TECH BMW PROCEDURE

2002tii fuel injection

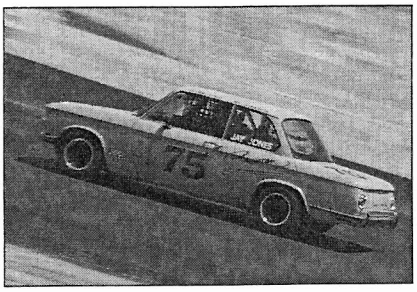
by Brendan M. Lopez
PHOTOS BY THE AUTHOR

Fuel injection technology has long been utilized by European automobile manufacturers to extract power and efficiency from their engines.

Porsche, BMW and Alfa Romeo were quick to develop cars using fuel injection. Due to the associated development and production costs, Japanese and American manufacturers were historically reluctant to universally apply fuel injection technology.

On a production scale, BMW first used fuel injection on the four-door 2000tii sedan of 1969. The tii nomenclature was used to designate the car was a performance BMW model. The term tii is roughly translated as "Turismo Internationale Injection." Unlike modern cars with electronic fuel injection systems, the 2000tii used a Kugelfischer mechanical fuel injection system. The Kugelfischer mechanical fuel injection system was derived from the fuel injection system used by the BMW factory 2002 racing cars of 1968. For the 1969 season, BMW raced a pair of 2002s fitted with Kugelfischer injected and turbocharged engines. The turbocharged race engine produced an astonishing 290 hp and enabled the 2002 to exceed 150 mph. It would be another five years before BMW would produce a road-going 2002 turbo. Clearly, this demonstrates how car manufacturers apply racing technology to improve their road cars. The tii engine soon found its way into the production two-door 2002. Thus, the 2002tii was born.

The Kugelfischer tii engine is as much an enigma today as it was 25 years ago. Like the Spica mechanical injection system used by Alfa Romeo, the Kugelfischer system is perceived to be problematic. This can probably be attributed to the lack of knowledge possessed by ordinary



mechanics who are bewildered by the workings of the Kugelfischer system. However, with a few simple tools, the Kugelfischer system can be tuned and maintained by a skillful auto enthusiast.

System Description

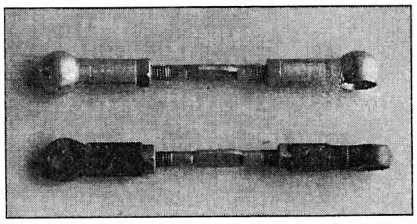
The Kugelfischer injection system consists of a fuel injection pump that elevates the pressure of the fuel from around 28 psi of system pressure to about 450 psi. The injection pump is driven by a cogged belt from the crankshaft pulley. The pump is synchronized to inject a metered amount of fuel into the intake manifold as the intake valve opens. Each cylinder has its own fuel injector and induction tube. All of the induction tubes are provided air by a large plenum chamber. Centrally located in the plenum chamber, is a large 55mm throttle body. A large air filter canister with two air filter elements provides clean air to the throttle body. For ease of maintenance, this large air filter canister is often replaced by a smaller, single K & N filter.

The pump itself is relatively simple. The pump has two basic inputs, engine speed and throttle position. A warm-up regulator bolted to the pump rear cover provides additional fuel when the coolant is cold. During cold start-up, an additional fuel injector in the throttle body delivers fuel according to ambient temperature.

