ClubbiesSA

The TV Stars!

The cars were the stars at a a recent film shoot at one of our Burnside third Sunday meetings. Over 30 clubbie cars turned up to show support.

The recent Easter Third Sunday gathering dropping down to just four or so cars, catching almost everyone unawares. However, most people were busy with traditional Easter family activities or on leave.

The Sundays at Burnside have seen some spectacular rollups of clubbie cars. Blessed with good weather, we have had record breaking turn ups of 33 and 39 cars, with all makes and marques represented.

The TV exposure was helpful in increasing the numbers of interested people to meet owners and we can only expect this to increase. The coffee shop has even bought a new coffee maker to keep up.

The addition of a website (see below) will further increase our exposure.

Feast of great articles inside

Check out clubbiessa.com!

Contact Sean Power for further Clubbie information on 0419710434

COMING EVENT TO NOTE

New website for SA clubbies.

Simon Gigney and I have started the development of the ClubbiesSA website that we are going to make one of the best looking resources around. Have got the site already but starting with the graphic designer to make sure the site will look good and be functional and informative.

Check out the address here
http://www.clubbiessa.com/clubbiessa.html

Stan Ward and his Bulant

"The Bulant was built by Bulant Motors at Amaroo Park, NSW, by Brian Rawlings. Brian built a total of 17 cars, commencing in the early 70's, most of them of the racing clubman type like mine. His first clubman was, in fact, a road registered car and is still being driven by a happy NSW owner today. It may not be well known, but Rawlings worked for Gary Cooper at Elfin for a few years in the mid 60's and perhaps was inpired to do his own thing after that valuable grounding.

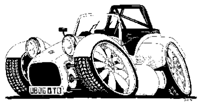
My car was built in 1972 and was designated a Mk 6. The car utilises a 3K Corolla motor, bored to 1295cc, a close ratio Corolla gearbox, built by Needham and also has a Corolla differential. Suspension uses Cortina bits including front Discs, while Cooper discs are used on the rear. The motor is highly developed and produces around 140 HP at 7500 RPM at the flywheel, which is very good for this relatively simple push rod motor and with the car weighing only 360 Kg (before I sit in it) it has a very good power to weight ratio.

This car was raced successfully by Rawlings himself for a couple of years until 1974 when he sold the car to Les Rose. Les raced the car very successfully from 1974 to 1983. The car was rebuilt, around a Mk 7 chassis in 1978, after Les hit a wall rather hard at Amaroo. It was bought by Greg Gardner and raced continuously by him in the period 1983 to 1994.

I purchased the car in 1996 and by that time the car had been modified by the addition of side pods, a wide nose section for streamlining and a swept up rear tail section. These modifcations were allowed for cars competing in Clubman racing in NSW at that time but unfortunately there was no such class running in SA. After sprinting the car for a couple of years in that form (its best time around Mallala then was 1m 17.7secs with 1500cc motor) I set about restoring the car to its original specifications and in September 1999 the car was granted an Historic log book as Historic Group Q.

I have enjoyed competing in historic racing since and have had good success in circuit racing and hillclimbing, both in SA and interstate. The car has won its class in the Australian Hillclimb championships at Bathurst in 2000 and SA in 2005. It holds the Collingrove class record of 33.48sec, was third outright in the Winter Cup, 2004 and has held the SA Hillclimb championships class title continuously since 2000.

My present challenge is to get my modern Elfin Clubman type 3 performing to the same level as the Bulant. To achieve the same power/weight ratio with the Elfin means raising engine power from 170 to 220 HP or shedding lots of body weight from its present 550kg."



Pictures from "The Masters Games 2005"

Jayne off the line!

The Woods Bagot car with clubbies in the background

Stan and his deserved class win

Class winners

Funny story or a Clubbie drivers worst nightmare. – by Jayne White

Guess which Green Puma owner got caught out in that really heavy rain we had on friday afternoon in the clubby.

My brother Craig was at Darlington in heavy traffic when the rain hit. He had people openly laughing at his plight as he sat at the lights while he was drenched and his car slowly filled with water. He took refuge in the shell service station where water washed over the side of the car as he created a wave while negotiating the swollen gutter.

The service station staff bought him out a piece of plastic in hysterics. He finally abandoned the car and went inside to the amusement of other customers.

The service station manager suggested that "he had made about 15 peoples day". Craig reminded him of the hundred or so that were laughing at him when was driving and at the traffic lights.

Run to Birdwood Sunday 19th of March for Mike laws Birthday

The day started out at Burnside for the monthly gathering, sun shining and around 30 or so clubbies in attendance. There was a bit of a buzz with people not quite sure about wishing Mike Laws happy birthday or not… especially those who would not be going on the run to Birdwood.

Mike was blissfully unaware that upon arrival to the Birdwood Motor Museum there would be a BBQ lunch in honor of his 60th birthday.

The Sirius gang had organized for a photographer to capture the moment and run a feature of some description in a magazine… yet to be published??

After a short but moving speech by Sean engines sprang to life and clubbies started to disperse in all directions with around 20 odd cars heading into the beautiful Adelaide hills for the run to Birdwood.

