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EFFECT OF INITIAL REACTION TEMPERATURE ON THE DEVELOPMENTS SYNTHEISS OF ACETYLENE FROM METHANE IN AN ARGON PLASMA STREAM

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The synthesis of acetylene from methane is one of the most important process carried in an low temperature plasma stream. This process relied upon introduced methane into plasma stream. The plasma stream flowed out with of arc generatory. The methane is warmed to high temperature 2000 - 6000 K. In the reaction chamber occurring methane-to-acetylene conversion. In effect of the strong endothermal reaction course and of heat exchange by the reaction chamber walls the temperature decrease into final value 1000 - 3000 K. Next the post-reaction mixture leaving the reaction chamber is quenches into temperature at which acetylene is durable. The quickly freezing prevent of formation of by product: soot and acetylene polimers.

If process reaches into of homogeneous equilibrium then temperature in the reaction chamber end is equivalent of equibrium quenching temperature. Then the acetylene concentration reaches of maximal value givens start conditions.

With hithertoes investigations on the synthesis of acetylene from methane in plasma stream follows that unit energy consumption is of complicated function many process parameters [1-10, 12, 13]. Its make very dificult description of process. There has been rised necessity of choise several starts parameters which to permit defined the unit energy consumption and methane-to-acetylene conversion at synonymous way. For settle construction of chemical plasma reactor the start this: initial reaction temperature, initial compositions of argon-methane mixture and thermals efficiencies of plasmotron and reaction chamber.

If time of mixing is infinite short that homogeneous mixture of argone and methane does not starting to react then the initial reaction temperature responding of average temperature of argon-

-methane mixture. At of the initial temperature the sum of argon and methane enthalpy is equal plasma strem energy flowed out with of nozzle-anode plasma generator E_{pl}. The temperatur@ can be calculated with of the equation energy balance:

$$E_{pl} = M\eta = H_{Ar}/Tr/ + V_{CH_4}\ H_{CH_4}/Tr/ \qquad /1/$$

where: V_{Ar}, V_{CH_4} - flow of argon and methane in m^3/h

$H_{Ar}/Tr/$, $H_{CH_4}/Tr/$ - enthalpy of argon and methane in kWh/m^3, expressed by mean temperature functions [11].

The reaction temperature bind four fundamentals initials parameters of work of chemical plasma reactors: power and efficiency of plasmotron and flow of argon and methane.

Primary conditions of process can be descripted by means the equation energy balances of plasma stream flowed out with anode plasmotron:

$$E^{p}_{CH_4} = \frac{E}{V_{CH_4}}\ [illegible]\ H_{Ar}/Tr/ + H_{CH_4}/Tr/ \qquad /2/$$

where: $E^{p}_{CH_4}$ - the specific energy of methane count respect of plasma stream energy in kWh/m^3,

X - relation of argon-to-methane flow .

X - characterise the initial composition of argon-methane mixture. From the literature date [1-9, 12, 13] it is possible an assumption that occuring only desirable reaction

$$2CH_4 \rightleftharpoons C_2H_2 + 3H_2$$

which run into equilibrium at quenching temperature.

From this assumption follows that, U_p - the degree of methane-to-acetylene conwersion calculated from energy balance equation in the end of reaction chamber-

$$U_p = \frac{E^{p}_{CH_4}\ \eta_k - X\ H_{Ar}/Tz/ - H_{CH_4}/Tz/}{0{,}5\Delta H^{o}_{Tz}\ [C_2H_2]} \qquad /3/$$

where: η_k - efficiency of reaction chamber,

$H_{Ar}/Tz/$, $H_{CH_4}/Tz/$ - thermal enthalpy of argon and methane at quenching temperature,

$\Delta H^{o}_{Tz}\ [C_2H_2]$ - change of reaction enthalpy of acetylene synthesis from methane at quenching temperature.

