$\min_{\omega,y} \Psi = c^T y + p(\omega)$,	Design criterion (target function) Ψ – total cost as a function of flowsheet variables *y* and process variables *ω*.	(1)
With constraints:		
$r(\omega) = 0$,	Matter and energy balance constraints.	(2)
$s(\omega) + By \leq 0$,	Purity, performance constraints and flowsheet constraints.	(3)
where $\omega \in R^n$, $y \in \{0; 1\}$		

the flowsheet, with 0 or 1 for the absence or presence of a unit or material stream. Process variables ω indicate process conditions and unit dimensions. The cost matrix c^T and function $p(\omega)$ give the total capital and operative cost of the process.

The matter – energy balance constraints are given by the mathematical model of the process, commonly carried out in commercial simulators. The purity, performance and flowsheet constraints are given arbitrarily.

The solution of the program in (1)–(3) consists in finding the values of the y and ω variables that minimize the total cost Ψ. This is performed by optimization algorithms, which must be capable of handling non-lineal target functions, non-convex constraints and integer variables [3].

3. Application to the design of ETBE reactive distillation processes

Reactive distillation integrates product synthesis and separation in a single distillation column. Ethyl tert-butyl ether (ETBE) is produced by reactive distillation of a mixture of isobutylene (in a typical C4 fraction) and ethanol. Details on the reaction and its kinetics can be found on [4].

As for a process integration design approach, the search space is represented by a superstructure (fig. 1). A preliminary cost-optimal design has been carried out without energy recuperation units, with the variables, results and solution diagram presented in figure 2.

The reactive distillation process was modeled in Aspen Plus, and the optimization problem was solved using the MADS direct search algorithm [5], available as a solver plugin for Microsoft Excel. Aspen Plus and Excel are linked through an ActiveX interface on the Excel side.

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THE INFLUENCE OF PULSED E-BEAM TREATMENT ON PROPERTIES OF PCL SCAFFOLDS LOADED BY PARACETAMOL

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Tissue engineering is a developing area, the purpose of which is to create devices that promote the regeneration of various tissues and organs. To achieve this goal, scaffolds with different physicochemical characteristics can be used both as an extracellular matrix for a new tissue formation, and for delivering various drugs, cells and enzymes. Today, the main problems that need to be addressed in this area are to achieve a correlation between the rate of degradation process and the formation of new tis-

Table 1. Molecular weight of PCL samples before and after irradiation

Paracetamol content, wt.%	M_w, g/mol	
	Before e-beam irradiation	After e-beam irradiation
0	$(2.72\pm0.27)\cdot10^5$	$(2.06\pm0.21)\cdot10^5$
2	$(2.56\pm0.26)\cdot10^5$	$(1.16\pm0.12)\cdot10^5$
8	$(2.42\pm0.24)\cdot10^5$	$(2.26\pm0.23)\cdot10^5$
16	$(2.91\pm0.29)\cdot10^5$	$(1.86\pm0.19)\cdot10^5$
32	$(3.08\pm0.31)\cdot10^5$	$(2.03\pm0.20)\cdot10^5$

sue, as well as the determination of the optimal drug release rate of to inhibit inflammatory processes and stimulate the new tissue formation.

Polycaprolactone (PCL) is an aliphatic polyester of caproic acid, which is widely used in regenerative medicine due to the long rate of degradation, the absence of inflammatory reactions in the body, and also as a suitable carrier of drug molecules [1]. Electrospinning is a promising method for production of nonwoven scaffolds with a large surface area and developed porosity, which is important for the formation of a new tissues. The use of PCL-based drug delivery systems does not always guarantee the optimal kinetics of drug release for a number of uses. Methods of chemical and physical modification are applied to achieve the optimal yield kinetics. These include modification with cold plasma, as well as electron beam irradiation. The use of pulsed e-beam irradiation is promising because of the achievement of a higher dose rate than constant electron irradiation, which leads to better kinetics of drug release for a number of applications.

Materials and methods. The scaffolds were prepared using PCL (Sigma-Aldrich) solution in hexofluoroisopropanole (Ekos-1) with 7 wt.%. For the preparation of 2 wt.%, 8 wt.%, 16 wt.% and 32 wt.% paracetamol-loaded PCL solutions, previously dissolved in HFIP paracetamol powders were added to PCL granules and then refilled with the rest of the solvent. The nonwowen materials were produced by electrospinning method using NANON-01A (MECC) device. The drum collector with a 200 mm diameter was used under following conditions: feeding speed was 5 ml/h, the potential on the needle was 20 kV, collector rotation speed was 50 rpm.

