Analysis of the causes of failures of pyrolysis units

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Abstract. This paper presents the classification of pyrolysis units for the disposal of oil waste (oil sludge). Using statistical methods of quality control (Ishikawa diagrams and Pareto diagrams), the main factors affecting the process of oil sludge pyrolysis were identified, as well as the causes of defects that are of paramount importance in eliminating them.

1. Introduction

Oil is a special form of fossil organic matter, transformed by geological time, temperature and pressure. For many centuries, oil has been used for energy, construction, agricultural activities, etc. The products of its processing are used to create various chemical materials, such as synthetic fibers, plastics, lubricants, paints, and much more.

With the development of technology, oil consumption increases and, as a result, the volumes of stored oil waste (oil sludge) increase. Oil sludge is formed during production processes such as oil production, transportation and refining. Other causes of oil sludge are natural processes. Such processes include cleaning oil from mechanical impurities and water, cleaning process equipment, as well as various accidents and spills [1].

2. Classification of pyrolysis units

Today, a number of technologies have been developed based on the thermal destruction of petroleum wastes, which make it possible to obtain valuable gaseous and liquid hydrocarbons and hydrogen, suitable for use as high-energy and environmentally friendly fuels, with minimal environmental impact. The central node in the existing technological installations is the pyrolysis unit or pyrolysis reactor [2-12].

Design pyrolysis reactors can be divided into the structure types such as forms of the body: vertical and horizontal corpuses; the degree of mobility: mobile and stationary location; by the method of supply of the oxidizer: with the supply of the oxidizer, without the supply of the oxidizer; by the number of working sections: single-section, multi-section; by the location of heaters: internal and external ones; by the type of electric and gas-liquid heater; by the presence of auxiliary working bodies: without auxiliary working bodies (figure 1).

Technological types maybe selected by working pressure: vacuum, atmospheric, high pressure; by small, medium, large productivity; by the degree of periodic and constant raw materials loading; by the degree of: autonomous, not autonomous autonomy (figure 1).

Thermal types, the following can be distinguished: by the method of radiant, convective raw materials heating; by the low, medium, high temperature heating (figure 1).

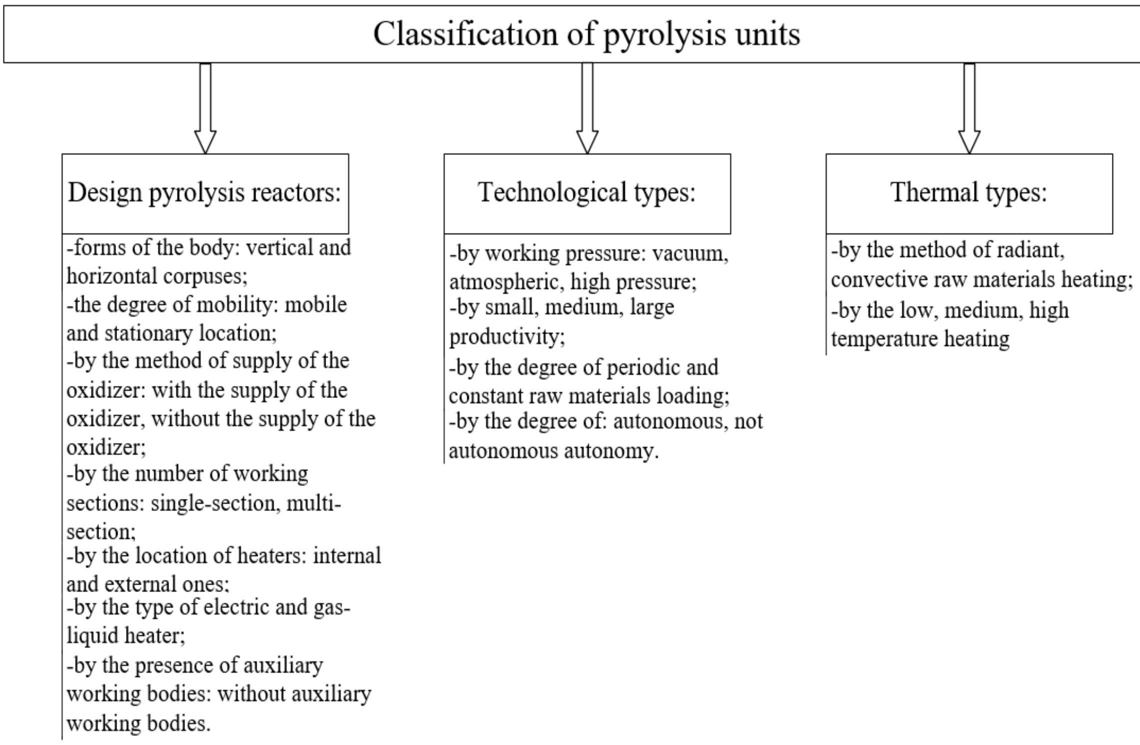

Figure 1. Classification of pyrolysis units.

