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Minimization of environmental risk by optimization of the end-of-pipe processes

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ABSTRACT

Purpose: of the paper has been an attainment of the thesis that efficient minimization of environmental risk of processes can be realised not only by usage of new technologies creating no contaminants, but also by - fulfilling cleaner production requirements - the 'end-off-pipe' solutions.

Design/methodology/approach: used for the analysis has covered optimization of hydrocarbon degradation as the 'end-of-pipe' process by determination of the efficiency of hydrocarbons chemical and biological degradation and evaluation of the effect of the initial content of the hydrogen peroxide on alkanes biodegradation.

Findings: of analysis are as follows: both chemical and biological oxidation is a straight forward method for decreasing hydrocarbon concentration in the production wastewater, so - the possibility of optimization of the 'end-of-pipe' process.

Practical implications: can be applied in case of any organisation, which, because of financial or technological reasons, minimizes the concentration of hydrocarbons draining off to the environment by the 'end-off-pipe' technologies.

Originality/value: of the presented paper has been created by confirmation that application of the best available technologies is not the only way for efficient fulfilling legal requirements of integrated pollution prevention and control directive and cleaner production strategy assumptions.

Keywords: Improvement of process; Environmental management; Cleaner Production; Environmental risk

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1. Introduction

The increasing clients' requirements and expectations imply the more modern and based on the quality criterion solutions, which are increasingly risky for the natural environment not only in the context of the current activities but also in the meaning of the future development. That is why social requirements connected with the minimization of enterprises' influence on environment enforcement in the technological processes management, traditionally aiming at achieving the high effectiveness of the set quality aims realisation, pay close attention to the environmental aspect [1-4].

The approach being the reconciliation of the conflicting enterprise's businesses and environmental requirements is cleaner production - a kind of strategy of organization based on both the prevention of pollution of natural environment and the minimization of natural resources usage [5].

The rationalization of minimization of usage of materials and energy by changes in the integrated management, organization of production processes as well as technology seems to be aim which is difficult to realise.

However solutions aiming at minimization of: emission of gases and dust to air, releases of sewage to water and land, emission of noise and electromagnetic fields and production of waste are attainable regardless of the organization size and kind of the realised processes. Those proecological aims can be achieved by technical, technological and organisational solutions, which character is in most cases dependant on financial condition of the organisation. In specific cases, despite continuous searching for the best available technology, the only way for minimization of concentration of contaminants draining off to the environment, is end-of-pipe solution [6].

2. Natural environment protection practices

Proecological aims in the range of cleaner production and sustainable development strategy can be realized by the following technological solutions (fig. 1) [7]:

- supporting technologies based on using supervision measures to monitor the production process and maintain concentration of contaminants on the constant level,
- end-of-pipe technologies used as the last stage of the process for minimizing or eliminating contaminants, which have been already produced,
- in-process technologies improving the realized processes by new small infrastructure minimizing the contaminants quantity in different stages of technology,
- new technologies reducing the contaminants quantity by usage of new technological processes including new infrastructure and new principles.

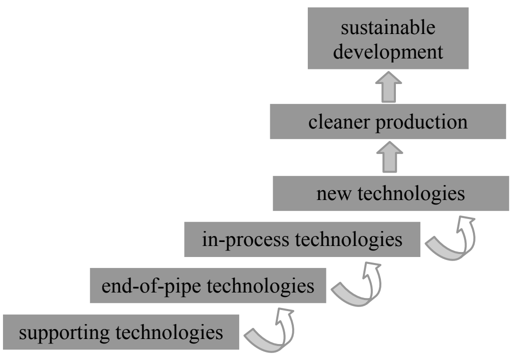

Fig. 1. Draft of stages of technological solutions in sustainable development strategy [7]

Because of the assumed costs criterion, the majority of the organizations, when accepting cleaner production and sustainable development strategy, chooses supporting and end-of-pipe technologies. The selection criterion are both: the lowest price and assurance of fulfilling the requirements of integrated permission [8].

The integrated permission is formal-legal tool introduced to the use in European Union countries by Council Directive 96/61/EC of 24 September 1996 concerning the integrated pollution prevention and control, which has been recently codified and replaced by Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning the integrated pollution prevention and control. The IPPC directive has been transposed to the Polish law by the Act of 27 April 2001 on Natural environment protection [9,10].