We could not have ordered better weather for it if we tried, the sun was shining, the birds were singing and a light breeze carried the melodious exhaust notes of 20 or so clubbies heading up to Norton Summit.

The Sirius photographer was precariously perched amongst the bushes on a hairpin bend heading up to the Summit happily snapping clubbies as they bunched up and accelerated out of the turn, and with the size of those smiles hopefully everyone remembered to brush their teeth a little longer that morning…

The run through to Lobethal was absolutely brilliant and after a short stop it was off again heading through Gumeracha and on to Birdwood, obviously the Supra club had a similar idea coming up Nth East Rd and there were numerous police sporting hair dryers (no cracks about 3SGE drivers…) We all came through well behaved, were left well alone and proceeded into the sun drenched grounds of the Motor Museum.

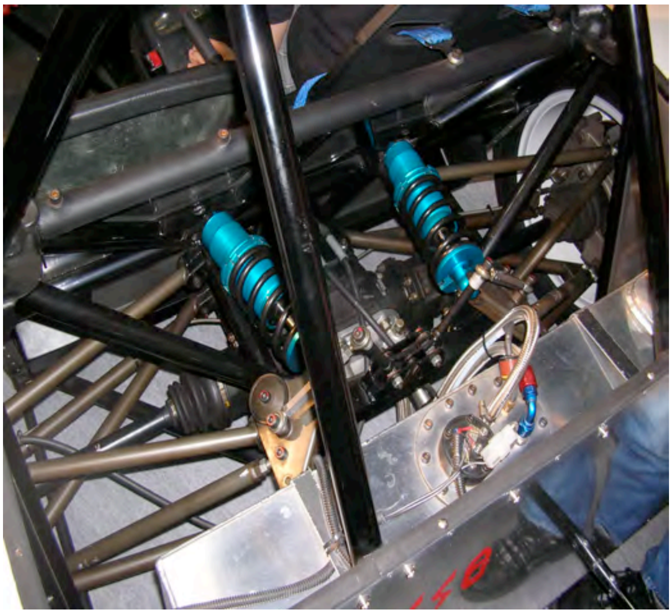
Even upon arrival to Birdwood Mike had not twigged to the fact that his whole family were already there setting up for the celebrations, then the penny dropped and he was overwhelmed that we had all kept him in the dark so well.

All in all everyone had a great time and Paul Daube made an hilarious presentation of an emergency tool kit for the Sirius to Mike for his 60th which had everyone rolling around laughing, a very thoughtful kit and apparently Paul had the store clerk a little concerned as to why he was walking around the shop laughing and giggling whilst looking at their products, after some reassurance that he was not laughing at the products as such he was left to his own devices…

Thanks to all involved for a fantastic day and particular thanks to Pat Umlauf, Sean Power, Jo Delyster(Laws), Barb Laws & Warren Scarman for their assistance.

Tim Laws

Hi Sean,
I took this photo of a clubman suspension built in Japan, while I was at the Tokyo Motor Show last year. - Kevin Wood.



Kym Ninnes leaving on his monumental trip – a wet & drizzly start

Kym & new visitors to Burnside

Climb to the Eagle participant (with my son) – not a clubbie!

Sirii (plural??) all in a row at Burnside

SAE TECHNICAL PAPER SERIES

2000-01-0671

Development of the High Speed 2ZZ-GE Engine

Takasuke Shikida, Yoshikatsu Nakamura, Tamio Nakakubo and Hiroyuki Kawase

Toyota Motor Corp.

The Engineering Society For Advancing Mobility Land Sea Air and Space®
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Development of the High Speed 2ZZ-GE Engine

Takasuke Shikida, Yoshikatsu Nakamura, Tamio Nakakubo and Hiroyuki Kawase
Toyota Motor Corp.

ABSTRACT

The 2ZZ-GE is a sporty 1.8 liter engine based on the 1ZZ-FE, which is currently being mass produced in Japan, USA, and Canada.

It was designed to fit into the same engine compartment as the base 1ZZ-FE, have equivalent vehicle performance as a 2.2 liter engine, and meet TLEV emission standards.

The main features of the 2ZZ-GE are the Metal Matrix Composite (MMC) reinforced all-aluminum cylinder block and the intelligent Variable Valve Timing and Lift (VVTL-i) system. These features were adopted for size and performance.

Other features such as a reinforced ladder frame, and an intake manifold spacer was utilized for a sporty engine sound.

The 2ZZ-GE delivers maximum power at 7600rpm and maximum torque at 6800rpm.

INTRODUCTION

The 1ZZ-FE, base engine to the 2ZZ-GE, was designed with the following targets.

1. To reduce exhaust emissions and improve fuel economy without extra systems. (i.e. direct injection)
2. To make compact and lightweight

The 2ZZ-GE was designed with the following additional targets.

1. Provide high speed performance
2. Retain low speed flexibility
3. Maintain same bore pitch as base engine
4. This was to keep the same outer dimensions
5. Maintain same emission standard as base engine Target TLEV
6. Achieve best power to weight ratio in the field

SPECIFICATIONS

Table 1 shows basic specifications of the 2ZZ-GE engine, in comparison with the base engine, 1ZZ-FE.

