Ammonia Oxidation at High Pressure as a Carbon Free Fuel

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Abstract

Ammonia can be burned directly without pollutant emissions. Its mixtures with CH_4 and H_2 improve its combustion characteristics. Therefore, the project thesis is the knowledge of the conversion at high pressures of NH_3 and its mixtures as well as the development of a suitable kinetic model.

Introduction

Low-carbon economy has a critical role in environmental issues of our society, such as climate change, security of energy supply and fossil fuels depletion. The principal aim is to reduce greenhouse gas emissions, which implies the use of carbon-free fuels, and guaranteeing security of energy supply.

NH_3 contributes to this objective because it can be a suitable alternative for stationary power, transportation, and energy storage[1]. Although it is mainly produced from natural gas, it can also be obtained using renewable energy sources and raw materials.

In addition, NH_3 can be used as a clean energy carrier because it can be burned directly[2] producing water and nitrogen (N_2). As a disadvantage, in the NH_3 combustion, nitrogen oxides (NO_x) can be formed from NH_3 oxidation, but also the join presence of NH_3 and NO in the combustion chamber can result in the joint minimization of both if appropriate operating conditions are used[3].

Another aspect to be considered is its relatively poor combustion characteristics, which justifies the co-combustion of NH_3 with other fuels such as CH_4 and H_2[4].

In this context, the overall objective of the project thesis is the knowledge of the conversion of NH_3 at high pressures, as well as its mixtures with CH_4 and H_2 under different operating conditions (temperature, air excess rate, concentration of ammonia and NO presence). To this end, this project will also include the development of a detailed reaction kinetic model in order to describe the conversion of ammonia and its mixtures under the studied conditions. This project thesis will contribute to evaluating the pollutant emissions that can be obtained during the use of ammonia in energy applications and determining the possible synergies due to the interaction of NH_3 and its mixtures with NO, which can result in a further reduction of this compound.

Experimental and modelling methodology

Conversion of reactants and gas emissions produced from combustion of NH_3, and its mixtures with CH_4 and H_2 are studied in well-controlled experimental conditions in an installation shown in figure 1.

This research is performed considering the effect of main variables: air excess ratio (from pyrolysis to highly oxidant conditions), pressure (1-60 bar)[5], temperature (400-800 K), concentration of CH_4 and H_2 in the mixture, and presence of pollutants such as NO.

In the experiments, concentrations of NH_3, CH_4, H_2, CO, CO_2, hydrocarbons, NO, NO_2, N_2O and HCN will be analysed.

Experimental results will be simulated and interpreted with a detailed kinetic reaction model, that allows us to describe the ammonia combustion process under the differen operating conditions.

This mechanism will be progressively developed, updated and improved according to the experimental results obtained.

Outcomes

It is expected to obtain a series of data that will allow us to increase the quality and quantity of knowledge about the combustion of NH_3 and its mixtures.

At the same time, developing a good predicting kinetic model, that allow us to design several simulation models with Chemkin and another multiphysics simulation softwares, obtaining a proper correlation among the experimental results, the kinetic model and simulation modelling.

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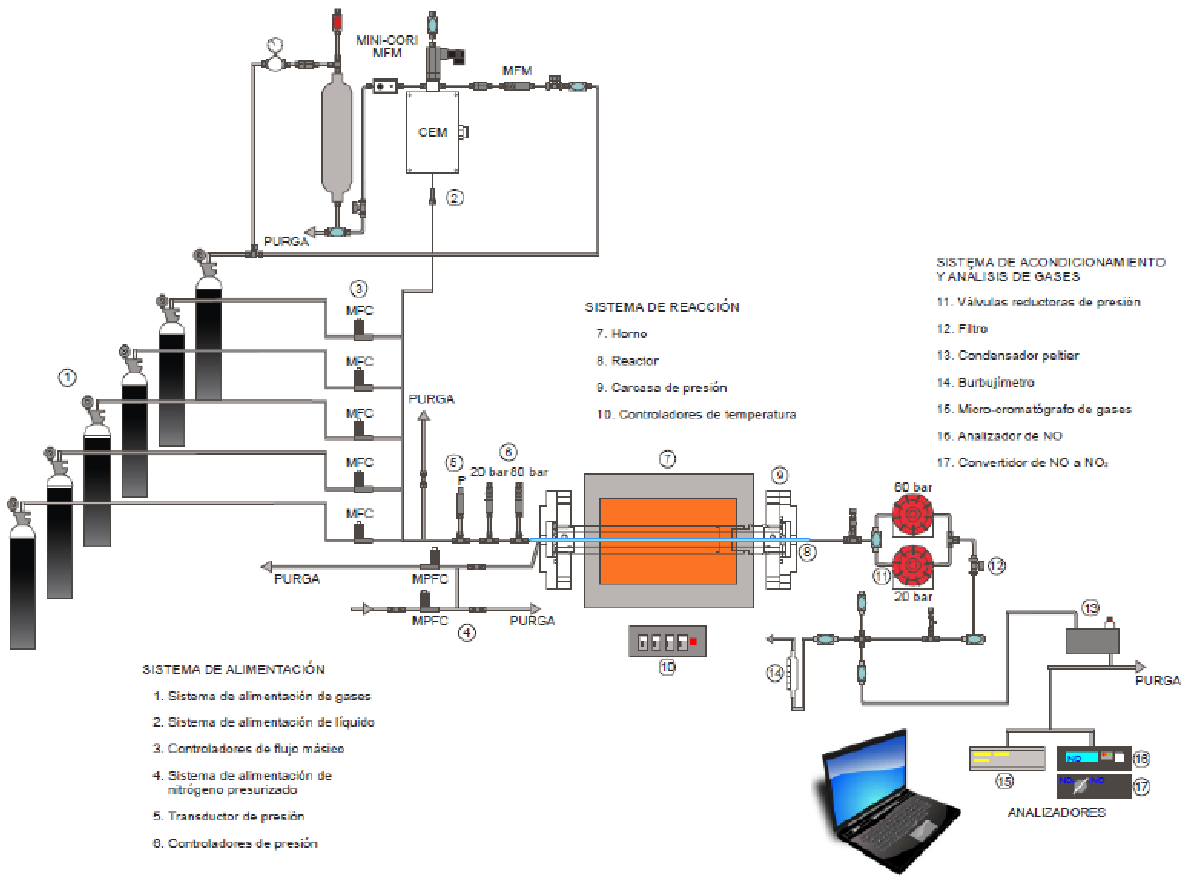

Figura 1: High pressure installation