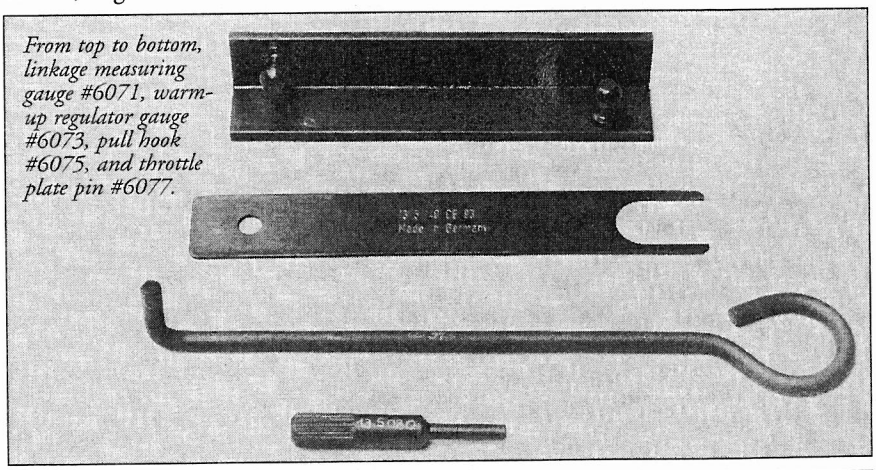
Apart from regular hand tools, special tools are required to tune a tii engine. Unfortunately, the tools are only available from a BMW car dealer. The tools are identified by two different numbers. The first number is a four-digit number used by the BMW factory for the factory 2002 repair manual. These numbers have been superseded by a regular 11-digit BMW part number. For ease of identification, the tools will be referred to by the factory 2002 repair manual numbers.(see table below)

Preliminary Inspection and Tune-up

Before the fuel injection system is set up, it is imperative to check that the engine, fuel supply and ignition components are in good working order.



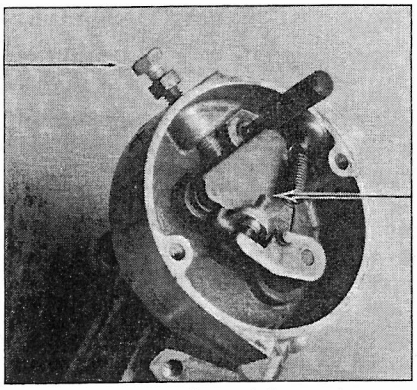
Later tii's use linkage with metal ends while earlier cars use better fitting nylon ends.



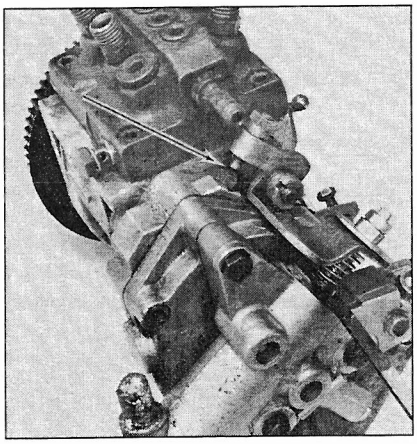
From top to bottom, linkage measuring gauge #6071, warm-up regulator gauge #6073, pull hook #6075, and throttle plate pin #6077.

Tool Number	Part Number	Description	List Price
6071	88 88 6 135 040	Linkage measuring gauge	$18.25
6073	88 88 6 135 140	Warm-up regulator gauge	$10.28
6075	88 88 6 135 050	Pull hook	$13.14
6077	88 88 6 135 080	Throttle plate pin	$7.13

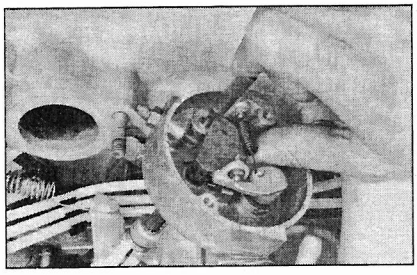
List prices from January 1994 retail price list.



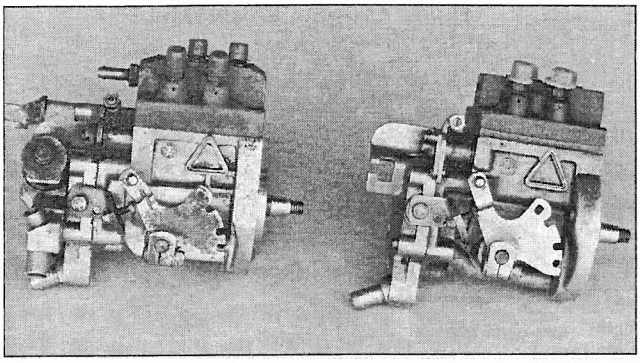
The large screw on the top left is used to set the idle speed. The small set screw inside of the throttle housing is used to set the mixture at idle.



