

Study of the Effect of Different Types of Membrane Reactors on the Catalyst in Methane Conversion

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Annotation

To date, a number of works have been carried out in the world on obtaining synthesis gas from methane in one stage and on its basis methanol and dimethyl ether, distinguished by economic efficiency. Selection of low-cost and active catalysts with high productivity and selectivity for carbonate conversion of methane with carbon dioxide and obtaining synthesis gas from steam and conversion of carbon dioxide and methane into carbon dioxide with the participation of carbonate conversion and steam and The process of extracting synthesis gas from carbonate conversion, based on a comprehensive study of its thermodynamic justification and the creation of energy- and resource-saving technologies, is of great importance.



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A distributor reactor used for catalytic and non-catalytic thermal conversion of methane using a catalyst with high catalytic activity and efficiency. In reactors of this type, used for thermal conversion of methane in the presence of a catalyst with high catalytic activity and efficiency, a membrane is usually used to maintain the minimum required concentration of one of the reactants (a substance included in the process) in the process mixture, thereby preventing additional processes.

Figure 1 shows various types of flow charts for feeding steam and methane gas into reactors designed for the conversion of carbon monoxide (IV) in the process of converting methane into carbon monoxide (IV).

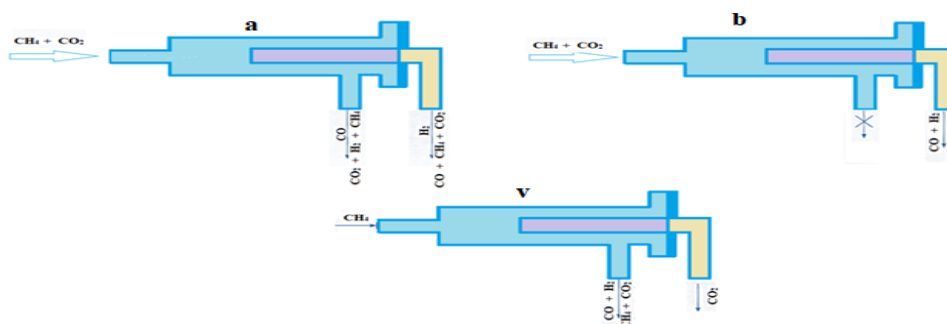


Fig. 1. Schemes of different types of membrane reactors designed for processing methane into water vapor and carbon dioxide: a-extractor , b-contactor , v -distributor

The Extractor type methane conversion with water vapor and carbon monoxide (IV) is suitable for methane conversion with carbonate under the influence of carbon monoxide (IV) and steam-carbonate conversion with water vapor and carbon monoxide (IV) in the developed membrane reactor (Fig. 1.a), the pre-mixed feedstock entering the process is fed into the reactor, designed for the conversion of water vapor, methane and carbon monoxide (IV), where the catalytic process and gas separation take place, then the products of the process, i.e. the exhaust gas and hydrogen from the reactor, designed for the conversion of water vapor, methane and carbon monoxide (IV), are released through two channels: standing channel (gases that have not passed through the membrane) and permeate channel (gases that have passed through the membrane). In the membrane reactor of the "contactor" type, designed for the conversion of methane with water vapor and carbon monoxide (IV) (Fig. 1.b), the feedstock entering the premix process is used for the conversion of methane with water vapor and carbon (IV) oxide is poured into the designated reactor and passes through the membrane, the products of the process, i.e. carbon dioxide and hydrogen, are removed through the permeate channel. In the case of the membrane reactor of the "distributor" type, designed for the conversion of methane with water vapor and carbon monoxide (IV) (Fig. 1.c), gases are fed separately to the reactor designed for the conversion of methane with water vapor and carbon monoxide (IV) are introduced: methane (propane) through the inlet, carbon dioxide through the permeate channel; The products of the process, i.e. carbon dioxide and hydrogen, are removed through a holding channel.

After completion of the tests in the membrane reactor designed for the catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts, the membrane catalyst was cooled to room temperature in a stream of inert gas (e.g. high-pressure nitrogen), passivated, and methane was removed from the reactor designed for the catalytic conversion in the presence of carbon dioxide and under the influence of catalysts with water vapor. In addition, to determine the catalytic activity in crushed form, the membrane catalyst was crushed to a fraction of <0.8 mm and placed in a reactor designed for the catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts.

If a membrane reactor designed for catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts operates on the "extractor" principle, then the membrane catalyst must perform not only catalytic tasks, but also separation tasks, therefore catalysts of the composition $(\text{Ni}_2\text{O}_3)_x \cdot (\text{Co}_2\text{O}_3)_y \cdot (\text{ZrO}_2)_z \cdot (\text{MoO}_3)_k / \text{SiO}_2$ were selected. If a membrane reactor designed for catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts operates on the "contactor" principle, then the membrane catalyst must ensure intensive contact of the starting materials entering the process with the catalyst and not perform separation tasks. If a membrane reactor designed for catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts operates on the "distributor" principle, then the membrane catalyst must have catalytic functions, but this is not the case. It is necessary to have separation functions.

