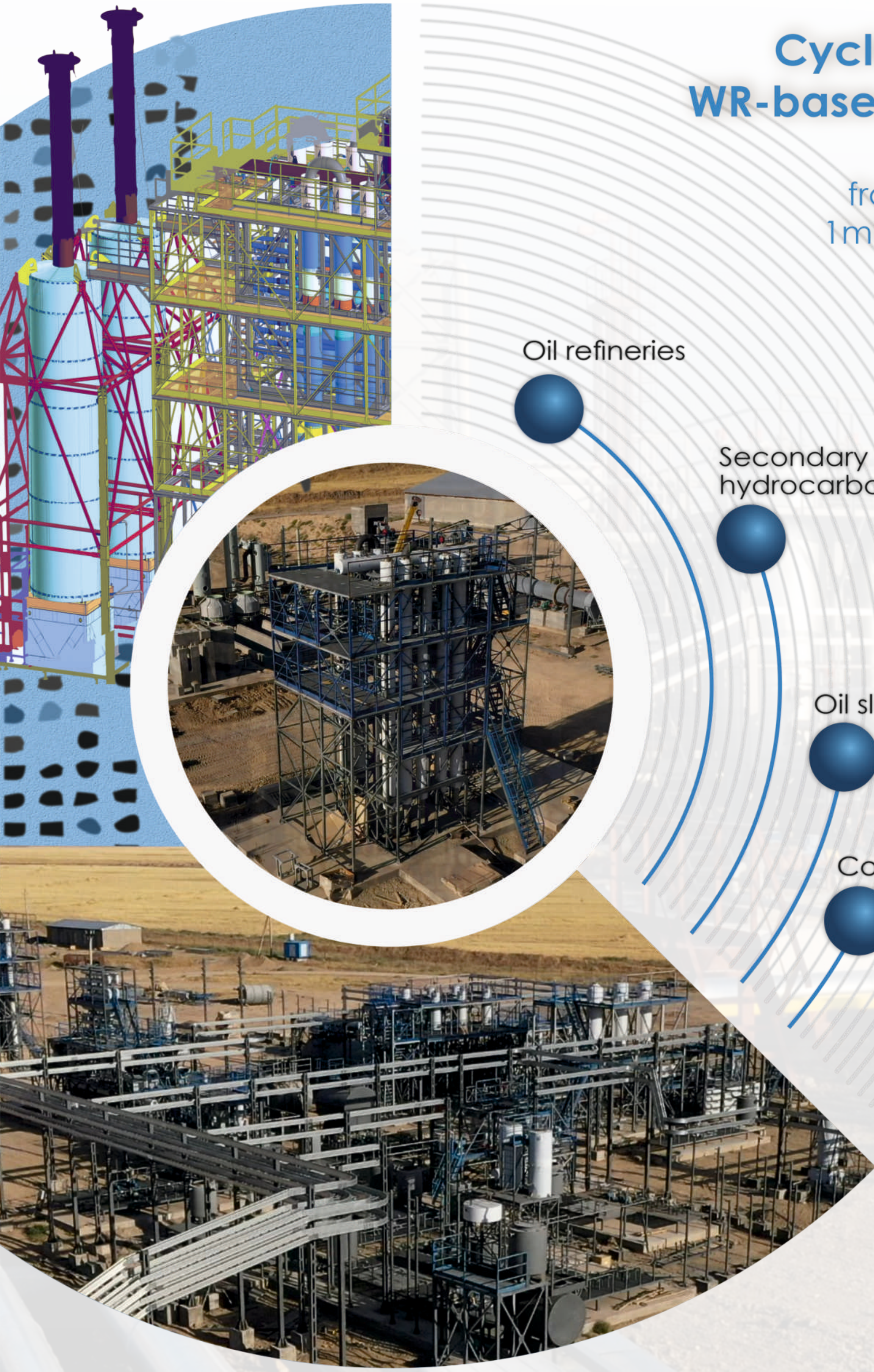
ETN - CYCLONE

Cyclone refineries WR-based technology

Performance from 10thousand to 1milloin tons per year



- Oil refineries
- Secondary advanced hydrocarbon processing
- Oil sludge processing
- Coal chemistry