ought to be equal to methane-to-acetylene conversion degree calculated from expressing for of equilibrium constant

$$U_p = f/Tz,\ X/ = \frac{\sqrt{X^2 + 4/\frac{\sqrt{K_p} + 1,299}{\sqrt{K_p}}//1 - X/} - X}{2\ /\frac{\sqrt{K_p} + 1,299}{\sqrt{K_p}}/} \qquad /4/$$

Solving the equation system /3/ i /4/ relative to Tz and U_{pe} for assumed start conditions /Tr and X/, it can be calculate the final conditions. Then the useful unit energy consumption /Zp/, defined as the ratio of energy plasma stream to the amount of acetylene, can be calculated from the formula:

$$Zp = \frac{2\ E^p_{CH_4}}{U_{pe}} = \frac{2\ E_{pl}}{V_{CH_4} \cdot U_{pe}} = \frac{2\left[X\ H_{Ar}/Tr/ + H_{CH_4}/Tr/ \right]}{U_{pe}} \qquad /5/$$

The unit energy consumption Z, defined as the ratio of energy supplied to of the arc generator to the amount of acetylene, can be calculated from the formula:

$$Z = Zp/\eta \qquad /6/$$

The minimal thermodynamic substantiation value of the unit energy consumption is getting by means above-mentioned of method. Can be, in above manner, to determine efficiency of process at function initial temperature the initial composition argon-methane mixture function and thermal efficiencies of plasma generator and reaction chamber.

In the present report of investigation results upon influence initial reaction temperature an the developments synthesis of acetylene from methane are presenting. The constant flows of argon 2 m^3/h and methane 1 m^3/h was maintained. Thus constant ratio of flow argon-methane X = 2 was maintained. Change of arc powers from 3,7 to 17,4 kW caused charge of the initial reaction temperature from 1900 to 6000 K.

The experimental investigations was operating by means of chemical plasma reactor [3, 6, 7, 9]. A schematic diagrams of experimental apparatus is shown in Fig 1.

The reactor consisted of three principal parts:

1 - plasmotron PL-100 with swirling stabilisation of low-voltage arc of argon stream,

2 - watercooled reaction chamber - 8 mm diameter, 54 mm long,
3 - quenching chamber, which consisted double-pipe heat exchanger.
Diameter of nozzle-anode at of dependendence into arc power was changed from 3.6 to 5 mm.

The experiments were carried out welding argon /1-st grade/ and technical methane /contents of methane 97 % vol/. Gas analyse were carried out by means gas-chromatograph GCHF 18 /Willy Giede - firm/ with catarometric detector and of activated coal in columns, the carrier gas - hydrogen or nitrogen.

The magnitude which characterises process was determinated according with methodic given by Szymański [3] . Initial and quenching reaction temperature was calculating with material and energy balance.

The experiments was operating at similar kinetic conditions. Average contact time carried out - 10^{-4}s.

The experimental result are showed in Fig. 2 /continous curves/. From of Fig. 2 shows that, the increasing reaction temperature cause continous increasing of quenching temperature from 1200 to 2800 K.

The increasing of reaction temperature to 4200 K cause linear into approximate rise of total degree of methane conversion and the degree of methan-to-acetylene conversion. Above 4200 K take place check of reaction. At temperatures exceed 5000 K the two degree of methane conversion reaches volues 0,8 - 0,87 and 0,9 - 1,0 respectively.

The different between total and desirable degree of methane conversion shows that take place of the side reaction. It does not depended at substantial manner on the reaction temperature. The side reaction product this: soot, solid and fluid polimers of acetylene and small amount of ethylene /not exceed 0,5 % vol/. Fig. 2 shows the main product is acetylene. The contents acetylene in outlet gas mixture consisted between 2 and 15 % vol.

Becouse of amount of methane entered to reactor is constant then increasing of plasmotron powers and, in a consequence, the reaction temperature to 4200 K causes to rise of acetylene amount. Into 2600 K relative increment of acetylene amount exceed relative increment of arc powers indispensable to increasing of temperature. In view of there the unit power consumption decreases appreciably.

