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Investigating the Effects of Cylinder Disablement on Diesel Engine Fuel Economy and Exhaust Temperature Management

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Abstract : Diesel engines are widely used in transportation sector due to their high thermal efficiency. However, they also release high rates of NO_x and PM (particulate matter) emissions into the environment which have hazardous effects on human health. Therefore, environmental protection agencies have issued strict emission regulations on automotive diesel engines. Recently, these regulations are even increasingly strengthened. Engine producers search novel on-engine methods such as advanced combustion techniques, utilization of renewable fuels, exhaust gas recirculation, advanced fuel injection methods or use exhaust after-treatment (EAT) systems in order to reduce emission rates on diesel engines. Although those aforementioned on-engine methods are effective to curb emission rates, they result in inefficiency or cannot decrease emission rates satisfactorily at all operating conditions. Therefore, engine manufacturers apply both on-engine techniques and EAT systems to meet the stringent emission norms. EAT systems are highly effective to diminish emission rates, however, they perform inefficiently at low loads due to low exhaust gas temperatures (below 250°C). Therefore, the objective of this study is to demonstrate that engine-out temperatures can be elevated above 250°C at low-loaded cases via cylinder disablement. The engine studied and modeled via Lotus Engine Simulation (LES) software is a six-cylinder turbocharged and intercooled diesel engine. Exhaust temperatures and mass flow rates are predicted at 1200 rpm engine speed and several low loaded conditions using LES program. It is seen that cylinder deactivation results in a considerable exhaust temperature rise (up to 100°C) at low loads which ensures effective EAT management. The method also improves fuel efficiency through reduced total pumping loss. Decreased total air induction due to inactive cylinders is thought to be responsible for improved engine pumping loss. The technique reduces exhaust gas flow rate as air flow is cut off on disabled cylinders. Still, heat transfer rates to the after-treatment catalyst bed do not decrease that much since exhaust temperatures are increased sufficiently. Simulation results are promising; however, further experimental studies are needed to identify the true potential of the method on fuel consumption and EAT improvement.

Keywords : cylinder disablement, diesel engines, exhaust after-treatment, exhaust temperature, fuel efficiency
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