Study Unit

Four-Stroke Engine Top-End Inspection

By

Ed Abdo

Author Acknowledgment

Edward Abdo has been actively involved in the motorcycle and ATV industry for more than 25 years. He received factory training from Honda, Kawasaki, Suzuki, and Yamaha training schools. He has worked as a motorcycle technician, service manager, and Service/Parts department director.

After being a chief instructor for several years, Ed is now the Curriculum Development Manager for the Motorcycle Mechanics Institute in Phoenix, Arizona. He is also a contract instructor and administrator for American Honda's Motorcycle Service Education Department.

Preview

Top-end engine disassembly is a process by which all of the components of the top end of an engine are removed. Engine disassembly is a task you'll perform often in your job. An engine may be disassembled to make needed repairs, or to complete the first step in an engine rebuild. During an engine rebuild, the engine is completely cleaned and restored to a *like-new* condition.

This study unit introduces you to the procedures used to disassemble the four-stroke engine top-end assembly. You'll start by learning the important preliminary steps you must complete before taking the engine apart. Then, you'll learn the engine disassembly procedures. The procedures we describe apply to almost all four-stroke engines (regardless of model or manufacturer), however, we illustrate the procedures with real engine examples. Next, we explain how to visually inspect and measure the components of the engine top end. Throughout the discussion, we point out the tools used in the process and provide you with some review information about the function of certain engine components. In addition to the disassembly process, we also cover reassembly procedures.

When you complete this study unit, you'll be able to

- State the procedures for removing a four-stroke engine from the chassis
- State the procedures for disassembling the top end of a four-stroke motorcycle or ATV
- Diagnose common problems related to four-stroke engine top-end failure
- Inspect the components of the top end of a four-stroke motorcycle or ATV
- State the procedures for reassembling the top end of a four-stroke motorcycle or ATV

Contents

Four-Stroke Engine Top-End Inspection

INTRODUCTION

When we speak of repairs to the four-stroke engine's *top-end assembly*, we're referring to work done on the rocker arm, valve, pistons, rings, cylinder, camshaft, and related parts. In this study unit, the focus is on disassembly and repair of valves and their components, as they pertain to the four-stroke motorcycle and ATV engine. This is the major physical difference between four-stroke and two-stroke engines.

Repairs to the top-end assembly of most four-stroke motorcycle and ATV engines require that the engine be removed from the chassis. Some models, however, don't require the engine to be removed to repair parts located above the cylinder. The manual for the particular model you're working with tells you which is the case.

Repair Procedures

The procedures in this study unit are general in nature and not intended to be used for actual disassembly and repair. Their purpose is to familiarize you with the types of activities you'll encounter. Always refer to the appropriate motorcycle or ATV service guide for maintenance information. The service guide contains all the information to do the job correctly, including detailed instructions for the specific make and model of motorcycle or ATV, special tools, and service tips. Above all, the service guide contains the appropriate safety information.

Engine Disassembly and Assembly

When disassembling an engine, be careful not to remove parts that don't need to be removed. Close inspection of the motorcycle, or reference to a service manual, can save many hours of time spent removing and replacing parts unnecessarily.

When rebuilding the top-end components of any engine, you need to be both patient and precise. Before you begin any repair job, take time to assemble the proper tools and the materials you'll need (micrometers, valve refacing tools, lapping tool and compound, cleaning solvent, and so on). Also, be sure to have the proper service manual for the motorcycle or ATV engine on which you'll be working. If an engine is to work properly, the measurements involving its piston and valves must fall within the manufacturer's specifications. Be patient and careful as you make the required measurements. Use the proper measuring instruments and record all your measurements accurately.

When you disassemble and rebuild an engine, examine the condition of each component. Check the parts before you clean them. For the most part, this should be a preliminary examination. The *as-is* condition of the parts can reveal a lot about the operation of an engine. After you've examined the parts and recorded your observations, clean the parts thoroughly and proceed with the rebuild. Then measure and determine which parts need to be replaced and which can be reused.

Let's begin our demonstration of the four-stroke engine top-end inspection by removing the engine from the chassis.

FOUR-STROKE ENGINE REMOVAL

Many four-stroke motorcycle and ATV engines use long *stud bolts* to secure the head and cylinder to the engine cases. Stud bolts have threads at each end. One end is screwed into the engine crankcase; a nut is screwed on the other end outside the cylinder head. This holds the head to the cylinder. Removal and replacement of stud bolts is very difficult and requires more time than removing and replacing the engine in the frame. Therefore, these engines are best removed before attempting cylinder repair, cylinder head repair, or any repair requiring major engine components to be disassembled. Procedures to remove two-stroke engines from the frame were described in the last study unit. Procedures for the removal of a four-stroke motorcycle or ATV engine are, as you'll see, very similar.

Removal of most motorcycle engines from the frame follows a pattern; that is, certain parts must be removed on each model. This pattern generally applies to all makes and models of motorcycles and ATVs. Parts that need to be removed usually include, but aren't limited to, the following.

- Battery, when applicable. This is a safety measure to prevent the possibility of fire. The spark of an accidentally grounded positive battery cable on spilled gasoline may start a fire.
- Fuel tank. This lets you free control cables and engine mount bolts.
- Fairings and bodywork
- Chain
- Control cables

- Ignition and other electrical wiring that may be attached to the engine
- Engine mounting bolts

Certain models require that some smaller parts be dismantled to facilitate removal of the engine. It's not possible to list each part for each brand and model. You need to refer to your service manual for the exact information concerning engine removal. However, you need to remove only those components that interfere with lifting the engine in or out.

In the following section, we describe procedures for removing the engine from our example

- Motorcycle—a liquid-cooled double overhead cam (DOHC) Kawasaki GPZ 500S, shown in Figure 1
- ATV—an air-cooled single overhead cam (SOHC) Suzuki LT 250S, shown in Figure 2

We discuss the specific differences between removing the engines from these machines, but as you'll see, there are many similarities as we remove the engine from the chassis. We follow the procedures in steps, to help you better understand the correct way to remove an engine from a four-stroke motorcycle and ATV.

FIGURE 1—The Kawasaki GPZ 500S Motorcycle (Courtesy Kawasaki Motor Corp., U.S.A.)

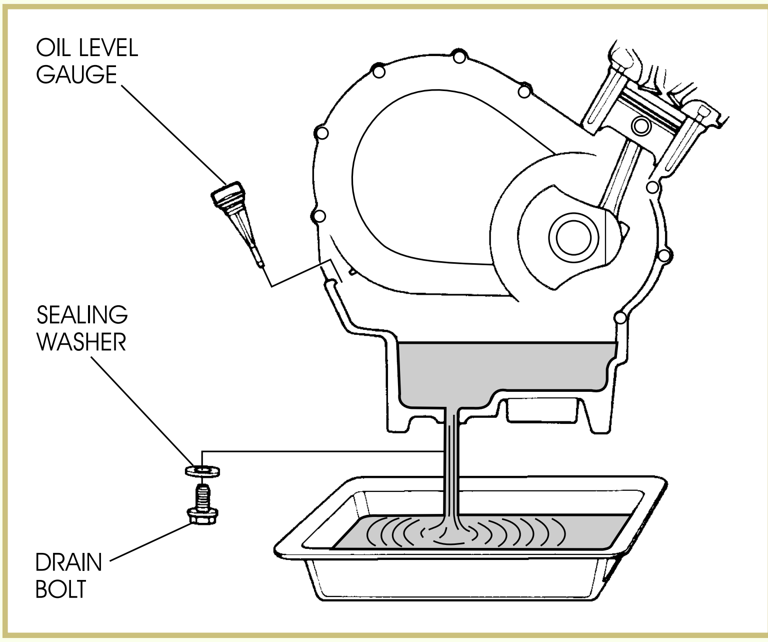
FIGURE 2—The Suzuki LT 250S ATV (Courtesy of American Suzuki Motor Corporation)

Cleaning the Engine and Draining the Fluids

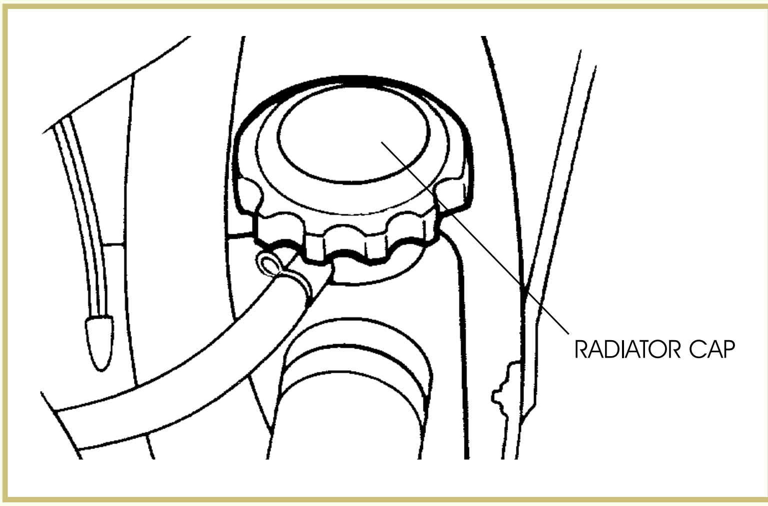
Before attempting to do any work on a motorcycle or ATV, it's extremely important that you clean the engine and the surrounding components thoroughly with a suitable cleaner. There are many types of cleaning agents available at automotive parts stores, as well as at your local motorcycle or ATV dealership. You'll find that disassembly is much easier when you're working with a clean piece of equipment.

Note: The illustrations used in the following example procedure are courtesy of the American Honda Motor Co. Inc., and reprinted with permission.

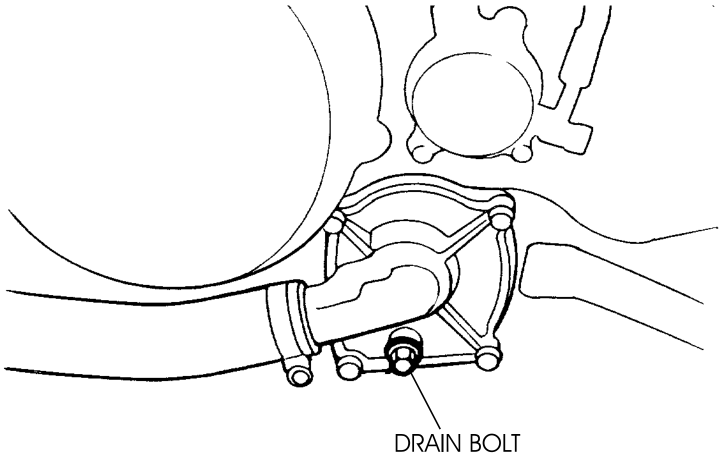
1 Remove the engine oil drain bolt. This prevents oil spillage while you're removing the engine from the chassis.



2 If you're working on a liquid-cooled motorcycle or ATV, remove the radiator cap. This is a preliminary step to draining the engine coolant. You'll find that the coolant flows out easier if you first remove the radiator cap.



3 Remove the coolant drain plug to drain the engine coolant. This plug is usually located on the water pump.



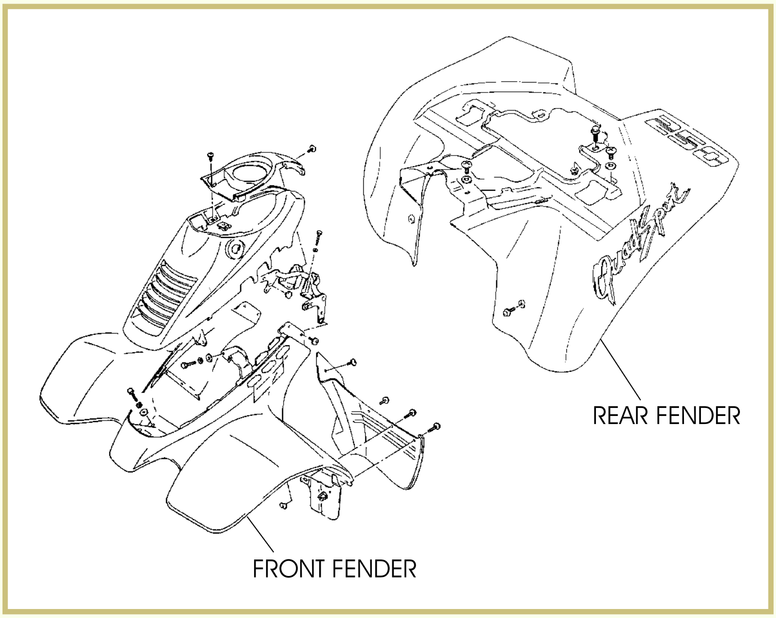
Removing the Engine Body Components

While the fluids are draining in the appropriate containers, continue to remove all necessary chassis and body components. These components include, but aren't limited to,

- Seat side covers
- Battery (on applicable models)
- Fuel lines
- Fuel tank
- Fuel tank brackets

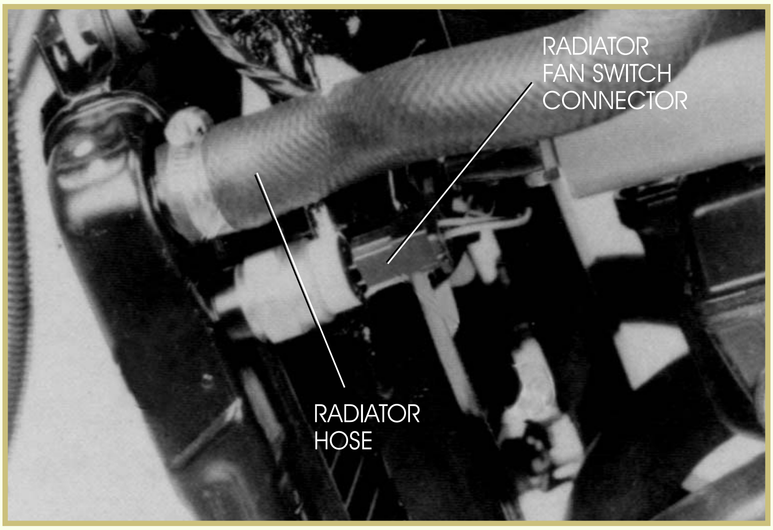
To remove the other components, complete the following steps.

1 Remove the front and rear fenders. This is necessary for engine removal on some ATVs.



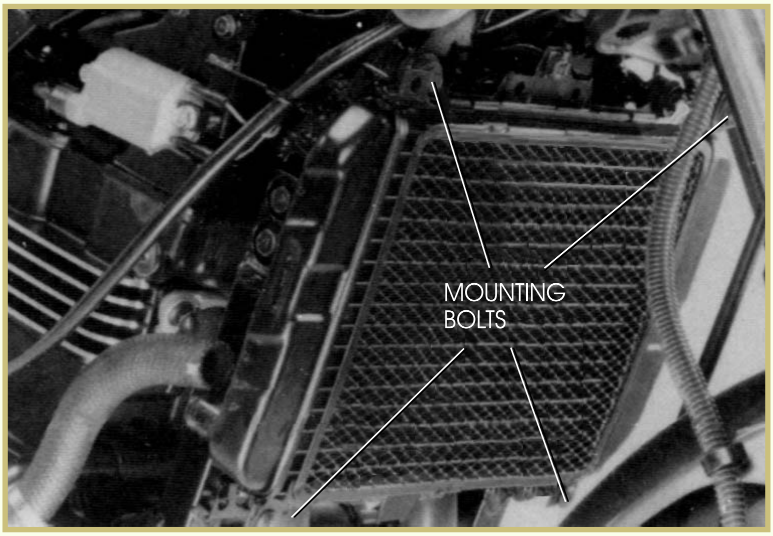
(Courtesy of American Suzuki Motor Corporation)

2 Remove the coolant hoses and switch connectors (on liquid-cooled models).



(Courtesy Kawasaki Motor Corp., U.S.A.)

3 Remove the radiator (on liquid-cooled models). The radiator is secured by four bolts in this figure.

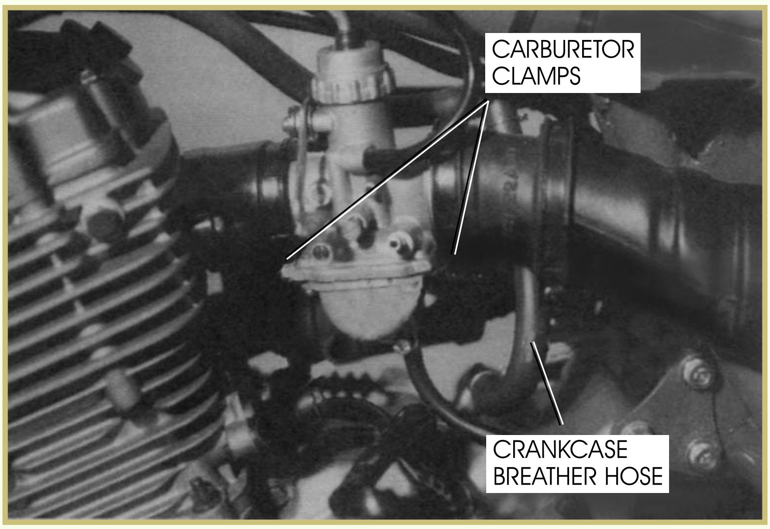


(Courtesy Kawasaki Motor Corp., U.S.A.)

4 Remove the ignition coils (on most models).

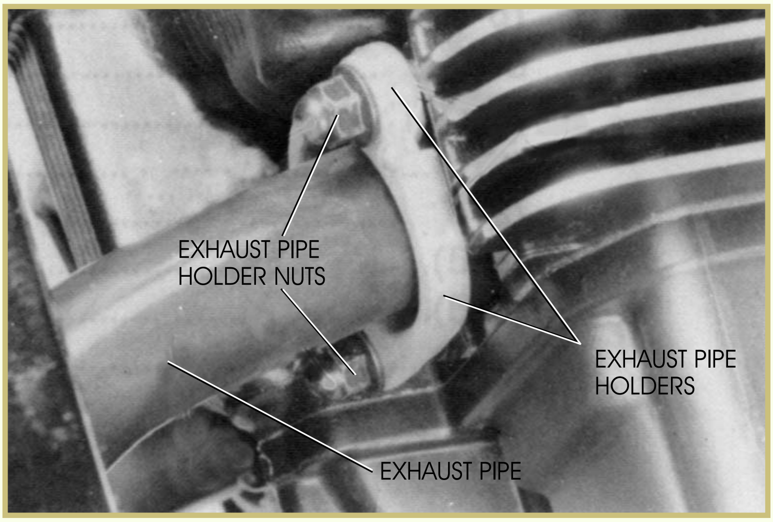
5 Remove the carburetor(s).

6 Disconnect the crankcase breather hose.



(Courtesy of American Suzuki Motor Corporation)

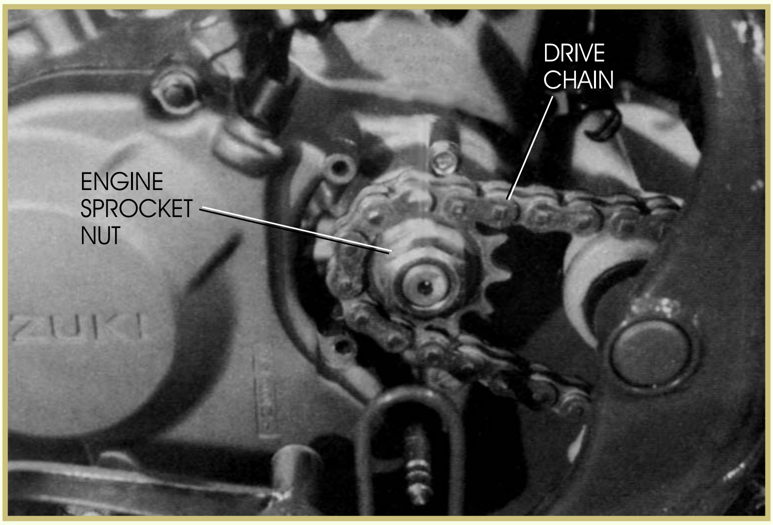
7 Remove the exhaust system. The exhaust system is secured by the exhaust pipe holders and nuts.



(Courtesy Kawasaki Motor Corp., U.S.A.)

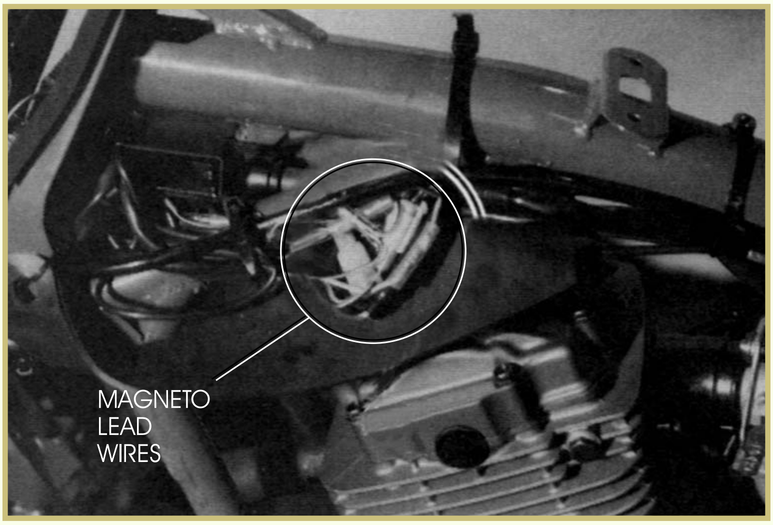
8 Remove the engine sprocket bolt or nut. To ease removal, put the engine in gear and apply the rear brake firmly before removing the drive chain or drive shaft engine sprocket.

