CHEMICAL ENERGY AND TYPES OF ENERGY USED IN THE CHEMICAL INDUSTRY

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ABSTRACT

The development of the chemical industry is accompanied not only by a quantitative increase in energy consumption, but also by a change in its quality. This is expressed in the increasingly rapid introduction of new types of energy and effects into the chemical production, such as plasma-chemical, ultrasonic, photo- and radiation effects, low-voltage electric discharges, and the effects of laser radiation. These extreme effects contribute to the activation of the molecules of the reaction system, the appearance of excited particles in it and the start of a chemical process, including a process with high selectivity..

Keywords: low-voltage electric discharges and laser radiation, synthesis of endothermic refractory compounds, separation of metals from their oxides and salts, photo and radiation effects

INTRODUCTION

The development of the chemical industry is accompanied not only by a quantitative increase in energy consumption, but also by a change in its quality. This is expressed in the increasingly rapid introduction of new types of energy and effects into the chemical production, such as plasma-chemical, ultrasonic, photo- and radiation effects, low-voltage electric discharges, and the effects of laser radiation[1]. These extreme effects contribute to the activation of the molecules of the reaction system, the emergence of mobile particles in it and the start of a chemical process, including a process with high selectivity[2]. This field of phenomena constitutes a new branch of chemistry high-energy chemistry (HVE), which studies the composition, properties and chemical transformations of systems containing excited particles[3].

Among such processes, plasma-chemical processes, that is, chemical transformations occurring in plasma, are particularly promising and universal. Plasma is a partially or fully ionized gas that contains molecules, atoms, ions, and electrons[4]:

$$A2 \Leftrightarrow 2A,$$

$$A \rightarrow A+ + e.$$

There is a low-temperature plasma with a temperature of 103-104°K and a high-temperature plasma with a temperature of 106-108°K[5]. In chemical technology, low-temperature plasma is used to obtain various products, their industrial methods have been developed. High-temperature plasma is used in TOKAMAG-type devices[6].

Currently, more than 70 technological plasma processes have been studied, and some of them have been introduced into industry. These include[7]:

synthesis of endothermic refractory compounds (uranium and tantalum carbides, titanium, aluminum, tungsten nitrides)[8];

extraction of metals from their oxides and salts (iron, aluminum, tungsten, nickel, tantalum);

oxidation of various substances (nitrogen, hydrogen chloride, carbon monoxide, methane);

pyrolysis of natural gas, oil products;

one-step synthesis of compounds from simple substances (ammonia, hydrogen cyanide, hydrazine, hydrofluorocarbons)[9];

synthesis of compounds formed only under plasma-chemical conditions (ozone, krypton difluoride, sulfur oxide (II), silicon oxide (I)).

On an industrial scale, plasma-chemical processes are used to obtain synthesis gas in the production of acetylene and hydrogen from natural gas, acetylene, ethylene and hydrogen from petroleum products, vinyl chloride, titanium dioxide, etc[10]. Plasma reactors of various designs are used. to carry out plasma-chemical processes.

In the form. 2.8. A direct current reactor consisting of four main units is presented: a plasma torch, where plasma is generated under the influence of an electric arc or high-frequency currents; a reactor into which the generated plasma is introduced and reagents are supplied, a quenching device that provides rapid cooling (quenching) of the reaction mixture, and a unit for holding the reaction products[11].

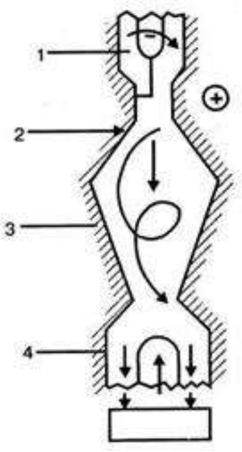


Figure 1 Plasma reactor:

1 - plasma torch; 2- reactor; 3- hardening device; 4 - grip unit

Plasma-chemical reactors are characterized by a very short reaction time of 10-2 to 10-5 seconds. This determines the very small dimensions of the reactor. Plasma-chemical processes are easily controlled, optimized and amenable to modeling[12]. The energy costs for their implementation do not exceed the energy costs for traditional processes[14].

A characteristic example of a plasma-chemical process is the production of acetylene by pyrolysis of methane[13].