Figure 1 shows the outline of the 2ZZ-GE compared to the 1ZZ-FE. The basic outer dimensions were kept equal while performance was increased.

Table 1. Basic Specifications

	2ZZ-GE	1ZZ-FE
Displacement (cc)	1795	1794
Bore x Stroke (mm)	82 x 85	79 x 91.5
Compression	11.5	10
Valve Train	DOHC 4 Chain Driven VVTL-i	DOHC 4 Chain Driven VVT-i
Aspiration	natural	natural
Cylinder Block	Aluminum w/MMC liner	Aluminum w/Cast iron liner
Bore Pitch (mm)	87.5	87.5
Bore wall (mm)	5.5	8.5
Valve Dia. (mm)	Int 34 Exh 29	Int 32 Exh 27.5
Max Power	135kw/7600rpm	107kw/6400rpm
Max Torque	180Nm/6800rpm	172Nm/4400rpm
Size (LxWxH) (mm)	652 x 608 x 659	639 x 586 x 632
Dry weight	115kg	102kg

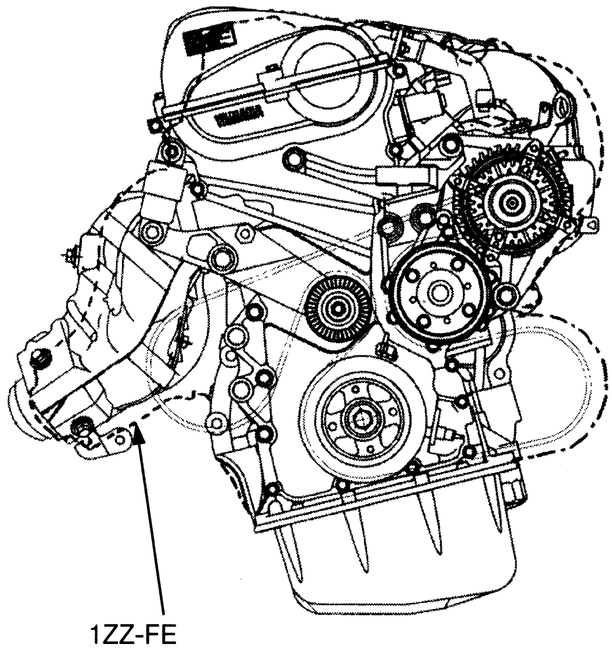

Figure 1. Engine Outline

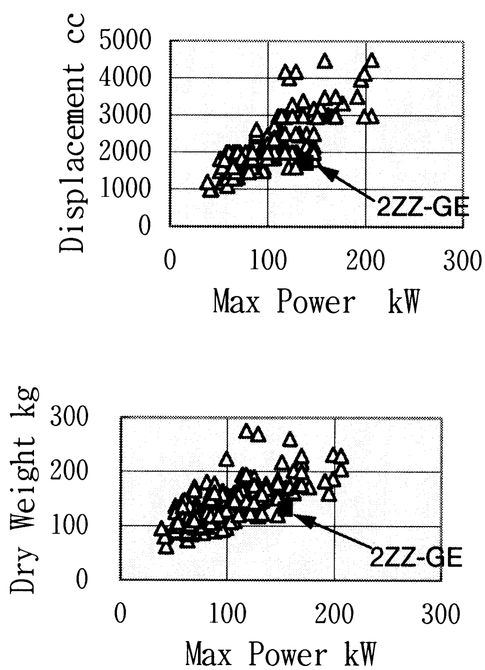

Figure 2. Power to Weight and Power to Displacement Comparisons

Figure 2 shows the Power, weight, and displacement of the engines in the Japanese market. 2ZZ-GE is among the top of all engines.

The MMC all-aluminum cylinder block with a minimum bore to bore wall thickness of 5.5mm made this compactness and low weight possible. The aluminum alloy cylinder bore has been reinforced with ceramic fibers and particles, a combination which we found most favorable amongst thermal spraying, plating, and a cast-wrapped aluminum liner.

Table 2. Comparison of Aluminum Blocks

	Linerless			Cast-wrapped liner	
	MMC	Thermal spray	Plating	Aluminu m	Cast iron
Bore temp.	B	B	B	B	D
Bore rigidity	A	B	B	C	C
Bore strength	A	B	B	C	C
Head Gkt seal	A	B	B	B	B

A; excellent B; very good C; good D; poor

The details of the MMC cylinder block will be introduced in a separate paper.

HIGH SPEED PERFORMANCE AND LOW SPEED TORQUE

The 2ZZ-GE adopted a Variable Valve Timing and Lift system called VVTL-i. The system changes valve timing over the entire speed range in accordance to engine speed and load. This feature is also used in the base engine. VVTLi also changes valve lift and event angles at 6000rpm from low to high. Table 2 shows the changes in valve timing and lift.