9 Remove the drive chain.



(Courtesy of American Suzuki Motor Corporation)

10 Remove all electrical wiring connected to the engine.

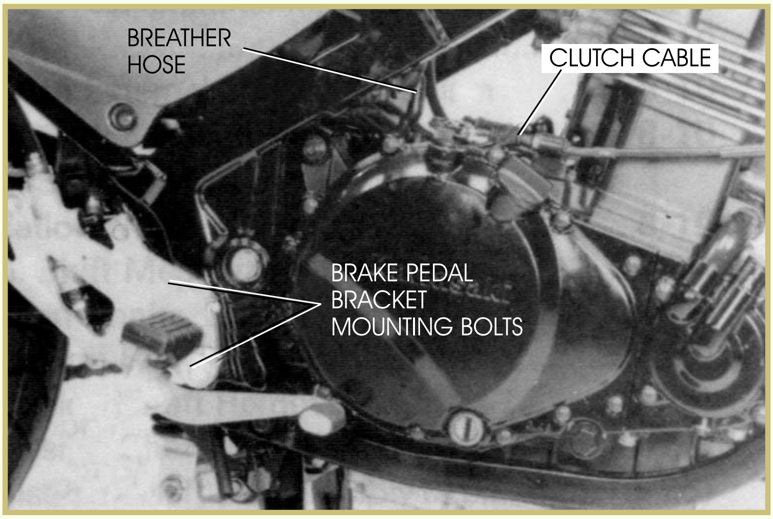


(Courtesy of American Suzuki Motor Corporation)

11 Remove all necessary control cables, such as the clutch cable.

12 Remove brake pedal bracket.

13 Remove breather hoses.



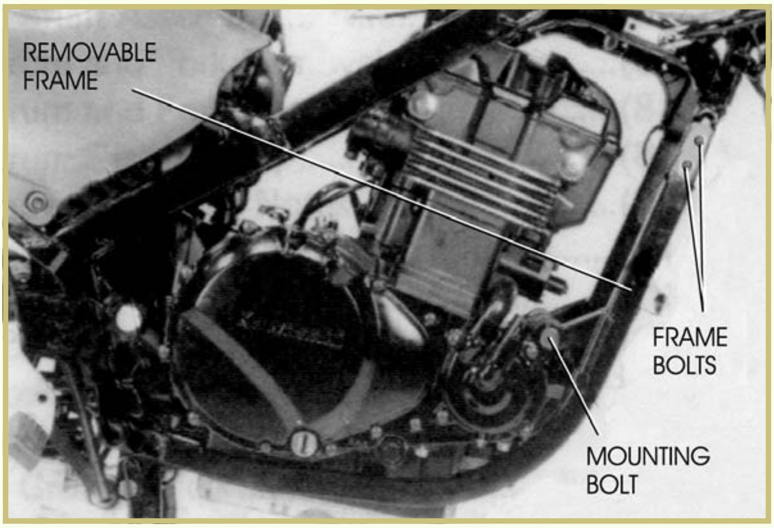
(Courtesy Kawasaki Motor Corp., U.S.A.)

Removing the Engine

Depending on the machine, an engine can weigh over 300 pounds! Therefore, it's advisable to use an assistant when taking the engine out of the chassis. Note that, depending on the motorcycle or ATV, the engine is removed from the left or from the right side of the chassis. Check your service manual; this information makes engine removal easier.

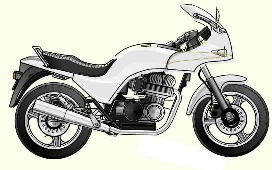
1 If necessary, remove the four bolts securing the removable frame section.

2 Remove the engine mounting bolts. The position of mounting bolts varies with different machines. Note that some motorcycle and ATV engines have more mounting bolts than others. Also, some motorcycles have the ability to remove a section of the frame to ease the removal of the engine. The mounting bolts of the Kawasaki are shown in this figure.



(Courtesy Kawasaki Motor Corp., U.S.A.)

Road Test 1



At the end of each section of *Four-Stroke Engine Top-End Inspection*, you'll be asked to check your understanding of what you've just read by completing a "Road Test." Writing the answers to these questions will help you review what you've learned so far. Please complete *Road Test 1* now.

1. *True or False?* When you disassemble the top-end assembly of motorcycles and ATVs, the engine is normally left in the chassis.

2. Before doing any work on a motorcycle or ATV, you should always thoroughly _______ the machine.

3. How can you make removal of the engine sprocket bolt easier, as you prepare to remove the engine from the chassis?

   ____

4. On a liquid-cooled engine, what should you remove (besides the drain bolt) to allow the coolant to drain out the engine easier?

   ____

Check your answers with those on page 63.

DISASSEMBLING THE FOUR-STROKE ENGINE TOP-END ASSEMBLY

After you've removed all parts that might interfere with disassembling the top-end assembly, or removed the engine from the chassis as described in the previous section of this study unit, you're ready to start disassembling the engine. Our example for illustrative purposes is the single-cylinder Suzuki LT 250S ATV, which uses a single overhead camshaft design. We'll explain the different procedures used when disassembling a double overhead camshaft model as needed. However, note that most procedures are identical when taking the four-stroke engine apart.

Removing the Spark Plug

Remove the spark plug from the cylinder head. This relieves engine compression and allows the engine to rotate easily when necessary.

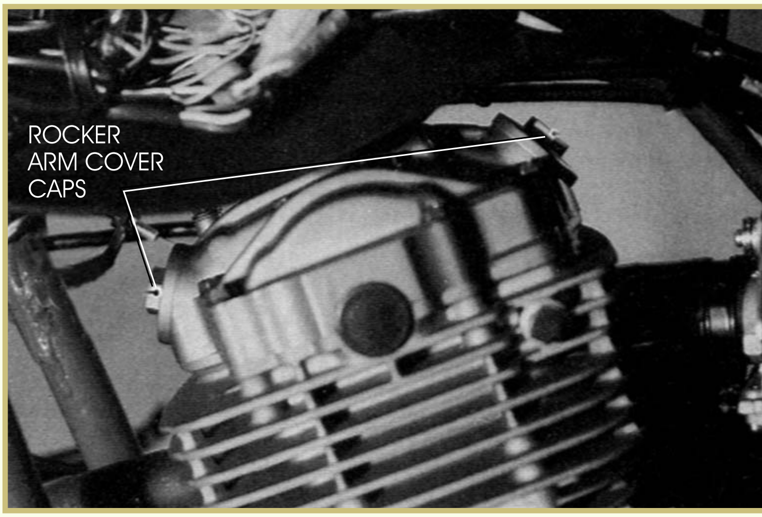
Removing the Cylinder Head Cover

Depending on the model you're working on, there may be either a simple *valve cover* or a *rocker box* mounted on the top of the cylinder head. The term *rocker box* refers to engines that have the entire rocker arm assembly and cover case built together as one assembly. Valve covers or rocker boxes are both known as *cylinder head covers*. Our example uses the rocker-box style cylinder head cover.

Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation, unless otherwise noted.

1 Remove the rocker arm cover caps. You'll now be able to see the intake and exhaust valves.

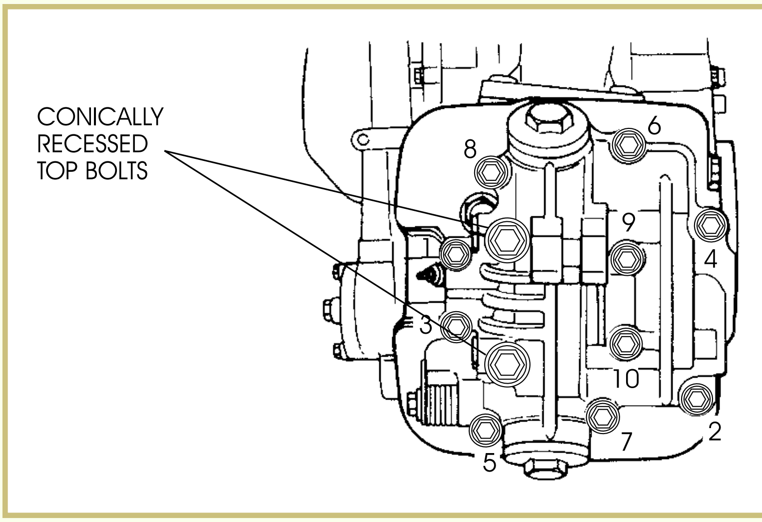
2 Rotate the engine to top-dead-center on the compression stroke. Do this by watching the intake valve open and close. As the intake valve closes, the piston approaches top-dead-center compression. The valve springs fully extend when the valves are closed. There should be minimum tension on the rocker arms.



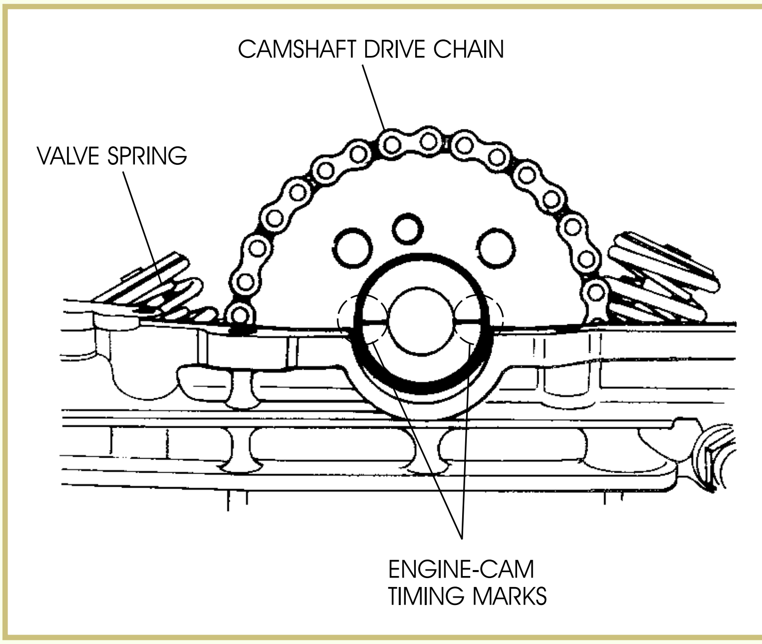
3 Loosen the rocker arm adjusting nut and screw just enough to ensure that all pressure is relieved on the valve springs. This ensures valve-to-rocker arm clearance and makes cover removal easier.

4 Remove any overhead-valve oil lines from the connection at the front or rear cylinder head cover.

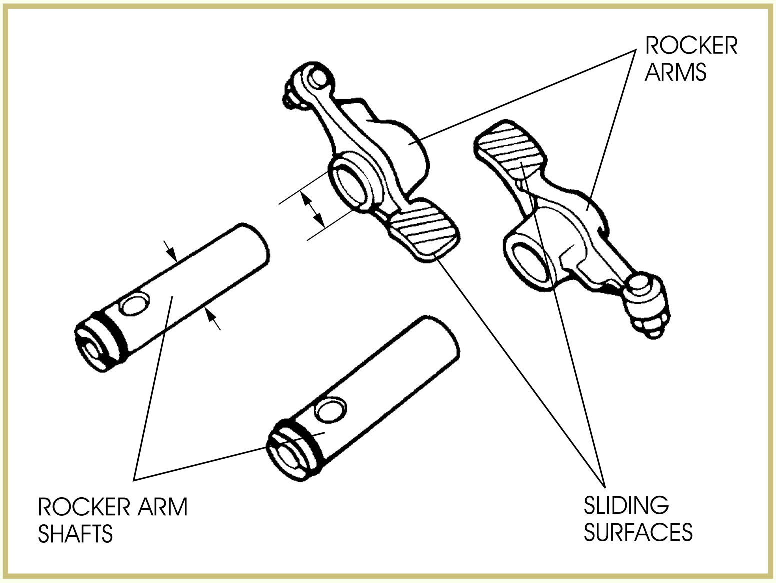
5 Remove the fasteners that secure the cylinder head cover to the cylinder head. These fasteners are located on the very top of the engine. Remove the bolts in the order indicated in the illustration. Don't remove the conically recessed top bolts.



6 Remove the cylinder head cover. A slight tap with a soft mallet may be required to break the gasket seal between the cylinder head cover and the cylinder head. Tap squarely with the mallet. Don't pry the cover off with a screwdriver, as you may damage the sealing surface of the cylinder head. The cylinder head cover can now be lifted free and inspected. You'll notice that the engine-cam timing marks are visible at this time. Remember that the camshaft must be timed precisely with the crankshaft to ensure the valves open and close at the correct time. Camshaft timing is discussed in detail later in this study unit.



7 While the cover is off, check for free, smooth movement of the rocker arms on the pivot shafts. Also, check for oil leaks where the pivot shaft enters the cover. There are rubber O-rings, oil seals, or sealing washers used where the shaft goes through the cover; they may need to be replaced. Finally, inspect the condition of the rocker arm's sliding surface for pitting and galling. If damage or wear is noted, the affected part must be replaced.

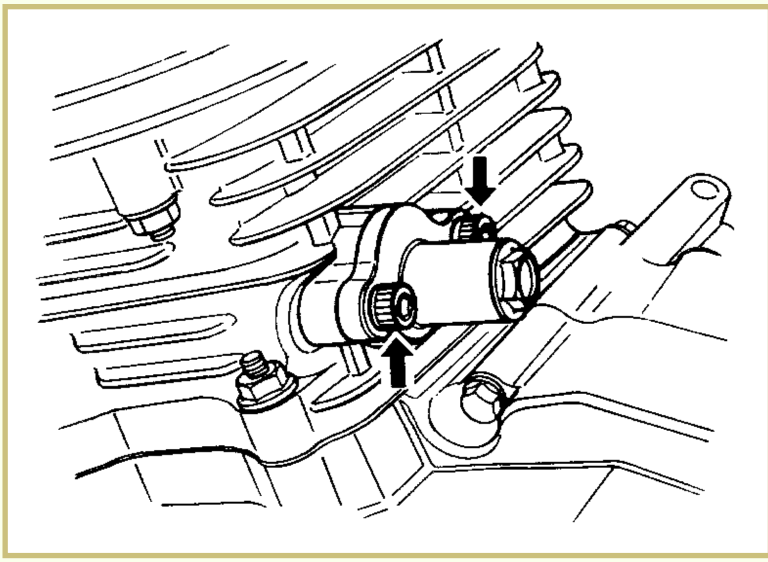


Removing the Camshaft

Before the camshaft can be removed, you must relieve the tension on the cam chain. After removing the camshaft, take special care not to drop the cam chain into the crankcase, as it may be very difficult to retrieve! Use a screwdriver or a piece of wire to keep the cam chain in sight.

Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation.

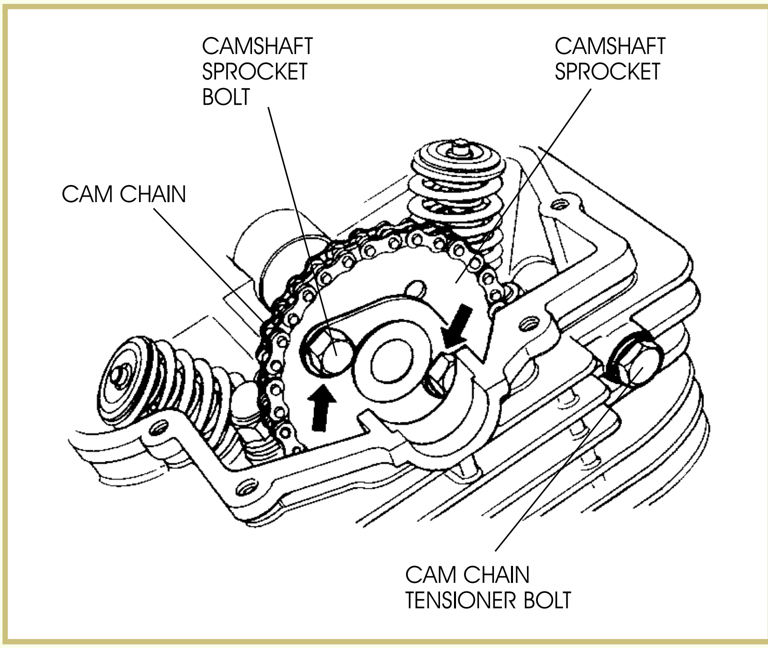
1 Remove the cam chain tensioner.



2 Remove the tensioner bolt to relieve tension on the cam drive chain.

3 Rotate the engine and remove all fasteners attaching the sprocket to the cam. The engine rotates easily if you've already removed the spark plug, as was suggested previously.

Note: When working on a DOHC engine, the procedures are the same, with one exception. On a DOHC, there are two camshafts held in place by cam caps. In most cases, you'll not be required to remove the camshaft sprockets on a DOHC top end to remove the cams.

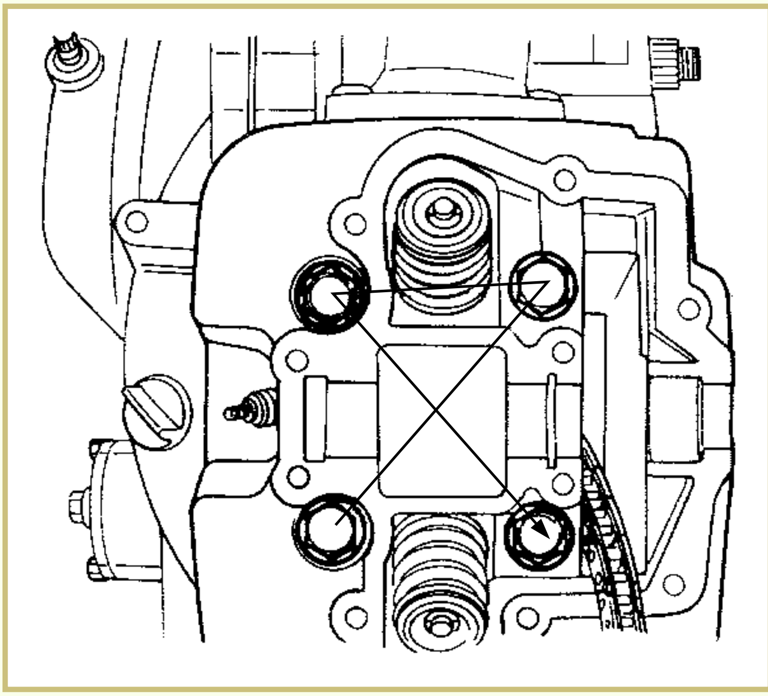


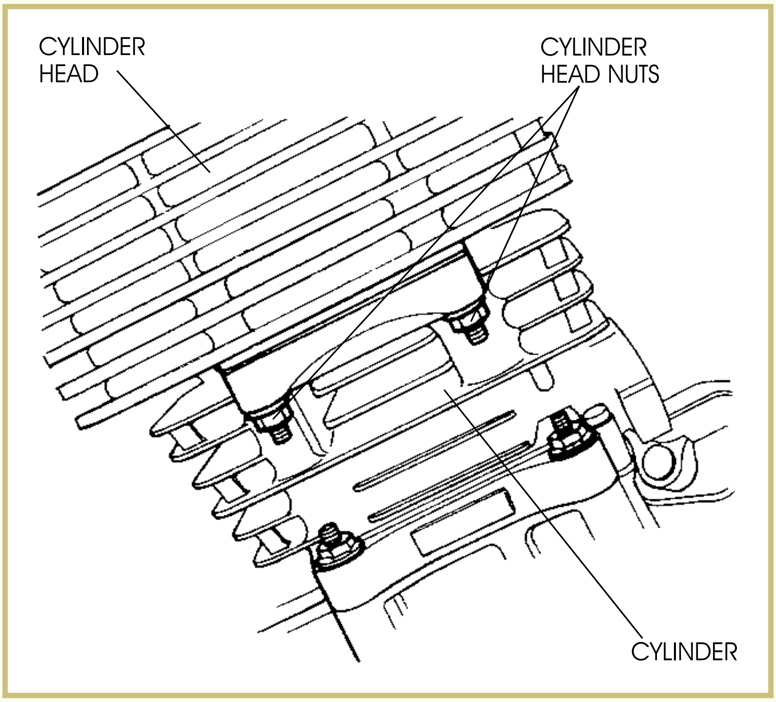
Removing the Cylinder Head

The cylinder head must be removed properly to avoid warping or other damage to the head assembly. Be sure to inspect the cylinder head assembly after it has been removed.

Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation.

1 Remove the cylinder head holding nuts and bolts. Loosen the fasteners in a crisscross pattern in two or more steps, to prevent warpage of the cylinder head.





2 Some models use additional fasteners located in various places to help secure the cylinder head to the cylinder. It's necessary to remove these fasteners to allow the head to be separated from the cylinder by lifting it off the stud bolts.

3 Remove the cylinder head from the cylinder. If it's difficult to separate the cylinder head from the cylinder, gently tap on the side of the head with a soft mallet to break the seal between the gasket and the cylinder head.

4 Visually inspect the cylinder head and camshaft. The bearing surfaces for the camshaft must be smooth and within the clearance specifications stated in your service manual. The surface of the cam lobes (where the rocker arm rides) should have no indentations or signs of wear. A more detailed explanation of inspection and repair of the cylinder head and camshaft is given in the next section of this study unit.

