ECONOMIC AND ENERGETICAL ANALYSIS OF IMPROVED WASTE UTILIZATION PLASMA TECHNOLOGY

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Purpose. Energy and economic evaluation of the improved plasma waste utilization technological process, as well as an expediency substantiation of the use of improved plasma technology by comparing its energy consumption with other thermal methods of utilization. Methodology. Analysis of existing modern and advanced methods of waste management and its impact on environmental safety. Considering of energy and monetary costs to implement two different waste management technologies. Results. Studies have shown regular gasification ensure greater heating value due to differences, a significant amount of nitrogen than for plasma gasification. From the point of view of minimizing energy and monetary costs and environmental safety more promising is to offer advanced technology for plasma waste. To carry out the energy assessment of the appropriateness of the considered technologies-comparative calculation was carried out at the standard conditions. This is because in the processing of waste produced useful products, such as liquefied methane, synthetic gas (94% methane) and a fuel gas for heating, suitable for sale that provides cost-effectiveness of this technology. Originality. Shown and evaluated ecological and economic efficiency of proposed improved plasma waste utilization technology compared with other thermal techniques. Practical value. Considered and grounded of energy and monetary costs to implement two different waste management technologies, namely ordinary gasification and using plasma generators. Proposed plasma waste utilization technology allows to obtain useful products, such as liquefied methane, synthetic gas and a fuel gas for heating, which are suitable for sale. Plant for improved plasma waste utilization technological process allows to compensate the daily and seasonal electricity and heat consumption fluctuations by allowing the storage of obtained fuel products.

Key words: *waste, pyrolysis, gasification, plasma utilization, synthesis-gas, energy parameters, economic parameters.*

Scopul. Evaluarea energetică și economică a procesului de eliminare a deșeurilor de plasmă, precum și argumentele pentru utilizarea tehnologiei cu plasmă prin compararea energiei și indicatorilor economici cu alte metode termice de eliminare. Metode. Analiza metodelor moderne existente de gestionare a deșeurilor și impactul acestora asupra mediului ambiant. Evaluarea cheltuielilor energetice și financiare pentru a introduce două tehnologii diferite de gestionare a deșeurilor. Rezultate. Studiile au arătat că gazificarea regulată asigură o putere mai mare calorifică datorită prezenței unor cantități semnificative de azot decât gazificarea cu plasmă. Din punctul de vedere al energiei și al minimizării costurilor materiale și al siguranței mediului, prezintă interes tehnologia modernă a deșeurilor de plasmă, care este mai reușită pentru viitor. Cu scopul de a realiza evaluarea energetică a caracterului adecvat al tehnologiilor avansate, a fost făcut un calcul comparativ conform condițiilor standarde, ceea ce se explică prin faptul că în procesul de prelucrare a deșeurilor se obțin produse utile, cum ar fi: metan lichefiat, gaz sintetic (94% metan) și gaz combustibil pentru încălzire, potrivite pentru implementare, care asigură eficacitate economică acestei tehnologii. Noutatea științifică constă în evaluarea eficienței ecologice și economice a utilizării tehnologiei avansate cu plasmă în comparație cu alte tehnologii termice. Semnificația practică. Au fost estimate și argumentate costurile energetice și materialele pentru realizarea a două tehnologii diferite de gestionare a deșeurilor și, anume, gazificarea convențională și utilizarea generatorului de plasmă. Tehnologia propusă a deșeurilor de plasmă oferă o destinație-țintă: metan lichefiat, gaz sintetic (94% metan) și gaz combustibil pentru încălzire, necesare pentru aplicare. Instalarea tehnologiei avansate a deșeurilor de plasmă permite echilibrarea consumului zilnic și sezonier de energie electrică și termică, datorită asigurării capacității de depozitare a produselor obținute de combustibil.

