Daniel BUCZKOWSKI

AUTOREPORT

presenting description of output and scientific achievements

Annex no. 2

to an application for performing habilitation procedure

1. First name and family name

Daniel BUCZKOWSKI

2. Qualified diplomas and scientific degree – name, place and year of their obtaining and the title of Ph.D. dissertation

M.A. Eng. - scope - *mechanics*, specialty - *armament*, Faculty of Mechanics and Technology, Warsaw Technical University, 1983 y.

Ph.D. in the field of technology - scope *mechanics*, specialty *mechanics of explosion*, Faculty of Mechatronics, Military Academy of Technology, 2006 y. Title of Ph.D. dissertation - „*Influence of physical structure of prills on explosive properties of ammonium nitrate and ANFO explosives*", professor conferring a degree: professor Bogdan Zygmunt (Faculty of Mechatronics, Military Academy of Technology).

Post graduate studies - graduated with the result very good with distinction, scope *Technology of explosives*, Faculty of Chemistry, Silesian University of Technology, 2002 y.

3. Information on until now employment at scientific enterprises

Present place of employment
Institute of Industrial Organic Chemistry
Department of Highenergetic Materials
Annopol 6 Street
03-236 Warsaw

Run of employment
From 16.04.1987 till now Institute of Industrial Organic Chemistry, in succession on positions: specialist, assistant and tutor.
From 01.12.1986 till 15.04.1987 Research Centre of Excavators and Hydraulics, Warsaw, engineer.
From 01.09.1985 till 30.11.1986 Industrial Institute of Automatics and Measurements, Warsaw, engineer.

4. Indication of the achievement ensued from article 16 passage 2 Act from the day 14 March 2003 y. about scientific degrees and scientific title and degrees and title in the scope of art (Dz. U. nr 65, poz. 595 ze zm.)

My scientific achievement in interpretation of article 16 passage 2 Act about scientific degrees and scientific title and degrees and title in the scope of art from the day 14 March 2003 y. is monothematic cycle of publications titled:

Examinations of detonation properties of ammonium nitrate and explosives containing ammonium nitrate

Indicated monothematic cycle of publication contains following papers:

I. Journals from Scopus base:

1. B. Zygmunt, D. Buczkowski, *Obniżanie wybuchowości nawozowej saletry amonowej (Reduction of explosiveness of fertilizer grade ammonium nitrate)*. Przemysł Chemiczny 2007, 86, 7, p. 672-676, IF 0,196.
   Cited 3 times in Scopus, 4 in Web of Science, 2 in Scholar Google,
   List A MNiSW (Ministry for Science and University Education).
   My contribution (45%) was participation in selecting additions, participating in planning, supervision of manufacturing of testing batches of ammonium nitrate with selected additions on industrial installations, next performing test (physical properties, ability to detonation, running of phase transition) and participation in elaborating results of the examinations.

2. B. Zygmunt, D. Buczkowski, *Influence of ammonium nitrate prills properties on detonation velocity of ANFO.* Propellants, Explos., Pyrotech., 32 (2007) 5, p. 411-414, IF 1,122.
   Cited 36 times (including 4 selfcitations) in Scopus, 29 in WoS, 47 in Scholar Google,
   Scopus citescore – 1,25, List A.
   My contribution (40%) was participation in elaborating plan of tests, preparing samples of ammonium nitrate (making them porous, milling, sieving etc.), preparing samples of ANFO explosives, performing examinations of physical properties and detonation velocity and participation in elaborating results of the tests.

3. D. Buczkowski, B. Zygmunt, *Modyfikowanie fizycznej struktury granul saletry amonowej do wytwarzania saletroli (Modification of physical structure of ammonium nitrate used for manufacturing ANFO explosives).* Przemysł Chemiczny 2008, 87, 6, p. 707-710, IF 0,254.
   Cited 4 times in Scopus, 6 in WoS, 2 in Scholar Google, List A.
   My contribution (60%) was participation in elaborating plan of tests, performing porous ammonium nitrate, preparing samples of ANFO explosives, participation in selecting samples for testing by scanning electron microscope and participation in elaborating results of the tests.

