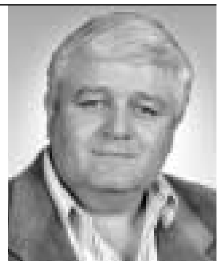
# OBD II Shop



**Norm Brandes** *owns and operates Westech Automotive, Inc., a machine shop and vehicle repair service business located in Silver Lake, WI.*

## Powdered Metal Will Become More And More Popular In The Coming Years

### OEs are using it to improve fuel economy; while sales are brisk in the aftermarket

Powdered metal technology isn't new, just new to automotive engine applications. The first powdered metal products appeared in the 1930s. Automotive use didn't start until around 1980 when powdered metal valve seats first appeared on some import engines.

The use of powdered metal has increased since OBD-II standards were implemented in the mid-1990s. With the most recent round of tighter emission standards that will begin in 2002, expect even greater use of powdered metal in engines of the 21st century.

At the rebuilder level, powdered metal components require new procedures, and possibly new equipment. Dealing with powdered metal is more different than difficult, but getting a handle on the differences can be frustrating. Until more information is readily available, learning how to work with powdered metal will be a do-it-yourself project for most rebuilders.

Although powdered metal has many automotive engine uses, this column will cover only valve seats and valve guides. Several companies manufacture OE powdered metal seats. Only two or three companies actually manufacture aftermarket parts, but a number of firms private label seats made by one of the manufacturing companies. I haven't found an aftermarket supplier for powdered metal valve guides, OE manufacturers are the only source. For some applications, no replacement parts are available — one bad valve seat means replacing, not rebuilding, the head. The aftermarket supply situation is expected to improve as demand for replacement parts grows.

### Why powdered metal

A brief background in metallurgy and cylinder head design explains why powdered metal seats and guides are so popular. The combustion process subjects cylinder heads to three major stresses:

1) **Thermal stress** is the result of the expansion and contraction of the head as it goes through the normal operating cycle of cold start, warm up, running, and shut down;

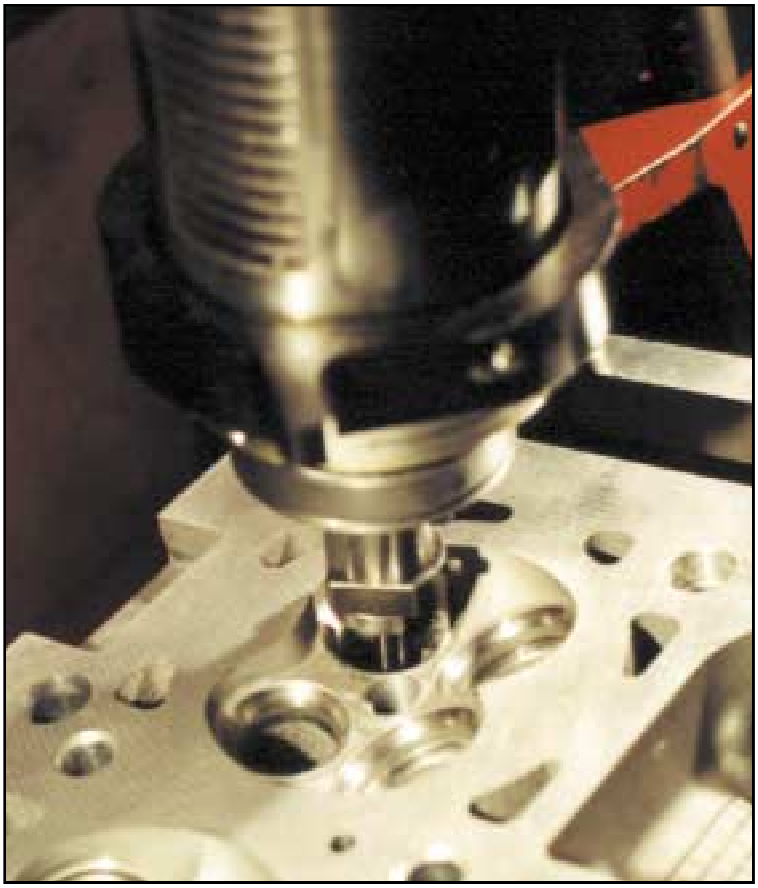
2) **Impact stress** is the result of the force of the valve striking the valve seat as the valve closes;

3) **Friction stress** occurs primarily between the valve stem and the valve guide as the valves open and close, although there is some friction between the valve and seat.