Disassembling the Cylinder Head

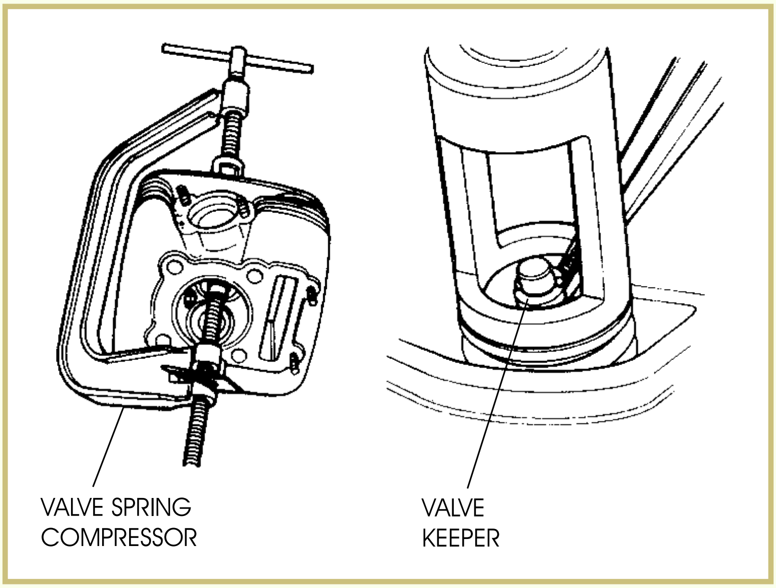
After you've completed your visual inspection of the cylinder head, you can disassemble its parts. You'll need a *valve spring compressor* for the removal and replacement of the valves. This tool is used to compress the valve springs while also preventing the valves from opening. In this way, the valve keepers can be removed and the valve components disassembled.

1 Position the valve spring compressor so that one end of the compressor is on the valve head and the other is on the valve collar.

2 Tighten the valve spring compressor to compress the valve spring.

3 With the spring fully compressed, remove the valve keepers using a pair of needle nose pliers or a small magnet.

4 Slowly and carefully release the pressure of the valve spring compressor so you can extract the valve from the guide.



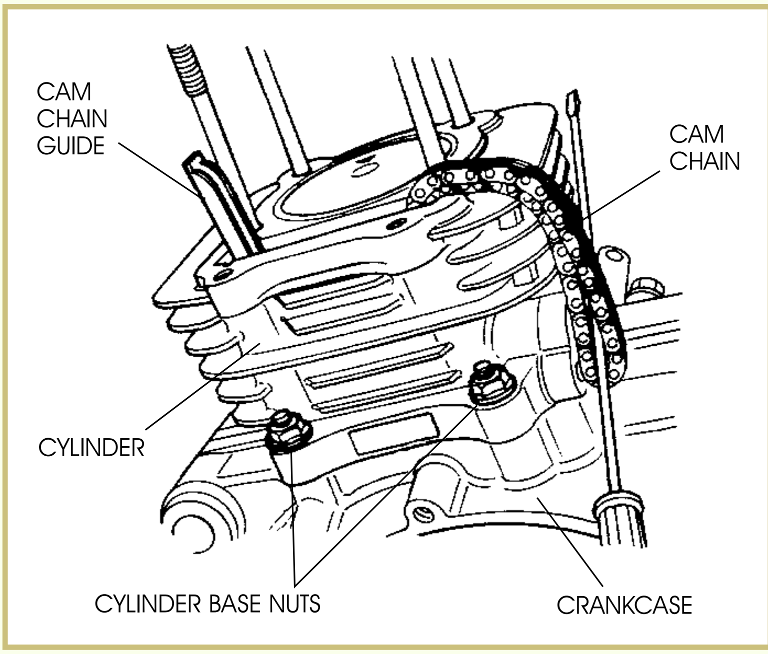
(Courtesy of American Suzuki Motor Corporation)

Removing the Cylinder

It's necessary to remove the entire cylinder to expose the piston and rings. Be careful to keep the internal parts of the engine clean and free from foreign objects.

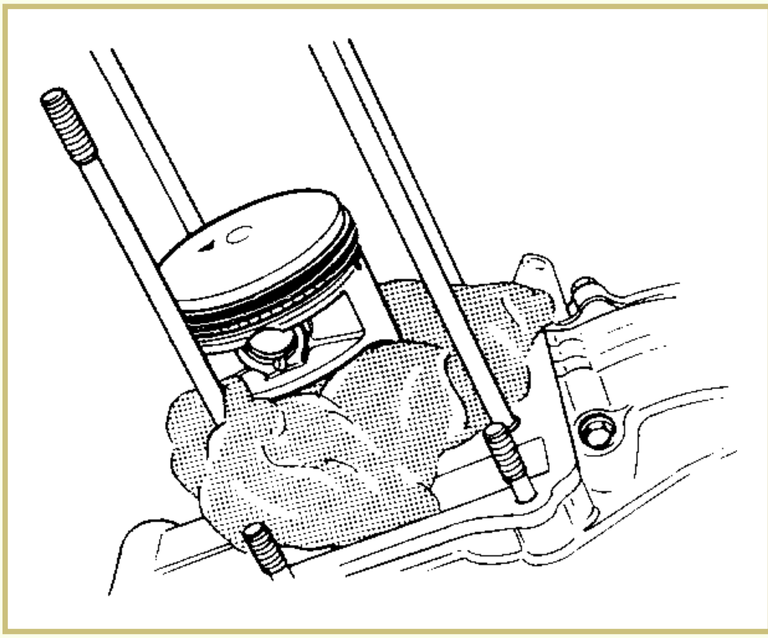
Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation.

1 If the cylinder is secured to the crankcase with cylinder base holding nuts, as shown in the figure to the right, they must be unscrewed before the cylinder can be lifted. You may also be required to remove the camshaft chain tensioner, chain guide, or both.



2 Lift the cylinder off the base of the engine to expose the crankcase cavity and the piston along with the crankshaft connecting rod.

3 Place a clean rag in this cavity to prevent foreign particles (for example, old gasket material, piston pin retaining rings, broken rings, and dirt) from entering. The rag also protects the piston from damage.

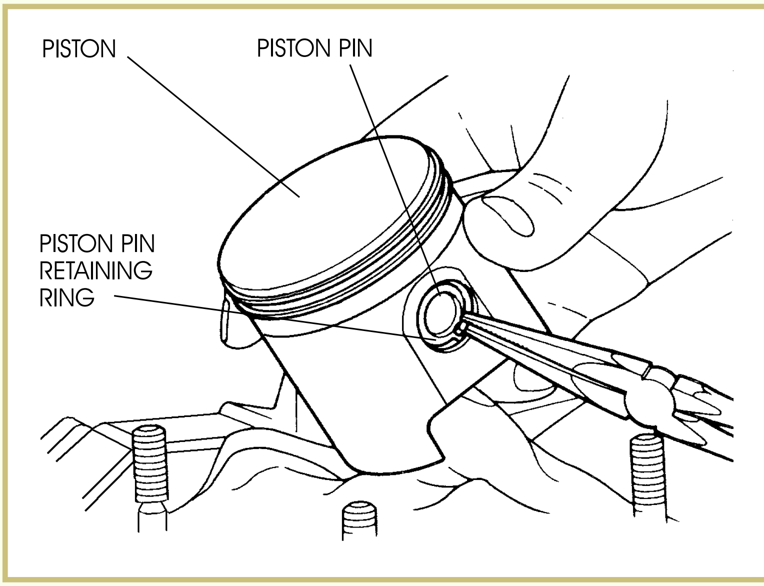


Removing the Piston and Piston Rings

After you've exposed the piston and rings, you'll notice major differences between the four-stroke piston and the two-stroke piston. One difference is the use of at least one more piston ring. The four- stroke engine normally uses one oil scraper ring and two compression rings, whereas a two-stroke engine typically uses only one or two compression rings. Why the extra piston ring? Remember that oil is mixed with fuel and both are burned in the two-stroke cylinder. In the four-stroke cylinder, fuel is burned without oil; lubrication is supplied by a separate oil supply. An oil scraper ring is used to prevent the oil in the lower-end assembly of the four-stroke engine from passing the piston and entering the combustion chamber.

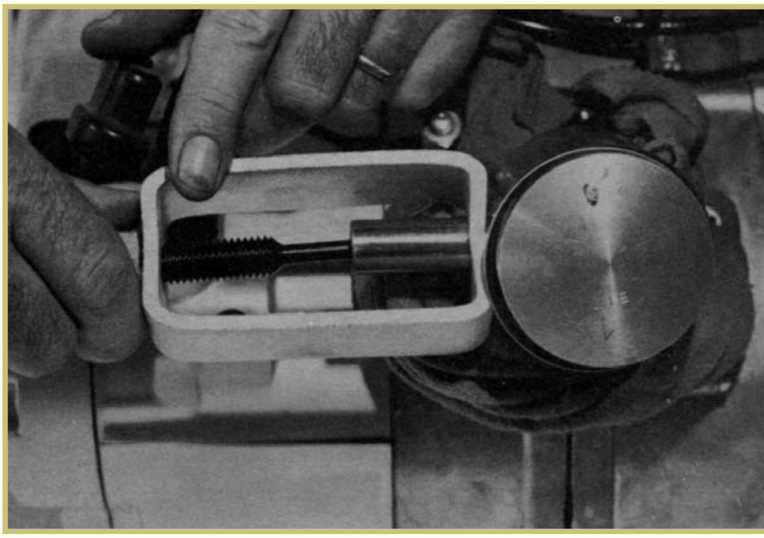
Another difference between the four-stroke and two-stroke engine is in the top of the pistons. *Cutaways* are often provided for valve head clearance in the four-stroke piston. These cutaways, or *pockets*, are designed to allow valve head and piston clearance as they both move. This clearance prevents the piston from hitting and bending the valve as it opens and closes.

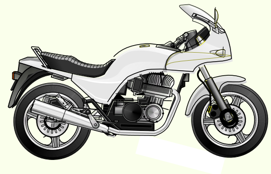
1 Remove the piston pin retaining rings and slide the piston pin out of the piston.



2 You may need to use a piston pin puller, to aid in removing piston pins that are too tight to simply push out.

3 After the piston is removed from the connecting rod, you can remove the piston rings. Use piston pin pliers to remove the rings. If this proves difficult, try to remove them by hand by spreading the end gap open and sliding the ring upward. Be very careful not to break the rings when removing them from the piston!





Road Test 2

1. Pistons used on motorcycle and ATV four-stroke engines normally have _______ piston rings.

2. Why is a scraper ring used on a four-stroke engine?

____

3. You should remove cylinder head fasteners in a _______ pattern to prevent warping the cylinder head.

4. What special tool is used to help remove the cylinder head valves?

____

5. Four-stroke pistons often have _______ in them to prevent the valves from contacting the piston while the valves open and close.

Check your answers with those on page 63.

FOUR-STROKE ENGINE TOP-END INSPECTION

There are many components in the four-stroke top end that require careful inspection and measurement. We'll begin our visual inspection of a four-stroke engine with the piston. Then we'll move on to the piston rings, wrist pin, cylinder head, valve train, and camshaft.

Inspecting the Piston

As you'll recall, the piston is the cylinder-shaped component that moves up and down the cylinder bore. The piston assembly consists of the piston itself, its wrist pin (or piston pin), and the piston rings.

As you're now aware, an engine produces its power by burning the air-and-fuel mixture in the combustion chamber directly above the piston. Each time the spark plug fires, the air-and-fuel mixture ignites with an explosive force. The burning process heats the gases, causing them to expand rapidly, forcing the piston down the bore. The piston movement is what allows the engine to perform useful work. As you can imagine, the piston has to withstand a tremendous amount of physical force as well as extremely high temperatures during engine operation. Therefore, as part of the rebuild procedure, you must carefully inspect the entire piston assembly for damage.

Checking the Piston for Damage

Start your inspection of the assembly with a visual examination of the piston itself (Figure 3). Check the piston for cracks or any other signs of surface damage. Pay particular attention to the sides of the piston. Examine the piston's sides in the areas of both the skirt and the rings; these areas are the most common sites of damage. One of the most common types of damage to the piston skirt is *scoring*. Score marks are deep, vertical scratches. A similar type of damage is *scuffing*. Scuff marks are wide areas of wear on the piston that usually appear as shiny patches. Scuffing may or may not be accompanied by score marks.

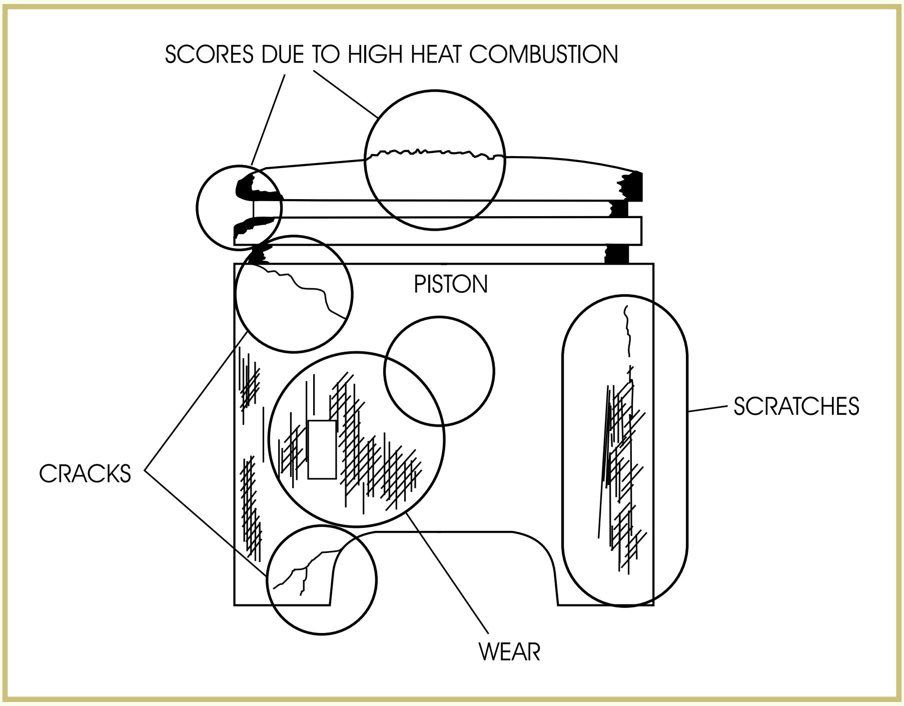


FIGURE 3—Problems to Look for When Inspecting a Piston (Image courtesy of Yamaha Motor Corporation, U.S.A.)

Scoring and scuffing can be the result of a variety of conditions. In most cases, the marks are created by excessive friction and heat. Under certain extreme conditions, the temperature in a cylinder can approach the melting point, or *weld point*, of aluminum. These very high temperatures can be caused by a problem in the engine's cooling system or excess friction between the cylinder wall and the piston rings. Excessive friction is often due to improper lubrication or to the piston fitting too tightly within the bore of the cylinder.

If you find score marks or scuff marks on a piston, try to determine the cause so you can prevent the damage from reoccurring. This is one of the times you can take advantage of the notes and observations you made earlier in the disassembly process. During the disassembly, you should have checked to determine that the proper amount of oil was present in the engine. Also, you should have noted any defects in the lubrication system. If you noted a possible source of damage during disassembly and later found marks on the piston, you have important clues for use in the troubleshooting process. In such a situation, you may also want to talk to the customer or machine's operator to find out whether the engine was overheating during operation.

Looking for Oil Residue

Engine overheating, in addition to causing scuffing and scoring, usually produces a buildup of oil residue on the piston and the rings. Extreme heat breaks down the viscosity of oil and reduces its lubricating ability. When oil breaks down, it starts to *bake* onto the engine components, forming a residue that resembles varnish. This residue can coat the piston rings and eventually cause the rings to stick firmly to the piston. If this occurs, the rings are no longer able to seal the combustion chamber properly. Therefore, always check to ensure that the rings are free to move on the piston and that both the piston and rings are free of any buildup.

Examining the Piston Crown

Although the skirt is the most frequently damaged site on a piston, you must also carefully examine the piston crown. If you find any damage, try to determine the exact cause so you can prevent the damage from happening again. Damage to the crown is usually the result of the fuel mixture burning improperly in the cylinder. If the fuel mixture ignites incorrectly, a violent explosion can result. The concentrated heat created in such an explosion can burn a hole right through the piston crown! Also, the explosion itself can be powerful enough to break right through the top of the piston. The following two terms describe different conditions that cause the fuel mixture to burn improperly.

Preignition. When *preignition* occurs, the air-and-fuel mixture ignites in the combustion chamber before the spark plug actually fires. This may sound strange. How can the mixture ignite before the plug fires? The explanation is based on the fact that the burning air-and-fuel mixture produces a lot of heat. The lingering high temperature in the combustion chamber can cause the mixture to ignite without a spark. Preignition can also be caused by excessive compression of the air-and-fuel mixture. The carbon that sometimes builds up inside the cylinder reduces the overall volume of the combustion chamber. The chamber's reduced volume results in an increase in the compression force exerted on the air-and-fuel mixture.

Detonation. In the engine condition known as *detonation*, the air-and-fuel mixture fails to burn smoothly. Instead, the mixture begins to burn in only one area of the combustion chamber. Then, as the pressure and heat in the chamber increase, the mixture ignites a second time in another area of the combustion chamber. Thus, two separate flames can burn at the same time in the chamber. When the two flames collide, a shock wave is created. The shock wave effectively *hammers* the top of the piston and the piston rings. Eventually, this hammering, or detonating, damages the piston and rings.

You may already be familiar with engine detonation. Most of today's automobiles exhibit it under certain conditions, particularly when the vehicle is under a load (for example, going uphill). The pinging noises that are often heard in such a situation indicate that detonation is occurring inside the engine's cylinders.

The most common cause of detonation is the use of gasoline with an octane rating that's too low for the engine. The recommended octane rating for the fuel in a particular engine can be found in the owner's manual and in the manufacturer's service manual for that engine. Detonation may also be caused by incorrect ignition timing. If the ignition timing is too advanced, the spark occurs earlier than it should. In this case, the fuel mixture ignites and starts to burn when the piston is still rising on the compression stroke. This disruption of the normal burning pattern results in detonation.

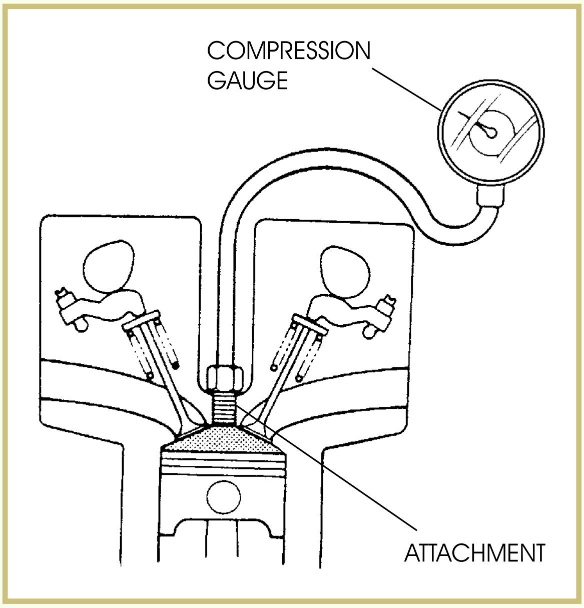
Inspecting the Piston Rings

The next step is to check the piston rings for signs of damage. The condition of the old piston rings can provide clues to certain engine problems. For example, small scratches found on the edge of the rings usually mean that dirt or other debris has been getting into the engine. This may indicate a faulty air filtering system.

Piston rings should be replaced when an engine is taken apart. Normally, rings that are reused won't *seat-in* properly, resulting in poor engine performance.You may recall that when new piston rings are installed in an engine, they must wear themselves into position against the cylinder walls to form a tight seal. Once this process of seating-in has occurred, the rings lose the ability to do so again. That is, if old rings are reinstalled in an engine, they won't be able to conform once again to the cylinder walls and make a tight seal. Without a tight seal, the combustion gases leak past the rings. This reduces the amount of horsepower the engine can produce. In addition, oil from the crankcase seeps past the rings and into the combustion chamber. The engine thus consumes larger amounts of oil. Oil that enters the combustion chamber burns along with the air-and-fuel mixture. Any oil burning in the combustion chamber is revealed by excessive exhaust smoke as the engine runs.

Worn piston rings are usually bright and shiny at the point where the edge contacts the cylinder wall. Worn rings can also be detected by performing a *compression check* on the engine before it's disassembled A compression check is a simple test that measures the amount of pressure produced in the combustion chamber on the compression stroke (Figure 4). The compression is measured with a special gauge inserted in the spark plug hole. If the piston rings are worn, the gauge displays a pressure reading that's much lower than the manufacturer's specification. The reading is low because, instead of being compressed, some of the air-and-fuel mixture is leaking past the worn rings and into the crankcase.

