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Abstract

The SR engine is a new medium-size, all aluminum (cylinder block, head, rocker cover and oil pan) in-line 4-cylinder gasoline powerplant developed as a replacement for CA engine in Nissan's compact passenger cars. The development aim set for this engine was to achieve excellent power output and ample torque in the middle-and high-speed ranges, as well as a clear, linear engine sound up to the red zone. These performance targets have been achieved through the use of the 4-valve-per-cylinder DOHC design featuring a Y-shaped valve rocker arm system. This system allows a straight intake port for high power output and a narrow valve angle for a compact combustion chamber. The result is ample torque output as well as good fuel economy.

THE G20 is added INFINITI channel' sthird 1991 model to the North American and Canada area. The G20 concept centers on driving pleasurs, and the model was designed as a sport/luxury sedan. lie main aim was to develop an outstanding power unit with low fuel consumption, ample torque and a pleasant engine sound. This was realized by the SR20DE engine, which was designed simultaneously with the G20 model.

Engine Design Concept

In the last few years, the tendency was to increase the displacement of power unit for compact passenger car to 2.2 to 2.4 1 to increase the driving power. However, we dared to choose 2.0 1 for the G20. This was an excellent choice because it allowed its highly efficient 2.0 1 engine to be combined with compact design, good adaptability to future emission control regulation, and a high degree of driving pleasure. In the development of this engine, special emphasis was placed on the two following points.

1. A good balance between high output and fuel economy.

2. A pleasant engine sound at all stages from idling to its highest rpm.

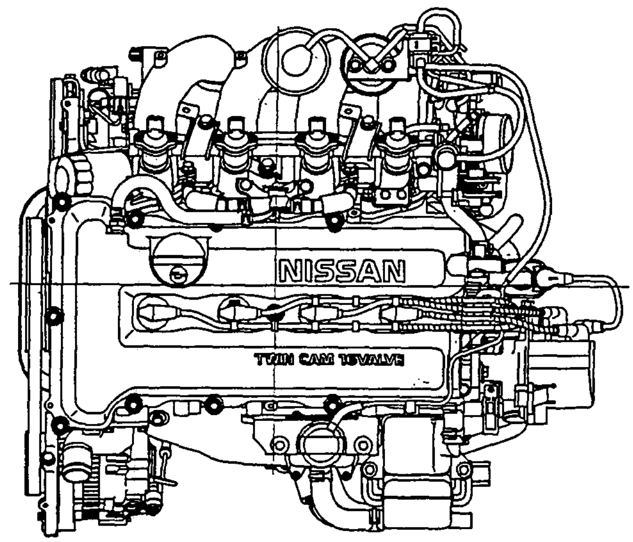
To achieve these goals, Nissan spared no effort, even going beyond their most modem technologies, to design an engine and to select outstanding: parts; thus, a car was created which completey satisfies the above requirements.

Table 1. MAJOR SPECIFICATIONS

Type	:Water cooling gasoline 4 cycle
Number of cylinder, arrangent	:4, in line
Type of combrustion chamber	:Cross flow, pent roof type
Valve mechanism	:DOHC4 valve per cylinder,chain drive
Displacement	:1998cc(l22cuin)
Bore x stroke	:86.0x86.0
Bore pitch	:97.0
Block height	:211.3
Compression ratio	:9.5
Crankshaft journal dia	:55.0
Crankpin dia	:48.0
Connecting rod length	:136.3
Valve dia	:Int 34.0,Exh30.0
Fuel system	:Multi point injection,ECCS
Recommended fuel	:Unleaded regular
Emission control system	:TWC+ramda control +EGR+EM
Max power	:140hp/6400rpm(SAE net)
Max torque	:1321b.ft/4800rpm(SAE net)
Dimension(LxWxH)	:685x610x615

Overview of the SR20DE engine

A cross-section of the SR20DE engine is shown in Fig.2. Its basic construction and special features are described below. To achieve light weight, an aluminum cylinder block is used. The upper deck is closed, and the skirt is deep. The combustion chamber is of the compact pentroof type with crossflow, and the spark plug is located in the center of the chamber. Two valves each have been provided for intake and exhaust. The valve angle is a narrow 29 degrees. The intake



