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STUDY OF THE EFFECTIVENESS OF THE NEW METHOD FOR THE RAPID PAHS ANALYSIS IN SOIL

Abstract
The aim of this research was to compare the effectiveness of highly-selective chromatographic PAHs determination method with the new, simpler, non-selective spectrophotometric method, designed for the rapid monitoring of PAHs contamination level in soil. The conducted experiment includes the 2 series of PAHs content determinations, in 4 types of soils, with use of HPLC and spectrophotometric techniques. The obtained results, showed that the developed, PAHs content in soil determination method, can be used for quick and non-specific environmental monitoring of soil. However the effectiveness of this method is dependent on the content of organic matter in the analyzed soil samples.

Key words
PAHs, PAHs determination, Spectrophotometric analysis, HPLC analysis, soil, environmental monitoring.

Introduction

The presence of organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs) in soil, used for crops production, is considered as a big issue in the field of modern agriculture. Due to the toxic nature and mutagenic, cancerogenic and theratogenic activity of some compounds from PAHs group, their occurrence in soil can cause a numerous of problems, such as: induction of economic losses (decreased yield), generation of a threat to human health and impact on the ecological homeostasis (toxic influences to endogenous flora and fauna). The issues associated with risk to humans, results from the fact that, those pollutants can migrate to the plant tissues, causing contamination of food or feed [1,2].

Taking in account the above-mentioned characteristics of pollutants from PAHs group, it can be noted that, conduction of effective monitoring of PAHs contamination levels, in soils used for agricultural purposes, should be a common practice. Unfortunately, for the current moment, the techniques used for determination of PAHs content in soil, are very expensive, labour-intensive and require the use of sophisticated laboratory equipment [3,4]. The most commonly used methods for PAHs analysis in soils are chromatographic techniques, including High Performance Liquid Chromatography (HPLC) and high performance gas chromatography with mass-spectrometry detector (GC-MS) [5]. Both of these methods are characterized as highly accuracy and allow performing a detection of results in the nano and pico-metric scales. However, this type of method requires complex sample preparation, is complicated in execution and generates high procedural costs [1,3,5].

One of the most commonly used PAHs detection techniques is a spectrophotometric method. This technique can be used directly or as part of the chromatographic system. It involves measuring the absorbance of light waves by molecules of presented in studied solution substances. In the case of the compounds from PAHs group, aromatic rings, also called chromophoric systems, absorb light waves. The presence of such structural element in PAHs molecule, cause the absorption of the light spectrum, which leads to the decrease in the electromagnetic energy of wave. The absorbed energy is converted into electron energy, oscillation energy or rotation energy. According to this principle, knowing of a measurable amount of absorbed energy can be calculated in to amount of substance that adsorbs this energy [6,7].

The use of traditional spectrophotometric methods for PAHs determination is associated with some methodological issues. In most cases the presence of a one compound from this group is treated as an indicator. In practice it means that in such situations, in studied material, other substances of similar origin also are present.

Taking into account the above-mentioned fact it can be stated that there is a strong likelihood of interference in data obtained with those types of detections [6,8,9].

The solution to this problem could be the introduction to the process of preparation of samples for analysis of preliminary selective designated analytes separation techniques. This type of methods includes the conventional extraction (for soil solid-liquid extraction) or advanced SPE techniques (solid phase extraction) [10,11,12]. SPE consists of passing a known volume of the test solution (liquid extract) by the material that has the capacity for selective adsorption of the analytes. The most commonly used materials in the PAHs isolation from extracts are silica gel with the modified functional C18 groups. PAHs molecules, present in the solution are retained by the strong hydrophobic gel structure and then they may be washed with an appropriate solvent. This type of procedures has found a wide range of applications in scientific papers and is widely described in publications [11,13].

The aim of this research was to compare the effectiveness of highly selective chromatographic PAHs determination method (HPLC technique) with the new simple, non-selective method, designed for the rapid monitoring of PAHs contamination level in soil.

Material and methods

The experiment was conducted in four stages. In the first stage, the initial calibration, with use of spectrophotometric method, was performed. This procedure includes a series of absorbance measurements, 5 dilutions of the standard solution (0.1; 0.075; 0.05; 0.025; 0.01). The used standard was a RESTEK mixture of 16 PAH's - RESTEK 610 Calibration MIX A. This solution contains a mixture of listed below compounds, dissolved in acetonitrile. The list of PAHs in used standard includes: acenaphthene (1000 µg/ml), acenaphthylene (1000 µg/ml), anthracene (1000 µg/ml), benz(a)anthracene (500 µg/ml), benzo(a)pyrene (500 µg/ml), benzo(b)fluoranthene (500 µg/ml), benzo(k)fluoranthene (500 µg/ml), benzo(g,h,i)perylene (500 µg/ml), chrysene (500 µg/ml), dibenz(a,h)anthracene (500 µg/ml), fluoranthene (500 µg/ml), fluorene (1000 µg/ml), indeno(1,2,3-c,d)pyrene (500 µg/ml), naphthalene (1000 µg/ml), phenanthrene (500 µg/ml), pyrene (500 µg/ml). On the base of obtained results, the linear calibration curve has been prepared and the formula for total PAHs content calculation was developed. The calibration curve is presented on the chart - figure 1.

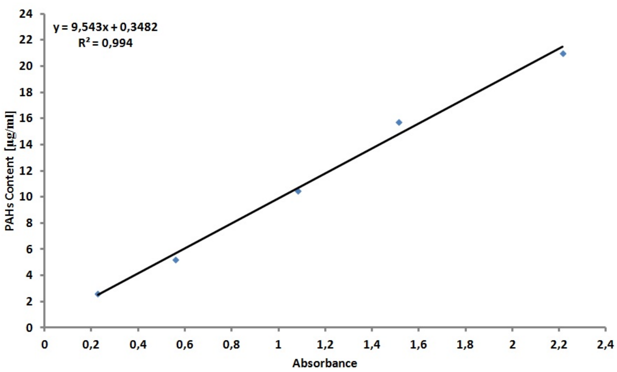

Fig. 1. Spectrophotometric calibration curve

The second step includes the analysis of basic physical and chemical properties of used materials. In the experiment, the four types of soils were used. First soil material was taken from the crop field (cultivation of *Brassica napus*), located in the Silesia region Poland. This material was characterized as loamy sand with low level of organic matter and low pollutants content. Second soil comes from the fallow lands, located near the highway. This material also was characterized as loamy sand with low level of organic matter and low pollutants content. The third soil material was the commercially available, cultivation medium. It consist high level of organic matter and medium level of pollutants content. The last soil was taken from the heavy contaminated industrial site, located in Silesia region of Poland. This material consist a medium level of organic matter and very high level of pollutants content. All collected materials were subjected to following analysis: dry matter; organic matter; pH in water (the active acidity), pH in potassium chloride solution (the exchangeable acidity) - (PN-ISO 10390:1997); CEC (Cation Exchange Capacity) Kappen's method [14,15].

The third stage, was concerned on the analysis of PAHs contamination levels in all above mentioned soil samples. This procedure was performed by two techniques. The first, was selective chromatographic analysis (HPLC method), while the second, was spectrophotometric analysis. To the PAHs analysis, the air-dry soil samples (samples weights: 10g - soils 1, 2, 4; 1g - soil 3) were used. In order to provide a wide range of statistically correct results all air-dry soil samples were divided into 6 subsamples. To the carefully weighed soil subsamples (3-reps for each subsample) the 30 ml of acetonitrile were introduced. Next they were subjected to the sonification for 30 min. in an ultrasonic bath. The obtained extracts were also been shacked for 24h. After that extracts were purified by centrifugation and filtration over PP membrane filters (0.45 m). The final phase of samples preparation was the concentration of extracts, by using SPE (Solid Phase Extraction) technique. For this purpose the ChromaBond C18 6ml/500mg columns were used. Following the above procedure, 3 ml sample volumes were obtained. Spectrophotometric analysis was performed on HACH DR 6000, and the chromatographic analysis was run on Thermo Scientific SpectraSystem [16,17].

The HPLC analysis was based on the existing methodologies [3,5,11]. The used procedure was based on gradient elution technique, with use of a mixture of water, methanol and acetonitrile as mobile phase. The analytes separation was carried out in the reversed phase, on the Restek Pinnacle II PAH HPLC column, at a temperature of 30°C. Detection of results was carried out by using a UV-VIS detector at 254 nm wavelength. Spectrophotometric analysis was based on the absorbance measurements also at 254 nm wavelength [16,18].

The final stage of the study includes the comparison of the results of total PAHs content, obtained in both types of conducted analysis. It consisted of calculations of the Pearson correlation coefficients and the graphical presentation of the level of similarity between them.

Results and discussion

The results, obtained during the execution of physical and chemical properties analysis, of all studied materials, are presented in Table 1. Based on those information's, it can be observed that the first two types of soils 1 and 2, have high dry matter content and low organic matter content. The pH of these soils is in range of 7 and the cation exchange capacity (CEC) is relatively low. In the case of soil 3, it can be seen that this material had the lowest content of dry matter and the highest content of organic matter. The pH of this material is slightly acidic and the cation exchange capacity is twice higher than in the previously discussed soils. The last type of soil 4 was characterized as material with approximately high dry matter content and a relatively high content of organic matter. The pH of the material is acidic and cation exchange capacity is placed among the highest values of all tested materials.

Table 1. The physical and chemical properties of used materials

Parameter	**Soil 1**	**Soil 2**	**Soil 3**	**Soil 4**
Dry matter [%]	92,4	93,2	48,7	88,8
Organic matter [%]	4,9	4,2	88,9	45,7
pH (in H_2O)	6,99	7,15	6,42	5,99
pH (in KCL)	7,15	7,57	6,58	6,15
CEC [cmol(+)/kg]	16,3	14,5	32,3	44,8

The next section of charts contains the set of results obtained from the both spectrophotometric and chromatographic analysis. Figure 2 presents the results obtained from the determination of the sum of PAHs in soil 1 and 2. Figure 3 contains a set of data obtained from the soil 3 and 4 analyses.

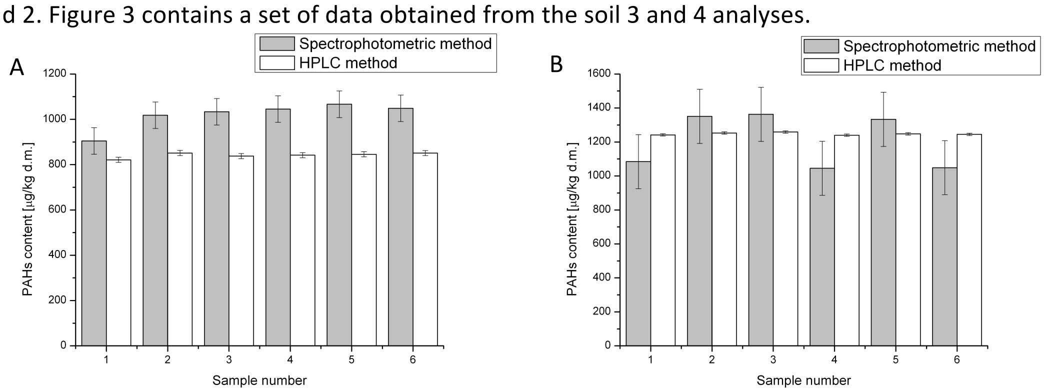

Fig. 2. The results of PAHs determinations conducted with both spectrophotometric and HPLC methods. Chart A applies to soil 1 and chart B applies to soil 2.

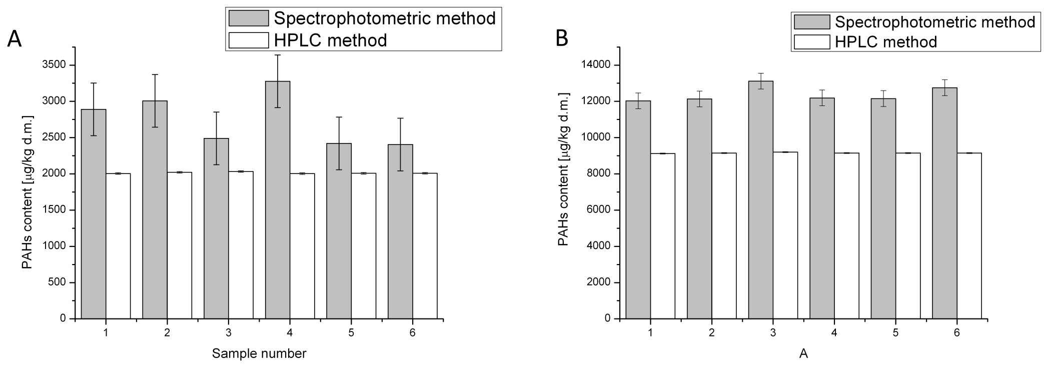

Fig. 3. The results of PAHs determinations conducted with both spectrophotometric and HPLC methods. Chart A applies to soil 3 and chart B applies to soil 4.

On the basis of presented above results, it can be seen that in all studied cases the PAHs contents, obtained by using spectrophotometric method, were higher than the values obtained with use of HPLC technique. This phenomenon can be caused by the non-specific nature of spectrophotometric analysis. Techniques based on the chromatography enable to separate designated groups of compounds from other substances (background), which may be expressed by seemingly reduced analytes content. However such situations does not mean, that HPLC methods are less effective. Selective isolation of only the desired substances, and precise detection of data, makes chromatographic methods much more reliable then spectrophotometric techniques. This fact is supported by the observed in obtained results standard deviation values. In case of the results obtained during spectrophotometric analysis, the values of this parameter were significantly higher than values obtained from HPLC analysis.

The results also show that the soil characterized by increased content of organic matter (soil 3), causes significantly greater measurement errors, during the spectrophotometric analysis. A similar situation also applies to the results obtained from the highly contaminated industrial soils (soil 4).

The presence of large amounts of soil organic matter is associated with the intensive background influences on the absorbance measurement. The compounds with the most important impact on this issue are phytohormones, natural dyes, pesticides and oil origin pollutants (compounds that do not belong to the group of PAHs). Due to the fact, that the detection methods, based only on the spectrophotometry, are not specific, the presence of mentioned above compounds within the soil matrix, can contribute a significantly high level of disturbance in the effectiveness and reliability of this type of methods.

The last set of results concerns the statistical comparison of both PAHs determination methods. The results of this step of research are presented at 4 charts. Figure 4 applies to the soils 1 and 2 while figure 5 to soils 3 and 4. These charts illustrate the degree of linear relationship, between the results of spectrophotometric analysis and HPLC analysis. In the table 2 the standard deviations and calculated correlation coefficients for both studied method are presented.

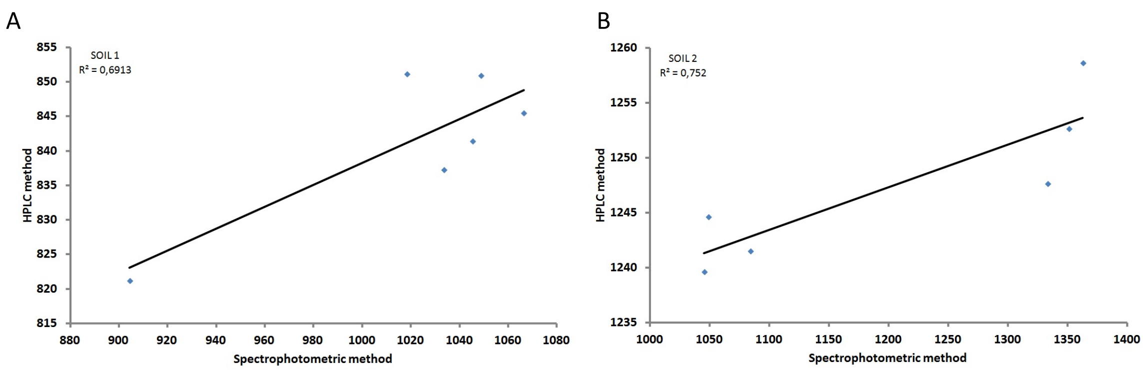

Fig. 4. Statistical comparison of both PAHs determination methods. Chart A applies to soil 1 and chart B applies to soil 2.

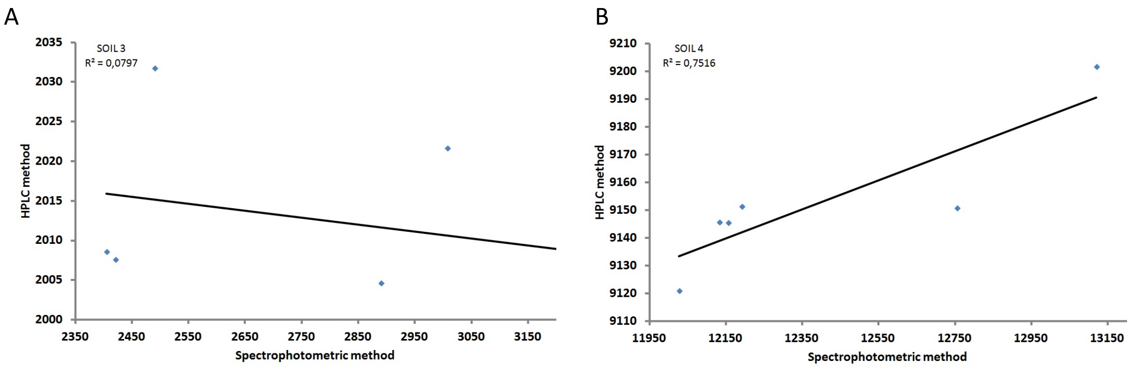

Fig. 5. Statistical comparison of both PAHs determination methods. Chart A applies to soil 3 and chart B applies to soil 4.

Table 2. Correlation coefficients and standard deviations of the studied methods

	Correlation coefficient	± HPLC [%]	± Spectrophotometric [%]
Soil 1	0,83	4,18	12,65
Soil 2	0,87	5,14	11,37
Soil 3	-0,28	9,35	25,03
Soil 4	0,87	7,45	31,64

During the results discussion the following thesis was assumed: the results obtained with the use of chromatographic method are reliable and provide a reference for the results obtained with the use of spectrophotometric technique. A statistical comparison of both those methods shows that in the case of soils 1, 2 and 4, a high degree of correlation was observed, values > 0.8. In case of soil 3, the correlation coefficient was lowest and reaches only a value < 0.3. Comparing the precision of studied spectrophotometric method with methods presented by other authors, it should be noted that the developed technique has greater measurements errors. For example the method used by Juliane Hollender et. al. showed standard deviations in range 2-10 %, depending on the analyzed compounds. Similar variations can be observed at Oleszczuk et. al., Smol et. al. and Sun et. al. [19,20,21]. Presented in current paper, spectrophotometric technique, depending on the type of soil, has the standard deviations in the range of 11.37% to even 31.64%, in the case of highly contaminated soil (sample 4). In result, such large discrepancy of obtained data, disqualify the presented method from most research work, however this technique was designed only for estimating purposes and they scope of potential applications is quite different. Due to the fact, that spectrophotometric method is much more affordable (cheaper test equipment) and the time of analytical procedure is much shorter (spectrophotometric method 2-5 min/sample; chromatographic methods - up to 60 min/sample) this type of technique might find some applications in the fields of implementation of a preliminary assessment of soil contamination, during cyclical monitoring of PAHs content in soils or during the performance of preliminary tests, that do not require precise determination of the strict composition in studied medium.

