

Development of General Purpose V-Twin Cylinder Engine GCV530/520

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ABSTRACT

A 90-degree V-twin OHC vertical shaft engine for riding mowers has been developed. The V-twin cylinder layout and the aluminum sintered alloy connecting rod enabled the offset between cylinders to be decreased, the weight of the reciprocating parts to be reduced and the vibration level to be reduced by 50% compared to conventional single cylinder engines. The OHC construction with built-in timing belts, plastic cam pulleys and a turbo shaped cooling fan facilitated a noise level reduction of 4 dB compared to conventional single cylinder engines. Further, ease of assembly was improved with the application of uni-block cylinders, common parts for both cylinders and sub-assembly constructions. The engine size and cost are comparable to those of conventional single cylinder engines.

1. Introduction

General purpose vertical shaft engines have a world-wide market scale of approximately 1.5 million units per year, and of these approximately 90% are mounted on home use riding mowers. Price competition in this market is extremely fierce, and low-cost single cylinder engines with a simple construction dominate the market.

Home use riding mowers are generally used for about two hours once or twice per week from spring to autumn. The most common request from users is to “make work easier,” so the engine specifications include ample power and low vibration and noise. In addition, compliance with environmental regulations is also necessary.

The 16 HP general purpose V-twin engine GCV530 shown in Fig. 1 was developed as a new engine to meet these needs. The 14HP specification GCV520 was also

developed to meet a wider range of needs. At the same time, an engine for professional use riding mowers that require additional durability compared to home use has been developed.

2. Development Concept

Development of this engine was based on the concept of realizing the optimum vertical shaft engine for use on riding mowers. The price to power positioning was set as shown in Fig. 2, and a market-competitive engine was developed focusing on the following points:

- (1) Easy to use and not tiring
 - Ample power
 - Low vibration
 - Low noise
- (2) Optimal for the application



Fig.1 External view of GCV530

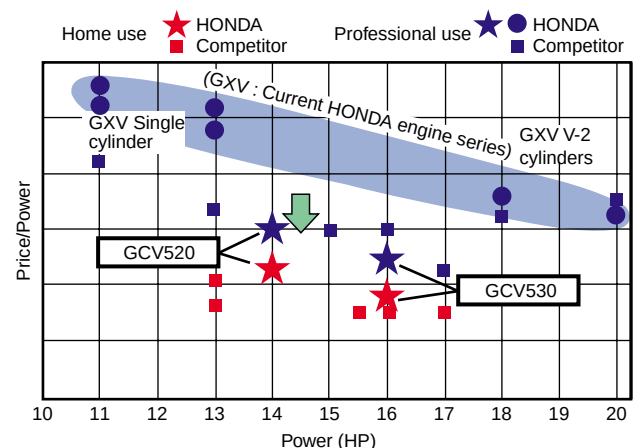


Fig.2 Positioning of GCV530/520

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- Durability (home/professional use)
 - Interchangeability (with single cylinder engines)
- (3) Compliance with environmental regulations
- California Air Resources Board (CARB) and Environmental Protection Agency (EPA) exhaust emissions regulations
 - European Norm (EN) noise regulations

3. Main Specifications and Basic Construction

The basic construction of the GCV530/520 is a vertical shaft type engine with a vertically positioned crankshaft. The displacement was set at 530 cc to provide ample power compared to competitors' 500 cc class single cylinder engines, and a 90° V-twin cylinder construction was adopted to achieve low vibration and noise. The main technologies used to achieve a size comparable to single cylinder engines and ensure market competitiveness while still maintaining low vibration and noise performance are: (1) uni-block cylinders, (2) a valve train with built-in timing belts, (3) aluminum sintered alloy connecting rods, (4) a turbo shaped cooling fan, (5) parts constructions for subassembly, and (6) exhaust emissions reduction technology, etc. In addition, a left-right asymmetrical cylinder layout was used to enable interchangeability with single cylinder engines without changing the mower body construction. GCV520 has a smaller bore carburetor, and the professional use engine has cast-iron sleeves instead of sleeveless aluminum cylinders. Table 1 gives the main specifications of the GCV530/520, and Fig. 3 shows the sectional drawing.

