Newly Developed V6 MIVEC Gasoline Engine

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Abstract

This paper describes the new V6 engine developed for the new OUTLANDER sport utility vehicle (SUV) for the North American market.

Since 2004, Mitsubishi Motors Corporation (MMC) has been refining gasoline engines for passenger vehicles under the common themes of achieving higher performance, better fuel economy, lower emissions, and weight and size reductions. MMC has thus far launched the 4A9 4-cylinder engines (1.3 L and 1.5 L) for the COLT for Europe in May 2004, the 4B1 4-cylinder engines (2.4 L) for the OUTLANDER for Japan in October 2005, and the 3B2 3-cylinder engines (0.66 L) for the "i" in January 2006. The introduction of the fourth engine, the 6B3 V6 engine (3.0 L), now completes the lineup of these new-generation engines.

Like the other new engines, the new V6 engine offers class-leading performance in maximum output and torque, etc., by employing such technologies as a variable valve timing mechanism, an aluminum cylinder block, and a resin-made variable intake manifold. Furthermore, the new engine weighs approximately 25 kg less and offers approximately 5 % better fuel economy than our conventional 6G7 V6 engine (3.0 L). In addition, through the use of high-performance catalysts, etc., the new OUTLANDER has acquired Super Ultra Low Emission Vehicle (SULEV) certification stipulated in the California Low Emission Vehicle Regulations. Furthermore, by conforming to the zero evaporative emissions regulations, the new OUTLANDER has earned the title of the first qualified Partial Zero Emission Vehicle (P-ZEV) among the compact SUV category models with 3.0 L-class engines.

Key words: *V6, MIVEC, Gasoline Engine, P-ZEV*

1. Targets

The 6B3 engine was designed to excel in quietness and low-vibration which are suitable for 3.0L V6 class engines.

In addition, this engine achieves better fuel economy, lower emissions and weight and size reductions, which are common to all engines in the new engine lineup developed under the engine renovation program since 2004.

State-of-the-art technologies and MMC's know-how are applied throughout the 6B3 engine's design to achieve all these targets.

2. Features

This section describes the technologies employed for achieving the above-mentioned targets for the 6B3 engine. Since many of these technologies (including the components that embody them) relate to achievement of more than one target, they are indicated in **Table 1** to show how the technologies and components correspond to the targets.

2.1 High output and low fuel consumption

This engine achieved class-leading output and fuel economy while achieving the abundant low- and middle-speed torque requested as an SUV.

The first of the main strategies used to achieve this is to improve air intake efficiency by applying the MIVEC™ (Mitsubishi Innovative Valve-timing Electronic Control) system (valve timing & lift switching-type), and also optimizing the intake/exhaust-ports in the cylinder head, and employing a variable intake manifold.

The second strategy is to reduce mechanical friction by using an offset crankshaft and other technologies.

The third strategy is to improve anti-knocking performance by more efficient cooling of the cylinder head/combustion chambers.

The fourth strategy is to adopt twin knock sensors (for sensing & control in each bank) to optimize combustion.

Fig. 1 shows the engine performance curves with wide-open throttle, **Fig. 2** shows the structure and benefits of the MIVEC system, and **Fig. 3** shows the benefits provided by combining the MIVEC system with variable intake manifold.

2.2 Low emissions

The emissions of the 6B3 engine were reduced by the following means: optimization of intake/exhaust port design in the cylinder head; improvement in mixture charging efficiency and combustion stability by using the effect of the low-speed cams of MIVEC; improvement in combustion by ultra-fine atomization injectors; and the upstream heat capacity of the catalyst

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Table 1 Applied technologies and their objectives

Technology/component \ Target	High performance and fuel economy	Weight and size reductions	Low emissions	Low vibration and noise	High reliability
Aluminum die-casting cylinder block		○		○	
Offset crankshaft layout	○				
Resin-made rocker cover		○			
Variable valve timing system (MIVEC) (valve timing & lift switching type)		○		○	○
Cogged belt-driven camshaft		○		○	○
Auto tensioner for the accessories drive belt				○	○
Guideless oil level gauge		○			
Resin-made two-stage variable intake manifold	○	○			
Catalyst integrated in exhaust manifold			○		
Water-cooled EGR					○
Twin knock sensor system	○			○	○
Directly mounted crank angle sensor (stick type)		○			○

was reduced by adoption of the clamshell type exhaust manifold which has a built-in catalyst to make catalyst activation earlier.

Another low-emission strategy is reducing the emissions of untreated exhaust gases directly discharged from the engine (or gases upstream of the catalyst) by the following measure: the setting of compression ratio at a rather low ratio of 9.5:1 to optimize the balance between performance and emission level; the reduction of unburned hydrocarbons in exhaust gases by the reduction of the volume of gaps in combustion-chambers where flame cannot propagate.

Moreover, the OUTLANDER with the 6B3 engine sold in California in the US has been certified as a partial zero emission vehicle (P-ZEV), the first vehicle in the 3.0L-class SUV segment in the world.

This is thanks to measures such as a new high-performance hydrocarbon-trap catalyst and a direct ozone reduction (DOR) catalytic radiator*.