Summary and conclusions

On the basis of described above results, the following conclusions can be made:

- The developed PAHs in soil determination method can be used for quick and non-specific environmental monitoring of soil.
- The effectiveness of new spectrophotometric method is dependent on the organic matter content in the analysed soil samples. High levels of organic matter have negative impact on the reliability of obtained results. The spectrophotometric method is affected by higher measurement errors then chromatographic techniques. The measurement errors increase proportionally with the increase in environmental contamination of analysed soils.
- The developed method can be used for quick and non-specific environmental monitoring of soil.

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INNOVATIVE HYBRID POLYMER COMPOSITES CELLULAR POLYMER-METAL POWDER OBTAINED IN EXTRUSION PROCESS

Abstract
Polymer matrix composites used for different cable coatings or pipes, are fabricated from materials containing various kinds of powder fillers or fibrous. Properties and structure of these materials depend on the type of added ingredients, their miscibility and quantity. Proper processing method also plays an important role, which allows for obtaining products of homogeneous reproducible properties. The composition was prepared by extrusion with changed processing parameters according to solid plastics. The roughness of obtained shapes was measured with the use of linear method. Results shows that adding blowing agent has a significant influence on mechanical properties.

Key words
extrusion, poly(vinyl chloride), blowing agent, metal powder, composite

Introduction

The extrusion process of polymer materials has been extensively researched. However, as a result of constant improvements to this process, as well as changes and modifications of polymer material, it is vital to analyse the influence of this modification on the processing itself, as well as on the characteristics and structure of the obtained products. Widely used thermoplastic polymer materials such as LDPE, HDPE, PP, PS, PVC contain various types of additives to change their characteristics [1, 2, 3]. Some of the most often used additives are: fillers, nucleating agents, anti-adhesive agents, and retardants.

Among these agents there are also porous agents and microporous agents (blowing agents), in which the structure of the polymer changes as a result of the emission of gas products during the processing. Porous agents used in polymer processing are categorized usually into physical and chemical ones. This categorisation is based on the way the porous gas is emitted [4]. Physical porous agents (physical blowing agents) during the blowing process do not change their chemical structure, but only their state of matter. Thus, these are liquids or gases dispersed under pressure in a polymer material, which after raising the temperature and lowering the pressure evaporate or are liberated in the form of bubbles. This group includes organic liquids with low boiling point: mostly aliphatic compounds and their chlorine and fluorine derivatives. Chemical porous agents (chemical blowing agents) operate in a way similar to physical blowing agents, but gas products causing blowing are created of their dispersion in the polymer. They can be divided into inorganic and organic. Inorganic blowing agents are mostly certain carbons and hydrocarbons, for instance sodium hydrogen carbonate. At elevated temperatures they are decomposed with liberation of gas, usually CO_2 and NH_3. Organic blowing agents are currently the most important group of chemical blowing agents used in the extrusion of polymer materials. They belong to several groups with different chemical structure. They are, inter alia: azo compounds, hydrazine derivatives, semicarbazides, azides, N-nitroso compounds, triazoles, tetrazoles and urea derivatives. The most important of those is an azo compound, diamide of azo-formic acid, azodicarbonamide. These blowing agents have a wide range of decomposition temperature and the amount of the emitted gas [5].

Blowing agents used in the blowing process of polymers have either exothermic or endothermic distribution characteristics. However, the agents used until now in the extrusion process have exothermic distribution characteristic. The initiated distribution of the blowing agent is automatic, even after cutting off the energy supply. Therefore, porous products produced with the use of such agents have to be cooled to prevent deformation and to maintain appropriate porous structure. The main representatives of this group are hydrazides, e.g. sulfohydrazide, and azo compounds, e.g. azodicarbonamide [2, 5].

Commonly used blowing agents may take the form of a solid (powder, granulate), liquid or gas. However, the use of a chosen blowing agent determines the selection of the appropriate processing methods and the elements of technological line. The extrusion process in which a blowing agent or a microblowing agent is added to the polymer material is called respectively foam extrusion and micro-foam extrusion. An agent causing a modification both in the extrusion process and in the extrudate can be added to the polymer during its processing or during its production.

As a result of modification of a polymer material with a blowing agent, substantial changes are observed in the characteristics of both the processing and in the structure and characteristics of the obtained products. The resulting changes may be of a different nature and depend on many factors, such as particular conditions of the processing, the type of polymer material used in the process, the type and the content of the modifier – blowing agent, elements of machines and equipment used in the processing [6]. Auxiliary agents in the form of powders are added to polymers to improve the mechanical, dielectric, thermal, chemical or processing properties (better flow, reduced processing shrinkage). These agents primarily include: calcium carbonate, magnesium oxide, beryllium oxide, talc, chalk, and oxides of metals (aluminum, brass, nickel, copper and iron). The addition of metal powders to a polymeric material results in a significant change in its characteristics and structure. The addition of aluminum and brass enhances acoustic conductivity, nickel powder increases impact resistance, and copper improves thermal stability.

Polymer composites, type polymer-metal, may take different forms; inter alia, we can distinguish layered composites – laminates, porous or conductive. Their form depends mainly on the manufacturing process, primarily by injection molding or laminating [7]. Mixing metal materials with polymer ones brings with it many benefits. Obtained products are characterized by a simplified construction and reduced weight, which affects the increase in efficiency and reduction of costs [9]. Hybrid polymer composites containing metal powders are gaining attention due to their novel properties, such as efficient screening of the magnetic field. Furthermore, they are characterized by low specific gravity, resilience to corrosion, flexibility and ease of processing. In the work [12][13] an analysis of the properties of polymer composites containing copper powder or flakes was conducted. The electromagnetic properties and the structure of the obtained composites were established. In the study, materials such as EVA, LDPE, LLDPE, PP and PVC were used as the polymer matrix. Studies have shown magnetic permeability of value less than 1 and large dielectric permeability. It has been shown that two-layer composites have the best shielding properties.

Composites obtained by a team from the Israel Institute of Technology [8] included microparticles of Al, Ag and Ni in polymer matrix made of low-density polyethylene, and thermoplastic elastomer. Obtained composites were injected and then their mechanical and tribological properties and their structure were analysed. In the analysed solution the polymer matrix was solid throughout. The study showed a significant effect of hardness, elastic modulus, dynamic friction and state friction with the increasing content of individual metal powders. However, at the smallest metal content (2% wt.) there was a decrease in the tested properties, and with further increase of the amount of metal in the material, the tested properties' values were increasing. The analysis of the literature revealed that studies of polymer compositions containing metals concern only the solid polymer materials, not porous ones [9, 10, 11]. In all analyzed cases the added metal had the form of fibres, not powder and was produced in the process of injection molding or galvanization, not twin-screw extrusion [11, 12]. The addition of the metal powders results in obtaining new products with new, special properties like electrical, thermal and magnetic conductivity, as well as reduced wear. In addition, an increase in the barrier and strength properties, such as hardness or tensile strength was observed [13].

The main goal of this work is closer investigation of the effect of modification of poly(vinyl chloride) plasticized, with selected special blowing agent and metal powders on the course and efficiency of the extrusion process, the selected properties of the resultant porous extrudate and on its structure. A further aim of this work is to obtain an extrudate in the form of tubes with porous structure and satisfactory physical properties, relevant geometrical features, as well as meeting the requirements of the market. These objectives will be achieved through experimental research process of extrusion blowing of poly(vinyl chloride) plasticized and experimental studies of selected properties and characteristics of this material.

Experimental studies

The process of extrusion blowing of poly(vinyl chloride) modified blowing agent and metal powder was carried out on a laboratory pipe extrusion process line. The applied technological line was equipped with a single screw extruder T-32-25 with variable screw rotation speed, extruder head and standard auxiliary equipment (cooling device in the form of a cooling bath and a receiving device). The study used straight spindle extruder head for pipe extrusion, the appearance and diagram of which are shown in Fig. 1. The extrusion head used was dedicated to obtain shapes with open and closed sections, such as mainly struts and pipes. The nozzle used in research, and is characterized by an outer diameter of 19.5 mm and a channel diameter of 13.5 mm inner channel. The process used the classic screw intended for the processing of poly(vinyl chloride).

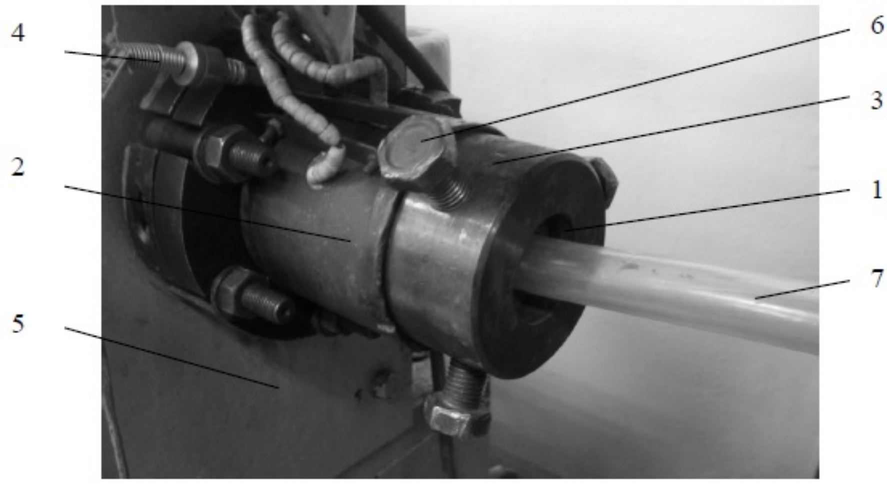


Fig. 1. View of extruder head: 1 - body of the nozzle head, 2 - heater ring, 3 - head body, 4 - temperature sensor, 5 - fragment of the extruder plasticizing unit, 6 - adjustment screws nozzle body 7 - formed pipe
Source: author's own work

Prior to the experimental process, the temperature was adjusted within a zone of the plasticizing unit and extrusion head by means of automatic control, in which the extruder is equipped with a T-32-25. The values that are matched to the temperature processed poly(vinyl chloride) and a blowing agent used based on the manufacturer the of the material and blowing agent and the results of preliminary exploratory studies. The temperature in the individual zones of the plasticizing unit was appropriate, in accordance with the program of research: 110, 120, 140 and 140°C, while the temperature in the extrusion head equalled to 160°C. Microcellular extrusion process was initiated at stabilizing the distribution of the set temperature. A process was carried out at a screw rotation of 50 rpm.

The investigation of selected mechanical properties of the obtained section was conducted using strength testing machine Zwick Roel Z010. It was assumed that the speed of stretching was 50mm/min and was constant during the experiment. The temperature was 23^{o}C, and the mean humidity 50%.

The roughness of the surface layer was examined with the use of linear method. The roughness testing was conducted using a TR200 profilometer with an in-built detector and specialised software. This is a contact device comprising a measuring head ended with probe, mapping linear profiles of tested samples. Research was executed according to standard PN-EN ISO 4287:1999.

In experimental studies the following factors was research:

- temperature distribution T1, T2, T3, T4, T5, at certain points along the plasticizing unit of the extruder and along the extrusion head, °C
- rotational speed of the screw υ, s-1
- type of coolant,
- the coolant temperature t, °C
- Dw diameter measurement samples, mm
- Dd nozzle diameter of the head, mm
- length L of sample measurement, mm
- force Fr when picking measurement samples, N
- initial area A0-sectional area of measurement samples, mm^2
- Δlr increase in the length measurement section at a breaking point measurement samples, mm
- initial length l_0 samples measuring section, mm
- arithmetic mean deviation of the profile Ra, µm
- maximum height of the profile Ry, µm

- maximum depth of the profile peak Rm, µm
- profile asymmetry Sk,
- sum of the maximum peak height Rt, µm
- average spacing of individual peaks of the profile S, mm
- maximum height of the profile above the average line of the measuring section Rp, µm
- avarage spacing of the profile spread Sm, mm

As an indirect result the following factors were considered:
- ρn normal density measurement samples, kg/m^3
- porosity SP measurement samples, %
- tensile strength σr measurement samples, MPa
- elongation at break εr measurement samples, %
- Barus effect of β, %

For those modifiers based on:
- blowing agent content in the material, %
- iron content in the material, %
- copper content in the material, %

The numerical values of variable factors are summarized below.

As permanent factors, the following were considered:
- material tested – poly(vinyl chloride) plasticized.
- way of proportioning of blowing agent,
- structural elements of the plasticizing unit, tray, extrusion head and other components of cellular extrusion process line.

The study may also present other factors such as variable: power voltage, humidity, and ambient temperature. It is estimated that the impact of changes in these factors on the results of studies is very small and can be omitted without detriment to the work. The research used plasticised PVC with trade name GFM Alfavinyl GMF/4-31-TR in the form of granules and the endothermic blowing agent Hydrocerol 730 in granulated form. The content of the blowing agent was 0%, 0.5% and 0.5% wt. PVC was also modified with powder of iron Fe and copper Cu in the amount of 0%, 1.5% and 3%. Metal powder had irregular forms, granulation in the amount of 45-60 µm and bulk density 1660 – 3200 kg/m^3.

Results

As a result of the research, an open profile was obtained (fig. 2) with a diameter of 18.20 mm and thickness of 3.42 mm, which was tested on selected physical and mechanical properties. The physical and geometric structures of the profile's surface were also analysed. Fig. 3 shows morphology of obtained extrudate containing 0.5% of blowing agent and 1.5% of Fe and Cu powder.

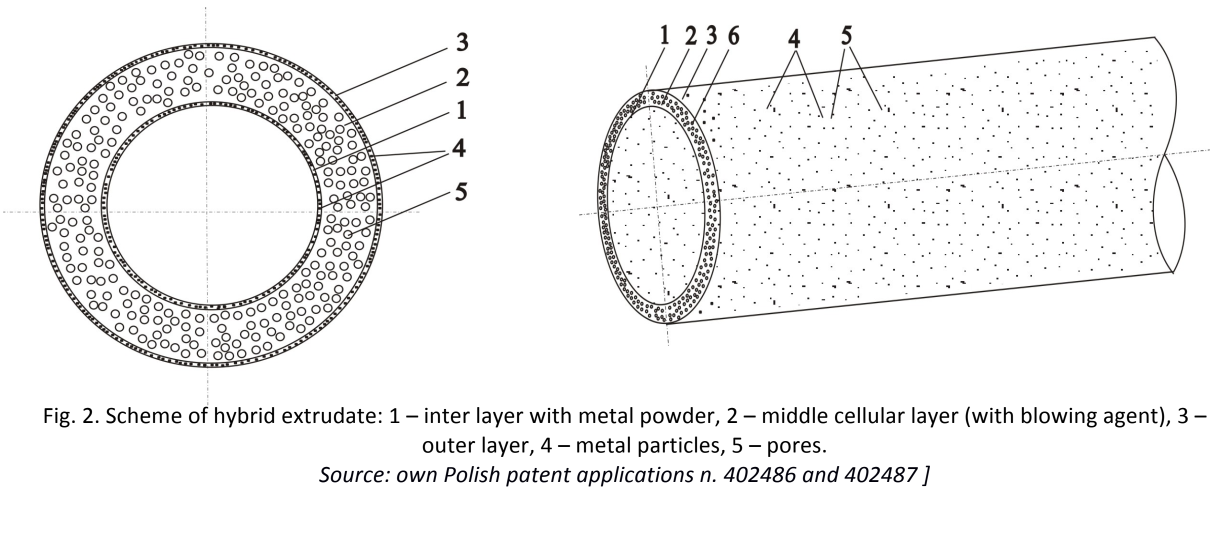
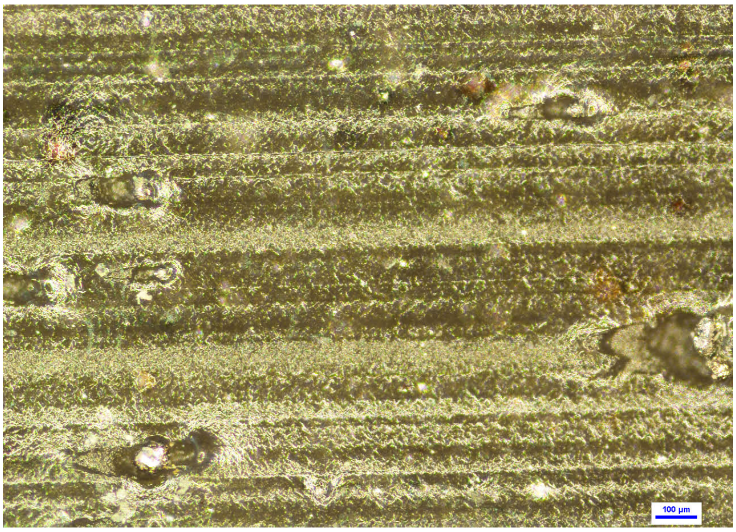


Fig. 2. Scheme of hybrid extrudate: 1 – inter layer with metal powder, 2 – middle cellular layer (with blowing agent), 3 – outer layer, 4 – metal particles, 5 – pores.