4. Technologies Used to Achieve Target Performance

4.1. Uni-block Cylinders

The uni-block cylinder technology⁽¹⁾ used in the general purpose engine GCV160/135 to achieve compact, light work equipment was adapted to reduce both the size and the number of parts. The cylinder heads and cylinders were integrated, the cylinders were bolted to the crankcase, and the #1 and #2 cylinders shared a common design. As no

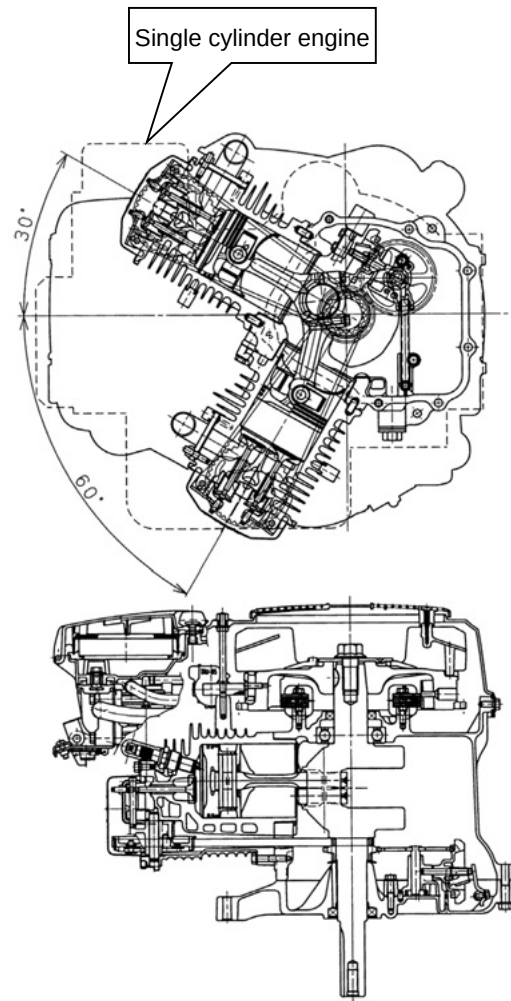


Fig.3 Layout of GCV530/520

Table 1 Specifications

Model name	GCV530	GCV520
Engine type	Air cooled 4-stroke OHC V-90° Twin-cylinder	
Bore × Stroke (mm)	77 × 57	
Displacement (cm ³)	530	
Compression ratio	8.0	
Maximum power (kW/rpm)	11.3/3600	9.7/3600
Maximum torque (Nm/rpm)	34.3/2500	33.0/2500
Lubrication	Splash	
Carburetor type	Twin bore, float, butterfly, side draft	
Carburetor venturi bore (mm)	18	14
Ignition system	Transistorized magneto	
Starting system	Electric/Recoil	
Dimensions (L × W × H) (mm)	456 × 427 × 331	
Dry weight (kg)	30.5	
Cylinder sleeve	Home-use : Aluminum (Sleeveless)	
	Pro-use : Cast-iron	

head bolts are used, it is possible to position the spark plugs roughly in the center, thus improving combustion efficiency. In addition, an OHC valve construction was used to eliminate the cam pulleys inside the crankcase thus reducing the crankcase size and weight. Fig. 4 compares the new construction with the conventional construction.

In terms of specifications, two types of cylinders were prepared: sleeveless aluminum cylinders and cast-iron sleeve molded cylinders, with the former applied to home use and the latter applied to professional use mowers which require higher durability. Furthermore, this construction allowed the specifications to easily be changed according to the application. Fig. 5 shows sectional drawings of the cylinders.

This construction reduced the overall weight of the aluminum die cast parts by approximately 45%. Fig. 6 shows the weight comparison with a conventional twin cylinder engine. Furthermore, in terms of manufacturing efficiency as well, two types of cylinder die cast molds were previously required, but these were integrated into a single type. Also, production was made possible with the same size casting machine as for conventional engines. The crankcase die cast machine size was also reduced from 1,250 tons to 800 tons, thus greatly improving manufacturing efficiency and reducing die investment costs.

