July 2012

Technical Newsletter

Automotive Electronic Control Systems

AECS

Training, Equipment and Data for Automotive Diagnostic Specialists

Vitals on Vitara

This article is a true description of an AECS technical help desk problem and how it was solved.

Vehicle

2001 Suzuki Vitara Bosch Common rail Diesel with a Peugeot 2.0Ltr turbo engine.

To get a true appreciation of the diagnostic process and the costs involved you need to read the whole story in detail.

Problem presented to the Helpdesk

This car developed a sudden lack of power while driving. It smokes white/blue, badly and starts misfiring at higher RPM. The revs will not go past around 3500RPM; it does rev up very doughy.

Upon good advice from a friend, the car's owner decided to drive the car with the air cleaner removed, as the old one was extremely dirty …

The car had been to a number of workshops. The car had 2 fault codes logged; Air mass sensor and EGR system faults. After replacing those items with no result, the diagnosis was that the injectors and high-pressure fuel pump where faulty, as everything else was tested and found to be perfect.

Eventually the car was brought to an AECS customer who owns a Diesel and Turbo specialist shop and who recently bought the ATS 5000 scope.

The injectors and high-pressure fuel pump were replaced upon request.

The car ran just as bad as it did before.

Diagnose properly

The Diesel specialist offered the garage to do further diagnosis on this vehicle to find out what the problem really was. The old injector pump was fitted back again, but the new injectors remained in the engine, as they could not be restocked.

When this Diesel specialist heard the engine run, it was to him sounding and smelling like there was an EGR fault (stuck open valve), a timing issue (retarded injection timing), or a breathing issue.

A new EMS2-1 Chip programming course is planned for Auckland. - 18th & 19th July 2012
See inside for further details.

Also if you want to view the scope patterns of this article in higher resolution - see our website - www.aecs.net

EGR elimination

A blanking gasket was made for the EGR valve, which knowingly would log a fault code, but it would confirm if the problem was an EGR issue. No effect at all.

Breathing problems elimination

To make sure the engine was breathing properly the exhaust was removed to confirm that the catalytic converter wasn't blocked up. No change, just more noise.

The turbo with intake / exhaust manifold was taken off and inspected just in case the intake was blocked with carbon deposits from EGR problems, or if the turbo was seized blocking exhaust and intake flow at higher RPM.

The vacuum operated throttle was disconnected to get it into the wide-open position, just in case.

The crank case ventilation was disconnected from the manifold, in case there was a lot of blow by entering the manifold.

Nothing untoward was found and putting it all back together made no difference to the running of the engine. The disconnected crank ventilation showed very little clean air movement during running, while the exhaust was smoking badly.

It's been expensive so far wouldn't you agree? Please make in your head a quote for the work so far.

Timing issues elimination

Now we are in scope territory. The injectors on this common rail system are controlled by the ECU. This means that the injection timing is purely controlled by the ECU, not by moving the pump around like with older style Diesel engines.

Diagnostically you need to first identify the inputs, which the ECU needs to control the timing.

In no particular order;

- we could have an ECU input fault (sensors like RPM, load, temp, gearshift, etc.),
- we could have an ECU output fault (injectors, injector driver, power supply to injectors, fuel pressure, etc.)
- we could have right in the middle a fault with the ECU itself.

All the above have an effect on when the actual Diesel enters the combustion chamber, and could more or less be the reason for this engine to misbehave.

So where to start?

We firstly wanted to know if the timing was actually erratic while the engine was misfiring, we also wanted to know if the problem was with one cylinder or running across all cylinders.

The scope was used to record the injector signals versus the crankshaft sensor signal.

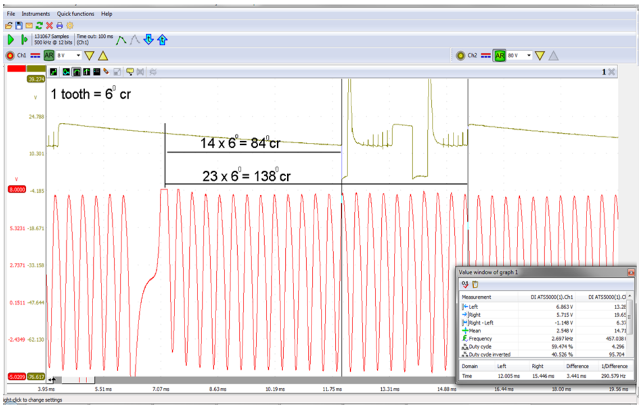
ATS 5000 dual channel detailed scope recording of 12 revolutions of the injector pattern vs the injection pattern while the engine is misfiring and smoking.

An analogue RPM trace was added to the dual channel measurement. This pattern is a calculated RPM value based on each crankshaft sensor's pulse frequency. It gives us incredible detailed information about slight RPM changes during compression and ignition. This is used to

determine if a misfire is random or cylinder specific, just like how this is done inside modern ECU's to set the OBD P03xx codes when the fuel quantity compensation cannot get the RPM changes even, across all cylinders.
It is clear to see that each cylinder puts in an effort and that not one cylinder stands out, this in my view determines that the engine has no big compression and ignition problems.

More detail

Let's look at this pattern in more detail to see if the quantity and timing are erratic.

