

## EVALUATION AND USE OF THE FRACTIONS FROM CRACKING OF WASTE PLASTICS ON PRODUCTION UNIT

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### Abstract

*Described technology operated by Castor & Pollux enables the processing of separated plastic waste to liquid fuel, which can be used plastics mechanically contaminated with water content, with of different colors and forms and without removing the printed matter which recycling by re- granulation is very difficult and costly. Presented results showed that the catalytic cracking of plastic waste can be used as components of motor fuels as feedstock for pyrolysis, respectively. heat and electricity cogeneration units.*

**Keywords:** waste plastics, thermal cracking, catalytic cracking, gasoline fraction, diesel fraction, co-generation.

### 1. Introduction

Raw materials (chemical, tertiary) recycling of plastic waste use technological processes in which chemical reactions take place. At higher temperatures macromolecules cracks to monomers, which can be reused for the synthesis of polymers and liquid hydrocarbons which are by nature close to petroleum fractions. They are used in the chemical industry. Two major chemical recycling processes are thermal and catalytic degradation. For thermal degradation, a large range of products and requires high operating temperatures from 500°C to 900°C. On the other hand, catalytic degradation may provide a solution to these problems, controlled distribution of products and reducing the reaction temperature.

### 2. Materials and Methods

Technology PCP 700 is based on cracking of separated waste plastics based on polyolefins (PE and PP) in the presence of a catalyst at a temperature of 390 to 420 ° C. The process of liquefaction of waste plastics in the reactor being heated with natural gas and gas produced during the cracking. Heat transfer between flue gas and bottom of the reactor as a heat transfer medium was used for liquid metal or other inorganic melt. Plastic waste is melted in the reactor and subsequently cracked (originally long molecules are broken down into shorter, respectively.), to give the product in the gas phase, which is in tubular heat exchangers cooled and fractionated in two stages. The degree of conversion or degradation efficiency depends on the operating temperature, with increasing temperature increases the depth of transformation chains and increasing the share of gas units. The described technology consists of two devices PCP 700th Any technological line PCP 700 is comprised of 2 reactors with furnace, two stage cooling and fractionation, with a hydraulic unit for compression -

compaction and displacement of material input into the reactor, pipe systems with pumps for transportation of hydrocarbon mixtures into the tank and the gas mixture to the burner, lens stack and control panel. Tanks products, post-combustion flue, waste storage input and some smaller facilities are common to both devices PCP 700.

After cracking and condensation of liquid hydrocarbons gaseous product are burned in special burners. Gas yield is about 12 to 18% by weight. Gaseous products include hydrocarbons C1 to C5., their composition depend on the composition of the starting material and reaction temperature.

Wide fraction is the product of decomposition of plastics in the first reactor. Depends on the composition of the starting material and process control (temperature). The attached table shows selected parameters of the test operation of the plant. The product is light brown, at normal temperature is solid, when heated, has the appearance of clear liquids. It can also be used as heating oil, but in the process is used as a feed into the second reactor in which cracking takes place to light fraction.

Tab. 1 Properties of wide fraction form PCP 700

Parameter	Test	Unit	Value	Precision
Sulphur	EN ISO	mg/kg	20-	2,5 %
Density at 15 °C	EN ISO	kg/m <sup>3</sup>	822,	0,1 %
Ash	EN ISO	% wt.	0,00	20 %
Iodine number	EN 14111	g J <sub>2</sub> /100	68	2 %
Kinematic viscosity 40	EN ISO	mm <sup>2</sup> /s	3,13	1,5 %
Carbon residue	65 6210	% wt.	0,06	20 %
Cetane number	EN ISO	-	54,4	1,0 %
Heat capacity	STN 65	kJ/kg	44	
Nitrogen	ASTM D	mg/kg	502	
Total acid number	STN 65	mg	7,79	2 %
CFPP	EN 116	°C	40	3°C
Lubricity (wsd 1,4)	ISO	microm	405	10 %

Naphtha fraction from cracking of plastic is a light yellow clear liquid, which contains about 6.9% by weight. monoaromatics and the rest is a mixture of n-alkanes and alkenes, in particular 1-olefins. This corresponds to a high number and value of bromine number and aniline point. Sulphur content is low. For comparison of FCC gasoline fraction contains an average of 25.3% wt. aromatics, 0.88 wt%. benzene, 24.6 mg / kg of sulfur, 32, 89 wt% olefins. The difference is in the structure of olefins.

Middle fraction (CPoil MF) is a mixture of liquid hydrocarbons in the range of bp 150-360oC. It is a pale yellow liquid with a characteristic odor. The average composition is in Table 2. Middle fraction can be used to power diesel engines for cogeneration heat and electricity. The advantage is the low content of polyaromatic hydrocarbons. The sulfur content depends on the impurities that are present in the raw material. For use in diesel engines is necessary to add lubrication additives. Given the content of unsaturated hydrocarbons oxidation stability is surprising. Middle fraction can also be used as a component in diesel fuel as a potential for steam cracking for olefin production.

