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ABSTRACT

The objective of this study is to investigate the impact of the Exhaust Gas Recirculation (**EGR**) or/and the Water Injection (**WI**) on the Turbocharged Diesel Engine performance (Brake Power (bp), Brake Specific Fuel Consumption (bsfc), and Brake Thermal Efficiency (BTE)), in addition to examining the effects on exhaust gas emissions such as Nitrogen Oxides (NO_x), Carbon Monoxide (CO).

A series of experiments were carried out in Sudan University of Science and Technology Laboratories on a Turbocharged Diesel Engine. The experiments results obtained showed that, the brake power decreased in the presence of EGR and continues to decrease as the ratio of EGR is increased, while the power increased by using the low and medium rates of injected water at the mid and high engine speeds. The combination of 5% EGR and low injected water rates increased the engine power. %10 of EGR ratios and less water rates caused a decrease in the power, but still are greater than that obtained by EGR setups.

The bsfc increased by using EGR system, while the WI system was found to decrease the bsfc, mostly in the low and medium rates of injected water. Much water rate has led to increase the bsfc strongly and has achieved results between those obtained by the TC and NA engine. Combined 5% EGR and less water rates are shown to decrease the bsfc, and are equal to less than that given by the TC engine particularly at mid and high engine speeds. Increasing EGR ratio to 10% and less water volumes setups have kept the values of the bsfc between the TC and EGR setups.

The Brake Thermal Efficiency (BTE) decreased when using the EGR system, while it increased by the low and medium volumes of injected water at the mid and high engine speeds. The BTE given by Combined 5% EGR and less water volumes is found to be greater than those given by the TC engine, mostly at the mid and high engine speeds. Combined 5% and much water caused to decrease the BTE and were found less than those given by the TC engine.

The emission of NO_x is reduced by the EGR system. WI affected positively in reducing the NO_x emission, and as the volume of injected water increased the emission of NO_x is decreased. The combined system caused a reduction in the emission of NO_x significantly.

CO is increased by the EGR system, while the WI is caused to decrease the CO emission. This might be attributable to the water-gas shift reaction, in addition to the positive effect of WI on combustion efficiency. Emission of CO in the presence of the combined setups increased significantly. 5% EGR + WI systems emitted CO more than that obtained by 5% EGR. EGR ratio greater than 5% and WI setups emitted CO greater than that given by EGR setups.

الملخص

الغرض من هذه الدراسة هو التحقيق في الآثار المترتبة على إعادة تدوير جزء من غاز العادم (EGR) أو/ و حقن الماء (WI) على أداء محرك الديزل مثل (القدرة الفرملية (BP), الاستهلاك النوعي للوقود (bsfc)، و الكفاءة الحرارية (BTE)). بالإضافة إلى دراسة التأثير على انبعاثات غازات العادم مثل أكاسيد النيتروجين (NO_x) وأول أكسيد الكربون (CO).

أجريت سلسلة من التجارب في معامل جامعة السودان للعلوم والتكنولوجيا على محرك ديزل. أظهرت النتائج أن القدرة الفرملية انخفضت في وجود نظام تدوير غاز العادم، ويزيد الانخفاض مع زيادة نسب إضافة غاز العادم. نظام حقن الماء يزيد القدرة الفرملية للمحرك، عند حقن معدلات الماء القليلة والمتوسطة عند سرعات المحرك المتوسطة والعالية. عند دمج نظام تدوير العادم بنسبة 5% مع حقن الماء بالمعدلات القليلة والمتوسطة أظهرت النتائج ان القدرة الفرملية زادت مقارنة بقدرة المحرك ذو الشاحن التوربيني. 10% من نظام تدوير غاز العادم مع حقن الماء بالمعدلات القليلة والمتوسطة خفضت القدرة ومازالت اكبر من القدرة الناتجة من استخدام نظام تدوير غاز العادم.

