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Why Hot Start problems occur

The hot start problem this post refers to, occurs after short stops - usually 15-45 minutes. On restart, the engine either will not start at all or it runs poorly. This is most common on cars with low pressure fuel systems, like the early D-Jetronic and carbureted cars.

Using an air-fuel ratio gauge on my car (350SL 4.5L), it has become very clear, is that when the hot start problem occurs, the mixture is very **LEAN**. In other words, the engine is not getting enough fuel. A fuel pressure gauge indicates that fuel pressure hardly changes, which would lead would seem to indicate that the fuel pump is doing it's job. But the pump should be checked to ensure fuel flow is according to car's specs.

A natural instinct is to pump the pedal when car won't start. This actually makes sense in this case, because on most cars there is the equivalent of an accelerator pump and it will cause more fuel to be injected, which is what IS needed.

Why does mixture go lean?

These factors likely contribute:

Fuel Specifications

Back in the 60's and 70's all fuel was quite volatile and had Reid Vapor Pressure in the 13-13.5 range. Difficult hot starting was common and MB tried many solutions on our cars with limited success. Since that time, environmental concerns have resulted in a reduction of RVP for summer fuels down to the 7.0 range. These fuels are less likely to vapor lock, except in very hot areas. Winter fuels still have RVP in the 13-15 range and contain light volatile fractions, like butane. They are a likely cause of poor hot starting.

Fuel cooling system

As the car is driven, the fuel supply gets heated up due to friction in the fuel pump and due to the heat in the engine bay. The fuel tubing, FI rails and pressure control valves are subjected to engine heat and the fuel warms up. Because a large portion of the fuel pump's output is recycled, this heat is dissipated in the fuel tank where there is a volume of cooler fuel as well as some cooling due to evaporation. Air flow over the tank, pump and tubing likely also helps. This cooling system works, although not that well if you are low on fuel. Some cars use fuel coolers to assist the cooling process. Some of these use the car's A/C refrigerant as coolant and others use air coolers. The coolers likely work, but only while the car is running. They may help, in that the fuel will not be as warm before stopping.

Heat Soaking

When car is stopped, coolant stops circulating immediately. The engine is still very hot and heat is radiated to the surroundings. As a result, the fuel supply system gets hotter. This is often called "heat soaking". What happens next depends on just how hot the fuel gets and the characteristics of the fuel including RVP. At 30 psig rail pressure, summer fuels should stay in liquid form up to about 212F. But winter fuels may start to form vapor bubbles at as low as 150F.

Flashing of hot fuel

When car is restarted, fuel starts to circulate and injectors attempt to discharge fuel into the intake ports. By this time, fuel is usually still pressurized, but may have leaked down (say from 30 to 20 on D-Jets) . Because of the heat soaking, some fuels can be close to (or already) vaporizing in the rails and in the injectors themselves. Then, as the fuel is discharged through the injectors (and through the fuel pressure regulator), the liquid fuel flashes to a mixture of vapor and liquid. It does this because the pressure on the downstream side of the injector or valve is at atmospheric pressure or less. An orifice or a valve has greatly reduced capacity when flowing a vapor or a vapor/liquid mixture, when compared with just a liquid. As a

result, flow through the injectors can be much less than required. Some fuel enters the intake, but not enough. We have a lean mixture and engine either won't start or runs poorly.

Solutions?

It should first be ascertained that the fuel system is in good condition and that the fuel pump delivers the specified flow (2L/min for early 8-cyl D-Jets – check manual for other engines). This way owner will know that there is proper circulation back to tank. Leak down through injectors, fuel pressure regulator and back through pump should be checked. Excessive leak down makes things worse.

If winter fuel is the problem, there is not much that can be done about it (other than hoarding summer fuel!)

Keeping the fuel cool while running so that it does not reach as high a temperature during the stop should be beneficial. Failing that, a way to get the engine going is needed so that cool fuel from the tank will reach the engine more quickly and clear the vapor.

Possible Solutions (Mainly for D-Jetronics)

If problem is minor, it may be possible to get the car running properly by switching the ignition key on and off a couple of times so that the fuel pump runs and circulates some fuel. Pumping the pedal a few times as soon as the engine fires also seems to help. Once running, keeping pedal down so car idles at 1000-1200rpm for a minute or so also helps clear vapor from the system (AFR gauge shows mixture going from lean to normal in that time).

If the above techniques do not work, the following could be tried:

- Install a push button to manually operate the COLD start injector - This would discharge a little fuel into the intake and get the engine going. It will then hopefully soon flush out vapors and run smoothly. There are reports that this has been done with success. (Note - Need a diagram here on how to do this)
- Install a push button to manually operate the fuel pump before starting. This will bring cool fuel from tank into rails. It may still be hard to start the engine because of the vapor forming at the injectors but the idea seems reasonable and has apparently been used. (Note - Need a diagram here on how to do this)
- Install a fuel cooler. Air cooled fuel coolers are available at low cost from stores like Summit Racing. These might keep the circulating fuel at a low enough temperature so that the heat soak is not as severe. MB installed refrigerant cooled coolers on some D-Jet cars as did others like Jaguar.
- Increase fuel pressure to say 35 psig while at same time adjusting mixture controls to give proper exhaust CO or Air-fuel ratio. This could reduce vapor formation in the fuel system, but does not help flashing across the injectors. (It does help on my own car)
- Disconnect air temperature sensor (using switch) or modify output of coolant sensor by installing switched 50ohm resistor in series so that ECU is fooled into opening injectors for longer periods. This works to some extent in that it flushes vapors out. (Note - Need a diagram here on how to do this)
- Install higher capacity fuel pump so as to provide better cooling. Perhaps combined with fuel cooler option? This can't hurt so long as flow increase is not beyond capability of fuel pressure regulator, filter and other fuel systems.

On my own D-Jet car, we have a minor hot start problem in Fall and Spring (car is not used in winter) This is presumably caused mainly by the winter fuel we get from October-April. In summer the 4.5L D-Jet engine starts fine with RVP 7.0 fuel even when hot. On very hot days, it could happen in summer too. But we don't get many very hot days!

Personal plan

- We already run at higher fuel pressure. But with mixture adjusted to provide correct exhaust %CO.
- Considering installing a push button for the cold start valve so as to get a richer mixture on hot start and get the car going quicker.
- Try to keep fuel tank topped up.
- Consider installing a higher capacity pump when replacing existing (which is apparently no longer made)

I am interested in further input and comments and will edit this document as new information comes to light.

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'72 350SL, '85 300D, '98 E320