Source: own Polish patent applications n. 402486 and 402487] a)



b)

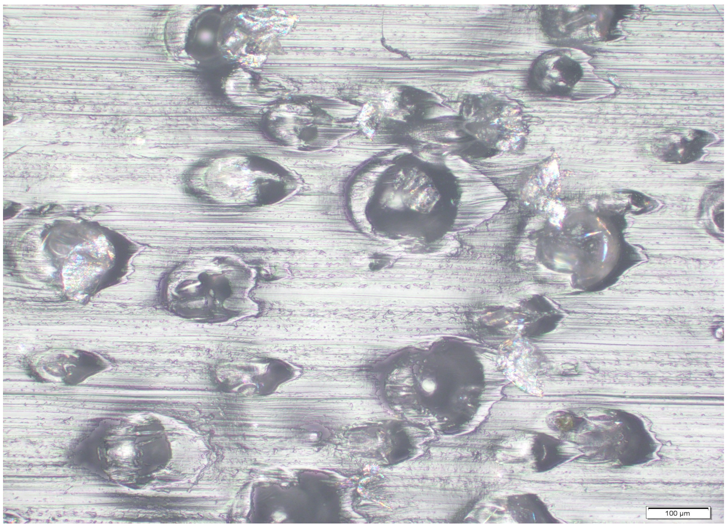
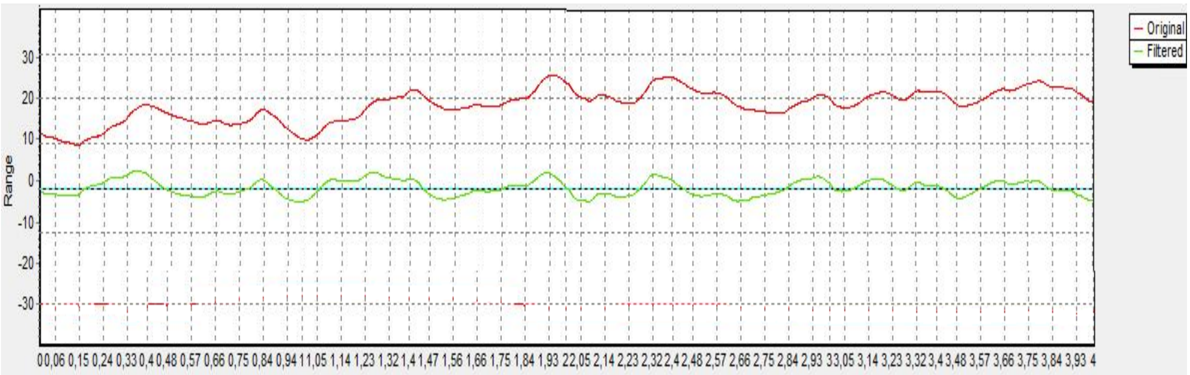


Fig. 3. View of the extrudate morphology: a) outer layer containing metal particles, b) middle cellular layer containing blowing agent
Source: author's own work

The obtained section is characterized by a uniform distribution of blowing agent in the entire cross-section of the extrudate. The created pores have different diameters, which could have been caused by uneven cooling of the extrudate during the extrusion process. The addition of fillers in the form of iron and copper powder caused a creation of a metallic glossy coating on the inner and outer surfaces of the profile.

A preliminary analysis of surface geometry revealed significant changes in surface roughness of the obtained extrudate. The conducted study of characteristics of the geometric surface included measurements of surface roughness parameters, i.e. Ra, Rm, Ry, Rp, Rt, Rq, S and Sm. The results are summarized in Table 2. The results of the tests also include profiles of the individual samples shown in Fig. 4.

a)



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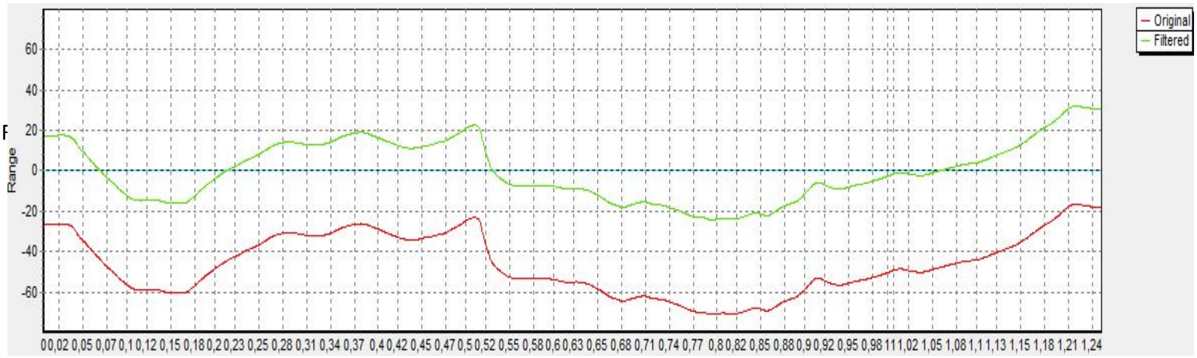

c)

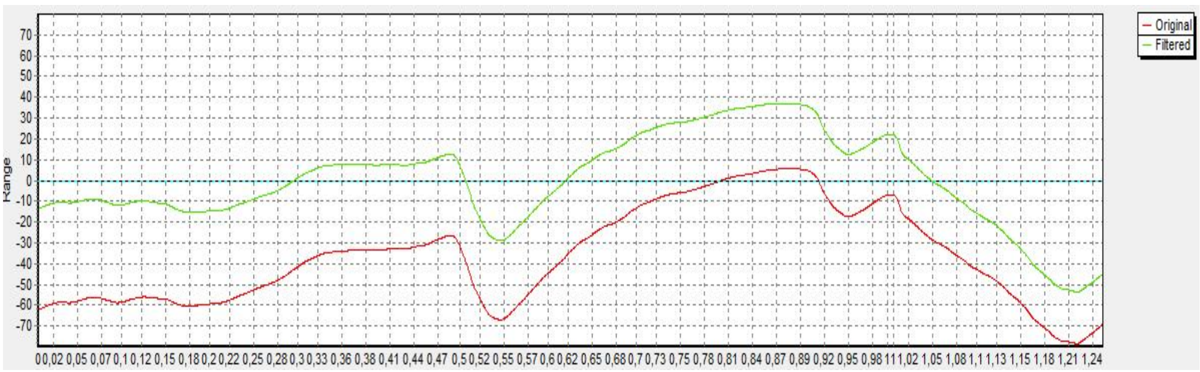

Fig. 4. Profiles of extrudate surface roughness for: a – solid sample, b – sample with 0.5% of blowing agent, c – sample with 0.8% of blowing agent

Source: author's own work

Table 2. Results of roughness measurement

Sample series	Ra [µm]	Ry [µm]	Rm [µm]	Sk	Rq [µm]	Rt	S [mm]	Rp [µm]	Sm [mm]
I	0.281	1.228	0.611	0.230	0.327	2.380	0.307	0.615	0.5714
II	13.130	32.000	15.760	0.207	15.02	57.750	0.208	19.230	0.6250
III	18.550	42.400	22.000	-0.440	20.49	93.000	0.625	20.390	0.6250

Source: Author's

The results showed a significant effect of added fillers on the geometrical structure of the surface. Comparing the roughness values presented in Table 2 the extrudates from solid PVC and the extrudates from PVC with 0.5% of additive, the increase in the roughness parameter Ra differs considerably. Also, when comparing extrudates from PVC with the addition of blowing filler, the values of surface roughness Ra increase by approx. 56%. Changing the roughness parameters is preferred for adhesive joints. Then, there is no need for additional measures to enhance the adhesion on the surface of the material.

The resulting section was tested on its physical characteristics, among others density, porosity, water absorption, and mechanical characteristics, such as tensile strength, elongation at break, tensile impact, hardness. The results of selected mechanical properties are shown in Fig. 5 – 8.

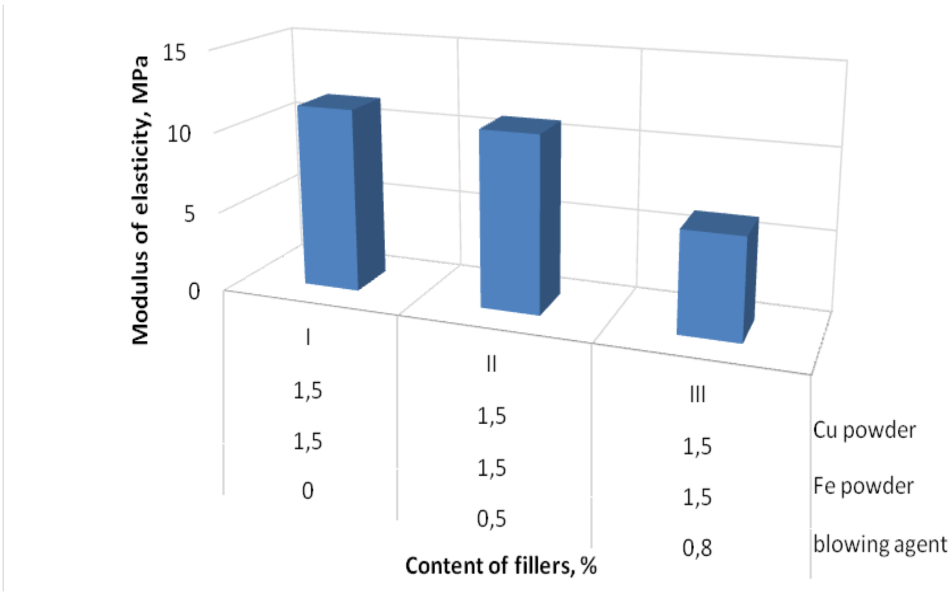

Fig. 5. Dependence of modulus of elasticity on content of fillers
Source: author's own work

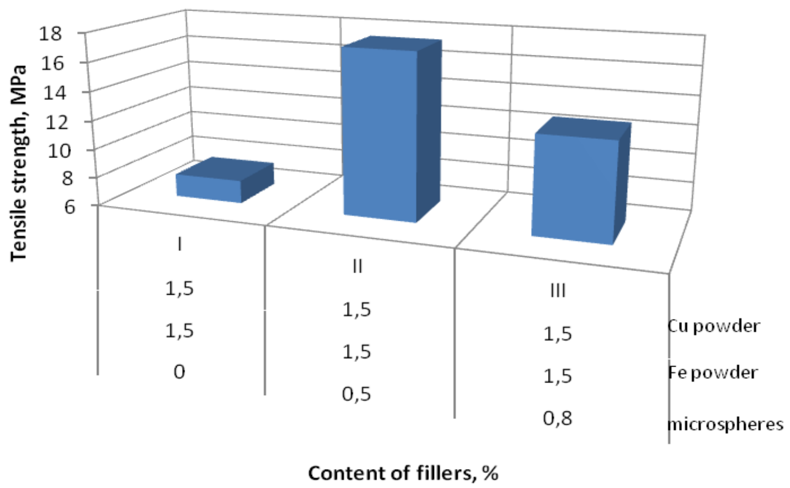

Fig. 6. Dependence of tensile strength on content of fillers
Source: author's own work

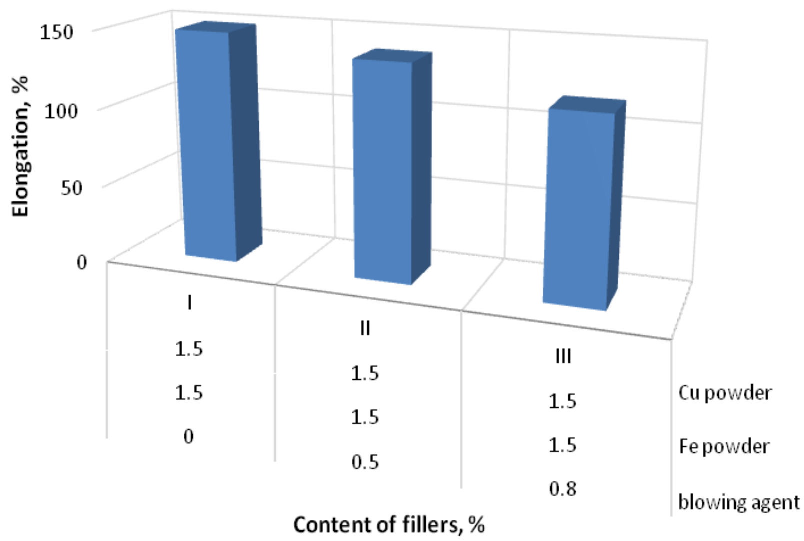

Fig. 7. Dependence of elongation on content of fillers
Source: author's own work

As a result of the modification of poly(vinyl chloride), there was also a change in tensile strength of the tested extrudate. As a result of addition of the blowing agent, strength of the porous pipes decreased by an average of 20% for dosing 0.5% and of 50% for dosing 0.8%. A greater decrease in tensile strength is observed during the addition of copper powder, slightly lower as a result of modification of iron powder. Modification with the use of the blowing agent causes a significant reduction in the mass of the extrudate, and thus increasing its porosity. As a result of modification, the greatest porosity is 25% for the content of the agent in an amount of 0.8%.

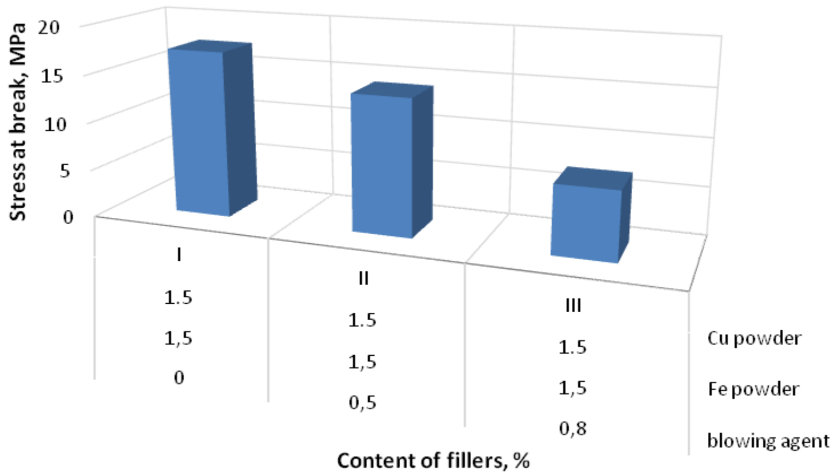

Fig. 8. Dependence of stress at break on content of fillers
Source: author's own work

Summary and conclusions

Studies have shown that the described modification with a blowing agent results in a change in a pipe structure of poly(vinyl chloride) from a solid to cellular only in the inner layer of the pipe, i.e. in its core. In contrast, the addition of filler in the form of copper and iron powders modifies the outer surface of the pipe; however, a larger sedimentation of metal powder occurs on the inner surface of the extrudate. The lowering of the mass of the section by the addition of the blowing agent significantly lowers the wear of the polymer. The resulting hybrid section has modified properties, such as density, strength, roughness, which can be used in fermenters of dairy wastewater treatment plants. Furthermore, the addition of metal powder makes the product quickly identifiable using detectors or defectoscopes. Obtained results revealed changes in selected properties of the extrudate. These changes also occurred in the composites morphology. It caused necessity of conducting studies of physical structure and electrical properties.

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COMPARISION OF BUCK-CONVERTER PARAMETERS QUALITY DEPENDING ON COIL SELECTION

Abstract
Buck-Converters belong to DC/DC converters group. One of the main problems during the design stage of DC/DC converter is the proper component selection. The aim of this article is to describe selection of the optimal inductor for the Buck-Converter, enabling to minimize the device output overvoltage, while getting possibly high device efficiency. In order to verify the quality parameters, author made an efficiency comparison of the buck converter, depending on used inductor. Conclusions from this paper allow for optimal selection of coils for the Buck-Converter depending on given criteria.

Key words
Buck-Converter, Step-down Converter, DC/DC Power Converter, Overvoltage, Coil selection

Introduction

Buck-Converter, known also as Step-down Converter, is the basic part of power section in many electronic devices. It is also called Step-down Converter. Such converters are commonly used in various types of power sections of modern electronic devices, such as notebooks or smartphones. One can find in literature two topologies of Step-down Converters: synchronous and nonsynchronous [2]. The synchronous converter has an additional switching key in parallel branch. In that case the transistors work complementary what means when one transistor is switched on, the second one is switched off and conversely. However, due to existence of gate-source capacity, it is needed to include additional dead time, necessary for proper switching control. Often, however, nonsynchronous Step-down Converters are used.

What is more, Buck-Converter is a part of buck family. In this group one can find: buck, buck-boost and buck-boost-buck Converters [1]. Buck-Converters work in continuous and discontinuous mode. Generally Buck-Converter is used to reduce the input voltage. However this converter can adjust output voltage range from zero to the input voltage value. The main impact on work of this device has proper selection of elements in particular coil, capacitor and two switches: diode and transistor. Proper selection is understood by small size and improving quality of Buck-Converter. The most important characteristics of the buck converter are input and output voltage, nominal current and switching frequency. It is also important to define the quality requirements regarding tolerance to voltage and output current ripples [3]-[5]. The designer must also pay attention to economic factors, such as obtaining a possibly small size of the converter, high efficiency and low prices.

In this article author presents research results of coil selection impact on mentioned parameters quality of Buck-Converter. This is as a development of considerations made in [6]. In the literature one can find theoretical thesis about work of Buck-Converter. In this paper author included only practical tests to check real work of Buck-Converter with different inductors (in figure 1 marked as L1) and their influence on efficiency and overvoltage.

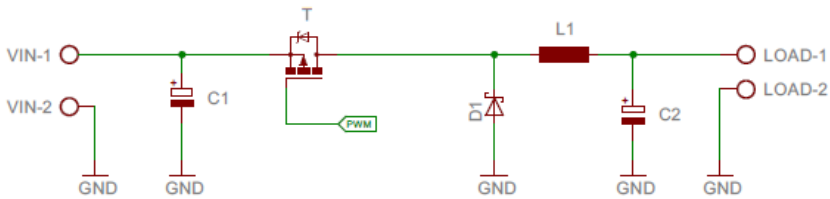

Fig.1. Step-down Converter circuit diagram. L_1 – tested coil, C_1,C_2 – capacitors, T – MOSFET transistor, D_1 – Schottky diode, Load – resistor, PWM – Pulse-Width Modulation
Source: Author's

Impact of coil selection on size and price of Buck-Converter

In this thesis author analysed work of Buck-Converter with six different inductor models: solenoid (wounded copper wire without any core) as a reference and five inductors with core. Author used few core coil types: DTP, DTMSS, SMD and two bobbin coils. All used coils have the same inductance 330 µH but different core materials, shapes and physical parameters as shown below in figure 2.

Fig. 2. Different coil types used in Buck-Converter research, from left: air coil, DTMSS coil, bigger bobbin coil, DTP coil, smaller bobbin coil and SMD coil
Source: Author's

Table 1 presents dimensions and prices of tested inductors (shown in figure 2), which affect the economic aspect. All inductors have different shapes as shown in figure 2, so occupied space in table 1 is an approximate value. The air coil was a reference inductor, which is free of the core influence.

Table 1. Coil dimensions and prices

Coil symbol	Height [mm]	Thickness [mm]	Outside diameter [mm]	Occupied space [cm^3]	Price [PLN]
Solenoid	34	8	34	9.3	7.00
DTMSS-27/0,33/2,0	27	15	27	10.9	14.00
DSz-20/330/6,3	18	20	20	5.7	4.00
DTP-17,5/0,33/2,8	21	9	21	4.0	4.20
DSz-14/330/2,2-V	15	14	14	2.3	2.50
DSMD-10/330/0,5	5.4	9	10	0.3	2.00

Source: http://www.feryster.com.pl/polski/index.php?lang=pl.

The graphs in this paper uses the following shortcuts:

- S – solenoid (without core),
- DTMSS – DTMSS-27 / 0.33 / 2.0 (DTMSS-type reactor core type RTMSS),
- DSz20 – coil DSz-20/330 / 6.3 (bigger coil of DSz type with core type RSZ),
- DTP – coil DTP-17.5 / 0.33 / 2.8 (DTP-type coil with core type RTP),
- DSz14 – coil DSz-14/330 / 2.2-V (smaller coil of DSz type with core type RSZ),
- SMD – coil DSMD-10/330 / 0.5 (inductor SMD with ferrite core Ni-Zn RSMD E6H).