Table 2. Valve Timing and Lift

	Exhaust			Intake		
	Open BBDC (CA)	Close ATDC (CA)	Lift (mm)	Open BTDC (CA)	Close ABDC (CA)	Lift (mm)
Low	34	14	7.6	-10 to 33	58 to 15	7.6
High	56	40	10.0	15 to 58	97 to 54	11.2

VVTi mechanism allows the valve timing of the intake cam to be changed continuously in the range shown.

VVTL-i MECHANISM – The valve timing change mechanism of the VVTL-i system, VVT-i, has already been introduced in other papers.

Figure 3 shows the schematic drawing of the lift change mechanism of the VVTL-i. Figure 4 shows the detail of the mechanism set inside the rocker arm.

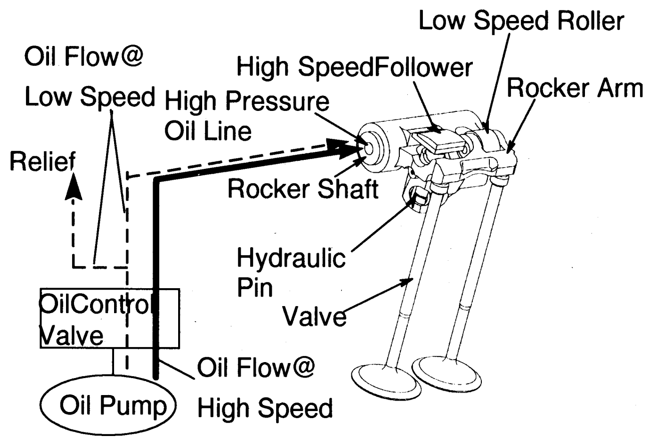

Figure 3. Lift Change Schematic

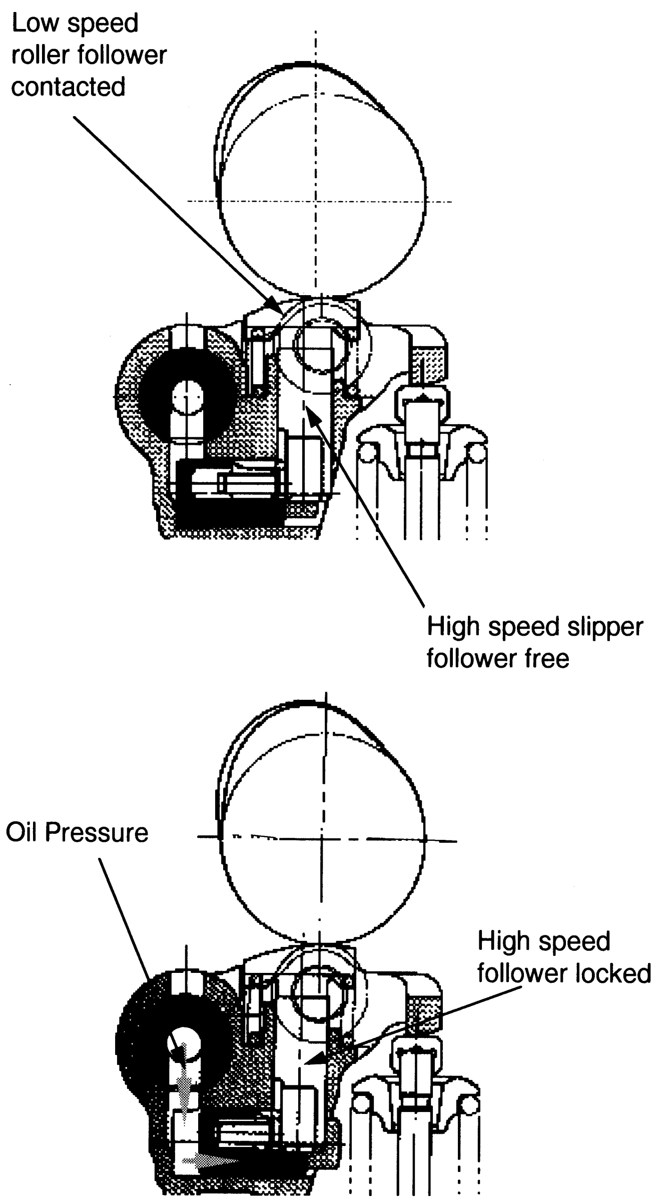

Figure 4. Detail of Mechanism

At engine speeds below 6000rpm, the rocker arm moves according to the low lift roller follower. When engine speed is above 6000rpm, hydraulic pressure is applied to the locking pin, which slides under and locks the high lift slipper follower to the rocker arm. This creates the difference in valve lift, for the rocker arm will now move according to the high lift slipper. When engine speed is below 6000rpm, the return spring pushes the locking pin back, and the high lift slipper is freed.

Choice of Follower – A few considerations were made when choosing a follower which best suited the 2ZZ-GE.

1. To provide high speed performance
2. To have low speed flexibility

These requirements came from the original targets.

Volumetric Efficiency – Angle-lift area of the cam angle to lift curves has a large effect on the volumetric efficiency of an engine. The volumetric efficiency has a large effect on engine maximum performance.

Figure 5 compares angle-lift areas of slipper, direct drive, and roller followers. Throughout the speed range, a slipper shows the largest angle-lift area.

