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CONVERTING A 90´S NISSAN 200SX INTO FLEXIBLE FUEL VEHICLE.

Bachelor's Thesis
Automotive Engineering

December 2011

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KUVAILULEHTI

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Tekijä(t) Jani Vaara	**Koulutusohjelma ja suuntautuminen** Auto- ja kuljetustekniikka
Nimeke Kuinka muuttaa 90-luvun Nissan 200SX Flexible Fuel-autoksi.	

Tiivistelmä

Työn tarkoituksena oli selvittää mahdollisuus muuttaa 90-luvun Nissan käyttämään nykyaikaisia etanolia sisältäviä polttonesteitä. Selvityksen kohteena oli vuonna 1995 valmistunut Nissan 200SX.

Autovalmistajien Flexible Fuel-autoissa käyttämiä ratkaisuja ei Nissanin moottorinohjainlaite kykene jäljittelemään, joten päädyin tutustumaan moottorinohjainlaitteisiin. Uudella moottorinohjainlaitteetta varustettuna Nissan ymmärtäisi nykyaikaisien antureiden antamaa tietoa. Jolloin se osaisi ohjata polttoaineen syöttöä, polttoaineen ominaisuuksien ja ajotilanteiden mukaisesti.

Selvitystyössä käytin lukuisia Internetistä löytyviä lähteitä, materiaalien ominaisuuksista ja niiden soveltumisesta etanolia sisältävien polttoaineiden säilytykseen. Soveltuvien anturien ja toimilaitteiden valinnassa valitun moottorin ohjainlaitteen ohjekirja oli suureksi avuksi. Sieltä löytyi rohkaisevaa tietoa ajoneuvojen valmistajien anturien ja toimilaitteiden toimimisesta jälkiasennus moottorinohjainlaitteen kanssa, sekä ehdotuksia uusista antureista mitkä toimivat ohjainlaitteen kanssa. Osien hintatiedot löytyvät Internetin verkkokaupoista, missä niitä on myös helppo vertailla.

Selvityksessä kuvailtu muutos on taloudellisesti kannattamaton. Ympäristöllisten syiden pohjalta olisi kestävämpi käyttää julkisia kulkuneuvoja ja kävellä tai ajaa polkupyörällä lyhyemmät matkat. Jos autoharrastus johtaa moottorinohjainlaitteen vaihtoon, kannattaa projektiin sisällyttää myös polttonesteen koostumusanturin asennus. Muissa polttoainelinjan muutoksissa tulee kiinnittää erityistä huomiota materiaali valintoihin.

Asiasanat (avainsanat)

bensiini, etanoli, moottoripolttoaineet, polttomoottorit

Sivumäärä	**Kieli**	**URN**
16	Englanti	http://www.urn.fi/URN:NBN:fi:amk-2011120917779

Huomautus (huomautukset liitteistä)

Ohjaavan opettajan nimi	**Opinnäytetyön toimeksiantaja**
Juhani Martikainen	

DESCRIPTION

MIKKELIN AMMATTIKORKEAKOULU Mikkeli University of Applied Sciences	**Date of the bachelor's thesis** 20.11.2011
Author(s) Jani Vaara	**Degree programme and option** Bachelor of Automotive Engineering

Name of the bachelor's thesis

Converting a 90´s Nissan 200SX into a Flexible Fuel Vehicle.

Abstract

The purpose of my thesis was to find out how it is possible to convert a 90's Nissan into a modern Flexible Fuel vehicle. The subject was a Nissan 200SX produced in 1995.

In Flexible Fuel vehicles major car manufacturers use such technologies that my old Nissans engine management system couldn't use their sensors. This led me to looking into engine management systems. With new engine management system the old Nissan could make sense of the new sensor data and would be able to adjust the amount of fuel injected according to the fuels properties and driving situations.

In my research I used numerous Internet sources to find out which materials could be deployed in a use of storing fuels containing ethanol. The chosen engine management systems manual was very helpful when looking for the suitable sensors and devices to be used in conjunction with it. Prices for the parts are easy to find in the Internets many Internet online stores.

The conversion described is not economically viable. It would be more environmentally friendly to use public transport and to walk or ride a bicycle for shorter distances. In a case where a hobby involving cars demands the change of engine management system, it would be recommended to add the fuel composition sensor into the project. In other fuel line modifications one should pay serious attention to the used materials.

