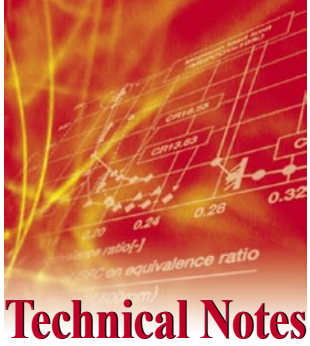

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Fuel Injection System for Smaller Motorcycles

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1 INTRODUCTION

Electronically controlled fuel injection systems provide the potential for highly precise control of the air/fuel mixture ratio, which makes them ideal for use in combination with catalytic converters to achieve cleaner exhaust emissions. For this reason, fuel injection systems are used on almost 100% of today's automobiles. Use of these systems on motorcycles is also on the rise in recent years, beginning with the larger-displacement models.

Given today's market conditions and environmental concerns, demand for fuel injection systems for smaller motorcycles and scooters is also expected to rise, and over the last several years Yamaha has undertaken research and development efforts directed at small-motorcycle fuel injection systems. Developing fuel injection systems for smaller motorcycles presents several problems not seen in automobile systems, and considerably more demanding limitations than those applying to systems for large-displacement motorcycles. However, we were able to overcome these problems and develop a system that has been successfully introduced on the Taiwan market model YP125FI, as reported in a separate article in this issue. Here we report on the contents of this development project and the resulting system.

2 OUTLINE OF THE FI SYSTEM

The FI system, which is intended for highly precise control of the air-fuel mixture ratio, is an electronically controlled system consisting of a variety of sensors, actuators and an ECU (Engine Control Unit) shown in **Fig.1**. This system has a long history of nearly 30 years of use in automobiles. It works to calculate the optimum fuel injection amount based on information about the air volume, engine conditions, environmental factors and the rider's actions detected by various sensors, and then feed a highly precise amount of fuel coming in a pressurized state from the fuel pump through the injector and into the engine.

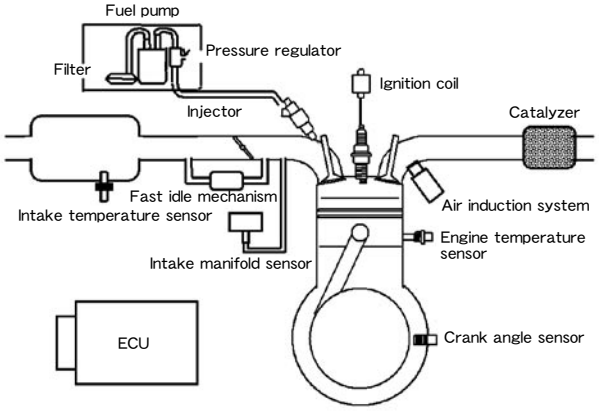

Fig. 1 System diagram

3 AIM OF THE DEVELOPMENT

We took up the following four development issues for an FI system for smaller motorcycles.

(1) Low cost
(2) Small and compact
(3) Low electric power consumption
(4) Improved engine performance

In the following we report on our approaches to the individual issues.

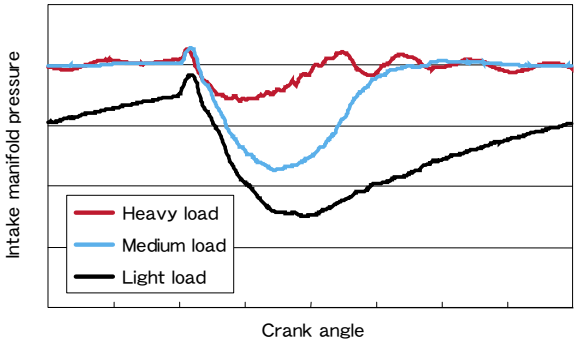

Fig. 2 Crank angle/ waveform of intake manifold pressure

3.1 Low cost

Smaller motorcycles are less expensive than automobiles and larger-displacement motorcycles. For this reason, in introducing an FI system for use in smaller motorcycles as an environmental measure, it is necessary to reduce the cost of the system to maintain a low price. In order to cope with this issue, we aimed at achieving the development of a simpler system, that is, the development of a system consisting of fewer components. For that purpose, we focused on the unique characteristics of a single-cylinder engine in which the pressure variance (dynamic changes) in the intake manifold is interrelated with the atmospheric pressure and throttle opening (**Fig. 2**) and developed a system for making multipurpose use of this information. While maintaining a high level of reliability, we were able to create a simplified system that reduced the number of sensors to only four, that is half of the number of sensors used on the system in Yamaha's larger model FJR1300 (**Fig. 3**). Also, for the injector, the fuel passage and electric wiring were integrated into a single part by the use of a cap. And, for the fuel pump system, we developed and employed a module integrating the fuel pump, pressure regulator, and filter all into one unit. We were also successful in incorporating into the ECU a function to stop the engine when it determines that the motorcycle has been overturn. The fewer components used in this way contributed not only to a reduction in parts cost but also to a reduction in the amount of wiring necessary, thus resulting in far less total cost.