*: Radiator with ozone reduction catalyst (Prem-Air®) (catalyst capable of directly resolving ozone)

2.3 Light weight and compact design

The weight of the engine has been reduced by using aluminum die-casting for the cylinder block and resin materials for the rocker cover and variable intake manifold.

Other parts of the engine have also been made lighter, such as the use of a guideless oil level gauge, direct mounting of accessories to the engine block and shape optimization by CAE analysis. In all, these strategies have reduced the weight of the engine by approximately 25 kg compared with the conventional 6G7 3.0L engine in spite of the adoption of MIVEC system.

Compact design strategies include a single overhead camshaft (SOHC) design to reduce the size of the cylinder head, thus minimizing the overall size of the base engine. In addition, the layout of the accessories as well as their mountings onto the engine was reviewed for optimization and reducing the overall width. As a result, the overall width of the 6B3 engine is 60 mm less than that of the 6G7 SOHC 3.0L engine, which enables the crashable zone to be increased and collision safety to be enhanced.

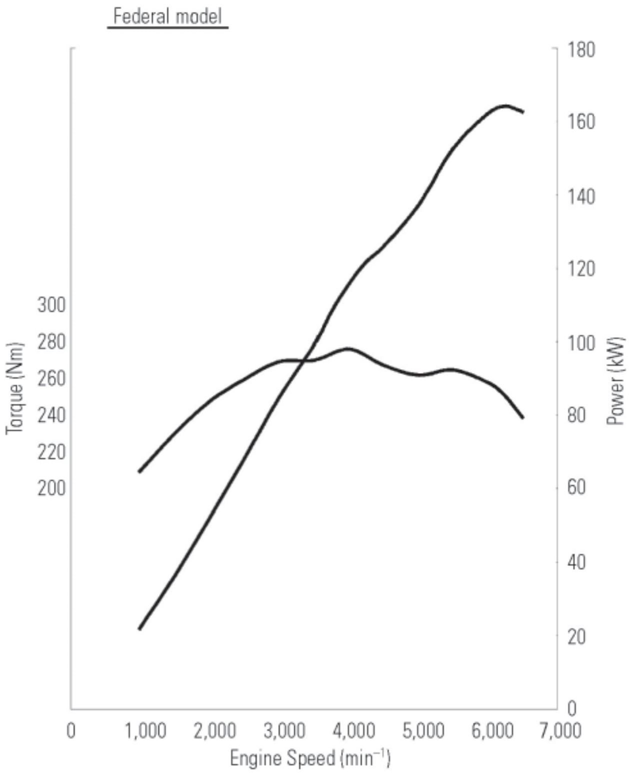

Fig. 1 Engine Performance

2.4 Low vibration and noise

Low vibration and low noise are achieved by substantial improvement of the flexural rigidity of the powertrain (by higher stiffness of the cylinder block and oil pan), and adoption of auto-tensioner for the accessory-drive-belt, and the MIVEC system for stable combustion.

