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EXPERIMENTAL ANALYSIS OF HYDROGENATION(SABATIER) REACTOR OPERATION

Abstract

A human being isolated as in spacecraft consumes approximately 0,9 kg oxygen per day. With O2 and H2 produced by water electrolysis which supplies are replenished from outside. H2 does not find further application. On the International Space Station (ISS) and in other low orbit missions, the metabolically generated CO2 is removed from the cabin atmosphere and vented into space. The CO2 reduction system converts H2 and CO2 and allows 2/3 of water amount required for oxygen generation to be returned to the cycle. In recent years the existing technologies for processing carbon dioxide for space life support systems based on thermal catalytic hydrogenation to form gaseous products (Sabatier reaction (1)) has received the most attention.

- CO2+4H2 -> CH4+2H2O+181 kJ/mole(1)

Based on the previously available data and taking into account the results of the shortcomings of an existing prototype the mathematical model of thermal processes taking place in the reactor has been created, allowing a selection of the optimum design parameters for the specified conditions. By using already existing reactors the following investigations have been carried out:

- a selection of the catalyst type and its characteristics;
- an evaluation of the optimal reaction temperature for each catalyst;
- the influence of the external factors on the heat transfer processes in the reactor;
- the estimation of the volume rations of feed reagents CO2 and H2;
- the assessment of the pressure of CO2 and H2 mixture upstream the reactor;
- the determination of the minimum required catalyst volume and an optimal speed of the gas stream; a mathematical model has been enhanced based on the experimental data gained.

In the preliminary tests of the hydrogenation reactor prototypes, the following provisions have been assumed:

- an increase in the reaction temperature should not lead to an increase in the conversion rate since the optimal thermal conditions for the conversion rate is reached in the narrow temperature interval inherent in every variety of catalysts;
- decrease in the temperature down to 120-140oC at the end of the catalyst bed allows the most optimal conversion rate to be reached;
- the usage of advanced catalysts makes it possible to reduce the process temperature and ensure a quick ignition of the reaction.

As a result, the conversion rate of the test pilot reactor has increased from 74 to 92 percent.