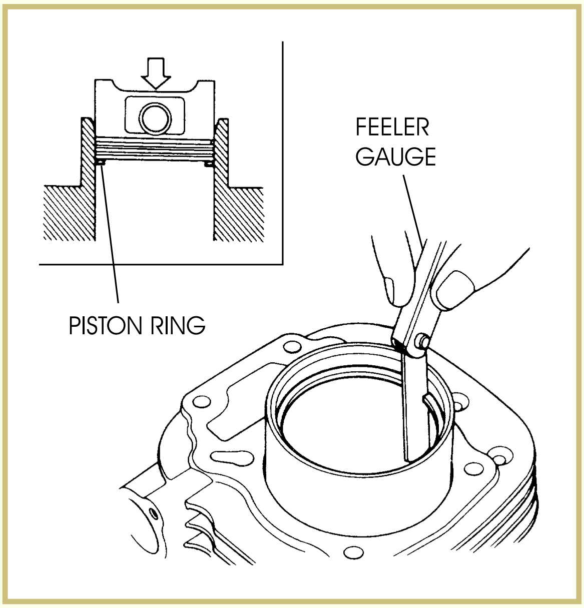
FIGURE 4—A compression test can help to diagnose a problem before disassembling a four-stroke motorcycle or ATV engine. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Measuring the Piston Rings

New piston rings are measured by fitting them into the cylinder and checking the end gap with a feeler gauge. This is done by inserting a piston ring into the cylinder squarely, using the piston as a guide. After the piston ring is inserted, you can then check for the end gap using a feeler gauge (Figure 5). Each piston ring should be measured at the top, middle, and bottom of the cylinder. The specification for the proper ring end gap is given in the appropriate service manual.

FIGURE 5—Procedure for Checking Ring End Gap
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)



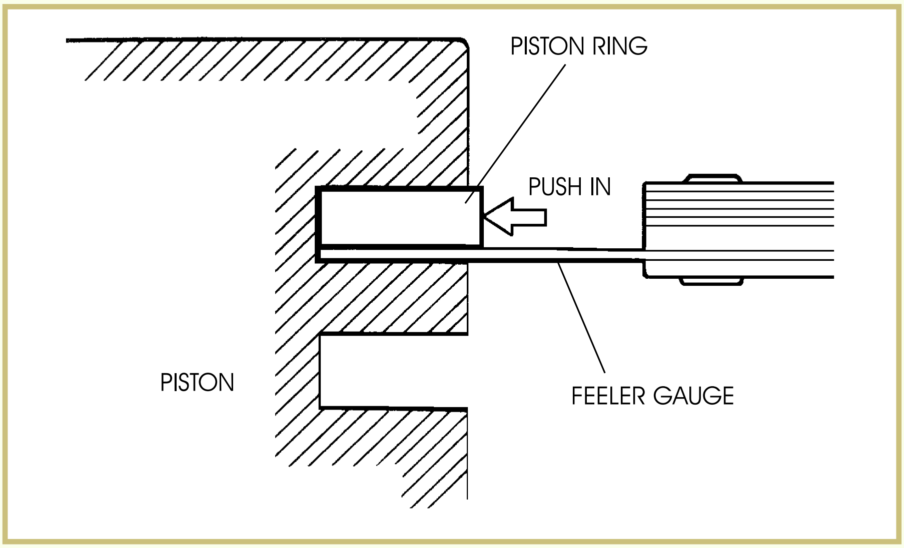
Inspecting the Piston Ring Grooves

The *ring grooves*, cut into the sides of the piston, hold the piston rings in place. The *ring lands* are the uncut areas between the ring grooves. The ring grooves are actually slightly wider than the piston rings. As a result, the rings can move slightly, or float, within their grooves. The rings are able to actively conform to the cylinder walls while the engine is operating. The small amount of space between each piston ring and the bottom side of its groove is called the *piston ring side clearance*.

As you can imagine, the combustion gases forcing themselves onto the piston get down into the ring grooves and leave behind a residue. Therefore, to inspect the ring grooves for excessive wear, you must first clean the grooves thoroughly. When cleaning the grooves, remember that the piston is made of aluminum, a soft metal. Be careful not to dig into the piston and remove any metal, especially along the inner sides of the ring grooves. The most common tool used to clean the piston ring grooves is an old piston ring. Made of a very tough material, old piston rings work well because they fit the ring grooves perfectly and, therefore, won't damage the sides of the grooves. If you use an old ring for this purpose, break it in half to produce a scraper-like edge. Then, insert the edge into the groove and scrape the residue out.

After the ring grooves are cleaned, the piston can be wiped off and the side clearance for the piston rings can be checked. As mentioned earlier, this dimension is the clearance between the piston ring and the inner side of the ring groove (Figure 6). This small amount of clearance performs an important function. During the power stroke, the pressure produced by combustion pushes the piston down the bore. Some of the expanding gases are also forced down the side of the piston and behind the floating piston ring. The resulting pressure behind the piston ring forces the ring outward, hard against the cylinder wall, thus helping to better seal the combustion chamber. By allowing the ring to seal better, the proper ring side clearance helps the engine produce more power.

FIGURE 6—Measuring the Piston Ring Side Clearance
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

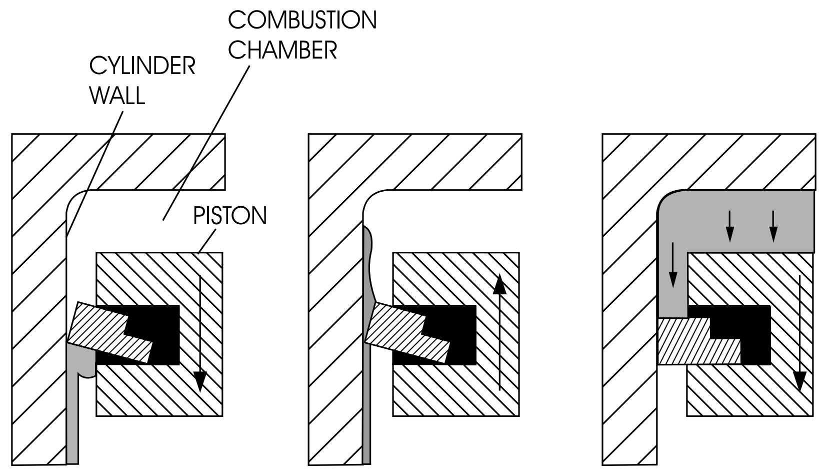


Note that because a small amount of clearance should always be present, a ring tips slightly under normal operating conditions, as shown in Figure 7. As the piston goes down the cylinder during the intake stroke, the ring tips and scrapes excess oil off the cylinder wall. During the compression and exhaust strokes, the piston rises and the tipped ring glides over the oil film remaining on the cylinder wall. During the power stroke, forces pushing down on the ring cause it to sit squarely, providing a better seal and, therefore, better power.

The proper clearance between the piston ring groove and the piston ring can be critical. If the clearance is too large, the ring tips excessively as the piston moves up and down, reducing its ability to seal. The excess movement of the ring on the piston may also cause the ring to break. If the clearance is too small, the ring binds in its groove when the piston heats up and expands.

After you've measured the piston ring side clearance, compare your measurement with the manufacturer's specification. Also, because each ring groove may be worn differently, you should check the side clearance in all of the piston's grooves.

FIGURE 7—Piston Ring Movement within the Piston Groove



Measuring the Piston

After the piston and rings have been visually inspected, you can prepare the piston for measurement. If the piston is to be measured properly, its rings must first be removed. To remove a ring, spread the ring open so you can slide it out of its ring groove and off the piston. As mentioned previously, using piston ring pliers is very helpful, although some technicians spread piston rings open by hand.

A typical piston appears to have a simple shape, like a can. However, looks can be deceiving. As mentioned in a previous study unit, a typical piston is manufactured with a taper. That is, the diameter at the very bottom of the piston's skirt is larger than the diameter at the piston's crown.

The service guide shows where to measure the diameter of the piston. Figure 8 provides an example. The piston must be measured with a micrometer. It's a good idea to keep track of the piston's actual diameter because you can use that measurement when calculating the clearance between the piston and the cylinder walls. Once you've measured the diameter of the piston, compare your measurement to the appropriate specification or specification range. If the diameter of the piston is outside the specification, the piston should be replaced. If the piston is within specifications and shows no visual signs of damage, you can reinstall it in the engine.

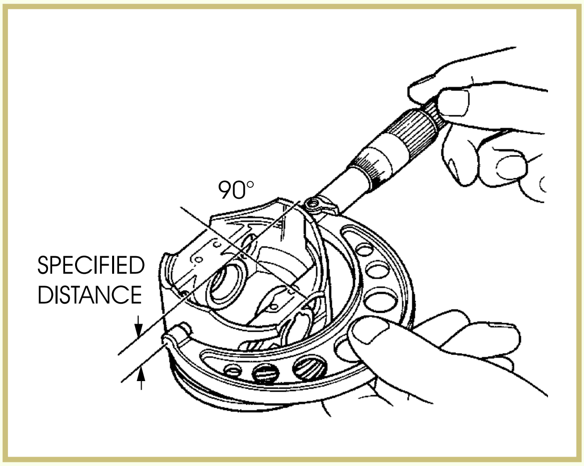


FIGURE 8—Measuring a Piston (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Measuring the Cylinder

Now we'll measure the cylinder to determine the amount of wear that has occurred on the cylinder walls. Movement of the piston and rings within the cylinder contributes to cylinder wear. The areas of wear are the locations in which the rings travel, as well as the areas in which the piston skirt contacts the cylinder walls. Cylinder wear is also caused by the piston rocking on the wrist pin, due to the piston tipping slightly during its travel. Piston rocking can create a noise known as *piston slap*. Under these conditions, the cylinder bore wears more on the front and back than on the sides. By front and back, we mean at a 90° angle to the wrist pin.

Cylinder measurements are taken from front to back and side to side. These areas are called the *X* and *Y* axis of measurement. To measure the cylinder, a *cylinder bore gauge* is used (Figure 9).

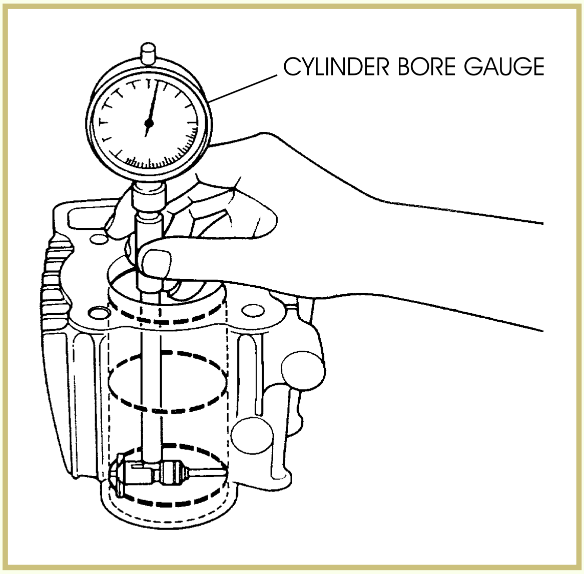


FIGURE 9—A Cylinder Bore Gauge (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Insert the cylinder bore gauge at a point near the top of the cylinder and take a reading of the micrometer. The gauge is then moved to a point near the center of the cylinder and a reading is taken there as well. Finally, the gauge is positioned at the bottom of the cylinder and another reading is taken. This is done for both the X and Y axis measurements to determine the cylinder's trueness (Figure 10). The readings are compared and the difference indicates the amount of wear.

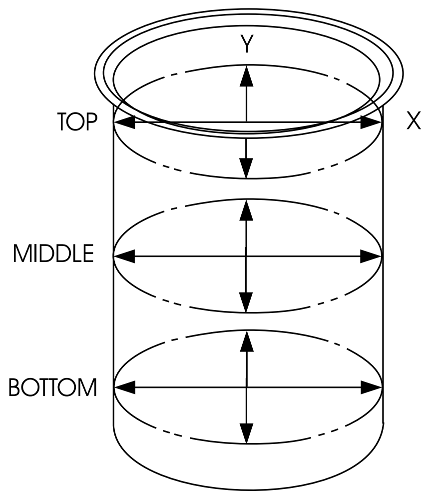


FIGURE 10—The X and Y Axis Measurements for a Four-Stroke Cylinder
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The difference between measurements taken on the same axis is known as *cylinder taper*. The difference between the two axes is called *out-of-round*. The taper and out-of-round must not exceed factory specifications for the engine on which you're working. Each model has its own specifications. If the measurements exceed allowable limits, in many cases the cylinder may be *bored* or recut to a new size and fitted with a new and larger piston and ring set. Not all cylinders can be bored; check the appropriate service manual to determine if the cylinder is capable of being bored.

Cylinder Boring. Boring a cylinder is a job that requires the use of special machine tools and is normally done by a specialist. Boring can be done at most automobile machine shops, as well as at many dealerships.

Measuring the Piston-to-Cylinder Clearance

A piston expands as its temperature rises. Because the metal of the piston typically expands more than the metal of the cylinder wall, some clearance must be allowed between these components when both are cold. This clearance is called the *piston-to-bore clearance*, or *piston clearance*, for short. The proper piston clearance for an engine is given in the appropriate service manual.

Piston Clearance—A Critical Dimension

If the clearance is too small, the piston fits too tightly in the cylinder when the engine heats up, resulting in excessive friction. Friction between the piston and the cylinder can be so great that the piston *seizes* in the bore. That is, the piston may wedge itself so tightly into the cylinder that it can't move up or down. If this occurs, the engine stops running and the starting mechanism won't be able to rotate the engine. You may be able to free a seized piston after the engine cools down again; however, both the piston and the cylinder wall will probably be badly scored and damaged.

If the piston clearance is too large, the piston isn't held in place and tends to rock back and forth while the engine is running. This rocking motion creates a knocking noise and may eventually break the piston skirt. In addition, the ability of the piston rings to seal the combustion chamber is greatly reduced.

Determining Piston Clearance

To determine the piston clearance in an engine, you'll need to measure the diameter of both the piston and the cylinder bore. Compare your measurements to the manufacturer's specifications. Then, subtract the outside diameter of the piston from the inside diameter of the cylinder bore. The result of your calculation is the actual piston clearance. Finally, compare your calculated clearance to the manufacturer's specification. If the clearance is outside specifications, the piston and cylinder must be resized to make the clearance conform to specification. This method is the most accurate way to measure the piston-to-cylinder clearance.

Some technicians prefer to measure the clearance directly, using feeler gauges. Although this method isn't normally recommended, it's mentioned here so you'll be aware of it. Using this method of measuring the piston clearance, the piston (without the rings installed) is placed into the cylinder bore. A blade from the feeler gauge is also inserted into the bore along either side of the piston skirt. Two blades are sometimes used, one on each side of the piston, so the piston remains centered in the bore. The various sizes of the gauge blades are inserted until the correct measurement is found. The blades that give the correct measurement produce a slight drag when pulled. The measurement read off the blades is the actual piston-to-bore clearance. To make this procedure a little easier, many technicians use longer-than-normal feeler gauges. These are available from most tool suppliers. The increased length of the blades makes it easier to measure the clearance inside a cylinder bore. It's usually more difficult to get accurate results using the feeler gauge method than by taking the actual physical measurements of the piston and cylinder.

Inspecting the Wrist Pin

The *wrist pin* is a cylinder-shaped component of the piston assembly. It's used to link the connecting rod to the piston. The connecting rod's bearing surface for the wrist pin allows the end of the rod to rotate freely around the pin as the piston travels up and down. The wrist pin must transfer each power stroke's downward physical force from the piston to the connecting rod. To ensure the wrist pin is strong enough to handle the task, the engine manufacturer usually makes the pin of high-quality steel, a very hard metal. For this reason, you won't usually see much wear on the pin itself. However, to guarantee that a wrist pin isn't worn, measure the pin's diameter with an outside micrometer and compare your measurement with the specification given in the service manual (Figure 11).

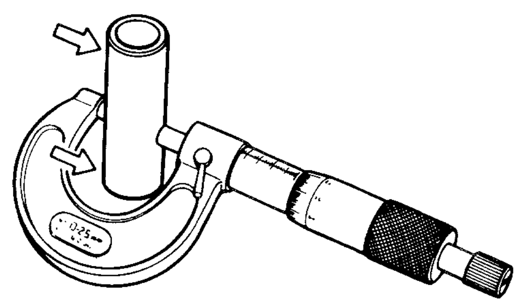


FIGURE 11—Measure the wrist pin in three locations using an outside micrometer. (Courtesy of American Suzuki Motor Corporation)

Inspecting the Cylinder Head

In addition to containing the valves, the *cylinder head* is the component that seals the top end of the cylinder. The cylinder head is usually attached to the top of the engine cylinder by several bolts. A gasket between the head and the block helps create an airtight seal. Because the cylinder head must seal off each cylinder, the head must be in good condition and free of cracks and warps. Before you can accurately determine the condition of a cylinder head, you should thoroughly clean it with a cleaning solvent.

Removing Carbon and Gasket Material Buildup

The combustion area of the head may require some special attention when you're cleaning the head. *Carbon buildup* from the combustion process may be present on the surface. Carbon buildup is a hard residue that's often found on surfaces exposed to the burned air-and-fuel mixture. Because the residue tends to be quite stubborn, you'll probably need a wooden scraper, a putty knife, or a wire brush to remove the buildup from the cylinder head.

In addition, since a gasket is used to help form the seal between the head and the block, there may be some gasket material left behind when the cylinder head is removed from the cylinder. This leftover material can be removed in the same way you would remove carbon buildup. Remember that most cylinder heads are made of aluminum, which is a relatively soft metal. Be careful that you don't dig into the cylinder head with the scraper or brush when cleaning it. After the carbon residue and gasket surfaces are scraped off, the head can be cleaned with cleaning solvent.

Checking for Damage

After the cylinder head is cleaned, it can be thoroughly checked for any visible signs of damage. Check for small cracks or other damage in the area of the combustion chamber. Also, if cooling fins are broken on air-cooled engines, the head may need to be replaced. When working on liquid-cooled engines, check all the water jackets to ensure there are no obstructions. In most cases, cylinder heads are very reliable.

The most common cylinder head problem you'll see is damage to the threads in the spark plug's hole. On all four-stroke motorcycle and ATV engines, the spark plug is threaded through a hole in the cylinder head. After the head is removed from the engine, you can easily clean and check the condition of the threads in the spark plug's hole. Because most cylinder heads are made of aluminum, the threads in the head can be easily damaged. If the threads appear to be damaged, repair them by running a thread tap through the hole or by installing a new threaded insert.

Checking Cylinder Head Flatness

Now you can move on to check the flatness of the surface where the new head gasket will be installed. Remember that the cylinder head must seal tightly to the top of the cylinder. The gasket between the head and the engine block can compensate for some variation in flatness, but the surface of the head must still be quite flat or the seal will fail. The manufacturer's service manual tells you the maximum amount that the surface of a usable cylinder head can be warped.

There are two methods you can use to check the flatness of the cylinder head's surface. Both methods involve the use of feeler gauges to measure warping.

With the first method, the surface is checked using a straightedge, such as a metal ruler. Place the cylinder head so the surface on which the gasket will be installed is facing up. To check the flatness, place the straightedge across the surface of the head, as shown in Figure 12. If you notice clearance anywhere between the straightedge and the head, insert the blades of a feeler gauge to measure the warping at that point. The thickness of the blade that fits the clearance is the amount of warp at that particular location. Because the straightedge is narrow, it should be moved about the surface of the head to check several locations. Measure the flatness in several directions across the cylinder head. In most cases, the best indication of the head's flatness is found when the straightedge is placed diagonally across the head's surface. Generally, the measurement you should use to compare against the manufacturer's specification is the maximum amount of warp measured at any point on the surface.

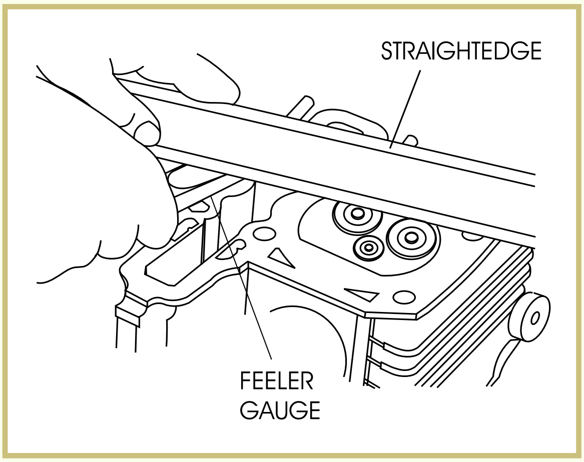


FIGURE 12—Use a straightedge and a feeler gauge to check for cylinder head warpage. (Courtesy of American Suzuki Motor Corporation)

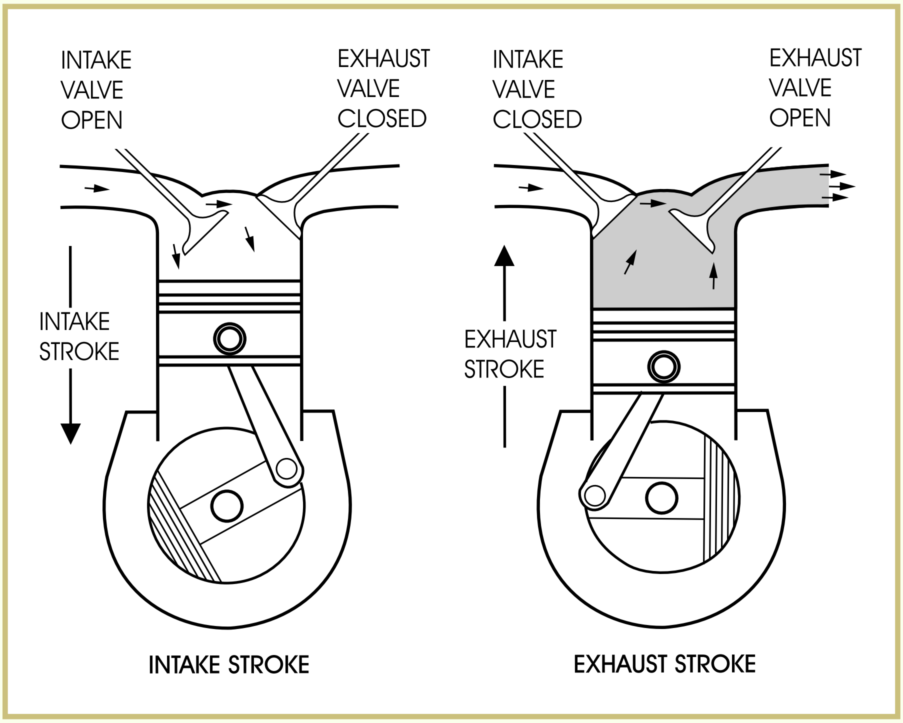
You can also use a *surface plate* to check the flatness of a cylinder head. A surface plate is a flat piece of material with a perfectly smooth surface. Special surface plates made of very thick metal or granite are used for high-precision machine work; however, for checking a cylinder head, a special surface plate provides a greater degree of precision than is actually needed. A surface plate good enough for checking a cylinder head can be a simple piece of plate glass, such as a window pane. Plate glass has a very flat surface and is readily available from most hardware stores.