The integrated permission is a special kind of permission connected with all the emissions in any organisation. That is the reason why the organ being responsible for the issuing the integrated permission, has to take into account also the sector requirements [10].

According to the Act on Natural environment protection the integrated permission is required by the exploitation of every installation, which due to both kind and quantity of the conducted activity can cause significant pollution of the environmental elements or of the environment as whole. In that context installation can be understand as „stationary technical unit where one or more activities listed in Annex I are carried out, and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution [11].

The integrated permission is issued for one or more installations, which fulfil the criterion of the Regulation of 26 December 2004 on Kinds of installations which exploitation needs the notification indicating kinds of installations, from which the emission doesn't need the permission, and the exploitation of which needs the notification to the environmental protection organ at the request of the owner of installation [9,10].

Informational and operational parts of application for the integrated permission should include [12]:

- characterisation of installations and devices,
- characterisation of the environmental influences,
- characterisation of environmental influences of emissions,
- characterisation of manners of prevention or minimization of the environmental influence,
- specification of applied maximal parameters of emissions,
- specification of proposed maximal parameters of emissions,
- grounds for the proposed maximal emissions,
- characterisation of range of monitoring of emissions, rules of gathering and passing on monitoring results as well as proposed criterions of identification of significant influences and their monitoring,
- conditions of verification of changes of permission content.

The integrated permission, apart from the general conditions, should also cover [12]:

- acceptable level of noise,
- quantity of gas emission,
- quantity of dust emitted to air,
- conditions of water consumption,
- conditions of wastes production,
- conditions of releasing sewage.

3. Searching for optimization of the end-of-pipe technology

3.1. Aliphatic hydrocarbons characterisation

Hydrocarbons are chemical compounds that contain only carbon (C) and hydrogen (H). Hydrocarbons, on the basis of their sources and properties, can be classified as aliphatic or aromatic [13,14].

Aliphatic hydrocarbons are divided into three main groups according to the type of bonds they contain. All hydrocarbons except alkanes contain multiple bonds and undergo addition reactions in which the hydrocarbon (C_mH_n) confines with some other species [13,14].

The type and size of the hydrocarbon molecule affect its ability to be metabolized by microorganisms. The shortest chains are usually toxic for many microorganisms. The straight-chain alkanes (10 to 24 carbon atoms) are the easiest to metabolize. As the length of a chain increases, the resistance for biodegradation decreases; hydrocarbons with molecular weights of 600 and more can be treated by microorganisms as a carbon source [15].

3.2. Chemical degradation using hydrogen peroxide

Hydrogen peroxide is the most important covalent peroxide. It is a strong oxidizing agent in both acidic and basic conditions, and at the same time it has low toxicity so it is easy to handle [16,17].

Hydrogen peroxide is used in metals industry, textile industry, pulp and paper industry, in chemical industry. By-products of hydrogen peroxide are gentle effectiveness and harmless and that is why hydrogen peroxide finds the application in treating industrial and municipal wastewater. Its anti-bacterial properties make it useful in disinfection of water and food [16,17].

Hydrogen peroxide is one of the strongest oxidizers; stronger than chlorine, chlorine dioxide, and potassium permanganate. Hydrogen peroxide, through the, catalysis can be transformed into hydroxyl radicals (· OH) with reactivity second only to fluorine - the most powerful one (table 1) [19].

Table 1.
Specification of oxidation potential of different oxidants [19]

oxidant	oxidation potential [eV]
hydrogen peroxide	1.8
hydroxyl radicals	2.8
ozone	2.1
fluorine	3.0
chlorine	1.4

Despite its oxidizing power, hydrogen peroxide is a natural metabolite of many organisms, which decompose hydrogen peroxide producing oxygen and water [18,19].

Hydrogen peroxide can be used for different applications (inhibition of microbial growth, encouragement of microbial growth, treatment of both easy-to-oxidize and difficult to oxidize pollutants), because of its selective activity. Adjusting the conditions of the reaction (e.g., pH, temperature, dose, reaction time, and/or catalyst addition), can direct H_2O_2 to oxidize different pollutants or even to favour different oxidation products from the same pollutant [19].

Simple hydrogen peroxide reactions

Hydrogen peroxide decomposes spontaneously into water and oxygen, but in the normal environmental conditions only the minimal decomposition occurs. Activation of H_2O_2 in these 'simple' applications may be affected by the presence of catalyst, the adjustment of pH, temperature and reaction time ($2\ H_2O_2 \rightarrow 2\ H_2O + O_2 + 196.2$ kJ) [13,14].