Subject headings, (keywords)

ethanol, gasoline, internal combustion engines, transportation fuels

Pages	**Language**	**URN**
16	English	http://www.urn.fi/URN:NBN:fi:amk-2011120917779

Remarks, notes on appendices

Tutor	**Bachelor's thesis assigned by**
Juhani Martikainen	

CONTENT

1 INTRODUCTION

There are climatic, economic and political reasons why a country would like to decrease its dependency on imported fuels. As an answer to European Union directive 2009/28/EC Finland has adopted a new fuel mixture at the beginning of 2011 known as 95E10 that contains up to 10 % of ethanol /1, p. 2/. This directive is drawn up to set rules for the European Union's promotion and use of energy from renewable sources. It sets strict goals to the use of renewable energy to each nation within the union that they should achieve until the year 2020.

FlexiFuel vehicles sold by vehicle manufacturers are able to use any blend of ethanol and petrol, I set my goal into finding a way to convert my car to be able to use ethanol-petrol mixes up to and including 85% of ethanol. The Internet is filled with numerous web-sites with easy-to-follow steps to turning a vehicle running solely on petrol into a car able to run on ethanol. Following these instructions usually render the used vehicle into ethanol only vehicle or a vehicle that uses only a very strict blend of petrol and ethanol, which in my opinion renders the exercise futile. As a purpose of flexible-fuel vehicle is to allow a variety of fuels to be used depending on current supply.

My example car for converting into a flexible-fuel vehicle is a 1995 Nissan 200SX. 200SX isn't rated by the manufacturer as compatible with the new 95E10 fuel. The new Ford Mondeo is an example of what people expect a FlexiFuel vehicle to be like, modern mass produced car with expensive and complicated engine. That is partly true; FlexiFuel vehicles have been on the market for a few years now and usually don't cost considerably more than petrol equivalent of the same model. Ford for example sells FlexiFuel and petrol powered cars at the same price. I decided to investigate what it would take to convert my Nissan into a full flexible-fuel vehicle.

The Nissan 200SX is a junior sports car that seats two at the front and two in the small rear seats. It has a turbocharged intercooled two litre petrol engine, 5-speed manual gearbox and a rear wheel drive. Motor of my Nissan is called SR20DET and it has multiport fuel injection and direct ignition, one spark plug and ignition coil per cylinder. SR20-engine family has two overhead camshafts and four valves per cylinder. It

has closed loop feedback from heated oxygen sensor, and exhaust gasses are processed by a three-way catalytic converter. All engine functions are controlled by electronic engine control module.

2 FUELS

We are living interesting times considering the future of transport as scientists are researching alternative fuels to replace the fuels we have been relying for decades. Oil is running out, they say, but still there have been new oilfields found recently /2/. At some point there will be so little oil left that it is too expensive for anyone to use. Other reasons for researching new fuels are the environmental and political reasons. It has been proven that burning all that oil has increased the carbon dioxide in the atmosphere and this is causing global warming /3/. To prevent further warming or at least slowing it down there is pressure to come up with a fuel that doesn't add any more carbon to the atmosphere. Political reasons for finding renewable energy sources rise from where the biggest oilfields are located, the Middle East. For example United States of America is looking ways to guarantee energy security in the future.

There are a number of different fuels for transportation use and I´d like to divide these into two groups. First group includes fuels used by spark ignition (SI) engines and the second group by compression ignition (CI) engines. Currently fuels designed for SI engines are still mostly petrol with varying amounts of added alcohol. Compression ignition engines fuels are also distilled from crude oil and it also has varying amounts of bio components.

Gasoline is still the most popular fuel for passenger cars. Popularity of petrol is mostly down to the fact that there was only one real alternative to it, diesel. Petrol powered cars are easy to refuel, have a decent range and new advances in engine technology and downsizing have brought fuel consumption closer to diesel engines. Gasoline is distilled from crude oil and consists of paraffin's, olefins, aromatics and oxygenates also additives are added to achieve desired qualities /4, p.320/. I would recommend a modern petrol powered car for a people who mostly drive short distances, for example commute to work and to the shops.

