ISSN 2067 – 9564 Volume **12**, Number **1**/**2020** 

# USE OF THE PYROLYSIS PROCESS IN WASTE MANAGEMENT

Nicoleta IONESCU[1], Adriana NICOLAE[2], Gabriel CEACHIR[3], Andrei ICHIM[4]

**Rezumat.** *Lucrarea își propune să scoată în evidență avantajele utilizării deșeurilor rezultate din: gunoi menajer, cauciuc, plastic, deșeuri lemnoase, deșeuri textile, în procesul de piroliză. Uleiul pirolitic rezultat poate fi utilizat drept combustibil neconvențional, pentru motoarele diesel, prin emulsionare. Utilizarea unei emulsii diesel impune rezolvarea unei probleme de stabilitate pe termen lung a emulsiei și a capacității acesteia de a funcționa perfect cu toate tipurile de motoare diesel. Prin utilizarea unei tehnologii adecvate se propune o soluție inovativă și fiabilă de economisire a combustibilului și reducerea noxelor și a particulelor grele.*

**Abstract.** *The paper aims to highlight the advantages of using waste resulting from: household waste, rubber, plastic, wood waste, textile waste in the pyrolysis process. The resulting pyrolytic oil can be used as an unconventional fuel for diesel engines by emulsification. The use of a diesel emulsion requires solving a problem of long-term stability of the emulsion and its ability to work perfectly with all types of diesel engines. The use of appropriate technology proposes an innovative and reliable solution for saving fuel and reducing pollutants and heavy particles.*

**Keywords:** pyrolytic oil, unconventional fuel, waste management

## 1. Introduction

Pyrolysis is a thermal decomposition of materials at high temperatures in an inert atmosphere, such as a vacuum gas, by changing the chemical composition, and this decomposition is irreversible.

The pyrolysis process is an endothermic process and is performed in an enclosure, without oxygen or with low oxygen supply to reach the high temperatures necessary for the volatilization of organic compounds.

In the current situation, it is the only efficient method of capitalizing on waste from plastics, rubber, wood, household waste without a perfect prior separation of them on chemical compositions [1], [2], [3].

## 2. Classification of pyrolytic processes

The classification criteria of the pyrolytic processes are depending on:

[1] Eng., Director of Certification Department, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (nicoleta.ionescu@incertrans.ro)
[2] Commercial Director, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (adriana.nicolae@incertrans.ro)
[3] COLLIGO SRL, contact@colligo.ro
[4] EME INTERNATIONAL SRL, ichim.andrei.iustinian@gmail.com

- type of pyrolyzed material
- type of entrained gas
- heating speed and its control
- type of reactor and its heating mode, direct fire heating (retort), superheated gas or steam heating, electric heating, induction heating, microwave heating).

## 3. Influence of operating parameters on the distribution of pyrolysis products

Pyrolysis is an important technological alternative for capitalizing on biomass and recycled materials, being a complex process that requires fundamental research and development efforts.

Depending on the heating rate of the reactor, the pyrolytic process can be slow, fast or flash. Slow pyrolysis is generally used to obtain the solid phase, and fast and flash for a high production of pyrolytic oil (and / or gas). The distribution and composition of pyrolysis products are influenced by the properties of the raw material (chemical composition, shape, size, density, physico-chemical pretreatment), nature and speed of the entrainment gas, reactor heating rate, operating temperature, process duration, reactor type used, etc.

The influence of the reactor heating rate determines a high volatility and a low production of solid residue, by intensifying the depolymerization process in the primary volatiles.

The influence of the operating temperature has the effect of intensifying the secondary cracking reactions of the primary vapors of pyrolytic oil, so the gas production will increase and the oil production will decrease.

The influence of the entrainment velocity at a low entrainment velocity results in a long residence time in the reaction medium; and the secondary cracking reactions will be favored, so that larger amounts of gas and smaller amounts of oil will be obtained.

Influence of the composition - a higher lignin content of the biomass determines a higher amount of carbonaceous residue.

The influence of biomass particle size - the residence time in a layer of fine particles is longer, so more gases and less oil will be produced, as a result of the intensification of cracking reactions. Also, the heating rate of the fine particles is higher, which leads to a decrease in the production of solid residue.

Influence of the type of reactor - in the case of a rotary reactor more gases and less oil are obtained than in the case of a stationary one.

Modeling the pyrolysis process has an important role in the design, optimization and operation of reactors. Due to the large number of consecutive and parallel reactions, it is difficult to establish the exact mechanism of pyrolysis [4], [5].