Theoretically, it is possible to provide oxygen 5 to 50 times faster than pure oxygen using hydrogen peroxide, which may result in shortening of the oxidation time [13,14].

Variables affecting the technology's application

The most important variables which affect the application of H_2O_2 technologies are [13,14,18,19]:

- concentration of hydrogen peroxide; the higher hydrogen peroxide concentration provides faster reaction time but less efficient hydrogen peroxide use,
- ratio 'hydrogen peroxide:contaminant'; efficiency of the reaction increases with higher contaminant concentrations and decreases as target treatment levels become more stringent,
- time of reaction; applications of hydrogen peroxide follow first-order rate equation - contaminant removal is a linear relationship to hydrogen peroxide dose.

3.3. Hydrocarbons biological degradation

Microorganisms which degrade hydrocarbons are widespread in soil and aquatic environments. Population of hydrocarbon -degrading microorganisms constitutes less than 1% of whole community. For hydrocarbons biodegradation to be successful it is necessary 'to have the right microbes in the right place'. The right microbes are bacteria or fungi, which have the physiological and metabolic capabilities to degrade the pollutants. If microorganisms are not present in the required place they can be added in the unnatural way. To intensify hydrocarbons degradation, the inserted microorganisms can be genetically engineered to degrade [20].

A biodegradation process is based on the activities of aerobic or anaerobic heterotrophic microorganisms. Enzymes produced by microorganisms start to degrade the hydrocarbons molecules in special conditions. This activity is affected by a number of physical and chemical environmental parameters; these are: energy sources, pH, dissolved oxygen, temperature and inhibitory substrates [20].

Dioxygenases and monooxygenases are two of the primary enzymes employed by aerobic organisms during transformation and mineralization of hydrocarbons; alkanes are most commonly metabolized via terminal methyl oxidation [20,22].

There are several possible mechanisms of the introduction of oxygen into the substrate. The most widespread mechanism is the hydroxylation of the ω-methyl group. This reaction includes the direct incorporation of molecular oxygen (*Corynebacterium*). Other organisms such as *Pseudomonas oleovorans* perform ω-hydroxylation of the fatty acid that results in a diacidic intermediate. Certain organisms (*Arthrobacter, Mycobacterium,* some *pseudomonas*) degrade alkanes via subterminal oxidation, producing an internal ester, which is then cleaved into an alcohol and an acid [22].

The rate of hydrocarbons conversion in the time of biodegradation depends on the rate of contaminant uptake, metabolism and the rate of transfer to the cell and the bioavailability of contaminant is dependent mainly by diffusion and sorption [23].

Metabolism of an organic compound has been defined as the use of the substrate as a source of carbon and energy. It results in different microorganisms activity based on ability and availability of reduced organic materials to serve them as energy sources [23].

Table 3.
Specification of enzymatic features of microorganisms which degrade alkanes [22]

microorganisms	main pathways of alkanes oxidation		
	terminal	diterminal	subterminal
Pseudomonas aeruginosa	+	+	+
Pseudomonas putida	+	+	+
Acinetobacter suboxydans	+		+
Nocardia	+	+	+
Bacillus lentus			+
Candida lipolytica	+	+	
Candida parapsilosis	+	+	
Rhizopus nigricans	+		
Aspergillus flavus			+
Chlorella vulgaris			+

During aerobic heterotrophic conversion of organic matter, characterized by metabolic activities involving oxygen as a reactant, organic matter may be exposed to [21,24]:

- oxidation to carbon dioxide,
- assimilation in biomass,
- unchanged passage, which means biologically non-degradability of the matter,
- conversion into other organic matter .

Usually the percentage of substrate incorporated into the biomass declines and the percentage mineralized increases with time [21,24].

Acclimation period of the microbes to the substrate and the type of microbial transformation are affected by the following factors: microbial (biomass concentration, population diversity, enzyme activity), substrate (concentration, molecular structure, physical and chemical characteristics), environmental (pH, temperature, carbon and energy sources) [23].