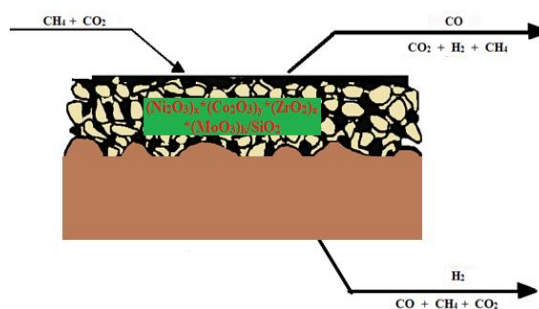


Fig. 2. Operating principle of a membrane catalyst in a membrane reactor designed for catalytic conversion of “ extractor ” methane in the presence of water vapor and carbon dioxide and under the influence of catalysts.

Fig. 2 shows the conversion rates of methane and carbon dioxide and the hydrogen specificity of the process of steam and carbon oxide (IV) oxide conversion (reforming) of methane during catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts. When carried out in a designed membrane reactor ($\text{CH}_4:\text{CO}_2=1:1$), the dependence of the initial gas mixture on the flow rate is shown.

3 shows the degree of change in methane and carbon dioxide gases, as well as the dependence on the volumetric flow rate of the initial gas mixture ($\text{CH}_4:\text{CO}_2=1:1$) of the specificity for hydrogen in the “contactor”. A membrane-water process (880°C and 910°C) is described in a reactor designed for catalytic conversion in the presence of steam and carbon dioxide and under the influence of catalysts.

If we assume that the rate of interaction of H_2 and CO_2 depends on the concentrations of the gaseous substances entering into both processes, then the higher the order of carbon dioxide, the greater the share of this process, as a result of which the specificity for hydrogen decreases. For the same reasons, the specificity of hydrogen increases with an increase in temperature from 880°C to 910°C .

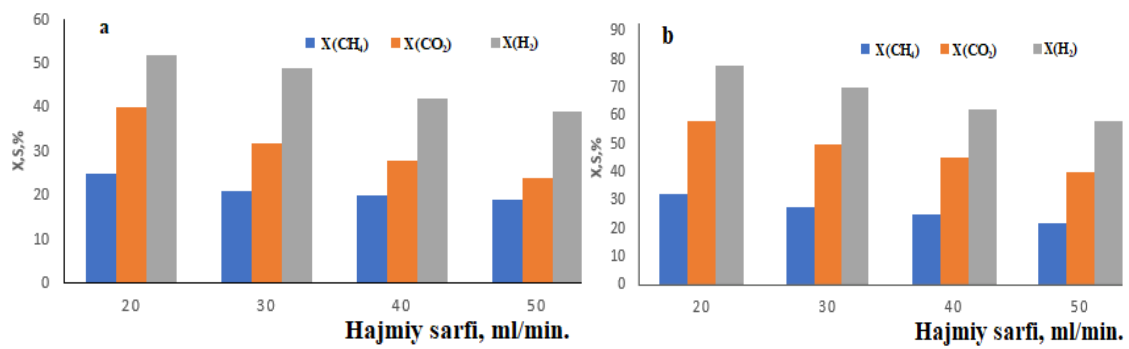


Fig. 3. Dependence of the conversion rate of methane and carbon dioxide on the consumption of the initial mixture for the process of methane conversion with carbon monoxide (IV) in a contactor-type reactor, at different temperatures: a- 880°C , b- 910°C .

The composition of the conversion products, i.e. carbon dioxide and hydrogen, is presented in Table 1 below.

Table 1. The composition of the conversion products is carbon dioxide and hydrogen.

T, $^\circ\text{C}$	Input, ml/min			Product composition, %				
	CH ₄	CO ₂	general	CH ₄	CO ₂	CO	H ₂	N ₂
880	25	25	50	37,37	35.58	18,14	6.17	2.8
	20	20	40	36.24	32.79	20.77	7.39	2.14
	15	15	30	35.55	30.04	24.15	9.05	1.97
	10	10	20	32.92	26.38	28.36	11.61	2.09
910	25	25	50	34.62	27.31	27.35	11.62	0.66
	20	20	40	33.02	24.51	29.96	13.37	0.67
	15	15	30	30.8	21.08	33.13	16.37	0.73
	10	10	20	27.11	17.47	36.46	20.72	0.87

This type is intended for catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts, for the conversion of methane with carbonate under the action of carbon monoxide (IV) and steam-carbonate conversion in the presence of water vapor and carbon monoxide (IV) consideration of the advantages of using the developed membrane reactor, only the main parameters of the conversion (reforming) process of methane with water vapor and carbon monoxide (IV) catalytic conversion of methane in the presence of

water vapor and carbon dioxide and under the influence of catalysts. It is possible to compare with analogs the indicators for other types of reactors intended for n.p.