After you've obtained a surface plate, lay the cylinder head on it. Place the head with the surface that will hold the gasket facing down. Then, use a feeler gauge to measure any clearance between the surface plate and the head. Feel for gaps all the way around the head. Finally, compare the largest clearance that you measured against the manufacturer's specification. If the cylinder head's surface is within specifications, then the head mating surface area should be satisfactory. However, if you find that the cylinder head is warped more than is allowed, the head will need to be either resurfaced by a machine shop or replaced. In most cases, cylinder heads used on motorcycle and ATV engines are quite expensive. Therefore, it's generally more cost-effective to repair a head.

Inspecting the Valve Assembly

The valves in a four-stroke motorcycle or ATV engine perform two vital functions during engine operation (Figure 13). The intake valve allows the air-and-fuel mixture to enter the combustion chamber so the mixture can be burned to produce power. The exhaust valve allows exhaust gases to exit the combustion chamber so a fresh supply of air and fuel can enter. The valves must seal tightly when they're closed, so the mixture in the cylinder doesn't escape during the compression and power strokes. Therefore, for an engine to operate properly, its valves must be in good condition.

FIGURE 13—Intake and Exhaust Valves at Work



The parts of a typical valve are labeled in Figure 14. The valve areas you'll need to check during a rebuild are shown on the right side of this figure.

- Dimension A is the diameter of the valve head.
- Dimension B is the angle of the valve face. This angle matches the angle of the valve seat.
- Dimension C is the width of the valve margin.
- Dimension D is the diameter of the valve stem.

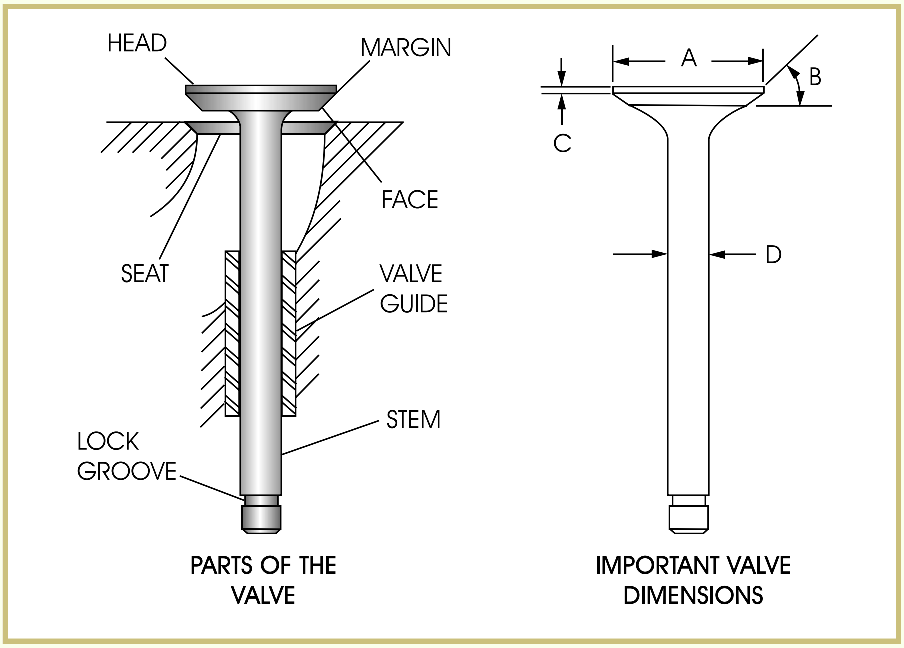


FIGURE 14—The Parts and Dimensions of a Four-Stroke Engine Valve

Valves must operate under a variety of extreme conditions. As a result, certain areas of the valve assembly often show signs of wear or physical damage. Because they're located in the combustion chamber, valves can reach temperatures of well over 1,000 degrees Fahrenheit under normal operating conditions! It's not surprising that they can actually begin to melt under these high temperatures. Heat tends to wear away the exposed surfaces, particularly the valve heads.

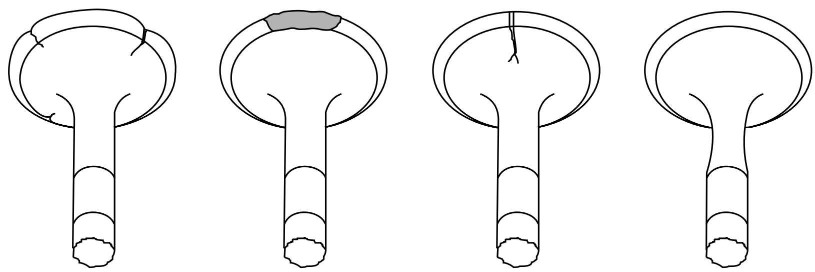
Heat, however, isn't the only problem valves face. In addition, friction between the valve stems and the valve guides produces wear. Keep in mind that each valve must open and close for every power stroke in a four-stroke engine. Because motorcycle and ATV engines operate at 8,000 rpm or more, valves must open and close about 4,000 times per minute. When a valve opens and closes this fast, friction builds up between the valve stem and the valve guide. This eventually leads to wear in the stem, the guide, or both. The rapid movement of the valve also tends to hammer on the valve seat. This hammering action distorts the seat, eventually allowing combustion gases to leak past the valve head, even when the valve is closed. For these reasons, all components of the valve assembly must be thoroughly inspected and reconditioned as part of any top-end engine inspection or rebuild.

Inspecting the Valves

Before a thorough visual inspection can be performed, the valves must be cleaned. Anything that comes in contact with a valve (such as oil, gas, and carbon) tends to get baked onto the valve surface. Ordinary cleaning solvents may not clean the valve completely. In most cases, the best way to clean a valve is to use a wire brush. This ensures the removal of any buildup. An ordinary handheld wire brush can be used, but a wire brush in the form of a wheel mounted on a bench grinder can make the job much easier. After you've cleaned the valves with the wire brush, wash them in cleaning solvent to remove any leftover dirt particles.

Now you can begin the actual visual inspection. Visually inspect both the intake valve and the exhaust valve. This includes inspecting each valve for signs of physical damage and determining if each valve is sized within specifications. Valves can be damaged as the result of several conditions. Most often, though, valves are damaged by heat. If a valve becomes overheated, its edges can melt or its head can crack. If the damage is severe enough, pieces of the valve can actually break off. Common types of valve damage are illustrated in Figure 15. If you notice any of these types of damage, you should replace the valve.

FIGURE 15—Typical Problems Associated with Valves



Measure the *valve margin* to detect any signs of distortion. The margin is the area between the valve's head and the line where the valve face begins. The valve margin is usually measured with a small ruler or with a Vernier caliper. A valve with too small a margin won't be able to withstand the heat in the combustion chamber. The valve will usually crack or burn through and won't be able to seal properly. When you're checking valve margins, always remember to read the manufacturer's specifications for the motorcycle or ATV engine on which you're working.

In addition to measuring the valve margin, you should measure the *valve stem*, which is the part extending down from the valve's head. A normal outside micrometer can be used to measure the valve stem's diameter. It's a good idea to measure the valve stem at the top, middle, and bottom. The diameters at all three of these locations should match the manufacturer's specification for the stem's diameter.

The valve springs must also be measured for their free length to ensure there's enough seat pressure placed on the valve itself. This measurement is done using a Vernier caliper, as illustrated in Figure 16.

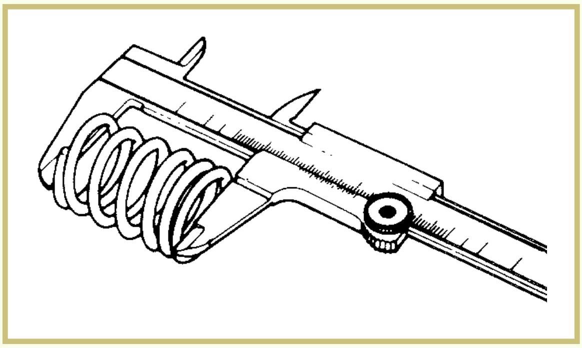


FIGURE 16—Using a Vernier Caliper to Measure a Valve Spring
(Courtesy of American Suzuki Motor Corporation)

Refacing Valves

If you inspect the valves and find that they're in good condition, they can be reused in the engine. However, all valves will experience some wear and distortion from use. Therefore, before you reuse a valve, the valve face should be reconditioned. Be sure to verify that the valve you're refacing does *not* contain stellite. If it does, and it's reconditioned, the valve will wear out very rapidly, as the stellite coating is very thin and is used to harden the valve surface.

The valve face of a non-stellite coated valve can be reconditioned to make it smooth and give it a uniform shape. The process of reconditioning the face of the valve is commonly called *valve grinding*, or *refacing*. A machine like the one in Figure 17 is used for this process. A refaced valve seals property when reinstalled in the engine. Keep in mind that most modern engines come with stellite-coated valves and, therefore, shouldn't be resurfaced. If these valves show excess wear, they need to be replaced.

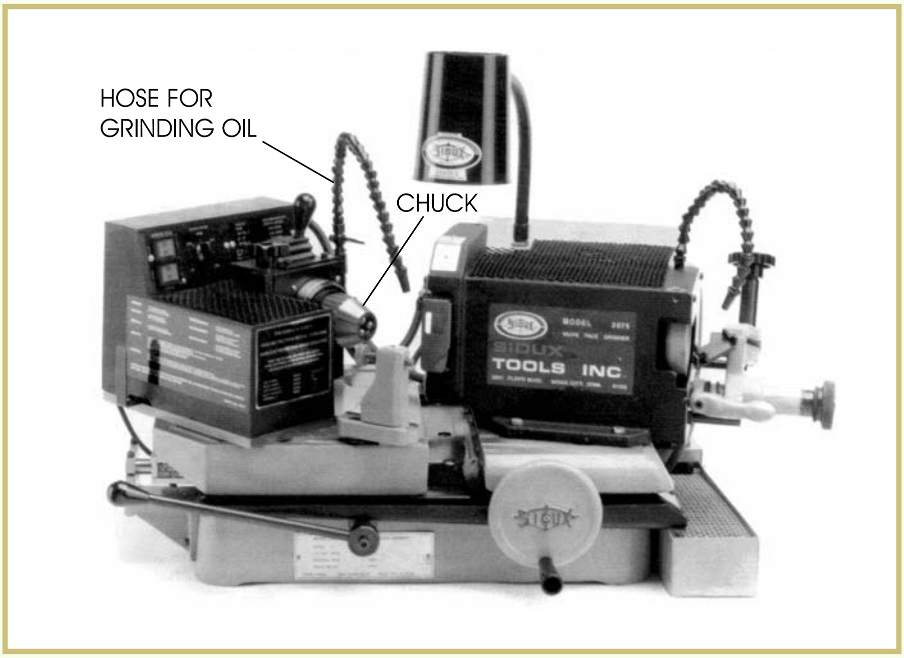


FIGURE 17—A Typical Valve Grinding Machine
(Courtesy of Sioux Tools, Inc.)

Inspecting Valve Guides

Now that the valves have been inspected and deemed acceptable, we can move on to the *valve guides*. These components of the valve assembly are used to properly position the valves in the engine and to guide the valves as they move up and down. The valve guide's job is difficult. Not only must it keep the valve in position, but it must also allow the valve to move freely up and down, even in extreme heat. The extreme heat around the valve guide makes it difficult for oil to properly lubricate the guide. If insufficient oil is available for lubrication, excessive friction rapidly wears down the guide. If more oil is present than is needed, the excess oil becomes baked onto the valve stem. The baked-on oil can build up and block the valve openings.

Valve guide wear. This is a phrase referring to the amount of clearance between the valve stem and the valve guide. Keep in mind that the valve opens and closes thousands of times each minute. This leads to wear in the valve guide. As the valve guide wears, the valve begins to move slightly side-to-side as it opens and closes. This side- to-side movement, if excessive, can cause the valve to seat improperly and thus fail to completely seal the cylinder. For this reason, the guides must be checked and replaced or repaired if they're found to be worn beyond the manufacturer's specifications.

Determining valve guide wear. Valve guide wear is determined by comparing the measurement of the inside diameter of the guide to the outside diameter of the valve stem. Because the inside diameter of the guide is quite small, a small-bore gauge is required to measure that dimension (Figure 18). As discussed earlier, a typical outside micrometer can be used to measure the valve stem's diameter. The stem diameter is then subtracted from the guide diameter to find the clearance between the stem and guide. Finally, the calculated clearance is compared with the manufacturer's specifications given in the service manual.

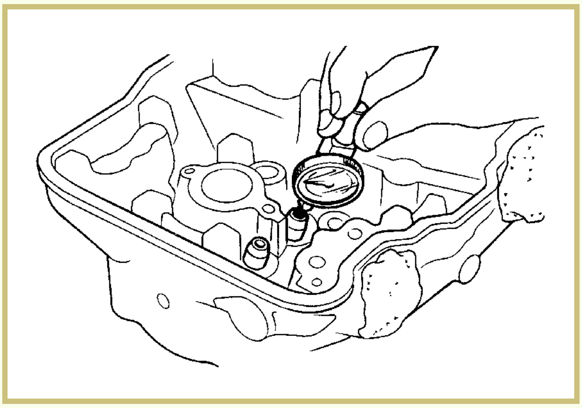


FIGURE 18—Using a Small-Bore Gauge to Measure a Valve Guide
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Replacing Valve Guides

Let's look closely at the construction of a valve guide. A valve guide is located in the cylinder head (Figure 19). Generally, valve guides are made of soft metals, such as bronze or cast iron, to reduce the amount of friction created by the moving valve stem.

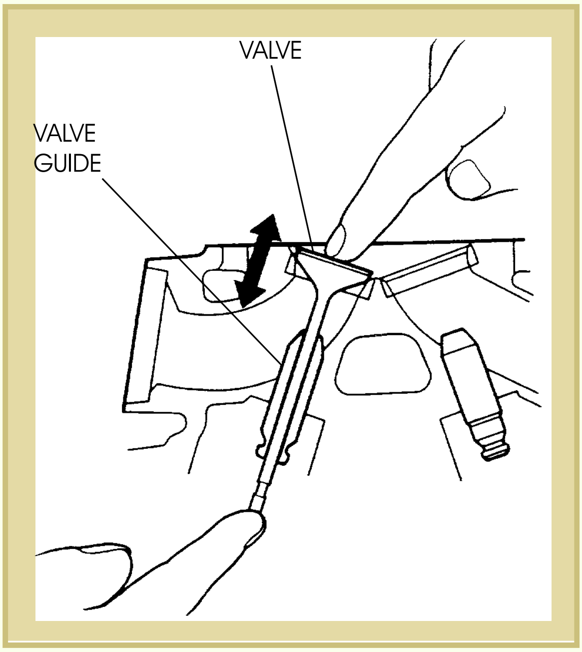
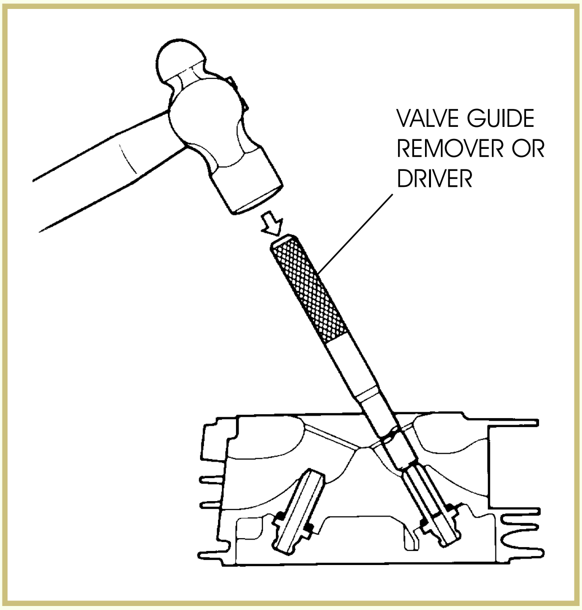


FIGURE 19—Valve guide location is shown in this cutaway illustration.
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Worn valve guides can be removed with a driver and a ball peen hammer or a press (such as an arbor press). Whether you select a hammer or a press, you should use a special driver tool when removing the old guide (Figure 20). These tools are available from the motorcycle and ATV manufacturer. When driving out the old valve guide, be sure that the cylinder head is supported so it won't move. A few small blocks of wood under the cylinder head provide the proper support. After you've obtained the proper size driver, place it on top of the valve guide. Then, use a ball peen hammer or press to knock or push out the guide. Even though either method can be used on most engines, always refer to the service manual to determine the exact procedure for the particular engine on which you're working.

Inspecting the bore. After you've removed the old valve guide, use solvent to clean the bore in the cylinder head where the guide was located. Visually inspect the bore for deep scratches or other signs of physical damage. If any damage is present, the new replacement guide may not fit tightly enough. If the bore appears to be damaged, the replacement valve guide needs to be slightly oversized (that is, its outside diameter needs to be larger than the outside diameter of the old guide). If you have a replacement guide that's large enough, you'll be able to correct the damaged bore by reaming it out to fit the oversized guide. Keep in mind that oversized guides aren't available for all engines, and some engines won't have enough metal around the guide bore to allow for enlargement. In this case, your only choice is to replace the cylinder head.

FIGURE 20—Removal of the valve guide is aided with a ball peen hammer and the proper valve guide remover. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



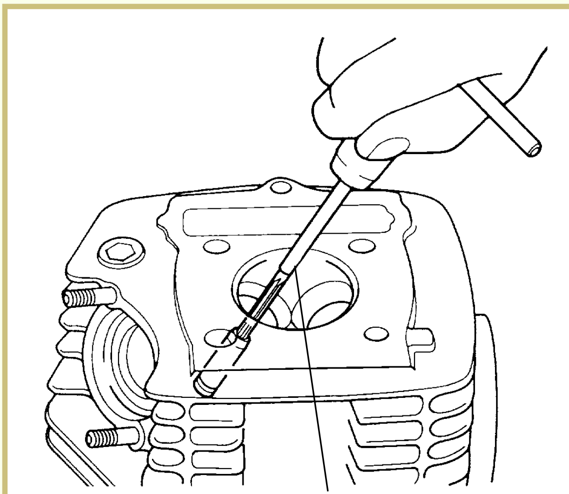
Replacing the valve guide. When the guide bore is determined to be in good condition, you're ready to install the new guide. The new valve guide must fit very tightly in the guide bore. Remember that when metals are chilled, they *contract* (get smaller), and when heated, they *expand* (get larger). Therefore, to make it easier to insert the tightly fitted valve guide, place the guide in a freezer for about an hour. The cold temperature causes the valve guide to shrink. Also, you may want to heat the cylinder head on a hot plate to allow the head to expand. When the guide has cooled off and the head has heated up, insert the guide into the cylinder head. A special driver with a ball peen hammer or arbor press can again be used to install the new guide into the cylinder head. Because the cold guide has shrunk somewhat, and the cylinder head has been heated, the guide should slide into the guide bore easily. When you insert the guide, be sure that it's placed in its proper position as described in the engine's service manual.

Reaming the valve guide. After you've replaced the guides, you'll need to ream out the newly-inserted valve guides to meet specifications. A new guide has a slightly smaller inside diameter than is necessary. After the guide is installed, its inside diameter must be enlarged to be slightly larger than the valve stem. The hole in the guide is enlarged using a *reamer.*

A reamer is a long, round cutting tool with cutting edges along its length. The tool operates much like a drill bit. Unlike a drill bit, however, a reamer doesn't cut on its end; it can't be used to actually drill a hole in a piece of metal. The cutting surfaces of a reamer are along its sides. The tool is used to remove material only along the inside surface of an already existing hole.

To ream out a valve guide, the reamer is inserted into the hole and turned clockwise until it penetrates the entire length of the guide (Figure 21). Because of the typical design of the reamer's cutting edges, the tool should always be turned in the clockwise direction (turning it in the opposite direction will dull the edges). Even when you're backing the reamer out of the valve guide, you should continue turning it in the clockwise direction.

FIGURE 21—A Typical Valve Guide Reamer
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)



The appropriate inside diameter of a valve guide depends on the size of the valve stem. The service manual for the engine specifies the proper diameter. This allows sufficient clearance for the stem to move through the guide as the valve opens and closes. After a valve guide has been reamed, any metal particles should be removed with compressed air. Then the area should be washed with solvent.