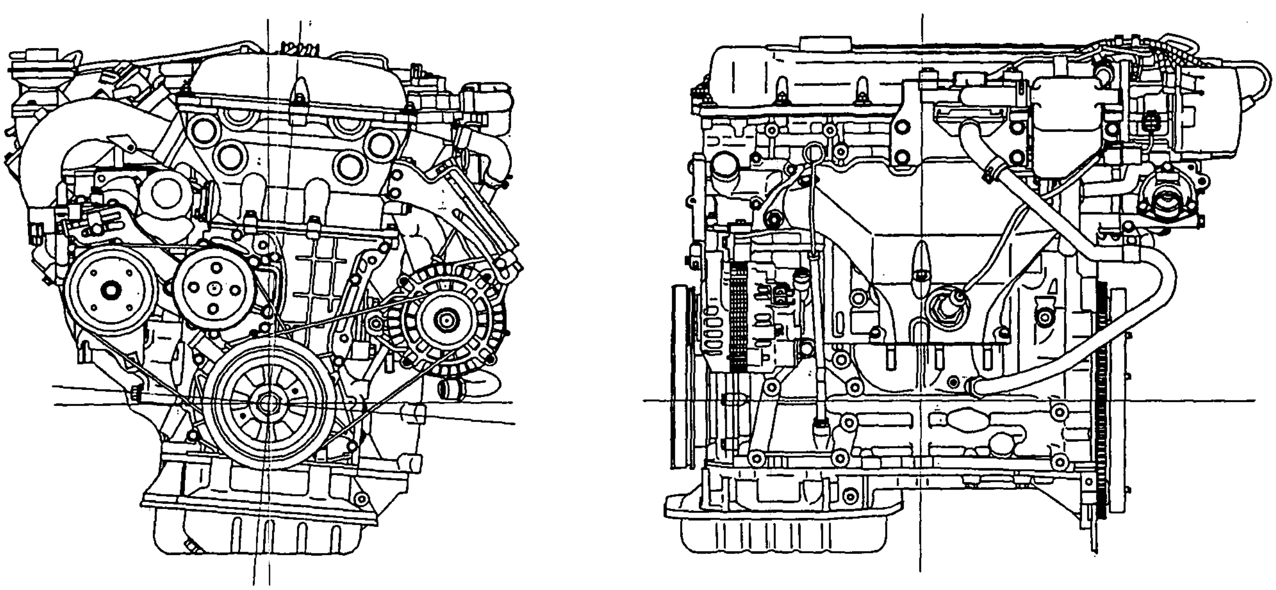


Fig. 1. 3-VIEW OUTLINE DRAWINGS

port is straight, mid an aerodynamic intake port (AD port) is provided. To achieve the highest possible valve lift in the valve train, a rocker arm system adopted, and as the end pivot interferes due to the straight configuration of the intake port, Y-shaped rocker arms were used. The camshafts are driven by single roller chains; the tensioner achieve high reliability and exceptional quietness by the combined use of oil pressure and springs. To enhance the rigidity of the coupling between the cylinder block and the transmission, an oil pan made from aluminum is used. To prevent damage to the bottom part it is divided and formed from sheet metal. This also facilitates maintenance considerably. The thermostat was placed ahead of the water pump and keeps the water temperature at the engine inlet at a fixed level. By employing a special passage to return oil in the aluminum oil pan and a large oil separator, it was possible to obtain excellent separation of the oil and the blowby gas even at high rpms and under heavy loads. It is prevents oil deterioration and extends the time interval between oil changes.

Output Performance and Fuel Economy

1.Combustion Chamber Design

To combine high power with good fuel economy we started with our design of combustion chamber. To improve thermal efficiency and to attain steady combustion, a compact pentroof shape was selected for the combustion chamber, and for uniform propagation of the flame, the spark plug was located in the center. To make the area of the valve openings as large as possible, 4 valves-namely two valves for the intake and two valves for exhaust were provided; to reduce heat losses, efforts were made to reduce the valve angle. The angle was made as small as 29 degrees. (for the result refer to Fig.4)

2.Intake Port Design

After designing the combustion chamber, me designed the intake port. The straight intake port was selected to reduce resistance and to allow intake of the largest possible amount of air. This is the so-called high port configuration which serves