Environmental requirements for microbial growth

Environmental requirements determining microbial growth are [21,24,25]:

- oxygen; obligatory aerobic bacteria can grow only in the presence of oxygen, in most cases respiration depends on the transfer of electrons to oxygen,
- temperature; bacteria have adapted to wide range of temperatures; mesophilic bacteria are those in which optimum growth occurs at 20°C; for temperature range 32-0°C the removal rate is constant after which it usually declines drastically to be zero around 45°C; in the termophilic range 50-0°C the process rate is approx. 50% higher than at 35°C,
- pH; most bacteria grow in the range of neutral pH values, between 5 and 8,
- toxic substances; many substances act toxically on aerobic organic mass conversions by competitive and non-competitive inhibition,
- water; the majority of bacteria needs water concentrations greater than 98 percent,
- concentration of pollutants; if the concentration of hydrocarbons is too high it will reduce the amount of oxygen and nutrients that are available to the microbes.

Nutrional requirements for microbial growth and adaptation

Carbon is the most basic structural element of all living forms and is needed in greater quantities than other elements. The nutrional requirements of carbon to nitrogen 10:1 and carbon to phosphorus 30:1 [21,24].

For nitrogen and phosphorus low concentrations microbial growth is inhibited [21,24].

Adaptation period is a length of time between the addition of the chemical into an environment and evidence of its detectable loss and characterised by no change in concentration [21,24].

The length of the adaptation period can be affected by several environmental factors [24]:

- temperature; it has a major impact on the duration of lag phase, as indicated by the longer interval before the onset of rapid degradation at lower than at higher temperatures,
- pH and aeration; the affection depends on compounds and microorganisms,
- concentration of N and P; it affects the biodegradation of N- and P-containing organic compounds.

4. Own research

4.1. Aims

The primary objective of the research was to minimize the environmental risk by optimization of hydrocarbon degradation as the end-of-pipe process [6].

The established aims were achieved by:

- demonstration that an aerobic biodegradation would be an appropriate way of hydrocarbons degradation,
- evaluation of the effectiveness of hydrocarbon microbial degradation,

- evaluation of the effectiveness of hydrocarbon chemical degradation,
- determination of the influence of the initial content of the hydrogen peroxide on hydrocarbon biodegradation.

4.2. Methodology

To estimate the extent of biodegradation, several tests were performed. Each test consisted of two or three bioreactor studies.

Five tests were performed in bioreactors inoculated with non-adapted activated sludge.

One test was carried out with two bioreactors inoculated with non-adapted activated sludge.

Third bioreactor was inoculated with adapted activated sludge.

Test II

The main purpose of the second test was to determine the efficiency of hydrocarbon biodegradation and to evaluate the effect of the initial content of the hydrogen peroxide on alkanes biodegradation.

Studies were performed in three bioreactors with the same inoculum. A microorganisms consortium was obtained from wastewater treatment plant and it was not acclimated to use this kind of wastewater as the carbon source. The vessels were filled with 2.5 dm^3 of the sludge and 2.5 dm^3 of the mixed, with different mixing rates, wastewater. The mixing rates were:

- reactor 1 spinning wastewater : bleaching wastewater - 1:5,
- reactor 2 spinning wastewater : bleaching wastewater - 1:1,
- reactor 3 spinning wastewater : bleaching wastewater - 5:1.

After filling, the vessels were tightly closed to the end of the test. Reactors were incubated at 25°C with natural pH-value on a rotary shaker at 200 rpm for 8 days.

The physical and chemical conditions at the beginning of the test have been shown in table 4.

Table 4.
Specification of physical and chemical conditions at the beginning of the second test

parameters	R 1	R 2	R 3
Hydrocarbon content in the spinning wastewater [mg H/dm^3]		190.4	
H_2O_2 content in the bleaching wastewater [mg H_2O_2/dm^3]		180.00	
Hydrocarbon content in the wastewater mixture [mg H/dm^3]	9.2	30.9	46.7
H_2O_2 content (theor.) in the wastewater mixture [mg H_2O_2/dm^3]	150.0	90.0	30.0
Biomass content in reactor [g dry mass/dm^3]	3.0	3.1	3.0
Hydrocarbon content in reactor [mg H/dm^3]	4.6	15.0	23.1
Hydrocarbon sludge loading [mg H/g dry mass]	1.5	4.8	7.7
BOD_5/COD	0.24	0.21	0.25

All of the tests were conducted using laboratory bioreactor system, which is optimally adapted to the demands of modern biotechnology and consists of (figure 2):