The use of an appropriate ferromagnetic core increases the self-inductance of the coil, so that you can get smaller sizes coils similar electrical properties as solenoid [10]. The size of the elements is important for designing printed circuit boards for small size devices. While analysing economic factors the most optimal in terms of size and price is SMD coil. In contrast, the biggest and the most expensive is DTMSS coil. DTP coil is widely used in Buck-Converters but as one can see is neither the cheapest nor the smallest one. Another idea for achieving smaller device size is presented in [7]. This article can help to improve idea of using two inductors instead of one coil in classic Buck-Converters.

To show electrical parameters practical tests were made. Founded test scenarios were implemented using logic analyser controlling work of converter gating transistor and adjustable power supply, which was setting input voltage. With the help of measuring equipment, which included a digital oscilloscope and digital meters, author made practical measurements, in order to investigate the effect of inductor selection on the device parameters.

In this article the following shortcuts are used:
η - efficiency [%]
f – transistor switching frequency [kHz]
I – Buck-Converter input current [A]
V_{GS} – gate-source transistor voltage [V]
V_{out} – Buck-Converter output voltage [V]
V_{max} – maximum overvoltage amplitude [V]
V_{min} – minimum overvoltage amplitude [V]

Impact of coil selection on efficiency in Buck-Converter
To show the impact of coil selection on tested device efficiency, the following tests were made. Figure 3a shows the efficiency changes as a function of current for all analysed coils. Measurements were made for following current values: 0.5 A, 1 A, 1.5 A and 2 A, the frequency of 20 kHz and a duty cycle of 50%, with a load of 5 Ω. Figure 3b shows the efficiency changes as a function of frequency. The author chose load value 10 Ω, input current of 0.5 A, duty cycle of 50% and frequency measurement values at: 20 kHz, 50 kHz, 100 kHz, 200 kHz, 300 kHz and 500 kHz.

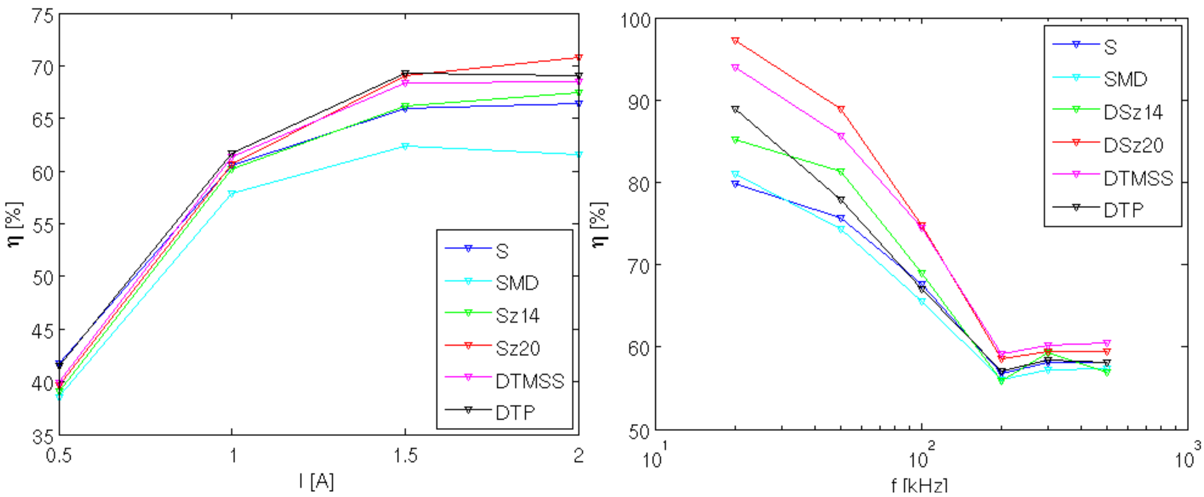

Fig.3. Efficiency changes: a) as a current function with 10 Ω load, b) as a frequency function with 5 Ω load, where η – efficiency [%]
Source: Author's

From figure 3a one can see that with the current also increases efficiency. It also can be seen that the greatest efficiency in analysed current range are bobbin coil DSz-20, DTP and DTMSS. The lowest efficiency was achieved for the SMD coil. Figure 3b reflecting the efficiency evolution as a function of frequency, confirms earlier findings that a significant difference in the coil selection is noticeable for frequencies up to about 100 kHz. As before, the highest efficiency was obtained for bobbin coil type DSz-20, and the lowest for the solenoid and the SMD coil.

The following figures illustrate the efficiency changes as a function of frequency for the resistance load of 10 Ω, input current 0.9 A and duty cycle of 75% (figure 4a) and the load resistance of 5 Ω, the input current 0.9 A and duty cycle of 75% (figure 4b). In order to maintain transparency and for analysis used three selected coils: solenoid, bobbin DSz-20 and SMD coil, which had an average, the largest and the smallest efficiency. The frequency in all graphs is shown in logarithmic scale. Measurement points at graphs form figures 4a and 4b were selected for frequency values equal 10 kHz, 20 kHz, 30 kHz, 50kHz, 75 kHz, 100 kHz, 150 kHz and 200 kHz and 500 kHz.

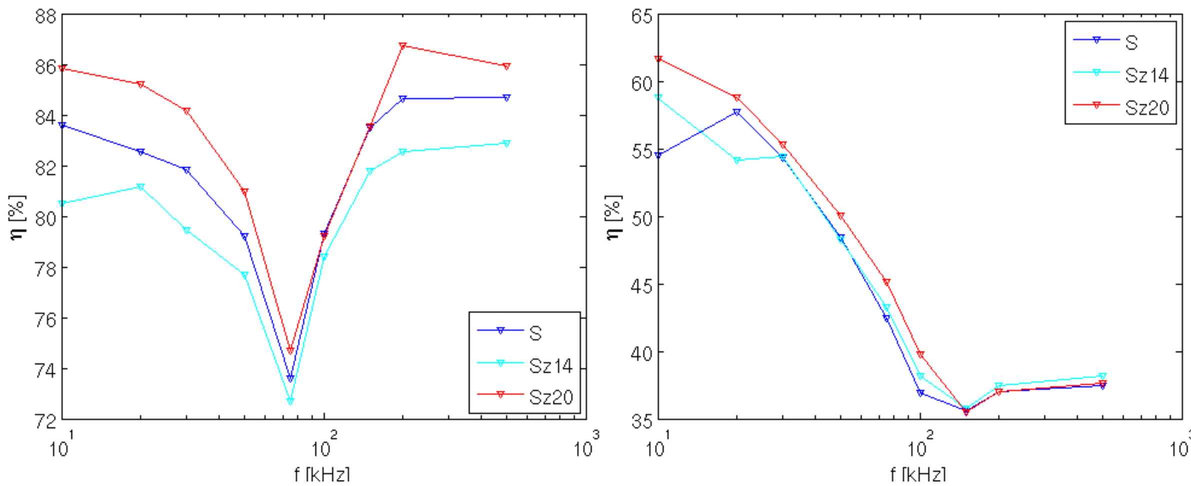

Fig.4. Efficiency changes as a frequency function with load: a) 10 Ω, b) 5 Ω, *Source: Author's*

Figures 4a and 4b show the efficiency in frequency function for the same currents and various load resistances. In Figure 4b efficiency is relatively lower comparing to the efficiency from Figure 4a, due to lower input voltage, and thus coupled with it voltage V_{GS}, which is required to achieve the same input current. In Figure 4a one can see a significant drop of efficiency for switching frequency of 75 kHz. Figure 4b shows that the minimum efficiency occurs at a frequency of 200 kHz. Change of the minimum efficiency point is dependent on both current and duty cycle. This phenomenon occurs regardless of the type of coil used in the inverter and is connected with the resonance [7].

Impact of coil selection on overvoltage in Buck-Converter

One of the most important features that define the quality of the output voltage of Step-down converter is output voltage peaks values. Overvoltage has negative impact on device work and may cause faster destruction and affect on electromagnetic compatibility. This test was designed to check the effect of coil selection on output voltage peaks depending on the frequency and current. Presented test results refer to the converter shown in Figure 1.

The first analyse was made just for solenoid which does not have core influence and can be used as the reference inductor. In figure 5a one can see output voltage changes in function of time which coming from oscilloscope measurements. Comparison was made for two current values of 0.5 A and 1 A. In figure 5b author presents output voltage signal for all tested coils in a function of time. The signals were observed for switching frequency of 20 kHz, duty cycle of 50 % and Buck-Converter input current equal 0.5 A.

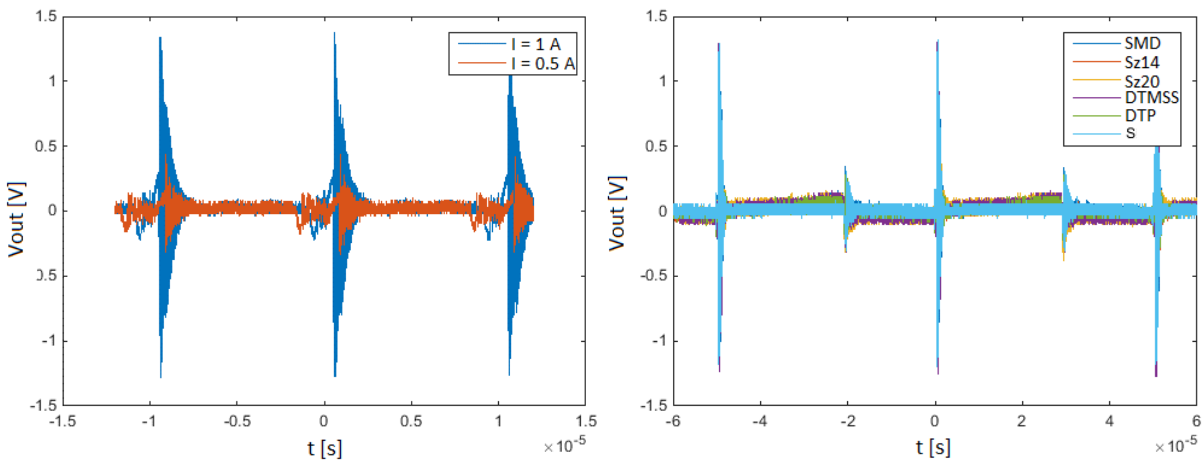

Fig. 5. Output voltage time changes a) for different current values with the usage of solenoid, b) for different coils *Source: Author's*

Analysing figure 5a one can see the dependence of voltage peaks from current value. For less current value the biggest voltage peaks appear with delay. It can be also seen that bigger current value causes elongation of transient state. Size of overvoltage will be discussed in the following paragraphs. In graph from figure 5b one can see that coil selection affects on overvoltage amplitude and the time of overvoltage occurrence. To check differences between overvoltage peaks the following analysis was made.

The below measurements were made for frequency equal 100 kHz. Graphs from figures 6 (a and b) show minimum and maximum voltage changes in function of input current for duty cycle 50%. Measurements were made for current values of 0.2 A, 0.4 A, 0.8 A, 1 A and 1.2 A.

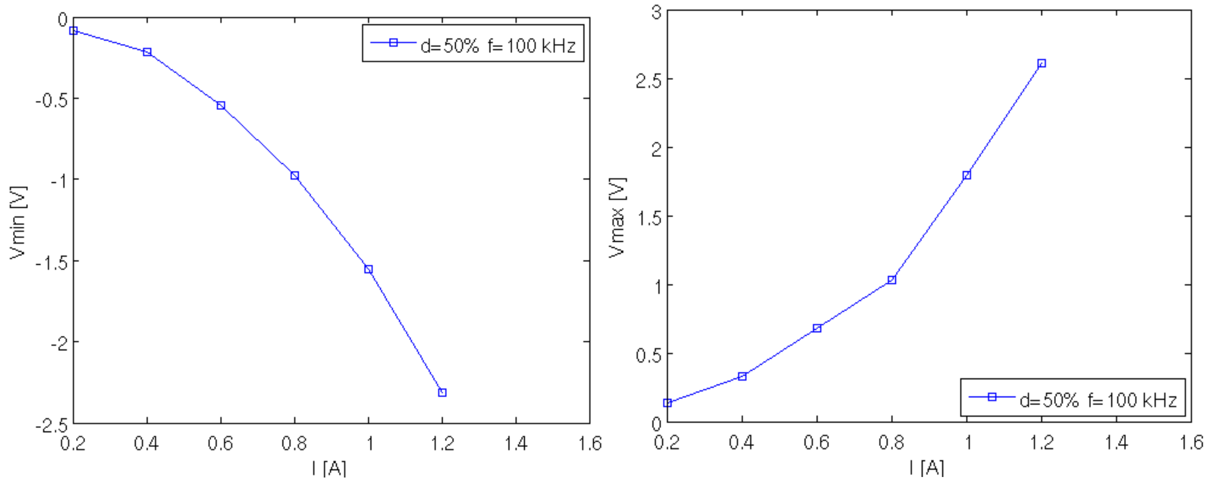

Fig. 6. Output voltage peaks for different currents with the usage of solenoid, for a) minimum voltage peaks, b) maximum voltage peaks

Source: Author's

Graphs in figures 7 (a and b) show minimum and maximum voltage changes in function of input current for duty cycle 75%. Measurements were made for current values of 0.4 A, 0.8 A and 1.2 A.

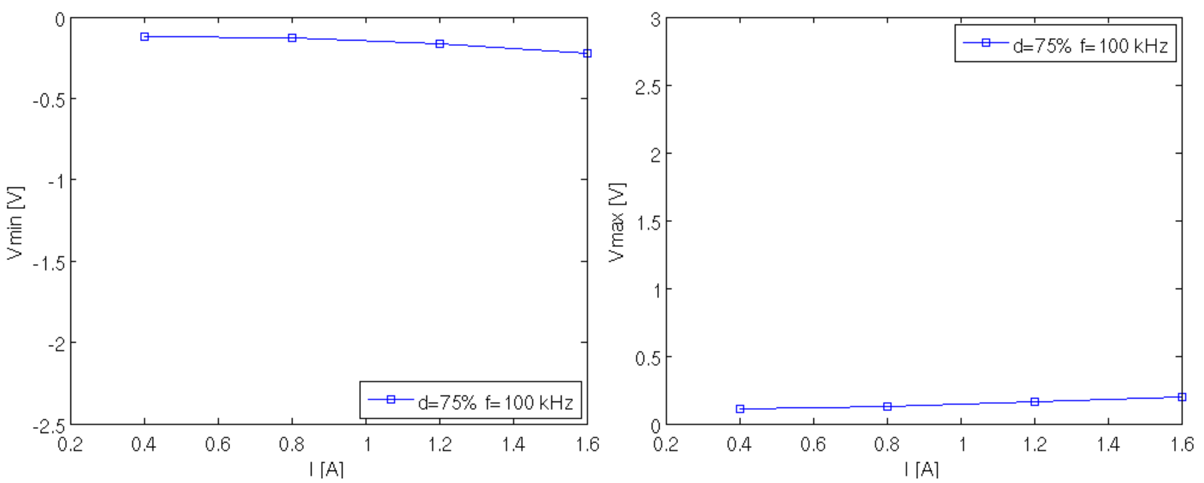

Fig. 7. Output voltage peaks for different currents with the usage of solenoid, for a) minimum voltage peaks, b) maximum voltage peaks

Source: Author's

Analysing the graphs above (in figures 6a, b and 7a, b) it can be concluded that the increase of input current, significantly floats on the value of the output voltage peaks, which is particularly visible to the duty cycle equal 50%. Moreover, the load voltage peaks increase exponentially during current changes. In the case of the duty cycle of 75% overvoltage changes are less noticeable, but the trend is the same. To compare overvoltage size, above figures have the same range of y-axis.

Figures 8a and 8b shows the output voltage amplitude changes as a function of frequency. Due to the asymmetry of voltage peaks, the author made a distinction between positive and negative peaks. Measurement points were selected for frequency values equal 20 kHz, 50kHz, 100 kHz and 200 kHz.

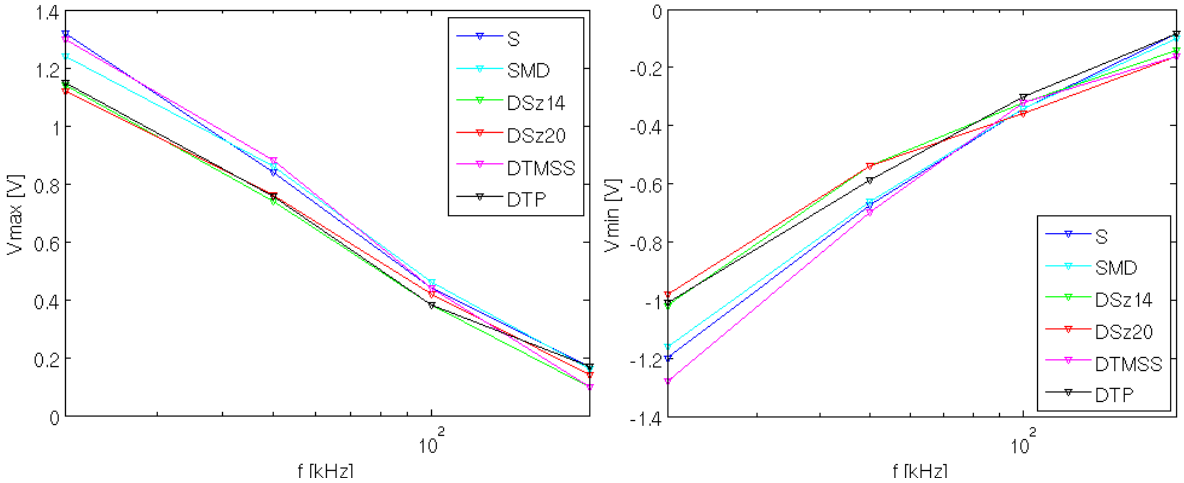

Fig.8. Peak values changes: a) maximum, b) minimum, as a function of frequency for input current of 0.5 A, *Source: Author's*

According to theoretical considerations from [5], [11] - [13], for the lower frequencies are voltage peaks have bigger values. In the case of a positive voltage peaks the author measured values from about 1.1 to 1.35 V, while in the case of a negative peak, recorded values from -1 to -1.3 Volts. For the lower frequency the smallest overvoltage occurred for the bobbin coil type DSz-20 while the biggest overvoltage appeared for solenoid and DTMSS coil.

Figure 9a and 9b show the output voltage peaks for current equal 1 A and duty cycle of 50%. For this case to maintain the parameters of voltage and current, the measurements were made only for two frequency values: 50 kHz and 100 kHz.