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Cuvinte-cheie: *deșeuri, piroliză, gazificare, utilizare de plasmă, gaz sintetic, indicatori energetici, indicatori economici.*

Цель. Энергетическая и экономическая оценка технологического процесса плазменной утилизации отходов, а также обоснование целесообразности применения усовершенствованной плазменной технологии путем сравнения энергетических и экономических показателей с другими термическими методами утилизации. Методы. Анализ существующих современных и усовершенствованных методов управления отходами и их влиянием на безопасность окружающей среды. Оценка энергетических и денежных затрат на внедрение двух разных технологий управления отходами. Результаты. Исследования показали, обычная газификация обеспечила большую теплотворную способность вследствие наличия значительного количества азота, чем при плазменной газификации. С точки зрения минимизации энергетических и материальных затрат и обеспечения экологической безопасности более перспективной является предложенная усовершенствованная технология плазменной утилизации отходов. Для проведения энергетической оценки целесообразности применения рассматриваемых технологий сравнительный расчет проводился из стандартных условий. Это объясняется тем, что в процессе обработки отходов получают полезные продукты, такие как сжиженный метан, синтетический газ (94% метана) и топливный газ для отопления, пригодные для реализации, что обеспечивает экономическую эффективность этой технологии. Научная новизна. Показана и оценена экологическая и экономическая эффективность предложенной усовершенствованной плазменной технологии утилизации отходов в сравнении с другими термическими технологиями. Практическое значение. Оценена и обоснована энергетические и материальные затраты на реализацию двух различных технологий управления отходами, а именно обычная газификация и с использованием генератора плазмы. Предложенная технология плазменной утилизации отходов позволяет получить продукцию целевого назначения, сжиженный метан, синтетический газ (94% метана) и топливный газ для отопления, пригодные для реализации. Установка усовершенствованной технологии плазменной утилизации отходов позволяет компенсировать суточные и сезонные неравномерности потребления электроэнергии и тепла за счет обеспечения возможности хранения полученных топливных продуктов.

Ключевые слова: *отходы, пиролиз, газификация, плазменная утилизация, синтез-газ, энергетические показатели, экономические показатели.*

JEL Classification: L0; L1; Q40; Q0.

Introduction. Wastes are the of environmental hazards formation sources, and therefore must be utilized. Their quantity is large and the choice of technology utilization is a responsible stage. Firstly, it is connected by that the implementation of some of the utilization technologies can reduce the level of ecological safety, which is unacceptable. Second, the selected utilization technology may be energy or economically effective. Countries that intend to avoid the landfilling of waste unsuitable for recycling, give preference to thermal methods for decontamination and disposal, such as incineration, pyrolysis and gasification.

Their use allows obtaining synthesis gas, in which structure except for the carbon monoxide (CO) and hydrogen (H_2), there are components such as carbon dioxide (CO_2), nitrogen oxides (NO_x), a small amount of methane (CH_4), ethylene (C_2H_4) and etc. The obtained low-calorie gas is used for direct combustion to produce heat for domestic needs and generate electricity. Thus, the use of thermal processes waste utilization reduces their quantity and allows to obtain useful products in the form of electricity and heat. At the same time, the plants implementing these methods of waste utilization and recycling has not ensure ecological safety, leading to the need for additional processing exhaust gases and solid residues (dross).

An alternative to the above manner is a plasma technology, which is based in the decomposition of high-toxic substances (dioxins and furans) into simpler molecules at extremely high temperatures and in the absence of free oxygen. At the plasma jet temperature completely destroyed any organic and biological materials, assured destroyed most toxic materials are melted and vaporized most refractory inorganic compounds. Plasma gasification process provides an ecologically pure waste utilization without the formation of tar and dioxins. The products of plasma gasification are a high-calorie combustible gas and a neutral solid residue as a glassy slag that does not require additional treatment.