The "Distributor" class is designed for the catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts, gasified methane under the action of carbon monoxide (IV) and steam gasification in the presence of carbon (IV) oxide using carbonate conversion of methane in a membrane reactor designed for the conversion. Fig. 4 shows the principle of using a membrane catalyst in a membrane reactor designed for the catalytic conversion of methane with carbon monoxide (IV) in the presence of water vapor and carbon dioxide and under the influence of catalysts. The raw materials (inputs) are fed from different sides of the membrane catalyst, mixed and interact in the catalyst, and the process products - carbon dioxide and hydrogen - are obtained from the methane feed.

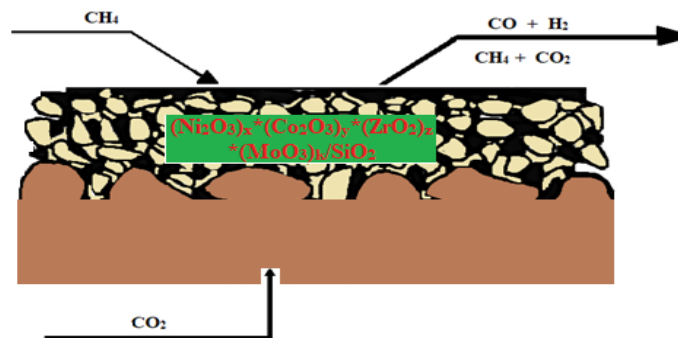


Fig. 4. Operating principle of a membrane catalyst in a membrane reactor designed for catalytic conversion of distributor-class methane in the presence of water vapor and carbon dioxide and under the influence of catalysts.

Class "Distributor" designed for catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts, gasified methane under the influence of carbon monoxide (IV) and steam carbonate in the presence of water vapor and carbon (IV), oxide conversion (reforming) of methane with carbon monoxide (IV) in a membrane reactor designed for conversion.

Table 2. The conversion products are carbon dioxide and hydrogen content.

T, ° WITH	Input, ml/min			Product composition, %				
	CH ₄	CO ₂	general	CH ₄	CO ₂	CO	H ₂	N ₂
880	25	25	50	36.32	37.09	16.34	8.62	2.04
	20	20	40	26.15	30.84	22.36	20.31	1.74
	15	15	30	12.7	18.36	33.15	36,38	1.77
	10	10	20	8.67	12.56	37.46	42.31	2.08
910	25	25	50	24.11	31.58	23.04	22.49	1.22
	20	20	40	9.44	16.59	33.07	42.68	1.14
	15	15	30	6.02	12.56	35.29	47.55	1.38
	10	10	20	4.49	10.72	37.17	48.68	1.9

In the process of methane conversion with carbon monoxide (IV), the "distributor" type is designed for the catalytic conversion of methane in the presence of water vapor and carbon dioxide and under the influence of catalysts into carbonated and water vapor under the influence of carbon monoxide (IV) and carbon monoxide (The principle of using a membrane reactor designed for steam-carbonate conversion in the presence of IV) oxide is explained in Fig. 5.

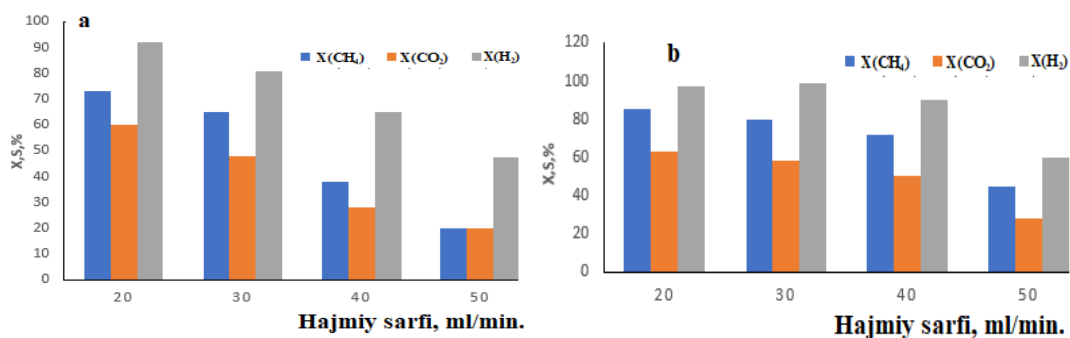


Fig. 5. Methane into carbon in a membrane reactor designed for catalytic conversion (reforming) of methane and carbon dioxide in the presence of water vapor and carbon dioxide and under the influence of distributor class catalysts at different temperatures of hydrogen (IV) specificity, flow rate dependence of the initial mixture for the oxide conversion process: a - 880°C, b - 910°C

Membrane reactors designed for carbonized conversion of methane under the influence of carbon monoxide (IV) and water vapor and steam-carbonate conversion in the presence of carbon monoxide (IV), extractor, distribution and contactor membrane reactors. Possibilities of use in synthesis gas. Extraction processes with carbonate conversion have been studied and it has been proven that the process is carried out in a membrane apparatus.

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