Pulsed e-beam irradiation of PCL scaffolds was conducted using pulsed e-beam accelerator TEA-500 with range of absorbed dose of 25 kGy under following conditions: the diameter of e-beam was 5 cm, kinetic energy of electron beam – 350–450 keV, electron beam current – 6 kA, electron beam current pulse duration at half height – 60 ns. The thickness of titanium foil was 50 μm.

Investigation of molecular weight was conducted by gel-permeation chromatography (GPC) using liquid chromatograph Agilent 1200 LC with refractive detector (Agilent).

Results and discussions. Results of measurement of molecular weight by GPC are shown in Table 1.

The results of molecular weight investigation show that pulsed e-beam treatment causes a decrease in molecular weight for control PCL and PCL samples with different drug loading. These changes are a result of cleavage of carboxyl chemical linkages in backbone main chains under the pulsed e-beam irradiation. It is also seen that the e-beam treatment does not cause the cross-linking of polymer chains, which is possible in the presence of additional cross-linking agents. The correlation between the content of paracetamol and molecular weight before and after e-beam irradiation is not observed.

In conclusion, it should be added that pulsed electron beam irradiation affects the physicochemical properties of PCL scaffolds with loading paracetamol. There is a decrease in molecular weight after irradiation, which may be the reason for more rapid release of the drug. Thus, modification with a pulsed e-beam is a promising method for altering the output kinetics for PCL-based drug delivery systems.

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EXTRACTION OF RARE EARTH METALS FROM MAGNET WASTE

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In current time production of permanent magnets based on Nd–Fe–B and Sm–Co alloys is the most advanced field of rare earth metals industry. However, a magnet production is a process generates a large amount of waste. Up to 40 % of the magnetic material is lost with waste. Due to this problem, recycling of rare earth metals is in the scope of interest.

The aim of this work is to study parameters of extraction of rare earth metals from magnet waste.

Objectives of the work are:

1. Selection of the agent for the extraction.
2. Investigation of the effect on the process the following factors: acid concentrations, temperature and process time.

In this paper the waste of magnets from the JSC "Uralredmet" company were used. Elemental composition of it was determined by atomic emission spectrometer iCAP 6300 Duo. Obtained data are presented in table 1.

For the selecting of the best agent, extraction was performed by aqueous solutions of acids, hydrochloric acid, and sulfuric acid in a wide range of concentrations (20, 40, 60 and 80 %).

It was shown that dissolving the waste in all these acids generates a large amount of hydrogen that indicates of presenting of metallic phase in the waste.

Obtained solutions were investigated by physicochemical analysis.

Nonsignificant difference in extracting ability of the acids was shown. Sulfuric acid is one of the most widely used acids in different industries due to low cost and technological effectiveness, while the use of such a reagent as chlorazotic acid on an industrial scale leads to difficulties due to corrosion.

The effect of concentration of sulfuric acid on extraction was studied. The process was carried out under elevated temperatures for better dissolution of the precipitate. The results are presented in Fig. 1.

As can be seen from Fig. 1, at concentration of sulfuric acid is equal 20 %, the extraction was 62.65 %, at concentrations in range from 40 to 80 % ≈ 80 %. It should be noted that a further increase of concentration did not lead to the significant changes of the extraction.

Consequently, the most suitable concentration of sulfuric is 40 %, which also allows avoid precipitation of double sulphates.

The influence of temperature on extraction of rare earth metals from waste was studied in a thermostat at isothermal conditions.

Samples (2 g) were dissolved in 40 % sulfuric acid, at different temperatures – 20 °C, 30 °C, 40 °C, 60 °C, 70 °C. Time of each experiment was 10 minutes.

As a result of these experiments, precipitates of

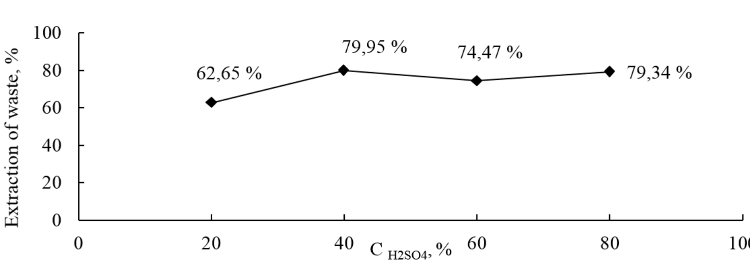

Fig. 1. *Extraction of waste, %, vs. concentration of sulfuric acid, %*

Table 1. The elemental composition of the waste from the JSC "Uralredmet"

Element	Fe	Co	Sm	Nd	Ce	Pr	Er	Dy	Zr	Gd	Tb	Al
Content, %	29.38	25.66	22.21	8.23	6.51	2.71	1.75	1.59	1.33	0.41	0.27	0.28