Table 2 Properties of middle fraction

Properties	Test method	Unit	Requirement EN 590	Middle fraction
Density at 15 °C	EN ISO 12185	kg/m <sup>3</sup>	820 – 845	797
Cetane number, min.	EN ISO 5165		51	43,7
Distillation % (V/V) recovered at 250 °C, % (V/V) recovered at 350 °C, 95 % (V/V) recovered at	EN ISO 3405	% (V/V). % (V/V). °C	65 85 360	35,1 97,3 336
Viscosity at 40 °C	EN ISO 3104	mm <sup>2</sup> /s	2,0-4,5	2,518
PCA	EN ISO 12916	% (m/m).	11	0,5
Sulphur, max.	EN ISO 20846	mg/kg	10	1,2-20
Total contamination max.	EN 12662	mg/kg	24	1,8
Oxidation stability, max.	EN ISO 12205	g/m <sup>3</sup>	25	0,71
MTF (CFPP), max. - class B	EN 116	°C	0	+7

### 3. Results and discussion

Middle fraction was tested on engines:  
Volvo TAD 1643GE / V ACT injection  
Volvo TAD 532 GE / V ACT injection  
Deutz F8M1015CP / common rail -  
Cummins KTA19G8 / common rail.

Best value of the ratio of output / consumption engines achieve fuel at 63 ° C. The tested engines were set on diesel fuel for use on medium fraction must be reset. In original setting the fuel consumption is higher by about 6%. Liquid product from polyolefin cracking were tested by pyrolysis GC applying addition of depolymerisates to the raw material distilled up to 300°C; distillation residue was also obtained. Similar procedure was used without the depolymerisates added.

Ethylene yields are higher in pyrolysis with 5% wt. addition of LDPE depolymerisate below 300°C than with residual undistilled LDFE depolymerisate at all temperatures (800, 820, 840°C). Propylene yields are approximately the same with both depolymerisate types from all raw material types. Clearly much higher yields of benzene (almost 100% increase, 800°C) than with pyrolysis of pure heavy gasoline were achieved by the addition of 5 weight % of residual non-distilled HDPE depolymerisate.

On the basis of the achieved results, it can be stated that up to 5 weight % of the raw material for heavy gasoline pyrolysis can be replaced by residual non-distilled PP and HDPE depolymerisates, while the yields of basic pyrolysis constituents (such as ethylene, propylene and ethane) are approximately the same. However, even the substitution of 5 weight % of the heavy gasoline raw material by HDPE, LDPE and PP depolymerisates in distillation scale below 300°C is more than successful.

The chance to use depolymerisates from polyolefins as a part of the raw material for FCC was checked by help of MAT (microactivity test). Depolymerisates should not contain organic constituents such as nitrogen, sulphur, metals which are catalytic poisons for the FCC catalyst. Joining the waste plastics cracking process with refinery technologies such as FCC is a feasible solution for the processing of waste plastic materials with economic goal. Compared to combustion in power stations, the use of waste plastics in refinery will result in a visible economical effect. The use of depolymerisate from LDFE and HDPE appears to be optimal for practical application in the FCC process. In most samples, the addition of depolymerisates to standard FCC raw material increased the fraction yield which increases with rising temperature, and decreased the production of LCO, MCB and coke; this is rather desirable in the production of gasoline.

### 4. Conclusion

Products of cracking of waste plastics can be used to produce energy, as a component of motor fuels as well as the feed for the pyrolysis. But require treatment with additives or can be used as fuel components. The advantage of the processing of polluted waste plastics.

### References

- [1] Lee K., Noh N., Shin D., Seo Y. Comparison of plastic types for catalytic degradation of waste plastics into liquid product with spent FCC catalyst, Polymer degradation and Stability 78, 539-544, 2002.
- [2] Ding W., Liang J., Anderson L. Thermal and catalytic degradation of HDPE and commingled post-consumer plastic waste, Fuel Processing Technology 51, 47-62, 1997.
- [3] Ucar S., Karagöz S., Karayildirim T., Yanik J. Conversion of polymers to fuels in a refinery stream, Polymer Degradation and Stability 75, 161-171, 2002.
- [4] Serrano D.P., Aquado J., Escola J.M., Rodríguez J. M. Influence of nanocrystalline HZSM-5 external surface on the catalytic cracking of polyolefins, Journal of Analytical and Applied Pyrolysis 74, 353-360, 2005.
- [5] Walendziewski J. Continuous flow cracking of waste plastics, Fuel Processing Technology 86, 1265-1278, 2005.