In the rang 2600 - 4200 K of acetylene amount and of arc power increasing proportional. In this interval the unit power consumption does not dependents at real manner upon the initial reaction temperature.

Above 4200 K increasing the reaction temperature does not lead to increasing of acetylene amount. It is lead to increasing the unit power consumption.

From showed dependences follows that exist optimal range of reaction temperature in which the unit power consumption reached minimum value 26 - 28 kWh/m^3. Precise determining optimal range is difficult becouse experimental error reaches to 10 %.

The run of experimental dependences is according to theoretical calculations run. Theoretical run was calculated according to formuls /2 - 6/. At calculations received the middle experimental value of efficiencies: reaction chamber 0,75 and plasma generator 0,6. The results are shown in Fig. 2 of intermittent line.

Obtaining high values /87 - 50 % at least profitable of event/ of the practical yeld defined by ratio of experimental degree of methane-to-acetylene conversion to equilibrium degree of methane conversion. This is indicating that process in the end of the reaction chamber reach the final conditions close to homogenic equilibrium [2, 5, 13] .

The satisfied conformity theoretical calculations in which take into considerations only desirable reaction with experimental results was obtainded. Thus working out calculations method can be useful at of investigations upon determining of optimum conditions synthesis of acetylene from methane in the low temperature plasma stream. The method basing upon start parameters: the initial reaction temperature and initial compositions of argon-methane mixture. The start parameters can be planing before experiment and to control in the course of experiment.

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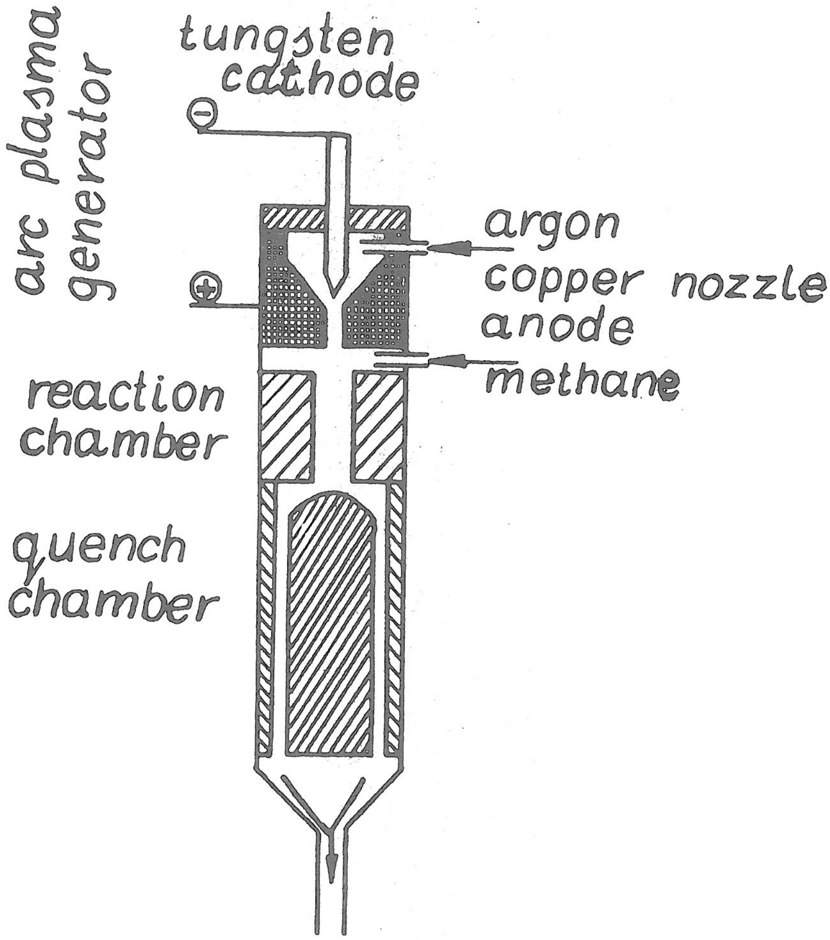