The classification made allows us to analyze the existing pyrolysis units in order to identify deficiencies in their design, which will subsequently allow us to develop a more efficient and reliable pyrolysis reactor.

3. Statistical methods for controlling the quality of pyrolysis units

When implementing quality control, systematization, processing and research of a large number of collected data are carried out using various methods in order to identify certain patterns, the data are called statistical data, and the methods used are called statistical methods [13].

All statistical methods are based on the concept of scatter. Statistical control of the spread of process or product parameters allows you to graphically present information that is easy to understand: if the spread is small, you can weaken the control, if it is large, this should be taken as a signal to the need to regulate the process to increase its stability.

From the whole variety of statistical methods of quality control, it is advisable to use the methods Ishikawa diagram and Pareto diagram.

3.1 Ishikawa diagram method

The Ishikawa diagram is designed to identify and structure causal relationships between the object of analysis and the factors that influence it, which allows you to correctly direct efforts to solve a problem or achieve certain purpose.

The ultimate purpose of using the Ishikawa diagram method for a particular object is:

- identification of various factors affecting it;
- visualization of causal relationships;
- distribution of priorities for the analysis and solution of the task on the basis of determining the relative importance of factors [14].

We apply the Ishikawa diagram method to the equipment under study (figure 2). Thus, the reasons for stopping the waste recycling process are: the human factor; control and measuring equipment; quality of raw materials. The most significant factor is the condition of the technological equipment and components of the reactor.

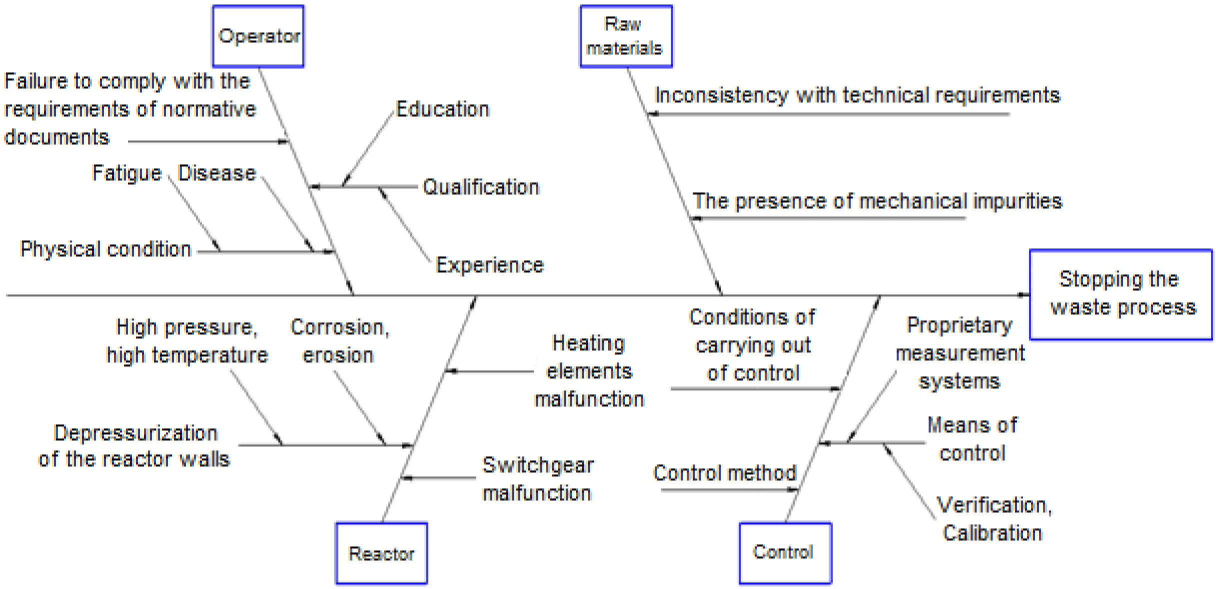

Figure 2. Ishikawa diagram of the problem «Stopping the recycling process».

3.2 Pareto diagram method

Using the Pareto diagram method, the most significant defects in the pyrolysis aggregate can be determined. A Pareto chart is the most common form of visual representation of data. This method is used to diagnose the process, i.e. in order to search for a few essential reasons for the violation of the quality of the process among numerous factors [14].

We construct the Pareto diagram presented in figure 3. Calculations based on data for the last 5 years are presented in table 1.

Table 1. Results of data registration by types of failures.