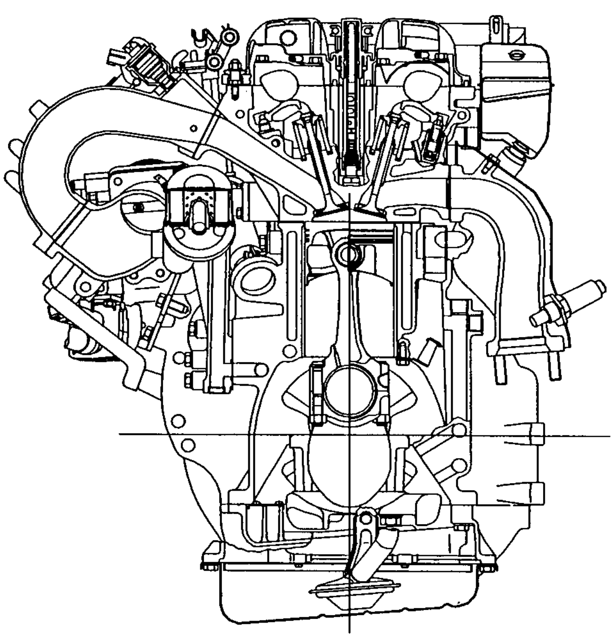


Fig. 2. CUTWAY VIEW

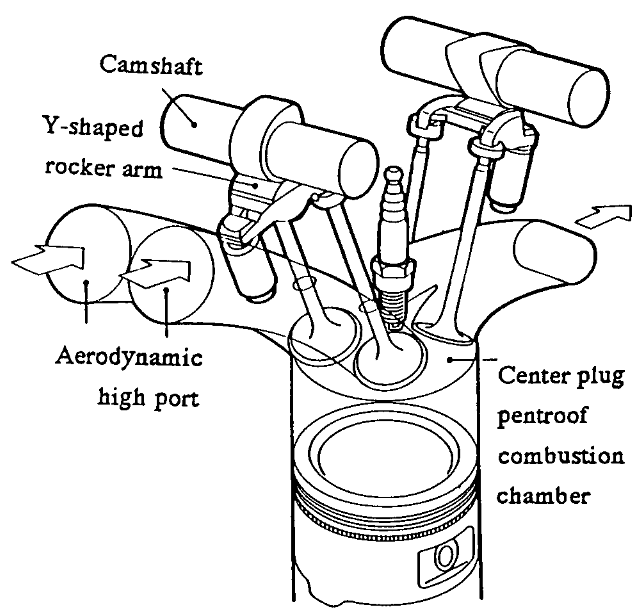


Fig. 3.
3-D VIEW OF COMBUSTION CHAMBER AND VALVE GEAR TRAIN

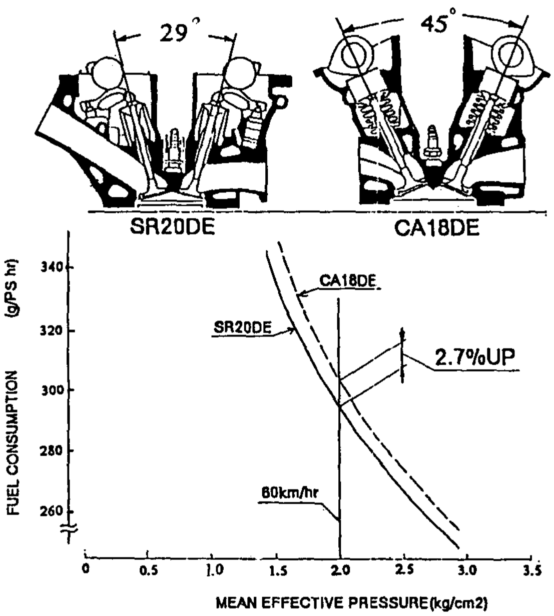


Fig. 4. EFFECTS ON FUEL CONSUMPTION BY VALVE ANGLE

to narrow the angle formed by the valve center and port center lines. The comparatively great length of the port is effective in improving torque in the low and medium speed ranges. (for the result refer to Fig.5) It was possible to make the port 450 mm long without increasing the overall hight of the engine by the designing it as a downward port holding the collector. At the same time, the overhang of heavy weight items could be reduced, and so vibrations could be lessened. An aerodynamic reduced, port (AD port) was used as it reduces the port diameter in the direction from the collector towards the valve. This is the same method as applied for 300ZX,VG30DE and Q45,VH45DE.

3.Design of the Valve Gear Train

The lift of the intake valve was increased to raise the efficiency of the air intake. For this purpose the rocker arm type was selected, because direct drive valves limit the tappet size. To make a small valve angle possible, the end pivot has to be placed outside the valve. However, this leads to interference with the intake port. This problem was overcome by using a Y-shaped rocker arm and by placing the end pivot between the intake ports. This Y-shaped rocker arm has another advantage: it reduce the contact area of the cam followers and also allows a reduction of the inertial weight so that the friction of the valve gear train is lowered.