Diesel is the most popular fuel for commercial vehicles. It is also product distilled from crude oil. Petrol's boiling range is between 30^{o}C and 210^{o}C diesel fuels boiling range is from 180^{o}C to 370^{o}C /4, p.320/. Diesel has gained popularity as a passenger cars fuel in recent years due to favourable taxation changes around Europe. The advances in engine technology haven't hurt diesel powered cars popularity either. Old diesel cars are slow; they smell bad, are noisy and smoke a lot. New diesel engines sound "diesely" only right after they are started, produce heaps of torque at moderate engine speeds, smoke problem has disappeared due to catalytic converters and particle filters. Modern car powered by a diesel engine is a good choice for a person or a family that travel long distances frequently by car.

Ethanol is currently the most used alternative fuel for cars /5/. As it was the easiest way to introduce a bio component to the already existing vehicle base and distribution network. At low concentrations (~5%) the use of ethanol in petrol engines doesn't require any modifications. When the ethanol content is increased to 10% the old carburettor fuelled vehicles start to run lean if fuel supply isn't corrected. Around 10% also the materials start to show signs of compatibility issues by expanding, hardening and increased corrosion.

Ethanol has a lower calorific value than petrol thus vehicles consume more of it for the same amount of work. Ethanol (C_2H_5OH) is a clean burning fuel. Combustion produces mostly CO_2 and H_2O /6/. On the other hand there are some concerning reports that especially in the bellow freezing temperatures running an internal combustion engine on ethanol blends can produce concerning amounts of possibly cancer inducing compounds including formaldehydes /7/. The production of bioethanol in European Union is rapidly growing as can be seen from Figure 1. On the other hand, comparing production figures to Brazil and USA in Figure 2, gives some perspective on how small the production of bioethanol is in EU.

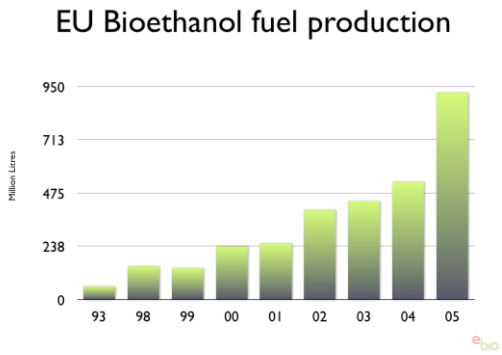

FIGURE 1. Fuel bioethanol production in EU /8, p. 2/.

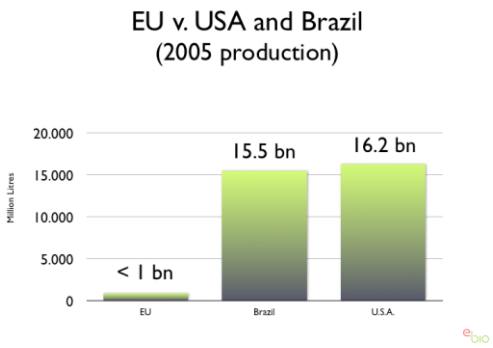

FIGURE 2. Comparing bio ethanol productions of EU, Brazil and USA. /8, p. 5/.

E85 is one specific blend of petrol and ethanol. This blend contains a maximum of 85% of ethanol and no less than 15% of petrol. Due to ethanol's inherent cold start problems the ethanol content is reduced during winter months. Also to ensure cold starts manufacturers for example Ford add an electric engine heater to their FlexiFuel vehicles. Only vehicles designed to accept E85 are able to use it. Vehicle that is not designed or converted to use it may suffer major engine malfunctions. As E85 consist mostly of ethanol its properties are very similar, see Table 1. I think the proportion of petrol is there to help with cold starts.

As with E85, 95E10 is a blend of petrol and ethanol but in this case the proportions are reversed, 10% or less of ethanol. When alcohol is mixed with petrol it is called oxygenate, as it brings oxygen into the fuel blend. As can be seen from Table 1, 35% of ethanol's weight is oxygen. This oxygen doesn't participate in the combustion event and thus decreases fuels energy content and because of this the air fuel mixture of fuels containing oxygenates must be higher. Why do we have to have ethanol in our fuel? Oxygenates decrease the CO and HC emissions, especially on older vehicles. 95E10 is said to decrease CO-emissions by 25-30% /9, p. 128/. On the other hand, acetaldehydes are reported to increase by 73%, on older reports even by 150-200%. Acetaldehydes are carcinogenic, cancer inducing /9, p. 129/. Acetaldehyde emissions are non governed emissions.