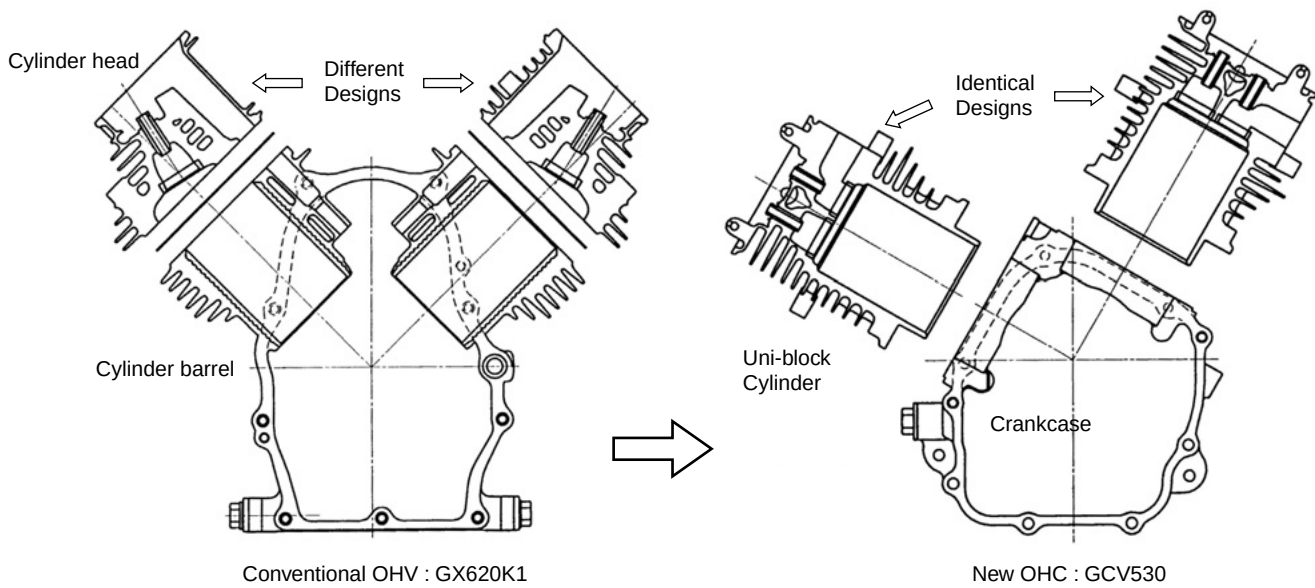


Fig.4 Comparison of cylinder and crankcase constructions

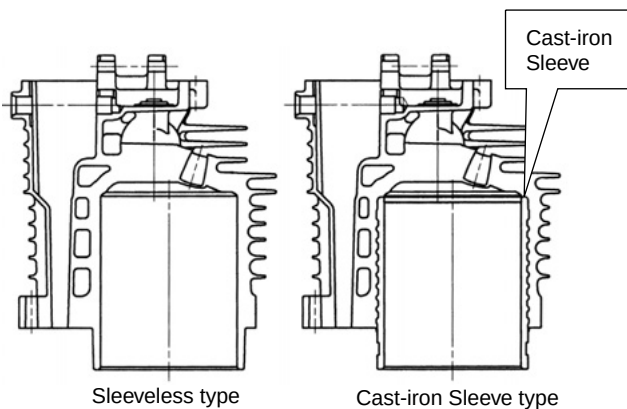


Fig.5 Comparison of cylinder sleeves

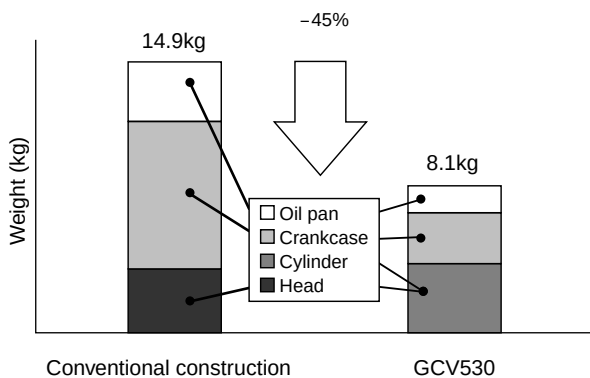


Fig.6 Weight comparison of aluminum die cast parts

4.2. Valve Train with Built-in Timing Belts

Achievements in noise, size, weight and cost reduction were made based on the OHC mechanism parts configuration consisting of timing belts built into the engine, L-shaped pressed rocker arms, and a plastic one lobe cam and pulley used first in the GC/GCV135-160⁽¹⁾ series which has been mass produced since 1997. The new engine attached two timing belts to the one piece sintered timing pulley press-fit onto the crankshaft, and used an L-shaped rocker arm to allow the cam pulleys to be positioned on the intake and exhaust valve sides. Fig. 7 shows this construction, and Fig. 8 shows the sectional drawing.