Analysis of published data and problem statement

Experience in the use of plasma technology for the processing and decontamination of solid municipal, industrial and medical waste is described by many authors, including those in S.V. Petrov, S.G. Bondarenko, E.G. Didyk, G.S. Marinsky, A.V. Chernets, V.N. Korzhik, M.N. Bernadiner, A.L. Mosse, V.V. Savchin, A.V. Lozhechnik, Pragnesh N Dave, Asim Joshi, Hua Zhang, Liming Shao. Waste utilization plasma technology involves large amounts of electricity, in contrast to the high temperature pyrolysis or gasification processes, that are used as fuel obtained gas. From the authors A.V. Artemov, A.V. Pereslavtsev, Y. Krutikov, V.V. Vambol, V.N. Kobrin, N.V. Nechiporuk, Nickolas J. Themelis, Marco J. Castaldi denoted that the main factors that hinder the widespread industrial use of plasma technology for the processing of waste are not large enough resource of low-temperature plasma generators, as well as the fact that the plasma arc discharge is a relatively local source of heating.

On the other hand, it was proved experimentally that the synthesis gas produced during the plasma technology utilizes more calories than in conventional gasification. In the article V.M. Batenin, V.I. Kovbasyuk, L.G. Kretova, Y.V. Medvedev compared the energy efficiency of processes of plasma and autothermal gasification at 1400 K for waste utilization. It is shown that an additional energy output from the synthesis gas, is achieved through the use of plasma generators, with the existing methods of energy conversion can't cover the real costs of consumed electricity.

In [1], [2], the authors proposed an advanced technology of plasma waste disposal, which includes the following processes: thermochemical gasification, plasma post-combustion of the resulting gases, their sharp cooling, preliminary cleaning, methanation, final purification of gases and cryogenic separation of synthesis gas for fuel products.

Object, purpose and problem of research

Object of research – energy and economic indicators of improved plasma waste utilization technology. Purpose of research is energy and economic evaluation of plasma waste utilization technologic process and also grounding of application expediency of improved plasma technology by the way of comparison of its energy and economic indicators with other thermal waste utilization methods. For achieving of setting research purpose solved the following problems:

- evaluation of plasma waste utilization application energy efficiency from point of view of its energy costs minimization in comparison with other thermal methods;
- evaluation of plasma waste utilization application economic expediency from point of view of its recoupment period in comparison with other technologies;
- evaluation of usability of fuel products obtained during utilization process for energy and monetary costs reducing.

1. Material and results of energy and economic indicators of improved plasma waste utilization technology researching.

1.1. Evaluation of energy indicators. It is proposed to carry out a comparative assessment of waste utilization energy costs for the conventional gasification technology ("Technology 1"), and improved plasma utilization technology ("Technology 2"). In the improved plasma waste utilization technology [1] the reactor made up of two chambers, one of which is the gasification reactor, and the other – the plasma reactor, Figure 1. In the gasificator carried out the process of high temperature waste gasification and then the its resulting products – steam-gas mixture (synthesis gas) and slag – are processed in the plasma jet. Such stepwise waste treatment reduces energy consumption, due to the fact that in a plasma reactor there are not processed all raw materials, but only a portion (about 20%).

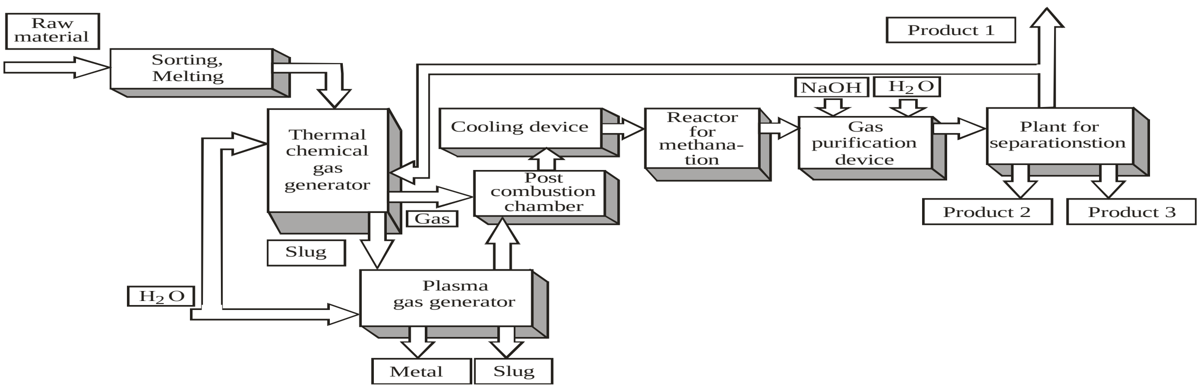

Fig. 1. Scheme of waste utilization plant

Source: [1].