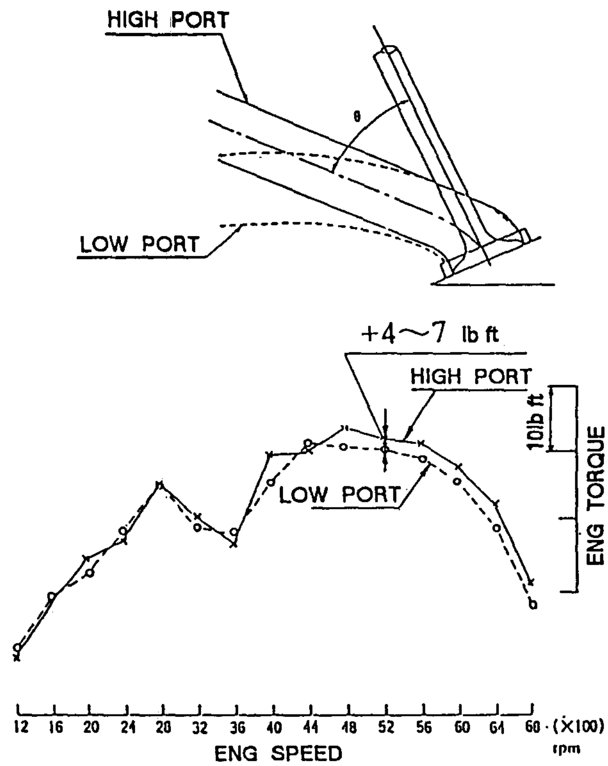


Fig. 5. EFFECTS ON OUTPUT TORQUE BY INTAKE PORT DESIGN

4. Exhaust design

The exhaust system was designed last. An increase in the opening area was made possible by two exhaust valves and increased lift induced by the rocker arm. To suppress the influence of exhaust pulsation, exhaust manifolds 1 and 4, and manifolds 2 and 3 were combined into a dual manifold. The dual part of the exhaust pipe extends until the rear part of the oil pan.

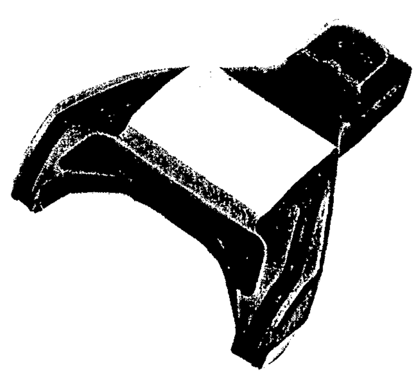
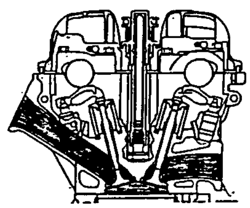
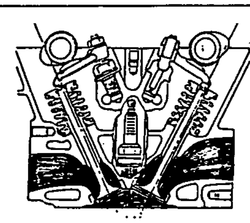
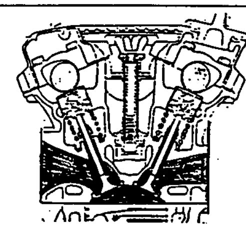
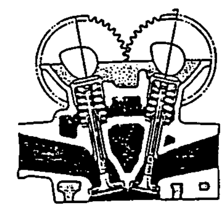