The timing belts being built into the engine eliminates the dust and water contamination that affect general purpose engines and limit the belt environment to an oil-only atmosphere, thus improving timing belt reliability and

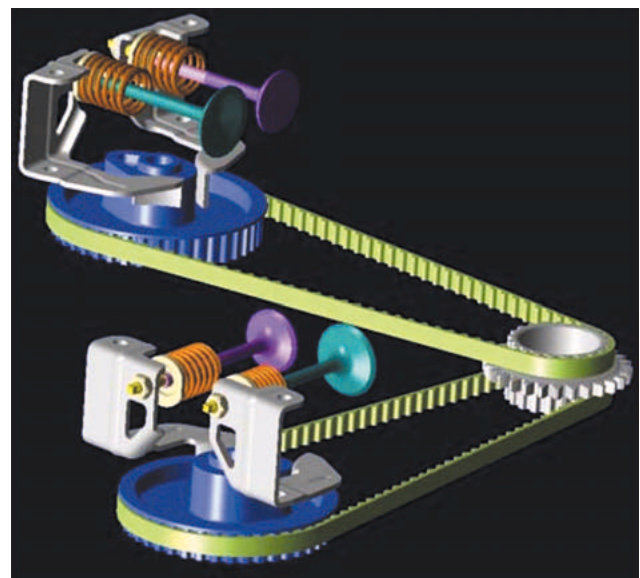


Fig.7 Valve train

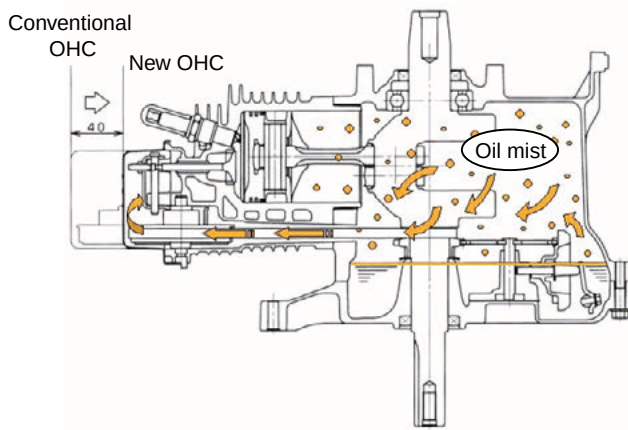


Fig.8 Lubrication system

durability. These timing belts made it possible to: (1) Greatly reduce the mechanical noise produced by the valve train and cam shaft drive train compared to regular gear-driven general purpose engines. (2) Supply oil to areas around the cam pulley and valves using an oil slinger and the rotation of the timing belts without increasing the dedicated lubricating parts such as oil pumps. (3) Replace the valve lifters, push rods and other parts with timing belts, thus reducing the number of parts and the weight.

The L-shaped pressed rocker arms decrease the dimension in the cylinder direction by approximately 40 mm compared to the conventional OHV, making it possible to keep the same dimensions as the conventional OHC. The elimination of machine tooling for the pressed rocker arms and plastic cam pulleys and completely common parts for both cylinders achieved weight and cost reductions of approximately 30% compared to conventional twin cylinder engines.

4.3. Aluminum Sintered Alloy Connecting Rod

The GCV530/520 uses aluminum sintered alloy connecting rods⁽²⁾ to achieve a size comparable to single cylinder engines and reduce vibration. These connecting rods were improved as follows compared to conventional products. (1) The fatigue strength was doubled. (2) The surface pressure limit for wear was approximately doubled by dispersing the pro-eutectic Si and optimizing the grain diameter. (3) The same high material dimensional accuracy as ferrous sintered products was ensured.

The basic twin cylinder, built-in timing belt construction causes the engine height to increase, and this height must be suppressed to achieve a comparable size to single cylinder engines. However, strength requirements made it difficult to reduce the sectional shape of the connecting rod or the width from the bearing surface to the connecting rod bearing for the die casting aluminum connecting rods used in general purpose engines.