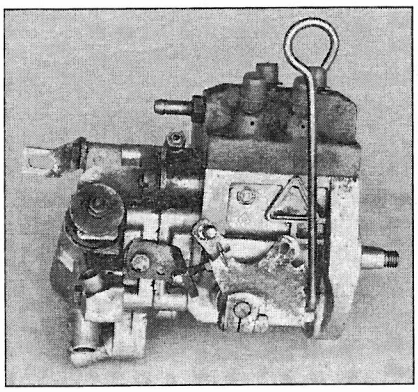
With the tool #6073 inserted into the warm-up regulator, the distance from the mixture screw and its stop should be 2.6mm, plus or minus .3mm

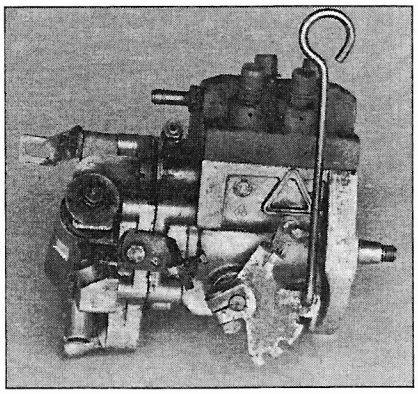


With the pump locked in idle position, insert the pin #6077 into the throttle body. By loosening the clamp bolts and holding the throttle cam against the pin, the relationship between throttle position and fuel delivery can be changed.



LEFT: The racing injection pump on the right is calibrated for higher fuel delivery. Note the racing pump doesn't have a warm-up regulator. BELOW LEFT: This photo shows the injection pump locked into full throttle position. BELOW RIGHT: This photo shows the injection pump locked into the idle position.





A compression check should be done to ensure the engine is in good condition. The compression test should be done with the engine at operating temperature with the throttle opened. The compression should read between 135 and 150 psi for an average broken-in engine. Compression readings that are higher are advantageous while lower readings are less than desirable. Low compression can be attributed to worn piston rings, broken piston rings, worn cylinder walls, burned valves, or any combination of the above.

The engine should also be checked for vacuum leaks. The tii engine has a large plenum chamber and four induction tubes that can leak vacuum if improperly sealed. Early tii engines have plastic induction tubes that should be handled with care. At $99.53 each, the reason is obvious.

Next, the valves should be adjusted while the engine is stone cold. When the valve clearance is excessive, there will be a noticeable tapping noise emanating from the valve cover. Bear in mind that worn rocker arms and rocker shafts can cause valvetrain noise as well; noise that will not be cured by adjusting the valves.

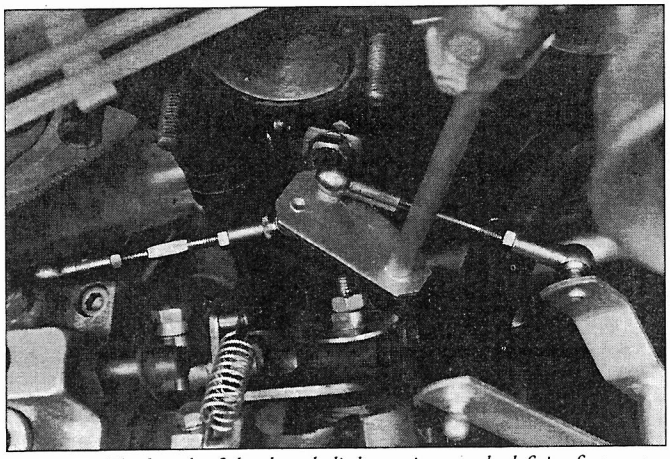
Adjusting the valve clearance on a single cam BMW engine is a simple process that requires only a few simple hand tools. A spark plug socket, ratchet, 3-in. socket extension, 10mm socket, 10mm box end wrench, feeler gauge set, and a small piece of 3/32-in. welding rod (about 6 in. long) are needed to undertake this operation. The welding rod is used to rotate the eccentric on the rocker arm to adjust the clearance. The welding rod should have a 90-degree bend about one-half in. from the end. A special eccentric rotating tool can be purchased from the dealer for about $40. In this instance, a homemade tool will suffice.