A lot of research has gone into using methanol as a transportation fuel. It has many of ethanol's good qualities, but its tendency for corrosion and thus the use of more resilient materials needed and the low caloric value has steered research away from it.

Methanol has 50% of its weight in oxygen. If we compare methanols and gasolines caloric values from Table1, we can see that methanol has less than 50% of petrol's energy content.

The use of biodiesels are probably the easiest way of going green for the customer, as all diesel engines are able to use modern biodiesel fuels. Consumer should be able to get the similar fuel economy using biodiesel as when using petroleum diesel. As with ethanol there are many blends of biodiesel ranging from B100 (no petro-diesel) /10/ to regular petroleum diesel (no bio component). In cold climates biodiesel blends can suffer from high cloudpoint, but apparently Neste Oil have overcome this problem in their new NExBTL biodiesel as they were conducting testing of a new B100 blend of their second generation biodiesel in the first half of 2010 /10/. The long term storage of biodiesel doesn't differ from petro-diesel storage /11/.

Hydrogen isn't very popular fuel of the future in the internal combustion engine. The BMW is running 100 7-series cars on hydrogen, other car manufacturers are investing in fuel cells using hydrogen as a fuel. Using hydrogen as a fuel for vehicle is a challenge for its volatility which makes storing it in a car demanding. In the light of emissions I think it is superior to all other fuels as when hydrogen burns it only forms water. There is considerable efficiency difference depending on how the hydrogen is being used. Using hydrogen in a fuel cell to run electric motors is 12-16 % more energy efficient than burnt in internal combustion engine /4, p.328/.

Liquid Petroleum Gas (LPG) is used in spark ignition engines in conjunction with petrol or in a standalone configuration. LPG systems form air fuel mixture like most petrol engines by injecting liquid fuel into intake manifold. Storing LPG in a car takes extra fuel tank in which the fuel is being storied under pressure. The advantages of LPG in comparison to petrol are the non-controlled vehicle emissions. Legislation controlled emissions are only slightly lower than in petrol fuelled vehicle but the non-controlled emissions that are carcinogenic are significantly lower /4, p.327/.

At the beginning of automobiles or horseless carriages electric vehicles were beaten by combustion engines superior speed and range. Now electricity is coming back into vehicles, first in hybrids and slowly as a sole means of propulsion. Electric motors

have many virtues as they are simple in construction, have good efficiency and produce maximum torque from low revolutions. The main problem in electrifying cars is how to store enough electricity to ensure adequate range for the vehicle. A range of a few kilometres is sufficient for a golf cart, fifty kilometres is a plenty for a city car. But as the range, ease and speed of refuelling are compared to internal combustion engines today's bulky battery driven electric cars just can't compete. Combine electric motor driving the wheels, with smallish battery pack and a range extender in a vehicle and this creates worthy option for vehicles powered solely by internal combustion engines. Range extender can of course be pretty much anything from a small combustion engines running at optimum revs or as Jaguar did with their concept car in 2010, Figure 3, a pair of micro-turbines running two generators recharging batteries or alternatively offering more power for the driving motors /12/.

FIGURE 3. Jaguar Project C-X75 /12/.

TABLE 1. Properties of fuels and hydrocarbons /4, p. 331-332/, /13, p. 8/.

Substance	Density, kg/litre	Main constituents, %/weight	Net caloric value, MJ/kg	Ignition temperature, ^{o}C	Air requirement, theoretical kg/kg
Gasoline	0.75	86C, 14H	41.5	~ 350	14.7
Ethanol	0.79	52C, 13H, 35O	26.8	420	9
Methanol	0.79	38C, 12H, 50O	19.7	450	6.4
Diesel	0.83	86C, 13H	43.0	~ 250	14.5
LPG	0.54	C3H8, C4H10	46.1	~ 400	15.1
Hydrogen	0.09 kg/m3	100H	120	~ 560	34
E85	0.78	57C, 13H, 30O	29.1	*	10

***Depends on percentage and type of the hydrocarbon**

3 MATERIALS

There are some stories how ethanol is this and does that. Firstly it isn't the ethanol that does the damage to metals but what it brings with it. Ethanol is hygroscopic, it absorbs water easily. Now it's the water that helps to dissolve corrosive salts and the salts do the damage to the metals /5, p. 16/. On the other hand VTT concludes that adding ethanol up to 10% does not create any transformation in tested materials. The tested materials were designed to work in or close proximity of petrochemical fuels; all materials do not behave similarly to these materials tested by VTT.