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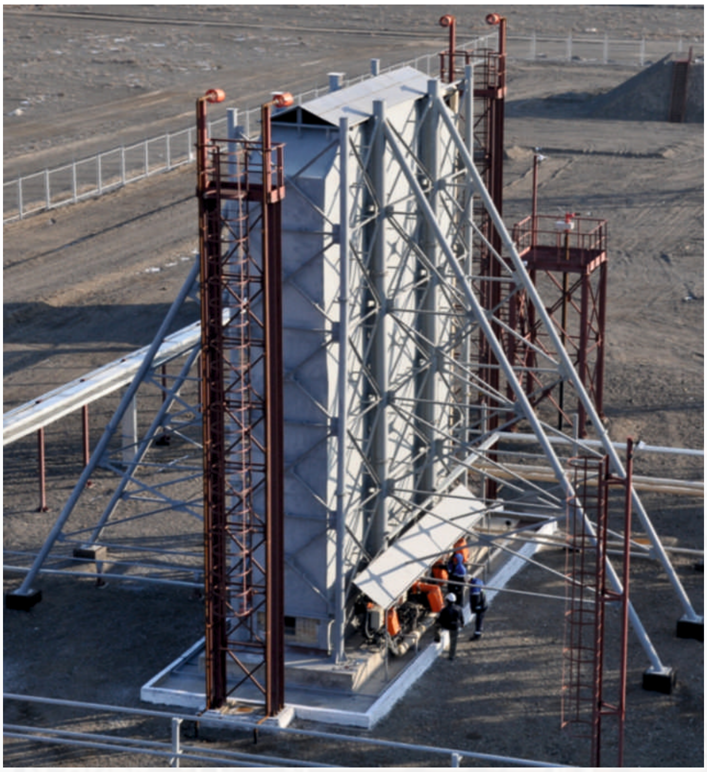


Since 2005 a **new oil refining method** and oil-refining plants based on this method have been brought into practice and successfully applied. The method is conventionally called the whirl refinery – **WR technology**. The unconventional method is featured by very good ecological properties (as opposed to classical methods there is no need in discharge of waste liquids – oil sludge because they are not produced!). Air emissions are identical to exhausts of internal combustion engines.

The method for refining of hydrocarbons is based on flash evaporation and step-by-step cooling at each refining stage. *The new feature is use of **cyclone separators / evaporators** for separation into vapor phase and liquid phase at all refining stages*. They are designed not only to ensure high-efficient separation of vapor and liquid phases through whirling motion, but also to efficiently restrict exit of vapors of heavy fractions along with vapors of light fractions to the next refining stage. Therefore, the implemented approach is ***based on the gas-dynamic solution of the problem associated with fractioning of hydrocarbons.***

Advantages of the method allows successfully processing light and heavy oils, gas condensates and hydrocarbon mixtures with the same refinery plant based on the WR technology.

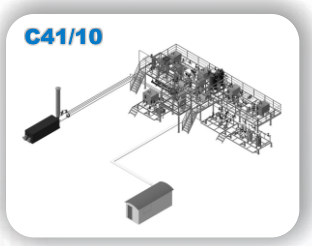
Using our experience in the practical application of the method, we identified its additional advantages relating to refining of hydrocarbons, new application areas and new high-efficient oil refining solutions.

Oil-refining plants		Secondary (in-depth) Processing of hydrocarbons
	High-Efficient Directions of the WR Technology	
Oil refinery tankers		Refining of Oil Sludge

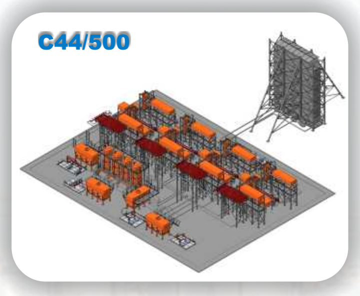
Direction 1
Oil-refining plants

Oil-refining plants of different purposes and capacities. First of all, direct distillation at atmospheric pressure.

Oil refining plants based on the WR technology principles are successfully operated in climatic conditions from +45ºC to -45ºC.



The plants with the capacity from 10 tons per day to 500 thousand tons per year (raw materials) have been developed and constructed.



Purpose and Application of Plants

The advantages listed above allow using the plants in the following areas of application:

1. General-purpose high-efficient and failure-free oil-refining equipment *for production of motor power-plant fuels.*
2. General-purpose equipment ***for refining oil sludge.***
3. General-purpose equipment for production of diesel fuel in development of ***oil and gas-condensate fields.***
4. High-efficient equipment for extraction rectification, e.g. for extraction of aromatic hydrocarbons.

Additional Advantage.

The preliminary skimming processing unit designed for processing of light oils and gas condensate enables ***high-efficient* dehydration** *(with water content up to 7-8%)* and **desalting *of oil*** that has been poorly pretreated.

Note: - the process (dehydration and skimming processing) is conducted in the mode of **straight** oil distillation!

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Advantages for implementation of the method into practice.