During afterburning process in a plasma reactor, the slag is converted into an ecologically safe glassy mass and synthesis gas contains mainly carbon monoxide and hydrogen. This gas can be used as a fuel instead of methane for heating and maintaining the gasification process. The “Technology 2” also suggests further methane-enriching of obtained synthesis gas by implementing the process of methanation [3], [4] and further its purification and low-temperature separation to produce fuel products suitable for sale [5]. Thus, the products of waste processing by “Technology 2” in contrast to “Technology 1” are, in addition to heat and electricity, liquefied or gaseous methane and synthesis gas containing methane, to compensate unevenness daily and annual energy consumption by stockpiling.

To carry out the energy assessment of the appropriateness of “Technology 2” a comparative calculation was made at the standard conditions, and namely has been chosen the most typical variant and type of waste – processing of municipal solid waste with productivity of 1.6 tons/day (66.8 kg/h, 529 t/year). Initial data and results of comparative calculations are presented in Table 1.

Table 1

Comparing evaluation of Technologies by amount of produced energy

Indicators	**Technology 1**	**Technology 2**
Amount of raw materials kg/hour	66.80	66.80
Amount of raw materials tons/day	1.60	1.60
Amount of raw materials tons/year	529.06	529.06
Yield of products per hour		
methane liquefied, kg/day		16.80
synthetic gas (94% methane), kg/hour		6.20
fuel gas for heating, kg/hour	60	37.10
slug, kg/hour	6.8	6.68
Yield of products per hour (330 days)		
methane liquefied, tons/year		133.06
synthetic gas (94% methane), tons/year		49.10
fuel gas for heating, tons/year	380.16	235.07
Composition, %		
N_2	3	20.6
CH_4	11	0.1
H_2	31	31.14
CO	23	48.16
C_2H_4	4	
CO_2	28	
Net calorific value, kJ/м^3	12584	9467
density, kg/м^3	0.96	0.827
Net calorific value, kJ/kg	12081	7829
Net calorific value, kW·h/kg	3.36	2.17
Efficiency factor of steam generator	0.9	0.9
Heat energy, kW·h/h	181.21	72.62
Heat energy, kW·h/year	1435180	575123
Efficiency factor of steam cycle	0.3200	0.3200
Electric energy in steam cycle, kW·h/year	459258	184039
or Efficiency factor of gas turbine cycle	0.45	0.45
Electric energy in gas turbine cycle, kW·h/year	645831	258805
slug, tons/year	53.86	52.91
Recalculation to 1 tons of raw materials		
Products tons per 1 ton of raw materials		
methane liquefied, tons/ton of raw		0.25
synthetic gas (94% methane), tons/ton of raw		0.09
fuel gas for heating, tons/ton of raw		0.44
Heat energy, kW·h/ton of raw	2713	1087
Electric energy in gas turbine cycle, kW·h/ton of raw	868.07	347.86
or **Electric energy in gas turbine cycle**, kW·h/ton of raw	1220.72	489.18
slug, tons/ton of raw	0.10	0.10

Source: [3, 4].

As a result, waste disposal by “Technology 1” is formed of 60 kg/h of fuel gas and 6.8 kg/h of slag. The products of this technology are heat or electricity. When implementing the “Technology 2” we obtain the following products: liquefied or gaseous methane at a pressure of 25 MPa – 16,8 kg/day, liquefied or gaseous synthesis gas (94% methane) – 6.2 kg/h, the fuel gas – 37.1 kg/h, slag – 6.8 kg/h.