Disintegration of plastics and rubbers used in the fuel system are the biggest concern when using fuels with high concentrations of alcohols. According to VTT report on bio fuels safe distribution, there is very little consumer can do to guarantee his/her modified fuel systems materials will be able to withstand solvents absorbed by plastics and rubbers. Only way to have some reliability is to purchase seals, tubes and connectors from a major vehicle manufacturer that have done proper material tests. VTT found out in their tests that even materials that were appointed the similar names by two different manufacturers behaved differently /5, p. 17/.

Metals tested by VTT for their report on bio fuels safe distribution /5/ concludes that only ethanol affects metals by corrosion and lead to zinc erosion in brass. Stainless steel is able to withstand all fuels without corrosion. Aluminium in pure form is not a good material to be used in contact with fuels containing ethanol, but properly alloyed aluminium can be as durable as stainless steel. U.S. Department of Energy gives some advice on metals in their Handbook for handling storing and dispensing E85 /13, p. 12/ that are in line with VTTs findings.

4 ENGINE, COMBUSTION AND EXHAUSTGASSES

Nissans SR20DET is a four stroke petrol engine. The strokes are called intake-, compression-, work- and exhaust strokes. Prior to intake stroke, an intake valve opens allowing fresh air/fuel mixture (air charge) to enter the cylinder. There is a small overlap before exhaust valve closes cutting a direct route into the exhaust manifold. Air

charge is pushed into the cylinder after the piston, which is pulled towards the bottom dead center (BDC).

When piston reaches its further most position from cylinder head it has reached BDC and is stopped to begin its way towards top dead center (TDC). After piston has left BDC the inlet valve closes and as piston is forced towards TDC by rotating crankshaft, the air charge is being compressed. Before piston arrives to TDC sparkplug ignites the volatile air/fuel mixture which by burning rapidly begins to expand. Expanding gasses reach its peak pressure after the piston has passed TDC.

Now that pressure is pushing piston again towards BDC and forcing crankshaft to rotate, thus creating torque. Before piston reaches bottom dead center an exhaust valve opens, releasing the decreased pressure into the exhaust manifold. Before piston reaches top dead center an inlet valve opens and another revolution of the motor begins.

As SR20DET is equipped with a turbocharger not all of the exhaust gasses energy go to waste as the remaining pressure and momentum of the spent air charge is being used to run the turbine that turns the compressor via common shaft. The function of a compressor in a turbo is to create a positive pressure to the inlet manifold to increase the amount of air rushing into the cylinder during intake stroke.

Engines without direct fuel injection run on a very narrow fuel/air mixture of approximately 14.7 kilos of air to 1 kilo of petrol. As turbocharger adds air into the cylinder the engine management system must add fuel to keep the charge stoichiometric. This of course increases the power output of the engine. The stoichiometric mixture of air and fuel is also known as lambda value one, $\lambda=1$.

Engines running on gasoline, no alcohols added; at stoichiometric mixture require ignition energy of 0.2mJ. When direct injection engine running in lean mode, $\lambda>1.4$, can require energy up to 3mJ. This also applies to engines running rich, $\lambda<1$. Largest power figures are achieved at around $\lambda=0.9$. The stoichiometric mixture is used because it gives the best compromise between fuel consumption, power and emissions. The three-way catalytic converter works best at lambda value 1 /4, p.496 – 500/.

Running manifold fuel injection (MFI) engine on one of the ethanol blends complicates things a bit. As Table 1 shows us, the energy content of these fuels are lower than plain gasoline. Also you can notice that the stoichiometric value for each blend is slightly different than the next. To compensate for this ECU should have means to determine before fuel injectors what kind of fuel is in the fuel lines. DTAfast S80 PRO is calibrated to use GM's fuel composition sensor to do just that, also with closed loop feedback from lambda sensor it has the possibility of adjusting the air/fuel mixture accordingly.

