

ENGINEERING APPROACH IMPLEMENTATION OF CATALYSIS INTERACTION NATURAL GAS WITH WATER VAPOUR SUBJECT TO STOICHIOMETRIC RATIO

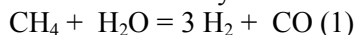
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Process of reception of hydrogen of natural gas as a whole is described by chemical reaction:



This reaction passes with absorption of heat 206 kJ/mol or 6070 kJ on 1kg products participating in reaction. Technical realization of reaction (1) in tubular furnaces on the nickel catalyst in the industry is one of base processes and consequently his influence on an environment appreciably. In tubular furnaces reaction (1) is carried out at surplus H_2O up to 5 times above stoichiometrical the relation [1], i.e. reaction (1) can be written down:

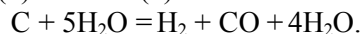


It is visible, that expenses of energy for preparations water pair are adequate to expenses for realization of reaction. Surplus of water is necessary for prevention of adjournment of carbon in the catalyst. Now it is not known any case in industrial production where catalytic conversion of methane would be carried out in the ratio equal stoichiometrical to the relation. Laboratory methods of realization of reaction (1) in *стехиометрии* are known at temperatures above 1300K. These are authentic results - for example [2], [3]. However these technologies in the industry are not used, since auxiliaries for real operation in industrial production demand difficult special and power-intensive devices.

Laboratory researches of conversion of natural gas in a mix with water the ferry on the catalyst in a warmed pipe [4] offer a way of realization of reaction (1) in stoichiometrical the relation without allocation of carbon. It is possible to familiarize with the concrete description of the device of a way and industrial tests in [5], [6], [7].

The idea of a way is based on two statements: first course - carbon is allocated on the catalyst as a result of deficiency of heat in a zone of the most active reaction (3HAP). second course - reaction (1) passes in two stages: reactions of decomposition of methane - $\text{CH}_4 = \text{C} + 2\text{H}_2$ (3) which absorbs heat 75 kJ/mol and reactions of gasification of carbon $\text{C} + \text{H}_2\text{O} = \text{H}_2 + \text{CO}$ (4) with endothermic effect 131 kJ/mol. Reaction (3) decomposition of methane passes, and heat on full

gasification of carbon does not suffice. The part of carbon which could not react, remains in the catalyst and destroys it. In the industrial furnace it is artificial the thermal effect of reaction is reduced (1) surplus H_2O . Therefore in reaction (2) thermal effect on reacting products will be - 1943 kJ on 1kg products participating in reaction. Proceeding reactions (2) reaction (4) will be following:



In such conditions carbon is completely installed gas.

In [4] on an input of reactionary mix CH_4 and H_2O in a warmed pipe, a part of granules of the catalyst were replaced with granules from reactions (1). General length of a pipe 1,5m and 0,46m on an input, occupied spheres inhibitor, other part of a pipe was filled inhibitor by the catalyst. On granules inhibitor reactionary mix CH_4 and H_2O did not react and was heated up to temperature to close temperature of a wall of a pipe (1300K) then acted in granules of the catalyst where reacted without allocation of carbon in the catalyst. In specially certain modes on experimental installation [4] were carried out steam and carbon dioxide catalytic conversion of methane in stoichiometric ratio. For industrial reception of pure mix H_2 and CO the way [5] is offered.

For industrial tests [6] the device [7] was realized and the problem of realization of conversion of natural gas with relation $\text{H}_2\text{O}/\text{CH}_4 = 1,5$ was put. In the device [7] fixing of a zone of the most active reaction (3HAP) was used. On installation [4] this zone was in a layer of the catalyst right after borders of the unit inhibitor and the catalyst and did not exceed 0,2m. The device [7] assumed a warmed pipe of the industrial sizes (about 10m). In such pipe on an input the first layer of granules inhibitor such length was placed, that the initial mix of gases (at the set charge) has heated up to temperature to close temperature of a wall. Further granules of the catalyst were placed, i.e. begins 3HAP. The temperature of a mix of gases reacting in the catalyst sharply falls, but length 3HAP should be such that temperature in a layer of the catalyst has not fallen below 1023K.

After achievement by a reacting mix of this temperature after the catalyst again it is placed inhibitor, carrying out functions of the first layer, i.e. the reacting mix again was heated up to temperature of a wall. Such serial change of layers proceeds up to the end of a warmed pipe where the final contents of methane will achieve the set concentration. Such design of filling of conversion pipes granules in furnaces of conversion of natural gas (ПКПГ) does not break structure and operating mode ПКПГ. Industrial tests passed, on separate pipes furnaces of the enterprise. For check of the device have given the ПКПГ: the Novocherkassk factory of synthetic products (НЗСП) and Oskolsky electrometallurgical combine (ОЭМК). Tests have passed successfully.

On laboratory installation and industrial tests it was used inhibitor which granules have been executed as spheres. Spheres in the device [7] occupied about 80 % all the length long pipes, other part of a pipe was occupied with granules of the catalyst executed as Rashig rings. Hydraulic resistance to a gas stream of a layer of spheres is much less than layer of Rashig rings, therefore hydraulic resistance of a pipe on the average was less on $\Delta p = 2.5$ the Bar in comparison with a pipe filled only granules of the catalyst. (For example: 1. For full loading by the catalyst. The charge (normal conditions) $Q = 114 \text{ m}^3 / \text{hour}$, speed of reacting gases $v = 4.29 \text{ m/s}$, pressure upon an input{entrance} in a pipe $p_1 = 5.5 \text{ bar}$, pressure upon an output from a pipe $p_2 = 0.7 \text{ bar}$, $\Delta p = 4.8 \text{ bar}$., 2. for a pipe filled serially inhibitor and the catalyst according to [7]: $Q = 140 \text{ m}^3 / \text{hour}$, $v = 5.3 \text{ m/s}$, $p_1 = 2.4 \text{ bar}$, $p_2 = 0.7 \text{ bar}$, $\Delta p = 1.7 \text{ bar}$.) It is additional economy of energy.

At radical modernization of pipes ПКПГ are possible perfection of section of a separate pipe, for increase in submission of heat at an external surface of a pipe and transfer heat inside a warmed pipe. These actions are combined with the purpose of reduction of hydraulic resistance of layers of the catalyst and ингибитора.

The note: In the present work the thermodynamic equilibrium structure of the reacted mix of gases which includes CO_2 and residual maintenance{contents} CH_4 , and also corresponding amendments for thermal effect is ignored, but at calculations they should be taken into account. Absolute pressure of gases in structure of described process is not examined also.

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