№	Qualitative indicator	Whirl refining Plants	Conventional plants (Feasibility)
1	Ease and reliability of operation.	✔	✖
2	High level of automation, metering and control	✔	✔
3	High safety level – pressure in the processing line is close to atmospheric pressure.	✔	✔ ✖
4	**Insensibility to variations in percentage composition of feed stock. This is an essential advantage**, when the plant is to operate with different types of raw materials coming from different sources and on the basis of the just-in-time system. *(This allows using one and the same plant for processing of heavy and light oils, light and black gas condensates, as well as for refining or reprocessing sp*oiled oil products!)	✔	✖
5	High output of light fractions with maintenance of quality parameters of diesel fuel.	✔	✔ ✖
6	Octane number of straight-run gasoline calculated on the basis of motor method test is at least 5-6 units higher than the similar indicator for traditional column-type plants (for most oil grades and gas condensate).	✔	✖
7	Low materials consumption of the equipment.	✔	✔ ✖
8	The plant reaches the high-quality mode of operation (product meets the quality requirements) in 40-50 minutes after starting.	✔	✖
9	The plant can be operated at 35% of its rated capacity with retention of quality parameters.	✔	✖
10	The plant can be used for refining oil with high water content (up to 7%).	✔	✖

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Scientific and production association ETN-Cyclone

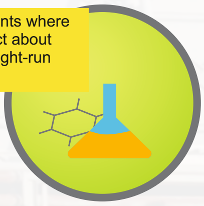
Recommended composition of the refinery

The combination of the recommended process plants can be very diverse, depending on the raw materials being processed, the capacity and the products selected.

Complete block unit for reverse conversion of aromatization and oligomerization

- It allows to obtain from gas direct conversion a high-octane gasoline component (oligomerizate) with an octane number of 95, or a mixture of aromatic hydrocarbons BTK
- The reverse conversion is subjected to 65% gases
- True where propane / butane is not in demand, and it must be converted back to gasoline.

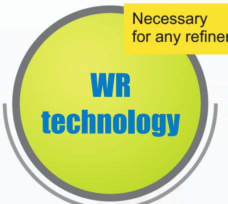
Recommended for plants where direct conversion affect about 30 thousand tons straight-run gasoline a year.



Installation complete-block refinery with a host of toppings

- The installation for the primary distillation of raw materials to naphtha fractions with the provision of the main indicators of GOST for all types of raw materials

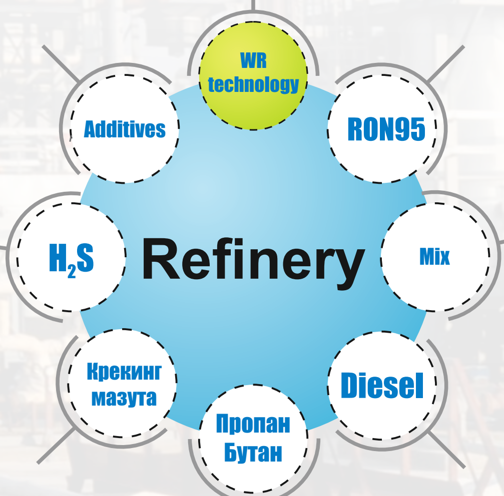
Necessary for any refinery



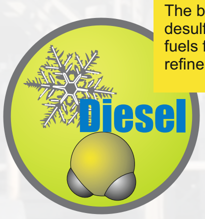
Installation complete-blockdirect conversion gasoline fractions

- Provides obtaining of high-octane gasoline from 80 to 95 of straight-run gasoline
- Upon receipt of the AI 92-93 from straight-run gasoline up to 35% of its mass goes into a gas propane/butane

Recommended for any refinery with processing of 20 thousand tons of raw materials per year



The best method desulfurization motor fuels for small refinerypower.



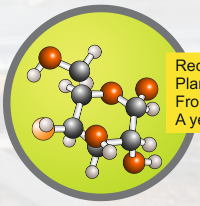
Installation of acid desulfurization oil

- Provides the receipt of winter varieties of diesel fuel from paraffinic raw materials
- Large volumes of summer diesel fuel

Recommended for Any modern refinery oriented for receipt Motor fuels

Mixing of components Motor fuels

- Production of mixed gasoline based on catalysts and additives

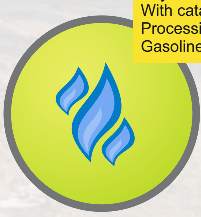


Recommended for Plants with capacity From 40 thousand tons A year for raw materials.

Combined fuel oil cracker (Gas oil), with a direct conversion unit Light cracking products

- It allows you to get from fuel oil (if the oil content of light 60-61%) additionally up to 7-8% of cracking gasoline and up to 35-37% of diesel fuel from the mass of fuel oil.
- When processing gas oils in recycle mode, the yield of light is 75% (of which 85% of diesel fuel and 15% of gasoline)

It is necessary to Any refinery With catalytic Processing Gasoline and fuel oil



Gas separating unit with compression unit Propane / butane and fuel delivery system Gases to the furnace burners

- It allows you to extract from the gases the conversion and cracking of the propane / butane fraction, liquefy it and send it to the commodity park, and send the remaining gases to the furnace burners.