- culture vessel, installed in a supporting frame; the culture vessel is jacketed glass vessel with thermostat jacket outside; the vessel is made of borosilicate glass and it includes an internal concave bottom section; all parts in contact with the medium are made of stainless steel,
- drive system; the stirrer is driven by the motor, which is directly mounted to the top-plate; drive motor and stirrer shaft are connected by an elastic coupling, which minimizes wearing of the parts,
- thermostat system; the operation temperature ensures a precise and constant temperature control; the thermostat system is designed as an open, pressure-free system; an electric heater supplies the necessary energy to the system; acentrifugal pump delivers water of the preadjusted temperature to the vessel,
- gas supply system; in the system a membrane pump is installed and a mass flow controller, also installed in the air supply line and allows a precise control of supply of gas or air, the air is supplied to the culture vessel via a sparger ring, two sterile membrane filters providing a gas supply and exhaust,
- digital measurement and control unit; designed for the automation of the bioreactorware offers all functions such as data acquisition, sensor calibration, control loops; the operator terminal is integrated and the processes data are indicated on an easy to read alphanumerical display.

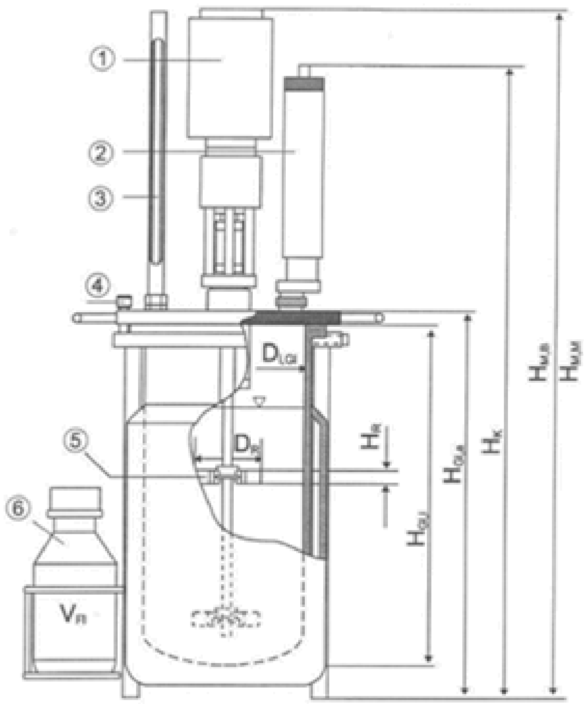

Fig. 2. Design of culture vessel system; 1- motor, 2 - exhaust cooler, 3 - thermometer, 4 - top plate screw, 5 - blade disc impeller, 6 - corrective solution bottle

Analysis have taken into account measurement of:

- hydrocarbon content in liquid mixture,
- hydrocarbon content in the sludge,
- biochemical oxygen demand (BOD),
- chemical oxygen demand (COD),
- H_2O_2 content,
- dry mass (tests on sludge)
- dissolved oxygen,
- pH-value.

Technological parameters and sludge activity have been defined by:

- Hydrocarbon sludge loading factor - C_H
- Relationship between BOD_5 and COD
- Hydrocarbon total removal - HTR
- Hydrocarbon daily removal - HDR
- H_2O_2 \ H ratio

4.3. Results and results discussion - test II

Specification of hydrocarbon concentration and reduction during chemical and biological degradation has been shown in Tables 5-7.

Table 5.
Specification of hydrocarbon content and reduction during chemical degradation

kind of wastewater	hydrocarbon content [mg H\dm^3]	H_2O_2\h ratio [mg H_2O_2\mg H]	hydrocarbon reduction [%]
spinning	190.4	-	-
spinning : bleaching 1 : 5 dilution + oxidation	9.2	-	95.2
spinning : bleaching 1 : 1 dilution + oxidation	30.9	-	83.8
spinning : bleaching 5 : 1 dilution + oxidation	46.7	-	75.5
spinning : bleaching 1 : 5 dilution	31.7	-	83.3
spinning : bleaching 1 : 1 dilution	95.2	-	50.0
spinning : bleaching 5 : 1 dilution	158.7	-	16.6
spinning : bleaching 1 : 5 oxidation 150 mg H_2O_2\dm^3	-	4.8	11.9
spinning : bleaching 1 : 1 oxidation 90 mg H_2O_2\dm^3	-	0.9	33.8
spinning : bleaching 5 : 1 oxidation 30 mg H_2O_2\dm^3	-	0.2	58.9