Fig.1. Schematic diagram of chemical plasma reactor

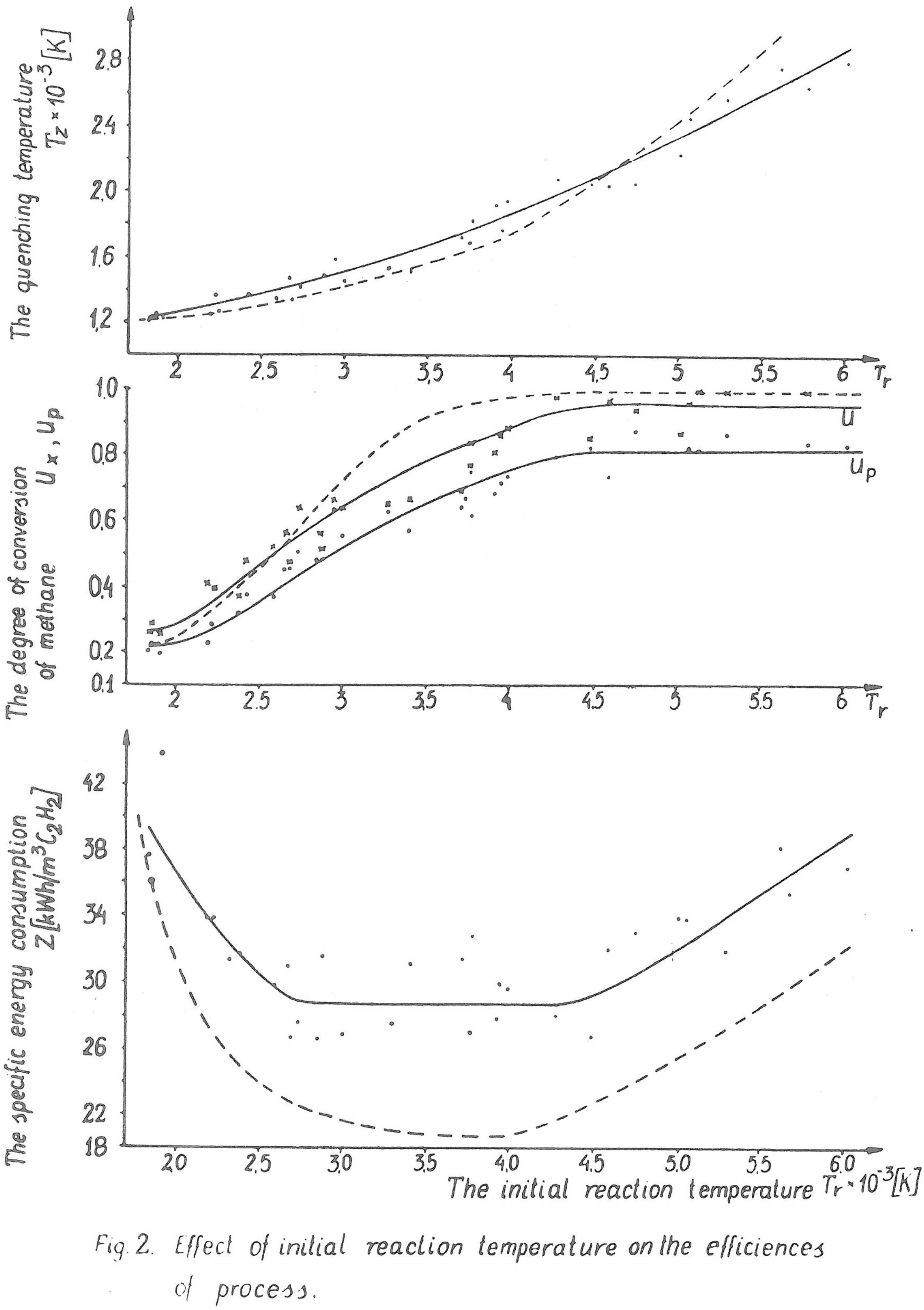

Fig. 2. Effect of initial reaction temperature on the efficiences of process.