HIGH PERFORMANCE PYROLYSIS REACTOR WITH TURBULENT HEATING OF THE RAW MATERIAL BY INERT GAS

Estimated operating time of the plant: 340 days a year

The main production sites:

1. **Waste segregation site: selection of glass, metal, stone, reinforced concrete, checking materials for radioactivity.**
2. **The facility of raw materials grinding to a certain fraction.**
3. **Raw materials movement section.**
4. **Raw materials pyrolysis site.**
5. **Isolating capacitors park for pyrolysis oil.**
6. **Pumping and filtration site.**
7. **Carbon black warehouse.**
8. **Storage area of non-pyrolysis materials.**
9. **Electric powerstation.**
10. **The site for pyrolysis liquid separation into fractions.**
11. **The park of isolating capacitors for finished products.**
12. **Finished products delivery facility.**

The concept of turbulence discovered in 1883 allowed us to implement our state-of-the-art and currently the most environmentally friendly technology for the disposal of industrial and domestic waste.

At the first stage, the reactor produces turbulent gasification of solid or liquid waste. This forms a pyrolysis gas containing carbon monoxide, hydrogen, and hydrocarbons. Typically, pyrolysis gas when processing complex organic compounds wastes contains, in addition to hydrogen, carbon monoxide and carbon dioxide, etc., an aerosol consisting of very small droplets of hydrocarbons or resins which chemical composition is determined by the nature of the processed raw materials. In our technology, the gas is removed from the gasifier at the temperature of 450-500°C, passes through the zone of 850°C, whereafter it does not contain unburned carbon, organic residues, and dust.

The high velocityof gas flow in the gasifier, due to the supply of an inert gas heated to ultra-high temperatures through our turbulent blowers, leads to the complete absence of solid dust particles in the produced gas.

Gasification is carried out at atmospheric pressure. The pyrolysis gas obtained during processing is partially condensed in special vessels with directional gas-liquid cooling. The non-condensable gas fraction is burned in a honeycomb heat generator, allowing the inert gas to be heated to ultra-high temperatures and thereby increase the rate of its entry into the pyrolysis reactor due to accelerated gas expansion.

The advantage of the proposed technology is in its high energy efficiency. The efficiency factor at the gasification stage reaches 97% in the absence of external energy sources.

The ability to process solid and liquid high-ash and high-humid wastes poorly processed in other devices, with the formation of soot and other products of incomplete combustion. Thus, for instance, in the turbulent heating mode, it is very effective to gasify coal-bearing rocks with ash content up to 80-85% and organic materials with moisture up to 65-80%. Relative simplicity and low cost. The gasifier is a modified counterpart of a shaft furnace. High environmental cleanliness of the process: complete combustion, no soot, carcinogens or other toxic substances, no dust in flue gases.

Ease of raw materials preparation. There are no stages of fine crushing or even grinding. Currently, we have developed processing technologies for: high-ash bitumen, aviation fuel and cattle carcasses. Technology options obtaining high-purity, completely desulfurized pyrolysis liquidare possible.

Recycling of old tires, tire and rubber industry wastes; forestry and pulp-and-paper industry wastes, such as chips, trimmings, bark, lignin, etc.; petroleum and oil refining industry wastes, such as 50-75% acid sludge, soils contaminated during oil spills with partial restitution of hydrocarbons; industrial oils not subject to regeneration; household garbage, hospital and specific industrial and agricultural waste containing significant amounts of organic compounds (including toxic ones).

A mobile unit option of the technology implementation is possible. The volume of waste processing is 50% dependent on the size of the device.

The history of our development began in 1992 with a pilot mini installation. The raw materials for processing were household waste and pig manure. The processing volume made 5 m^3 per day. The technology of low-temperature wet pyrolysis with forced pumping out of pyrolysis gas and its subsequent condensation at negative temperatures was tested.

At the next stage of processing, the pyrolysis liquid was fractionated in a horizontal vacuum apparatus at temperatures close to the boiling point of water.

The obtained synthetic liquid fuel samples, in their characteristics, were identical to summer and winter diesel fuel.