These stress loads are increasing on newer head designs because of OBD-II emission requirements, government mandated mileage regulations, and the need to meet consumer performance expectations.

Stricter emission standards and the goal of better mileage and performance mean higher combustion temperatures that increase thermal stress. On new engines, exhaust valve/valve seat temperatures can reach 1,600° F. To improve fuel economy, aluminum is the metal of choice for heads because it weighs less. However, aluminum not only con-

**Carbide tool bits** *produce a good finish on powdered metal seats, with a light touch, slow speed (100-200 RPM), and sharp cutters. Bits should be checked and resharpened frequently, usually after each 20 to 50 seats.*



**Equipment manufacturers** *offer a variety of carbide cutting bits. Get recommendations from both your tool supplier and your valve seat supplier on the best bit to use for powdered metal seats.*

ducts heat better than cast iron, it also expands and contracts more than cast iron in response to temperature change. So while thermal loads are increasing, engineers are using a metal that is more sensitive and responds faster to temperature change.

Engine speeds tend to run higher to provide better overall performance, but high speeds mean more impact stress as valves strike the seats more often. Increased engine speeds mean more friction between valve stems and guides.

Friction load is also increasing because modern engine design calls for reduced oil flow between the valve stem and guide. Less oil here reduces the risk of oil entering the combustion chamber, increasing emissions and fouling the catalytic converter.

With cast iron heads, engineers can use induction hardened seats and guides or use inserts. Aluminum cannot be induction hardened; inserts are the only option. Powdered metal inserts also help aluminum heads deal with thermal, impact and friction stress.

## Uniform mixture

"Powdered metal" is a process, not a product. There are no standard mixtures for powdered metal components. The mix is usually tailored for a given application. In one sense, powdered metal is a metallurgist's best dream come true because the process creates a totally uniform or homogeneous mixture of even the most complex alloys. As a matter of fact, casting, forging, injection molding and other metal working techniques cannot match powdered metal for uniform consistency. Powdered metal can create alloys impossible to form using any other process.

Powdered metal starts by melting or liquefying the compounds that will create the mix. After the mixture is uniformly blended, the liquid is diffused into very small droplets that cool and solidify quickly, creating a powder. All droplets have the same consistency and because the droplet cools quickly, the consistency is maintained as the powder is formed. If some elements cannot be melted or liquefied together, two or more separate mixtures are created. Each mix contains only compatible materials. Each mixture is independently diffused into droplets to create a powder. The different powders then are blended into a uniform mixture.

The rapid cooling to create the powder softens the alloy. As the powder is compressed to form a part, it is "sintered" which is the application of heat to increase the bonding strength of the particles and temper the alloy to regain the hardness. Sintering also promotes a better integration of the alloys within the part.

Powdered metal can be used to make compounds impossible to achieve by any other means. For example, powdered metal can combine a high grade iron alloy, with its inherent tool lubricating and graphite rich properties, that is uniformly distributed within a matrix of tempered tool steel. Many other combinations are currently being tested by manufacturers within the automotive aftermarket and beyond.

## Powdered metal advantages

Powdered metal has many unique advantages which are discussed below.

