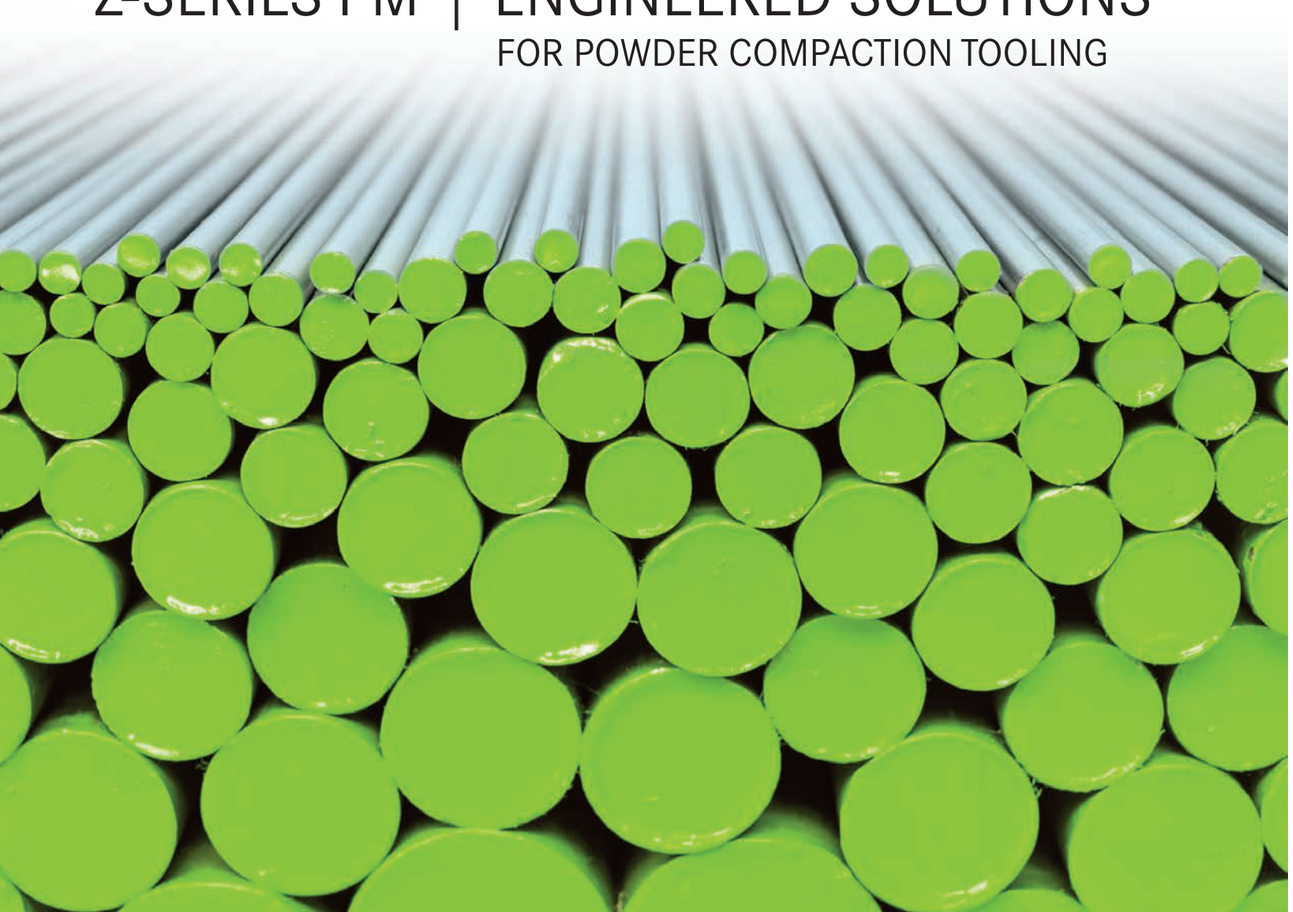
TOOLING ALLOYS | TOOL STEEL SELECTION

zapp

Z-PM

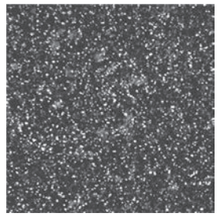
Z-SERIES PM | ENGINEERED SOLUTIONS
FOR POWDER COMPACTION TOOLING



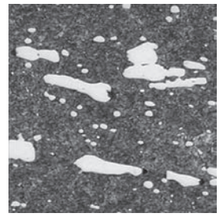
ENGINEERED SOLUTIONS for Powder Compaction Tooling

