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OBTAINING UNSATURATED HYDROCARBONS FROM COAL

The article is devoted to the improvement of the technology of obtaining Liquid Motor Fuels from Coal. Unsaturated hydrocarbons are the most important chemical raw material products and are widely used for producing polymers, alcohols and some other organic substances. The paper considers the proposition of technological process of obtaining Synthetic Fuel from Coal with a positive yield effect of the final product with high quality. It is possible to organize the production of Liquid Fuel is made of Coal conversion. The method of Coal conversion into Liquid Motor Fuel is its gasification and hydrogenation but this is not the only way out. The paper proposes the possibility of creating the small plants for the production of synthetic fuels and components of organic synthesis, which can be used of the capacity of metallurgical factories and shops of machine-building enterprises that are vacated areas. In modern society the need is growing to use alternative liquid fuel technologies, for example, by indirect liquefaction of coal. This is especially important for Ukraine during and after hostilities. Ukraine does not have sufficient oil and gas reserves, but it has coal deposits in the coal basin in the west of the country.

An important aspect that is insisted on is the achievement of energy independence. Given the historical traditions and the existing structure of energy deposits in Ukraine, one of the ways to solve this strategic task should be the development of the coal industry. In addition, the environmental component of each of these types of security can be an integrator that integrates them into the national security system. This will help to find their optimal ratio in this system. Moreover, today there is no doubt that any aspect of national security, whether economic, technological or defense, loses its meaning in the event of unfitness of the environment for human life and activity. An influential factor in increasing production of coal for processing in the western part of Ukraine is the maximum extraction of coal reserves and at the same time protection of subsoil.

Keywords: *coal conversion, liquefaction of coal, liquid fuel, calcium carbide, electro-thermal furnaces, shaft furnace.*

Introduction

The rising of world prices for energy resources amid rising of their consumption to set the task of finding the production of alternative types of Motor Fuels [1]. Such Fuels can be obtained on the basis of Coal conversion. At some countries this kind of research is carried out within the framework of Government Programs in order to ensure the energy security of States [2, 3].This is especially true for Ukraine which does not have sufficient Oil and Gas reserves. An important task for the next decade is the creation of Production Plants for alternative types of synthetic Motor Fuels, which can be obtained from Coal and brown Coal.

Natural Fuels include Coal and brown Coal. Alternative Fuels include Liquid Fuels which are an alternative to the corresponding Traditional Fuels and which are produced from non-traditional sources and types of energy raw materials.

Alternative types of Liquid Fuels include: combustible liquids obtained during the processing of solid fuels (coal, peat, shale) [4].

Unsaturated hydrocarbons / alkenes are the most important chemical raw material products and are widely used for producing polymers, alcohols and some other organic substances. The Paper considers the capability of producing Synthetic Fuel from Coal with a positive yield effect of high quality output product.

It is possible to organize the production of Liquid Fuel made of Coal conversion. The method of conversion Coal into Liquid Motor Fuel is its gasification and hydrogenation but this is not the only way out.

Just more recently the production of the main products of organic synthesis was based on Acetylene which is produced by the interaction of Calcium Carbide with water.

In modern society there is a growing need to use alternative Liquid Fuel technologies, for instance by indirect liquefaction of coal. This is especially important for Ukraine, which does not have sufficient Oil and Gas reserves, but has big coal deposits in the Lviv-Volyn Coal basin.

The purpose of the Paper

The purpose of the work is to give the possibility of creating small plants for the production of Synthetic Fuel and components of organic synthesis, which can use the capacities of metallurgical plants and workshops of machine-building enterprises that are released.

Indeed, this Work proposes a modification of a forgotten method of producing Motor Fuel proposed in the middle of the last century.

Setting the task

- to improve the technological process of obtaining Liquid Motor Fuel.
- to make this process adapting to carry it out in Electric Furnaces.