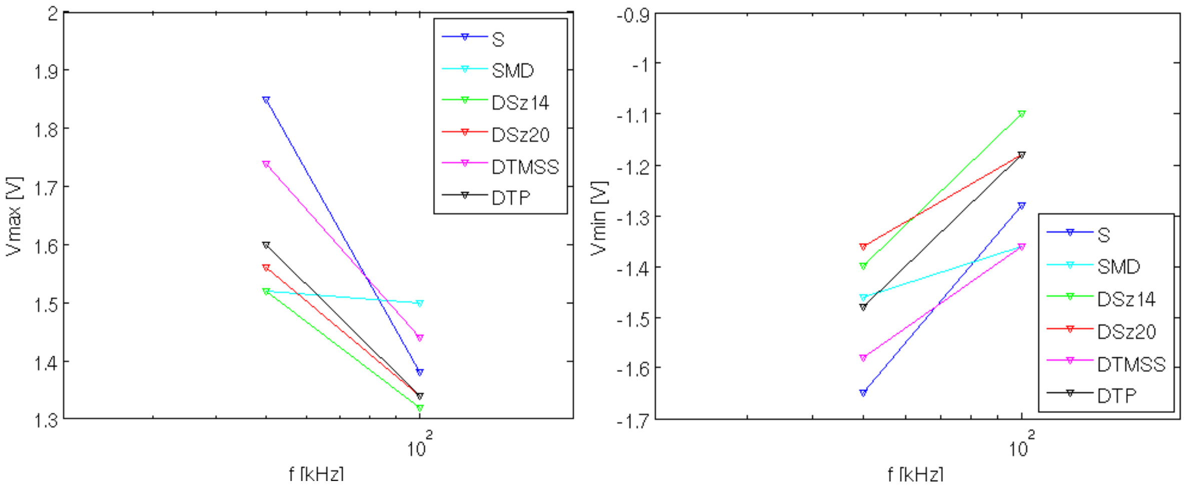

Fig.9. Peak values changes: a) maximum, b) minimum, as a function of frequency for input current of 1 A
Source: Author's

Analyzing the figures 9a and 9b one can see that both positive and negative overvoltage the worst results were obtained for the solenoid, while the best results for bobbin coils: DSz-14 and DSz-20. Despite the limited number of measurement results, this study gives important information, because it allows observing the scale of overvoltage growth during current increase. In this study, appropriate coil selection affects on the device quality in terms of overvoltage for lower frequencies. With increasing frequency, these differences become less visible.

Summary and conclusions

The article presents studies results of using different inductor types impact on Buck-Converter parameters. All presented results come from real tests. Author obtained the influence of coil selection on output voltage characteristics and efficiency changes, depending on frequency and current. This paper also shows how the proper coil selection helps to reduce appearing overvoltage on the output of the Buck-Converter.

It is hard to indicate just one coil that gives the best results. The first important problem is to reduce size of power supply section. Clients usually want to have possibly cheap and small devices. Designers try to make devices with high efficiency and limited overvoltage. To minimize converter size and reduce price, author recommend using SMD coil. This coil is noticeably cheaper than other coils and takes the smallest surface. In the other hand the best result, in the case of overvoltage, we can get using bigger bobbin coil (DSz-20). This bobbin coil also allows achieving the biggest efficiency and has medium size. Presented tests can be used during projecting Step-down Converters.

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CLUSTER FORMAT FOR ARRANGING AND IMPLEMENTING INDUSTRIAL POLICY

Abstract
The article investigates cluster approach to arrange economic policy in world countries. Cluster implication is discussed as a formation with its specifics and main characteristics. Cluster policy contents, essence, goals, types and differences are reviewed. Practical implementation of cluster policy in leading European countries is researched; problems and achieved results are determined. The problem of identifying and building up cluster formations is debated. Challenges and prospects for creating territorial clusters are determined together with cluster policy implementation in Ukraine as well as public and regional policy in supporting clusters' development is reviewed. The article proves that public authority bodies' activities in the sphere of cluster model implementation for Ukrainian industry development should be directed on activating the government role in cluster formation on the basis of public-private partnership as well as on creating favorable macro-economic, information and legal-regulatory environment to develop cluster-type business networks.

Key words
industrial policy, economic policy, cluster, cluster policy, cluster approach.

Introduction

In the course of its development each country forms up and implements specific economic policy. Industrial policy is its inseparable component directed either on supporting some specific industry branches or on developing potentially competitive regions.

The processes of globalization and international competitiveness strengthening that characterize world economy, are an objective precondition to change competitiveness management paradigm, which means renunciation of traditional industrial policy and transfer to the new system of production arrangement based on utilization of cooperation and profiling advantages together with supporting different cluster formations.

Implementation of cluster industrial policy has a number of advantages –potentials of separate regions and territories are utilized much more efficiently; dialog "business – public authorities" intensifies; regional economy gets diversified; the number of tax-payers together with tax base increase; budget dependence on separate monopolistic business formations decreases [1].

Therefore, in modern conditions the issue of determining directions, priorities and formation mechanisms as well as industrial cluster policy build-up and implementation is actually topical.

Review of the modern theory and practice

Wider interpretation of the "cluster" concept is in treating it as a network of enterprises and organizations with interconnected and supplementary economy branches, which are concentrated on some specific territory (country, region) and have the goal of obtaining synergy effect together with competitiveness enhancement and competition-cooperation interaction [2].

In general, there are three cluster definitions, each of which strengthens the main feature of their functioning:

- Regionally limited forms of economic activity inside affined sectors usually connected with certain scientific establishments;
- Vertical production elements, narrowly determined sectors, where adjoining production process stag-

es create cluster nucleus (a chain: supplier – producer – seller – client). Networks that are formed around parent companies also belong to that category;
- Industrial branches identified on a high aggregation level (e.g., chemical cluster) or assemblages of sectors on a still higher aggregation level (e.g., agro-industrial cluster) [3].

Among the major preconditions for cluster formation we may differentiate the following ones: possibility to involve companies into cooperation located on a regional territory; cost saving capacity at the expense of scale production; low operational costs; ability to have full access to information; accessibility to specific natural resources; provision of special workforce; proximity to consumer markets; ability of several regional companies to work for one customer (branch).

As of today experts determine 7 main characteristics of a cluster, the combination of which dictates the selection of a cluster strategy:
- Geographical: build-up of spacious clusters of economic performance to include local ones (e.g., gardening in the Netherlands) and really global ones (aerospace cluster EADS in Europe);
- Horizontal: several branches/sectors could constitute a bigger cluster;
- Vertical: clusters may have complementary production process stages; it's important nevertheless, who exactly of the network participants is an initiator and end performer of innovations in a cluster framework, being at the beginning or at the end of the chain to create and promote an innovative product;
- Lateral: different sectors unite into a cluster, and they may ensure saving at the expense of scale effect, which entails new combinations' formation;
- Technological: assemblage of branches that use the same technology (e.g., biotechnological cluster);
- Focus: companies' cluster is concentrated around a single centre – enterprise, research institute or educational establishment;
- Qualitative: the important thing is not only whether the companies cooperate, but also how they do it [3; 4].

Specific feature of cluster approach to territorial development lies in comprehensiveness and systematicity of tasks assigning and synergy effects strengthening due to utilization of different tooling. Clusters development helps ensure optimization of companies' placement in value creation production chain to guarantee enhancement of raw materials reprocessing level, import substitution and growth of its production components localization as well as increase of goods' and services' non-price competitiveness level and public-private partnership intensification [5]. In this sense cluster policy implementation in the country appears to be a promising and powerful tool to promote scientific research and innovation creating a ground to enhance competitiveness, economic growth, industrial output productivity and the population quality of living level. Government cluster policy positively impacts scientific-innovation potential, investment climate, ensures creation of favourable and dynamic business environment that provides for considerable competitiveness increase of cluster participants and the territory in general. Research of clusterization numerous processes performed in more than 25 countries has vividly testified that their increase of their competitiveness largely depends on specific clusters' strong positions, which are the moving force for competitiveness enhancement [6].

As of today, a number of European countries have selected cluster approach in arranging their economic policy. For example, Denmark has been implementing the program to form up and develop clusters on the national level. Danish scientists have developed high-tech production capacities and technologies in agricultural and industrial sectors. Regional clusters include both traditional industrial branches – textile, furniture, etc., and innovative ones – mobile and satellite communication.

Great Britain actively uses cluster strategy and implements balanced competitive policy. The most efficient clusters are located in London and South-eastern part of the country. Their differentiating feature is intensive interconnection of industrial companies, business centres and scientific laboratories. Clusters in the northern regions have been formed around processing industry. The southern region clusters are mainly focused on providing services (business-services, software production).

The level of Portugal key clusters, like foot-wear and wine production, has considerably increased due to the government strategy of production development to transform some export branches of Portuguese economy into full-scale clusters, which has stimulated cooperation between companies and provided for technological infrastructure formation [7].

Swedish competitiveness growth in the area of pulp and paper production is connected with both scientific-intensive equipment, necessary for paper production, and associated consumers – producers of conveyor lines, production packaging, etc. German specialists use innovative technologies in automobile production business. Italy uses cluster policy elements in the sphere of metal processing, skins and footwear production, wood processing and furniture production, fashion and design. Chinese experience is rather attractive in this regard, when competitive clusters in textile industry have been formed on the basis of scaly investments, and the products of those clusters totally go for export. Similar clusters act also in the sphere of sports goods production, tableware and toys manufacturing as well as in other economy branches [8].

In general sense, the majority of authors [3; 9; 10; 11; 12; 13] interpret cluster policy as joint activities of all levels of public authorities and municipalities, directed to support economy clusterization processes targeted to enhance competitiveness of the territorial system. Cluster policy is regarded as an alternative to traditional "industrial policy" that impedes competition, or as a new form of traditional policies integration, connected with business and regional development (industrial and cluster policies are regarded as policies-substitutes and policies-complements).

In this context, enterprises' and separate industrial branches' competitiveness and innovation potential enhancement, SME development and support to national economy diversification through regional sectoral clusters stimulation and development are the aims of cluster policy [9].

Also many authors treat cluster policy as an element of industrial policy [14]. It unites industrial and regional policies, small business policy, investment and innovation policies, human resources and social policies. In other words, if industrial policy is targeted on creating and developing prioritized branches, cluster policy deals with prioritized economic agglomerations capable to open up the territorial potential in the conditions of already formed economic structure.

To our estimation the main differentiating feature of cluster policy lies in the fact that it is not a supplementary tool for state governance and regulation, but a new approach to using the available tooling. The novice feature of such approach is in the fact that industrial policy content is transformed: measures of government support are oriented not on the assistance to separate enterprises and branches, but on the development of mutual interactions between territorial subjects of economic performance.

Cluster approach is capable to drastically change the contents of state industrial policy. In such a case government industrial policy should be directed not on supporting separate enterprises and branches, but on the development of mutual relations between suppliers and consumers, end consumers and producers. At the initial stage cluster policy main objective is infrastructure improvement and eradication of unfavourable organizational conditions, after which it should be focused on eliminating restrictions for innovative development. It's obvious that such approach changes the principles of state policy. It requires transforming state control system, changing the authorities' mentality, replacing information support system with new models to analyse economy condition not on the branch-wise basis, but on the level of separate markets and enterprises [12].

Two general types of cluster policies could be differentiated: administrative one and democratic one [3]. Administrative policy follows the following rules:

- Government forms up priorities (industry-specific and regional priorities are determined as well as the clusters that have development potential);
- It also forms up goal-oriented infrastructure for prioritized clusters (management bodies, universities' affiliates, scientific-research institutes, airports, roads, etc.);
- Government independently determines the regions for clusters formation and the financing volumes.

Democratic policy has different rules:

- Central government "grows" clusters, which firstly are formed by market;
- Central government participates in creating cluster infrastructures very rarely;
- Central government creates stimuli for regional authorities, which are fully responsible for clusters formation (it finances projects, provides special grants to separate regions to develop clusters, including also depressed regions).

Research [15] in the field of cluster policy implementation in European countries has demonstrated that interventions into developing areas are much more risky than working with the already functioning clusters. Therefore, cluster programs developers should clearly understand that programs for developing clusters should be different from the programs for already developed clusters.

Transnational Alliance of Clusters Towards Improved Co-operation Support (TACTICS) [13], which is coordinated by French national organization for SME support, unites seven leading national and regional European organizations of innovation and cluster policies, the activities of which are directed to develop more efficient cluster policy strategies as well as develop practical tooling of their implementation in Europe. The Alliance specialists researched evolution of the implemented cluster policy in 17 European countries on the basis of analysing 13 national programs and 15 regional programs (Fig. 1).

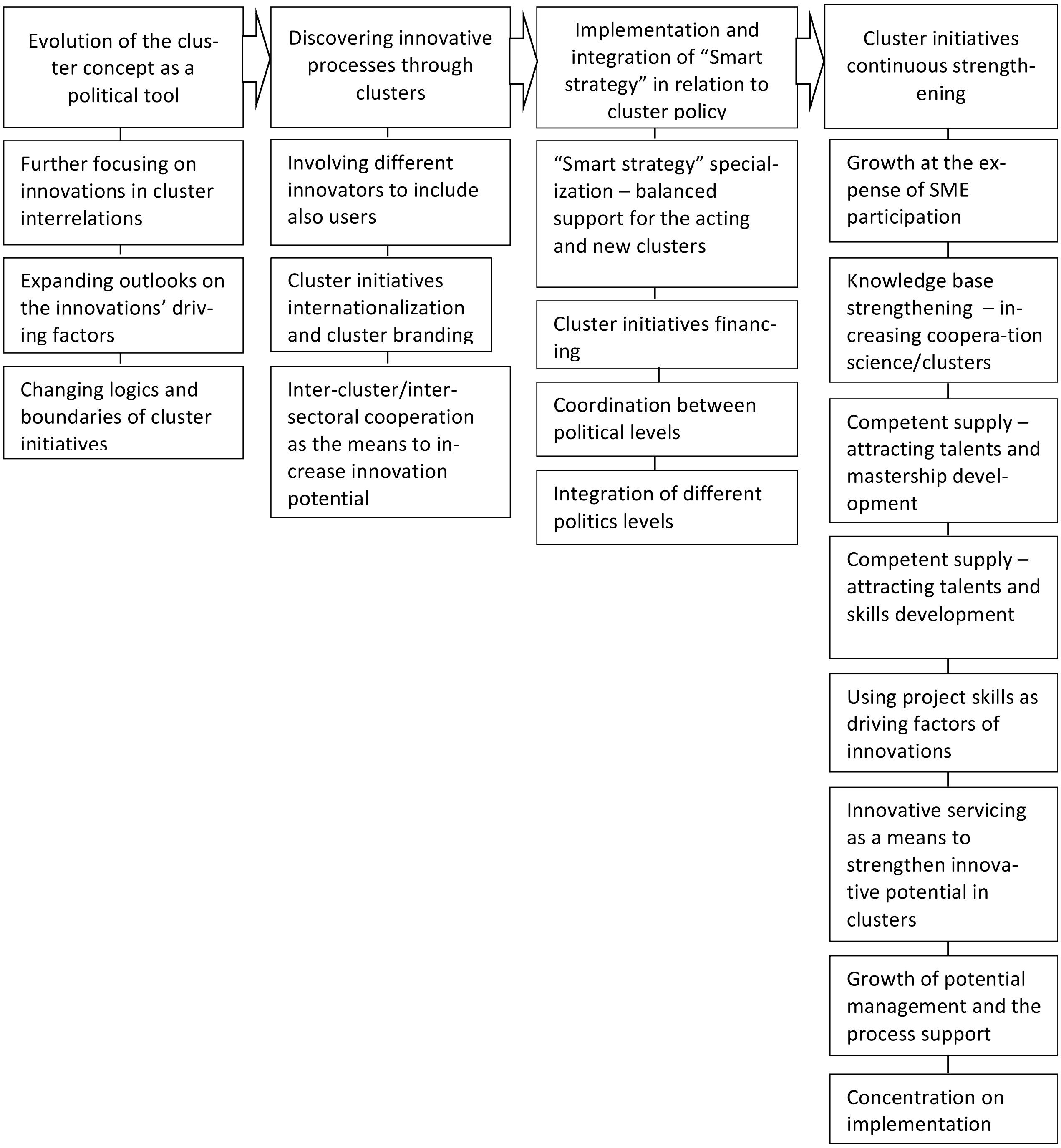

Fig. 1. Trend of the cluster concept evolution as a political tool

In 2010 the Commission of the European Communities decided to finance cluster programs for regional development within the framework of structural funds program basing on “smart strategies” of regions' specialization [16].

One more research [17] carried out on the basis of reviewing the implemented cluster policy in 31 European countries determines some of their common characteristics. Firstly, cluster policy plays a less important role for the countries with federal form of government (Belgium and Switzerland). Secondly, the level of autonomy at the regional level also plays a very important role (Denmark, Italy). Research of the national cluster policy implementation level in those countries testified:
1. All the countries have cluster policy programs at the national and/or regional levels. At the same time, cluster policy is still at the early development stage in many countries. Nearly half of the researched countries started to implement cluster policy after 1999.
2. There are big differences between countries when dealing with the issue of how many and which exactly national ministries are responsible for cluster policy implementation.
3. Understanding of the cluster policy importance is different in world countries. 30% of the researched countries regard cluster policy to be important, 40% consider it to be of medium importance and 30% - of low importance. The last group is dominated by countries with federal form of government or with very autonomous regions.
4. With some exceptions, clusters have not yet been playing important role in national policies directed on innovations and high technologies implementation, regional economic growth and SME development. Clusters play a very important role in the sphere of science and education.
5. Two thirds of the countries published their political documents at the national level, where cluster approach is a component of the innovation policy. Cluster policy is becoming more and more important in course of time [17].

Other all-European benchmarking research [18], where 33 cluster programs from 23 countries were compared in 2011 – 2012, indicated that:
1. Different types of cluster programs serve different goals. Cluster programs in general are focused on one of three main goals: regional economic development; national industry development; commercial exploitation of a national scientific-innovative potential.
Moreover, there are programs which provide for industry development at the expense of scientific-innovative networks, which very often have national and regional scales. At the same time, networks created with the help of this type of programs in many cases are very closely connected with clusters.
2. The majority of cluster programs are still under development. The majority of such programs in Europe have high priority at the nationwide or regional levels though many of them have been under development for more than 10 years. Moreover, the majority of them have been built-in into the nation-wide strategies or implemented on the basis of their budgets.
3. Coordination of cluster programs financing with other programs indicates that they are not sufficiently adjusted. High priority of cluster programs does not mandatory mean good coordination with other financed programs. Cluster programs are much better coordinated with the national R&D programs than with the infrastructure development policy.
4. Internationalization is often a key topic for cluster policy. Clusters internationalization is an important task for many cluster policy programs, but at the same time there is often a big gap between political rhetoric and intensity of measures, actions or finances really available to support clusters and their actors entering the international level.
5. Programs' customers started to play a more active role in developing separate clusters. A paradigm of developing and supporting within the framework of cluster programs has changed. Individual professional support for cluster organizations through specialized services has become more important and also become a key element in many cluster programs. Cluster programs management occurs in direct interconnection between customers, developers and managers, which was not noticed in the past.
6. Mastership in cluster programs management has become more important. Perfection in cluster programs management is considered to be one of the key success factors; therefore, the majority of the programs today are developed on the basis of the cutting edge experience, but not on the concept of the “number of clusters”. Cluster programs support today is not a simple cluster buildup, but creating clusters that have strong national/regional roots and are competitive on the international level.
7. Cluster programs efficiency evaluation has become considerably important. But as before, this sphere is rather problematic. Many program developers consider that development and efficiency evaluation in the

course of the program implementation are more valuable, as they provide the corresponding information, which could be used in "real time" to improve the program, in contrast to the program "post-evaluation". However, well-balanced approaches to the evaluations that satisfy such a need are lacking, though a certain progress has been recently noticed.
8. Cluster policies have started to play a more serious role after EU expanding. EU member-countries that joined it after 2003 are more focused on implementing cluster programs than the old member-countries.
9. Creation of European Regional Development Fund (ERDF) entailed strengthening of interrelations between innovation and cluster programs. Coordination of cluster programs with national development programs is better for the programs that started to function after 2007. Those new programs often gain momentum in the context of ERDF, where cluster support is one of the main goals in promoting regional competitiveness and employment enhancement [18].

