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Study on the design of petroleum treatment equipment based on Plasma discharge Technology

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Abstract: *With the rapid development of modern industry, the emission of carbon dioxide is increasing, which has caused serious harm to the environment. In recent years, CO2 emission reduction has attracted extensive attention all over the world. In order to reduce the environmental pollution caused by a large amount of CO2 produced in the production and excessive use of petroleum products, including natural gas, such as global temperature rise, agricultural production reduction, air and water pollution and energy dilemma, based on the plasma discharge technology and the principle mechanism of plasma catalyzed CO2 reaction, this work optimizes and proposes a new CO2 treatment method based on the traditional CO2 treatment methods. A treatment system and device for directly hydrogenation of CO2 to methanol by plasma discharge technology are proposed. By capturing and treating the by-product CO2 produced in the production and use of petroleum products, it can produce important chemical raw materials while reducing carbon emission.*

Keywords: *Carbon emission reduction, plasma discharge technology, methanol*

1. Introduction

The global economy develops rapidly with the acceleration of industrialization, followed by huge fossil energy consumption and a large number of greenhouse gas CO2 emissions, leading to global warming[1]. In order to deal with this worldwide environmental problem, China made a commitment at the United Nations General Assembly held on September 22, 2020 that "China will increase its national independent contribution and adopt more effective policies and measures." carbon dioxide emissions strive to reach a peak by 2030 and strive to achieve carbon neutralization by 2060[2]. There is no doubt that the emission reduction and resource utilization of CO2 will be one of the important research hotspots in the 21st century. In order to achieve "carbon neutralization", in addition to adjusting the energy structure from the source and reducing carbon emissions, another important and feasible way is to improve the carbon utilization rate and realize the resource utilization of CO2. As China's coal-based energy structure will not change in a short period of time, and the current utilization of coal resources must be accompanied by a large number of CO2 emissions. Although the clean use of energy is being promoted in coal, petrochemical and power industries, the technical problem of CO2 emission reduction has been a key factor restricting the development of the industry. Therefore, the development of resource carbon sequestration process with industrial application prospect is of great significance for carbon emission reduction and green development of energy and chemical industry[3].

By promoting the implementation of CO2 emission reduction technology, it is not only of great strategic significance to the development of China's green economy, but also of great help to the global ecological environment and carbon emission reduction, and contribute to the response to climate change. At present, the main technical means of carbon sequestration are divided into physical carbon sequestration and chemical carbon sequestration. The main technical methods of physical carbon fixation include geological storage technology, CO2 oil displacement technology, CO2 displacement coalbed methane technology, etc. Geological storage technology is to inject CO2 into appropriate geological sites (depleted oil fields, salt water layers, basalt aquifers, etc.) to achieve permanent storage; Norway built the world's first geological storage project in 1996 to store CO2 in the offshore salt water layer. China Shenhua Group built the largest geological storage project in Asia in Ordos in 2010 to store CO2 in the onshore salt water layer[4].

From the point of view of resource utilization, CO2 is a huge carbon source. Chemical carbon sequestration technology is mainly to prepare CO2 into a variety of chemical raw materials and products through chemical reactions. The research direction is mainly focused on the synthesis of urea, methanol,

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formic acid, ethanol and other small molecular compounds by CO2, CO2 hydrogenation to gasoline, CO2 to olefins and so on. Due to the low fractionation activity of CO2, the development of low-cost and technically feasible chemical carbon sequestration process is still very challenging, and its industrialization process lags behind the physical carbon sequestration technology. At the same time, it is also faced with low conversion and other environmental problems, and low comprehensive utilization. Although it has a great application prospect. But there is still some way to go before large-scale industrial production.

2. System design

2.1. Basic structure

The overall system design scheme of this work is shown in Figure 1. The plasma discharge device is used to capture and catalyze the hydrogenation of a large number of by-product CO2 produced in the production and use of petroleum products, and convert CO2 into methanol. While realizing carbon emission reduction, it can prepare chemical raw materials, which not only protects the environment but also alleviates the energy dilemma to a certain extent.