Rejection reason	Number of failures	The percentage of the number of failures	The accumulated sum of failure	Cumulative percentage
Nozzle wear (if equipped)	12	28	12	28
Depressurization of the reactor walls	7	19.6	19	47.6
Supply equipment malfunction	5	15.2	24	62.8

Malfunction of the pimping equipment	5	15.2	29	78
Malfunction of the heating elements	3	11.2	32	89.2
Control system malfunction	2	10.8	34	100

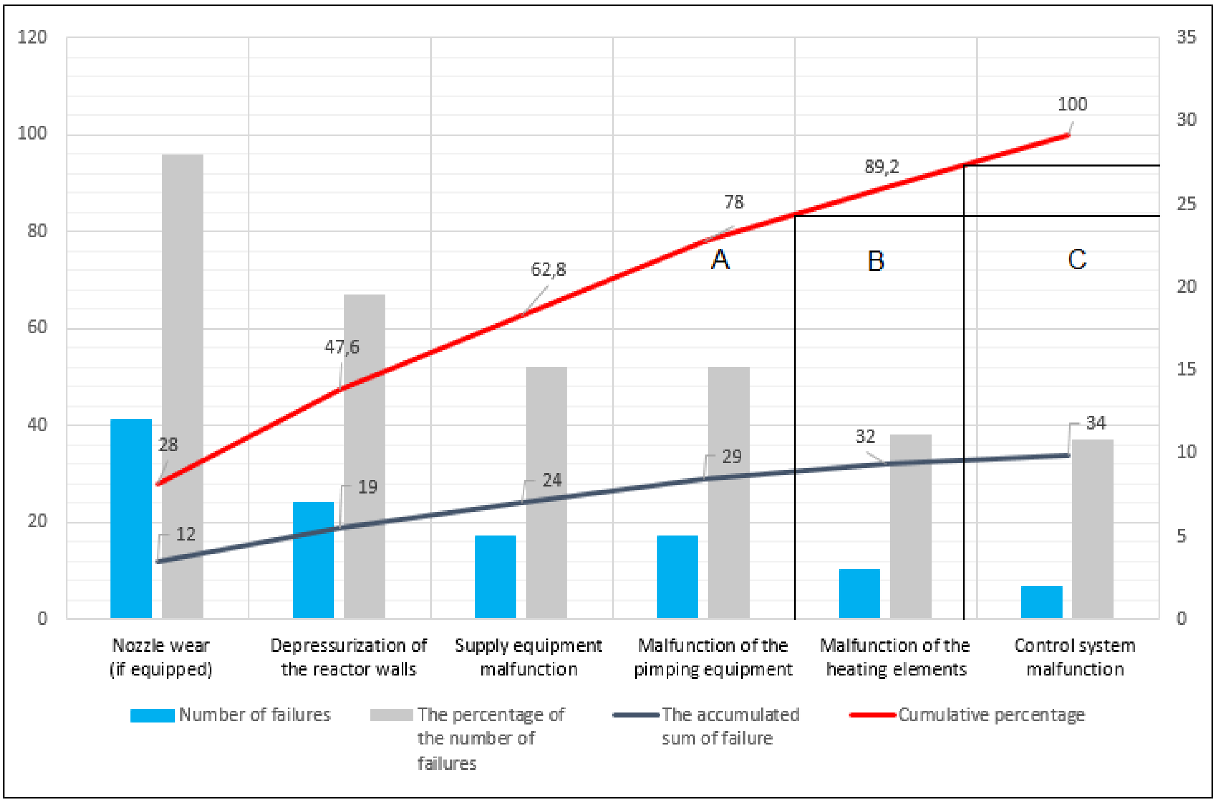

Figure 3. Pareto diagram.

After constructing the Pareto diagram, we apply the so-called ABC analysis. We divide the components by which the analysis is made into three areas: A, B, C. Group A accounts for 70-80% of all failures, group B 10-25%, group C 5-10. Thus, zone A includes the following defects: nozzle wear, depressurization of the reactor walls, supply equipment malfunction and malfunction of the pimping equipment; zone B includes malfunction of the heating elements; zone C – control system malfunction.

4. Conclusion

In the course of the research, the following was revealed:

- The most significant factor affecting the process of pyrolysis of oil waste is the state factor of technological equipment and components of the reactor.
- Area "A" includes the causes of failures of the pyrolysis units to be eliminated as a matter of priority.
- In order to prevent the causes of failures, it is necessary to fulfill the following requirements:

- timely inspection of equipment by ultrasonic flaw detection using a flaw detector, as well as sensors located inside the case with a temperature compensation function;
- carry out preventive repair of equipment in accordance with the prediction of residual life by extrapolation based on the data obtained.

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