The problem of identifying such formations is one of the key issues of cluster approach. According to the available experience the present methodological approaches to identify clusters considerably differs. However, the majority of them rest on two conceptual frameworks. According to the first one, which conditionally could be named "bottom-up", clusters are identified on the specifically selected territory on the basis of the availability of the enterprises and industrial branches-leaders, around which a network of interconnected enterprises is built up. The second approach uses the methods, which could conditionally be named "top-down", where spacious localization of production capacities oriented on specific types of economic performance is researched [19].

"Top-down" approach traditionally could be subdivided into two types with regard to two unchangeable clusters' characteristics - functional interconnection and geographic proximity:
1. Functional one, oriented on identifying industrial clusters.
2. Spacious one, oriented on identifying geographic clusters.

As of today it has been generally noted that the best results of cluster identification "top-down" are achieved with the help of combining industrial and spacious approaches. Such synthetic approaches include also M. Porter's approach [20], which has become classic and is one of the most widely spread.

M. Porter's method to identify clusters, used by the Institute for Strategy and Competitiveness to compare Canadian and US regions, is based on the following cluster characteristics:
1) Specialization (by employment indicators) in a specific sector, the development of which in different regions is not uniform; therefore, it could be regarded as a competitive advantage;
2) Joint location between other specialized (affined) types of economic performance, "the affinity" of which is determined on the basis of the relations "buyer-seller", or on the basis of technological similarity;
3) Cluster scale of critical mass, which is determined as absolute employment;
4) Specialization (by employment indicator), calculated in relation to nation-wide employment;
5) Scale or cluster industrial branch width, determined as local specialization in the majority of separate branches that include the cluster.

European Cluster Observatory methodology is but an adaptation of M. Porter's methodology [21], where three main indicators are differentiated to identify and assess potential clusters: Size, Specialization and Focus. "Size" is determined as a part of the regionally employed people within the cluster group of totally employed nationwide. Meaningfulness by the indicator "size" has sense if the region falls within 10% of the regions - eaders by this indicator. "Specialization" is evaluated by the localization factor, which is considered to be meaningful in case it exceeds "1". "Focus" is determined on the basis of the cluster part in totally employed in the region. It is considered meaningful if it falls within 10% of the same type of clusters which demonstrate the biggest employment rate within the given region total employment figure. Regional cluster receives a "star" if it corresponds to the criteria of "meaningfulness" by each indicator.

The methods "costs – output" are also widely used in the practice of cluster structures identification. The work [22] researches the methods that use tables "costs – output" to identify the so-called techno-economic "megaclusters" in Belgian and Swiss economies. Specific feature of this research lies in the fact that when conducting a final stage in combining branches that are cluster components, the authors used two alternative approaches. The first one was used when analysing Swiss economy and was meant to delineate clusters boundaries on the basis of exclusively quantitative indicators obtained with the help of "costs – output" tables review. The second approach was used to the tables “costs – output” that characterize Belgian economy, and accounted not only statistical indicators, but also subjective scientific assertions concerning “functional dependence” of branches after their unification into clusters.

The work [2] suggests identifying regional cluster structures in two stages. At the first stage, “points” of the regional economic growth are determined together with the dominating product types within them. By “points” of regional economic growth we mean the level of production capacities localization, characterized by sectoral *i*-product manufacturing localization indicators on the territory of *j*-region and to be exported *i*-product manufacturing localization indicators on the territory of *j*-region. If the values of calculated indicators are sufficiently high, the production is assessed as the “point” of economic growth in the region. The products are considered dominating if they have the highest values of calculated localization indicators of their production output in the region as well as positive growth dynamics in general, including also the exported products.

At the second stage the structural build-up and interrelations within the cluster group are determined. The composition of the “nucleus” is determined – leading regional companies (among which a focal enterprise is identified), as well as supplementary, complementary and servicing cluster enterprises and organizations. Cluster structure focal enterprise is determined by the branch dominating products manufacturing indicators. Simultaneously the level of the company market adaptability is assessed by the indicator of focal enterprise products specific weight on the external market in comparison with other producers of analogous goods.

Also scientific literature contains methods to identify clusters on the basis of experts polling, but generally they are but complementary to quantitative methods.

Recently Cambridge university specialists headed by M. Porter [23] have developed a new clusterization algorithm, which is a combination of previous world developments. The algorithm has been implemented on the basis of US industry data of 2009, and it includes determination of inter-branch relations of joint location. It also accounts input-output relations and similarity of the employment type. It is designed to determine mutually exclusive clusters, when each type of economic activity is uniquely categorized into one cluster. The method also provides for measuring bondage between any couple of (mutually exclusive) clusters and also for determining overlapping clusters. In this algorithm each cluster configuration is created with the help of clusterization function, which uses specific inter-sectoral similarity matrix and determined parameters as input data. Clusterization algorithm provides results that are determined by the quality of each configuration. It also helps refer “anomaly candidates” to the cluster, with which they have the most effective interconnections [23]. Practical implementation of the clusterization algorithm by this method has been performed when researching a group of 778 trading activities in the sphere of services and production.

Therefore, cluster approach to organizing economic policy has received a wide application in world countries. Presently, Ukraine faces the urgent need to form up and implement efficient cluster policy. Despite the fact that as of today Ukraine has no single methodology to form up cluster industrial policy, in short perspective, basing on the world developed countries experience, creation of territorial clusters in Ukraine appears to be inevitable. Therefore, the state and regional authorities face a rampant task to develop comprehensive strategy of cluster industrial policy basing on world developed countries experience with regard to the national specifics.

Review of the process of the national industrial policy implementation in the country helps differentiate inside that process three main sub-processes: review of the goals to manage development of the national economy, and opportunities of their implementation as well as resources provision; determining strategy and mechanisms of the industrial policy implementation with the aim of reaching the set goals; developing comprehensively balanced measures of industrial policy necessary to implement that strategy as well as identifying prioritized directions of targeted provision of the corresponding resources necessary for its implementation [24].

As the report [25] specifies, the task of Ukrainian industrial policy must be to implement structural-technologic upgrading of the industrial system and to transfer to higher technological paradigm. Industrial policy should become a tangible tool of economic reforms and a mechanism to ensure post-crisis renovation on the qualitative basis, increas potential of industrial production as a foundation for economic growth in long-term perspective.

Innovation policy should be the main direction of industrial policy. It should be able to form up technological nucleus for developing production cluster model together with public-private partnership and for implementing prioritized development projects. Ukraine has a very serious clusterization potential, i.e., sustainable functioning within the system of interrelated through clusters branches, including machine-engineering, instrument engineering, chemical industry, light industry, bio- and nano-technologies; creating new materials and information technologies; developing agro-industrial complex and processing industry as well as other potential [10].

As of today Ukraine has a specific feature of its clusters development which is orientation of the majority of prospective clusters on traditional industrial branches – light industry, civil engineering, agro-industrial complex, metallurgy, while European countries have their priorities in high-tech innovative clusters in the spheres of machine-engineering, bio-pharmaceutics, electronics, etc.

Following the sources research [9; 24; 25; 26; 27; 28; 29; 30], pro-active position of central authorities and local governments is a mandatory precondition for successful implementation of development cluster model in Ukraine. Regardless of the existence of different methods and directions of state and regional policy of clusters support, the main methods and directions are the following:

- adopting regulatory-legal basis of clusters functioning to provide for development of efficient cooperation to support economy competitiveness; increase confidence level between participants of business-networks; activate the government role in clusters formation and in developing public-private partnership; create and appoint organizations responsible for government cluster policy implementation;
- conducting large-scale research of markets and their development prospects; studying specific features of scientific-technical and production potential of the regions;
- creating favorable macro- and micro-economic conditions to support competitive environment, i.e., on the national and business subjects levels there should be created specific conditions when investments, innovations, upgrading and just distribution of the gained profit are guaranteed;
- the necessity of the state leading role in implementing cluster industrial policy is stipulated by the fact that in contrast to other economically developed countries Ukraine has no structures capable to replace the government in decision taking of such scale;
- internationalization of cluster initiatives, that would provide for Ukrainian positive image creation among world partners and accelerate Ukrainian economy integration into international economic community;
- providing clusters openness to external environment; supporting the increase of clusters participants' number and creating closed production chains that would ensure enterprises' deeper specialization together with the manufactured products quality increase;
- ensuring efficient support for projects that are directed to enhance competitiveness of cluster participants (by the following directions: support for SME development; for implementing specific policies in innovation and technological upgrading, in education development, in investments attracting, in export development, in transport and energy infrastructure development, etc.);
- creating efficient methodological, information-consulting and educational support for cluster industrial policy implementation on the regional and sectoral levels; ensuring coordination of executive bodies' activities on the level of state, regions, local governments and entrepreneurs' alliances to implement cluster industrial policy as well as to attract NGOs to cooperate in that direction;
- developing and adopting conceptual model of cluster industrial policy development on the government level, where motives, goals, tasks and directions for cluster policy development should be indicated;
- including cluster support program into regional programs of socio-economic and innovative development; integrating cluster approach into state policy for different economic branches and sectors development, which are implemented by the corresponding ministries and establishments;
- developing scientifically grounded criteria system to measure current & end results of cluster performance; establishing indicators for checking implementation of planned activities both on the level of separate clusters and on the level of programs in general;
- supporting development of innovation infrastructure: innovation centers that are to conduct research and which are demanded by industrial enterprises; business incubators; techno-polices and, industrial parks, that combine science and business;

- implementing a system of mechanisms directed to enhance cluster participants' competitiveness (support program designing for long-term partnership research; cooperation of enterprises when financing and implementing R&D; support attraction and streamlining of venture capital; subsidize a part of enterprises costs on producing industrial prototypes; register and provide legal support for innovations in foreign countries; establish benefits when paying regional and local taxes and duties; provide loans, including also interest-free ones; jointly implement educational programs as well as programs to search and attract foreign talented specialists);
- supporting cluster products expansion on international markets to include export support programs, products certification by the international standards, support in conducting market research, support in participating in the corresponding exhibitions and fairs (their organization).

Cluster policy formation in Ukraine occurs in specific conditions, connected with special economic features and national mentality. The most important factors that complicate cluster development model implementation in Ukraine include:

- Absence of confidence between state authorities and business, as well as between different companies; reluctance of companies to open and share their internal information due to the possibility of abuse and emergence of dependence from more powerful partners;
- Absence of state support for cluster initiatives. All the available Ukrainian clusters have been created without governmental participation whatsoever;
- Weakness of clusters due to low competitiveness level on the domestic market;
- Absence of "aggressive" suppliers and demanding customers;
- Lack of foreign investments and venture capital, which are an important source for clusters development in developed countries, assisting clusters, among other things, to reach international level through increasing their competitiveness;
- Inadequacy of legislation framework for clusters functioning; considerable bureaucratic obstacles for business development;
- Incoherence in implementing long-term strategies due to unstable political situation that provides for low confidence between business and government;
- Absence of systematized information base on the existent and potential clusters, that hampers awareness building in the society as regards the advantages of cluster alliances, and also hampers creation of the holistic picture of the available Ukrainian clusters and the achieved results. As of today Ukraine does not have single information resource that may serve as comprehensive information source about Ukrainian clusters and could have been used to increase existent clusters efficiency as well as to increase their number [23].

State authorities' performance in the sphere of cluster development model implementation for Ukrainian industry development should be oriented on activating the government role in clusters formation as well as in creating favourable macro-economic, information and regulatory-legal environment to develop business-networks of cluster type.

Summary

The conducted research has provided for making the following conclusions:

- Cluster approach to form up and implement governmental industrial policy is the most prospective strategy for the national economic growth;
- Determining benchmarks and parameters of the cluster model for economic development, forming favourable environment for broad cooperation and strategic partnership between government, business and social institutions are the preconditions for efficient implementation of cluster industrial policy;
- There is no single universal approach to implement cluster industrial policy neither for industrially developed countries nor for developing counties; each separate case requires developing a unique system of measures and mechanisms of the policy implementation on the basis of generally recognized principles and tools, but with considering specifics and conditions of the national socio-economic development;
- Cluster industrial policy is to be implemented on all government levels, for which it is necessary to develop a system of coordinated measures directed on quantitative and qualitative transformations of the national economy;
- Cluster industrial policy implementation must be based on the advanced scientific experience, on attracting highly qualified specialists and managers perfectly skilled in those issues;

- Cluster industrial policy implementation in Ukraine must be preceded by legislation improvement, the corresponding infrastructure creation, proper arranging of organization-information support, setting a financial-loan providing mechanism, human resources provision, bright investment opportunities providing, providing the territories with the status of the most favoured treatment zone.

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PROSPECTS ON BIO-ECONOMY DEVELOPMENT: BIOTECHNOLOGY IN AGRICULTURE AND ENVIRONMENTAL SAFETY ON THE BASIS OF NBIC-TECHNOLOGIES

Abstract
The article reviews modern trends in bio-economy development on the basis of biotechnologies application in environmental safety and agriculture including the genetically modified and other agricultural crops. The article demonstrates that in the implementation of converging NBIC-technologies in agricultural-industrial system is achieved a synergy effect for the development of the bio-economy in the World and Ukraine in following directions: industrial biotechnology (food biotechnology; biotechnology of sea products; biotechnology to increase oil recovery); environmental biotechnology (cleaning soil from pollution; environmentally friendly biocides to protect materials from bio-damage and oxidation; waste water treatment from toxic metals and radio-nuclides; air cleaning, including also cleaning of enterprises' vent emissions from volatile organic components, etc.); biotechnology in power engineering (modular biotechnological equipment, including bio-reactors and bio-diesel).

Key words
bio-economy, biotechnologies, NBIC-technologies, agriculture, environmental safety.

Introduction

Production of primary bio-products today and in future would be connected with human natural life support systems efficiency improvement at the expense of a number of things including also biotechnology implementation. In future, biotechnologies would play exceptionally important role in agriculture and environmental safety because our planet population is expected to considerably grow and correspondingly, the demand for bio-products would also grow. As to OECD data, the Earth population as of today is 7 billion people; by 2030 it would reach 8.3 billion and by 2050 it would grow up to 9 – 10 billion.

Growth of agricultural products production rate at the expense of plough land area increase has very strict limitations. According to Food and Agricultural Organization (FAO) review, to satisfy the needs of the developing countries in food it would be necessary to develop more than 120 million hectares of land during the next 30 years, which is 12.5% of plough land increase, and which would be very dangerous as regards the planet environmental impact increase [1; 2].

The more efficient problem solving would require implementation of innovative biotechnologies based of nano-, bio-, info- and cogno- (NBIC)-technologies, which would empower people in the 21st century to satisfy the needs of the growing planet population in food, in drinking water, and in other natural resources on the basis of increasing efficiency of bio- and hydro-resources as well as on the basis of the planet atmosphere potential increase [3, p.258]. Many well-known scientists dealt with the mentioned problem and with other issues regarding convergence of knowledge, technologies and society - M. Roco, W. Bainbridge, B. Tonn, G. Whitesides [4; 5]; the issues of using nanotechnologies for bio-economy - L. Foster [6]; development and future prospects for NBIC-civilization – A. Kazantsev, V. Kiselev, D. Rubwalter, O. Rudenskiy [7], including also Ukrainian scientists: M. Kyzym, I. Matyushenko, I. Buntov, O. Khanova, Yu. Moiseienko, V. Khaustova, et al. [8 – 14].

At the same time, implementation of biotechnologies on the basis of NBIC-technologies in developed countries' economies requires review of the technologies to be utilized for bio-economy build-up in the World and Ukraine. The aim of the article is to study design and production trends in biotechnology implementation in agriculture and environmental safety on the basis of NBIC-technologies.

Materials and methods

Content analysis has been used as the main method of research, which allowed making a meaningful analysis of classic papers and researches of modern economists-practitioners devoted to the peculiarities of the modern prospects of bio-economy in the World and Ukraine with using of NBIC-technologies. General scientific methods make up a methodological foundation of the research. They include: description, comparison, statistics review, system analysis and others, which help characterize this phenomenon development in a more comprehensive way. We also apply the methods of dialectic cognition, structural analysis and logic principles that provide for making authentic conclusions as regards the investigated topic. Official statistical data of the state institutions and international organizations, publications of reference character, analytical monographs, annual statistical bulletins, and Ukrainian National Academy of Science reports serve as an information grounds for our research.