I haven't been able to locate information from a reliable source concerning what happens within the combustion chamber when running on fuels that consist mainly of ethanol. Also the changes in exhaust temperatures would have been interesting information. I would imagine that the ECU should compensate for ignition advance as well as to the amount of fuel injected. DTAfast S80 PRO has only one box to tick to tell the ECU that there is fuel composition sensor connected. That apparently enables the engine management system to add fuel and adjust ignition timing when ethanol is being detected by the fuel composition sensor. The change in exhaust temperatures would have been good to know, because if there is bigger heat load with ethanol than petrol it would command a change of exhaust valves.

5 EQUIPMENT AND INSTALLATION

There are probably numerous ways to run an internal combustion engine on different blends of petrol and ethanol. General Motors FlexiFuel vehicles determine the mixture with fuel composition sensor in the fuel line, and oxygen sensor giving information about exhaust gases remaining oxygen content. Ford on the other hand relies on their FlexiFuel vehicles solely on oxygen sensor. To convert an older vehicle to run properly on a fuel that wasn't in production when said car was designed takes new and improved sensors and devices.

Devices controlling the engines functions are called engine management systems or electronic control units (ECU). Other devices are controlled by ECU.

To reliably tune engine to run on varying blends of fuel, I would recommend installing an engine control unit that has the capability of using some sort of fuel composition sensor and a wide band lambda sensor. I chose the engine management device on the basis of Marko Kasurinens Jälkiasennusluistonesto 80-luvun autoon – thesis as it convinced me with the DTAfast devices versatility and ease of installation and setup /14/. As Marko used an older engine control unit that is only available as pre-owned unit I decided to look into DTAfast current selection of ECUs. S80 Pro-device, seen in Figure 4, seems to have all the needed functions and more /15/.

FIGURE 4. DTAfast S80 PRO ECU /15/.

In spark ignition engines the correct timing of spark is crucial. Things affected by ignition timing include produced torque, composition and temperature of exhaust gasses. Timing is controlled by ECU, but there are devices that significantly contribute to the quality of combustion.

DTAfast S80 PRO has its internal amplifier and it can drive independent or amplified ignition coils. As I have established in chapter 4 the energy requirement of running engine with a rich or lean A/F-mixture can be 15 times greater than with a petrol fuel at stoichiometric mixture. Starting an engine with E85 at cold temperatures requires large amounts of fuel. The original Nissan ignition system wasn't designed to run on ethanol and to enhance reliability it needs to be replaced. Nissan 200SX has worldwide enthusiast base. Someone has figured out that there is stronger spark available from Bosch products than with Nissans original ignition coils. These ignition coils, seen in Figure 5, are usually found in cars with a 1.8 litre turbocharged VAG-engine and are direct replacements for Nissans originals /16/.

If possible I would recommend anyone who is in the process of converting their car into a FlexiFuel vehicle to upgrade their ignition system to provide higher energy for the spark plugs.

Spark plugs deliver the spark to the air/fuel-mixture in cylinder. I wasn't able to find any research data to suggest why to change the type of spark plugs on the engine being converted. During the engine management tuning there could be a time to experiment with the spark plugs air-gap. Perhaps with more experience running the converted vehicle, one could try spark plugs with a different heat range. Hotter or colder according how the used spark plugs are wearing out.

FIGURE 5. Bosch ignition coils with aftermarket wiring harness /16/.

Fuels containing ethanol have lower caloric value thus requiring larger quantities of fuel for it to achieve the same power as gasoline. New higher capacity fuel pump, Figure 11, and injectors are required to deliver the extra fuel. DTAfast S80 PRO engine management system controls fuel injectors by pulse width modulation (PWM).

What PWM does is a means to tell injectors how long they must stay open. Example of injectors compatible with Nissan SR20DET-engines fuel rail can be seen in Figure 6. PWM is a very reliable way of measuring the amount of fluids as long as the pressure, time and injectors flow capacity are known.

In a forced induction engine the inlet manifolds pressure varies and thus alternating the pressure difference between fuel rails and inlet manifolds /4, p. 623/. To achieve optimum and predictable performance a precise amount of fuel must be injected into the inlet manifold. This precision is achieved by keeping the pressure difference constant, by regulating the fuel pressure. Figure 10 shows a photo of fuel pressure regulator.

FIGURE 6. Tomei 555cc fuel injectors /9/.

Sensors tell the engine management system various information about the engines functions. Without some of this data the engine simply couldn't work, other information is there to help run it smoother and cleaner. As I want to use as many of Nissans original sensors as possible, it was important that the chosen ECU is able to utilize them.