Table 6.
Specification of hydrocarbon concentration during biological degradation

day of the determination	hydrocarbon content [mg H\dm^3]					
	reactor 1		reactor 2		reactor 3	
	liquid	liquid + sludge	liquid	liquid + sludge	liquid	liquid + sludge
0	4.5	4.6	14.7	15.0	22.6	23.1
1	1.7	2.0	3.9	4.4	1.8	3.5
2	1.2	1.6	2.2	4.0	1.4	2.6
3	0.9	1.3	1.6	3.6	1.2	2.4
4	0.7	1.0	1.3	3.0	0.9	2.2
5	0.6	0.8	1.0	2.6	0.7	1.9
6	0.4	0.6	0.8	2.4	0.6	1.7
7	0.3	\	0.6	\	0.5	\

Table 7.
Specification of hydrocarbon removal during biological degradation

day of the determination	hydrocarbon concentration reduction [%]											
	reactor 1				reactor 2				reactor 3			
	liquid		liquid + sludge		liquid		liquid + sludge		liquid		liquid + sludge	
	daily	total	daily	total	daily	total	daily	total	daily	total	daily	total
1	62.2	62.2	41.3	41.3	74.8	74.8	70.6	70.6	92.0	92.0	84.8	84.8
2	29.4	73.3	30.0	69.6	43.6	85.0	9.1	73.3	22.2	93.8	25.7	88.7
3	25.0	80.0	18.7	71.7	27.3	89.1	10.0	76.0	14.2	94.7	7.7	89.6
4	22.2	84.4	23.1	78.3	18.7	91.1	16.6	80.0	25.0	96.0	8.3	90.5
5	14.3	86.7	20.0	82.6	23.0	93.2	13.3	82.7	22.2	97.3	13.6	91.8
6	33.3	91.1	25.0	86.9	20.0	94.5	7.7	84.0	14.3	97.7	10.0	92.6
7	25.0	93.3	\	\	25.0	95.9	\	\	16.7	97.8	\	\

Chemical oxidation

The experimental studies including chemical oxidation prove that there are two processes present during wastewater pre-oxidation: physical process of dilution and chemical process of oxidation. It is also proved that physical process of dilution is the basis of hydrocarbon reduction in the mixture of hydrocarbon wastewater and hydrogen peroxide wastewater.

Hydrocarbon reduction during chemical oxidation with bleaching wastewater (180.0 mg H_2O_2) has been shown in table 5 and figure 5. When the spinning wastewater is diluted with bleaching wastewater in the proportion 1:5 (mixture 1) the hydrocarbon concentration is reduced by 75.5%. After dilution 1:1 hydrocarbon content is reduced by 83.8%. After dilution 5:1 (mixture 3) hydrocarbon content is reduced by 95.2%. Taking only dilution into consideration hydrocarbon content is reduced by 16.6% in mixture one, 50.0% in mixture two and 83.3% in mixture three. Chemical oxidation reduces alkanes concentration only by 58.9% (M1), 33.8% (M2), 11.9% (M3).

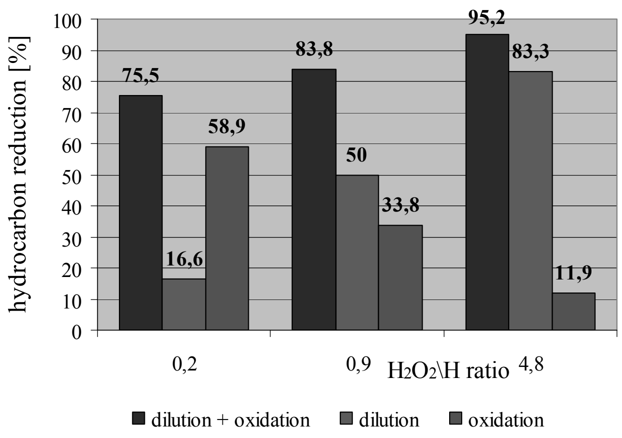

Fig. 5. Specification of hydrocarbon content and reduction during chemical degradation

Biological reduction

The experimental studies carried out allow stating that all of the hydrocarbons in the spinning wastewater are very well biodegradable. During all of the biodegradability tests using activated sludge, hydrocarbon concentration is reduced by 95±5% and a hydrocarbon content at the end of the tests is between 0.3 and 8.4 mg H\dm^3 in the non-sediment samples and between 0.2 and 3.7 mg H\dm^3 in the liquid samples. Hydrocarbons concentration, biodegradation rates and hydrocarbon reduction depends on the same parameters. Several of them may have important effects on biodegradation rates, although aliphatic hydrocarbons degradation is found to occur at a wide range of all the factors. On the other hand, even though each of these factors plays an important part in the biodegradation process, only certain parameters can be manipulated. Parameters by which a biodegradation is strongly affected, in most cases can't be manipulated; these parameters, with stable biomass content, are initial hydrocarbon concentration and initial hydrocarbon sludge loading.

