Numerical simulation of syngas combustion in rotary engine

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The synthesis gas can be considered as a key intermediate in energy conversion from fossil fuel to decarbonized and low-carbon technologies [1]. The synthesis gas (abbreviation – syngas) is a mixture mainly comprised of hydrogen and carbon monoxide. Usually it can include other gases: methane, carbon dioxide and nitrogen depending on the oxidation agent. Syngas can be produced from various carbonaceous feedstock (natural gas, naphtha, coal, biomass, etc.) with a limited gasifying agent (air, oxygen, steam), thus providing ample opportunities for fuel flexibility [2].

The internal combustion engines represent well-established technology of syngas utilization for power generation in remote areas [3]. However, there is a lack of knowledge related to syngas utilization in alternative engine types with different design such as the Wankel rotary engine. It is interesting to analyze the possibilities of the rotary engine fueled by syngas, produced on a large scale from various feedstocks by mature technologies. The biomass, coal and natural gas are considered as representative sources for syngas generation. The operation of the rotary engine fueled by natural gas is considered as a reference case.

It was shown that the main performance characteristics of the rotary engine are affected by the chemical composition of the fuel used. The high hydrogen concentration with minimum inert content of CO_2 of syngas produced from natural gas via steam methane reforming results in maximum power, heat release rate and thermal efficiency for stoichiometric and lean conditions. The natural gas and syngas produced by coal gasification provide comparable characteristics of indicated thermal efficiency under stoichiometric conditions. However, the presence of hydrogen in syngas produced by coal gasification allowed the enhancement of combustion characteristics at lean conditions in comparison with natural gas due to the increased reactivity of the mixture. Nitrogen addition and lower H_2 concentration in syngas produced from natural gas by non-catalytic partial oxidation and syngas produced by biomass gasification have an inhibiting effect on efficiency with a drastic decrease at lean conditions.

A great advantage in terms of emission is not always achieved by syngases fueling of the rotary engine. 71% of hydrogen in syngas produced from natural gas via steam methane reforming results in maximum NO_x emission due to high flame temperatures. the opposite trend can be observed between NO_x and CO emission pathways.

The use of syngas in a rotary engine can be considered as a valid method of electricity, power and heat production. The choice of appropriate production technology depends on the local availability of resources without excessive transportation costs. Syngas power generation system can provide environmental sustainability to the industry and reduce the external demand of energy carriers.

The reported study was funded by Russian Science Foundation according to the research project №21-79-00170, https://rscf.ru/en/project/21-79-00170/.

References

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