4. D. Buczkowski, B. Zygmunt, *Detonation Properties of Mixtures of Ammonium Nitrate Based Fertilizers and Fuels*. Central European Journal of Energetic Materials, 2011, 8(2), p. 99-106, *IF in 2012 y. 1,327.*
   Cited 34 times (including1 autocitation) in Scopus, 27 in WoS, 2 in Scholar Google,
   Scopus citescore – 1,68 *List A.*
   My contribution (70%) was participation in elaborating plan of tests, preparing samples of fertilizers (milling and mixing), performing explosives and measurement of their detonation velocity, participation in performing cylindrical test and participation in elaborating results of the examinations.

5. D. Buczkowski, *Ammonium nitrate – A threat of accidental explosion and terrorist attack,* Chemik, 2012, 66(3), p. 231-234. *List B.*

6. B. Zygmunt, D. Buczkowski, *Agricultural Grade Ammonium Nitrate as the Basic Ingredient of Massive Explosive Charges*. Propellants, Explos., Pyrotech., 37 (2012) 6, p. 685-690, IF 1,245. *List A*
Cited 9 times in Scopus, 10 in WoS, 13 in Scholar Google Scopus citescore – 1,53.
My contribution (40%) was participation in elaborating plan of examinations, preparing samples of fertilizers (making them porous, milling and mixing), manufacturing explosives, performing measurements of detonation velocity and participation in elaborating results of the tests.

7. D. Buczkowski, *Metody badań właściwości wybuchowych nawozów zawierających azotan(V) amonu (Methods of testing explosive properties of fertilizers containing ammonium nitrate).* Przemysł Chemiczny 2013, 92, 12, p. 2244-2246, IF 0,367. *List A.*

8. M. Borowik, A. Biskupski, M. Dawidowicz, D. Buczkowski, *Zasady bezpiecznego magazynowania nawozowej saletry amonowej (Rules of safe storage of fertilizer grade ammonium nitrate).* Przemysł Chemiczny 2013, 92, 12, p. 2148-2152, IF 0,367.
Cited 3 times in Scopus, 3 in WoS, Scopus citescore – 0,29 Impact factor 0,367 (List A).
My contribution (30%) was performing calculations of overpressure of air shock wave, caused by explosion of charge of ammonium nitrate, and determining, on the base of performed calculations, minimum distances from charge of ammonium nitrate (warehouse) to different structures (dwelling-houses, transportation routes, high-tension system, building of public services).

9. D. Buczkowski, *Explosive Properties of Mixtures of Ammonium Nitrate(V) and Materials of Plant Origin.* Central European J. of Energetic Materials, 2014, 11(1), p. 115-127, IF 1,250. (*List A)*
Cited 7 times in Scopus, 6 in WoS, 5 in Scholar Google Scopus citescore – 1,78.

10. A. Maranda, A. Nastała, D. Buczkowski, W. Witkowski, *Study of the effect of pesticides on detonation parameters of ANFO and ammonal explosives,* Chemik, 2014, 68(1), p. 23-28. *(List B).*

My contribution (30%) was participation in elaborating plan of tests, participation in manufacturing of ANFO explosives and ammonals, participation in performing measurements of detonation velocity and overpressure of air shock wave and participation in elaborating results of the examinations.

II. Other journals and conference's proceedings:

1. D. Buczkowski, W. A. Trzciński, B. Zygmunt, *Badania właściwości energetycznych saletroli metodami testu cylindrycznego i wahadła balistycznego (Examinations of energetic properties of ANFO explosives with using ballistic mortar and cylindrical test)*. Scientific Works of Central Mining Institute – Proc. from Conference „Safety of Works with Explosives in Mining". Ustroń, 2006, p. 77-86. (*List B).*

   My contribution (40%) was participation in elaborating plan of examinations, preparing samples of ammonium nitrate (making them porous and milling) and ANFO explosives, performing measurements of detonation velocity and with ballistic mortar, participation in performing cylindrical test and participation in elaborating results of the tests.

