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Combined ammonia recuperation and NOX reduction for increased efficiency in combustion engines

A reactor that combines selective catalytic reduction and thermochemical recuperation together to simultaneously decompose ammonia and convert unburned ammonia and NOX emissions

IP Status: Provisional Patent Application Filed

Applications

- Ammonia Combustion Engine
- Combined cycle heat and power plants
- Steam and gas turbine power plants
- Internal combustion engines
- Marine engines
- Stationary engines

Key Benefits & Differentiators

- **Enables ammonia combustion:** Selective catalytic reduction of NO_X emissions produces hydrogen to enable efficient ammonia combustion
- **Reduced fuel usage:** Thermochemical recuperation recovers waste heat and unburned ammonia to improve chemical energy of fuel
- **Eliminates need for dosing ammonia/urea into exhaust stream:** Unburned ammonia in the exhaust acts as the reductant in downstream reduction step

Ammonia fuels need to include a small fraction of hydrogen to be commercially viable

The increasing impacts of CO2 and fossil fuel emissions on the environment are driving interest into new alternative fuels, such as ammonia. Burning of ammonia results in no net CO2 or particulate emissions, and recent research has demonstrated that ammonia can successfully be used as fuel in combustion-powered devices. However, emission of highly reactive, poisonous NO_X gases is currently a major drawback in ammonia-fueled engines. In addition, to make its energy production a viable alternative to carbon-containing fuels, ammonia fuels need a source of hydrogen.

Combined ammonia recuperation and reduction for combustion engines

Prof. Northrop's research group at the University of Minnesota has designed a combined ammonia thermochemical recuperation (TCR) and selective catalytic reduction (SCR) system for combustion energy applications. In this design, a TCR reactor that utilizes sensible heat from combustion exhaust is combined with chemical heat provided by an SCR catalyst to partially decompose ammonia to hydrogen (and nitrogen) that is needed for complete combustion. Using the SCR system, unburned ammonia and nitrogen oxides (NO_X) in the engine exhaust is

Technology ID
2021-097

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catalytically reduced, thereby reducing poisonous gas emission while generating heat and hydrogen that can be recycled to improve combustion. This design can be installed in the exhaust stream of combustion-based power systems, enabling retrofitting onto existing power plants and engines, as well as incorporation as original equipment. This system ultimately reduces fuel consumption by 0.5-2%, improves the efficiency of ammonia combustion engines, and accelerates transition into carbon-free energy.

Phase of Development

TRL: 2-3

The described system is in the concept stage, with related technologies, including an ammonia TCR and SCR, having been functionally demonstrated and being covered under prior intellectual property. Further work is underway investigating the scale-up of the proposed system in marine engines, power plants, and stationary power generation.

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

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Researchers

- **William Northrop, PhD,** Associate Professor and Director of Undergraduate Studies, Department of Mechanical Engineering