We therefore decided that a rocker arm with a slipper follower would be the best choice to gain high speed performance.

Friction – At low engine speeds, valve train friction accounts for 30% of the total friction of an engine and therefore has a large effect on low speed flexibility of an engine.

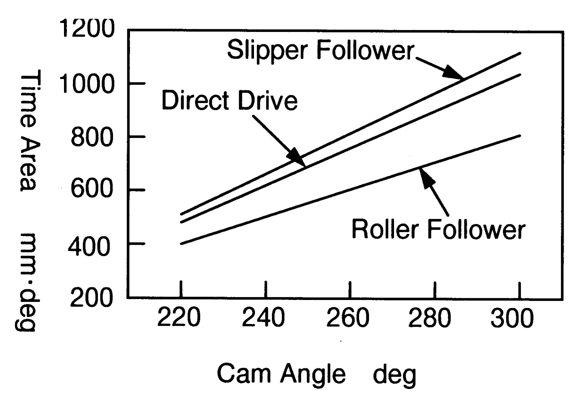

Figure 5. Angle Lift Area

Figure 6 shows friction for slipper, direct drive, and roller followers. Roller shows lowest friction, but at high engine speeds, the difference between followers is substantially smaller.

We therefore decided a rocker arm with a roller follower to be the best choice for low speed flexibility.

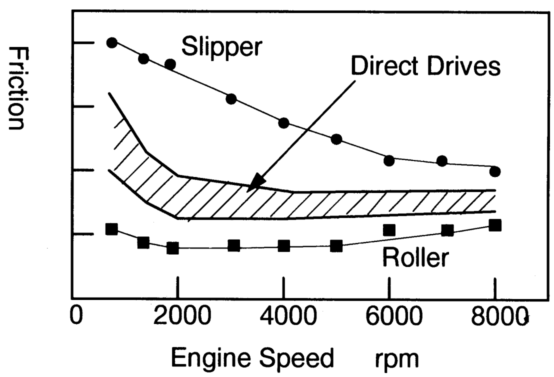

Figure 6. Friction

For the base engine, direct drive mechanism was adopted as the best single choice, but for the 2ZZ-GE, we chose the roller follower for the low speed cam and slipper follower for the high speed cam.

This means two different followers will be set onto one rocker arm.

Technical Problems with Two Different Followers

Material Selection – The roller will be made of hardened steel and the slipper from ferrous sintered metal. For the cam material, ferrous sintered metal was chosen for pitting and scuffing durability.

The cam is brazed to the shaft and sintered simultaneously. Then, two different surface finishes were applied separately to the high and low lift cams.

Special care was taken to control the initial wear of the high speed cam.

Lubrication – Slipper type follower needs to be lubricated for anti-scuff characteristics so shower lines were added to the head cover.

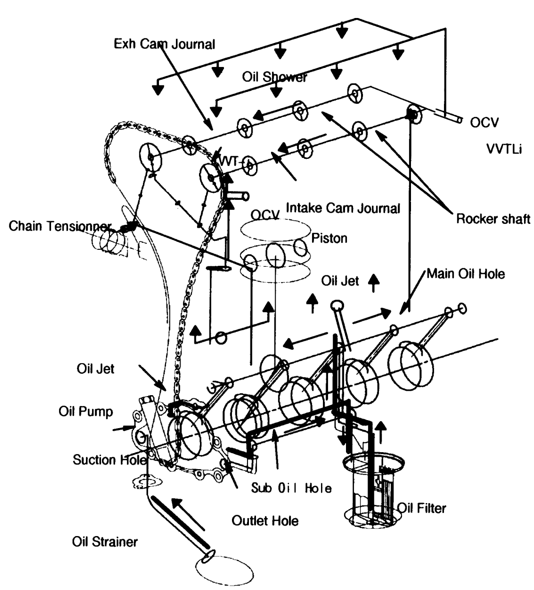

Figure 7. Lubrication System

Figure 7 shows the lubrication system of the 2ZZ-GE.

The hydraulic pressure line which passes through the rocker shaft also lubricates the rocker arms. Oil is fed through this line at all speeds, and at high speeds the oil control valve (OCV) allows additional oil to flow into the pressure line to lock the high speed follower.

Movement of Valve and Spring – Figure 8 shows the actual valve lift curves, before and after improvement of rocker arm rigidity and mass.

Inset shows detail of lift curves at high and low speeds.