2. B. Zygmunt, D. Buczkowski. *Saletra amonowa jako czynnik zagrożenia bezpieczeństwa przemysłowego i publicznego (Ammonium nitrate as a factor of danger of industrial and public safety)*. Wiadomości Chemiczne, 2006, nr 5-6, p. 365-378. (*List B).*

   My contribution (40%) was participation in writing the paper (describing accidents caused by explosion of ammonium nitrate, talking over terroristic attacks with using explosives based on ammonium nitrate, presentation of possibilities of formation of physical properties of ammonium nitrate).

3. B. Zygmunt, A. Maranda, D. Buczkowski, *Materiały wybuchowe trzeciej generacji (Explosives of third generation).* WAT 2007 (monograph 236 pages, including 113 pages of my coautorship)
   8 citations (including 3 selfcitations) in Scholar Google.
   My contribution (30%) was participation in writing two chapters of the monograph – 113 pages.

4. D. Buczkowski, B. Zygmunt, *Wpływ rodzaju saletry amonowej na prędkość detonacji saletroli (Influence of kind of ammonium nitrate on detonation velocity of ANFO explosives)*, Scientific Works of Central Mining Institute No. V/2008, p. 77-81. (*List B).*

   My contribution (60%) was participation in elaborating plan of examinations, preparing ammonium nitrate (making them porous, milling, collection from manufacturing line, sieving etc.) and ANFO explosives, performing measurements of detonation velocity and participation in elaborating results of the tests.

5. D. Buczkowski, B. Zygmunt, *Detonation Properties of Mixtures of Ammonium Nitrate Based Fertilizers and Aluminium*. Proc. XIII Sem. „New Trends in Research of Energetic Materials", p. 53-56, Pardubice (The Czech Republic), 2010.

My contribution (60%) was participation in elaborating plan of examinations, preparing samples of fertilizers (milling and mixing), manufacturing ammonals, participation in performing cylindrical test and participation in elaborating results of the tests.

6. D. Buczkowski, B. Zygmunt, *Saletrol o lepszych właściwościach detonacyjnych (ANFO explosive with better performance characteristics).* Scientific Works of Central Mining Institute, Katowice 2012, p. 13-16. (*List B).*

   My contribution (60%) was participation in elaborating plan of examinations, preparing samples of ammonium nitrate (milling) and modified ANFO explosives, performing measurements of detonation velocity and critical diameter and participation in elaborating results of the tests.

7. A. Maranda, W. Witkowski, D. Buczkowski, A. Nastała, *Study of the effect of pesticides on the detonation parameters of explosives containing ammonium nitrate*. Proc. of International Conference Blasting Techniques 2013, p. 249-254, Stara Lesna, (Slovakia).

   My contribution (25%) was participation in elaborating plan of examinations, participation in preparing ANFO explosives and ammonals, participation in performing measurements of detonation velocity and overpressure of air shock wave and participation in elaborating results of the tests.

8. D. Buczkowski, *Tańszy od saletrolu materiał wybuchowy, będący mieszaniną saletry amonowej i materiału pochodzenia roślinnego (Cheaper than ANFO explosive, containing ammonium nitrate and material of plant origin).* Scientific Works of Central Mining Institute, Katowice 2014, p. 140-147, (*List B).*

Description of scientific aim of the above mentioned works and obtained results, including treatment of their utilization

In January 2006 y., before the Scientific Board of Faculty of Mechatronics of Military Academy of Technology, I defended my Ph.D. dissertation titled *Influence of physical structure of prills on explosive properties of ammonium nitrate and ANFO explosives.* Professor conferring a degree was professor B. Zygmunt from Faculty of Mechatronics of Military of Academy of Technology and reviewers were professor M. Bossak from Faculty of Mechanics and Technology of Warsaw University of Technology and professor E. Włodarczyk from Faculty of Mechatronics of Military Academy of Technology. On the base of the performed examinations it was showed that broad scope of changing of detonation properties of ammonium nitrate and ANFO explosives, manufactured on a base of ammonium nitrate, is possible. Crucial influence on detonation

properties (detonation velocity, energetic characteristics and critical diameter) of the tested materials exerts physical structure of prills (particles) of ammonium nitrate, especially their porosity and dimensions.