Results of the biodegradability tests indicate that degradation process depends on microbial factors - biomass concentration. Unfortunately it's a factor which can't be controlled at the wastewater treatment plant conditions. It is also demonstrated that aliphatic hydrocarbons biodegradation rate isn't strongly dependent on the pH-value at the narrow range of this environmental factor and biodegradation occurs between pH 5 and pH 9 with the same biodegradation rate. It is also confirmed that in the case of aliphatics neither acclimation nor hydrogen peroxide activation had a strong influence on biodegradation process.

The decrease in concentration of n-alkanes has been illustrated in table 6. In every reactor, regardless of the initial hydrocarbon content (R1: 4.6 mg H\dm^3, R2: 15.0 mg H\dm^3, R3: 23.1 mg H\dm^3), hydrocarbons concentration drops to 2-4 mg H\dm^3 after only one-day biodegradation. During this day the average daily hydrocarbon content reduction is 43% in reactor one, 70% in reactor two and 90% in reactor three. After this time any significant differences are not observed in the counts among the different reactors and the daily hydrocarbon removal in every reactor is only about 35% (table 7). At the end of the test the alkanes content reduction is 86.9% in reactor one, 84.0% in reactor two, and 92.6% in reactor three (figure 6).

It can be also observed (figure 6) that for all bioreactors mineralization curves are similar without lag phase.

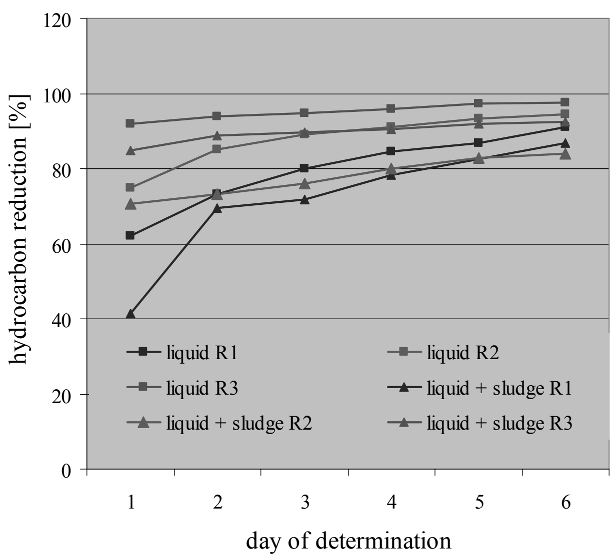

Fig. 6. Specification of hydrocarbon removal during biological degradation

5. Conclusions

Simultaneously fulfilling the conflicting enterprises' businesses and environmental requirements is very difficult to succeed, mostly because of the financial reasons. Environmental solutions eliminating the environmental risk and proposed by the interested parties to implement in organizations are usually based on new technologies reducing the contaminants quantity by usage of new technological pretended to be best available techniques.

Nevertheless it should be noticed that cleaner production strategy - the new attitude to the natural environment protection - takes into account prevention, minimization and, if it is possible, elimination of the pollution ‘at source’ in the integrated manner. Therefore taking into account the lowest price and assurance of fulfilling the requirements of integrated permission, the majority of the organizations, optimizing environmental influences uses the most often supporting and end-of-pipe technologies.

Every of the processes realised in any organisation should be continuously, according to the Deming PDCA cycle, improved. The improvement rule applies to the system of processes qualified as main, preparatory, auxiliary and management ones.

That is why the primary aim of work was optimization of the end-of-pipe process - hydrocarbon biodegradation processes as the auxiliary one.

To check chemical and biological degradability of aliphatic hydrocarbons in the production wastewater, several tests in different conditions were successfully conducted. The laboratory tests, including process of chemical oxidation, process of aerobic biodegradation and monitoring of hydrocarbon concentrations in bioreactors, demonstrated that both chemical oxidation and biological oxidation are a straight forward method for decreasing hydrocarbon concentration in the production wastewater emitting to the natural environment, so - the possibility of minimization of the environmental risk.

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