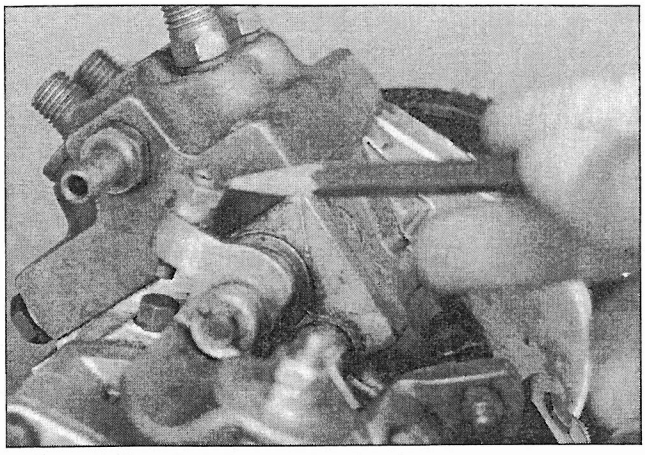
The first step is to park the vehicle on a flat level surface and allow the engine to cool. The spark plugs should be removed to make it easier to rotate the engine. The spark plugs should be kept in order so they can be inspected for signs of fouling.

It's easy to mix up the spark plug wires when re-installing the wires, particularly when the wires are not encased in a plastic tube. The wires can be marked with pieces of tape. If the spark plug wires do get mixed up, the firing order is cast into the valve cover. If you ever wondered what Zündfolge 1342 is, that is the firing order. Zündfolge translates as "ignition sequence."

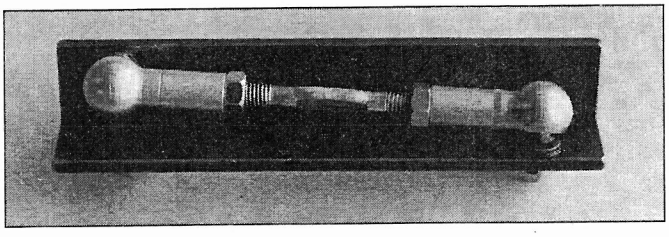
The valve cover can now be removed. It is retained by six cap nuts and one bolt. A small 6mm wave washer should be under each nut and bolt. When removing the valve cover, make certain to keep dirt and foreign objects out of the engine. The valve cover gasket can be re-used a couple of times before it needs to be replaced.

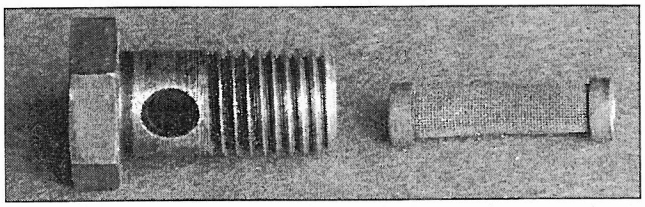
Once the valve cover is off, rotate the engine so the number one cylinder (front) is at TDC (top dead center). The engine can be rotated in a couple of different ways. The car can be put in gear and pushed forward to rotate the engine. This is not a task that one should do on a sloping driveway. The other option is to spend about $380 dollars on a special



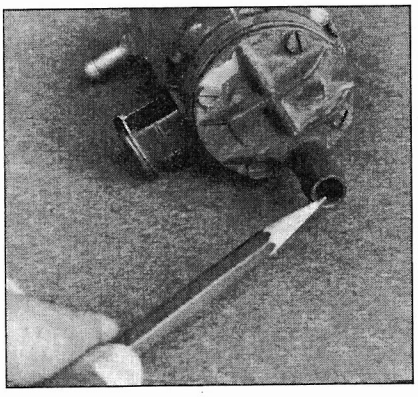


ABOVE: The length of the throttle linkage piece on the left is of utmost importance. BELOW: The length of the throttle linkage must be checked using tool #6071.





