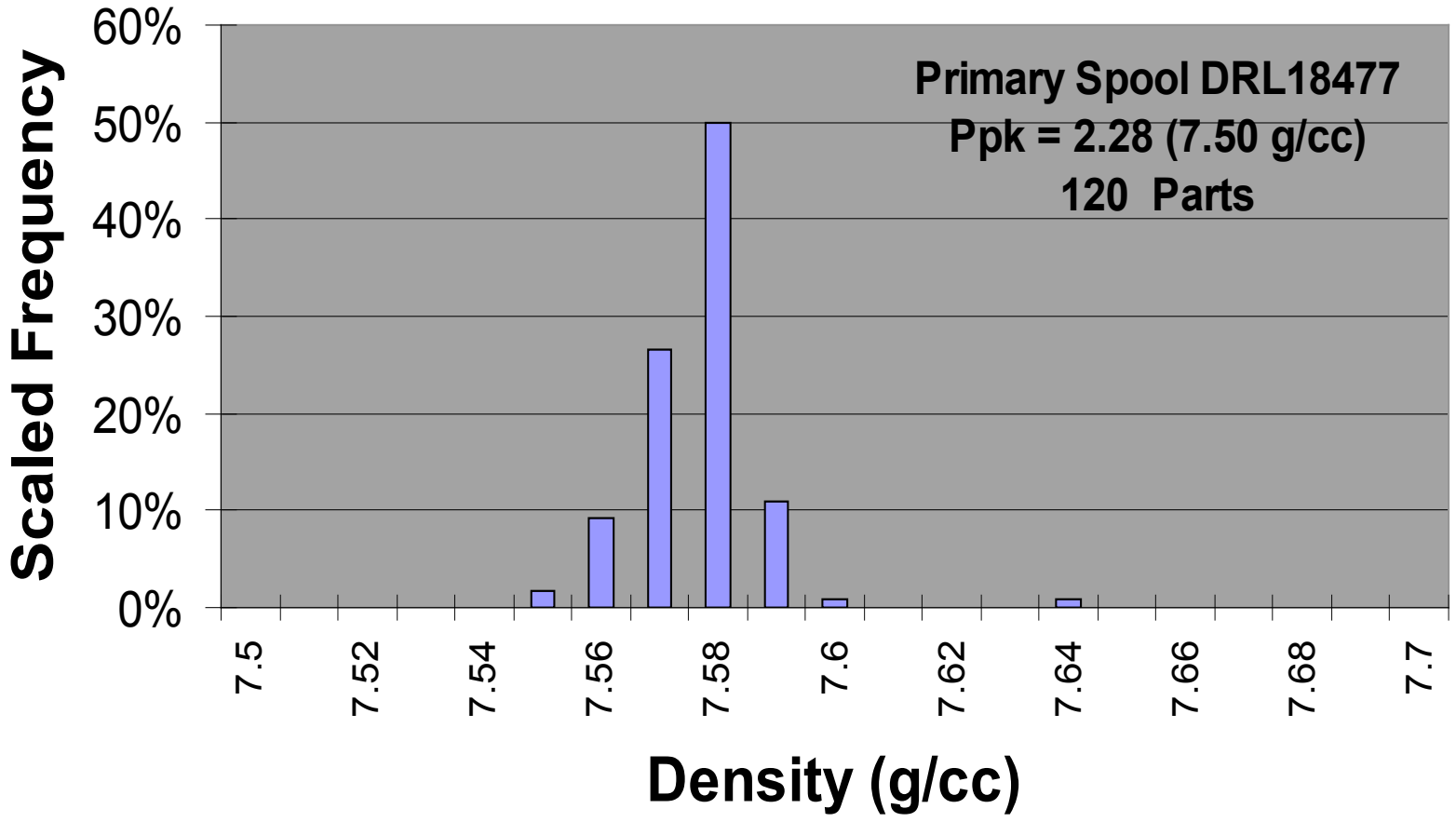


Magnetic Pressing
Metal Forming and Assembly

Pencil Core Dimensional Requirements Met

Parameter	Average Value	Range	Maximum Value	Minimum Value	PPK
Density(g/cc)	7.57	0.097		7.50	2.08
Length(mm)	77.17	0.460	77.67	76.67	1.76
Diameter (mm)	13.22	0.094	13.32	13.12	2.45

Process Capability



MAGNEPRESS® Systems

Power Supplies

Operator Panel

Cables

Coil