Topics

Diagnostics for Formation Mechanism of Deposits in Gasoline Engine

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1. Introduction

Inside an automobile engine, fuel, engine oil or their incomplete combustion products gradually accumulate. These substances are called deposits, and excessive accumulation of the deposits has adverse effects on emission and driveability. For suppressing the deposit, it is necessary to first clarify the formation mechanism. However, the characteristics of the deposit change according to the engine design, operating conditions and the area where it accumulates, and therefore, the technique for the uniform analysis of the formation mechanism throughout an engine has not yet been established.

In this study, a technique for diagnosing the formation mechanism of the deposit is proposed through the investigations of the deposit characteristics over the entire area of a gasoline engine.

2. Diagnosis of the deposit

(1) Identification of the deposit source

The characteristics of the deposit accumulating throughout an engine were investigated using various analytical techniques. As a result, the deposit was classified into 5 components according to the differences in the physical and chemical characteristics (**Table 1**), and their sources were identified. F_{ar} and F_{al} are fuel-source components; F_{ar} is generated by the oxidation and polymerization of the aromatic hydrocarbons of the fuel in the combustion chamber[1], and F_{al} is generated by the reaction of thermally decomposed materials of aliphatic hydrocarbons with NOx[2]. O_h, O_m and O_l are oil-source components, being different from each other in the heat history they receive in the process of accumulation.

(2) Prediction of the generation route

In an engine there are multiple combustion gas and oil consumption routes. In order to clarify the generation route of the individually identified components, the compositions of the deposit from the air intake system accumulating in the exhaust system of the engine were simultatenously analyzed.

An analysis example is shown in **Fig. 1**. The component O_l existing in the entire area of the air intake system comes from the oil mist flying from the positive crankcase ventilation (PCV) system. The component near the throttle valve F_{al} accumulates due to the retention of blowby gas through the PCV. The component F_{ar} near the injection and on the intake valve is generated by the influence of the gas spit back from the combustion chamber.

This technique is considered to be an effective means of quick diagnosis and a measure to reduce the deposits.

Table 1 Characteristics of deposit components

Source		Component	Solubility	Weight loss range by TG*2	Specific functional group	Specific element
Fuel	Far	Oxidation products of aromatic HC*1 in combustion chamber	Insoluble in hexane and chloroform	500 ~ 700℃	C=C ring C=O	C, O
	Fal	Reaction products of NOx and olefinic HC*1, combustion products	Soluble in chloroform	350 ~ 500℃	C=O C NO2	C, O N
Engine oil	Oh	Highly oxidized fractions (mainly inorganic oxides from additives)	Insoluble in hexane and chloroform	Residue at 700℃	SO_4^{2-} PO_4^{3-}	O Ca, Zn P, S
	Om	Partially oxidized fractions (organic additives and their oxidation products)	Soluble in chloroform	350 ~ 500℃	CH3-C-CH3 COO^-	C, O Ca, Zn P, S, N
	Ol	Slightly oxidized fractions (mainly base oil)	Soluble in hexane and chloroform	200 ~ 350℃	C H	C

*1 HC : Hydrocarbon *2 TG : Thermal gravimetry analysis (in the air)

References

1) Esaki, Y., et al. : Jidosha Gijutsukai Gakujutsu Koenkai Maezurishu, 964 (1996), 169 (in Japanese)
2) Kawamura, M., et al. : SAE Tech Paper Ser., No. 892105 (1989), 11p.

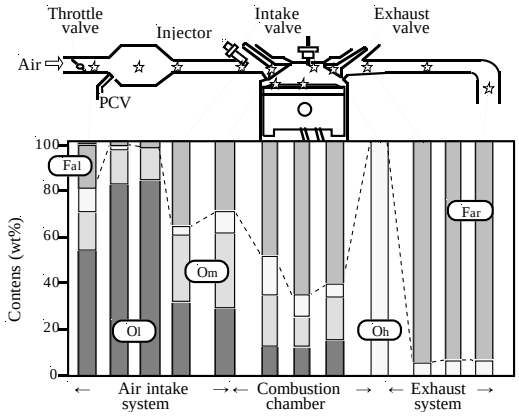

Fig. 1 Composition of each deposit in gasoline engine. (Test condition : 1.8L engine, 1600rpm, 57N· m, 300H)