ABOVE TOP: The pump mixture screw should never be tampered with. It is usually covered by a small plastic cap. ABOVE: The banjo bolt supplying fuel to the injection pump has an integral filter screen that acts as a last line of defense against dirty fuel.



The fuel pump inlet has a small pressed in conical filter that can become clogged with debris.

tool that grabs the timing chain to rotate the engine. These tools are available for both double row and single row timing chains.

Double row timing chains were used on 2002s and early 320i cars. Later 320i and 318i (E30 chassis single cam) cars used a single row chain. Under no uncertain terms should the camshaft, cam sprocket, or timing chain be gripped with pliers to rotate the engine.

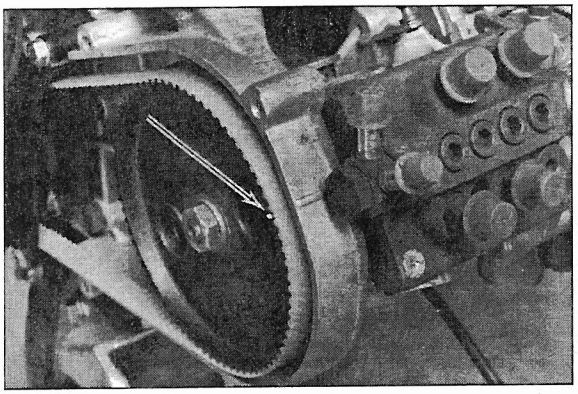
The number one cylinder is at TDC when the notch in the nose of the camshaft is aligned with the camshaft oiling tube. The notch can be found on the camshaft directly behind the camshaft gear. The lobes of the cam for the number one cylinder should be pointing downward. Insert a .007-in. feeler gauge between the valve stem and the rocker arm eccentric, loosen the eccentric bolt nut and rotate the eccentric to press lightly on the feeler gauge. If the cam has been replaced with an aftermarket or reground cam, the supplier should be consulted for the proper clearance specifications. Tighten the rocker arm nut while keeping pressure on the rocker arm eccentric to maintain the setting. Bear in mind the rocker arm nut is a small fine thread nut that doesn't require a lot of torque.

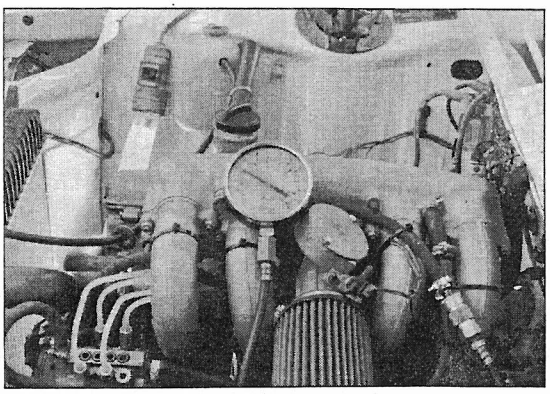
After rotating the camshaft clockwise (normal direction of rotation) in 90-degree increments, the operation can be repeated for the remaining three cylinders. Follow the firing order for the correct cylinder adjustment sequence. If you get mixed up, just remember the cylinder to adjust will have its camshaft lobes pointing downward, away from the camshaft oiling tube.

As long as the valve cover is off, the injection pump should be checked to ensure it is timed to TDC. Rotate the engine until the number one cylinder is at TDC. Compare the crankshaft pulley and the camshaft TDC timing marks to see if they correspond. Remove the black plastic upper injection pump belt drive cover in front of the injection pump. A small bump on the injection pump pulley should line up with a line cast into the metal front cover that supports the pump. If all of these marks line up, the pump is timed correctly, relative to the crankshaft. The injection pump belt can be slipped off its pulley and the pulley rotated to change the pump timing.