Recommended for Raw materials with high Paraffin content

Unit-block installation Direct conversion Kerosene fractions

- Provides the receipt of winter varieties of diesel fuel from paraffinic raw materials
- Large volumes of summer diesel fuel

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Direction 2
Refining of Oil Sludge

One of the key advantages of the method is the fact that significant variations in stock composition do not affect quality of finished products. This allows successful refining of hydrocarbons retrieved from different settling tanks and reservoirs for ***oil sludge*** that is impossible for the classical oil refining technology.

Processing of Liquid Raw Materials

1. Technical features of the cyclone plants developed by Scientific Production Association ETN - Cyclone allow high-efficient dehydration of oil and oil residues (with content of residual water up to 7-8%), as well as high-efficient refining of oils (including oils retrieved from slurry tanks) to motor and power-plant fuels. Collected oil residues may be exposed to thermal decomposition and produce black heating oil and cracked gasoline.

2. If bitumen and lubricating oils (vacuum gas oil) are required to be produced from oil residues, dehydrated oil residues are exposed to vacuum distillation through the same separator/evaporator of cyclone type. If necessary, vacuum gas oil may be exposed to thermal decomposition to produce cracked gasoline and heating oil. Such a process flow allows high-efficient refining of oil residuals having different compositions with one and the same

Any design for refining liquid oil sludge will include retrieval of crude oil from a sludge tank and primary fractionating.

Designs will differ in refining purposes, as well as in quality of finished products (depth of refining), depending upon local conditions. Capacity (amount of raw materials) is an additional characteristic of the plant.

Use of pyrolysis gases and increase in efficiency of disposal methods based on combustion of oil sludge

Combustion of oil sludge is one of the most popular methods for disposal of toxic waste. However:
1 – combustion produces a significant amount of toxic gases discharged in the air;
2 – combustion of oil sludge is a rather expensive process;
3 - valuable hydrocarbon component is lost during combustion.

We have developed the technique and the equipment that allow producing oil products from pyrolysis gases *(without preliminary selective separation of gases!)* a mixture of ethyl and isopropyl alcohols – i.e. **high-efficient high-octane additive to motor gasolines** (meets Euro-4 and Euro-5 requirements).

It should be noted again that any gas mixtures produced from oil refining and *gas mixtures from oil sludge exposed to pyrolysis* may be used as raw materials for this plant. Remaining gases that are not used for synthesis of alcohols are used as gaseous fuel for pyrolysis.

We have developed the plant with daily capacity up to 3, 10 and 200 tons of alcohol mixtures.

Directions of Refining in Relation to Finished Products

- Direct distillation
  - Masut
  - Distillates of light fractions

Additional refining stage:

- Thermocracking of heavy fuel oil
  - Dark heating oil
  - Distillates of light fractions
- Vacuum processing of oil residues + Thermocracking of vacuum gas oil + Preparation of high-octane additive To motor fuels from pyrolysis gases + Receiving construction And road bitumen
  - Bitumen, building and road
  - Dark heating oil + Distillates of light fractions
  - High-octane gasoline
  - High-octane additive
- Thermocracking of heavy fuel oil + Preparation of high-octane additive To motor fuels from pyrolysis gases
  - Dark heating oil + Distillates of light fractions
  - High-octane gasoline
  - High-octane additive

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Direction 3

Secondary (advanced) processing of hydrocarbons

WR-technology allows to perform secondary (deeper) processing of hydrocarbons. We have developed the following set of facilities that allow us to perform:

- Cracking of mazut (gas oil).
- Reforming gasoline (conversion of light liquid hydrocarbons - straight-run gasolines and gas condensates).
- Conversion of hydrocarbon gases.