**Fig. 1**. Pyrolysis pilot installation.

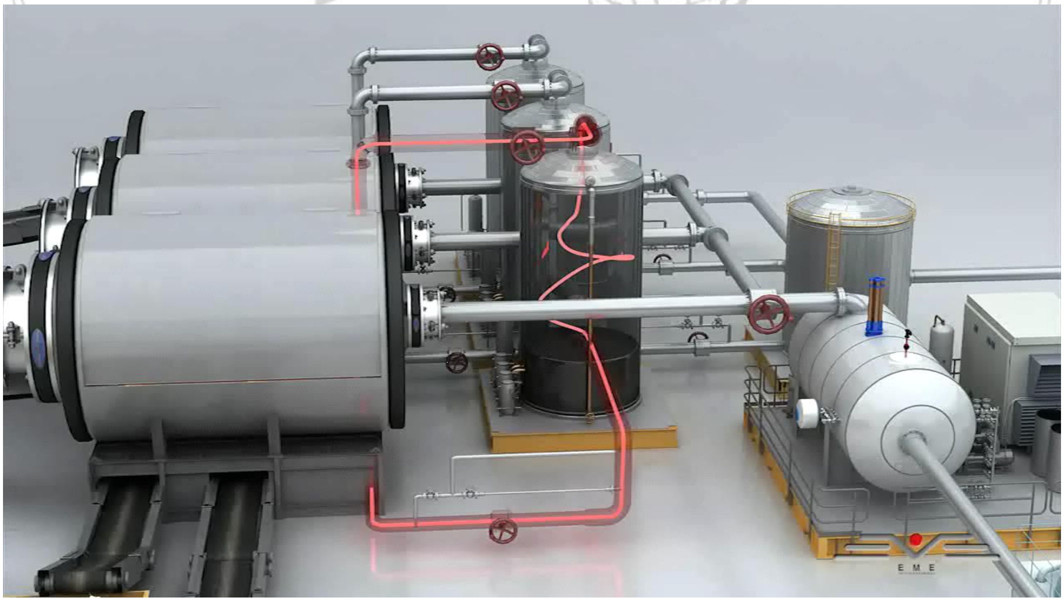

**Fig. 2**. Industrial pyrolysis installation.

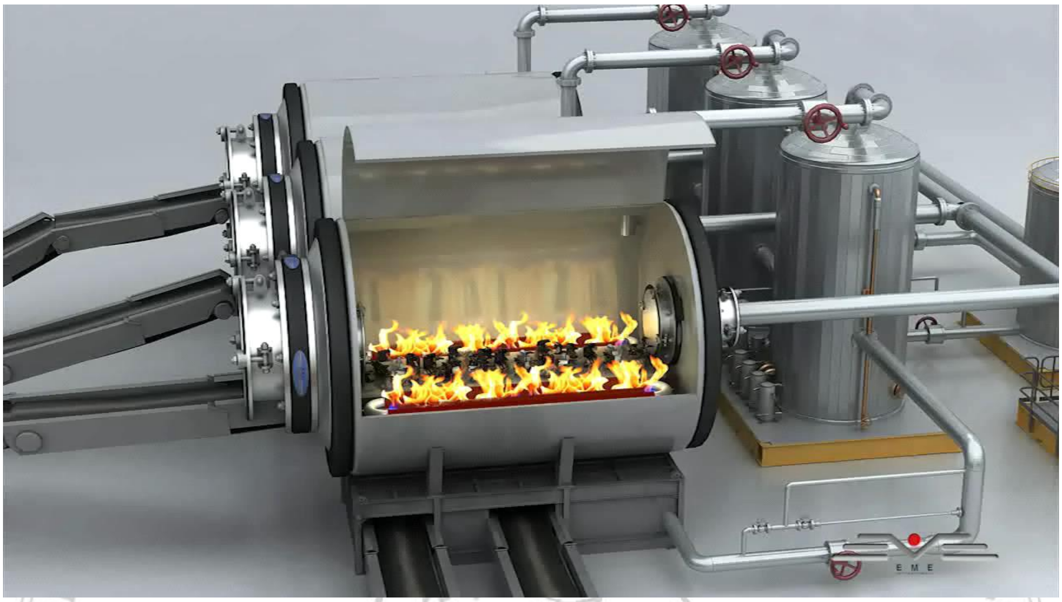


**Fig. 3.** Principle of operation.

**Process of operation of the pyrolysis installation:**

The waste to be introduced in the installation is crushed to the granulation required by the type of material. After crushing, the waste is introduced into a vertical (or horizontal) reactor, provided with a rotation system (1,7 – 2,5 rotations / minute).

Waste is discharged through an automated system, and the discharge time is adjusted in relation to the raw material and the temperature at which it is worked. The reactor can be heated with coal, pellets, wood and natural gas to obtain the temperature necessary for gasification (250-400 ° C). The temperature adjustment starts from 250° C, the temperature at which the roasting takes place (thermo-chemical process that results in the increase of the energy density relative to the unit of mass), the temperature at which the waste turns into gas. After the waste is transformed into gas, it is released into a condensing system (pressurized pipes) where it is liquefied, thus obtaining pyrolysis oil. The non-liquefying gas is redirected through a safety device to the combustion and heating system of the reactor. The pyrolysis station is almost entirely automated, the human intervention being minimal (Fig.1, 2, 3).

The obtained fluid products, respectively pyrolysis gases and pyrolytic oil, can be used as fuels, respectively sources of raw materials (hydrogen, methanol).