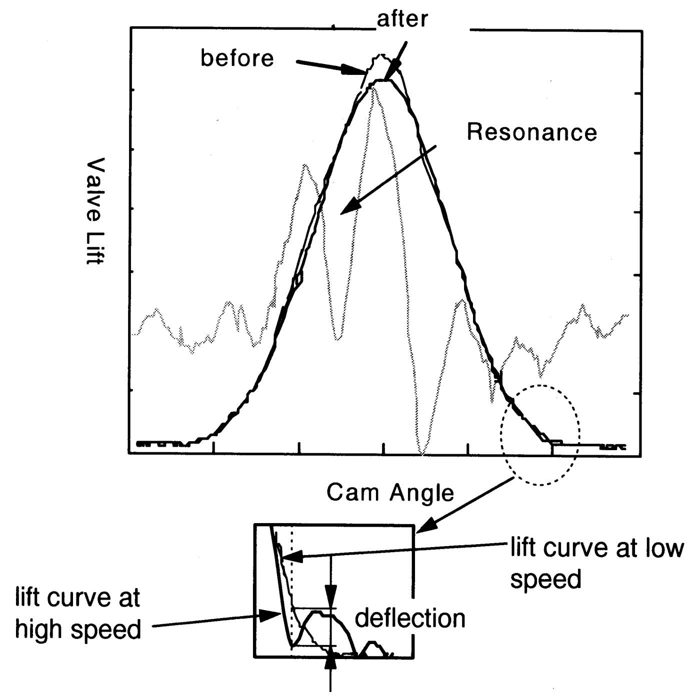

Figure 8. Actual Lift Curves

The original showed a resonance during lift, and a large deflection at valve closing. Resonance affects the reliability of the valve spring, and deflection affects the performance of the engine.

Valve lift acceleration was changed to improve resonance, and rocker arm rigidity was increased to improve deflection.

Lock Pin Durability – The lock pin does not slide under the high speed follower within 1 camshaft revolution. When the overlap of the lock pin and follower is still small, the pin can get kicked back. This will cause a slight wear of the corners of lock pin and follower, increasing the chances for the kick back to occur. When the average of the wears of the lock pin and follower exceeds a given value, the lock pin will always be kicked back, and the valve lift will not switch to high.

We decided the criteria number of low-high cycles based on an actual circuit run, and controlled the wear to an acceptable level. Two main methods were used to control the wear.

- Balancing the wear
  1. The same material and surface finish used for both lock pin and follower
  2. Optimization of corner shapes
- Increasing velocity of lock pin
  1. Increasing available hydraulic pressure
  2. Decreasing lock pin weight

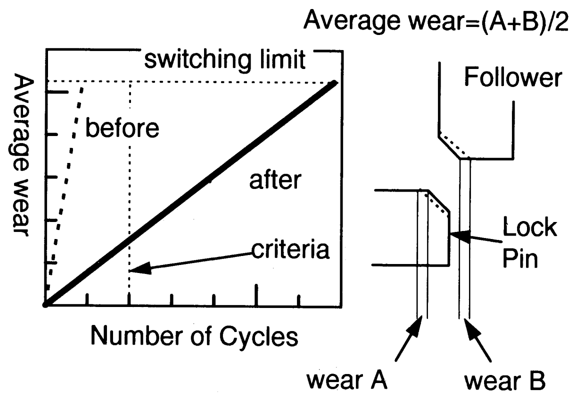

Figure 9. Lock Pin Wear

EFFECT OF VVTL-i – Figure 10 shows the torque curve of the 2ZZ-GE. The torque increase from variable valve timing is approximately 5% below 6000rpm and 2% above 6000rpm. At above 6000rpm, the variable valve lift shows a big torque increase of 22%.

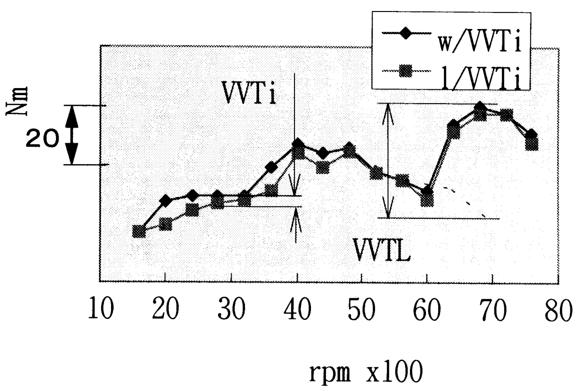

Figure 10. Torque Curve

OTHER FEATURES FOR HIGH SPEED OPERATION

Oil Pan – Figure 11 shows oil pan and baffle plate set on the ladder frame. The oil pan itself is without a baffle. This quickens the return of oil into the oil pan, increasing performance. Air suction was minimized by optimally positioning the suction pipe inlet. The 2ZZ-GE can withstand 1.0G without sucking air.

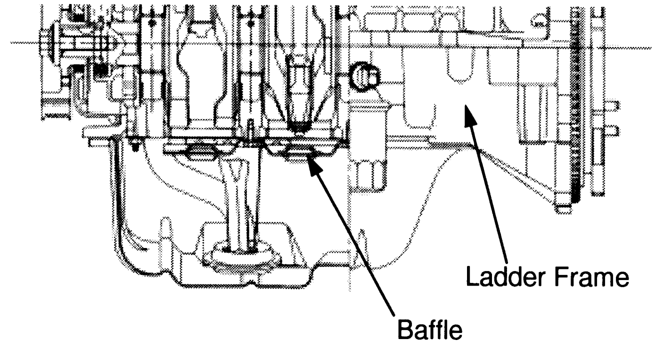

Figure 11. Oil Pan

Crankshaft and Connecting Rod – Table 3 compares the crankshaft dimensions with the base engine. The pin journal diameter was enlarged by 1mm and the stroke was shortened by 6.5mm.