Problem statement

Substantiation of expedience of the study

Well known Fischer-Tropsch Method (F-T) indirect liquefaction of Coal is known. The method consists in it at the Preparatory Stage the coal is a grinding (in Shredder) and then loaded into a Gas Generator (Gasifier), where the Stage of Coal Gasification takes place. The gasification product is sent to the Reactor, where under the action of high pressure, high temperature and catalysts, the Stage of Liquefaction of the finished product. That is, the process includes the Preparatory Stage, a Gasification Stage and a Liquefaction Stage. For instance: from 1000 liters of a mixture of Hydrogen H_2 and Carbon Monoxide CO at a pressure of 2,5 MPa and a temperature of 250 ° C is obtained 208,5 m^3 of final products. The weight of 1000 liters of the mixture is 475, 87 kg, so the yield is about 44 %. Almost from the final product is possible to obtain 80 % of Gasoline and Motor Fuel, so a yield is an approximately 31%. It should be noted that the quality of such Gasoline is low; the Octane Number is in the range of 50-60.

A scheme of realization of the technological process by the F-T Method can be presented as at Fig. 1.

The disadvantages of this method include the need to maintain both high pressure and temperature in the reaction zone, low yield of the finished product and its low quality. In addition, there is a very rapid senescence of the catalyst.

The disadvantages of the equipment in which the process F-T is carried out include: the need for high-quality chemical equipment with a large number of thick-walled temperature and corrosion-resistant elements of large volume, fire and explosion hazard of equipment.

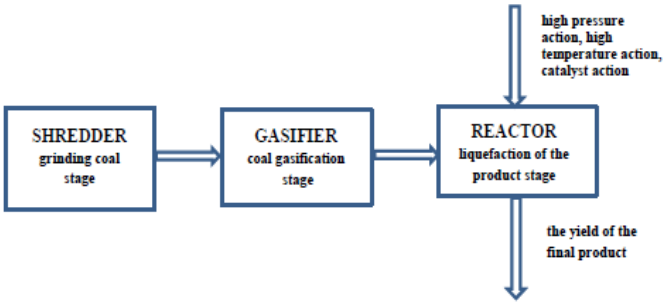

Fig.1. *The scheme of realization of the technological process by Fischer-Tropsch Method*

But more than 50 years a method for producing Calcium Carbide at simple Shaft Blast Furnaces has been known also. The required temperature was achieved by enriching the blast with Oxygen up to 60% in those Furnaces. However at that moment this method was not widespread due to the efficient factor of Blast Furnaces and the cheapness of natural gas (while at that time) as a raw product material for the production of Ethylene (that replaced Acetylene), which was obtained from Calcium Carbide. Using activated Carbon as a catalyst, Benzene-motor Fuel with an Octane Number about 108 [5] and a component of organic synthesis was obtained by reaction from Acetylene.

There is different important aspect that encourages the introduction of Motor Fuels from Coal. This is an environmental safety.

In a wide sense Ukraine's national security is interpreted as the absence of threats to human rights and freedoms, the basic values of a sovereign state. It is a way of self-defense of the people who have reached a certain level of organization in the independent state of Ukraine.

Environmental security is a component of national security that guarantees the protection of vital interests of man, society, the state and the environment from real or potential threats. Such threats can be created due to natural or man-made factors. In addition, the environmental component of each of these types of security can be an integrator that integrates them into the national security system. This will help to find their optimal ratio in this system. Moreover, today there is no doubt that any aspect of national security, whether economic, technological or defense, loses its meaning in the event of unfitness of the environment for human life and activity. Therefore, environmental security should not be seen as one of the components of national security, but as an integrator, able, on the one hand, to consolidate society, and on the other – to ensure its progress [6].

Processing of Coal into Liquid Fuel contributes to the establishment and strengthening of environmental safety, subsoil conservation and environmental protection.

Therefore the implementation of the technological process proposed in this Paper is one of the components of strengthening the environmental security of our country.