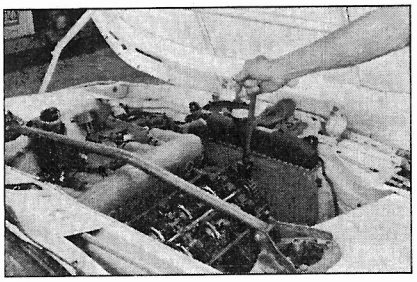
With the valves adjusted, new spark plugs can be fitted. Bosch W7DC plugs can be used with a 2002 or 2002tii. The spark plug gap should be adjusted to about .028 in. The spark plugs should be fitted with care. The aluminum threads in the cylinder head can be damaged if the plug is cross-threaded or over-tightened. The spark plugs require 18 to 22 lb/ft of torque. The spark plug wires should be inspected before attaching them to the spark plugs. They should be in good condition. If there is any doubt about their condition, replace them. It is a good idea to replace spark plug wires every couple of years anyhow.

The distributor portion of the ignition system should be checked next. The distributor cap, rotor, and points should be replaced if they exhibit any sort of wear or pitting. The condenser should be replaced as well. These items are inexpensive and should be replaced without hesitation. Distributor caps come in two different varieties.. Some have a locating tab, some don't. Make certain to purchase one that is





LEFT: With the crankshaft and camshaft TDC (top dead center) marks aligned, the dot on the injection pump drive belt pulley should line up with the pointer cast into the pump support housing.
RIGHT: With the ignition key on, the system should have 28 to 30 lb of fuel pressure.



The special engine rotating tool greatly facilitates the valve adjustment procedure.

exactly like the one you are removing.

The point gap should be set to .016 in. and should provide a dwell angle of 58 to 64 degrees. Set the static ignition timing to TDC (tii only). The 1974 USA model tii's have a distributor vacuum line that must be disconnected and plugged before the timing is adjusted. The dynamic ignition timing should be set to 25 degrees before TDC at 2700 rpm. Make certain the distributor achieves a maximum advance of 34 degrees. Correct ignition timing and advance makes all of the difference in the world between a tii that flies and one that doesn't.

Dynamic ignition timing is best ascertained by using a strobe timing light with a degree knob. A small hole is machined into the transmission bell housing to facilitate timing the ignition. By focusing the timing light into this hole, a small metal bead imbedded into the flywheel can be seen. With the advance degree dialed in, the bead should line up with the driver's side edge of the hole. Another TDC mark can be found on the front crankshaft pulley. This mark lines up with a pointer molded into the black plastic lower injection pump belt cover. With the engine fan in the near vicinity, it would be wise to use the timing mark in the flywheel when setting the ignition timing rather than the crankshaft pulley.

Fuel Supply and Delivery

With the basic engine components in order, it is now time to work on the fuel supply and delivery systems. The fuel supply system has four different screens and filters to provide a clean supply of fuel to the mechanical injection pump. The first screen resides in the fuel tank itself. At the bottom of the fuel pickup tube, there is a small plastic mesh filter. To change the pickup screen, it is necessary to gain access to the top of the fuel tank. This involves removing the right trunk floor panel and unbolting the fuel pickup tube. The pickup tube lifts up out of the tank after the retaining bolts are removed. The pickup screen snaps into the bottom of the pickup tube housing. The pickup screen (Part # 16 12 1 106 983) is made of plastic and should be replaced. The pickup tube gasket should be replaced as well (Part # 16 12 1 110 598). Otherwise, fuel can leak out of the gas tank.

The next screen is in the fuel pump itself. The fuel pump is under the car on the right side, near the differential. The screen is a conical shaped screen that is pressed into the fuel pump inlet. The screen is non-removable and non-replaceable. Simply clean it out the best you can. When removing the fuel line, fuel will leak out. Be prepared to take the necessary precautions.