الاستهلاك النوعي للوقود (bsfc) زاد باستخدام نظام تدوير غاز العادم، ونظام حقن الماء خفض (bsfc) باستخدام المعدلات القليلة والمتوسطة عند سرعات المحرك المتوسطة والعالية. عند دمج نظام تدوير غاز العادم بنسبة 5% مع حقن الماء بالمعدلات القليلة والمتوسطة، أظهرت النتائج ان (bsfc) انخفض مقارنة بالمحرك ذو الشاحن التوربيني. زيادة نسبة تدوير الغاز الى 10% مع حقن الماء بالمعدلات القليلة والمتوسطة تسببت في زيادة (bsfc) مقارنة بالمحرك ذو الشاحن التوربيني وما زالت اقل من نتائج نظام تدوير غاز العادم.

الكفاءة الحرارية انخفضت مع استخدام نظام التدوير، وتنخفض أكثر مع زيادة نسبة تدوير الغاز. حقن الماء زاد الكفاءة الحرارية للمحرك باستخدام معدلات ماء قليلة ومتوسطة عند السرعات المتوسطة والعالية. دمج 5% من تدوير غاز العادم مع حقن معدلات ماء قليلة ومتوسطة أدت الى زيادة في الكفاءة الحرارية مقارنة بنتائج المحرك ذو الشاحن التوربيني. انخفضت الكفاءة الحرارية عند حقن الماء بمعدلات اكبر في وجود 5% من غاز العادم وكانت النتائج اقل مقارنة بنظام اعادة تدوير غاز العادم.

انخفض انبعاث (NO_x) باستخدام نظام تدوير العادم ويزيد الانخفاض بزيادة نسبة غاز العادم مع الهواء. نظام حقن الماء خفض ايضا انبعاث (NO_x) ويزيد الانخفاض بزيادة معدل الماء المحقون. دمج النظامين أدى الى انخفاض كبير في انبعاث (NO_x).

نظام تدوير غاز العادم زاد من انبعاث (CO)، نظام حقن الماء خفض من انبعاث (CO) عند الحقن بمعدلات قليلة ومتوسطة، الانخفاض يعود الى زيادة كفاءة الاحتراق الناتج من زيادة كثافة الهواء الداخل للمحرك، انخفاض انبعاث (CO) يعود ايضا إلى تفاعل الغاز مع الماء ليتكون غاز ثاني اكسيد الكربون ويتصاعد غاز الهيدروجين. زاد انبعاث (CO) بشكل ملحوظ عند حقن الماء بمعدلات كبيرة. كما يزيد عند دمج 5% من غاز العادم مع حقن الماء بمعدلات قليلة ومتوسطة مقارنة بالكمية المنبعثة في حالة استخدام نظام تدوير العادم.

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List of Abbreviations

AC	Alternating Current
ADI	Anti – Detonant Injection
AFD	Adjustable Frequency Drive
ATDC	After Top Dead Centre
A/F	Air Fuel Ratio
ARES	Advanced Reciprocating Engine System
BDC	Bottom Dead Centre
bsfc	Brake specific fuel consumption
BTE	Brake Thermal Efficiency
CASE	Center for Advanced Studies in Engineering
CI	Compression Ignition
CO	Carbon Monoxide
CR	Compression Ratio
DWI	Direct Water Injection
Dyno	Dynamometer
EGR	Exhaust Gas Recirculation
EPA	Environment Protection Agency
FIE	Forced Induction Engine
HCs	Hydrocarbons
ICE	Internal Combustion Engine
ITE	Indicated Thermal Efficiency
LRS	Long Route System
MAP	Manifold Absolute Pressure
MCU	Main Control Unit
MEMS	Micro – Electromechanical System
MTBE	Methyl Tertiary Butyl Ether
N	Engine Speed
NA	Natural Aspirated Engine
NAAQS	National Atmospheric Air Quality Standard
NO _x	Nitrogen Oxides
NSCR	Nonselective Catalytic Reduction
PM	Particular Matter
ppm	part per million
PR	Pressure Ratio
PTFE	Poly tetra fluoroe thylene
RCU	Remote Control Unit
RON	Research Octane Number
rpm	revolution per minute
SCR	Selective Catalytic Reduction
TWC	Three-Way Catalyst
SI	Spark Ignition
SO ₂	Sulfur Dioxide
SRS	Short Route System
TC	Turbo Charged Engine
TDC	Top Dead centre
VGT	Variable Geometry Turbocharger
VOCs	Volatile Organic Compounds
WI	Water Injection