The solid residue, called pyrolytic coal, can be used as a fuel, having a calorific value similar to that of coal.

The resulting pyrolytic oil can be used as a flux for the preparation of storable asphalt mixtures, emulsifier for bituminous emulsions with cationic breakage or can be used as such burned in power plants in order to obtain electricity.

Pyrolytic oil can be distilled in a distillation plant, and depending on the degree of distillation, a high quality product is obtained that can be used for diesel engines.

Following this pyrolysis process, the following products and by-products are obtained, the quantities of which vary depending on the type and quality of the installation used, as well as the material introduced into it:

- Pyrolysis oil: 45% -85%
- Carbon ash: 15% -45%
- Non-liquefied gas to be reintroduced into the installation: 10% -15%.

Analysis of pyrolytic oil in laboratories abroad (eg SGS in Switzerland) has led to very good results, presented in the analysis reports Test Report: cE18-00306.001 and Test Report: GE1 7-00460.001.

***The advantages of the pyrolysis process are:***

- compared to conventional methods, the recovery of waste through the pyrolytic process is a simple and unpretentious method, which can recycle a wide range of waste, without prior sorting;
- with the help of this installation the amount of waste to be deposited on landfills is reduced, moreover, with the help of such an installation waste landfills are greened;
- the risk of pollution of environmental factors (water, air, soil) is reduced, the emissions into the atmosphere following the use of this equipment are very low compared to the burning of waste (another method of recovery);
- it takes place without pollution, no matter the type of waste;
- produces 190% more clean energy usable per ton of waste;
- produces four times more energy than it consumes;
- the excess gas is used for self-supply;
- significantly reduces the emission of pollutants into the atmosphere;
- offers $CO_2$, CO, $H_2$, $H_2S$, $CH_2$, various other gases, tars and oils;

- consumes only one-fifth of a ton of oxygen per ton of processed waste, while a conventional incinerator consumes 7 t of oxygen per ton of waste.

***Ecological products - emulsified diesel***

The pyrolytic oil can be emulsified with 10% water to obtain emulsified diesel. The method has been used for 30 years, but the technology has not been widespread, despite favorable legislation in some countries, due to problems with the long-term stability of the emulsion and the ability of the emulsion to work perfectly with all types of diesel engines.

Starting 2014, a series of tests were performed internationally (Italy, Switzerland), by testing white diesel on performance engines compared to those with car diesel fuel, in the same working conditions.

For example: in Italy, at the ORMAD SRL laboratory, a series of tests were performed on a revised endothermic engine mounted on an IVECO truck to determine consumption, emissions, power and yields.

In 2018, in the laboratory of GEO AS SRL were performed tests and analyzes emissions at boilers for emulsified diesel in order to verify the Company's contribution to air pollution, in accordance with the provisions of current European legislation.

In Italy, emulsified diesel is allowed to be used in the environment and in heavy vehicles with the values of the characteristics included in EN 590 ”*Automotive fuels - Diesel - Requirements and test methods*”[6]. This European standard applies to diesel fuel used in vehicles with diesel engines designed to run on diesel fuel and is an eligible specification for excise duty reduction.

The use of emulsified diesel has the following advantages:

- to the exchange of NOx, PM, BSFC in the emission points
- the performance of the engine, without making changes to the calibration, does not suffer damage, despite that part of the liquid injected, it is not diesel, but water.

## 4. Conclusions

The characteristics of the pyrolysis process are the following:

- the volume of residues is reduced to 40%, compared to 10-20% in case of incineration;
- the proportion of pyrolysis gases reaches up to 20% of the amount of gases resulting from the incineration of residues, which is very important for gas purification;

- 1/3 of the energy contained in untreated waste is available as gas for later use;
- realizes the capitalization of important quantities of solid waste;
- a yield of approximately 87 - 95%;
- the use of oxygen allows the efficient processing of waste with a varied composition;
- the resulting gaseous fuel is an important recovered resource, especially in view of the growing shortage of green fuels;
- the combustion of gaseous fuel produces emissions well below the maximum limit allowed by the legislation in force;
- it is an attractive process, both from an economic and environmental point of view.

In conclusion, the pyrolysis process of waste can be a solution for large agglomerations in Romania, for large cities that do not have alternative waste management solutions.

## R E F E R E N C E S

[1] Fisher, T., The Purox System, New York, 1982.

[2] Bumbu, I., Reciclarea, tratarea şi depozitarea deşeurilor solide, UTM, 2007.

[3] Davidson, P.E., Lucas, T.W., Solid Wastes and Residues - Conversion by Advanced Thermal Processes, ACS Symposium Series 76, 1978.

[4] Levy, S.J., Pyrolysis of Municipal Solid Waste, Waste Age, 5(4):14-20, October 1974.

[5] Weinstein, N.J., Municipal-Scale Thermal Processing of Solid Wastes, EPA/530/SW-1330, U.S. Environmental Protection Agency, 1977.

[6] EN 590 Automotive fuels - Diesel - Requirements and test methods