PROPER TOOL STEEL SELECTION is one of the critical components in producing cost effective, high productivity tools for powder compaction applications. The demands on these tooling components are complex and diverse ranging from requirements for extreme toughness to high abrasive wear resistance and many combination of mechanical properties. Zapp's Z-Series PM tool steels are engineered to withstand the most difficult powder compaction applications.

Zapp Tooling Alloys specializes in developing and servicing unique PM tool steel chemistries to address the demands of powder compaction tooling. Zapp's Z-Series PM materials have unique combinations of toughness, wear resistance and compressive strength, providing new solutions when conventional steels and common PM grades fall short. In addition to proprietary Z-Series PM materials, Zapp provides time-tested PM chemistries that are melted to our technical standards.



Z-WEAR PM



AISI D2

BENEFITS OF ZAPP Z-SERIES PM STEELS

The Particle Metallurgy process was developed to address key weaknesses of tool steel. Traditional ingot casting of highly alloyed tool steels has severe toughness challenges, caused by an undesirable microstructure. PM steels achieve a unifom microstructure, which dramatically increases toughness and allows for greater wear resistance.

Zapp's new generation of problem-solving tool steels can overcome many challenges in powder compaction tooling, but the tooling material is just one of many tool performance factors. There are many internal and external factors to be considered before making a tool steel selection. Zapp works closely with our global powder compaction customers to understand the many variables that impact tool performance:

- Powder chemistry, quality and structure
- Varying press density
- Surface treatments. Coatings or nitriding processes
- Process changes in tool manufacturing

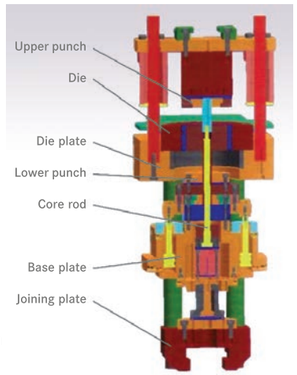
This holistic approach to tool steel selection enables Zapp to recommend the proper steel grade while suggesting other manufacturing process alternatives that have proven to extend tool life.

POWDER COMPACTION TOOLING COMPONENTS

Critical Component Characteristics

Upper and LowerPunches:

1. Toughness to withstand dynamic uneven loading
2. Compression to transmit compaction pressure
3. Abrasion resistance to endure powder flow
4. Z-Tuff PM, Z-Wear PM, Z-M4 PM, Z-9 PM



Die Inserts:

1. Abrasion resistance to endure both powder flow and part ejection
2. High compressive strength to transmit radial stress
3. Toughness is not as critical (supported, non-dynamic part)
4. Z-Max PM, Z10 PM

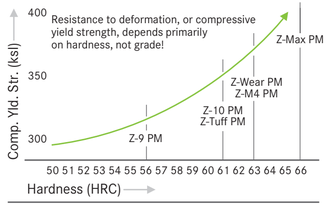
Core Rod & Pin:

1. Combination of high levels of bending strength, hardness and toughness
2. Long, thin, supported part
3. No compressive load
4. Z-Tuff PM, Z-Wear PM (nitrided)
5. If carbide breaks, then Z-Max PM