Example of work

Installation of direct gas condensate conversion

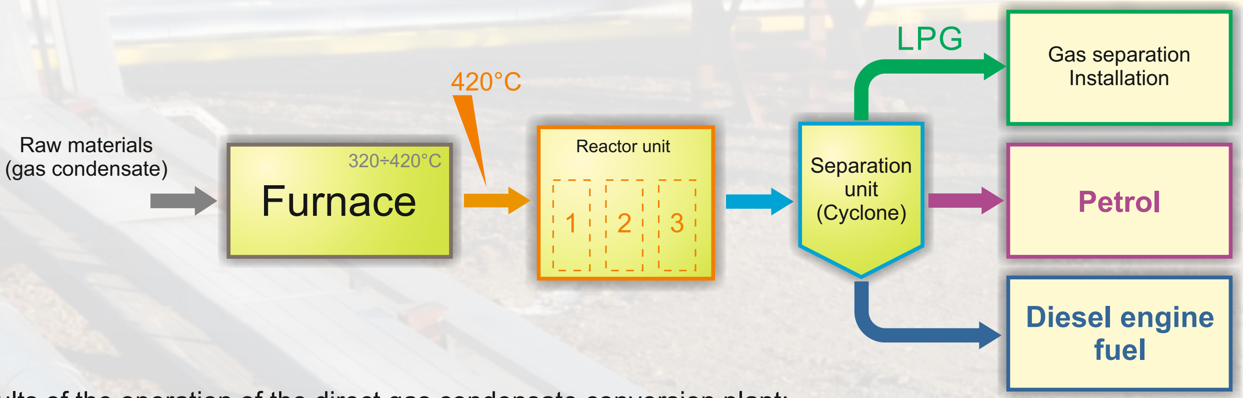
Raw materials with the help of raw pumps, through a block of heat exchangers, are fed from the raw material park to the furnace. In the furnace, the raw material heated to a temperature of 320 ÷ 420 ° C enters the reactor block. The reactor block consists of 3 reactors with zeolite catalysts (fixed bed), a thermal regeneration unit for catalysts and a nitrogen generator. After the reactor block, the resulting wide fraction of the catalyst is fed to the cyclone of the separation unit, Kerosene fractions after cooling in the air-cooling unit enter the intermediate storage capacity and from there to the commodity park, Gasoline fractions after passing a block of heat exchangers such as a pipe in a pipe and giving part of the heat to the raw material are cooled in the air-cooling unit and enter respectively into the intermediate capacity of gasoline, from where they enter the commodity park..

The obtained hydrocarbon gases enter the gas separation unit, from which they are supplied either to the furnace burners (including the catalyst regeneration unit) or to the torch.

For the operation of the catalytic unit, a scheme has been chosen for working with three reactors: one in operation, one in regeneration, one in starting availability.

- The operating time of catalysts before regeneration is 200-300 hours;
- Regeneration of catalysts is conducted at a temperature of 550-580 ° C with a mixture of nitrogen and air according to the work schedule;
- The amount of catalyst to be loaded into one reactor is 3.6 tons, or only 10.8 tons for processing capacity of 60,000 tons of gas condensate per year.

Technological scheme of installation of direct conversion of gas condensate



The results of the operation of the direct gas condensate conversion plant:

1. The production of high-octane gasolines (AI-92, AI-93, AI-95, AI-96)
2. Production of liquefied petroleum gases (propane / butane)

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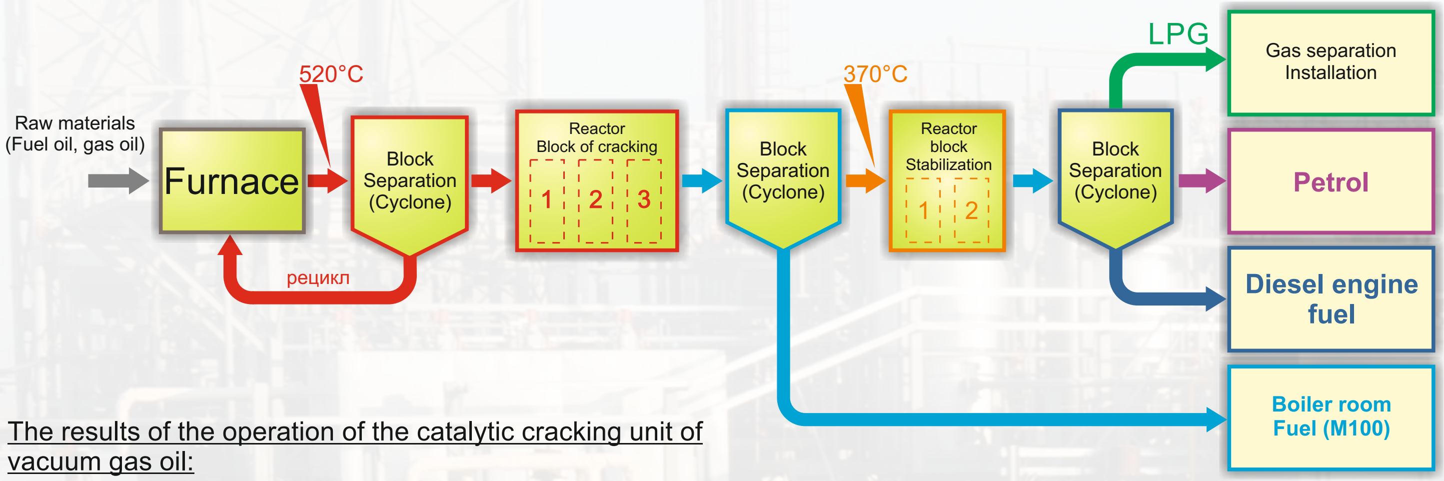
Example of work