To compare the two technologies the amount of heat we expressed in an amount of equivalent electricity. To determine the amount of electricity and heat, which can be obtained from the fuel gas, it is necessary to set the calorific value which is determined by the composition of the gas. For “Technology 1” typical composition of the synthesis gas which is produced during the gasification of municipal solid waste includes components: N_2 – 3%, CH_4 – 11%, H_2 – 31%, CO – 23%, C_2H_4 – 4%, CO_2 – 28%. The “Technology 2” accepted the worst scenario, when as a plasma gas used air, because in this case formed much amount of nitrogen which is ballasted fuel gas and reduce its heating value. More appropriate variant is the use of water vapor because in this case nitrogen and its oxides virtually absent. Composition of fuel gas obtained by “Technology 2” after the separation of useful product in the form of methane and synthesis-gas: N_2 – 20,6%, CH_4 – 0.1%, H_2 – 31,14%, CO – 48,16%. Net calorific value of the fuel additive function is a defined as the amount of calorific values of combustible components, constituting the fuel:

$$Q_n = Q_n^{CH_4} \cdot \mathrm{r}^{CH_4} + Q_n^{H_2} \cdot \mathrm{r}^{H_2} + Q_n^{CO} \cdot \mathrm{r}^{CO} + Q_n^{C_2H_4} \cdot \mathrm{r}^{C_2H_4},$$

where: Q_n^i – net calorific value of the *i*-th component; r^i – volume fraction of the *i*-th component.

Net calorific value of 1 kg of fuel is equal:

$$Q_{nm} = Q_n / \rho,$$

where: ρ – density of fuel that equal to amount of density portions of fuel components. Their values are given in Table 1.

The calculation results show that the net calorific value of gas obtained by “Technology 1” is 12584 kJ/m^3 (12081 kJ/kg), and obtained by “Technology 2” – 9467 kJ/m^3 (7829 kJ/kg). Conventional gasification provide more calorific value due to the presence of significant amounts of nitrogen in the plasma gasification process.

Fuel gas is sent to a steam generator for burning in the combustion chamber and further to the turbine to produce electricity. Energy comparison is made of the equivalent number of electric power produced by the fuel gas. We consider production of electricity in the steam cycle and at direct fuel combustion using a gas turbine. In the calculation of the steam cycle is accepted that the efficiency factor of the steam generator is equal to 90%, the efficiency factor of the steam cycle is 32%, then the amount of obtained of electricity is given by follow formula:

$$E_{EP} = \mathrm{Q_n} \cdot \eta_{SG} \cdot \eta_{\mathrm{SC}},$$

where: $\mathrm{Q_n}$ – net calorific value of fuel (synthesis) gas; η_{SG} – efficiency factor of steam generator; η_{SC} – efficiency factor of steam cycle.

Upon receipt of electric power on gas turbine plant it is assumed that thermal energy loss is 10%, and the efficiency of the gas turbine plant is 50%. The amount of obtained electricity is equal to:

$$E_{EP} = 0{,}9\,\mathrm{Q_n} \cdot \eta_{GTC},$$

where: η_{GTC} – efficiency factor of gas turbine cycle.

Calculations showed that the electricity produced in “Technology 1” in the steam cycle amounts to 868 kW·h/ton of raw materials, in a gas turbine cycle – 1221 kW·h/ton of raw materials. In the “Technology 2” electricity amounts to – 348 kW·h/ton of raw materials and 489 kW·h/ton of raw material respectively.

1.2. Evaluation of economic indicators. Products of waste utilization by “Technology 1” are electricity and for “Technology 2” – electricity, liquefied methane and liquefied synthesis gas. The wholesale price of the products obtained was chosen based on the prices listed in the Internet resources. The price of products for technology 1 is determined by the cost of electricity and equivalent amounts to $ 0.11 per 1 kW/h for 2 technology – accepted the same price for all products – $ 400 per ton. In addition to both technologies have a solid residue – slag.