Proposed approach to creation of small plants for production of Liquid Fuel

Systematic structure of the technological process of obtaining Motor Fuel

In the 70s Acetylene was substituted by Ethylene which was almost 2 times cheaper. However already in the early 70s experts began to get wise Acetylene is a strong competitor to Ethylene as a raw material for the synthesis of output products. Specifically it competes with Vinyl Chloride and Vinyl Acetate; both are produced in a relatively simple one-step reaction.

In this case, the requirements of expensive and critical catalysts are reduced, there is no need of high pressure and, therefore, reactors made of thick sheets of Titanium steel with strapping pipe of 50-70 km are not needed. In addition, the price differential has begun to reduce due to better energy consumption in the production of Calcium Carbide in electro-thermal furnaces. Now for the production of a tone of Calcium Carbide, 3000-3400 kW·h of electricity is consumed 0,95 tons of Lime, 0,55 tons of Carbon [7].

The process proceeds according to the reaction, which can be stoichiometrically represented as follows:

$$CaO+3C=CaC_2+CO-Q,$$

where CaO – Unhydrated Lime;

C – Carbon;

CaC_2 – Calcium Carbide;

CO – Carbon Monoxide;

Q – emitted heat.

The degree of Carbon Conversion is more than 98% in this case; it is the best among of the known processes of Carbon Conversion.

The first approximation suggests as follows scheme of indirect liquefaction of Coal through Calcium Carbide (see Fig. 2).

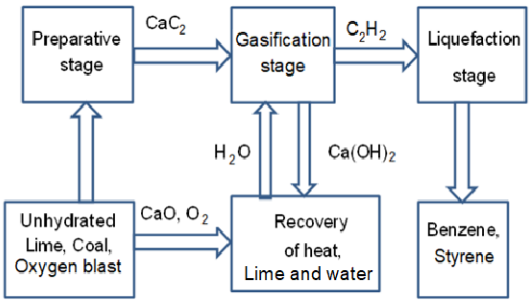

Fig. 2. *Scheme of implementation of the method of indirect liquefaction of Coal through Calcium Carbide*

Presentation of the process of indirect liquefaction of Coal

The process could be presented in the following sequence descriptively:

1. Unhydrated Lime CaO and Carbon C (coke / anthracite) are fed into the Shaft Furnace by skip lift.

2. CaO and Carbon both react in the Shaft Furnace to form Calcium Carbide (CaC_2) and Carbon Monoxide (CO) at a temperature about 2200 ° C, which is reached by enriching the blast air with Oxygen.

3. Molten Calcium Carbide is periodically discharged from the Furnace into the Accumulator Tank, from which Calcium Carbide is fed into the Cooler-crystallizer with pseudo-fluidized bed, in which the counter-flow of the cooling air makes coolness, crystallization, and granulation the Calcium Carbide fluid in the pseudo-fluidized bed. The basic mass of the cooled Calcium Carbide is automatically discharged through the appropriate side port-hole into the Storage-hopper of Carbide. Part of the Calcium Carbide is carried out by the flow of cooling air into the Cyclone of the Cooler-crystallizer in which the separation of hot air and the fine fraction of Carbide is made.

4. The cooled Calcium Carbide is fed to Acetylene Generator by feed like carbide-to-water. Gas yield is 95% approximately. Acetylene C_2H_2 is passed off to polymerization to Benzene / Styrene and Burnt Lime $Ca(OH)_2$ is passed off to Sedimentation Tanks, where residual gases are given out.

5. As needed Burnt Lime is fed into the Dryer from the Silt-settling Tank, and then into the Kiln-Dryer (Dryer with a vibro-liquefied bed) without contact of the heating agency and the $Ca(OH)_2$ substance, where Lime dehydration occurs by hot gases (blast furnace gas and hot air from the Calcium Carbide Crystallizer-cooler).

