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What would you expect to find inside an engine that had 200,000 highway miles on it, with infrequent oil changes along the way? Plenty of sludge? Lots of worn out parts? We were dying to find out the answers ourselves. That's why we decided to overhaul an engine that fit this description. It just happened to be the engine in the boss's 1987 BMW 535 iS.

The 535 has been our unofficial long-term test vehicle since *Import Service* got started in 1987, and has served as the basis for several articles in these pages over the years. The plan is to keep it for another 200,000 miles or until the odometer breaks, whichever comes last. It just came back from the body shop after a fresh coat of paint, so I think he's serious.

This will be a two-part article, with the first part dealing with upper engine repairs. There are several characteristic BMW "big six" engine wear areas that we'll point out along the way. We'll also explain one method of dismantling the cylinder head, including the camshaft, rocker arms, and rocker shafts.

We realize that many shops sublet their heavy engine work to a machine shop. If you work in one of these shops, you may be getting ready to turn to another page in this magazine. Even if you don't have the desire or

the special equipment to do your own engine work, there's something to be said for being able to take your own measurements.

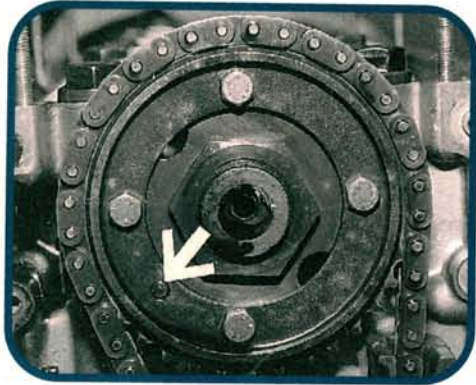
Unless you trust your machine shop implicitly, having the ability to make decisions on what work needs to be done is a definite plus. Taking your own measurements also makes it easier to verify that the work has been done properly and accurately after the rebuilt engine parts return from the machine shop.

This article focuses on the engine wear areas you can check yourself, after an investment in a small number of measuring tools. If you're just getting started with precision engine measurements, our sidebar on micrometer usage on page 22 should be of help. All import manufacturers quote their engine specifications in millimeters, so we'll be working with a metric micrometer.

We'll be back next month with a look at the bottom end, plus some engine assembly tips. A large box of engine parts just arrived, courtesy of Metrix Group, Inc. (Circle No. 141), and we're anxious to finish the job we've started.

— By Karl Seyfert

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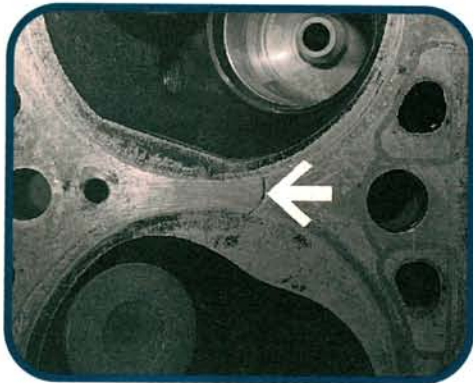
1

We'll skip most of the major engine disassembly formalities. Before removing the timing chain, rotate the crankshaft until the pointer on the front cover lines up with the "0" line on the damper. Cam sprocket bolts should parallel the upper head surface, with the pin at the lower left as shown.



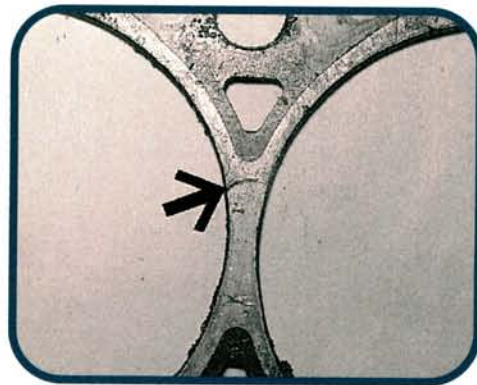
2

Carefully remove the timing chain tensioner cap. There's a large tensioner spring behind the cap, so don't get caught by surprise. Remove the cam sprocket bolts and cam sprocket. If you're only partially disassembling the engine, the chain can be placed out of the way inside the front cover.



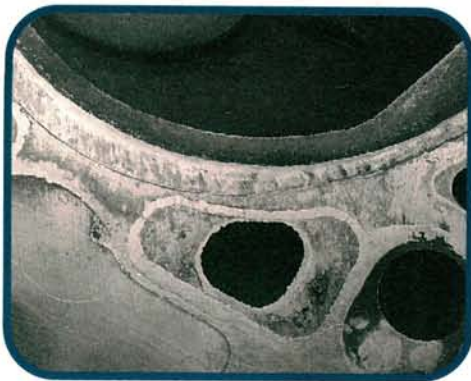
3

While inspecting the head, we discovered this carbon-filled OEM scratch between the number 1 and 2 cylinders. Only 0.3 mm (0.012 in.) is allowed for resurfacing. Rather than resurfacing the head to remove the scratch, we'll build up the damaged area first. A light cleanup cut will finish the job.