Fig. 6. Y-SHAPED ROCKER ARM

Table 2. COMPARISON OF GAINS AND LOSSES BY TYPE OF VALVE OPERTING SYSTEM

System			Outer end pivot type Y-shaped rocker arm type		Inner end pivot type throttle rocker arm type		Direct operated wide valve narrow angle type		Direct operated narrow valve narrow angle type	
Structural drawing										
Possibility of functional requirements	Higher output	High list construction of valve lift	○	Possibility of increase of lift with end pivot rocker arm	○	Possibility of increase of lift with end pivot rocker arm	×	Restriction of list depending on bucket size	×	Restriction of list depending on bucket size
		High port construction of suction port	○	Possible by disposing an end pivot between the suction ports with a Y-shaped rocker arm	○	Possible	○	Possible	○	Possible
		Aerodynamic port construction	○	Possible	○	Possible	○	Possible	○	Possible
	Reduction of fuel cost	Reduction of dimensions of combustion chamber (narrow valve, narrow angle)	○	Possible thanks to Outer end pivot	×	Impossible due to Inner end pivot	×	-	○	-
		Adoption of friction reducing roller rocker	○	Possible thanks to rocker system	○	Possible thanks to rocker system	×	Impossible with direct operated type	×	Impossible with direct operated type
		Reduction of friction & reduction of inertial mass	○	Possibility of reduction of inertial mass thanks to 2-valve 1-rocker system (Mass invariable even with HCL type)	×	Heavy mass because of 1-valve 1-rocker system	△	Disadvantageous with built-in HLC type	△	Disadvantageous with built-in HLC type
Weight		Cylinder head weight	△	Large head size because of outer pivot	○	Possibility of reduction of dimensions thanks to inner pivot	○	Possibility of reduction of dimensions thanks to direct operated type	○	Possibility of reduction of dimensions thanks to direct operated type

All these details enable the SR20DE engine to attain high output of 140 HP / 6400rpm and 132 lb ft / 4800 rpm while registering simutaneously favorable consumption figures of 32 mpg in highway mode and 24mpg in city mode. (G20,M/T, '91my)

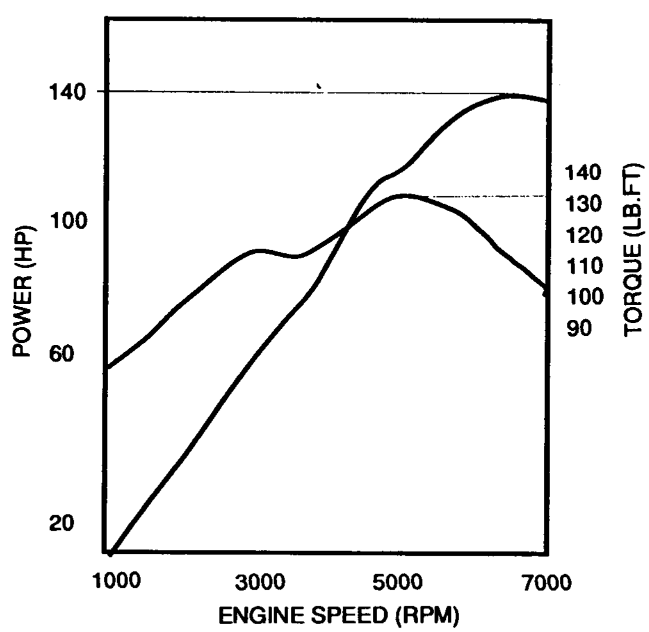


Fig. 7. OUTPUT POWER AND TORQUE

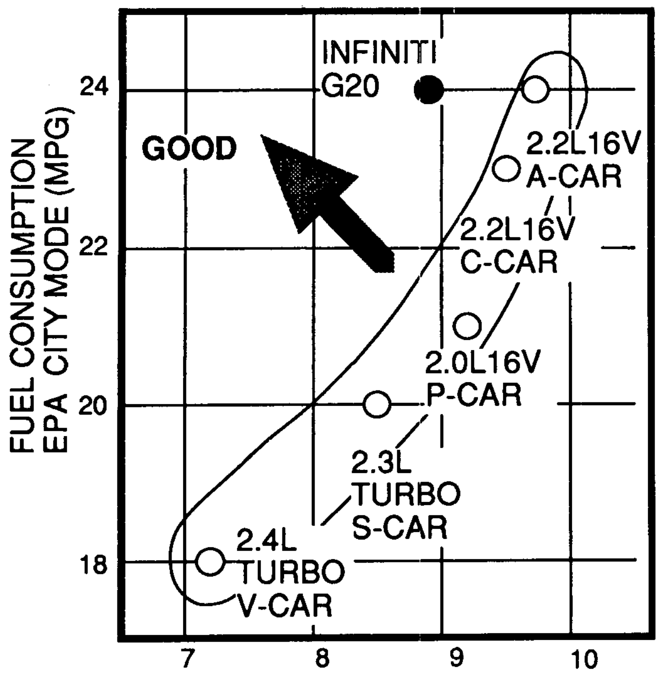


Fig. 8. 0-60mph ACCELERATING TIME (SEC)