Installation cracking fuel oil (gas oil)

Raw materials are fed from the raw stock park to the furnace through the heat exchanger unit, where it is heated to a temperature of 500 ÷ 520 ° C. The resulting vapor-liquid mixture enters the cyclone separator No. 1, then the liquid fractions enter through the heat exchangers and the air cooler into the intermediate tank for the boiler fuel. Pairs of fractions with a boiling point below 500 ÷ 520 ° C enter the reactor block of catalytic cracking. The reactor block consists of 3 reactors with aluminosilicate catalysts (with a fixed bed). Vapors of cracked products, coming out of the reactor unit through the cooler, enter the cyclone separator No. 2, in which the resulting vapor of light gas oil (diesel fraction) and cracked gasoline enter the catalytic stabilization unit, and heavy gas oil with a boiling point above 350-520 ° C is sent through the heat exchangers and cooler in the tank, and from there it can be recycled. Passing through the reactor block catalyst stabilization of a pair of light gas oil (diesel fraction) and cracked gasoline are fed through the cooler in the intermediate tank. The reactor stabilization unit consists of 2 reactors with zeolite catalysts (with a fixed bed).

The obtained hydrocarbon gases enter the gas separation unit, from which they are supplied either to the furnace burners (including the catalyst regeneration unit) or to the torch.

Technological scheme of the gas oil cracker and direct gas condensate conversion unit



The results of the operation of the catalytic cracking unit of vacuum gas oil:

1. When processing vacuum gas oil, 52% of the raw material passes into the light gas for one pass.
2. In recycled mode, when the resulting heavy fraction is recycled again, the yield of light is 80%. According to the results of laboratory studies, 12-15% of gasoline and 80-85% of the fraction of diesel fuel are present in light cracking products.

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Direction 4

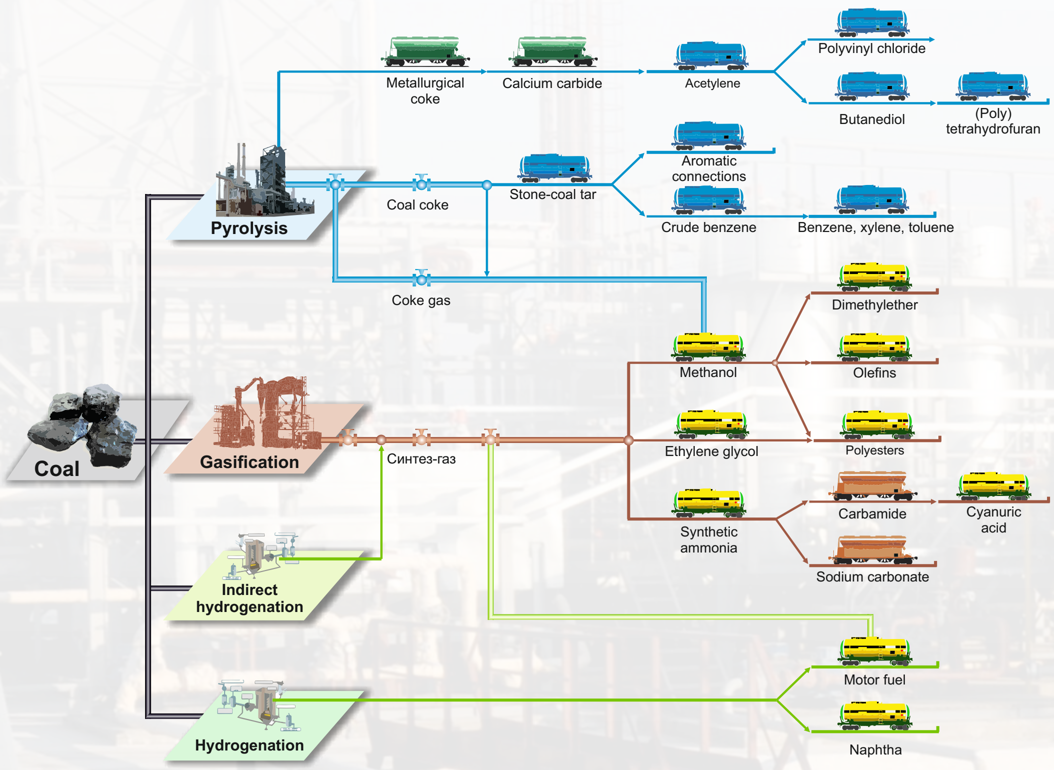
Coalchemistry

Since the technology of vortex rectification in cyclone plants is technically simple and economically very effective for extracting various hydrocarbons, primarily aromatics and phenols, by extractive distillation, one of the most interesting and promising directions of its application is petrochemistry in general and coal chemistry in particular.