4

We included this photo of the head gasket to prove that we didn't gouge the head. The carbon mark is also visible on the gasket (arrow). They say dead men tell no tales, but a lot can be learned from a dead head gasket. Take a close look at the gasket before you scrape it off the head or block.



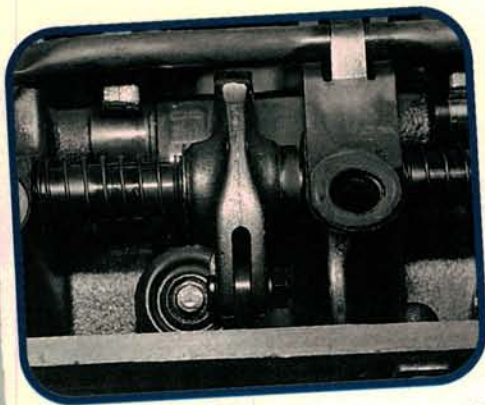
5

These corrosion marks near the combustion chambers indicate that the head gasket probably lost some of its original sealing ability over the life of the engine. The light surface cut should remove these marks from the head. Careful hand cleanup brought the block deck surface back to as-new condition.



6

Camshaft oil sprayer bar banjo bolts have a nasty habit of loosening up, depriving the cam lobes and rocker arms of vital lubrication. During reassembly, position the mark at the end of the bar (arrow) facing the front of the engine and use new crush washers and thread locker on the rail bolts.



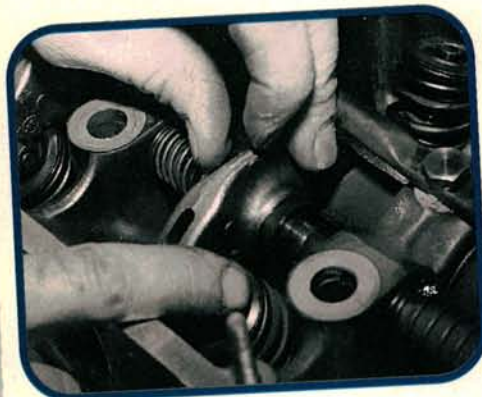
7

After loosening all of the rocker arm adjusters, two or three partially opened valves will prevent camshaft removal. A special BMW fixture is available to depress the valves, or screwdrivers may be used to open the valves. We chose to remove the rocker shafts first, then the camshaft.



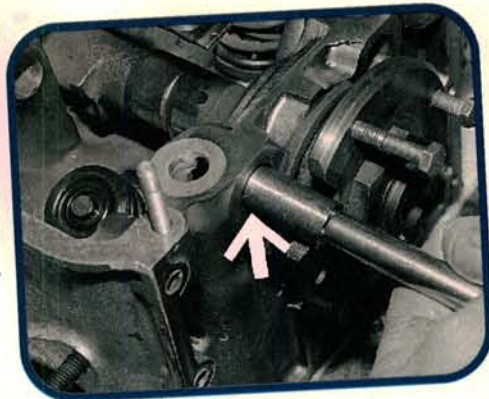
8

There are four rocker shafts, two per side. Each shaft is different, and can only be installed in one location in the head. Some shafts are tapped, with a hex head plug in one end (arrow). After removing the plug, a slide hammer adapter can be used to pull each rocker shaft out of the head.



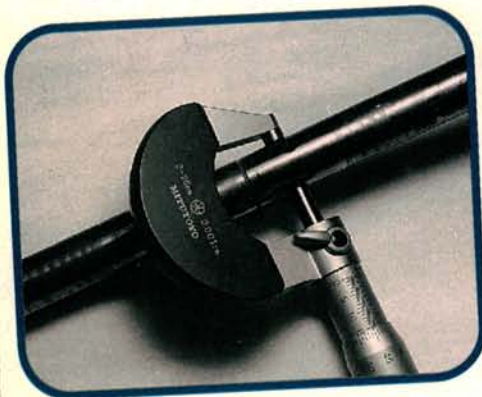
9

Turn the cam until most of the valves are closed. Push each rocker arm against its rocker shaft spring, then remove the rocker shaft spring clip with a pocket screwdriver. One side of the clip gets all the wear, due to contact with the thrust ring. Always replace these clips during an overhaul.



10

These rocker shafts aren't threaded, so we'll drive them out of the head instead. We used a modified socket and long socket extension to push out the rocker shafts. To avoid damaging the rocker shaft thrust rings, drive the rocker shafts from the end of the shaft facing the thrust rings.