The total annual income we define as the sum of products of product price and the quantity of the produced product of this denomination per ton of raw material. All calculations are carried out in US dollars, and assess the effectiveness per ton of processed raw materials. When assessing the cost of electricity based on the received steam-gas cycle because it gives less income than the gas turbine cycle. In addition, income includes revenues from the payment of municipal services for waste treatment. Then, the total annual income of "Technology 1" will be $ 84,961, and in "Technology 2" – 127,550 $. The increase in annual income is ensured by an additional product – liquid methane.

Plants made for the implementation of "Technology 1" and "Technology 2" are different first of all by capital investment. Plant for "Technology 2" has a larger capital investments than for "Technology 1". This is attributed with presences in the plant for implementing "Technology 2" two additional blocks: for methanation and for gas separation. Furthermore, plasma generators require powerful power sources and control system. The results of calculations of profit and payback period of plants using both technologies are presented in Table 2. The results of calculations (columns 2 and 3 of Table 2) are shown taking into account the capital investments required for the manufacture of a particular plant with setting performance in processed raw material. Capital investments of serial processing plant waste using plasma was determined by compiling a cost calculations based on current prices for completing parts, manufacturing of non-standard equipment, salaries and other expenses in view of VAT. To plant for conventional gasification to produce synthesis gas for power generation capital investments accepted by 1.5 times smaller. Accordingly, the construction and assembly works and pre-production costs are accepted by value in 2 times more, as associated with a lot of equipment.

Total capital investment in the use of "Technology 1" amount to 108,000, "Technology 2" – 176,000 $, that 1.63 times greater. Subjects to amortization cost are of equipment and construction and installation works.

Table 2

Compurgation of economic indicators for two Technologies

Indicators	**Technology 1**	**Technology 2**	**Technology 1**	**Technology 2**
1	**2**	**3**	**4**	**5**
Product wholesale price				
methane liquefied, $/ton of raw		400,00		400,00
synthetic gas liquefied (94% methane), $/ton of raw		400,00		400,00
electricity, $/kW·h	0,11	0,11	0,11	0,11
slug, $/ton of raw	1,00	1,00	1,00	1,00
Product quantity				
methane liquefied, $/ton of raw		100,60		100,60
synthetic gas liquefied (94% methane), $/ton of raw		37,13		37,13
electricity, $/ton of raw (steam-gas cycle)	95,49	38,26	95,49	38,26
or electricity, $/ton of raw (gas turbine cycle)	134,28	53,81	134,28	53,81
slug, $/ton of raw	0,10	0,10	0,10	0,10
metal, $/ton of raw		0,00		0,00
Proceeds of waste treatment, $/ton of raw	65,00	65,00	65,00	65,00
Income of products sale, $/ton of raw	160,59	241,09	160,59	241,09
Total annual income, $	84961	127550	84961	127550
Capital investments				
cost of equipment, 1000 $	80	120,00	31,74	40,63
construction and installation works, 1000 $	16	32,00	16	32,00
pre-production costs, 1000 $	12	24,00	12	24,00
Total capital investments, 1000 $	108,00	176,00	59,74	96,63
subject to amortization, 1000 $	96,00	152,00	47,74	72,63
Operational costs, 1000 $				
amortization expense (10%), 1000 $	9,60	15,20	4,77	7,26
capital repairs (5%), 1000 $	4,80	7,60	2,39	3,63
current repair (1,6%), 1000 $	1,54	2,43	0,76	1,16

Indicators	Technology 1	Technology 2	Technology 1	Technology 2
1	2	3	4	5
Electricity consumption				
plasma generators, kW·h/ton		240,00		240,00
separation bloc and other consumers, kW·h/ton	50	246,00	50	246,00
Sum of consumption electricity, kW·h/ton	50,00	486,00	50,00	486,00
Electricity tariff, $/kW·h	0,11	0,11	0,11	0,11
Electricity costs, 1000 $	2,91	28,28	2,91	28,28
Salaries, 1000 $	36,00	36,00	36,00	36,00
Accruals for salaries (37,5%), 1000 $	13,50	13,50	13,50	13,50
Additional costs, 1000 $, *including:*	4,0	4,0	4,0	4,0
innovation fund, 1000 $	1,3	1,3	1,3	1,3
allocations for road maintenance, 1000 $	1,2	1,2	1,2	1,2
other, 1000 $	1,5	1,5	1,5	1,5
Total operational costs, 1000 $	72,3	107,0	64,3	93,8
Profit, $/ton of raw	12615,0	20534,5	20625,6	33709,7
Recoupment, year	8,6	8,6	2,9	2,9

Source: [3, 4].