CHEMISTRY/CARBIDE VOLUME

	Z-Tuff PM	Z-Wear PM	Z-M4 PM	Z-9 PM	Z-10 PM	Z-Max PM
Carbon	.65	1.15	1.42	1.90	2.45	2.00
Chromium	7.50	7.50	4.00	5.25	5.25	4.00
Vanadium	1.00	2.40	4.00	9.00	9.75	5.00
Molybdenum	2.00	1.60	5.25	1.30	1.30	5.00
Tungsten	–	1.00	5.50	–	–	10.00
Cobalt	–	–	–	–	–	9.00
Nickel	1.50	–	–	–	–	–
Carbide Volume	3.50%	6.50%	12.50%	16.00%	17.50%	23.00%

HARDNESS vs. COMPRESSIVE YIELD



PROPER MATERIAL SELECTION

Z-Series PM Tool Steels – Engineered Solutions for Compaction Applications

Z-TUFF PM® — designed for extreme toughness in combination with good compressive strength.

- Impact resistance exceeds 200 Joules at HRC 60-62. Better than S7, 3V and 1V.
- Maximum attainable working hardness of HRC 63.
- Punch applications where high toughness and good compressive strength are required.

Z-WEAR PM® — optimized mechanical properties for balanced toughness, wear resistance and compressive strength.

- Impact resistance exceeds levels for A2, D2, M2 and PM M4.
- Good compressive strength with working hardness HRC 65 max.
- Punch applications where high toughness, good compressive strength and wear resistance are required.

Z-MAX PM® — designed for extreme wear resistance in combination with excellent compressive strength.

- Superior compressive strength with hardess of HRC 68-70 max.
- High carbide volume (23%) for excellent wear resistance.
- Cobalt content (9%) to enhance and strengthen matrix hardness.
- Higher total volume of vanadium, tungsten and molybdenum carbides combined with harder steel matrix for superior wear resistance when compared to 10V and 15V for powder compaction applications.
- High abrasive wear resistance and higher wear resistance allow upgrade from 10V/15V and applications where carbide may experience cracking or breakage.

Z-M4 PM® — traditional PM grade for powder compaction applications offering a good combination of toughness, wear resistance and compressive strength.

- Good compressive strength with working hardness to HRC 65 max.
- Higher impact resistance than A2, D2 and M2 but lower toughness than Z-WEAR PM.
- Punches requiring a combination good toughness and wear resistance.

Z-9 PM® — designed for good toughness with excellent wear resistance.

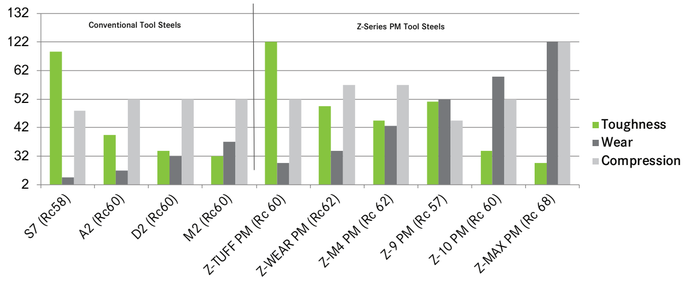
- Abrasive wear resistance superior to PM M4 with carbide volume of 16.50%.
- Maximum attainable hardness is HRC 57 so compressive strength is limited.
- Punches requiring excellent toughness along with high abrasive wear resistance when lower hardness is not a concern.

Z-10 PM® — designed for applications requiring high wear resistance with reasonable toughness capabilities.

- Toughness/impact resistance in the range of D2 and M2 at similar hardnesses.
- Good compressive strength with working hardness of Rc 63 max. Typical working hardness is HRC 60-62.
- Excellent wear resistance with a carbide volume of 17.50%.
- Die inserts and core pins where D2 wears out.

* 1V, 3V, 10V, and 15V are registered trademarks of Crucible Industries LLC.

Z-Series PM Mechanical Properties Comparison - Relative Data



HEAT TREATMENT

The importance of thorough heat treatment for any tool steel cannot be emphasized enough. Zapp offers a library of technical data sheets, heat treatment guidelines and technical training for vacuum and salt bath heat treatment. Proper heat treatment cycles and procedures ensure optimal mechanical properties for the required hardness. Information is available at https://www.zapp.com/us/products/plate-sheet/tooling-alloys.html.

