PLASMACHEMICAL SYNTHESIS AND REGENERATION (ACTIVATION) OF NANOSTRUCTURED CATALYSTS FOR METHANE STEAM CONVERSION

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There are 2D models of axially symmetric plasma-chemical reactors (PCR) for motion, heating, melting and evaporation (thermal destruction) of micron-sized particles (Ni, NiO, Al, Al_2O_3, CaO, Mg and MgO) developed. By means of these models, profiles of plasma (gas) density; temperature and rate in the plasma generator (plasmatron) in a PCR with "cold" (T_w = 500 K) and "warm" (T_w = 1500 K) walls are established, as well as the particle diameter changes along the length of the PCR; trajectory of the particles in the PCR, etc. A system of equations that describes the gas motion; equations for particle temperatures depending on the gas temperature; and equations for particle motion are used to model the hydrodynamic and heat-exchange processes in an axially symmetric PCR.

A universal programme is used and the equilibrium parameters of the multicomponent heterogeneous Ni-Al-O-Ca-Mg system are defined at for different initial ingredient compositions at a pressure of 0.1 MPa within the temperature range 1000 - 3700 K, as dependencies of the respective compound concentration in gas or condensed phase at an equilibrium system composition on the temperature are built. We set out to develop a three-dimensional model for the motion, heating, melting and vaporization (thermal destruction) of micron-size particles (Ni, NiO, Al, Al_2O_3, CaO, Mg and MgO) in an axisymmetric plasmachemical reactor (PCR), to determine the equilibrium parameters of the multicomponent heterogeneous Ni-Al-O-Ca-Mg system for the plasma-temperature range, and to carry out experimental studies concerning the plasma-chemical synthesis (PCS) of a catalyst for CH_4 steam conversion.

Considering the results of the model and thermodynamic calculations, we designed and built equipment for PCS and/or regeneration of spent catalyst for CH_4 steam conversion. Under the conditions of an electric-arc low-temperature plasma (LTP), we studied the Ni-O-Al system and performed a comprehensive physicochemical analysis of the ultradispersed product obtained.

It's the first time world-wide when the conditions of plasma-chemical synthesis and/or regeneration of CH_4 steam conversion catalysts under the conditions of electric-arc LTP are investigated, as depending on the plasma-chemical process (PCP) parameters and the plasma-chemical reactor (PCR) type (with CW- "cold walls" T_W = 500 K or WW - "warm walls" T_W = 1500 K), samples with a specific surface of to 120 m^2/g are obtained.

Plasma-chemically synthesised and/or regenerated samples have a homogenous chemical composition similar to that Girdller (USA) the conventional industrial catalyst. It is empirically established that the optimal temperature range in PCR for synthesis of maximum dispersity samples is 2000 - 3000 K. Results from investigation on plasma-chemically synthesised and/or regenerated CH_4 steam conversion catalysts dynamics and kinetics show that under LTP conditions premises for catalyst compositions formation are established. They are reduced 3 to 4 times faster than their industrial analogues.

The heightened catalytic activity of the plasma-chemically synthesised and/or regenerated natural gas reforming catalysts is determined by a whole complex of specific sample properties as follows: defective/faulty crystal structure of catalytically active phases with a lowered crystal lattice parameter; even distribution of the promoting ultra-dispersed components; high porosity, specific surface and dispersity; and appropriate chemical composition of the samples.

High specific surface of the samples, homogenous composition, high rate of active chemical surface forming by reduction, faulty crystal lattice of catalytically active phases and mostly high catalytic activity make them a potential competitor of their industrial analogues upon their probable production in catalyst shops.