11

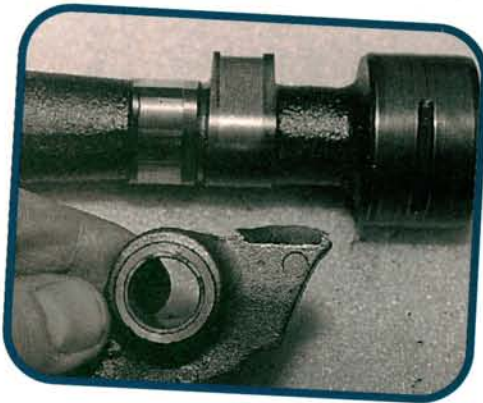
A very small amount of wear on the rocker shafts or rocker bushings can cause a noisy valve train. We measured the rocker shafts at several points with a micrometer, then slid a rocker arm over the shaft to check for radial play. Only 0.016-0.052 mm (0.0006-0.0020 in.) radial play is permitted.



12

Given the extended oil change intervals we knew this engine had endured, we expected to find a set of rocker arms like the one on the left. It's actually a ringer from a different engine with a lot fewer miles. Poor quality follower slippers have been known to break off the aluminum rocker arm.

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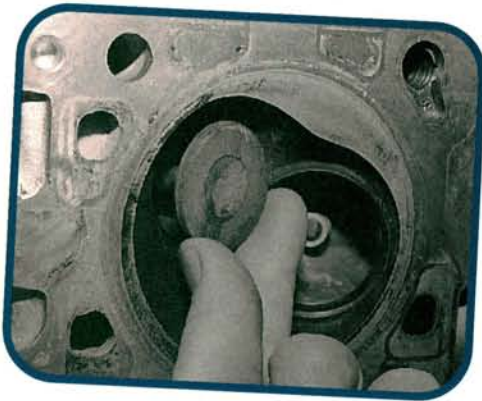
13

This heavily worn cam and lifter also came out of another BMW big six. Dirty oil, or a clogged or loose oiling rail above the cam can produce this much wear. Our cam was just beginning to show the stepped effect that is visible on this cam. We opted for a new cam, rocker arms, and rocker shafts.



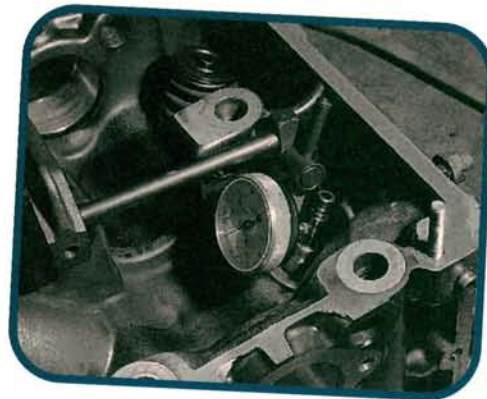
14

Disassemble the rockers and inspect the eccentric adjusting cams, bolts, and nuts for wear. Lock nut and bolt threads are often stretched by overtightening during valve adjustments (proper tightening torque is only 10 Nm). Worn adjuster eccentrics also prevent accurate valve adjustment.



15

BMW engines of this vintage were notorious for intake valve deposit problems. This engine has a history of running problems that responded well to treatments with injector and valve cleaning solvents. We expected to find heavy deposits, but found the intake and exhaust valves surprisingly clean.



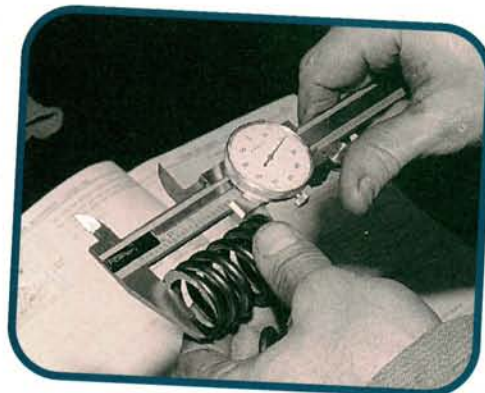
16

The engine had been using oil between changes. Worn valve guides and valve seals were a couple of likely causes. We inserted a new valve into the used guides, then measured play with a dial indicator. Maximum allowable play is 0.8 mm (0.031 in.). These guides flunked and will be replaced.