Samples of light gasolines were also obtained. But, since the technology required additional energy consumption and maximum raw material grinding, it was considered unprofitable, and we abandoned it.

Since then, we have developed **5 more experimental pyrolysis** units, including the one using heated solvent vapors for accelerated extraction of hydrocarbon fractions from the tested raw materials.

Through long research and many abandoned technologies, we have developed a highly efficient installation unit that allows us to obtain the maximum amount of pyrolysis liquid up to 55%, even with a depleted morphological composition of raw materials. We also developed the optimum process for the installation unit operation which minimizes the wear of those parts of the installation unit that are exposed to greatest loads.

DESCRIPTION OF THE PYROLYSIS COMPLEX OPERATION

The proposed technology consists in heating waste (hereinafter referred to as raw material) with no air access followed by further deep destruction, at which organic matter and associated volatile substances pass into a gaseous state (are gasified).

The unit is made of high quality heat-resistant stainless steel.

This technology involves heating the raw material through the wall of the reactor where it is loaded as needed. The reactor operates continuously, the outlet of the reactor is connected to the inlet of the condenser, where the steam-gas mixture is supplied when the reactor is heated.

The pyrolysis gas is separated in a cooled condenser into liquid and gas phases. The liquid phase enters the stabilizers settling tanks, then enters the pyrolysis fuel storage tank through the forced filtration system.

One part of the gas phase (GP) enters the heat generator of the reactor to maintain the operating temperature, the other part of the GP is diverted to the liquefaction apparatus and then to gas-reciprocating electrical units (GREU), which in turn supply the entire pyrolysis complex with the required amount of electricity.

Our unit can process raw materials with high humidity, while the loss will be minimal. The separated pyrolysis water is used in the operation of the unit as a condenser cooler.

To ensure a continuous operation cycle of the reactor, the raw material crushed to a certain fraction is fed by a special device into the loading hopper, from where it is dosed into the reactor.

The equipment consists of a heat generator, a pyrolysis reactor, a system of air and fuel filters, condensers, stabilizer tanks, a raw material supply unit, a carbon black unloading unit with a collection hopper, and a heat distribution system.

The composition and amount of pyrolysis products directly depend on the feedstock. If the raw material is dominated by rubber, then there will be more solid residue, namely, black carbon, which is used in the manufacture of rubber products, bulk filters, foundation blocks and briquettes for combustion in boilers. Also, using our technology, we get more pyrolysis liquid, namely, 40 to 50%.

When fractionating the pyrolysis liquid obtained from raw materials with high content of rubber and wood, we get a larger amount of diesel fuel. If plastics predominate in the morphological composition of raw materials, then the pyrolysis liquid will contain a large amount of light gasoline fractions and low quality carbon black.

Our technology for fractionation of pyrolysis liquid allows for the use of vacuum plants in which the final products of fractionation are subjected to minimal thermal loads, and this, in turn, improves the quality of the fuel.

To ensure the ecological safety of production, the complex employs three systems for filtration and binding of harmful substances:

1. Three-stage cleaning system for flue gases entering from the heat generator.

The first stage of the system is mechanical, it includes a dry cyclone capturing large mechanical particles and a scrubber with air-droplet irrigation of the gas flow which washes out mechanical inclusions that remained in the flue gases after the cyclone.

The second stage is gas-liquid. It is wet scrubber in which liquid absorbent circulates, constantly regenerated by a flow of a certain gas. This device removes acidic fragments from the gases.

The third stage provides maximum additional purification of flue gases, it employs a dry filter, an absorber with bulk composition, which allows converting carbon dioxide into industrial oxygen, thus completely absorbing all harmful substances. These filters are used in air purification systems in nuclear-proof shelters.

2. The two-stage purification of the pyrolysis gas before it enters the gas-fueled reciprocating power plant ensures maximum purification of the fuel gas, which, in turn, prolongs the lifespan of the power plant and reduces the amount of harmful exhaust gases emissions. Waste treatment plants consist of bulk absorbers with recyclable contents.

3. The two-stage purification of pyrolysis liquid is carried out by pumping heated pyrolysis liquid through a system of bulk absorbers with regenerated contents.

The equipment works around the clock without stopping.