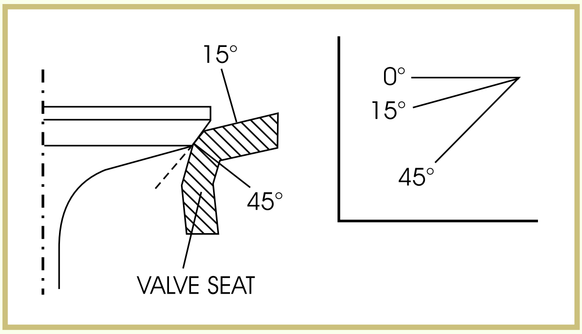
Reconditioning Valve Seats

A *valve seat* is that part of the valve assembly that mates with the *valve face* (Figure 14). Usually, a worn valve seat can be reconditioned to get it back into shape. The seal formed by the valve seat's precise fit with the valve face prevents leakage from the cylinder when a valve is closed. Due to the seat's location near the combustion chamber, a valve seat, like the valve itself, must be able to withstand high temperatures. A valve seat must also be able to conduct the heat from the closed valve and dissipate it to the engine's cooling system. If a valve seat didn't help dissipate the valve's heat, the valve would get so hot it would simply begin to melt.

Melting of a valve is often referred to as burning. Most often, the exhaust valves are the valves that burn. Exhaust valves get very hot from passing exhaust gases. An intake valve doesn't get quite as hot because the incoming air-and-fuel mixture tends to slightly cool it. When a valve closes, the valve face fits closely into the valve seat. As a result, the heat from the valve head is passed into the valve seat. From there, the heat can be dissipated to the engine's cooling system—to the air, in an air-cooled engine, or to the coolant, in a water-cooled engine. The valve seat's ability to dissipate heat is just as important as its ability to provide a proper seal.

As you can imagine, valve seats must be made of a tough material to withstand extreme heat. In most engines, valve seats are made of a very hard steel alloy. In an aluminum cylinder head, valve seats are usually in the form of inserts pressed into place by the manufacturer. Because of the extreme heat under which the valve seats operate, the seats, like the valves, become distorted and worn out over time. When the valve face or the valve seat becomes distorted, the sealing surfaces no longer match up; therefore, the valve doesn't seal completely when it's closed. For this reason, valve seats normally need to be refinished during the rebuilding process. The refinishing process, called *valve seat refacing*, restores the valve seat to a perfectly round shape with a smooth sealing surface. Also, the valve seat is beveled to match the angle of the valve face (Figure 22). By refinishing the valve seat, you ensure that the valve forms a proper seal when closed.

FIGURE 22—The Various Angles of a Valve and Its Seat (Courtesy of American Suzuki Motor Corporation)



The most common hand tools used to refinish a valve seat are pictured in Figure 23. The appropriate angle for a valve seat is found in the service manual for the motorcycle or ATV engine. The equipment for valve seat grinding is normally available from specialty tool manufacturers or from automotive supply stores.

The valve reconditioning tool uses a pilot to position the cutting device and to ensure that the tool remains centered properly. The pilot is simply a round piece of metal that fits tightly into the valve guide. The cutting device has a hole in its center that fits over the end of the pilot. The pilot can thus hold the tool centered in the valve guide. Because a pilot must be inserted into the valve guide to refinish the seat, the valve guide must be in proper condition *before* the seat is refinished.

After the pilot is inserted into the valve guide, the cutting device is placed over the pilot and into contact with the valve seat. The grinding tool is then rotated, as shown in Figure 24. The rotation of the tool removes metal from the valve seat and refinishes its surface. Metal is removed from the valve seat until a smooth, uniform surface appears. At first, the tool cuts only in a few spots due to the distortion of the valve seat. As the tool continues rotating, metal continues to be removed until the tool cuts evenly at all points all the way around the valve seat. When this occurs, the seat is completely refinished.

FIGURE 23—Valve Seat Refinishing Tools

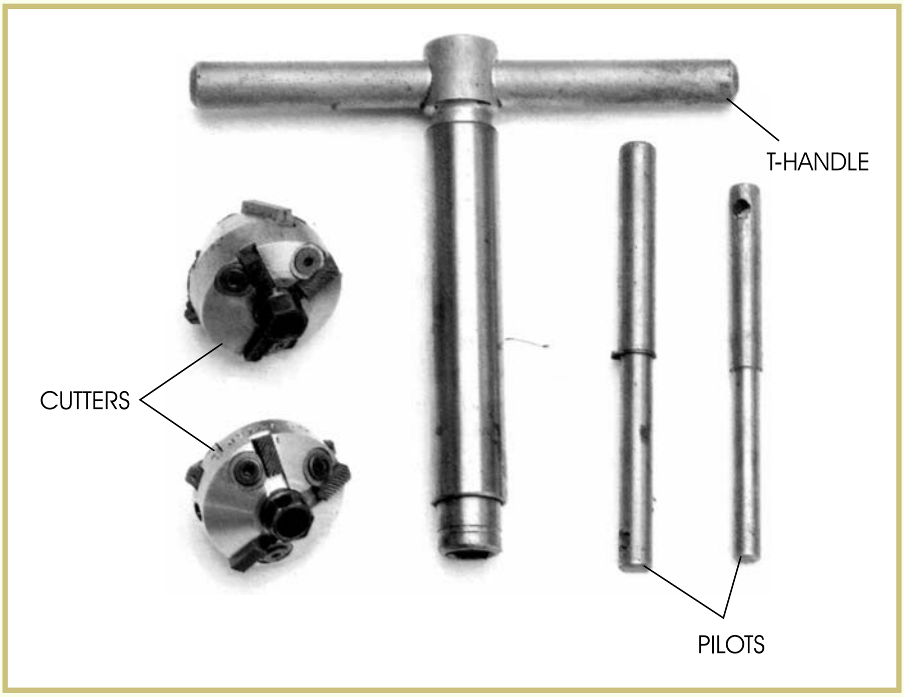
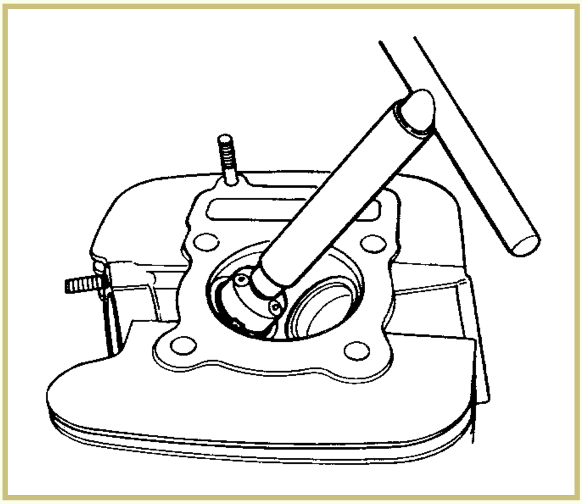
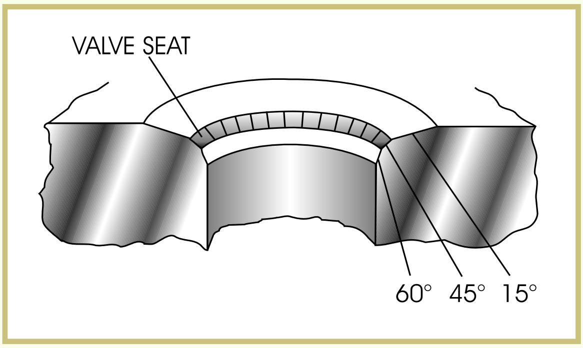


FIGURE 24—Placement of a Valve Seat Cutting Tool (Courtesy of American Suzuki Motor Corporation)



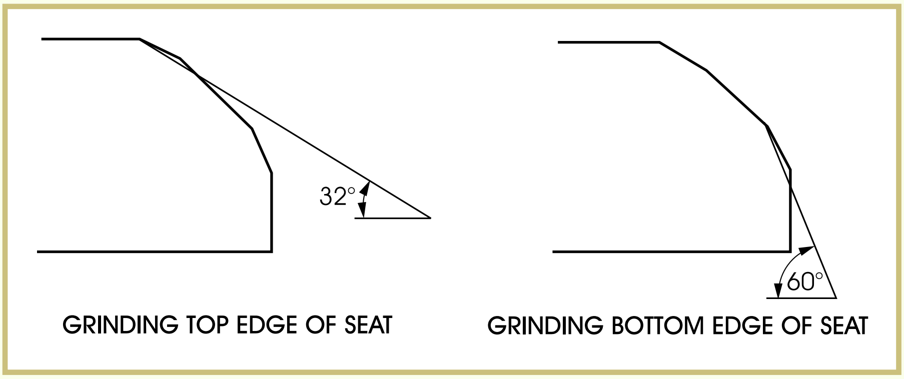
Your finished valve seat should look like the one shown in Figure 25. Note the different angles at the three different locations in the figure. The middle bevel (45°) is the actual seat that makes contact with the valve face. The width of the valve seat must now be measured and checked against specifications. A machinist's ruler or a Vernier caliper can be used to measure this dimension. Making the seat too narrow prevents the valve from sealing properly. Check the manufacturer's manual for the exact specifications for your engine.

FIGURE 25—The finished valve seat should have at least three cut angles.



After cutting the seat and measuring its width, you may find the valve seat is too wide. The width can be decreased by partially recutting the seat with either a wider or narrower cutting device. Most valve seats are usually beveled to 45 degrees. By using a cutting device designed to make a cut at a smaller angle to the horizon (normally 15 to 32 degrees), the top edge of the valve seat is ground down, thus decreasing the overall width of the seat (Figure 26). By using a cutting device designed to make a cut at a larger angle to the horizon (normally 60 to 75 degrees), the lower edge of the valve seat is ground down (Figure 26). Either of these methods can be used to narrow a valve seat to its proper width.

FIGURE 26—Using a Cutter to Decrease the Overall Width of the Seat



When the seat is narrowed to its proper width, the seat should be finished by cutting it lightly with the 45-degree cutter. This removes any tiny burrs left from narrowing the seat. However, should you narrow the seat by grinding away its top or its bottom? You can decide based on where the valve face makes contact with its seat. (It should be centered on the valve face.) At the same time, you can check on whether the valve face makes contact all the way around its seat. It's very important that you finish the job with a proper and complete seal between the face and the seat.

To decide which end of the seat's width you should grind down (and to check the seal), you can use a technique that involves the application of a blue dye called *Prussian blue.* This is a special dye that can be purchased from most automotive supply stores. First, remove the grinding tool and pilot from the valve guide. Then, place a coating of the blue dye on the valve face. Insert the valve into the guide and press it in until it firmly contacts the valve seat. When the face is in contact, apply a slight amount of pressure and rotate the valve one-quarter turn in the seat. Then, remove the valve and look carefully at the valve face. The dye mark left on the valve seat indicates exactly where the valve face contacts the seat. Ideally, the contact area should be in the middle of the valve width (Figure 27).

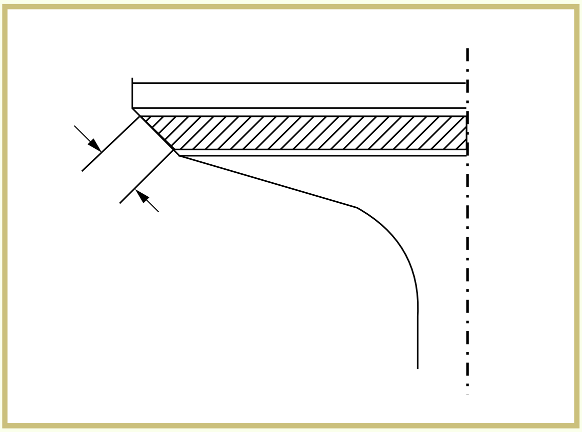
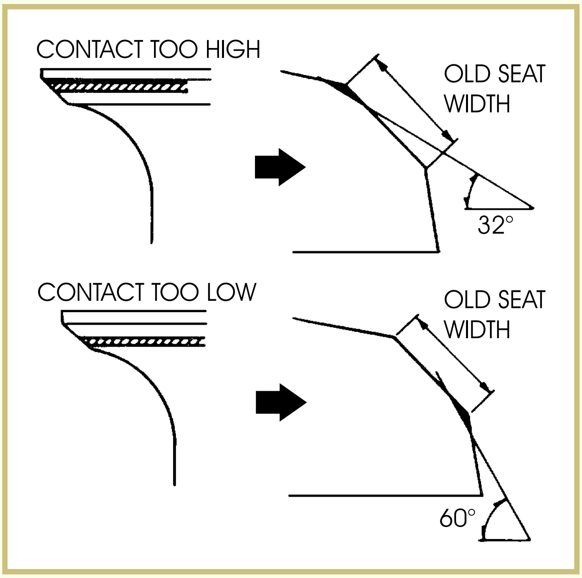


FIGURE 27—The valve seat should contact the valve in the center of the valve face. (Courtesy of American Suzuki Motor Corporation

If the contact area appears to be closer to the bottom of the valve seat, you should narrow the seat from the top, thus helping to center the contact area. Likewise, if the contact area is closer to the top of the valve seat, you can center the contact area by narrowing the seat from the bottom. Examples of this are shown in Figure 28.

The blue dye should have transferred evenly from the face to the seat. If the valve seat is properly machined and isn't out-of-round, the dye should be visible all the way around the valve seat. If the dye is distributed unevenly, either the valve face or the valve seat is out-of-round and should be refinished. You should repeat this procedure until the seat is narrow enough and the contact area is closely centered on the seat's width. Before you recheck the seal, though, be sure to wipe off any dye remaining from the previous check. Then, apply new dye to the valve and repeat the procedure. When the valve seat has been cut to its proper size and shape, the valve and seat are ready for the valve lapping process.

FIGURE 28—Determining Where to Narrow the Valve Seat Width (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Valve Lapping

Lapping is the process of mating the valve and the seat together to ensure a tight fit. Valve lapping produces the closest possible fit between the valve face and the valve seat. As a general rule, valves should be lapped to the seats any time the valves have been removed from the engine, even if they appear to be in good shape and you don't plan on reconditioning them. Even brand-new valves should be lapped before installing them into an engine.

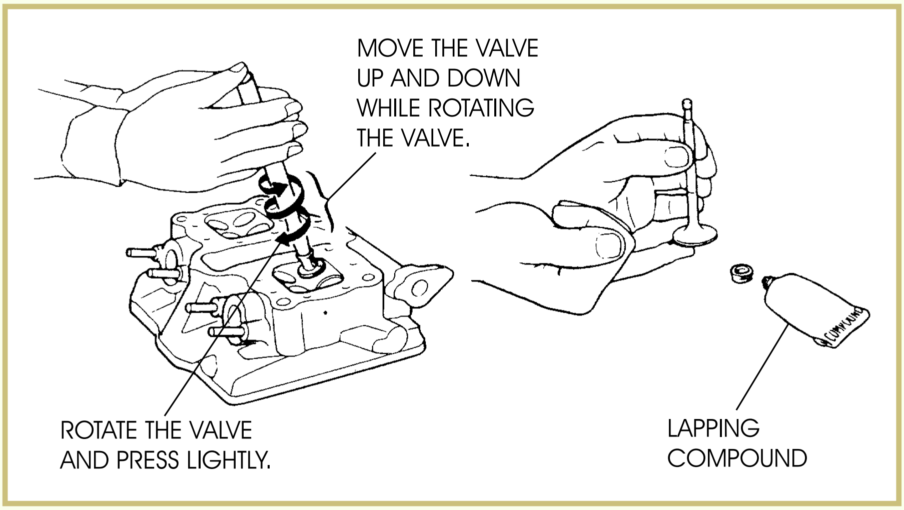
Valves are lapped using a *grinding paste*, or *lapping compound*, a substance that feels a lot like ordinary toothpaste, but contains fine, abrasive grains. When the compound is rubbed onto metal, the abrasive grains smooth the metal's surface. The paste is used with all four-stroke engines. Lapping compound is a common product that can usually be purchased from a local auto parts store. The compound is available in versions with grains of varying abrasives. Usually, a coarse-grain compound is used when first starting to lap the valves; the final lapping is done using a fine-grain compound.

Organizing the valves. Before beginning the lapping process, organize the valves you'll be installing in the engine. You may want to temporarily insert all the valves into their guides to keep them organized. Then, remove them one at a time and lap each one to its own valve seat. Another way to keep the valves organized is to cut several holes into a piece of cardboard. The holes should be slightly larger than the valve stem diameter. Then, use the cardboard as a holder for the valves. Write the location of each valve on the cardboard.

Lapping the valves. To begin lapping the valves, apply a thin coating of lapping compound to the face of a valve. When you've covered the contact area, insert the valve into the valve guide and push it down until it makes contact with the valve seat. When installed, each valve rotates rapidly within its own seat. Remember that the abrasive lapping compound is between the valve face and the valve seat. Therefore, when the valve is rotated, the abrasives in the compound wear away the surfaces slightly, thereby mating them to one another.

A *lapping stick* is a tool used to rotate the valves. The lapping stick consists simply of a round wooden or plastic shaft with a suction cup on the end. The suction cup is attached to the head of the valve. To help the suction cup stick better, many technicians moisten the cup slightly before attaching it. After you've attached the lapping stick, you can rotate the valve back and forth by spinning the shaft of the tool between the palms of your hands (Figure 29). While rolling the shaft back and forth, apply a moderate amount of downward pressure. This helps the lapping compound to mate the valve and the seat together.

FIGURE 29—Procedure for Proper Valve Lapping
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)



To check the valve seating, remove the valve from the engine and clean away all the lapping compound using solvent and a clean cloth. When the valve is clean, apply a thin coat of blue dye to the valve face. Then, insert the valve back into the valve guide. Apply a slight downward pressure with your thumb, and rotate the valve slightly. Remove the valve and observe the valve seat. If the blue dye is evenly distributed around the seat, the valve has been properly lapped. If the dye is distributed unevenly around the seat, more lapping compound should be applied and the valve should be re-lapped.

After all valves have been appropriately lapped, the valves and their seats should be thoroughly cleaned with solvent and then with soap and water. This removes any leftover lapping compound. Remember that lapping compound is abrasive; if it's allowed to get into the working engine, it may do serious harm to the bearings and other vital engine parts.

Inspecting the Camshaft

The *camshaft* is the component that controls the opening and closing of the valves in a four-stroke engine. As the camshaft spins, the cam lobes move the tappets, which, in turn, open the valves. Other components to note are the bearing support areas on each end of the camshaft and the large sprocket or gear with which the crankshaft can rotate the camshaft via a chain, belt, or gears (Figure 30).

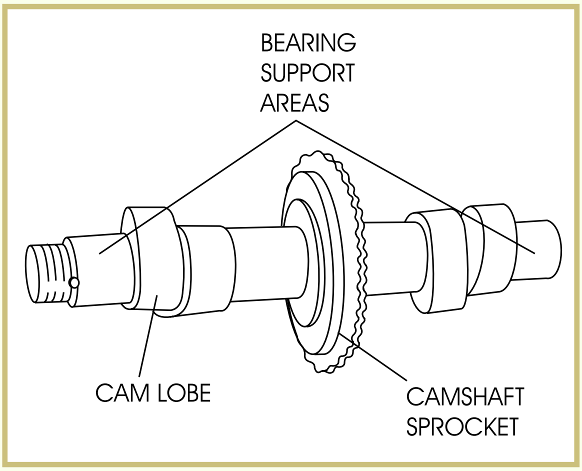
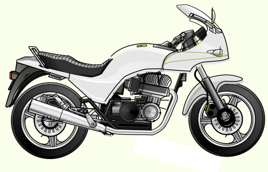


FIGURE 30—The camshaft controls the opening and closing of the valves in a four-stroke engine. (Image courtesy of Yamaha Motor Corporation, U.S.A.)

The camshafts used in motorcycle and ATV engines are quite dependable. It's rare to find a motorcycle or ATV engine camshaft that's been excessively worn. The camshaft in a small engine is normally well lubricated, especially in engines that use a high- pressure lubrication system. When you're rebuilding a motorcycle or ATV four-stroke engine, the camshaft should be visually inspected for any signs of damage. Specifically, look for any cam lobes that appear to have surface damage. Also, check the camshaft's ends that are supported in bearings. Look for any signs of scoring or other surface damage. Motorcycle and ATV manufacturers provide a specification for the diameters of each part of the camshaft. Measure those areas using a micrometer and check your measurements against the specifications.

Road Test 3



1. Scoring or scuffing on a piston is most likely caused by _______ and _______.
2. What part of the piston is the most frequently damaged?

   ____

3. If the cylinder is excessively worn, what can frequently be done to recondition it for reuse?

   ____

4. What tool is used to measure a cylinder's bore?

   ____

5. The difference between measurements taken on the same axis (X or Y) of a cylinder is called _______.
6. Name two engine conditions that cause the fuel mixture inside the engine to burn improperly.

   ____

7. *True or False?* All four-stroke engine valves must be refaced before installing them into the cylinder head.
8. The valve seat can be measured using a _______ or a _______.
9. The process used to mate the valve and the seat together is called _______.
10. What can be done to make the installation of a valve guide in a cylinder head easier?

    ____

Check your answers with those on page 63.

FOUR-STROKE TOP-END REASSEMBLY

We've discussed removal of the engine from the chassis, disassembly procedures for the four-stroke engine top-end, and inspection and measuring procedures for the various top-end components. Now it's time to begin the reassembly procedures. Note that we won't explain replacing the engine back into the chassis, but will cover this subject in the next study unit. Because the top-end was disassembled right down to the piston, we must begin our reassembly at that point. We'll again describe each procedure in steps, as we did when we disassembled the top-end.