Results and discussion

"Green Revolution" of 1960–1980 launched active utilization of chemical fertilizers to increase crop yield as well as utilization of pesticides to protect plantations from pests, but still by this time it has failed to solve food shortage problem. Moreover, intensive chemicalization of biosphere and human organisms caused serious side effects: burst of the population allergic incidence rate especially in developed countries; pollution of hydrosphere and lithosphere with chemicals, which are subsystems of human life support [1; 2]. Some modern biotechnologies, which also include genetic modifications, DNA sequencing (i.e., one of the mostly used methods to determine DNA molecules' nucleotides sequence), bioinformatics and metabolic engineering (technologies to change metabolism in a body), have already found their commercial use in specific agricultural sectors. For example, the mentioned technologies are mainly used in agricultural grain sector in the spheres of breeding and diagnostics, in animal farming and partially in veterinary medicine. Biotechnologies are widely used to generate new types of agricultural plants, food, fodder, fibre crops, domestic animals and poultry with improved genetic qualities. Table 1 presents examples of using biotechnologies in agriculture **[15, p.255].**

Table 1. Advantages and risks of using biotechnologies in agriculture

Technologies	**Advantages**	**Risks**
Transgenes (in general)	Opportunity to improve all forms of agriculture	Biodiversity decrease with the threat of new pathogens stronger impact; genetically modified products entry into human food intake without consumer's notification; technology may not work in new conditions
Resistance to herbicides	Agricultural productivity increase; decrease of herbicides use that are not bio-degradable	Outcrossing that entails emergence of super-weeds resistant to herbicides
Resistance to pests	Agricultural productivity increase, decrease of pesticides use that are not bio-degradable	Outcrossing that entails emergence of biotechnologically resistant pests; farmers that deal with organic husbandry would not be able to use bio-technologies; unfavourable impact on moths population
Feed value increase	Positive impact on food products nutritive value in the developing countries population intake	Could have inconsiderable effect, but at the same time could serve as only a promo method to throw dust into the eyes for commercial organizations
General resistance	Provide for agriculture development in the regions with unfavourable conditions	Development of super-resistant plants that could cause annoyance, e.g., grass that actively vegetate
Resistance to frost	Agricultural productivity increase	Could cause climate change

Technologies	Advantages	Risks
New food sources (lauric acid from genetically modified rape)	Cost decrease to produce some plantation products	Could cause losses and downfall in economy, that depends on traditional production methods
Biologically engineered agricultural animals	Increase of food production having animal origin	In case a trans-gene fish from the farm appears in wild nature it may force out the natural population

As of today, genetic and reproductive biotechnologies have a break-through impact on agriculture (especially in animal farming) in the developed world countries. For example, molecular genetics achievements have provided for an opportunity to build-up gene selection enginery mainly to combat animal diseases and alleviate gene defects. Innovative biotechnologies including also the technologies of cloning, transgenesis and somatic (body) material transfer would have an immense impact on animal and poultry farming in the 21st century.

One of the innovative methods is implementing genetic modification technologies with the help of transferring genetic material from one organism to another, which could not be done with the help of crossing. The other method is to use genetic material, which has natural crossing capacity, with other organisms with the help of genes “mixing”.

Moreover, reproductive biotechnologies also include artificial insemination (AI) and embryo transfer (ET) technologies [7, p.22]. As of today, animal farming in the developed countries actively uses artificial insemination biotechnologies. Technologies of embryo transfer and molecular-genetic technologies mainly include such innovative biotechnologies as, for example, molecular DNA-markers, that serve as tooling for genetic improvement of agricultural animals.

Biotechnologies, like, for example, biologic or chemical markers, are used to identify genetically modified plants’ characteristics, to shorten the time period of new types' generation, to improve their resistance and the ability to withstand the action of herbicides and pesticides. For example, in the USA till 2010 75% of 85 types of genetically modified plants (GM-plants) were recognized as herbicides-resistant and pesticides-resistant **[16, p.55].**

Preserving genetic diversity of agricultural crops is the most important goal for the modern biotechnologies development. Genetic resources of agricultural plants is the biologic foundation for human life support and global food safety including also pharmaceutics development, production of food and feed grains as well as biomass for animal farming, development of bioenergy, etc. As of today nearly 150 types of plants are under cultivation, of which 12 types yield 75% of world food.

Table 2 presents forecast for global use of plough land for genetically modified and other agricultural crops till 2015 [17].

Table 2. Forecast for global use of plough land for genetically modified and other agricultural crops till 2015

Years	GM soya beens		GM corn		GM cotton		GM rape	
	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%
1996	0,5	0,8	0,3	0,2	0,8	2,3	0,1	0,5
2000	25,8	34,7	10,3	7,5	5,3	16,9	2,8	10,9
2001	33,3	43,4	9,8	7,1	6,8	20,1	2,7	12,0
2002	36,5	46,2	12,4	9,0	6,8	22,7	3,0	13,1
2003	41,4	49,5	15,5	10,7	7,2	23,2	3,6	15,4
2004	48,4	52,9	19,3	13,1	9,9	28,9	4,3	17,1

Years	GM soya beens		GM corn		GM cotton		GM rape	
	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%
2005	54,4	58,9	21,2	14,4	9,8	29,7	4,6	16,7
2006	58,6	61,7	25,2	17,0	13,4	40,6	4,8	17,1
2007	58,6	65,0	35,2	22,3	15,0	45,5	5,5	17,9
2008	65,8	70,4	37,3	23,3	15,5	47,1	5,9	18,5
2009	73,7	76,0	35,5	21,9	16,3	49,5	6,2	18,9
2010	79,1	78,7	38,2	23,4	17,6	53,4	6,6	19,4
2011	84,6	81,1	41,0	24,8	18,8	57,2	7,0	19,9
2012	90,0	83,3	43,8	26,2	20,1	61,0	7,4	20,3
2013	95,4	85,6	46,5	27,5	21,3	65,0	7,8	20,7
2014	100,8	86,8	49,3	28,8	22,6	68,8	8,2	21,0
2015	106,3	88,2	52,1	30,1	23,8	72,7	8,7	21,3

GM-plants development is rather a costly matter; therefore, the leading world developers – biotechnological and chemical corporations – focused their efforts exactly on those crops the production output of which is rather big: soya, corn, cotton, rape and also canola. According to Table 2, in 2015 the world general plough land distribution for different GM-plants would be as follows: 88% - for GM soya; 30% - for GM corn; 72.7% - for GM cotton; 21% - for GM rape. According to FAO today we have nearly 50% of GM-soya and 20% of GM-cotton. In the USA practically all the soya (90%), corn (75%) and half of cotton are genetically modified [18, p.46]. Among other GM-plants we have potatoes, pumpkin, papaya and canola. GM-tomatoes, GM-coffee, GM-sunflower are in the course of development. Moreover, a number of food products are under development to have enhanced food value.

As of today, GM-crops available on the market have [3, p.275]**:**

- Increased protection level on the basis of created GM-resistance to plants' diseases caused by insects or viruses;
- Increased GM-resistance to herbicides.

In general, primary agricultural farms demonstrate GM-crops increased output, while enhanced plants' resistance to herbicides achieved due to bio technologies, entails decreased herbicides use, which generally goes in line with strengthening environmental systems sustainability. At the same time usage of GM-plants and GM-organisms could have negative impact on human health and on society in general, causing the need to set up corresponding research institutes to evaluate the mentioned risks and general safety of using GM-crops and GM-organisms. In relation with this, many world leading countries, which are developing genetically modified plants and organisms, create corresponding research institutes to assess biotechnological risks and bio-safety connected with GM-foodstuff to perform research by the following directions [19, p.1]:

- Direct impact on human health (toxicity);
- Possibility of allergic reactions manifestation (allergic impact of food products);
- Identifying components that may have both nutrition and toxic properties;
- Determining resistance capacity of the embedded gene;
- Impact on the nutritive process which relates to the genetically modified product, etc.

Implementation of nano-technologies and nano-materials in agricultural-industrial system is a vivid example of converging NBIC-technologies application to achieve a synergy effect in biotechnologies development. It includes [20, p.351–357]:

- Biotechnology (it pertains first of all to genetic engineering);
- Agro-industrial output production and reprocessing;
- Water treatment;
- Solving the problem of agricultural products quality assurance;
- Environmental protection (including also agricultural lands).

Solving the problem of providing sufficient volume of drinking water for the humankind would become one of the most important tasks for the next decades. With regard to the current water consumption volume, population growth and industrial development, two-third of the Earth population would experience lack of usable fresh water by 2050. Nano-technologies implementation to clean and disinfect water would help solve the indicated problem at the expense of using cheap decentralized water treatment and desalination systems, as well as systems to separate pollutants on the molecular level and cutting-edge filtration systems. For example, IBM company signed agreement with Saudi Arabia government to open a laboratory «Green nanotech», the most important task of which would be designing a water treatment system using nano-membrane materials for reverse osmosis and sea water desalination [21, p.49].

Increasing crops yield in agriculture is one more important task. Regardless of the world community protests, a number of world regions, where there is big rate of population growth and unfavorable conditions for agricultural work, would continue solving the food problem with the help of designing, creating and producing transgene high-productive plants with the help of bio- and nano-technologies, which would be resistant to virus infections.

It is stipulated that nano-technologies implementation would help change the technology of soil treatment at the expense of using nano-sensors, nano-pesticides and water treatment decentralized systems. Nano-technologies would provide for curing plants on the gene-level, would help create high-yielding breeds, which would be especially resistant to unfavorable environmental conditions.

In crop farming, usage of nano-powder, combined with anti-bacterial components, would ensure resistance increase to unfavorable weather conditions and would lead to two-fold increase of crop-yield of many food crops, as, for example, potatoes, grains, vegetables, and fruit & berry crops. Zeolite materials could successfully be used in the composition of fertilizers to ensure a more durable effect (prolongation effect), prevention of nutritious elements washing out after the application, or as pesticides carriers to optimize soil acidity as well as to prevent caking of mineral fertilizers in the process of their storage. New types of nano-bio-technological drugs could be generated to combat phytho-pathogenic bacteria on the basis of using new micro-organisms (predacious nano-bacteria) to serve as sort of "living antibiotics" for plants. Nano-technologies could also be successfully used for optical deciphering of protein-lipid-vitamin-chlorophyll system in plants as well as to decrease a harmful impact of motor transport on nature [14].

In animal farming bio-nano-technologies could be used to create bio-compatible materials, to restructure and build up tissues, create artificial tissues that are not rejected by organism, and create sensors (molecular-cell composition). Nano-admixtures are widely used in fodder production, where they provide for 1.5 – 3 times animal productivity increase as well as providing for the resistance to infectious diseases and stress. Nano-size of fodder admixtures helps not only considerably decrease their consumption but also ensure a more abundant and efficient digestibility by animals.

Research in the field of bio-nano-technologies is one more important direction of NBIC-technological work in agriculture. That research includes [14]:

- Directed protein synthesis to obtain peptides with desired immune-gene properties;
- Creating vector-systems to clone immune-meaningful proteins-causal agents of especially harmful animal diseases as well as cutting-edge vaccines, that have increased activeness and safety;
- Obtaining nano-particles of gene-engineering proteins; development of biotypes and test-systems for biologic screening, immunological monitoring and forecasting dangerous and economically meaningful infectious animal diseases;
- Implementing membrane systems as well as biocide surfacing material and materials on the basis of silver, which would provide for a simpler and improved keeping of agricultural animals and providing them with qualitative drinking water;
- Developing nano-bio-technological methods to identify markers, matched with economically valuable features and with virus, bacterial and parasite diseases in fish for their probable utilization in the practical fish-breeding;
- Developing nano-bio-technologies for functional food supplements and substances with using the methods of ultra- and nano-filtration, nano-encapsulation, disintegration as well as using directed ferment modification of nano-bio-structures (e.g., cheeses, yogurts, etc.) and so on.

Food companies use biologic nano-particles with the size of several hundred atoms in food products (edibles, beverages, chewing gum) in ever increasing scale. For example, nanometric layer of titan dioxide, which has been applied to Mars bar, increases its storage life several times. In reality we have a product, which is packed into a package (nano-foil) made of titan dioxide. With this, an organism can also digest the nano-metric titan dioxide. At the same time, similarly to nano-cosmetics, the level of safety of nano-technological admixtures wide use has not yet been clearly determined. For example, Dutch company “Friesland Foods” – one of the biggest cheese producers – has been developing technology of using nano-size sieves, which are more acceptable to ensure end product safety [22]. The aim of the work is to organize highly efficient milk separation into proteins, polysaccharides, and fatty acids. In near future nano-technological admixtures that are capable of changing food taste and dietary qualities would become mandatory components for many food products.

Conclusions

In conclusion, the results indicate that the most promising for the development of the bio-economy in the World and Ukraine are following directions: industrial biotechnology (food biotechnology; biotechnology of sea products; biotechnology to increase oil recovery); environmental biotechnology (cleaning soil from pollution; environmentally friendly biocides to protect materials from bio-damage and oxidation; waste water treatment from toxic metals and radio-nuclides; air cleaning, including also cleaning of enterprises’ vent emissions from volatile organic components, etc.); biotechnology in power engineering (modular biotechnological equipment, including also bio-reactors and bio-diesel).

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DETECION OF PATHOLOGICAL CRISIS PROCESSES IN BRANCHES OF ECONOMY (ON THE EXAMPLE OF AGRICULTURE OF UKRAINE)

Abstract
The article is devoted to applying the concept of early detection of pathological crisis processes to analyze the dynamics of Ukrainian agriculture development in 2003-2011. The analysis is based on time series of the export, import, production volume, export and import prices for agricultural products, volume of loans and investments. Despite the fact that the only branch that demonstrated the growth of output in 2008-2009 was agriculture, there were observed four years of crisis in agriculture during the period under consideration. The built signal panel and structural and logical model of pathological crisis processes detection in agriculture of Ukraine showed that the leading role was played by the investment balance deficit, reduction of the technological level of exports compared to imports and growth of domestic production credit bubble.

Key words
crisis pathological processes, agriculture, signal panel, imbalance, disequilibria, structural and logical model, detection, crisis indicators.

Introduction

At present, various aspects of the problem of occurrence and development of crisis phenomena in economy are the subject for the studying and discussion of scientists and practitioners all over the world. At that, a special attention in modern research and developments is paid to the issues of detecting the crisis processes in economy with a view to their prevention.

The financial crisis of 2008-2009 showed the imperfection of the existing methodological approaches to the problem of early detection of crisis processes in economy, which suggests the need for further research in this direction.

The study suggests such interpretations of the basic concepts [1]:
1. *Crisis* is a specific phase of development, which is characterized by deep distress, abrupt turn in the habitual way of the system functioning, dislocation of its equilibrium and balance caused by the dynamic irrevocable transformation of its elements and has negative consequences.
2. *Economic crisis* is an integral phase of the economic cycle and a negative economic phenomenon caused by imbalances arising in the process of production, exchange and consumption, which is manifested in sharp deterioration of the socio-economic situation in the country due to significant decline in production, breakdown of manufacturing relations, bankruptcy of enterprises, rising unemployment and inflation, and as a result — in decrease of the population living standard.

Review of the modern theory and practice

In the world theory and practice there used three main approaches to early detection of crisis processes in economy:
- qualitative analysis;
- using logit and probit regression models;
- signals approach.

Most approaches and methods are oriented towards prevention of banking, monetary and exchange crises. A detailed analysis of the approaches to development of systems for early detection of financial instability is presented in [2, 3], of banking crises — in [4, 5, 6] and currency crises — in [7].

Qualitative analysis lies in comparing the dynamics of fundamental economic indicators in the period before the crisis and crisis-free state. To identify crisis events two approaches are applied: the fixation of crisis events and exceeding of thresholds by some indicators. The first approach was used by B. Eichengreen, A. Rose, Ch. Wyplosz [8] to identify a currency crisis. The approach to the crisis identification based on threshold values seems more versatile. This approach is applied in most studies on the use of qualitative analysis to determine the parameters — harbingers of currency and banking crises [4, 5].

In a number of works qualitative analysis is supplemented by statistical estimations aimed at confirming the choice of leading indicators [9]. J. Azis, F. Karamazza, R. Salgado [10] conducted a comparison of macroeconomic indicators in calm periods and during the "crisis window" based on comparing the average values and evaluating the significance of their differences by means of the Student's t-test. The main disadvantage of qualitative analysis is a notable subjectivity in the interpretation of dynamics of the indicators, which can be eliminated by means of statistical criteria only partly.

Econometric approach involves the building, as a rule, of a multiple regression model evaluating the relationship of economic indicators with crisis probability in the chosen field. Most frequently there used logit and probit models of binary or multiple choices. In probit models there used the integral function of standard normal distribution [5]. The logistic distribution function estimates the probability of a crisis in logit models [11]. The model with censored data (tobit model) [6] suggests that the dependent variable is connected by the rule of censorship with the latent variable, and for the latent variable, in turn, a linear regression model is built.

Among the shortcomings of econometric modeling to build early warning systems for crises P. Trunin and M. Kamenskikh [8] emphasize that the main obstacle to the creation of effective system for early detection based on the econometric approach is the need for a large number of crisis episodes observed in one country and realization of statistical assumptions about the distributions of the indicators, which is difficult to achieve if synthetic indices are used as indicators.

Signals approach became widespread owing to the work dated 1998 by G. Kaminsky, S. Lizondo, S. Reinhart devoted to the analysis of currency crises in 25 countries from 1970 to 1995 [7]. The methodology of the signals approach is described in detail by the authors in [9]. The method is based on the assumption that the economy in the period before the crisis behaves abnormally. The idea of the signals approach is to test the main hypothesis that the economy is in a normal state, against the alternative one that within the following three to six months the occurrence of instability is possible. As with testing of any statistical hypothesis, it is required to choose a limit (critical value), which divides the indicator distribution into two zones. If the indicator value gets into the critical zone, that is, beyond the threshold value, it is considered that the indicator issues a signal. If the indicator issues a large number of "good" signals (i.e., has a high capacity for work), we can expect that the probability of instability, provided the signal is issued, will be greater than the absolute probability.

Among the shortcomings of the signals approach A. Gaytan, Ch. Johnson [5] indicate a lack of information, conditioned by using for prediction the macroeconomic information, which is available at a lower frequency than necessary; rather arbitrary choice of variables; the approach does not allow investigating the crisis severity; it is not possible to use standardized tests of statistical reliability and take into account regional differences.

Thus, the analysis of the developments for the past 15 years has shown that to detect and predict forthcoming of crises different methods are used, but the scope of their application is limited to the financial sector of the economy. To the real sector there devoted critically low number of works [11] concerning the crisis in the industry, and agriculture proper is not considered at all.

The purpose of the research is to assess the degree of development of pathological crisis processes in agriculture of Ukraine and their manifestations during the global crisis of 2007-2009.

Main results.

The study is based on the concept of the origin and development of pathological crisis processes in the real sector of the country economy suggesting analysis of the fundamental threats to development of a full-scale crisis on the basis of evaluating imbalances, disequilibria and growth of bubbles in individual industries of the real sector, presented in [12]. In accordance with this concept there proposed a methodical approach to early detection of origin and development of pathological crisis processes in the real sector of the country economy (Table 1).

Table 1. The methodical approach to early detection of the origin and development of pathological crisis processes in the real sector of the country economy

The stage and its purpose	**Sequence of operations**	**Tools**
I. Monitoring (detecting the origin of pathological processes and estimating the health of economic activity)	I. Estimation of the health of economic activity	Estimation scale
	1.1. Calculation of signal indicators	
	1.2. Comparing the indicators of signals with their threshold values 1.3. Detecting the pathological processes and identifying the stage of their development 1.4. Analyzing the dynamics of development of pathological processes 1.5. Estimating the health state of the type of economic activity	Static signal panel Dynamic signal panel Estimation scale
II. Analysis (diagnosing the relationship and causes of the formation and development of pathological processes in individual types of economic activity)	II. Diagnosing the causes of diseases of a certain type of economic activity	Structural and logical model Cognitive model Casual and logical analysis
	2.1. Diagnosing the state and development of pathological processes 2.2. Identifying the relations between the pathological processes 2.3. Revealing the reasons of formation and development of pathological processes	

It should be noted that the global financial crisis that began in 2007 affected all sectors of the world economy and the economy of Ukraine as well. Agriculture is practically the only industry of the real sector of Ukrainian economy, which was able to maintain a positive growth of output in the crisis period. The high share of agriculture in the country GDP (7.8% in 2012) and its socio-economic significance [2, 4] suggests the need to focus on early detection and prevention of development of crisis processes in the industries in connection with the potential threat to the entire economy.