I defended my Ph.D. dissertation in scope *Mechanics*, specialty *mechanics of explosion.* During the years 2006-2018 I have developed my interests in that specialty, carrying out experiments concerning influence of different physical factors on conditions of propagation of detonation wave in heterogeneous solid explosive mixtures, characterized with weak detonation ability. The main ingredient of the mixtures was ammonium nitrate (prills and particles). Explosive properties of ammonium nitrate was modified in two opposed directions: increasing or decreasing detonation ability, which implied changes of detonation parameters, mainly velocity of propagation of detonation wave and energetic characteristics.

In 2007 y. publishing house of Military Academy of Technology in Warsaw issued a monograph titled *Explosives of third generation* [II.3], authorship of professor B. Zygmunt, professor A. Maranda and my. The monograph contains 236 pages and includes five chapters. I'm the coauthor (with professor B. Zygmunt) of the second and third chapters containing 113 pages. The titles of the chapters are: *2. Ammonium nitrate and ANFO explosives –current knowledge* and *3. Ammonium nitrate and ANFO explosives – examinations of explosive properties.*

The main ingredient of *explosives of third generation* ammonium nitrate(V) (AN) is used mostly in two branches of economy:

- agriculture as one of the most frequently applied mineral fertilizers, used both alone and as mixtures,
- industry as an ingredient of many explosives, like: ammonites, dynamites, ANFO explosives and emulsion explosives, used mainly in civil industry.

These two different fields of applying caused that two different products are manufactured: fertilizer (agricultural) AN about as low as possible explosive properties and porous AN about significant explosive properties, which is able to absorb liquid fuel.

A tendency to bearing down traditional explosives containing classical explosive ingredients dominates in all countries where mining is developed. Examinations of new kinds of explosives were started in Poland in the beginning of the years 70. of the XX century at Institute of Industrial Organic Chemistry in Warsaw (ANFO explosives) and Military Academy of Technology (slurry and emulsion explosives). The authors of the monograph were the initiators of these works and implementations. In the monograph the authors described current knowledge referring to initiation and propagation of detonation in modern explosives: ANFO explosives (chapter 3), slurry explosives (chapter 4) and emulsion explosives (chapter 5). Intention of the authors was the trial of

explanation of causes of course of detonation process in multiphase mixtures, which do not contain ingredients characterized by significant explosive properties. Detailed results of experiments referring to influence of different physicochemical factors on detonation ability and explosive properties of the tested materials were also enclosed. The special role, that the multiphase mixture, containing ingredients without explosive properties, is an explosive, plays their reciprocal arrangement, i.e. texture for slurry and emulsion explosives and structure of prills for AN and ANFO explosives. Basic information on technology of manufacturing of the mentioned explosives and their using in mining and military applications were also mentioned.

Physical and explosive properties of basic raw material used for manufacturing *explosives of third generation,* i.e AN was very widely described (chapter 2, written by me as the coauthor). One of the subchapter was dedicated to extraordinarily current problem referring to industrial and public safety caused by mass production and availability to AN. The authors acknowledged as their duty to insert a short information about history of development of explosives and contribution of that field of technology in progress of civilization. Mentions about achievements, often connected with victims and suffering, of inventors and researchers who created development in all described kind of explosives, were also reminded.