Solid waste pyrolysis

STATISTICS ON THE OBTAINED PRODUCTS

Output of oil products based on 1 ton of solid waste:

- gasoline AI 92	– 60 liters;
- diesel Euro4fuel	– 120 liters;
- mazutM100	– 90 liters;
- heavy tar	– 100 liters;
- propane-butane gas	– 4200 m^3;
- building material (or carbon black)	– 200 kg.

PYROLYSIS OF AGRICULTURAL WASTE

The following types of agricultural waste are subject to pyrolysis processing at our plant:

1. **Manure, cattle bedding**

Brief calculation of pyrolysis products out of 1 ton of dry raw materials:

Pyrolysis liquid	– 600 l.
Carbon residue	– 150 kg.
Cinder/ash	– 70 kg.
Pyrolysis gas	– 200 m^3.

Brief calculation of fractionation products out of 600l of pyrolysis liquid:

Gasoline AI 92	– 192 l.
Diesel Euro 5 fuel	– 360 l.
Fuel oil M-100	– 12 l.

2. **Bird droppings, bedding**

Supplied for processing mixed with bedding and manure

Brief calculation of pyrolysis products out of 1 ton of dry raw materials:

Pyrolysis liquid	– 600 l.
Carbon residue	– 170 kg.
Cinder/ash	– 50 2g.
Pyrolysis gas	– 200 m^3.

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Brief calculation of fractionation products out of 600 l. of pyrolysis liquid:

Gasoline AI 92	– 204 l.
Diesel Euro 5 fuel	– 342 l.
Fuel oil M-100	– 6 l.

3. **Fallen cattle** (requires grinding to 70-100 mm fraction)

Bone crusher K7-FI2-S, dry freezer

Supplied for processing mixed with dehydrated manure

Brief calculation of pyrolysis products based on 1 ton of raw materials:

Pyrolysis liquid	– 600 l.
Carbon residue	– 180 kg.
Pyrolysis gas	– 200 m^3.
Pyrolysis water	– 150 l.

Brief calculation of fractionation products out of 600 l. of pyrolysis liquid:

Gasoline AI 92	– 180 l.
Diesel Euro 5 fuel	– 372 l.
Fuel oil M-100	– 12 l.

4. **Fallen poultry** (requires grinding to 70-100 mm fraction)

Supplied for processing mixed with dehydrated manure

Brief calculation of pyrolysis products based on 1 ton of raw materials:

Pyrolysis liquid	– 600 l.
Carbon residue	– 120 kg.
Pyrolysis gas	– 230 m^3.
Pyrolysis water	– 100 l.

Brief calculation of fractionation products out of 600 l. of pyrolysis liquid:

Gasoline AI 92	– 180 l.
Diesel Euro 5 fuel	– 372 l.
Fuel oil M-100	– 12 l.

5. **Expired fertilizers**

Bulk fertilizers are supplied for processing together with the main waste, liquid fertilizers are sprayed in measured doses in the reactor.

Amide and ammonia fertilizers undergo thermal destruction to harmless state.

Bulk nitrate and ammonium nitrate, 540 liters of pyrolysis liquid out of 1 ton.

Nitrate liquid 50%, 230 liters of pyrolysis liquid out of1 ton.

Brief calculation of fractionation products out of 600 l. of pyrolysis liquid:

Gasoline AI 92	– 204 l.

Diesel Euro 5 fuel – 342 l.
Fuel oil M-100 – 6 l.

6. Agricultural toxicants (pesticides, insectofungicides, agrochemicals)

DDT, hexachlorane, polychloropinene, heptachlor, phosphoric acid esters, thiophosphoric acid esters and dithiophosphoric acid esters (thiophos, metaphos, methyl mercaptophos, chlorophos, phosphamide, M-81preparation, karbofos, etc., derivatives of carbamic acid (sevin, arasan, carbin,PIA,chlor-PIA,eptam, etc.), urea derivatives (dichlororal urea, monuron, diuron), triazines (simazine, atrazine).

The bulk toxicants are processed together with the main waste, the liquid ones are sprayed in measured doses in the reactor undergoing thermal destruction to a harmless state.