This study is based on the data on the volume of output, exports, imports, GDP, cost-output tables for 2003-2011 [13]. To determine the periods of crises there was used the industrial output index and the index of agricultural output as the main indicators for the real economy [14].

The analysis of the dynamics of the rates of change in output of the leading industries in the real sector of Ukrainian economy in 2003-2011 showed that the greatest number of crisis years in Ukraine was observed in the production of petroleum derivatives — 6 years; agriculture — 4 years, food production and metallurgical production — 3 years each.

The period of the most severe crisis for all the considered types of economic activity was during 2008-2009. At that time, the largest decline in production was observed in mechanical engineering — 55.3%; metallurgical production — 64.3%; chemical and petrochemical industry —70.4% and production of non-energy minerals — 74.6%. The only economic activity, which preserved the growth rate of output in 2008-2009, is agriculture — 115.0% (calculated according to [13]).

In general in the period of 2008-2009 in agriculture there was observed an increase in production by 115.0% with insignificant decline in 2009 — 98.2% (Fig. 1). This decline was the lowest in the industry as compared with other major economic activities of the real sector of economy of Ukraine in 2009.

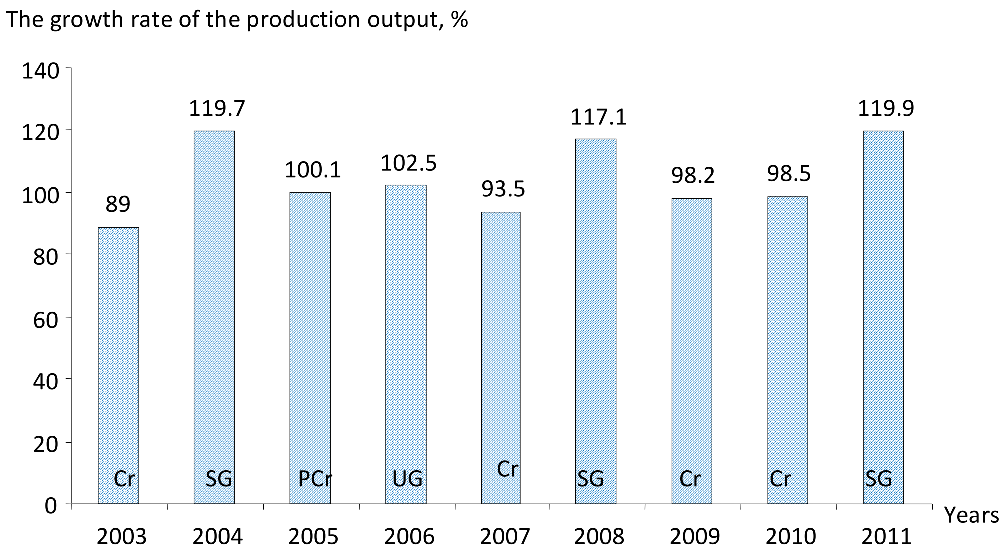

Fig. 1. Dynamics of production output in agriculture of Ukraine in 2003-2011. [13]:
SG – steady growth, UG – unsteady growth, PCr – pre-crisis state, Cr – crisis state.
(the same abbreviations are used in Fig. 2, Tab. 1)

At the same time it should be noted that agriculture is a specific type of economic activity of the real sector of economy, development of which depends largely on weather conditions in a given year, as can be seen from Fig. 2. During the period that preceded the global financial crisis of 2008-2009 in agriculture of Ukraine in 2003-2007 there was observed a decline or unsteady output growth.

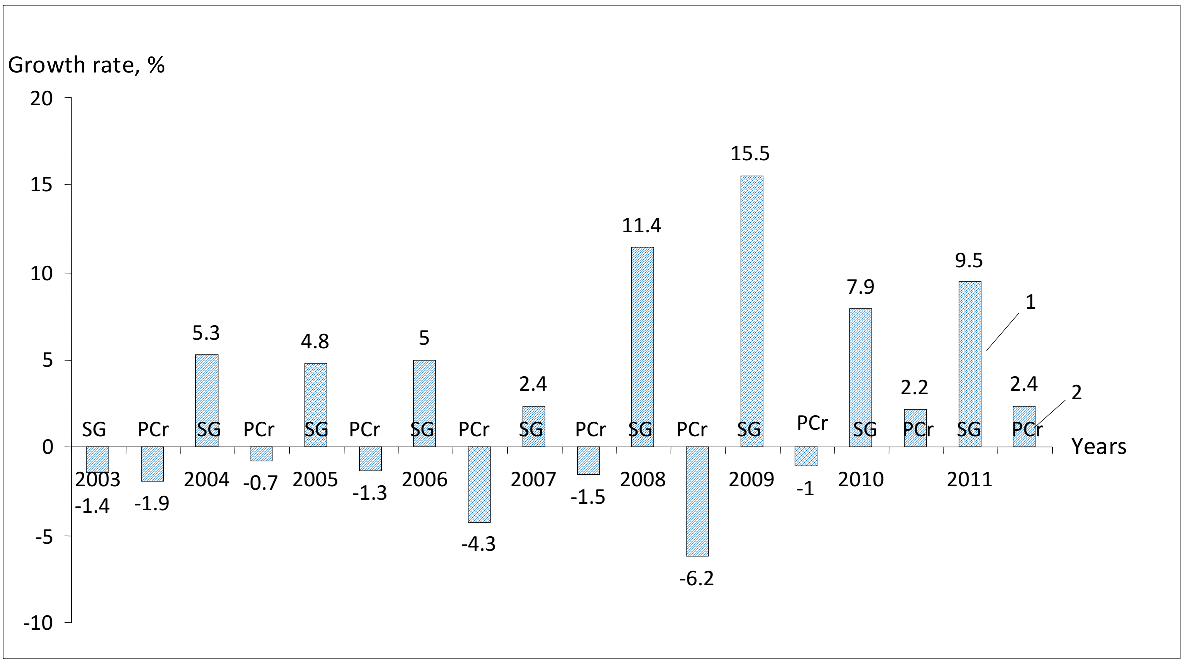

Fig. 2. Dynamics of development of imbalances in agriculture of Ukraine in 2003-2011:
1 – trade imbalance; 2 – investment imbalance (calculated by the authors)

As seen from Fig. 2, in 2003-2007 in agriculture of Ukraine there was observed a steady development of trade imbalance and development of pre-crisis investment imbalance. At the same time, by the end of the analyzed periods there decreased both the surplus of the trade imbalance and deficiency of the investment balance.

In the study there was used the structural and logical model for diagnostic of pathological processes in leading industries of the real sector of the economy presented in [12]. This model is based on calculation of the trade imbalance (Im_1) and investment imbalance (Im_2), forming them disequilibria and growth rate of external and internal bubbles.

The results of calculations based on the methodological approach presented in Table 1 are summarized in the signal panel of indicators for early detection of pathological processes in the agricultural sector of Ukraine in 2003-2011 (Table. 1) and the structural and logical model for diagnostic of pathological crisis phenomena (Fig. 3).

As can be seen from Table 1 the disequilibria in the ratio of external and internal demand (De_1) and the external and domestic supply (De_2) in 2003-2007 did not go beyond steady development (less than 15 and 10% respectively), and by the end of the analyzed period fell slightly.

At the same time the disequilibrium in the ratio of export and import prices for agricultural products (De_3) in 2003-2007 was practically all the time in the pre-crisis state (greater than 70%), either reducing or rising. However, the effect of this disequilibrium did not have a significant impact on the trade imbalance in agriculture of Ukraine.

The formation of the investment imbalances in agriculture of Ukraine in 2003-2011 was significantly affected by the considerable disequilibrium in investment adequacy (De_4) and debt load (De_5) with a slight influence of the disequilibrium in the solvency (De_6).

By the beginning of the financial crisis of 2008-2009 external and internal price bubbles in agriculture of Ukraine practically did not start. At the same time by this period the tendency to the starting of the domestic production credit bubble, the growth rate of which reached 631.7% of the level in 2003.

Summary

The main pathological processes that developed in agriculture of Ukraine in 2003-2007 were:
- investment imbalance (De_2);
- decrease in the technological level of exports compared to that of imports (De_3);
- growth of domestic production credit bubble (B_4).

The export bubble is mostly determined by credit growth. This can be explained by the need for crediting agricultural producers during spring and autumn field works. Import bubble is triggered by the rise in world prices, which is reflected in the export bubble as well. The import bubble itself stimulates the growth of the credit bubble, because an increase in import prices brings about the increase in the need for loans.

Table 1. The signal panel of indicators for early detection of pathological processes in agriculture of Ukraine in 2003-2011.

Indicator	**Year**								
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
$Im_1=(Ex-Imp)/V$	-1.4	5.3 ↑	4.8 ↓	5 ↑	2.4 ↓	11.4 ↑	15.5 ↑	7.9 ↓	9.5 ↑
	SG	SG	SG	SG	SG	SG	SG	SG	SG
$De_1=Exp/Cap$	5,6	9.4 ↑	8.9 ↓	9.5 ↑	6.8 ↓	18.4 ↑	25.8 ↑	15.3 ↓	16.5 ↑
	SG	SG	SG	SG	SG	UG	UG	UG	UG
$De_2=Imp/V$	7,1	3.6 ↓	3.7 ↑	4.1 ↑	4.3 ↑	4.9 ↑	6.2 ↑	6.2 ↓	5.4 ↓
	SG	SG	SG	SG	SG	SG	SG	SG	SG
$De_3 = Exp_1/Imp_1$	78,0	36.3 ↓	27 ↓	30.6 ↑	47.8 ↑	30.6 ↓	18.5 ↓	22.1 ↑	27.0 ↑
	UG	PCr	PCr	PCr	PCr	PCr	PCr	PCr	PCr
$Im_2=(NP-I)/V$	-1,9	-0.7 ↑	-1.3 ↓	-4.3 ↓	-1.5 ↑	-6.2 ↓	-1 ↑	2.2 ↑	2.4 ↑
	PCr	PCr	PCr	PCr	PCr	PCr	PCr	PCr	PCr
$De_4=I/V$	3,0	3.7 ↑	4.9 ↑	6.9 ↑	7.6 ↑	9.4 ↑	5.1 ↓	5.5 ↑	6.1 ↑
	PCr	PCr	PCr	UG	UG	UG	UG	UG	UG
$De_5=C/V$	6,4	5.6 ↓	8.1 ↑	11.2 ↑	13.1 ↑	16.1 ↑	14.2 ↓	11.8 ↓	11.4 ↓
	SG	SG	SG	SG	UG	UG	UG	UG	UG
$De_6=NP/C$	16,9	53.0 ↑	45.2 ↓	22.9 ↓	46.7 ↑	20.1 ↓	29.1 ↑	65.1 ↑	74.3 ↑
	UG	SG	SG	UG	SG	UG	UG	SG	SG
$B_1 =\Delta Exp_{val}-\Delta Exp_{ph}$		-17.1 ↓	-7.7 ↑	21.3 ↑	38.1 ↑	15.6 ↓	-61.9 ↓	21.2 ↑	37.1 ↑
		SlB	SlB	FG	FG	SlG	Col (FB)	FG	FG
$\Sigma B_1 =\Sigma\Delta Exp_{val}-\Sigma\Delta Exp_{ph}$		-17.1 ↓	-38.4 ↓	12.4 ↑	106 ↑	361.9 ↑	87.8 ↓	193.9 ↑	395.9 ↑
		SlB	SlB	S	FG	FG	FG	FG	FG
$B_2=\Delta Imp_{val}-\Delta Imp_{ph}$		27.3 ↑	26.1 ↓	9.7 ↓	14.1 ↑	66.5 ↑	774 ↑	15.9 ↓	11.7 ↓
		FG	FG	SlG	SlG	FG	FG	SlG	SlG

Table 1 (Continued)

Indicator	Year								
	2003	2004	2005	2006	2007	2008	2009	2010	2011
$\Sigma B_2=\Sigma\Delta Imp_{val}-\Sigma\Delta Imp_{ph}$		27.3 ↑	40.3 ↑	54.1 ↑	73.9 ↑	150.2 ↑	128.8 ↓	165.3 ↑	196.1 ↑
		FG	FG	SlG	SlG	FG	FG	FG	FG
$B_3=\Delta V-\Delta V_{ph}$		-14.0 ↓	8.0 ↑	-0.1 ↓	44.5 ↑	-6.8 ↓	8.2 ↑	31.5 ↑	-6.3 ↓
		SlB	SlG	S	FG	SlB	SlG	FG	SlB
$\Sigma B_3=\Sigma\Delta V_{val}-\Sigma\Delta V_{ph}$		-14.0 ↓	-5.6 ↑	-5.8 ↓	46.6 ↑	43.6 ↓	57.4 ↑	116.3 ↑	123.9 ↑
		SlB	S	S	FG	FG	SlG	FG	FG
$B_4=\Delta C$		14.4 ↑	57.0 ↑	45.8 ↓	36.8 ↓	76.3 ↑	-9.7 ↓	2.0 ↑	28.6 ↑
		SlG	FG	FG	FG	FG	SlB	S	FG
$\Sigma B_4=\Sigma\Delta C$		114.4 ↑	179.0 ↑	261.0 ↑	357.0 ↑	629.4 ↑	568.3 ↓	579.7 ↑	745.5 ↑
		SlG	FG	FG	FG	FG	FG	FG	FG
ΔV	89.0	119.7 ↑	100.1 ↓	102.5 ↑	93.5 ↓	117.1 ↑	98.2 ↓	98.5 ↑	119.9 ↑
	Cr	SG	PCr	UG	Cr	SG	Cr	Cr	SG

Notes. Exp – export, Imp – import, NP – net profit, Cap – home market capacity, V – production volume, Exp_1 , Imp_1 – the price for 1 ton of export, import correspondingly, C – loans, I – investments, ΔExp_{val} *u* ΔExp_{ph} – growth rate of products export correspondingly in value and physical terms, ΔImp_{val} *u* ΔImp_{ph} – growth rate of products import correspondingly in value and physical terms, B_1 – external export bubble, B_2 – external import bubble, B_3 – internal price bubble, B_4 – internal credit bubble, ΣB_4 – the bubble in relation to 2003, ΔV – index of production of agricultural products, PCr – pre-crisis state, Cr – crisis state, FG – fast growth (of the bubble), S – steady state, SlG- slow growth (of the bubble), SlB – slow burst/blow-off (of the bubble), Col (FB) – collapse (Col) or fast burst/blow-off (FB) (of the bubble). (calculated by the authors)

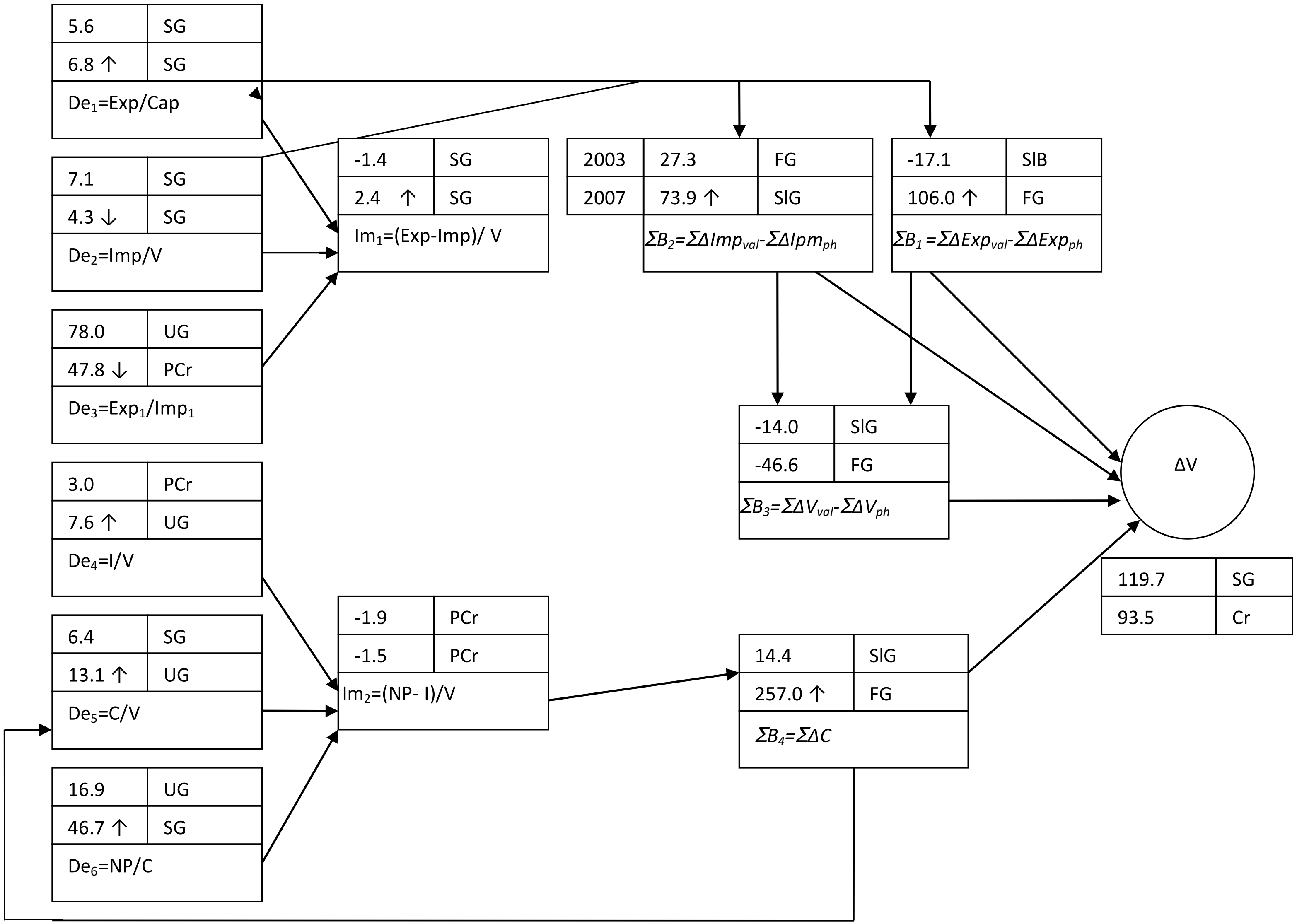

Fig. 3. Structural and logical model for diagnostic of the state and development of pathological processes in agriculture of Ukraine in 2003-2007 (developed by the authors)

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