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# CHARACTERISTICS OF INTEGRATED AIR CONTROL AND LOW-PRESSURE EXHAUST GAS RECIRCULATION VALVE FOR DIESEL ENGINES

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**ABSTRACT**–The purpose of this study is to investigate the characteristics of a newly introduced integrated exhaust gas recirculation (EGR) valve. Traditionally, a exhaust-pressure regulating valve is installed to increase the EGR flow rate; the method used in this study induces an increase of the EGR flow by restricting fresh intake. Unlike the two-motor two-drive system of the low-pressure (LP)-EGR system, the air control valve (ACV) and EGR valve are constructed in a linked structure. The two valves can be controlled simultaneously by a single driver, which permits reductions in volume and weight. In order to compare the existing LP-EGR system with the integrated LP-EGR system, the characteristics of the system were analyzed by a rig test and an actual engine test. It was determined that as the EGR valve opened, the EGR rate was increased and the torque was decreased under the same load condition because of the pumping resistance caused by the ACV closing.

**KEY WORDS** : Diesel engine, Exhaust gas regulation, DeNO$_x$, LP-EGR, HP-EGR, Integrated ACV

## 1. INTRODUCTION

Diesel engines can operate at high compression ratios and are lean-burning, facilitating the application of turbochargers. In addition, diesel engines have higher power outputs, lower fuel consumptions, and lower carbon dioxide emissions than gasoline engines. However, the diesel engine, which is a compression ignition system, produces significant particulate matter (PM) and nitrogen oxides ($NO_x$) because of incomplete combustion and high temperature, respectively (Lee and Park, 2017). These problems are well known to exacerbate various environmental problems and have led to increasingly strict environmental regulations for diesel engines. To solve these fundamental problems, various pre- and post-processing technologies have been developed to achieve improved, eco-friendly engines.

The exhaust gas recirculation (EGR) system is a pre-processing system that reduces $NO_x$ concentrations in the gas exhausted from engines (Langridge and Fessler, 2002). After combustion occurs in the combustion chamber, the EGR returns some portion of the exhaust gas with low oxygen concentration to the intake manifold. This lowers the temperature inside the cylinder by not only lowering the oxygen concentration but increasing the gas specific heat and suppresses the $NO_x$ creation that mainly occurs at high temperatures.

The EGR system can be divided into the internal and external EGR. The internal EGR shows the recirculation effect of exhaust gas through a continuous variable valve timing system in a gasoline engine, but it is limited in its effectiveness. For this reason, most diesel vehicles use external recirculation systems to increase the exhaust gas recirculation effect. Such external recirculation systems are divided into two types: high-pressure EGR (HP-EGR), which recirculates high-pressure exhaust gas generated after the engine combustion to the intake, and low-pressure EGR (LP-EGR), which utilizes relatively lower-pressure exhaust gas after it passes through a post-processing system such as a diesel particulate filter (DPF), diesel oxidation catalyst (DOC), lean $NO_x$ trap (LNT), and selective catalytic reduction (SCR) (Park and Bae, 2013).

HP-EGR has the advantage of a fast response time because the supply line to the intake air is short; however, the exhaust gas cannot be easily supplied at high speeds because of the increased intake air pressure.

The LP-EGR system generally has an EGR line connected before the turbo compressor that is applied to the

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