Comfortable Sound Characteristics

During the development of the SR20DE engine, great importance was placed not only on reducing the sound pressure level but also an improvement the sound tone and quality, which are important for sensory impressions. To create a pleasant engine sound, the sound components produced by the even-number order (2nd,4th,6th...) in a 4-cylinder in-line engine are of great importance. If the difference between the sound component levels of the odd-numberd and even-numberd order is a flat, a unpleasant feeling is obtained. If in addition the level of the intermediate components is high, a rumbling sound is generated. For this reason, during the design of the SR20DE special care was taken to enhance the rigidity of the engine itself as well as the rigidity of die power train which consists of the connected engine and a transmission. Concretely, a closed-deck aluminum cylinder block, a bearing beam, and an aluminum oil pan were adopted and die engine itself made of closed contruction to improve rigidity. Thanks to these measures, it was possible to reduce the intermediate sound components and those from the odd numberd order. (for the results, refer to Fig. 11) To enhance the power train rigidity even further, the transmission was connected over its whole

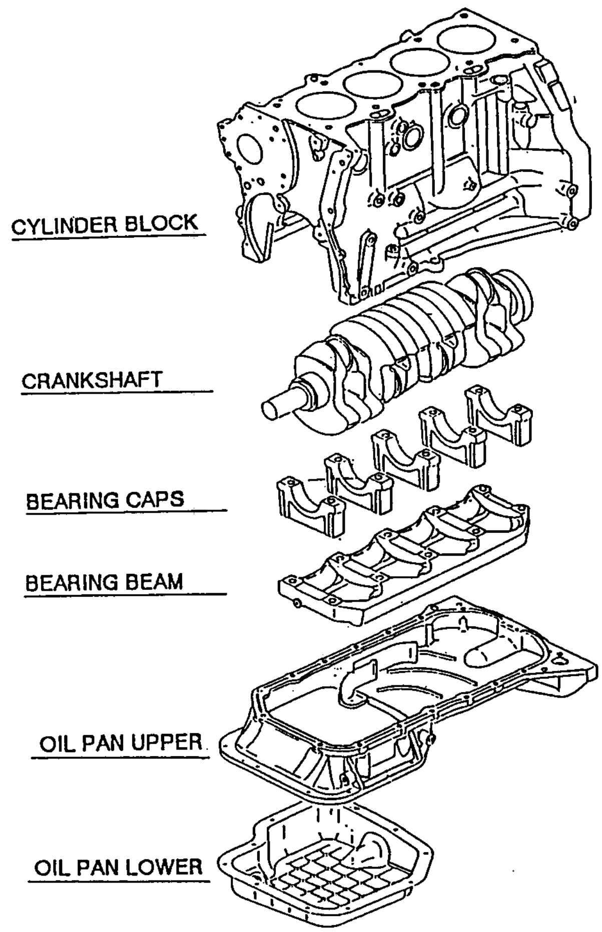


Fig. 9. MAIN PARTS FOR PROVIDING PLEASING SOUND

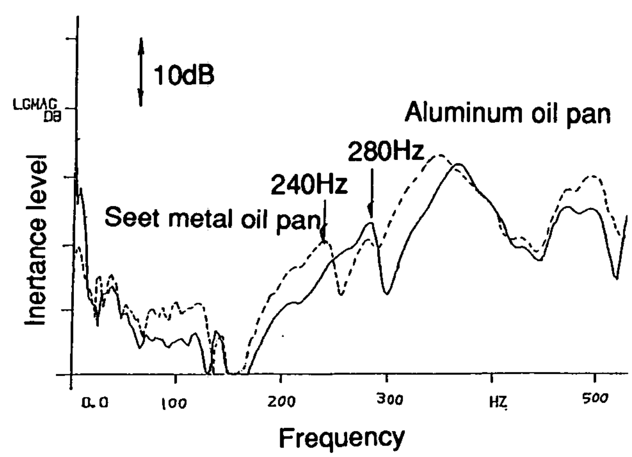


Fig. 10. COMPARISON OF FREQUENCY RESPONSE OF POWER PLANT

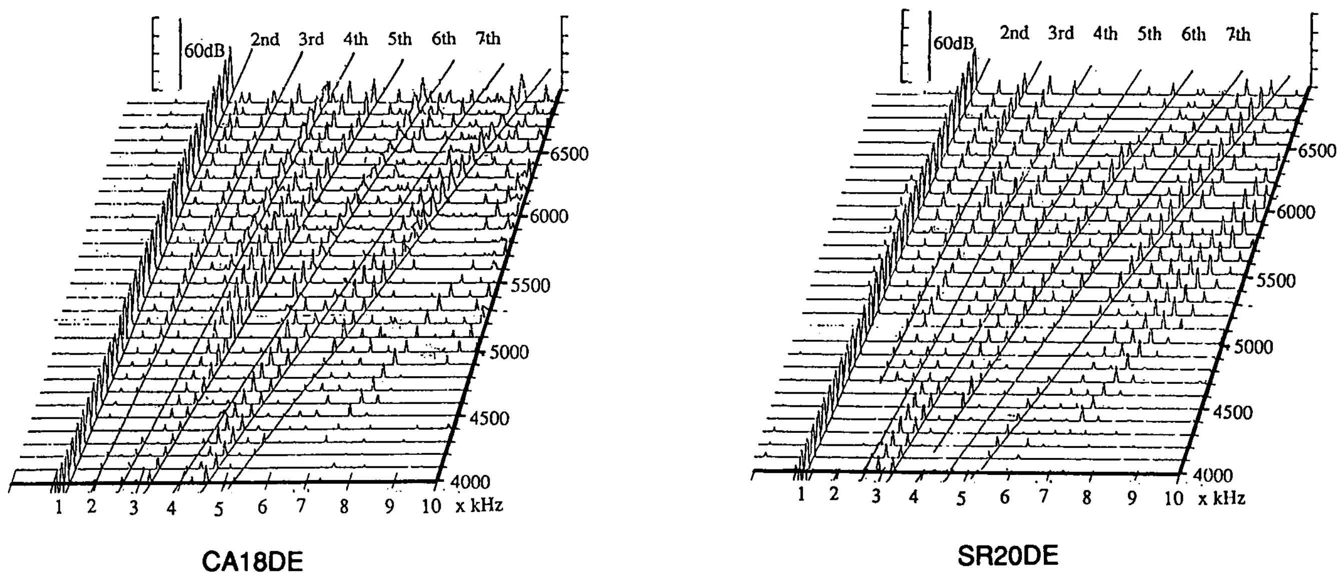


Fig. 11. 3-D MAP OF VIBRATION

circumference to the engine by 10 bolts togther with giving a conical shape to the extreme end of the cylinder block and of the alumnium oil pan. Through these measures, the resonance frequency could be raised to more than 250 Hz and sudden increases in sound pressure were suppressed up to 7500 rpm. (for the results, refer to ihg. 10) To reduce the basic vibration, the crank-shaft has been fully balanced by 8 counter weghts and by forged steel. Crank pully with dynamic damper has been used to suppress die twisting resonance of the crank-shaft. Besides, in line with the efforts for precise tuning, the air cleaner capacity was enlarged, and one Helmholtz type resonatir each was placed before and after the air cleaner to reduce intake noise.

Other Features

1.Reliability and Maintenance Free Operation