Adopting aluminum sintered alloy connecting rods made it possible to reduce the connecting rod width from 28 mm to 19 mm, which allowed the engine height to be reduced by 18 mm. The weight of the connecting rod alone was reduced by 37%. The vibration level was reduced by 50% compared

to conventional single cylinder engines by reducing the weight of reciprocating parts and using an offset between cylinders of just 16 mm, which is the smallest in its class. Fig. 9 shows a photograph of a conventional die casting connecting rod and the sintered alloy connecting rod.

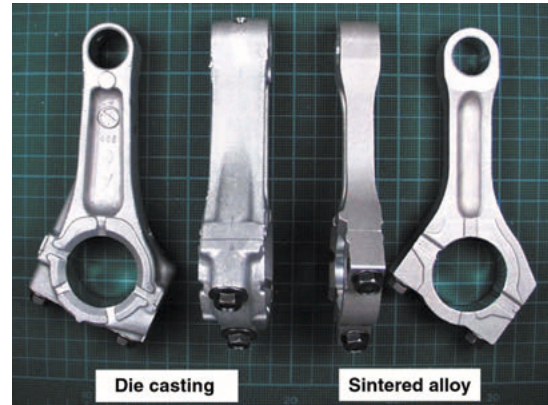


Fig.9 Comparison of connecting-rod

4.4. Turbo Shaped Cooling Fan

The normal rotating speed for air cooled general purpose engines is approximately 3,000 to 3,600 rpm, and sirocco shaped cooling fans are often used to obtain the air flow needed for cooling at this speed.

Turbo shaped cooling fans have a lower noise level than sirocco shaped cooling fans, but it is difficult to obtain a sufficient air flow with the same size fan. This development optimized the fan outer diameter, height, and the inlet and outlet angle of the vanes for turbo shaped cooling fans. Furthermore, a separator was set to increase the outlet air speed as a means of securing the required cooling air flow, and this both improved cooling performance and reduced noise. Fig. 10 shows a comparison of fan shapes, and Fig. 11 shows the degree of noise effects.

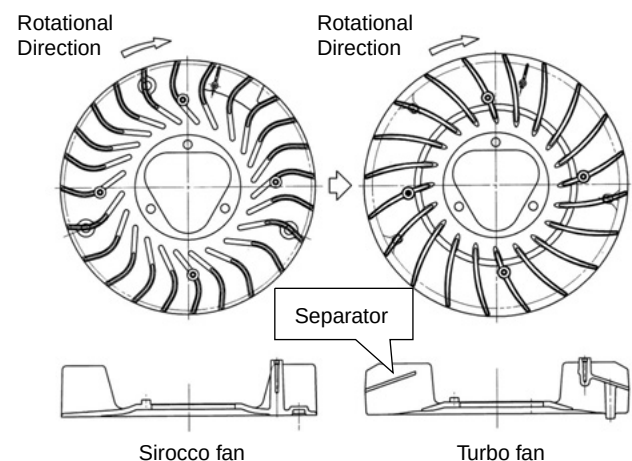


Fig.10 Comparison of cooling fan types

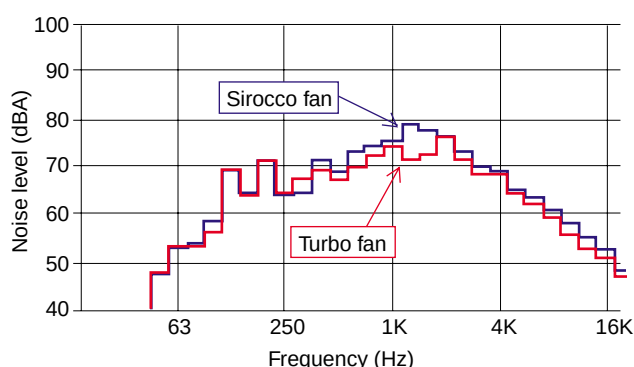


Fig.11 Noise level spectrum

4.5. Parts Constructions for Subassembly

Ease of assembly was improved by adopting the following parts constructions to allow for subassembly.