Table 3. Crankshaft Dimensions (mm)

	2ZZ-GE	1ZZ-FE
Main Journal Diameter	48	48
Pin Journal Diameter	45	44
Journal Overlap	4	0.25

As for bearings, the connecting rod uses Kelmet material, the main is aluminum.

Intake Manifold – Figure 12 shows the intake manifold.

A large surge tank (4.5 liters) and intake manifold runners made from aluminum pipes were adopted.

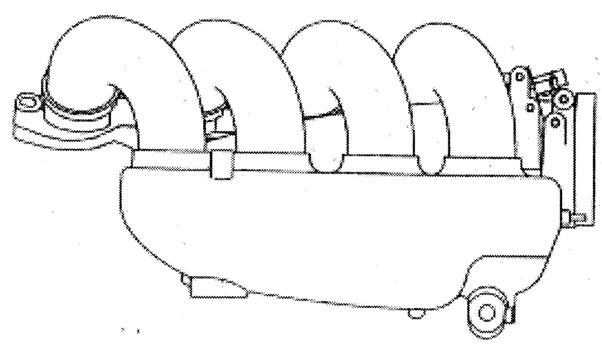

Figure 12. Intake Manifold

Compression Ratio – A high compression ratio of 11.5 was adopted. It was made possible by the adoption of an all-aluminum cylinder block.

EXHAUST EMISSIONS

THETA EXHAUST PIPES – Figure 13 shows the exhaust manifold.

In order to maintain high speed performance while keeping heat loss from the exhaust pipes to a minimum, a cylindrical pipe with a partition wall (theta pipe) was adopted.

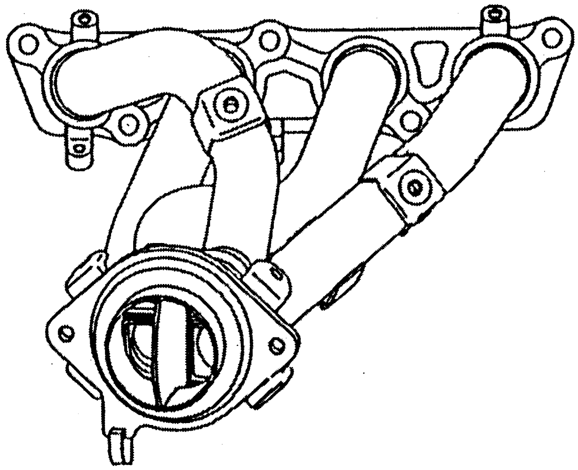

Figure 13. Exhaust Manifold

Emissions and Power – Figure 14 shows catalyst heat-up of dual exhaust pipes and theta pipe.Theta pipe shows quicker heat-up.

In order to meet TLEV standards, the theta pipe without other systems was selected.

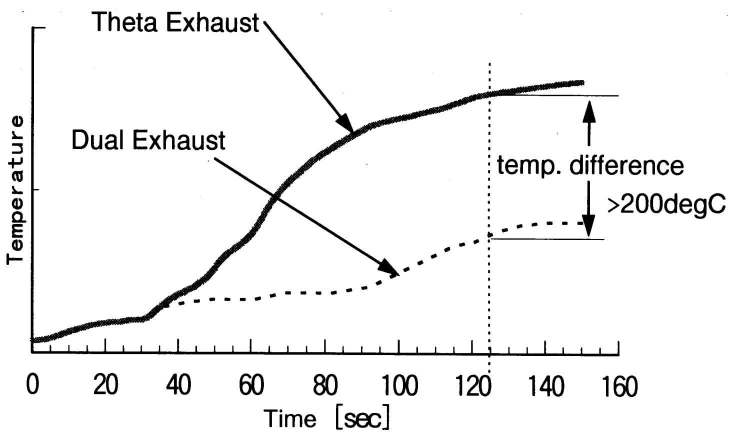

Figure 14. Catalyst Heat-up

Power to Aperture – Figure 15 shows the effect of aperture size between exhaust manifold and front pipe on maximum power. The larger the aperture, the lower the power. The aperture was set to the present level as a compromise between power, manufacturability, and design clearance (heat, vibration, etc).

Maximum power for dual pipe will be at aperture =0.