The share of coal in world energy generation tends to decrease, which means that coal mining enterprises and countries need new directions for using coal for survival. The direction **is coal chemistry.**

At present, such petroleum products as light aromatic hydrocarbons (benzene, toluene, xylene), heavy aromatics (naphthalene, anthracene and anthracene oil), phenols are obtained mainly from coal at coke plants. in natural oil these compounds are very small. In the synthetic oil obtained from coals, the required chemical compounds are much larger, and the processing technology and their extraction are the same for natural and synthetic oil. It is only necessary to choose the optimal method for obtaining synthetic oil from coal.

Simplified block diagram of coal conversion directions.



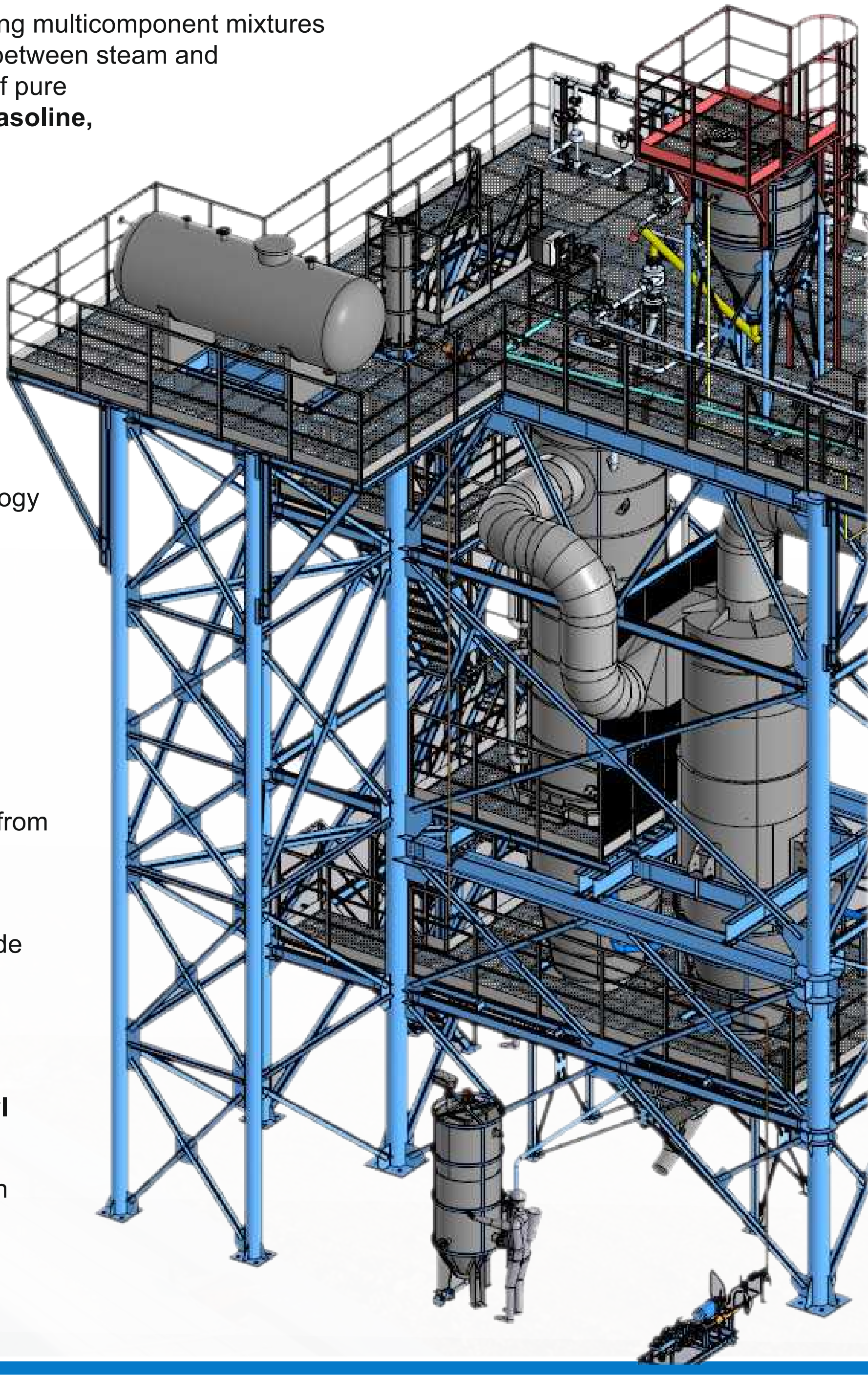
Having experience in designing and building coal and peat processing plants, we have developed technological solutions for the Carbon processing plants with a processing capacity of 50 and 100 thousand tons of coal per year to produce products such as BTK (benzene, toluene, xylene), naphthalene, anthracene oil, phenols.

