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THE THERMODYNAMIC EFFECTS OF STEAM INJECTION AND EXHAUST GAS RECIRCULATION APPLICATIONS ON COMBUSTION IN INTERNAL COMBUSTION ENGINES

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ABSTRACT

Applications of water/steam injection and exhaust gas recirculation (EGR) in the combustion chamber are methods proven to reduce harmful emissions and improve the performance of many internal combustion engine types. The two applications have become very popular to use both separately and together. Internal combustion engines are ensured to both increase performance and become environmentally friendly in this way. This study involves the thermodynamic simulation of the combustion of all fuels and mixtures containing CxHyOzNq in the combustion chamber of internal combustion engines. In the combustion analysis, the molarity of each exhaust type is determined with regard to chemical equilibrium according to the equilibrium-constant approach using the water/steam injection and/or EGR applications. According to previous researchers, the thermodynamic properties calculated with this approach based on the equilibrium composition are precise and used directly in predicting the performance of internal combustion engines. This study analyzes the effects from reactant mixtures using steam injection and/or EGR in combustion regarding their thermodynamic properties, as well as the adiabatic flame temperatures and combustion products by using a novel multi-feature equilibrium combustion model. The effect of steam injection and EGR has been calculated for the combustion exergy analysis while also considering changes in the equivalence ratio. Moreover, the indicated parameters for combustion performance, chemical exergy, physical exergy, total specific exergy, and exergy destruction have been painstakingly utilized in the calculations. With regard to the results obtained according to the change in the equivalence ratio, adiabatic flame temperature is observed to decrease as both steam injection and EGR increase. While the addition of steam is seen to increase the constant pressure specific heat, physical exergy, and specific combustion exergy values, the EGR application varies with respect to the lean and rich combustion regions. Meanwhile, the entropy and exergy destruction values have been concluded to increase by adding steam to the combustion chamber and to decreased when EGR is used.

Keywords: combustion, EGR, steam injection, combustion exergy, thermochemical analysis

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