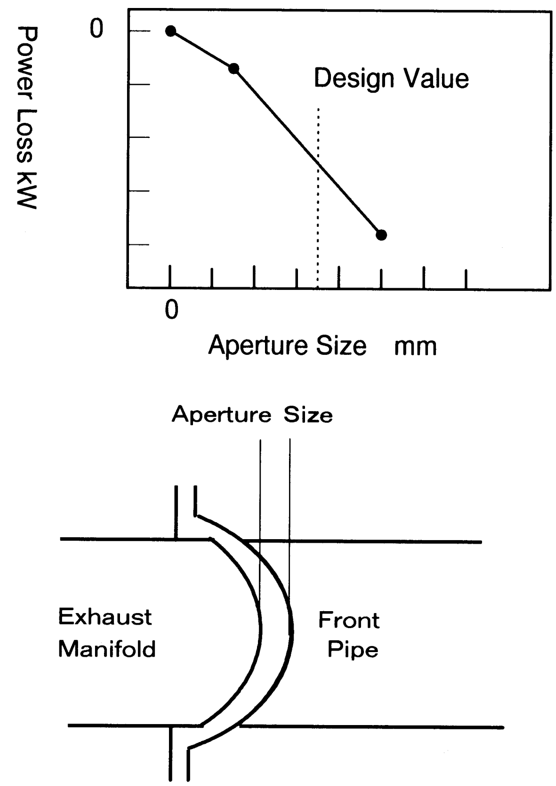

Figure 15. Aperture Size and Power Difference

FUEL ECONOMY

Figure 16 compares maximum power and fuel economy (City and Highway) for engines in the US market. When compared in terms of maximum power, the 2ZZ-GE shows high City fuel economy and is one of the best for Highway fuel economy.

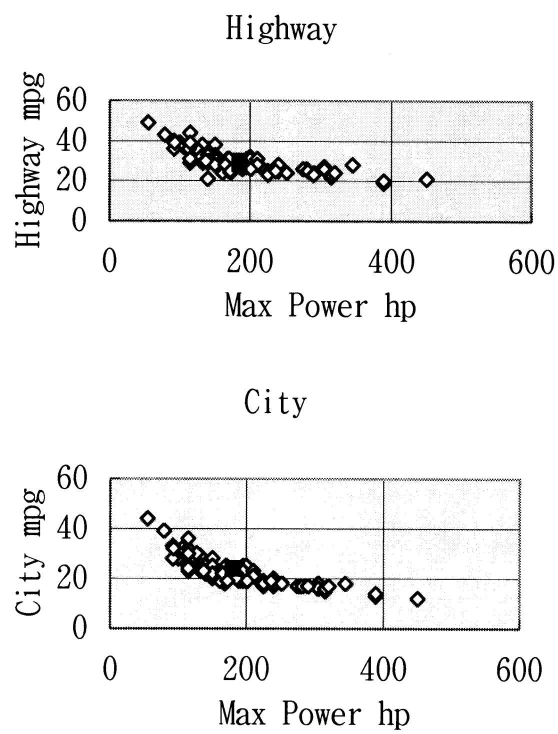

Figure 16. Max Power vs Fuel Economy

ENGINE SOUND

Since 2ZZ-GE is an engine with a high revolution limit, a low final gear ratio of 4.529 was chosen for the manual transmission. Noise suppressing insulation could not be added to the inside of the engine hood, because the hood line was low. Acoustic intensity was measured and a rubber spacer was added between the intake manifold and the block . This filled a volume which was acting as a resonance chamber.

Figure 17 shows the acoustic intensity measurement result.

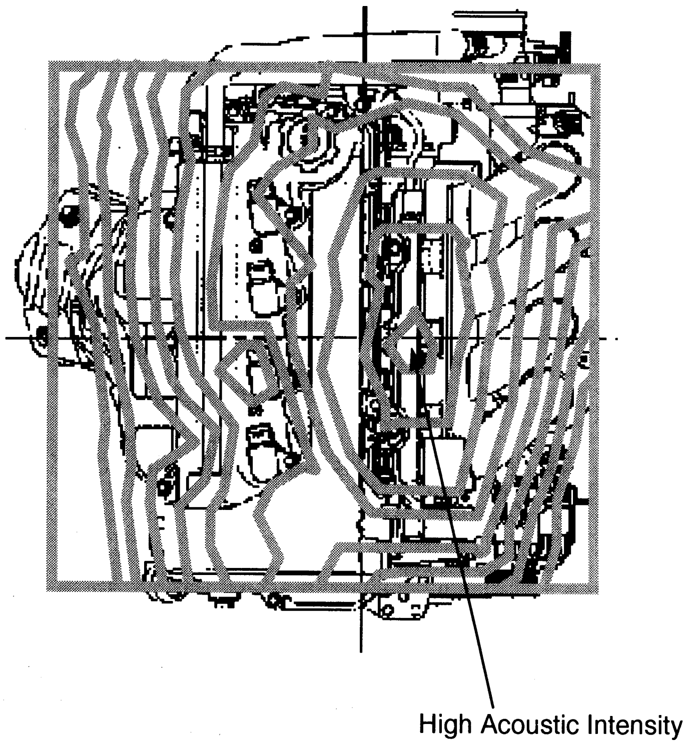

Figure 17. Acoustic Intensity

Improvements were also made to the head cover, timing chain cover, and transmission hole cover using this method.

CONCLUSION

1. A sporty, compact, lightweight, high power, and flexible engine was developed
2. An MMC all-aluminum cylinder block with bore wall thickness of 5.5mm was developed. This contributed to its compactness and low weight.
3. The VVTL-i system, which switches valve lift between low and high, and controls valve timing at the same time, was developed. This contributed to the 2ZZ-GE's high power and flexibility.

ACKNOWLEDGMENTS

The authors would like to thank those both within and outside our company including suppliers for their valuable assistance and advice offered to us. Special thanks to the Yamaha Motor Company for their help in developing this engine.