6. Hydration water gave out in the Kiln during dehydration of Burnt Lime $Ca(OH)_2$ is supplied to the Utilization Steam Turbine for driving auxiliary mechanisms (blowers, pumps, turbo expanders). Steam temperature 600° C; pressure 3, 5 MPa; turbine efficiency – 0, 34.

7. Liquid air from the Turbo-expander is directed to rectification for the goal of obtain Oxygen to enrich the blast.

8. Water is given out to the Acetylene Generator from the Condenser of the Steam Recovery Turbine and from the Burnt Lime Dryer.

9. Acetylene is polymerized at 550-650° C to Benzene on an activated Carbon catalyst. Heating is made out at the expense of the heat of the waste blast furnace gases.

10. Benzene is given out to clarification and cooling. Not reacted Acetylene is given out to polymerization again.

11. Residual gases from the Silt-settling Tank, gas from the Acetylene Generator is given out to the Absorber, where they are washed and absorbed. The Acetylene is given out for polymerization according to the scheme, and other gases with the solution are removed for neutralization.

12. Sulfur gases are neutralized with help of Lime to form Gypsum, Phosphite, respectively to form Calcium Phosphate.

13. Ammonia, which is released during the interaction of Calcium Nitride with water, is given out to the Plant of Nitrogen Oxide Suppression.

14. Burnt Lime from the Kiln and Coal are fed into the Hopper of the shaft Kiln.

15. It is possible to estimate approximately the expenditure of Coal, or rather the organic mass of Coal, per unit of the output product in the process with the utilization of heat of Lime and water.

If an efficiency factor of Shaft Furnace is 0, 4, then for the production of 1 kg of CaC_2 are needed:

- CaO – 0, 88 kg;
- Carbon – 0,563 kg.

If the fuel is Anthracite, then its theoretical expenditure for the production of 1 kg of CaC_2 will be 0,395 kg as fuel and 0,563 kg as a Carbon source. In general: 0,958 kg.

The energy needed to calcinations 1 kg of CaC_2 is 1,735 MJ, for calcining Burnt Lime and taking into account the efficiency factor of the Tunnel Kiln, it is 2,67 MJ.

Waste blast-furnace gases have a temperature in the range of 1000 -1400 ° *C*. A heat capacity is more than 1 J/g·deg. Waste gases have energy of at least 10 MJ / kg, since up to 5 kg of blast-furnace gases are released per 1 kg of CaC_2. This energy is sufficient for drying and Burnt Lime.

In additional hot air from the Cyclone Crystallizer-cooler of the CaC_2 can be directed to the Dryer and to the Kiln. Since1 kg of CaC_2 at a temperature of 2200° *C* has energy of at least 2 MJ / kg, the energy of air and blast furnace gas after the Lime dryer and Lime Kiln is sufficient for the polymerization of Acetylene into Benzene at 550-650 ° C.

So in the process of utilization of heat, Lime and water, taking into account that 406 g of Acetylene is released from 1 kg of CaC_2, 2,36 kg of Anthracite is needed per 1 kg of benzene. With efficiency factor of Shaft Furnace is 0, 6, then Anthracite are needed 1,911 kg respectively.

The implementation of this issue is especially important given the coal reserves in the Lviv-Volyn Coal Basin.

Really this work proposes a modification of the forgotten method of the production of Motor Fuel, which was proposed by Academician A. Petrov. In the middle of the last century Academician Petrov stood up for the harmonious and balanced development of Carbochemistry and Petrochemistry [8, 9].

The importance of developing coal minerals in Western Ukraine for energy-saving technologies

Achieving energy independence was perhaps the first to be mentioned among the priorities declared by the leadership of our country for many years.

Given the historical traditions and the existing structure of energy deposits in Ukraine, one of the ways to solve this strategic task would be the development of the coal industry.

However, the events of recent years have significantly complicated both the development of long-term development plans and the current situation in coal mining. The fact is that the lion's share of coal resources, namely 92, 4% is in the Donetsk coal basin. The Lviv-Volyn basin accounts for only about 2, 5% of total «black gold».

