Table 2. Results of dynamic behavior modeling for components mass fraction

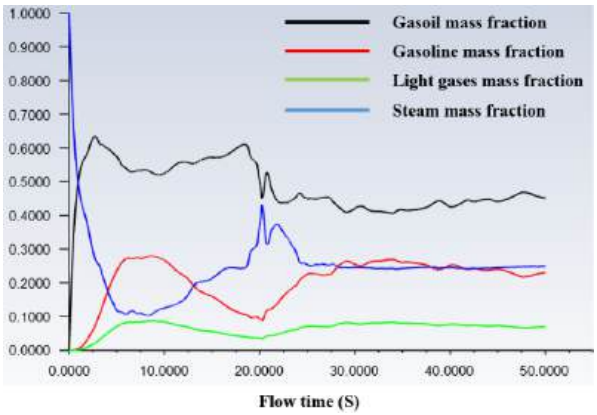
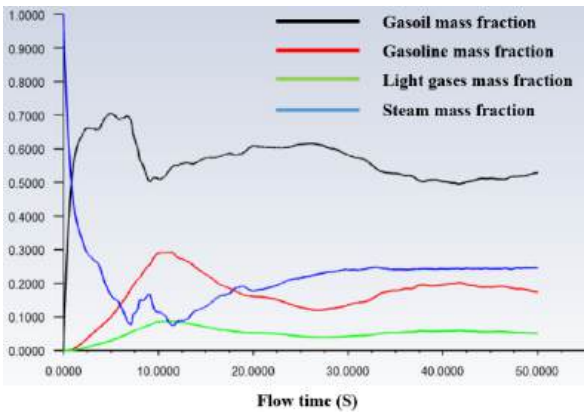
Case I	Case II
	

Table 2 represents the results for components mass fraction and catalyst mass fraction versus time. Case I has more severe operating temperatures and CTO compared with industrial case, while case II has more severe temperatures and less CTO regarding to industrial condition. It was observed from the figures that intransient state switches to transient state at 22–25 s, and 32–35 s for cases I and II, respectively, while the industrial operating case reported in previous work [5] showed 35–40 s for reaching to transient state.

It can be concluded that operating conditions has considerable effect on state of flow regime. However, the interaction of parameters can be further investigated in our future perspective.

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PROCESSING POLYMER WASTE INTO VALUABLE RAW MATERIALS

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In the last few decades the use of polymer materials has noticeably increased due to their relatively low price and a number of unique qualities: resistance to many acids and alkalis; resistance to organic solvents (alcohols and ketones); elasticity, which allows shaping a product; high strength which guarantees long usage.

In addition to this, polymer materials do not corrode, have low thermal conductivity and light weight of a final product in comparison with the product made of wood, glass or metal; besides, polymers can be easily recycled and used again in production, which allows reducing the cost of raw materials purchasing.

One of these polymer materials is called polylactide (PLA) – a biodegradable aliphatic polyester whose monomer is lactide (a cyclic dimer of lactic acid). PLA is primarily produced by polymerization of lactide, which is a product of depolymerization of a lactic acid (LA), the source of which is renewable resources – sugar beets and sugar cane [1].

PLA is used in the production of films, industrial packing, as well as surgical sutures and fibers for 3D printing [2]. However, the relatively high cost of polylactide is the major factor, limiting its large-capacity production and application as a consumer product, that is why the issues of recycling such a polymer and/or the products of its processing are highly relevant these days.

Due to its properties, PLA can be destroyed without harming the environment by composting, the products of which are carbon dioxide and water [3]. However, it is more economically profitable not to destroy, but to dispose it by the recycling method, that is a secondary processing, for instance, into the source monomer lactide and/or a lactic acid, with the possibility of recovering the polymer.

The purpose of this research is to assess the possibility of obtaining valuable secondary resources from substandard PLA-based polymers by thermochemical destruction.

The catalytic synthesis of lactide from substandard polymers is carried out in several stages: 1) destruction of polymer waste in the presence of zinc oxide as a catalyst at a temperature of 180–250 °C and a pressure of 10–20 mBar; 2) purification of raw lactide (LC) by recrystallization from one solvent – ethyl acetate (1 : 1 ratio) when heated for 10–15 minutes; 3) separation of lactide crystals from the mother liquor upon cooling; 4) separation of the resulting monomer by filtration under vacuum; 5) drying purified lactide to constant weight at 40 °C.

The results of the experiments show (Table 1) that during the thermochemical destruction of PLA waste, the yield of LS (in the form of a solid phase) and MK (in the form of a gas phase) reaches 65 and 31 wt. %, respectively. During recrystallization, part of the resulting product dissolves in ethyl acetate, so the yield of pure lactide from the loaded raw material does not exceed 22 wt. %.

The melting point of purified lactide is 86 °C – this is lower than the reference data (95–96 °C) by almost 10 °C, which indicates the presence of a meso-isomer of lactide with a melting point of 54 °C. Determination of the acid number by titration showed that, in addition to isomers, lactide also contains impurities of lactic acid.

Thus, the processing of PLA-based polymer waste, though with a small yield, allows not only obtaining a monomer for further polymer synthesis, but also reducing the total costs of material and energy resources in the production of polylactide.

Table 1. Material balance of the first stage of the process

Entry			Consumption		
Raw materials	Mass, gr	%	Product	Mass, gr	%
PLA	3.052	98.94	LC	1.973	64.65
			LA	0.962	30.51
ZnO	0.033	1.06	ZnO	0.033	1.05
			Pitch	0.117	3.79
Total	3.085	100	Total	3.085	100

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