- Subassembly of the piston, connecting rod, valve train, etc. to the cylinders was made possible by using split cylinders.
- Subassembly of the intake system parts was made possible by using upward-facing inlet ports (both cylinders on the same level).

Fig. 12 shows these constructions.

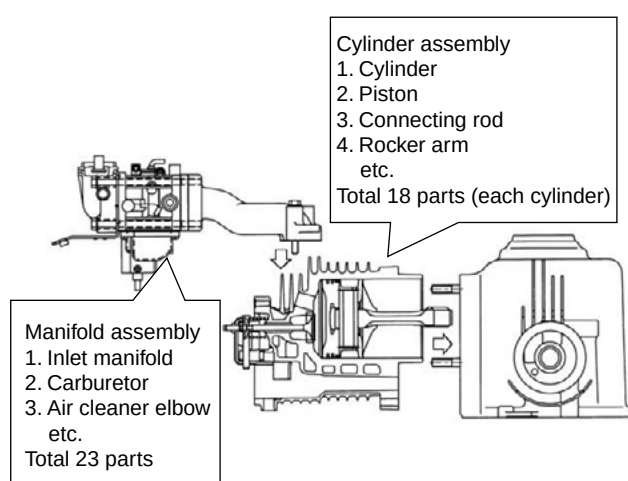


Fig.12 Parts construction of subassembly

4.6. Exhaust Emissions Reduction Technology

The following technologies were used to ensure compliance with the 2001 EPA Phase II and 2002 CARB Tier II standards.

- The spark plugs were positioned as close to the center as possible to improve combustion efficiency.
- The quenching areas in the corners of the uni-block cylinders were minimized.
- A twin bore carburetor optimizes the supply of the fuel-air mixture to each cylinder.

4.7. Effects of the Adopted Technologies

- (1) The 90° V-twin cylinder construction and aluminum sintered alloy connecting rods achieved a 50% reduction in the vibration level compared to conventional single cylinder engines as shown in Fig. 13.
- (2) The built-in timing belt OHC construction, plastic cam pulleys, turbo shaped cooling fan and other improvements achieved a 4 dB reduction in the noise level compared to conventional single cylinder engines as shown in Fig. 14.
- (3) Overall, the adopted technologies achieved a weight reduction of approximately 20% over conventional twin cylinder engines.

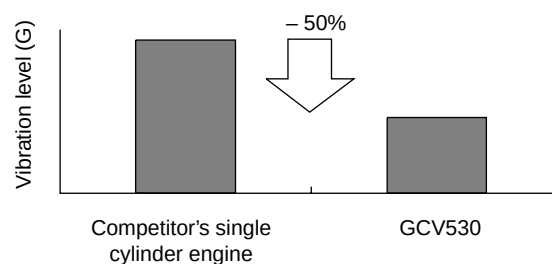


Fig.13 Comparison of vibration

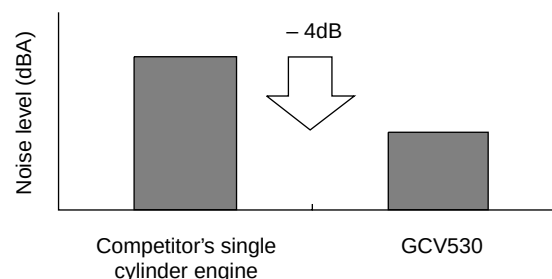


Fig.14 Comparison of noise

5. Conclusions

The 90° V-twin cylinder engines GCV530/520 for riding mowers were developed for a market that is dominated by single cylinder engines.

- (1) Ample power, low vibration and low noise were achieved by combining a displacement setting of 530 cc with various new technologies.
- (2) Interchangeability with single cylinder engines was ensured by a left-right asymmetrical cylinder layout, and the engine was given strong specifications and price competitiveness.
- (3) Compliance with the 2001 EPA Phase II and 2002 CARB Tier II standards was assured.
- (4) Home use and professional use specifications were set for the GCV530 and GCV520, respectively, to support a wide range of needs.

Honda is confident that these engines will be accepted in the riding mower market centered in the US and Europe. The authors wish to express their deep thanks to all parties

involved for their immense cooperation in developing these engines.

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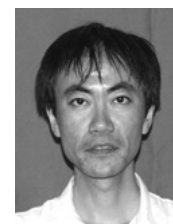
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