SURFACE TREATMENTS (NITRIDING/PVD COATING)

The entire Z-Series PM family of tool steels can be nitrided and/or PVD coated without any reduction in the hardness of the material. Specifically for powder compaction tooling, plasma nitriding has been quite successful. Plasma (ion) or Gas nitriding is a thermochemical case hardening process used to:

- Increase wear resistance and surface hardness.
- Improve fatigue life by generation of a hard layer.
- Increase compressive stresses benefiting overall tool life.
- Change material tribology where similar materials at similar hardnesses come into contact.

The best nitriding process is dependent upon tool geometry and production requirements. Customers should consult with their local nitriding source for the best process to achieve desired goals.

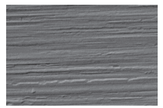
PVD coatings and the nitriding process both improve tool life in powder compaction applications. Nitriding has the advantage of not being a coating. Therefore, a nitrided surface is not susceptible to flaking in operation and better size control where extremely tight tolerances are required. Technological advances in the coatings industry are ongoing and accelerating. Requirements should be discussed directly with your coating supplier.

SURFACE FINISH QUALITY

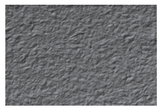
For powder compaction tooling applications, surface quality is especially vital. Imperfections will act as stress propagation points for powder particles to initiate cracks in the surface. Ground surfaces have microscopic imperfections that run in a specific direction causing tensile stresses in the surface. Tensile stresses are a primary contributor to tool fatigue from cracking. One process to improve the fatigue resistance for powder compaction tools is shot peening the surface. Shot peening creates a homogeneous surface while reducing the microscopic peaks and valleys while inducing valuable compressive stresses into the surface. The peening process lightly compacts the surface zone in the structure, which leads to an increase in strength. Compressive stress is beneficial to the tool because it increases the bending strength and counteracts the negative properties of tensile stresses.

Peening the surface can also be an effective way to remove EDM white layer inherent in the EDM machining process. As illustrated below, the recast white layer created by the EDM process can be light to heavy based upon the process parameters. EDM machining melts the steel through an electric current. The white layer is, therefore, an untempered and brittle structure. As can be seen quite vividly in the far right photomicrograph, this layer easily develops cracks that penetrate the re-hardened structure transition zone and finally into the unaffected tempered microstructure causing premature failure. The recast white layer caused by EDM machining MUST be removed to allow for maximum tool life potential.

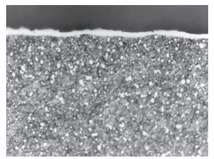
The peened and homogeneous finish also has the additional benefit of increasing the direct surface contact between the tool and powder spreading the pressures more evenly along the surface leading to improved fatigue resistance to crack propagation. Finally, the peened surface can be lightly polished for additional improvements in surface contact and tool life.



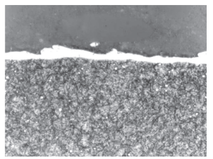
Z-Max PM, 66 HRc
Ground surface (0.12 Ra)
5000 MPa bending strength



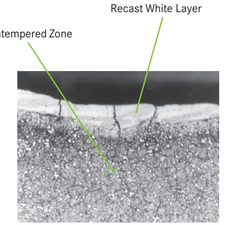
Z-Max PM, 66 HRc
Homogeneous surface (0.18 Ra)
6000 MPa bending strength



EDM 4µm



EDM 9µm



EDM 18µm

THE BOTTOM LINE FROM ZAPP

Zapp Tooling Alloys is committed to supporting the powder compaction tooling market with superior materials and overall customer support to develop "Engineered Solutions" for specific applications. Our metallurgical resources and technical support work in concert with customers to discuss process variables including, powder type, chemistry, press type and tonnage, tool design, surface finish and, finally, material selection to optimize production requirements and minimize costs. For more information, contact your local Zapp sales engineer.