Operating expenses include: depreciation charges, 10% of the capital investments subject to amortization, the cost of capital repairs – 5%, costs of minor repairs – 1.6%, the cost of electricity. Electricity consumption in the use of “Technology 2” is much larger. This takes into account the power consumption of the plasma generators, gas separation unit and other consumers. In the “Technology 2” of plasma generators electricity consumption is accepted on the basis of experimental data for plants of “Europlasma” – 240 kW·h/ton of raw material.

Electricity consumption in the separation unit together with other consumers (the plasma gas compressor) is determined on the basis of calculation and amounted to 246 kW·h/ton of raw material. The total electricity power consumption is about 486 kW·h/ton of raw material. In the “Technology 1” power consumption assumed to be equal 50 kW·h/ton of raw material, which is almost 10 times less. Accordingly, the cost of electricity is also 10 times less than in plasma process.

Salaries accepted the same for both technologies. Maintenance staff consists of 6 people, working for 12 months with an average salary of 500 $ per month. Accruals for salaries is 37.5% in both cases. Additional costs associated with payments to the Innovation Fund, the cost of roads maintaining and other costs taken the same.

Total operating expenses amounted to 72,300 $ for “Technology 1” and 107,000 $ for “Technology 2”. Thus, capital investment and operating costs for the implementation of “Technology 2” (plasma technology) significantly higher than for the “Technology 1” (conventional gasification).

Profit P is calculated by the formula:

$$P = D - E,$$

where: D – year profit; E – maintain costs.

The payback period is calculated by the formula:

$$T = \text{KB}_o / \text{P},$$

where: KB_o – total investment; P – profit.

Comparison of the two techniques indicates that in a conventional gasification “Technology 1” profit is $ 12615, in “Technology 2” – 20,534.5 $, which is 1.6 times higher. Payback period, calculated according to the above formula, is 8.6 years.

To verify the obtained results carried out additional calculations of economic indicators (columns 4 and 5, Table 2). In this case, the assessment of capital investments made on the basis of Nickolas J. Themelis, Marco J. Castaldi, according to which the capital investment for a conventional gasification technology is 60 $/ton of raw materials and for plasma technology – 96.63 $/ton of raw material, which is 1.6 times higher compared with a conventional gasification technology, and 1.8 times less than that taken earlier for plasma technology. Total investments were lower than in the first case, since it does not take into account the increase in their performance decreases. All other payments are made in accordance with the above data and formulas. Payback period in this case amounted to 2.9 years.

Conclusions:

1. Based on analysis of research in this field shows the ecological efficiency of the plasma waste utilization technology as compared with other thermal techniques.
2. The proposed improved plasma waste utilization technology more promising from the viewpoint of minimizing energy consumption, due to the fact that in a plasma reactor there are processed not all raw materials but only part of it (20%).
3. When implementing improved plasma waste utilization technology, quantity of received electric power is less than "Technology 1". However, during the waste treatment by "Technology 2", unlike "Technology 1", the useful products, such as liquefied methane, synthetic gas (94% methane) and fuel for heating gas suitable for sale.
4. The calculation results showed that the payback period is the same in both cases, however, the profit in the implementation of improved plasma waste utilization technology is higher due to producing fuel products.
5. Plant for improved plasma waste utilization technology allows to compensate the daily and seasonal fluctuations of electricity and heat consumption by creating fuel products suitable for storage and subsequent implementation.

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