The method of direct hydrogenation is taken as the basis of the technology for obtaining synthetic oil from coal.

Not every coal is suitable for liquid phase **coal hydrogenation**. First of all, it should have a low content of **inertites** (since this part of coal does not easily enter into hydrogenation reactions), and a high content of **vitrinites** (a part of coal actively enters into hydrogenation reactions), as well as a low **ash** and **moisture** content (i.e. waste rock).

The technological scheme of industrial complex processing of coal will represent the following processes:

- Open pit **coal mining** in the amount of up to 1**00 thousand tons per yea**r.
- **Coal preparation:** drying, crushing and sorting.
- Production of hydrogen-containing gases in the process of coal coking (decomposition of coal at high temperatures and without air access).
- **Hydrogenation of crushed coal** with the addition of anthracene oil (a chemical reaction involving the addition of a hydrogen molecule to an organic substance) followed by fractionation to separate the hydrogenated product into a gasoline fraction with light aromatics, for kerosene fractions with phenols and naphthalene, heavy fraction (fuel oil) and heavy fractions with sludge.
- **Extractive rectification** (the process of separating multicomponent mixtures due to countercurrent mass and heat exchange between steam and liquid) to extract from a crude gasoline mixture of pure **BTX product** (benzene \ toluene \ xylene) and **gasoline,** from **kerosene** fraction - **diesel** fuel, **phenol** and **naphthalene.**
- **Afterburning** of residual sludge to obtain the necessary heat for the technological process and heating of buildings and structures. The slag obtained after the afterburning of sludge is used as a building material in the production of cinder block products.



Important!

As for direct liquid phase technology hydrogenation of coal with hydrogen and for technology obtaining **dimethyl ether** from synthesis gas the technology of partial oxidation of coal is used steam-oxygen blast in a parallel flow in a special **gas generator** to obtain hydrogen-containing gas.

These technologies are actively developed and have been used in recent decades. Designed by **ETN-Cyclone** the **gas generator** allows to obtain hydrogen-containing gas (**synthesis gas**) from increased hydrogen content not only from any kind of coal, but also from heavy oil residues with a given ratio in the gas of hydrogen (H) and oxide carbon (CO).

So for the processing of coal by the method liquid phase hydrogenation requires maximum yield of hydrogen, and for the production of **dimethyl ether** a certain ratio of hydrogen and carbon monoxide, which allows you to get the design **gas generator** manufactured by ETN-Cyclone.

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Dimethyl ether production

Dimethyl ether with the technological solutions used by ETN-Cyclone can be produced from any type of coal (brown coal, bituminous coal, anthracite), and at the same time such a plant for the production of dimethyl ether can be built as environmentally friendly as possible, because and coal dust and evaporation of contaminated water - a product of chemical reactions, and this water itself is utilized in the gas generator in a natural way through the aspiration system at the plant and in the form of water vapor entering the gas generator for chemical oxidation reactions with coal.

Dimethyl ether plant can build as environmentally friendly as possible

The capacity of a plant for the production of **dimethyl ether** can easily be made at several hundred thousand tons per year in a relatively small area. It is also important to note that the production of **dimethyl ether** is carried out on two types of catalysts in **2 stages**: at the first stage, **methanol** is obtained, and at the second stage, **methanol** is converted into **dimethyl ether** (i.e., if methanol is in demand as a commercial product, you can stop at the first stage) ...

When receiving dimethyl ether or methanol water consumption per 1 ton of processed coal will be 1.5 tons.

Since dimethyl ether is a gas under normal conditions, its use as a motor fuel requires gas equipment, for which propane / butane motor fuel equipment is fully suitable. In this case, the pressure in the gas equipment for dimethyl ether requires no more than 6 atm.

Currently, **dimethyl ether** is considered an environmentally friendly fuel of **Euro 6 class**, because its smokeless combustion is ensured, and the amount of harmful emissions during its combustion is 90% lower than for traditional fuels. Due to these properties, in several European countries, municipal transport is switched to detyl ether (for example, Denmark, Belgium, Sweden), in China all heavy equipment is transferred to dimethyl ether.

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