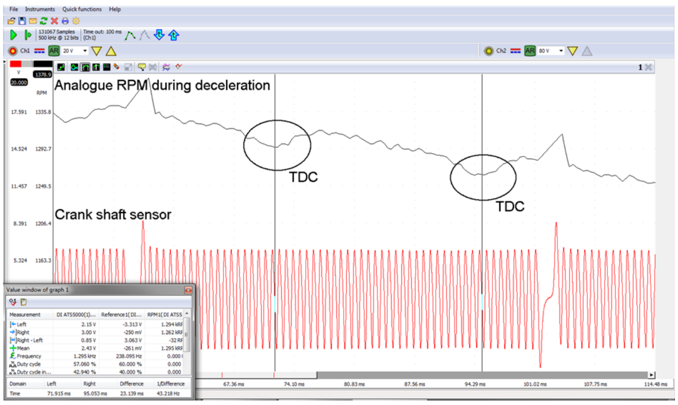


Crankshaft sensor vs injection zoomed in.

The start of injection and end of injection was measured on each of the 23 injection patterns recorded. They were all absolutely even and consistent in relation to the crankshaft sensor. This could only mean that the ECU is doing a consistent job (not necessarily a good job). It could of course be that the tone wheel had slipped on the crankshaft, or that the ECU was injecting consistently at the incorrect time. Please think about this!

Check actual injection timing

To check the actual timing is harder than you think. There is no way you can have a clip around the injector line with a timing light, it is also not useful to check pump timing like with older systems.
The diagnostician checked where TDC is on the crankshaft pattern by using the analogue RPM measurement once again. The simple fact is that the crankshaft (during deceleration) moves the slowest at the end of compression, just before decompression, which is TDC.



TDC determination with the ATS 5000 scope

This showed that TDC is at the 20st teeth after the reference mark, if you go back to the injection pattern you can see that the main injection starts just before the 20st teeth (about 5 degrees on the crank shaft).

We checked with the Launch scan tool the timing in life data at the same time. It showed 4 degrees BTC.

All this told us is that the ECU got what it wanted, that also confirms that the crank tone wheel is fixed solid on the crankshaft! Please imagine what job this would be, taking the flywheel off just to inspect the tone wheel….

ECU demand wrong?

It could still be that the ECU demanded the incorrect timing. 4 degrees BTC at about 2600 RPM does not sound okay, although many modern engines have very low compression and retarded timing to reduce NOx emissions.

We had to advance the timing, the easiest is to alter the coolant temperature sensor signal. For this, the ATS scope signal generator was used; it simply over rides the ECT signal into the ECU. We simulated -30 degrees Celsius, as that gives you a lot of advance.

The engine revved a little freer and sounded a little better but was still smoking and doughy.

Certainly not the fix we were looking for.

Back to Basics

At this stage all three engineers here at AECS did not know what else we could sensibly test to electronically find the fault with this system.

So as usual, when you hit that wall you need to go back to basics, and retrace your steps.

The engine was checked over by a number of other garages was the story, well that leaves us with no certainty at all, better check the simple stuff like cam timing and compression.

Wrong cam timing could send a plume of measured air back into the intake manifold and upset the compression pressure so that ignition would not happen properly.

Cam timing

Cam timing was good following the factory procedure. Maybe the cam marks where incorrect, the marks are on the cam gear, which could have slipped on the camshaft.

The TDC was determined with a dial gauge on the piston (= injector removal). The camshaft was set to rocking, this made the marks line up almost perfectly. So cam timing was confirmed good.

Compression

The compression looked good on the RPM signal, every rise and fall on the analogue RPM signal was similar. So the compressions could not be too bad, yet we needed to know for sure as the ECU has cylinder individual injection quantity compensation to stop the engine from vibrating in some case masking bad compression.

The compression test showed that cylinder 2 was 98% of the other cylinders, which is not bad at all. However since the injectors were out the diagnostician decided to do a cylinder leak test.

One of the old injectors was used to make a leak test adapter.

Cylinder 1,3 and 4 had 8% leakage, cylinder 2 had 25% leakage and a hissing sound in the intake manifold………..

Found it

What happened? The leaking intake valve blew high-pressure combustion gas into the intake manifold. The combustion gas was choking the other cylinders randomly as the pulse back into the manifold would have upset different cylinders at various RPM, due to the time it takes for the pulse of gas to travel.

The 25% leak was not a big enough leak to show up during compression tests as the pressure in a cylinder is only low at the end of a compression stroke (small leak) compared to combustion pressure.

On the scope, it was not visible as all the cylinder's combustion was upset, so there was not much in the way of relative compression and energy delivery checking possible in the analogue RPM pattern.

Was the valve damaged as a result of pieces of the extensively blocked air cleaner sucked into the engine? We will never know.

It must also be clear that, like with so many other support cases the team at AECS deals with, it is not possible to solve real faults like this one with simple software updates or by resetting fault codes.

The two logged fault codes (air mass and EGR) were of course the result of the air mass sensor measuring a lower quantity of air going into the engine as a result of the blow back into the manifold. A normal cause for this is a faulty open EGR valve. Both the airbases sensor and EGR valve where fine.

Conclusion

This job ended up being very expensive. However the one lesson that needs to be taken out of this story is that to assume that someone before you has done a good job is a 'no go' area.

In addition, one important lesson AECS has learnt, is that no matter how advanced our customer is (the workshop) on the other end of the phone, we must not skip the basics!

Prepare for cases like this with appropriate training, a backup team, and real equipment

Herbert

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