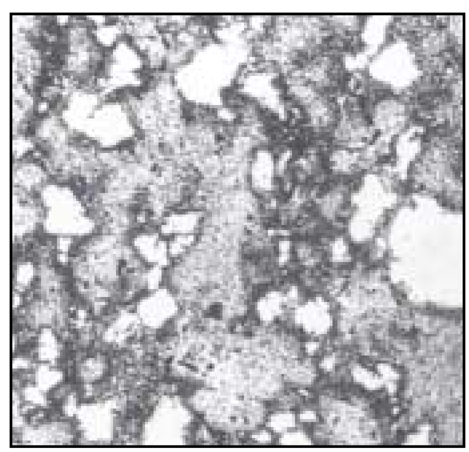
**Surface Smoothness**: At the microscopic level, cast metal surfaces are rough and jagged, which increases friction and accelerates wear. Powdered metal has a smoother surface. Any surface irregularities in powdered metal tend to be smooth, spherical shapes, not jagged edges. These surfaces act like microscopic ball bearings, further reducing friction and wear.

**Internal Consistency**: The internal structure of a casting is irregular, with voids and uneven distribution of alloys. Powdered metal has a smooth, consistent internal structure. The more uniform a metal's internal structure is, the more predictable and consistent its response is to changes in operating conditions.

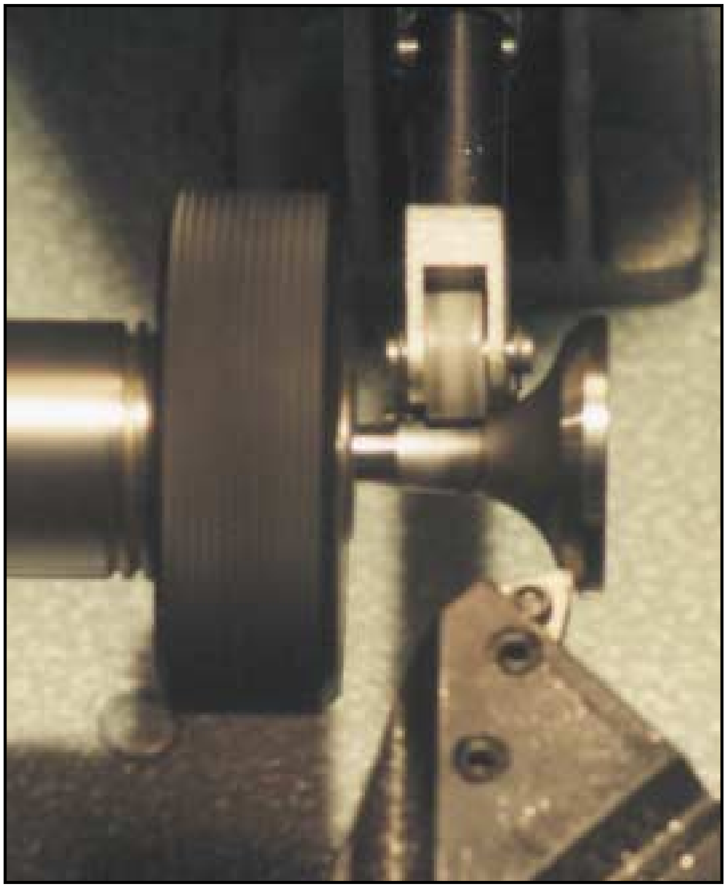
**Precision Fit**: The smoother, more even surface of a powdered metal part allows tighter tolerances for fit and performance. Run out on a powdered metal valve seat typically is about 0.001″. Cast seat run out is in the 0.003″ to 0.005″ range. That is a big difference when trying to maintain the tightest possible seal in the combustion chamber.

**Lightweight**: Typically, powdered metal parts are lighter than parts made by other processes. The weight savings is not significant with small parts like valve seats. However, in larger parts, like connecting rods, the weight savings makes a difference.

**Strength**: Powdered metal parts are



**Powdered metal** *magnified. Powdered metal has a smoother finish compared to cast metal surfaces.*



**The other half of a good** *valve seal is machining the valve face. Supporting the valve during machining makes it easier to obtain concentricity and a smooth finish.*

strong and their surface hardness better withstands repeated impact. The combination of strength and light weight gives powdered metal an excellent strength to weight ratio, a critical factor in building lighter weight, high-performance engines.