Because a single roller chain with hydraulic tensioner drives the camshaft, adjustment and change have become superfluous. It has become standard practice to use a timing belt as the camshaft driving method but Nissan selected the roller chain drive for greater reliability. This has also been use in the VH45DE for the INFINITI Q45. Thanks to the large size of the distributor, the necessary secondary voltage for up to 7500 rpm is amply available, and to the use of platinum tips spark piugs, don’t have to be changed and gaps need not be adjusted for up to 60,000miles. Cylinder head bolts are tightened in the plastic zone to reduce variations in axial force, thus raising reliability. Beside, high reliability in the water or oil seal parts was obtained by liquid packings, which were used nearly everywhere. Blowby gas is perfectly processed even a high rpm and under heavy loads so that the interval between oil changes could be extanded. 7000-->7500 miles.

2.Engine Control and Fuel System

A fully sequential, multipoint injection system for 4 cylinders with centraized electronic control (ECCS) was adopted. Bottom feed type injectors with high heal resistance were used, and a hot film type and bypass system air flow meter used. The emission controls consist of a three-way catalyzer plus a closed loop lamda control and EGR+EAI system. The 16-bit central controller unit reguiates all of the following; the air-fuel ratio with learning control by O2 senser and air frow meter. the ignition timing control, knock control, and the supplementary air during idling with learning control included. (Fig. 12)

Conclusion

Nissan spent about 3 years developing the SR20DE engine. At the same time, several variation (SR20DET, SR20DI, SR18DE, and SRI8DI) were also developed. All these will be the main engine for compact passenger car produced by Nissan in the 1990's. Amongst all these engines, SR20DE, which will be installed in the INFINITI G20, is the best balbnced engine in the SR series. We believe that the goal of this development, namely a good balance between high performance and fuel economy combined with a pleasant engine sound, has been attained by the design technique of the 4 valve DOHC engine which Nissan has been cultivating over many years, and by the solid reliability built into this car by Nissan's production technology. It is expected that in line with the CAFE regulations, new requests for better fuel utilization and for cleaner emissions will be made to this type of car, and we shall continue to meet these demands to supply the market with better and improved engines. Thank you giving us this opportunity to introduce the SR20DE engine.