For the reaction $2CH_4=C_2H_2+3H_2+DH$,

where DN=376kJ, the rate constant

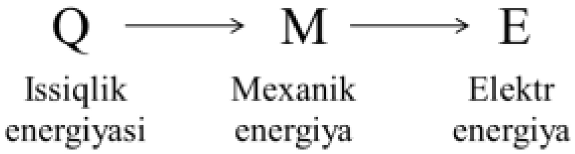
$$Kc= 1012\bullet e{-}79000/RT$$

A very high activation energy requires a high process temperature. Thermodynamically, the reaction is possible at temperatures above 1500°K, where the Gibbs energy is negative[15]:

$$\Delta G = 96.8-0.064\cdot T$$

According to this scheme, argon or hydrogen is used as plasma in the plasma-chemical process for the production of acetylene, and the reaction products are quenched by water injection[16]. The conversion rate of methane reaches 0.7 and the plasma reactor with a diameter of 0.15 m, a height of 0.65 m and a volume of 0.05 m3 has the capacity to produce 25 thousand tons of acetylene per year[17]. In terms of energy intensity, the plasma-chemical method (14.0 kW/kg) is comparable to the carbide method (15.5 kW/kg), but lower than the electrocracking and thermal oxidative pyrolysis methods[18].

The use of other alternative energy sources is limited by the problem of "energy concentration" (H.N. Semenov)[19]. For example, only 0.5% of the solar energy falling on the Earth can satisfy all the energy needs of mankind. However, to absorb and use it, solar plants with a total area of 130,000 km2 are needed. In this regard, the task of finding more technologically concentrated types of energy arises[20the24]. This can be solved by switching from conventional electrical energy to a mechanical energy generation scheme



To the scheme of direct conversion of thermal energy into electrical energy

It is used for this purpose:

$$\underset{\substack{\text{Issiqlik}\\ \text{energiyasi}}}{Q} \longrightarrow \underset{\substack{\text{Elektr}\\ \text{energiya}}}{E}$$

magneto-hydrodynamic generators (MHD generators)[23], in which the kinetic energy of low-temperature plasma is converted into direct current electric energy due to deceleration in the magnetic field (MHD generators)[21];

Fuel cells (electrochemical generators), in which the combustion energy of reactive fuel (hydrogen, alcohols, aldehydes and other active reducing agents) is directly converted into electrical energy[22].

In both cases, the efficiency of this process significantly exceeds the efficiency of conventional processes

The high share of energy in the cost of chemical products required its rational and economical use in production. The criterion of efficiency of all types of energy use is the coefficient of energy use, equal to the ratio of the amount of energy theoretically required to produce a unit of production (Wt) to the amount of energy actually spent on it (Wп).

$$n = \frac{\mathrm{Wt}}{\mathrm{W}\text{п}}$$

For high-temperature endothermic processes, the heat energy utilization coefficient does not exceed 0.7, that is, up to 30% of energy is lost in the form of heat losses with reaction products.

The rational use of energy in chemical production means the use of methods that increase the efficiency of energy use. These methods can be divided into two groups: development of energy-saving technologies and improvement of energy use in production processes. The first group of methods includes:

development of new energy-saving technological schemes;

increase the activity of catalysts;

replacement of existing methods of separation of production products into those that consume less energy (for example, rectification for extraction, etc.);

creating combined energy-technological schemes that combine technological operations that continue with energy (heat) release and absorption. Such a combination of energy and technology in one production makes it possible to use the energy of chemical processes and other energy resources more fully and to increase the efficiency of energy technology units.

The second group of energy saving methods includes:

effective thermal insulation and reduction of heat loss due to reduction of radiation surface of the equipment;

reduction of resistance losses in the electrochemical industry;

Use of secondary energy resources (SER).VER is divided into combustible (fuel), which represents the chemical energy of waste of technological processes of fuel processing and combustible gases of metallurgy; Thermal VER, which represents the physical heat of waste gases and liquids of technological units and the main production waste, and VER of overpressure, which represents the potential energy of gases and liquids coming out of technological units operating under overpressure.

Depending on the type and parameters of the VER state, there are four directions of their use in production:

Fuel direction in the form of direct use of combustible components of VER as fuel;

Heat direction in the form of using thermal WER;

Power direction in the form of using VER to produce mechanical or electrical energy;

combined route.

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