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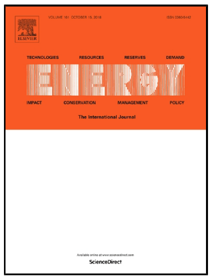

Reactivity Controlled Compression Ignition Combustion and Emissions using *n*-Butanol and Methyl Oleate

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ABSTRACT: Direct Injection of methyl oleate and PFI of n-butanol were used to conduct Reactivity Controlled Compression Ignition (RCCI) and minimize exhaust emissions in reference to conventional diesel combustion. Methyl oleate was investigated for validation of a single fatty acid methyl ester as a surrogate for biodiesel in engine operation. An experimental common rail engine was operated in RCCI and conventional diesel combustion modes under constant boost and similar combustion phasing. The RCCI strategy used two pulses of direct injections with a fixed first injection at 60° before top dead center and a varied second injection for smooth combustion. Ringing intensity was reduced by 70% for methyl oleate RCCI compared to diesel conventional diesel combustion. The molecular oxygen from methyl oleate allowed a reduction in soot by 75% and 25% compared to diesel in RCCI and conventional diesel combustion operation, respectively. Compared to conventional diesel combustion, NOx and soot decreased for RCCI by several orders of magnitude with both emissions approaching near zero levels at low load. The fuels produced a stable RCCI operation where mechanical efficiency was sustained within 2% for same load points and coefficient of variation of indicated mean effective pressure was limited to 2.5%.

Keywords: Reactivity Controlled Compression Ignition; Low Temperature Combustion; Combustion; Methyl Oleate; Biodiesel Surrogate; n-Butanol

1. Introduction

Diesel engines are essential in modern transportation and power supply applications; however, they can cause harmful exhaust emissions. Common emissions control is achieved through exhaust after treatment systems which tend be expensive and require extensive calibration. As an alternative, advanced combustion modes have been developed to rather control the in-cylinder emissions formation through low temperature combustion (LTC). Most prevalent methods to achieve LTC can be recognized as homogenous charge compression ignition (HCCI), premixed charge compression ignition (PCCI), and reactivity-controlled compression ignition (RCCI). HCCI lacks control of ignition timing, tending to autoignite prematurely due to high mixing rates early in the combustion cycle, inducing high maximum pressure rise rates (PPRR) and knock [1, 2].

PCCI addresses early ignition through control of the early injection [3], however, conventional PCCI achieves increased ignition delay with high rates of exhaust gas recirculation (EGR), resulting in lower combustion efficiencies under 90% at medium-high loads and can suffer from increased emissions from wall wetting [4]. The idea of use of different fuel reactivity was thus introduced in conjunction with variable injection to achieve stratified ignitability [5]. RCCI was thus developed to change the chemical kinetics for emissions control with better control of the heat release and lower exhaust gas recirculation (EGR) rates; the load range can be expanded with RCCI, reaching loads not attainable with HCCI nor PCCI [6]. In addition to concern in emissions, the transportation sector deals with a substantial demand on foreign oil supply [7]. In this study, RCCI is thus investigated with the use of renewable biofuels due to the limited sources of petroleum diesel and promote energy security. The effects of biodiesel on LTC strategies, such as RCCI, are still under investigation in literature.