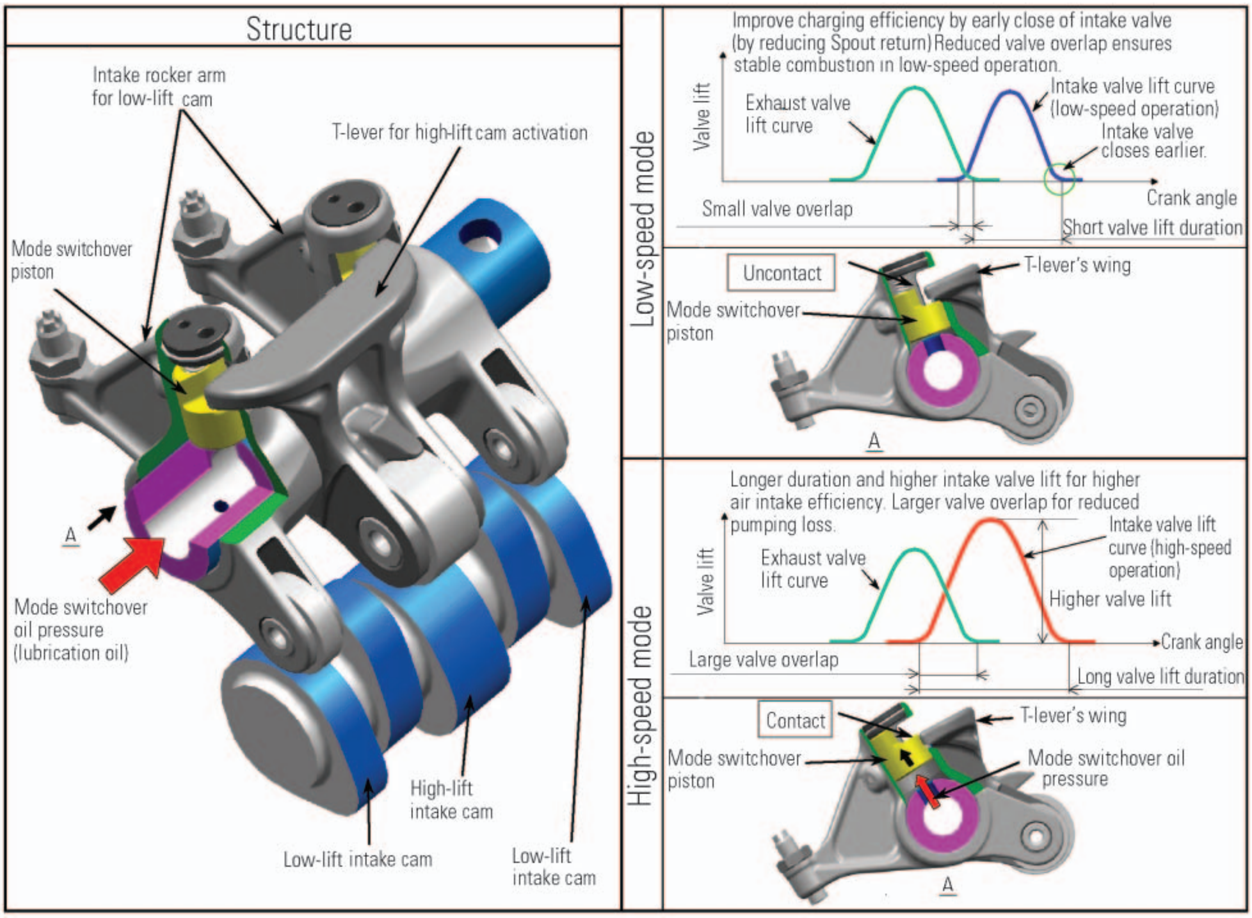

Fig. 2 Operation of MIVEC system

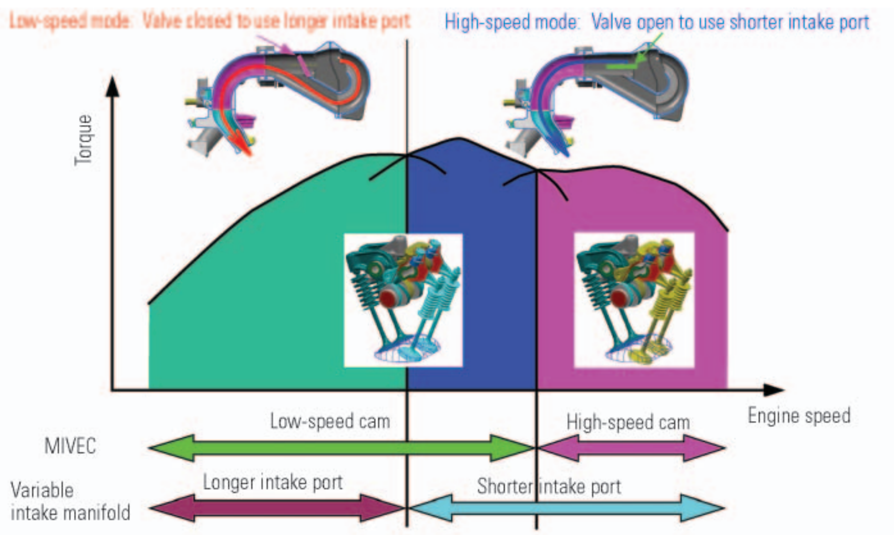

Fig. 3 Combined effects of MIVEC and variable intake system

Table 2 Major specifications

Item \ Engine	6B31 (3.0 L)		4G69 (2.4 L) <reference>		6G72 (3.0 L) <reference>
Vehicle model	New OUTLANDER		Current OUTLANDER		05MY ECLYPS
Market	FED	CALF+[*2]	FED	CALF+[*2]	FED (50S)
Conforming emission control standard	Tier2-Bin5	LEV2-SULEV[*3]	LEV1-LEV	LEV1-ULEV	LEV1-LEV
Displacement (cc)	2,998		2,378		2,972
Bore (mm)	87.6		87.0		91.1
Stroke (mm)	82.9		100.0		76.0
Stroke/bore ratio	0.95		1.15		0.83
Cylinder bore pitch (mm)	98		93		108
Big to small end distance of connecting rod (mm)	145		150		154
Compression ratio	9.5				10.0
Cylinder block material	Aluminum die-casting		Cast iron		
Valve mechanism	Roller rocker arm, SOHC, 24 valves MIVEC (valve timing & lift switching type), auto lash adjuster (exhaust only)		Roller rocker arms, SOHC, 16 valves MIVEC (valve timing & lift switching type)		Roller rocker arms, SOHC, 24 valves, auto lash adjusters
Variable intake manifold	Equipped		Not equipped		Equipped
Recommended fuel	Regular gasoline				Premium gasoline
Maximum torque (N·m/min^{-1})	276/4,000	276/4,000	220/4,000		278/3,750
Maximum output (kW/min^{-1})	164/6,250	159/6,250	120/5,750		157/5,750
Weight[*1] (kg)	155		149		180

*1: Base engine only (excluding mountings for installation on vehicle)
*2: California and other US states that adopt LEV2 emission standard
*3: P-ZEV certified

3. Specifications

The specifications of the 6B3 engine are indicated in **Table 2**.

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