**Lubrication**: Lubricants can be blended into powdered metal to further reduce friction. Powdered metal valve guides have tighter guide-to-stem clearance and need less oil for lubrication because of their built-in lubricants.

**Better Heat Transfer**: The homogeneous consistency of a powdered metal part, especially in a uniform shape like a valve seat, means faster, more consistent heat absorption and transfer. The seats more closely follow cylinder head expansion and contraction as thermal loads change, maintaining a tighter seal. Powdered metal seats are also more effective in removing heat from the combustion area and transferring it to the cooling system.

**Reduced Micro-Welding**: Depending on the exact formulation, powdered metal's surface oxides can reduce or eliminate micro-welding between the seat and the valve, even at very high combustion temperatures. Micro-welding accelerates valve and seat wear and reduces combustion chamber sealing.

Because there are so many different formulations for powdered metal parts, only a few general guidelines can be given for machining these parts. Expect wide variations in hardness and machining procedures with powdered metal.

Until OE/vendor information regarding machining powdered metal is more readily available, rebuilders must develop their own "procedures database." Keep detailed records of successes and failures. Keep records by engine type and year because specifications can change over the life cycle of an engine type. What worked well for one model year might not work for a different year.

The basic rule for machining powdered metal is to start with a quick, light touch using slow tool speed. Starting hard and fast on powdered metal is almost a guarantee for disaster. Reaming valve guides may require an initial drill speed as low as 150 to 200 rpm, which is much slower than the rpm setting for reaming cast guides.

Special tools may be needed to provide these slow speed settings. Gradually increase tool speed or work pressure or work time as long as successful results are obtained. Special tooling designed for powdered metal may be needed.

Be prepared for major hardness differences between new and used powdered metal parts. Powdered metal work hardens immediately after being put into service. If you replace some, but not all, of the seats and guides on a head, you will have to use different tool speed and feed rate settings for the new parts compared to the used, work hardened parts.

Some powdered metal formulations are so sensitive to work hardening, the part will work harden while being machined if not cut properly.

You cannot weld most powdered metal. Powdered metal's ability to resist micro-welding also means that a welding bead cannot bond to powdered metal.

Set up and accuracy are more critical than ever. At the OE level, powdered metal guides and seats are pressed into the head and then the entire head is gang cut. In some plants, a single tool reams the guide and cuts all the seat angles in one pass. By making all cuts at the same time with one bit, the manufacturer is assured of better concentricity between guide and seat. Most rebuilders are machining guides and seats as separate operations, but each time you change tools, you increase the chance for error and lose concentricity.

The tolerance for valve guide size and clearance between the guide and valve is so tight on some newer engines, older tooling cannot be used because it isn't capable of the precision needed.

Finish standards are approaching levels considered impossible a few years ago. Many rebuilders don't even have the equipment to measure finish to the levels necessary, let alone have the equipment to produce these finishes.

More sophisticated quality control equipment will be needed. Vacuum testing for valve seats is no longer an adequate indication of sealing quality. Run out gauges, capable of measuring to within 0.001″ are better. Pressured air gauges are the best way to measure valve seat sealing, but this equipment is very expensive.

## Trade offs

The advantages that make powdered metal appealing to OE manufacturers present new challenges for the rebuilder. Powdered metal is one more step in the total OE effort to make engines with tighter clearances, smoother finishes, and better performance than ever before.

After a customer has spent several thousand dollars having one of these engines rebuilt, will he or she be satisfied with less than new performance, mileage and emission levels? I don't think so.

In today's market, the only way a rebuilder can restore like new performance is to produce a rebuilt engine with the clearances, finish and precision it had when new. Otherwise engine performance and customer satisfaction could be compromised. **AR**

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