On the beginning of the years 90. of the XX century polish fertilizer's industry found efficient ways of reducing explosive properties of AN. That problem tried to solve team of employees of Institute of Industrial Organic Chemistry; on the beginning I had been a member of the team and next I led the works of the team. Significant part of chapter 3 of the monograph is dedicated to these examinations. In scope of carried works, additions that may significantly reduce explosive properties of AN was preliminary selected. Next on manufacturing installation experimental batches of AN containing selected additions were produced. Performed tests showed that physical properties of modified AN (mechanical resistance, porosity and amount of small particles) were better and ability to detonation was smaller than unmodified AN. Among used additions magnesium nitrate(V) was acknowledged as the best and next following batches of AN with different amount of that addition, with aim of determining its influence on properties of AN, was produced. Successively performed tests, of the above mentioned properties, enabled on determining optimal concentration of magnesium nitrate(V) in AN. Based on the results of that works, manufacturers of fertilizers implemented addition of magnesium nitrate(V) to AN.

Second problem described in the monograph are examinations of explosive properties of ANFO explosives, especially relation between them and physical properties of AN (chapter 3). ANFO explosives are mixtures of AN and liquid combustible ingredients, most frequently mineral oil. Sometimes, for modifying their properties or utilizing explosives originated from delaboring ammunition,

other ingredients are added, e.g.: fine aluminum, fine coal, , smokeless powders, trinitrotoluene etc. For the sake that ANFO explosives are applied mainly in mining industry, charges prepared for blasting relatively often contain disadvantageous additions, like: water or cuttings.

Examinations of relation between detonation properties of ANFO explosives and physical characteristics of AN required possession of AN about different properties. For that aim, i.e. producing porous from fertilizer AN, I utilized changes of crystalline structure of AN, run at defined temperatures. Manufacturing of porous AN consisted in adding porosity agent to AN and next heating and cooling such prepared fertilizer near temperature of polymorphic transition. Changing number of cycles of thermal treatment heating-cooling and using different amounts of porosity agent, I obtained samples of AN characterized with broad scope of density of prilled product - (from 0,5 to 0,9) g/cm^3. It should be noted that in majority of similar examinations authors perform and test ANFO explosives from trade kinds of AN and often have no info about their way of manufacturing and chemical composition. AN used for my tests originated from one production batch and during thermal treatment changed only physical structure but chemical composition was unchanged. Apart of basic test i.e. measurement of detonation velocity, cylindrical test and microscopic examinations with using scanning electron microscope (SEM) were also carried out. Cylindrical test enabled determination of energetic characteristics of ANFO explosives and SEM examinations showed how process of manufacturing porous AN influenced on physical structure of the prills. Performed examinations of physical properties of manufactured AN and produced ANFO explosives indicated that:

- on the beginning if porosity of AN increases detonation velocity of ANFO explosives manufactured from porous AN fast grows,
- continued increasing of porosity of AN caused smaller and smaller increasing of detonation velocity of ANFO explosives,
- next detonation velocity of ANFO explosives reaches maximum and if porosity of AN still increases detonation velocity of ANFO explosives decreases.

Such course of relationship between detonation velocity and porosity is characteristic for explosives detonating in so called non ideal regime. Performed examinations confirmed that ANFO explosives are such materials and exists optimal porosity of AN and connected with porosity density, that ANFO explosives reach the highest detonation parameters.

Performed tests indicated on prevail role of physical structure of AN prills (porosity and dimensions of prills) on detonation properties of ANFO explosives about stoichiometric composition.