17

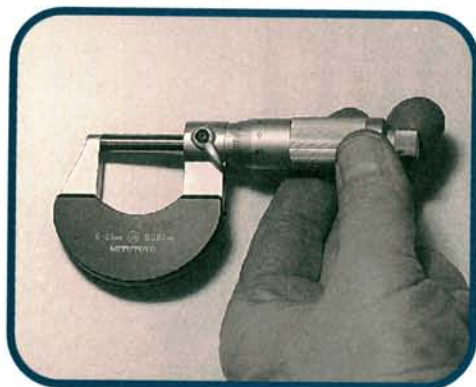
The valve tips were worn, although the sealing faces looked pretty good. Closer inspection revealed the extent of the stem wear (see the sidebar on micrometer usage for details). Measurement of the valve's overall length indicated that the valves had stretched slightly as well.



18

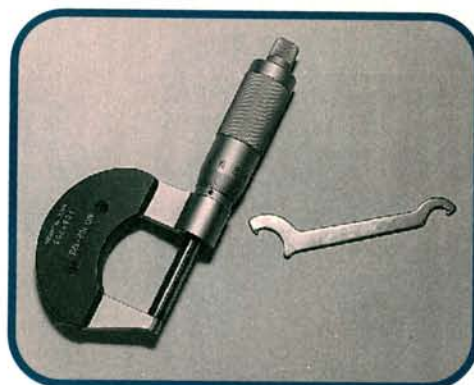
We planned to install new valve springs, but decided to measure the relaxed height, squareness, and compressed force of several springs to justify our decision. While each of the springs tested was within specifications, there's no telling how much life is left in a 200,000 mile valve spring.

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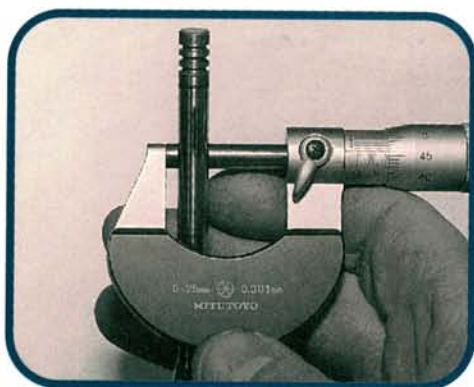
1

Accurate engine measurements require a properly adjusted micrometer. Turn the thimble until the spindle touches the anvil. Don't get carried away, it's not a C-clamp. The line next to the large 0 should meet the reference line. This mic's friction ratchet prevents overtightening.



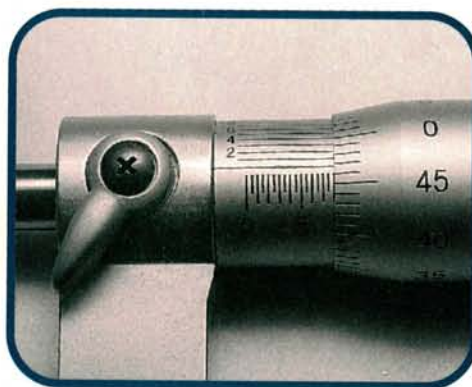
2

Most mics have a provision for adjustment if the mic has been overtightened and the 0 doesn't line up properly. This special spanner engages a hole in the mic sleeve for small adjustments. The sleeve fits tightly in the anvil. It may take several attempts before the 0 lines up perfectly.



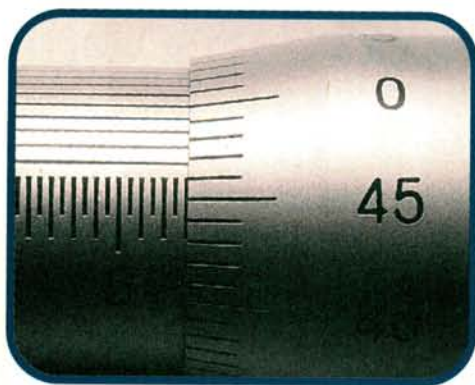
3

We measured a used valve in several spots along the valve stem. As you would expect, the stem thickness varied; with the smallest measurements in the valve guide area. The new valve stem diameter spec is 8 mm. The mic tells us this used stem is smaller. Let's find out exactly how much smaller.



4

Each long vertical line below the reference line equals 1 mm on this 0-25 mm metric micrometer. Each short line equals 0.5 mm. Seven long 1 mm lines and one 0.5 mm line are showing. This tells us the valve is at least 7.5 mm thick, with a little extra left over that still needs to be measured.



5

The thimble has 50 notches around its circumference. Each thimble notch adds 0.01 mm to our measurement. We started with 7.5 mm. We'll add 0.46 mm for the 46 thimble notches to bring the measurement to 7.96. Notice that the reference line is midway between the 46 and 47 notches.



6

The 10 numbered lines above the reference line add the final thousandths of a millimeter to our measurement. Only one of the sleeve lines on the left will line up with one of the thimble notches on the right. In this case it's the 7 line, so we add 0.007 mm for a final measurement of 7.967 mm.