Acknowledgment

The authors would like to express thier appreciation for being given this opportunity to introduce the new SR engines. The development of these new engines owe much to the enormous efforts and enthusiasm of many people in Nissan's R&D division both in Japan and overseas as well as in the manufacturing, sales and public relations departments. The successful development of these high-performance engines depended to a great extent on their hard work and wealth of experience, engineering skills and expertise. The authors would like to take this opportunity to thank everyone within and outside the company who contributed so much to the development, manufacture and marketing publicity for the new SR engines.

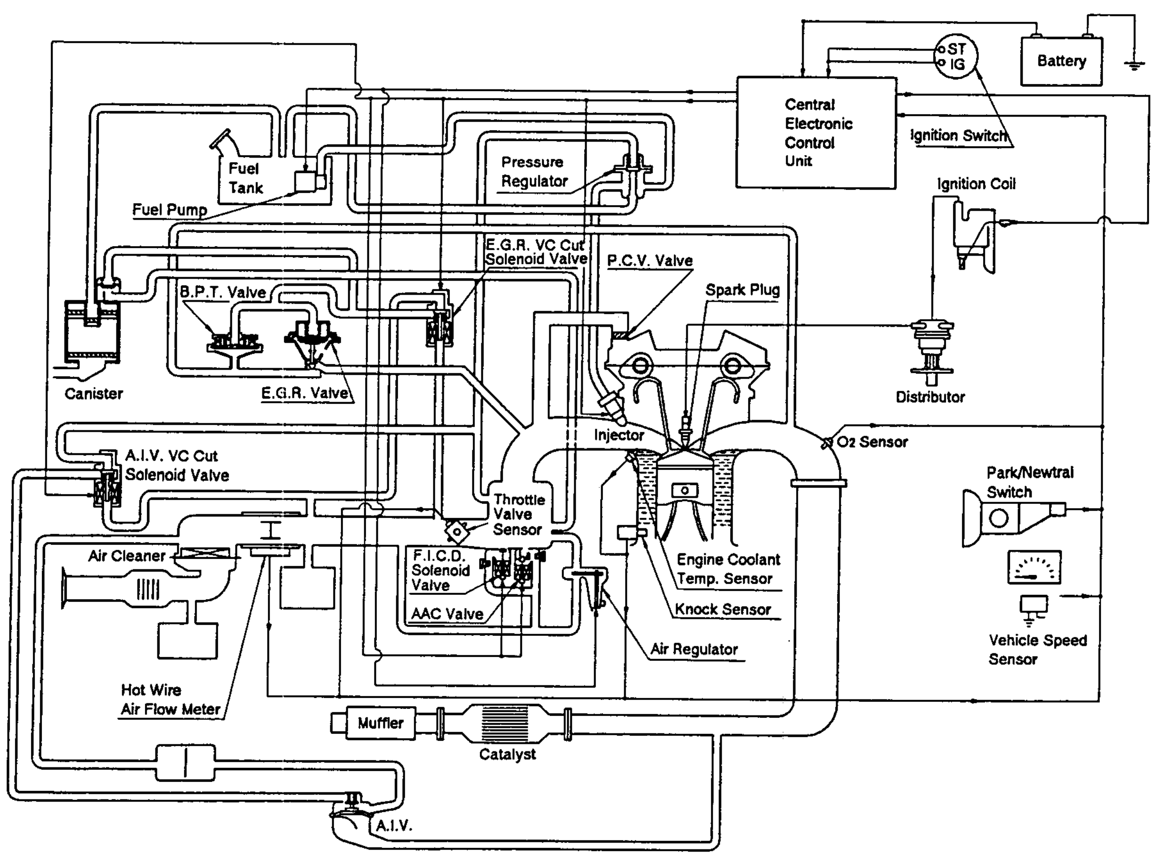


Fig. 12. ENGINE CONTROL SYSTEM

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