DTAfast S80 PRO engine control unit is able to use wide range of sensors used by vehicle manufacturers. As my car has been running without sensor related issues I will use Nissans original camshaft-, coolant temperature-, oil pressure-, knock-, vehicle speed-, wheel speed sensors and throttle position sensor. As my cars engine type doesn't use a crankshaft sensor, a camshaft sensor provide the vital information of engine speed and the engines position on its revolution. Seen in the Figure 7 is the camshaft position sensors rotor plate. It has 360 slits for determining engine speed and also four slits for determining piston position; this is usually monitored by crankshaft sensor. In SR20-engines camshaft sensor Nissan uses light emitting- and photo sensitive diodes for signal forming /17, p. EC12/.

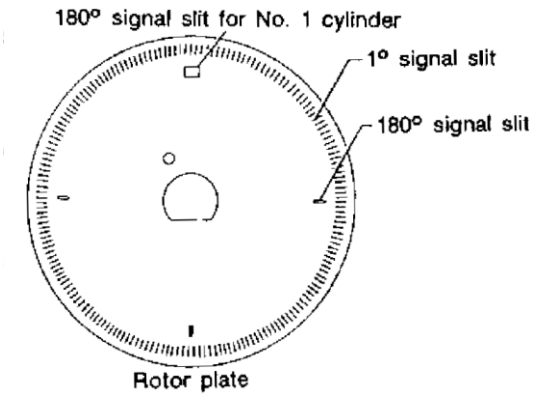

FIGURE 7. Camshaft sensors rotor plate /17, p. EC-12/

For my car to become FlexiFuel vehicle it needs new or improved sensors. Mostly it needs a fuel composition sensor, Figure 8, to determine the mixture of gasoline and ethanol in the fuel line. Without this information the new ECU wouldn't be able to calculate the necessary amount of fuel to be injected.

S80 PRO could use the old oxygen sensor, but as I want to determine the remaining oxygen content with greater accuracy I will install a wideband oxygen sensor, Figure 9. The use of wide band lambda sensor also gives the possibility of running the engine on different A/F ratios than just at lambda value one.

As the new ECU uses manifold pressure and air temperature to determine the amount of air being fed to the engine instead of air mass flow meter, I can remove the old device and install two new sensors near inlet manifold.

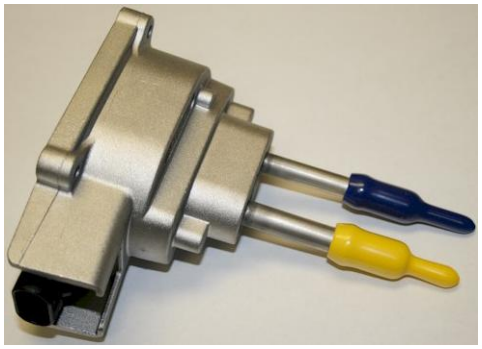

FIGURE 8, General Motors Flex Fuel composition sensor /18/. FIGURE 9. Bosch Lambda sensor LSU 4.2 /19/.

There are a few fuel system components that I should replace to ensure reliability in the future. Nissan hasn't included 200SX or Silvia on the list of vehicles that accept 95E10 as fuel. I would have liked to change my cars fuel tank, fuel lines and fuel rail. The fuel lines I will swap for stainless steel ones as established in Materials section to be able to withstand the attributes that ethanol brings. Fuel tank is such a shape that I haven't been able to find one made from ethanol resistant materials that can fit in the same location as original. There are of course fuel tanks that can be fitted into the boot of a car but as 200SX has a tiny boot to begin with, I am willing to take the risk of increased corrosion.

For other people I would highly recommend to changing their vehicles fuel tank to an item that is made from more corrosion resistant materials. Keeping the original fuel tank of course requires frequent fuel filter changes to allow good clean flow of fuel to the injectors. The rubber tubes connecting fuel line and fuel rail to and from fuel filter will be changed to ethanol resistant items.

Fuel rail is made of alloyed metal and as I haven't been able to find any information of its composition I was going to replace it with an aftermarket item but haven't been able to find a supplier to an aftermarket stainless steel or alloyed aluminium one, this leads me to use the original.

FIGURE 10. Nismo fuel pressure regulator /16/.