Installing the Piston Rings and Piston

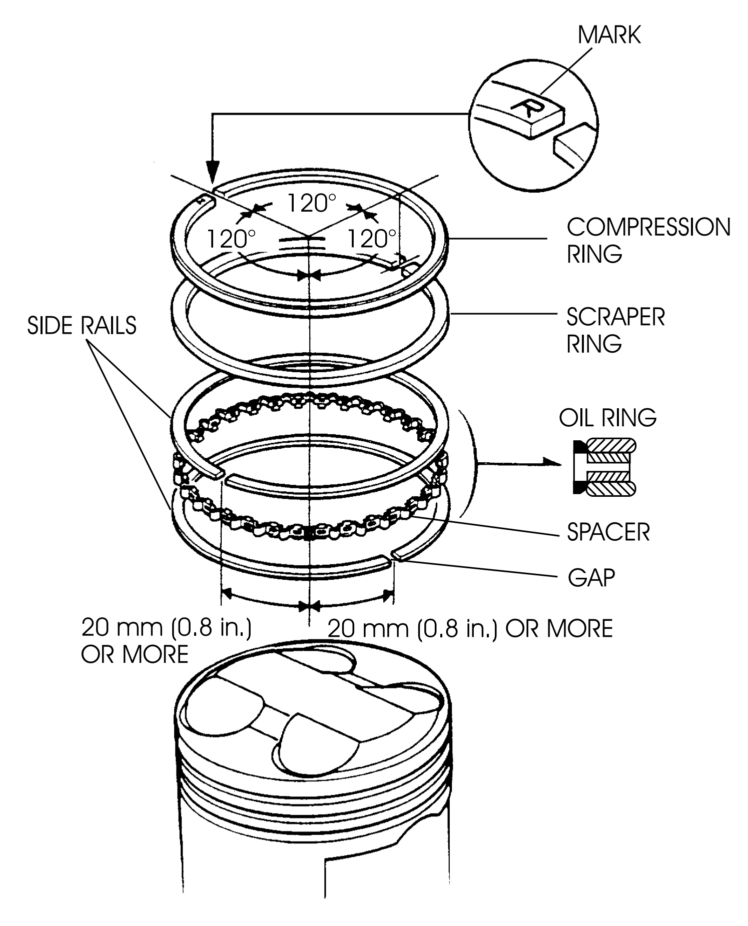
It's generally easier to install the piston rings on the piston while it's removed from the connecting rod. Piston rings have markings on them indicating which side of the ring goes towards the top of the piston crown.

Four-stroke engines will, as mentioned earlier, have three piston rings. The bottom ring is for oil control and should be installed first. Most modern-day *oil control rings* are in three separate pieces that include two side rails and the oil ring itself. The second ring to be installed is the *scraper ring*. It's generally a dark-colored ring. The top ring is a *compression ring* and most likely has a chrome-plated surface area on the outside of the ring itself.

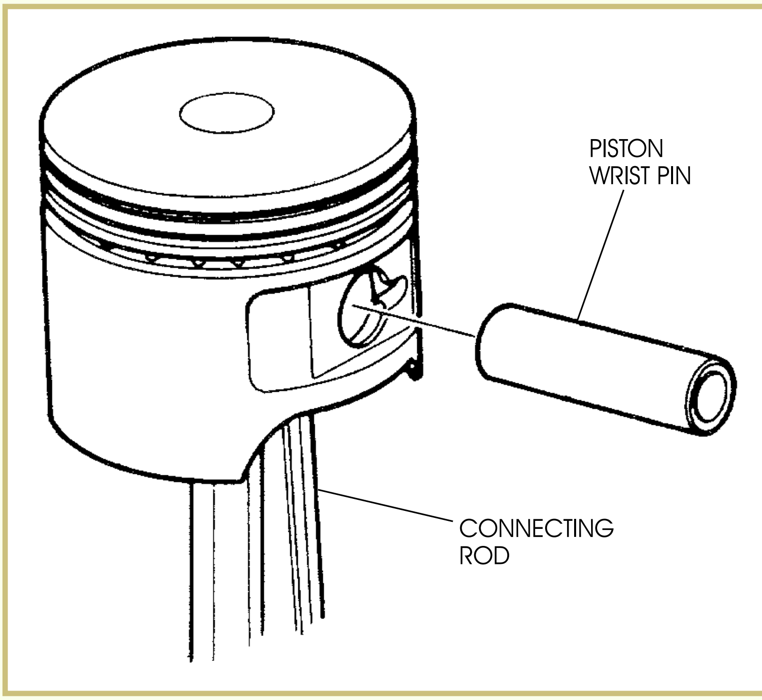
Note: The illustrations used in the following example procedure are courtesy of the American Honda Motor Corporation and reprinted with permission.

1 Install the piston rings by carefully spreading the ring gap to increase the ring size. Slip the opposite side of the ring over the piston into the appropriate piston groove. Install the rings so their end gaps are 120° apart from each other.

2 Place a clean rag over the base of the cylinder to prevent any foreign objects from falling into the crankcase.

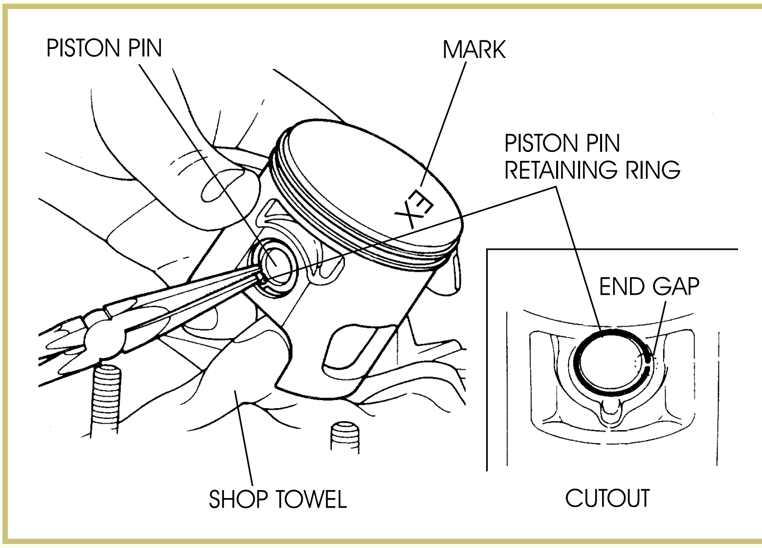


3 Apply a small amount of oil or moly lube to lubricate the piston wrist pin and the small end of the connecting rod.



4 Install the piston pin through the piston, making sure that the mark on the piston is facing in the correct direction.

5 Install new piston pin retaining rings, using a pair of needle nose pliers.



Installing the Cylinder

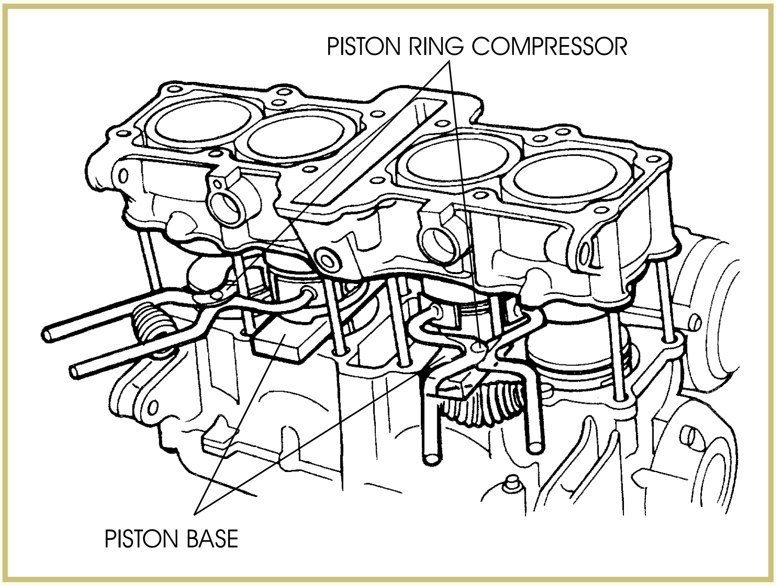
The procedure for rejoining the cylinder to the crankcase in the four-stroke engine is much the same as that for the two-stroke engine.

Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation, unless otherwise noted.

1 Clean the old gasket material from all surfaces.

2 Replace the cylinder base gasket, making sure it's properly aligned by installing any alignment or dowel pins.

3 When installing a multicylinder engine, lightly oil and compress the piston rings with a ring compressor. In fact, lightly oil all moving parts, as well as the cylinder bore, as you assemble them. When assembling a single-cylinder engine, you may prefer to compress the rings with your fingers.



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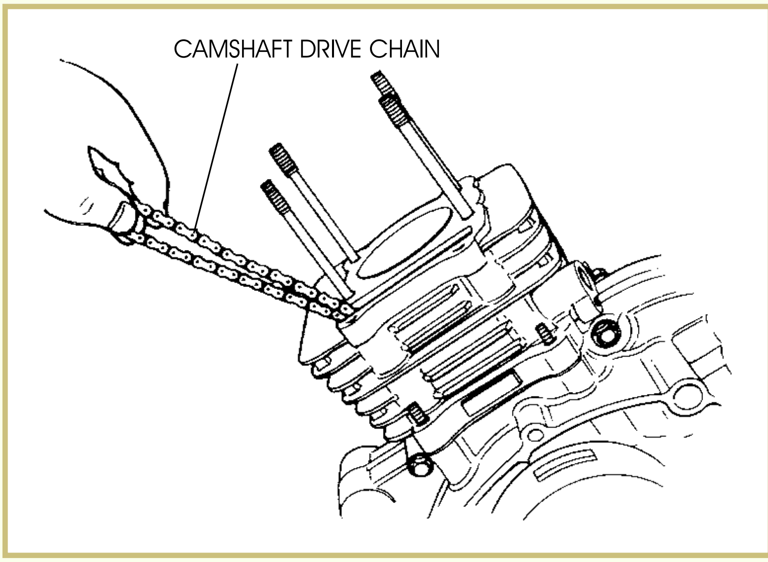
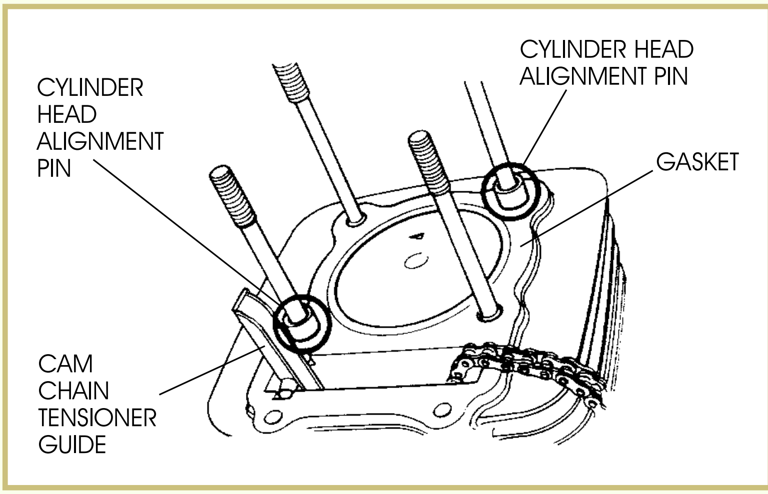
4 Lower the cylinder over the piston, then remove the ring compressors if they're being used. Make sure that you pull the cam chain out of the crankcase cavity to prevent the chain from being caught between the cylinder and the crankcase. Push the cylinder down tightly onto the crankcase.

5 Secure the cylinder base nuts, if base nuts are used. Tighten the base nuts to the manufacturer's suggested torque.



6 Install the cam chain tensioner guide into the cylinder, as well as the cylinder head alignment pins.

7 To complete the installation procedure for the cylinder, install the cylinder head gasket onto the top of the cylinder.

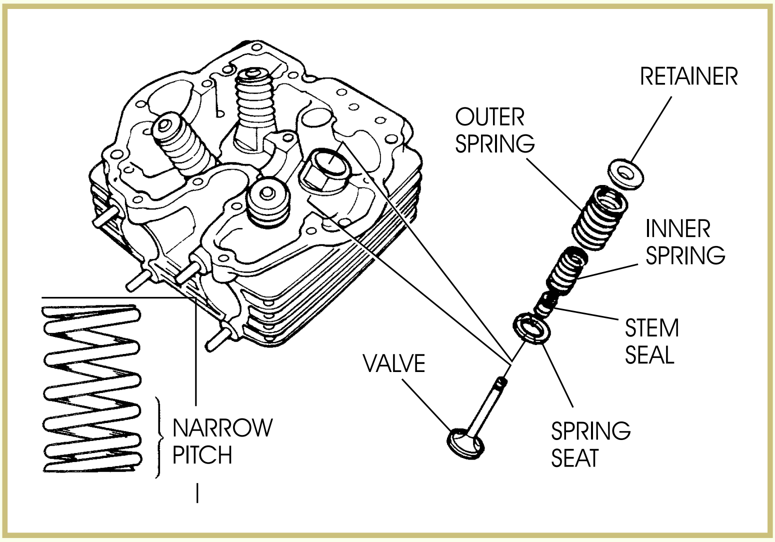


Installing the Valves

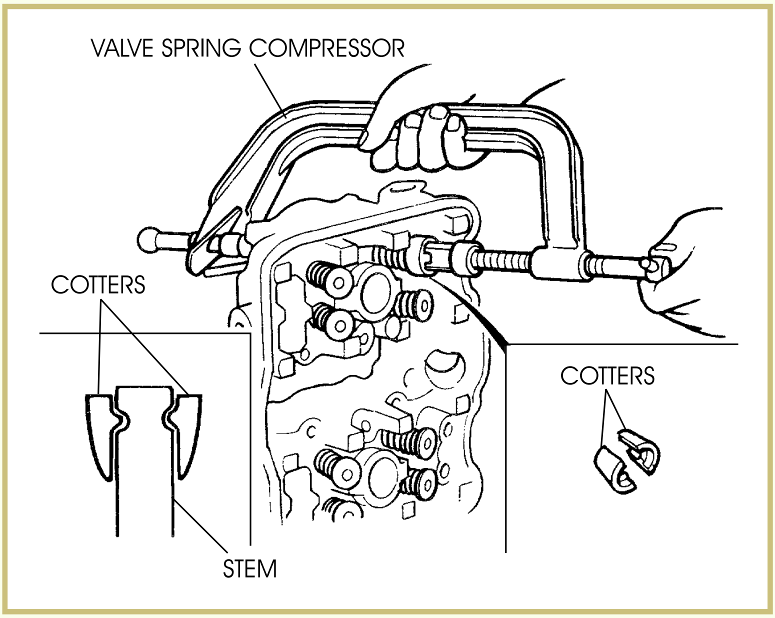
Valve springs must be installed so that the narrow pitch of the spring sits on the surface of the head. These parts are installed in reverse order from the disassembly procedures described earlier. Always replace the valve stem seals when the valves are removed, to prevent any chance of oil seal-related problems.

Note: The illustrations used in the following example procedure are courtesy of the American Honda Motor Corporation and printed with permission, unless otherwise noted.

1 Notice the proper order of installation of the valve assembly. The narrow pitch of the valve spring must sit on the surface of the head.

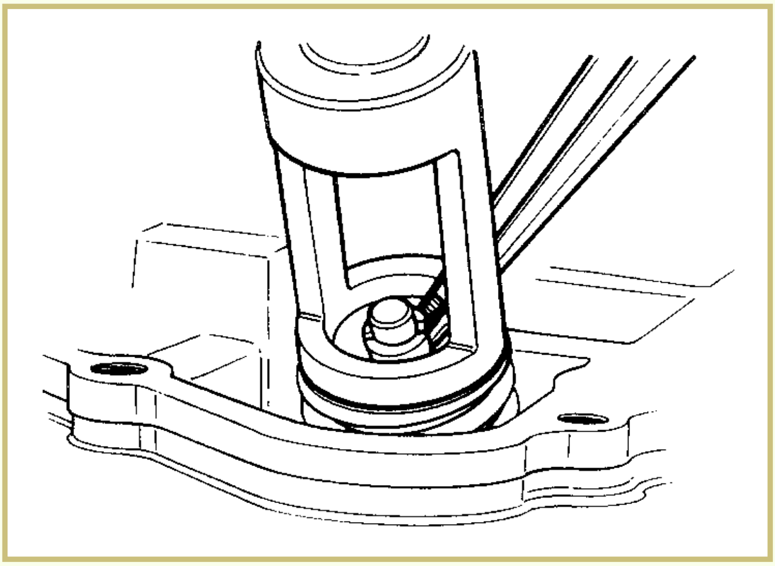


2 Reassemble the valves, using a valve spring compressor to hold the springs while installing valve keepers.



3 Install the valve keepers, or cotters, with a pair of needle nose pliers.

4 After you've installed each valve, it's a good habit to lightly tap on the valve stem to firmly seat the valve keepers in their grooves.



(Courtesy of American Suzuki Motor Corporation)

Installing the Cylinder Head

Place the cylinder head onto the cylinder and secure it by torquing the four outside bolts, as well as the cylinder head base fasteners. Remember to tighten the fasteners in a diagonal or crisscross pattern. After properly tightening the cylinder head base fasteners, re-torque the cylinder mounting fasteners to the proper specification.

Installing the Camshaft

The overhead camshaft engine is the most widely used engine in the motorcycle and ATV industry. We'll focus on this type of engine as we discuss the installation of the camshaft. Following our general discussion of camshaft installation, you'll find procedures for both the single overhead cam and double overhead cam designs.

You should now be aware that all four-stroke engines must be adjusted, or timed, so each rotating part is in the proper position, at the proper time, in relation to the other moving engine parts. The timing of the overhead camshaft rotation, in relation to the crankshaft rotation, is vital. This is because the camshaft must open the valves and allow them to close at specific degrees of rotation of the crankshaft. The induction and exhaust of gases must take place at specific times in the engine cycle; these times are controlled by the camshaft.

Relationship of Camshaft and Crankshaft Rotation

The timing for the valves to open is determined by the position of the camshaft. This position is indicated by degrees of crankshaft rotation. Recall that there are 360 degrees in a circle. A quarter of a turn is, therefore, equivalent to 90 degrees; half a turn is equivalent to 180 degrees; a three-quarter turn is equivalent to 270 degrees. The valves must open and close at specified degrees of crankshaft rotation. The gear reduction ratio between the crankshaft and the camshaft is always 2:1 on a four-stroke motorcycle or ATV engine. This means that the crankshaft makes two revolutions for each revolution of the camshaft.

Another way of looking at this relationship is that if the crankshaft is rotated 90° (or one-fourth of its circle rotation), the camshaft must rotate 45° (one-eighth of this circle of rotation). This relationship must remain constant during a complete rotation of the shafts; the shafts must always return to their starting points simultaneously.

Two parts must be timed for their positions in relation to the crankshaft. These two parts are the camshaft and the ignition system. All timing of the camshaft's position in relation to the crankshaft's position is done by aligning certain marks. However, there are various ways, and various places, where these marks may appear. One of the principal pieces of information you must have for every four-stroke engine is the exact location of the timing marks. These marks might be letters, dots, dashes, or simple lines. Normally the marks appear on the *alternator rotor* and the *cam chain sprocket*.

Aligning Timing Marks

The alternator rotor is used to generate electricity. It's keyed to the end of the crankshaft. As a result of its positioning, the rotor can be used to indicate the position of the piston. It's also used in connection with timing the ignition system. There's a timing mark on the *stator*, or engine case. Turn the rotor until its timing mark meets the stator. When you align the rotor with the stator, using these marks, the crankshaft is usually in one of three specified positions: T, which refers to Top-Dead-Center (TDC); F, which refers to the ignition firing point at engine idle; or II, which indicates full ignition advance.

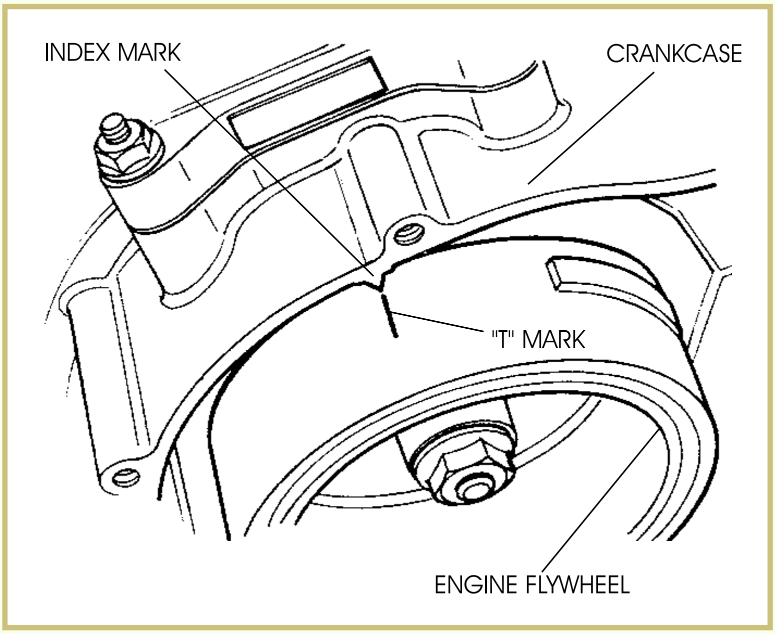
When you know the degree position of the crankshaft, you must get the correct corresponding position for the camshaft. Find a timing mark on the camshaft sprocket. The mark on the camshaft sprocket is usually aligned with a timing mark on the cylinder head. Then insert the camshaft into the sprocket and rotate the camshaft until it fits into the sprocket properly. As indicated earlier, there are other methods of timing. In a gear-driven overhead cam, where you don't have a sprocket and chain, one tooth on each gear is marked for timing alignment.