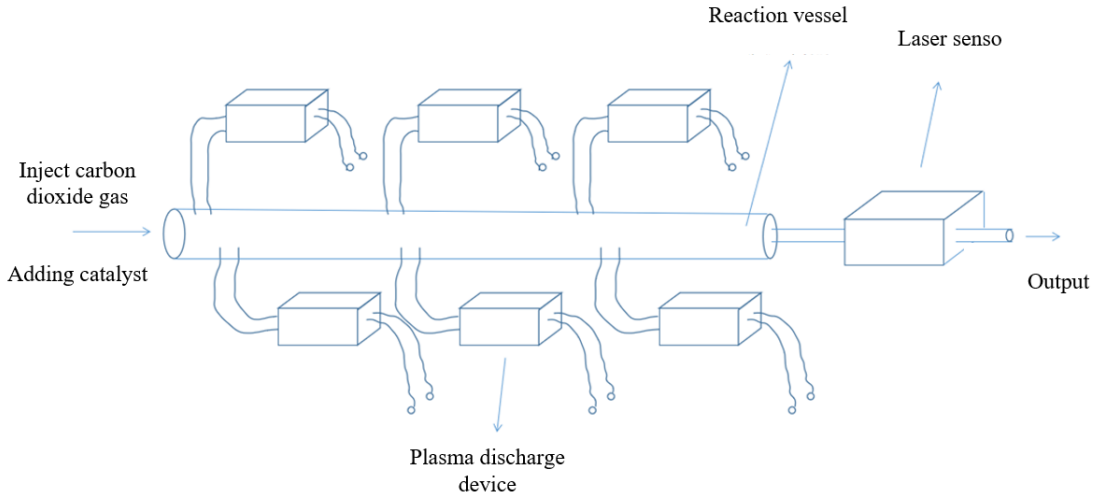

Figure 1: Schematic diagram of plasma discharge device

We have carried out a physical verification of the feasibility of this device. Take two clean empty bottles and add catalysts. One bottle is filled with clean carbon dioxide gas, and the other is filled with smoke. After the two bottles were connected to a stable DC current at the same time (using a dedicated DC voltage source generator), we found that the smoke disappeared quickly. Confirmed the occurrence of the reaction. Choose the appropriate time to disconnect the power. The gas products in the carbon dioxide bottle are collected many times and put into distilled water to form a solution. After the copper wire was heated to a red-hot state, it was immersed in the solution for many times (catalytic oxidation experiment). In addition, take a clean test tube, add an appropriate amount of silver nitrate solution, take the glue dropper and drop into the dilute ammonia water to see the white precipitation, then continue to drop the ammonia water until the precipitation is just dissolved. By adding the above solution to the test tube and heating the water bath in the test tube, you can see that the silver mirror is produced.

Figure 2: Production of silver mirror

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In the next time, we will carry out the physical production process of the idealized model of the above device.

2.2. Realization of catalytic CO2 to methanol

In the plasma carbon sequestration system, the flow controller is respectively arranged in the channel of the plasma reactor, the plasma reactor is connected with high voltage through the high voltage electrode and grounded by the ground electrode, and water, hydrogen or methane is mixed with carbon dioxide respectively. Under the control of the flow controller, the plasma reactor is fed into the plasma reactor in a predetermined proportion. The condenser is connected to the plasma reactor to condense the conversion products and unreacted reactants from the plasma reactor, and selectively circulate in the plasma reactor, so as to convert CO2 to methanol under the condition of normal temperature plasma technology and certain catalyst.