FIGURE 11. Walbro fuel pump /16/.

6 CONCLUSIONS

Environmental or political decisions don't usually come into mind when car enthusiasts consider altering their vehicles. What does is cost and possible return for the

modification. Converting an old Nissan to run on fuels containing more than 5% of ethanol is not cheap or easy. I wouldn't recommend taking on this task for anyone else than a seasoned mechanic who has a good grasp on what he or she is doing.

The cost of parts needed can be seen from Table 2, where I have listed prices for the parts I have thought I should replace on my car. The list doesn't contain the small but crucial parts like wires, connectors or tubes just because I don't know how much or how many is required.

TABLE 2. Cost of new equipment.

	Manufacturer	**Part number**	**Price**	**Shop**	
Air Temp Sensor	Bosch	280 130 039	$23.30	www.amazon.com	18 €
ECU	DTAfast	S80 PRO	1 240 €	www.turbotec.com	1 240 €
Flex Fuel Sensor	GM	12570260	248,98 €	www.RockAuto.com	250 €
Fuel injector seal set	Nissan	16618-53J00	$14.00/set	www.nissanraceshop.com	11 €
Fuel Injectors	Tomei	555cc	$609/set	www.z1motorsports.com	470 €
Fuel pressure regulator	NISMO	22670-RR580US	$124.00	www.nissanraceshop.com	96 €
Fuel pump	Walbro	250 litres/hour	139 €	www.z-power.fi	139 €
Ignition coils	Bosch	0986221024	150 €	www.z-power.fi	150 €
Lambda sensor	Bosch	LSU 4.2	75.00 €	www.livefast.fi	75 €
Manifold pressure sensor	Marelli	APS 05/01	151.80 €	euroamericanengineering.net	152 €
Wiring harness	Zuikkis	for S14	150 €	www.z-power.fi	150 €
				Total.	**2 751 €**

Other costs add to the price of parts. Labour, tools rented or purchased, tuning and testing costs can mount to considerable sums.

Labour costs can be reduced by doing installations and the crude tuning of engine management by yourself and with friends. If converted vehicle is intended for the public roads, it must pass yearly vehicle inspection. This comes up as it is illegal to modify a fuelling and ignition systems on this scale without proving that the vehicle can still pass the restrictions set to it.

The yearly inspection that is mandatory for vehicles older than five years contains a measurement where exhaust gasses are measured to expose any faults in the vehicle. Every inspection station has the capability of conducting this test. In Finland there is

at least one test facility, VTT, which is licensed to conduct an approved exhaust gas composition test. This test is extensive and cost approximately 1500€ per test.

If installations of new components and the fine tuning of engine management system have been done successfully and everything is working properly, there should be no problems achieving Euro II levels of controlled exhaust pollutants. The car must pass the Euro II restrictions for exhaust gasses because they came into effect at the beginning of 1996, year the vehicle was first registered for road use.

DTAfast S80 PRO has a self learning mode in which the engine management system dials in on the user set parameters; this should make the fine tuning less time consuming. To ensure the vehicles compliancy before the exhaust composition test the engine management system must be fine tuned. This should be done by experienced mechanic, as every exhaust gas composition test costs the same amount of money regardless the outcome.

If the task of converting the vehicle was given to a professional crew, the total cost of the conversion could be over 6000€. By converting Nissan 200SX into a FlexiFuel vehicle I would be able to use all ethanol and petrol blends, which would be convenient. The reliability should improve as should the fuel consumption due to more accurate sensors and fuel measuring devices.

If we consider money alone, average Finnish car is driven approximately 20 000 km's annually and if we assume the fuel consumption would decrease by as much as 10%, the conversion would save approximately 160 litres of fuel annually. Fuel costing 1.6 Euros per litre; it would take over 23 years to cover the cost of conversion made by professional engine tuning company. Savings could happen assuming that no other expense is increased by the conversion, cost of insurance for example could be affected.

On economical reasons alone it would be unwise to make above described conversion for a vehicle worth approximately 7 000€. It wouldn't add to the value of the car, just make it little bit more environmentally friendly. On the other hand I have seen people spent their time and money on rather questionable hobbies, like flying ultra light air-

crafts. So if a hobby requires a change of engine management system, I will recommend people to add the fuel composition sensor in to their project as it is comparatively affordable investment and it enables another good feature provided by the engine management system.

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