We'll now explain the procedures for timing the camshaft to the crankshaft on the two most popular engine designs used in the motorcycle and ATV industry: the single overhead cam (SOHC) and double overhead cam (DOHC) designs. Camshaft installation is slightly different between the SOHC and the DOHC engine. Therefore, we'll explain each one separately.

Single Overhead Cam Design

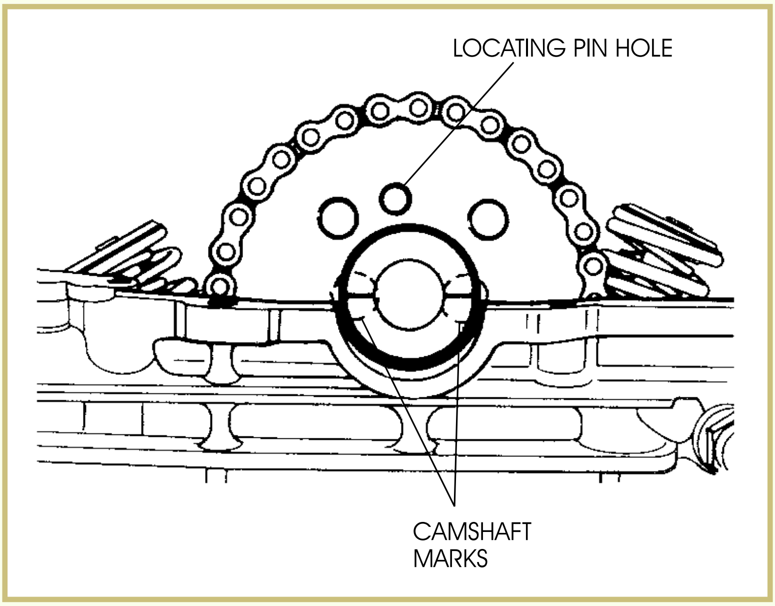
1 Align the "T" mark on the engine flywheel with the index mark on the crankcase, to verify that the position is at TDC. Keep tension on the cam chain while doing this. If tension isn't placed on the cam chain, the chain may get caught between the crankcase and the cam chain drive sprocket.

2 Install the camshaft so the cam lobes are pointing downward. (Engines with rocker arms above the camshaft must have their cams installed lobes down.) This ensures that the engine is at TDC compression, as the intake and exhaust valves are both closed in this position.



(Courtesy of American Suzuki Motor Corporation)

3 Engage the chain onto the camshaft sprocket. In our example, there's also a locating pin that lines up when installed correctly. Make sure the marks on the camshaft align in parallel with the surface of the cylinder head.

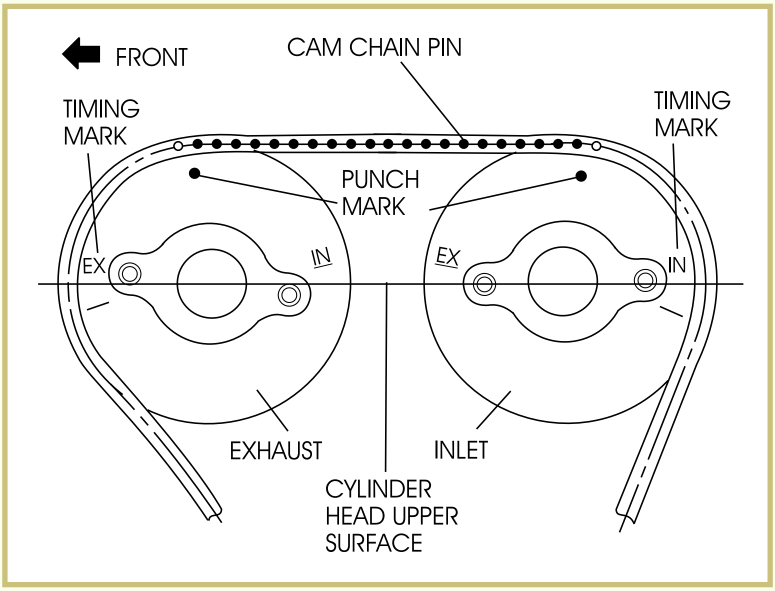


(Courtesy of American Suzuki Motor Corporation)

Double Overhead Cam Design

1 Install the camshafts into the cylinder head and install the camshaft caps and bolts. For our example, first align the "T" mark with the index mark. Keep tension on the cam chain while doing this. On engines with bucket-style valve depressors, the cam lobes should point upward. This ensures the engine is at TDC compression for that particular cylinder, as the intake and exhaust valves will both be closed in this position.

2 Engage the chain onto the camshaft sprockets while you ensure the marks on the camshaft align in parallel with the surface of the cylinder head. Some DOHC engines verify that the cam chain is installed correctly by counting the number of cam chain pins between the marks in the cam shafts.

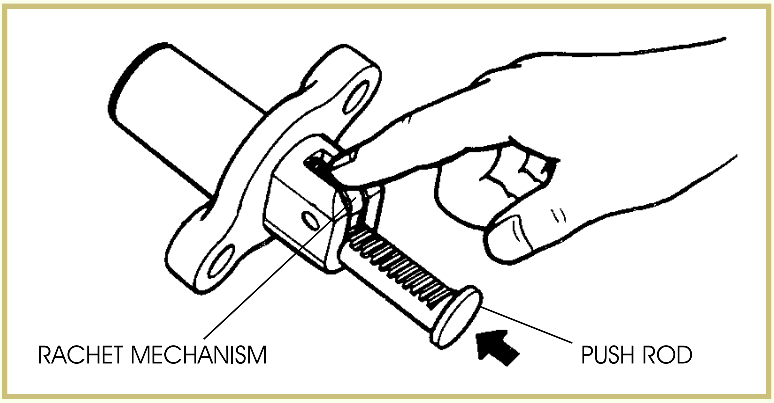


(Courtesy of American Suzuki Motor Corporation)

Installing the Chain Tensioner

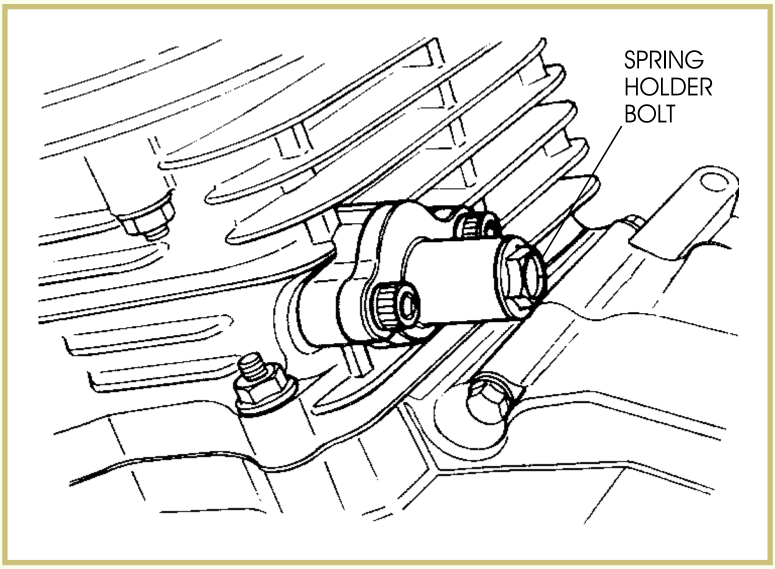
1 Compress the cam chain tensioner before installing it into the engine.

2 Mount the cam chain tensioner back onto the cylinder.



(Courtesy of American Suzuki Motor Corporation)

3 Install the tensioner spring into the tensioner assembly and tighten the spring holder bolt to the specified torque.



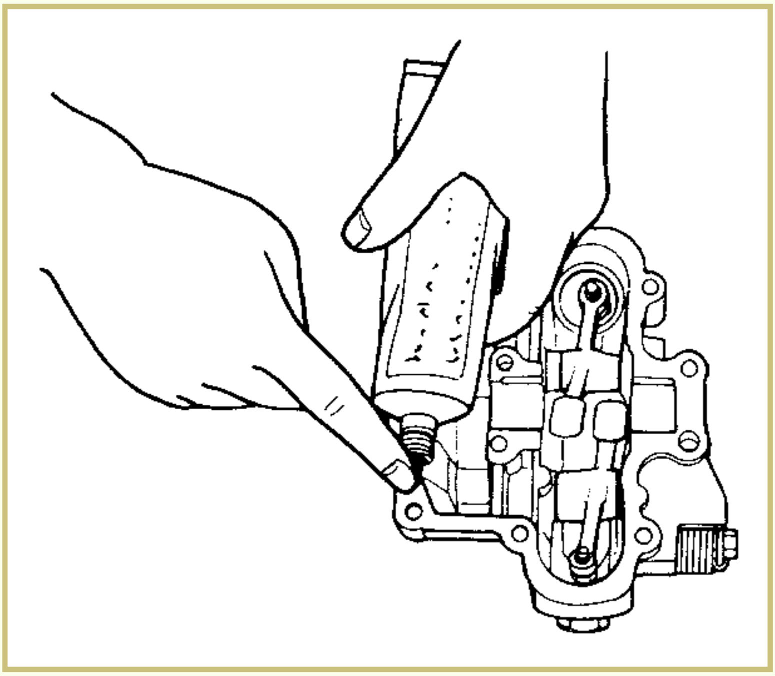
(Courtesy of American Suzuki Motor Corporation)

Installing the Cylinder Head Cover (SOHC Designs)

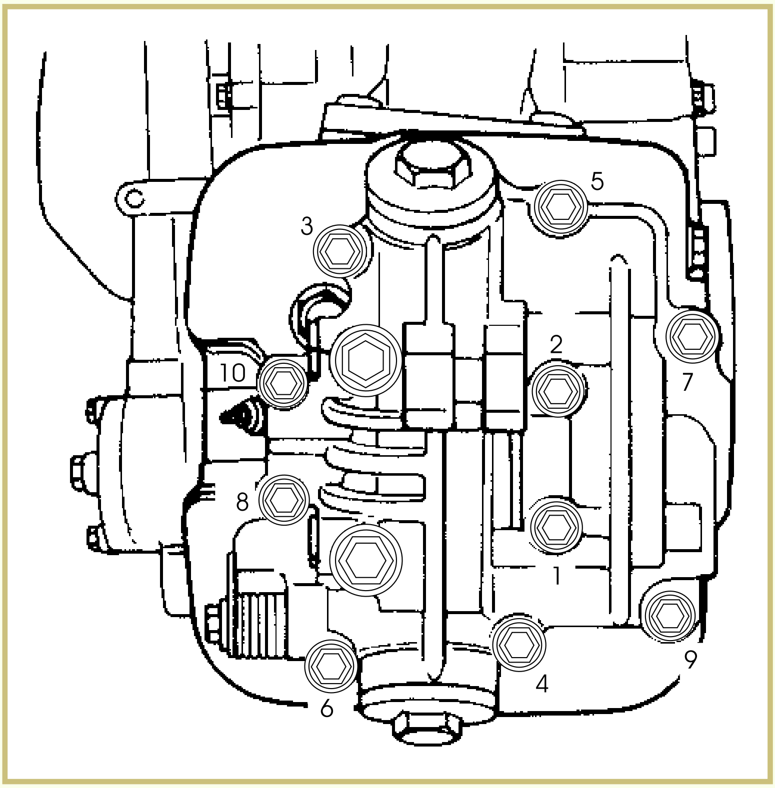
After the camshafts and valve assembly have been properly installed and timed to the crankshaft, it's time to check for the proper valve clearance. SOHC engines require the installation of the cylinder head cover before checking the valve adjustment, because the rocker arms are installed in this cover. DOHC-designed engines have the cylinder head cover installed after the adjustment of the valves.

Note: The illustrations used in the following example procedure are courtesy of the American Suzuki Motor Corporation, unless otherwise noted.

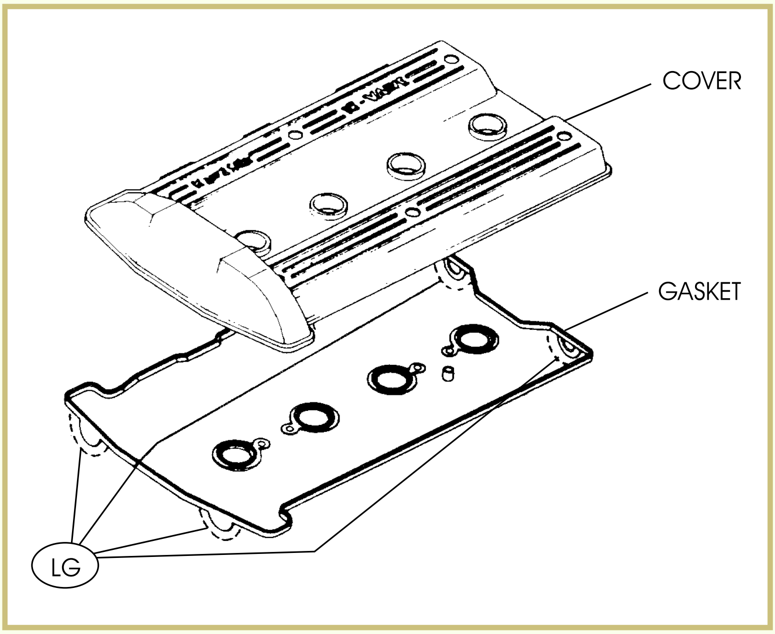
1 Most SOHC covers require that you seal the surface using a sealer.



2 Once sealed, install the cover and tighten the mounting bolts in the sequence shown.



3 Note that DOHC covers have a gasket installed between the cover and the cylinder head.



(Courtesy of American Suzuki Motor Corporation)

Checking and Adjusting Valve Clearance

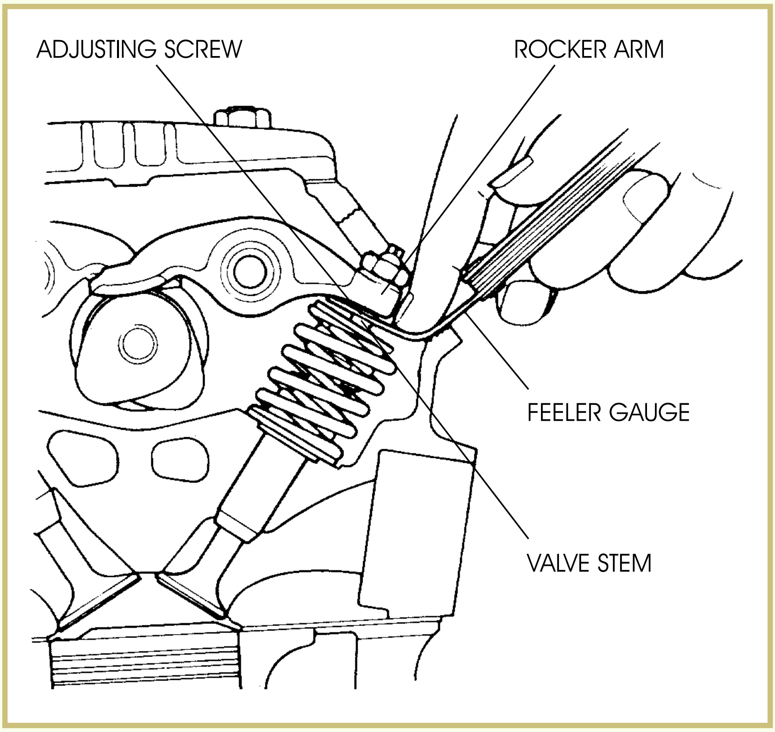
It's important to check the clearance between the rocker arm and valve stem tip after any work is done on the valves and valve assembly. Because the valve clearances may have been changed by the reconditioning and lapping procedures, the clearances should be measured and compared with the manufacturer's specifications. If a valve clearance is incorrect, it needs to be adjusted. The rocker arm has an adjusting screw for the technician to make the correct adjustment of this clearance.

There are different adjustment methods used for different valve arrangements. Valve clearance is normally checked when the cylinder is at top-dead-center (TDC). At the TDC position on the compression stroke, both the intake and exhaust valves for the cylinder should be completely closed. As a general rule, the valve clearance is greater on the exhaust valve than on the intake valve because the exhaust valve gets hotter, producing greater expansion of metal.

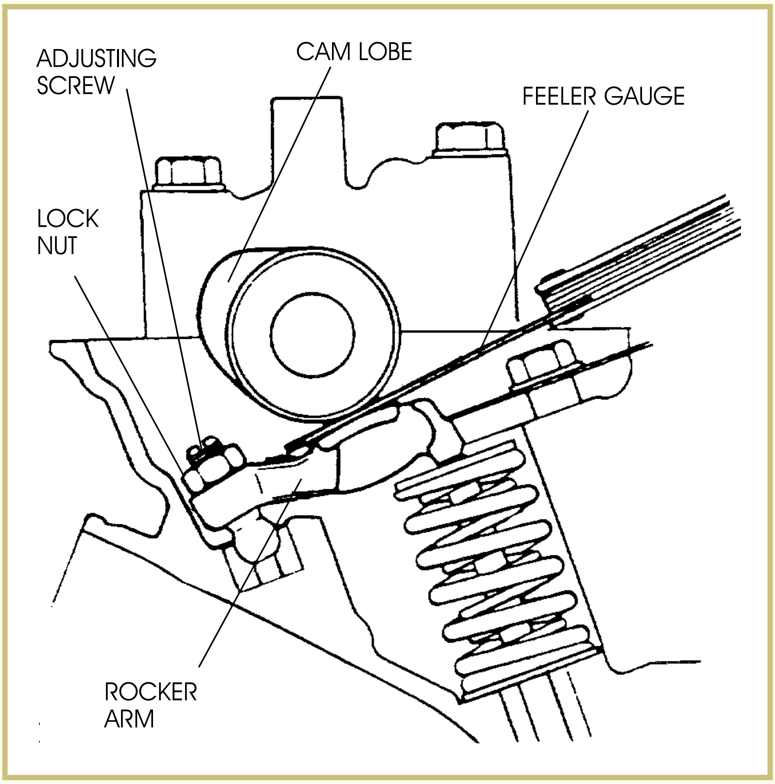
Motorcycle and ATV valves are adjusted when the engine is at room temperature. Specifications for valve clearance vary with each model of motorcycle. Valve clearance is designed to allow for the heat expansion rate of the parts to create a near-zero clearance when the engine is at its normal operating temperature.

Note: The illustrations used in the following example procedure are courtesy of the American Honda Motor Company and reprinted with permission.

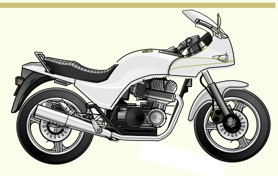
1 When the cylinder is at the TDC position, check the clearance using a feeler gauge. Insert the feeler gauge between the rocker arm and the valve stem to determine clearance until you find the blade of the proper thickness. The proper blade size resists with a slight drag when you attempt to pull it from between the valve stem and the tappet. If the blade moves without any drag, it's too thin; if you can't insert the blade between the components, it's too thick.



2 Adjust the clearance using the adjusting screw and locknut. The actual adjustment procedure for four-stroke motorcycle and ATV valves is discussed in detail in a later study unit.



This completes the top-end repair and inspection of the four-stroke engine. If the engine you're working on doesn't require the engine to be removed from the frame, consult your service manual to determine the order of reassembly of the components to complete your repairs. As mentioned earlier, we'll install the engine back into the chassis in the next study unit, after we disassemble, inspect, and reassemble the lower-end of the engine.



Road Test 4

1. Which side should the marking of the piston rings face?

____

2. The piston ring that may be in three separate pieces is called the _______ ring.

3. The valve springs must be installed so the _______ of the spring sits on the surface of the head.

4. A mark on the camshaft sprocket is usually aligned with a timing mark on the _______.

5. Which valve usually has more clearance between it and the rocker arm?

____

6. At what engine temperature are the valves adjusted?

____

7. What is the gear ratio between the crankshaft and the camshaft?

____

Check your answers with those on page 63.

Road Test Answers

1

1. False
2. clean
3. With the drive chain still installed, put the engine in gear and hold the rear brake.
4. Radiator cap

2

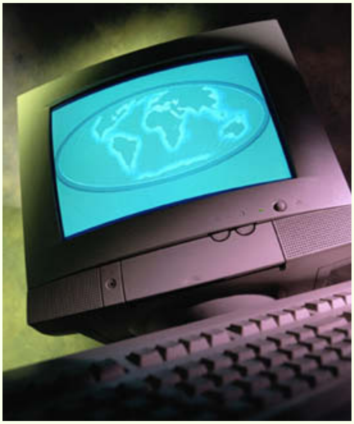
1. three
2. To help remove the excess oil from the cylinder walls
3. crisscross
4. Valve spring compressor
5. cutaways

3

1. friction, heat
2. The skirt
3. Boring it to a larger diameter
4. Cylinder bore gauge
5. taper
6. Detonation, preignition
7. False
8. machinist ruler, Vernier caliper
9. lapping
10. Freeze the valve guide to shrink it and heat the cylinder head to expand it.

4

1. Piston crown
2. oil control
3. narrow pitch
4. cylinder head
5. Exhaust
6. Room temperature
7. 2:1 (The crankshaft turns two times for every turn of the camshaft.)



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