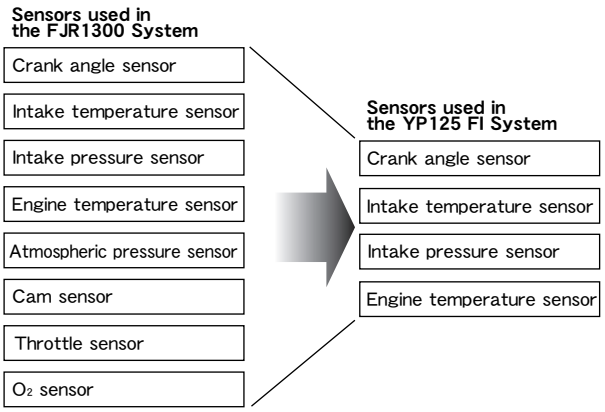

Fig. 3 Reduction in sensors

3.2 Compactness

It is inherently difficult to lay out a large number of parts in motorcycles. This is especially true in the case of smaller motorcycles because of their demanding layout limitations as compared to larger motorcycles. Under such circumstances, and in collaboration with AISAN INDUSTRY CO., LTD., we developed an injector and a fuel pump module both of which are half the size of conventional units as shown in the photos (**Figs. 4** and **5**).

This made it possible to mount the injector at a location best suited for engine performance and to place the fuel pump module in the fuel tank in a way that prevented loss of tank capacity. Furthermore, the ECU (**Fig. 6**) could be made about the same size as the ignition unit for inclusion in the layout (**Fig. 7**).

3.3 Low electric power consumption

Electric power generation loss cannot be ignored in smaller motorcycles because their engines do not produce much power output. It is also difficult to use a generator (alternator) with a large diameter. It is

Fig. 6 ECU

Fig. 4 Injector

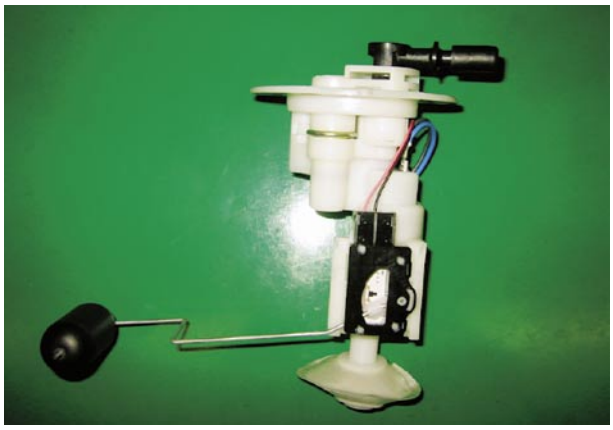

Fig. 5 Fuel pump module

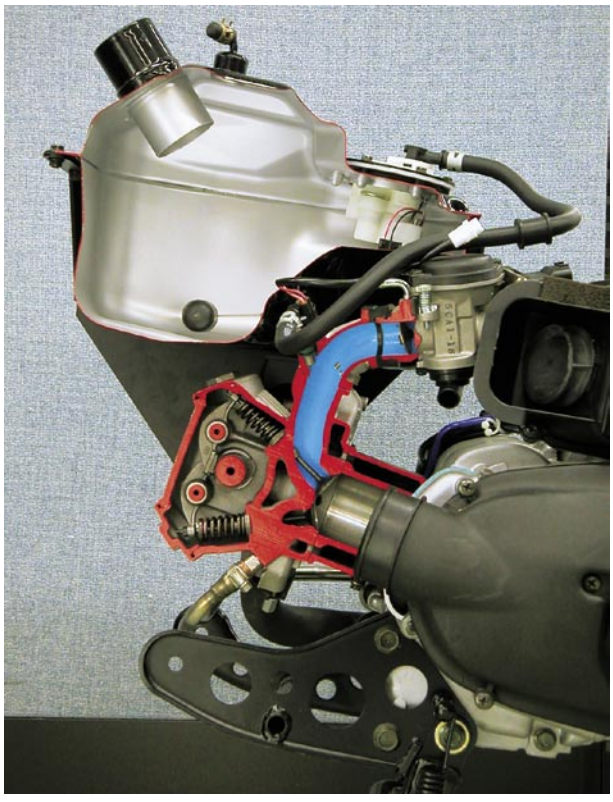

Fig. 7 Cutaway engine

therefore necessary to reduce the amount of electricity the (FI) system consumes. The system used in a larger-displacement motorcycle consumed a little over 5A, but reviewing the fuel flow and improving efficiency in collaboration with AISAN INDUSTRY CO., LTD., made it possible to reduce the consumption to 1.7A, about a third of 5A.

3.4 Performance

In addition to the environmental contribution, we also gave consideration to boosting engine performance with this FI system. Namely, we employed a suction piston and wax type fast idle mechanism that have performed so well on larger-displacement motorcycles. In combination with the FI system with its ability to provide optimum control in the different running conditions, the former produced a great improvement in drivability in transient conditions and the latter made a contribution to improved starting ability in different environmental conditions.

4 CONCLUSION

As explained above, we have overcome a number of issues involved with the use of an FI system in smaller motorcycles and now believe that we have been able to place on the market an FI system that is the world's simplest at the present moment. We also feel that we have laid the foundation for a new core technology through the development of this system. However, use of FI systems on smaller motorcycles has only just begun, and we realize that this development is more of a beginning point than a conclusion.

From now on, we want to continue to develop the competitiveness of this system in collaboration with people both inside and outside the company.

■ Authors

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From left in the front row: Yuuichirou Sawada, Tomoji Nakamura, Michihisa Nakamura