Experts from the Center for Energy Research propose to consider solving the problem of coal production of the required brands in terms of the real situation in Donbass and the possible consequences of the military campaign in the region. At the same time, the situation with coal deposits of grades G (gas) and D (long-flame) is quite good, as they are mainly located in the Western Donbas and Western Ukraine.

Coal in the Lviv-Volyn basin has a high degree of ash content, and therefore needs to be enriched for use in thermal power plants. Before entering the Power Electric Plant, the coal is processed at the Central Concentration Plant. In addition, it should be noted that recently the mines of the Lviv-Volyn basin, despite the amount of coal production, have had problems with sales for the needs of Power Electric Plants.

An important factor in increasing coal production is the maximum extraction of coal reserves and at the same time the protection of subsoil. It is known that losses of coal during mining are still significant and average from 27, 6 to 42, 6 %. To reduce losses, we need to introduce new highly efficient subsoil mining technologies that best ensure the preservation of the earth's surface.

An additional stimulus for the operation and development of Ukraine's mines and a source of hope is the fact that the potential of the Lviv-Volyn coal basin is far from spent.

Summing up the analysis of the situation in the coal mining industry of Western Ukraine, we can notice its difficult economic and technological situation. However, the urgent needs of our energy and industry for coal, the uncertainty of the situation in the Donbass together with significant reserves of the Lviv-Volyn Coal Basin determine the high prospects and feasibility of further development of coal mining in Western Ukraine.

The Lviv-Volyn Basin was not a strong participant in the Ukrainian Coal Market. Production in recent years was only 2% of all-Ukrainian. However, in a short time production from this basin could be doubled. [10].

There are significant prospects for the development of the Lviv-Volyn Basin. The total balance reserves of coal in this basin are more than 1, 5 billion tons. Industrial reserves of existing mines reach almost 100 million tons.

Conclusion. Really this work proposes a modification of the forgotten method of the production of Motor Fuel. The implementation of the technological process proposed in this Paper is one of the components of strengthening the environmental security of our country There is different important aspect that encourages the introduction of Motor Fuels from Coal. This is environmental safety.

Many of the technological components in the process scheme presented in this Paper are commercially viable, but several key ones have not yet found commercial use. In this section we offer the possibility of developing key technologies for Coal and converting it to Liquid Fuel.

The processing technologies listed are specific to certain raw materials. Finally, we conclude from a careful evaluation and analysis of issues around Coal conversion that the optimum technology for small processing plants to Liquid Fuels there is a proposed technology.

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ОТРИМАННЯ НЕНАСИЧЕНИХ ВУГЛЕВОДНІВ ІЗ ВУГІЛЛЯ

Стаття присвячена удосконаленню технології одержання ненасичених вуглеводнів із вугілля. В роботі розглянуто пропозицію технологічного процесу отримання синтетичного палива з вугілля з виходом кінцевого продукту високої якості. Метою роботи є створення технологічного процесу отримання рідкого палива в електротермічних печах на невеликих підприємствах, які можуть використовувати потужності металургійних заводів та цехів машинобудівних підприємств. Метод отримання рідкого палива – шляхом вугільної конверсії, непрямого зрідження вугілля. Процес відбувається в електротермічній печі за реакцією, яку зведено до одно-стадійної.

Реалізація запропонованого в роботі технологічного процесу – є однією зі складових зміцнення екологічної безпеки, а також досягнення енергетичної незалежності держави. Технологічні компоненти у схемі процесу, що наданий в цій роботі, є комерційно життєздатними, але кілька ключових з них поки що не знайшли комерційного застосування. У роботі автори пропонують можливість розробки сучасної технології переробки вугілля та перетворення його в рідке паливо. Ця технологія є специфічною для певної сировини і може бути запропонована для впровадження.

Ключові слова: *конверсія вугілля, зрідження вугілля, рідке паливо, карбід кальцію, електротермічна піч.*

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