While under the car, it is a good idea to inspect the fuel accumulator canister. It is a small black canister attached to the fuel pump. On older cars, the canister can leak at the seams or rust completely through. As long as you are under there, inspect all of the fuel lines for signs of cracking.

The main fuel filter (Part # 13 32 1 256 492) can be found in the engine bay to the left of the radiator. The filter is about 3 in. long and 2 in. in diameter. When changing this filter, note the direction of flow. The last line of defense against dirty fuel, is the banjo bolt that supplies fuel to the Kugelfischer injection pump. The banjo bolt has an integral filter screen that can be removed and cleaned. The banjo bolt filter is retained by a small spring clip. The spring clip and the filter screen are not available as separate parts and care should be taken when handling them.

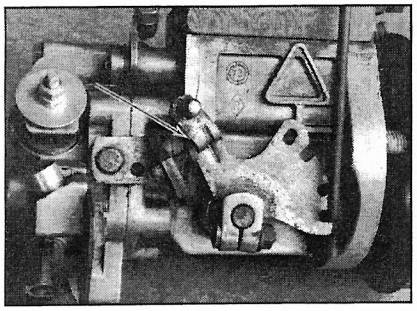
Fuel Pressure System

With the fuel system providing clean fuel, the next item to check is the fuel system pressure. The fuel pressure is checked by removing the fuel line to the cold start injector. The cold start injector can be found on the top of the throttle body. The cold start fuel injector line should be hooked up to a fuel pressure gauge that can read 20 to 40 lbs. With the ignition key on, the system should have 28 to 30 lbs of pressure. While you are in the area, inspect the four plastic lines that provide fuel from the injection pump to the injectors. The lines can rub together, thus causing wear. With the fuel being pumped at high pressure, the results can be disastrous should one of the lines rupture. Special separation clips are available to keep the injection lines from rubbing together.

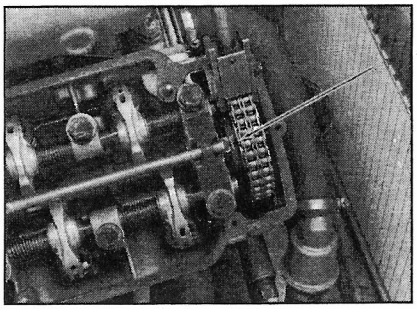
Throttle linkage and full load stops

The tii uses a multitude of linkage pieces and levers to actuate the throttle plate. Due to the relationship between throttle position and fuel delivery, it is crucial the linkage be properly set. Most of the tii linkage pieces are no longer available. In the past, it was always a good idea to replace the linkage pieces on all high-mileage tii cars.

To adjust the full load setting, use pull hook number 6075 in the bottom hole of the throttle lever to lock the injection



When the pump is in the full throttle position, the throttle lever should be lightly resting on its stop screw.



The No. 1 cylinder is at TDC when the notch in the nose of the camshaft is aligned with the camshaft oiling tube. Notch can be found on the camshaft directly behind.

pump throttle in the wide-open position. The 6075 tool fits through the holes in the injection pump throttle lever and into a small hole in the body of the injection pump. The lever should be lightly pressing on the stop screw when the pump throttle lever is in the full-on position. If the stop requires adjustment, the number one cylinder induction tube will have to be temporarily removed. The screw can then be rotated in or out to change the full load stop.

Adjusting warm up regulator

The warm-up regulator is bolted to the rear of the injection pump and is operated by the engine coolant. When the coolant is cold, the warm-up regulator is retracted. This acts on the lever controlling the height of the pistons within the injection pump, thus adding more fuel. The warm-up regulator also provides additional air to the engine. As the coolant become warm, the warm-up regulator extends from its housing, causing the pump to lean out the fuel mixture and the additional air to cease.