3. Effect of DC voltage on plasma discharge speed

The effect of DC voltage on the speed of low-voltage plasma discharge is studied. We use several identical bottles with the same amount of smoke to measure the plasma discharge device under different voltages. We use the time when the smoke in the bottle disappears completely to measure the discharge speed of the plasma generator at this time. The recorded data are shown in the table below:

Table 1: Experimental result

UDC-(V)	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
Disappearance time(s)	18.84	16.68	15.54	11.68	9.37	7.60	6.78	8.14	10.52	12.89	18.64	19.27	19.45

Draw the image as shown in the figure:

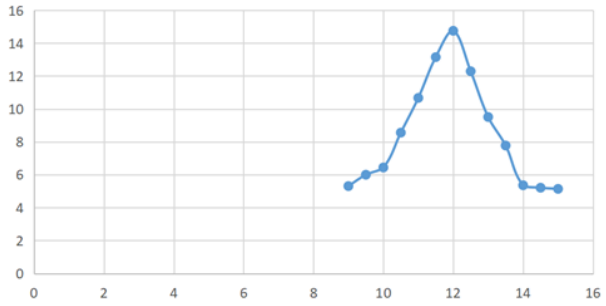

Figure 3: DC voltage on the speed of plasma discharge

The rated DC voltage of the plasma device is about 12V.

4. Practical effect

(1) The adopted technology is advanced, reliable, energy-saving and clean. Traditional carbon sequestration methods require a large number of toxic solvents or catalysts and large power and other energy support in the process of technical realization, or toxic and harmful elements are contained in by-products. While solving the problem of carbon dioxide utilization, this technology may lead to large energy consumption and new environmental pollution problems. The device proposed by us can realize carbon fixation under normal temperature and low pressure, solve the problem of energy consumption, and the reaction product is water and other non hazardous substances, which is friendly to the environment.

(2) Guided by national planning and in line with the actual market demand. Methanol is one of the most important bulk chemicals in the chemical industry. At present, China is the world's largest methanol producer. According to the prediction of IHS, a world-famous energy information company, China's methanol consumption will increase sharply in the next 10 years. At that time, China's methanol output will not be able to meet the rapid growth of methanol consumption, and the gap between supply and demand will increase. Our device can directly convert CO2 into methanol, which can alleviate the relationship between supply and demand to a certain extent.

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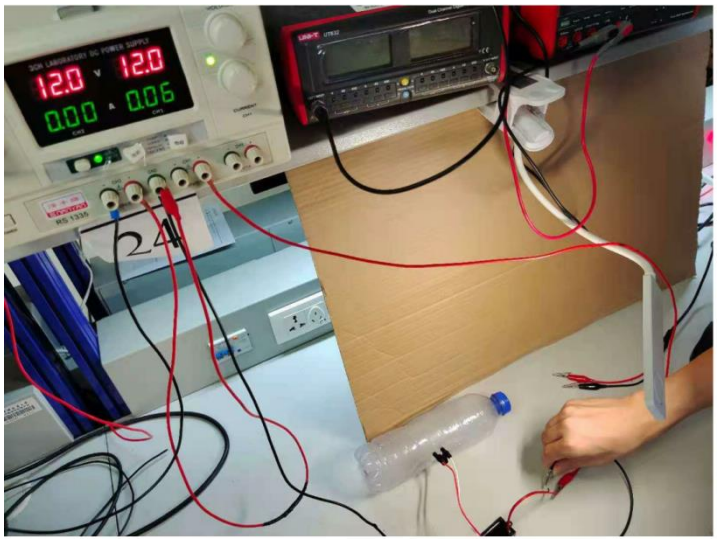

Figure 4: Physical picture

5. Conclusion

This product is mainly used in petrochemical industry. In addition, natural gas stations, oil and gas development and storage, production of biochemical products and other places are the potential markets of this device. Because the product can convert carbon dioxide into methanol under the condition of low temperature and high efficiency, it can not only realize carbon fixation, but also reduce energy consumption and increase economic benefits. The promotion of the product can alleviate the national energy contradiction and protect the environment, which is a great contribution to the national economic development and ecological environment construction. Our device pays attention to the economy and benefits of resource utilization. Its process technology has low cost, which is lower than the cost of preparing the product by using other raw materials or other mature process technology, so that the product cost has obvious comparative advantages and can be well popularized and applied in the market. When selecting the project and the proposed process technology scheme, we can meet the technical and economic feasibility, so that the project has not only good environmental and social benefits, but also good economic benefits, so as to make the resource utilization of carbon dioxide and the development of enterprises sustainable.

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