The warm-up regulator should be adjusted when the coolant is cold. To adjust the warm-up regulator, pull the spring-loaded regulator cone out of the housing until the 6073 tool can be inserted into the groove in the regulating cone. The distance between the mixture screw and its stop should be 2.6mm plus or minus 0.3mm. The mixture screw can be found on the back of the injection pump. The mixture screw should be covered with a small plastic cap with a triangle on the top. If not, the pump may have been tampered with.

To adjust the distance between the mixture screw and its stop, turn the nut and large washer on the threaded portion of the warm-up regulator. This will change the relationship between the regulator and the mixture lever. Under no uncertain terms should the mixture screw be turned. Turning the mixture screw will change the calibration of the injection pump, necessitating removal and re-calibration. When the coolant is hot, the warm-up regulator will be extended from its housing and the mixture screw will be against its stop. Sometimes, the mixture screw lever will not return to full warm position.

According to Bill Holmes at Bavarian Rennsport, a common problem is the clamp on the fuel return hose. The clamp is directly above the mixture lever. If the clamp is positioned improperly, the mixture lever will catch on the clamp. Thus, the car will be perpetually running on the warm-up setting.

Synchronize throttle valve with the injection pump

Throttle synchronization is of utmost importance. Without proper throttle synchronization, the fuel injection pump will not be delivering the correct amount of fuel for the amount of air the engine is taking in. First check to see that the connecting linkage between the injection pump throttle lever and the throttle-actuating rod is the correct length. This linkage piece should be checked with the special tool number 6071. Remove this linkage piece and fit it onto the 6071 gauge. The linkage piece should snap onto the 6071 gauge if it is the proper length. The lock nuts can be loosened, and the rod turned to adjust the length of the linkage. Reinstall the linkage when the correct length is achieved.

Next remove the throttle body cover plate and turn out the idle speed screw. A couple of turns should do it. The idle speed screw is on the outside of the throttle body on the left side (when viewing from the driver's side) near where the throttle body attaches to the plenum chamber. The linkage that controls the throttle actuation cam has an upper and lower half. They are connected by a clamp. By rotating the throttle actuation cam relative to the lower half of the linkage, the relationship between throttle position and fuel delivery can be changed. If this all seems too confusing, keep on reading and looking at the photographs. By studying your own car, it should become clear.

Early tii linkage has two bolts on the lower linkage, while later tii's have one. The bolt or bolts should be loosened now. Next, using the pull hook tool number 6075, lock the injection pump in the idle position. To lock the pump in the idle position, insert the pull hook through the upper hole in the injection pump throttle lever and into the hole in the injection pump body.

The pin tool number 6077 should be inserted into its hole in the throttle body. While pressing the throttle actuating cam against the 6077 pin, tighten the linkage clamp bolt or bolts. Remove the 6075 and 6077 tools. The throttle plate is now synchronized with the injection pump. The engine can now be run and the idle speed set. With the engine at operating temperature, the engine should be idling at 900 rpm plus or minus 50 rpm.

The final step is to adjust the idle emissions. The idle mixture is set with a small set screw inside the throttle body housing. The idle emissions are very sensitive to rotations of this screw. Small adjustments make big changes in the idle mixture setting. When fully warmed, the tii should emit between 0.8% and 1.2% of CO. European specification tii's run between 2% and 3% of CO. The CO percentage is best checked with an exhaust gas analyzer. If you do not have an exhaust gas analyzer at your disposal, carefully turn in the idle mixture screw until the engine just starts to oscillate. Turn back the screw until the idle is stable. This should put the idle mixture in the ballpark. With the idle mixture set, the throttle body cover can be re-installed.

Having done all of these things, your tii engine should be running smoothly and strongly without any flat spots. Unless you are comfortable doing basic tune-up type operations, try to do the preliminary things in one day, and the fuel injection set-up things on another. Otherwise, the task can appear overwhelming. A factory 2002 service manual or Haynes manual (#240 U.S.) should be at hand to supplement the information contained herein. Even if you don't plan to work on your tii, at the very least, you will have a better idea of what is required to do a proper tune-up on a tii. **BMWP**