Issued in Przemysł Chemiczny [I.1] paper written by prof. B. Zygmunt and me titled „*Reducing of explosiveness of fertilizer grade ammonium nitrate*" describes, apart from influence of additions on detonation ability of AN, also results of examinations of run of transformation of crystalline form IV←→III. Preliminary tests performed by differential thermal analysis (DTA) did not give satisfactory results. However interesting results were obtained with using, manufactured for performing thermal treatment, preceding test of resistance to detonation, bath with steering-measuring-registering devices. Performed temperature measurements revealed that during heating and cooling of AN with ammonium sulfate(VI) (typically used addition), there were plateau of temperature, but during heating and cooling of AN with addition of magnesium nitrate(V) there was monotonically increasing or decreasing of temperature. It enabled conclusion that in AN with addition of ammonium sulfate(VI) ran polymorphic transition causing significant decreasing of physical properties and significant increasing of explosive properties of the fertilizer. However addition of magnesium nitrate(V) prevented that transition and thermal treatment caused only slight decreasing of physical properties and slight increasing of explosive properties of such AN. These results confirmed that the main factor causing deceasing of physical properties and increasing of detonation ability of thermal treated AN is polymorphic transition IV←→III. It should be supposed that difference between results obtained by DTA method and during heating in the bath are caused by many times smaller rate of heating – a few degree Celsius per minute versus (0,1-0,2) °C/min – and many times greater mass – a few tens of milligrams and about 10 kg. Diagrams, registered during heating of AN with both additions, are showed below.

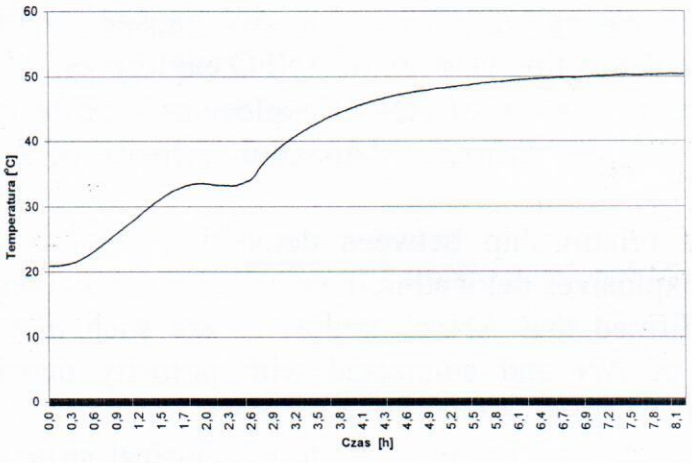


Fig.1. Diagram of changes of temperature during heating ammonium nitrate(V) with addition ammonium sulfate(VI) (there is clearly visible plateau at temperature about 33 °C)

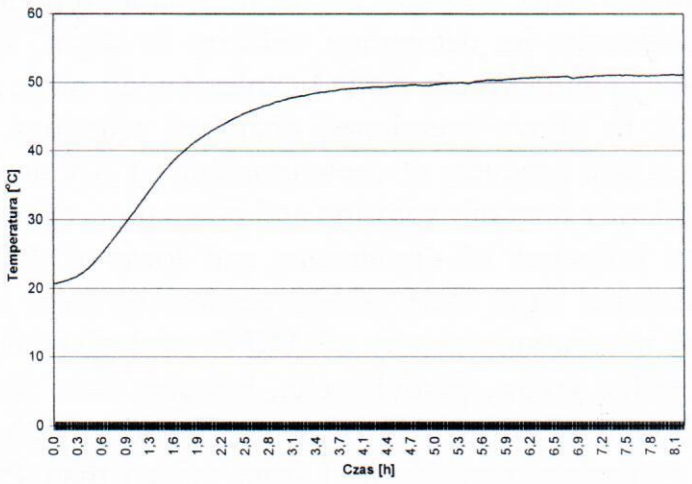


Fig. 2. Diagram of changes of temperature during heating ammonium nitrate(V) with addition magnesium nitrate(V) (there is no plateau)

Published in journal *Propellants, Explosives, Pyrotechnics* paper titled *Influence of Ammonium Nitrate Prills Properties on Detonation Velocity of ANFO* [I.2] presents results of examinations of physical properties of AN prills and detonation velocity of different kinds of ANFO explosives. Similarly to former works, basic raw material was agricultural AN, which was transformed into porous product. Next from porous AN about different porosity ANFO explosives were manufactured. Performed tests revealed that accordingly with increasing porosity of prills, which was accompanied by decreasing of density of AN, detonation velocity of ANFO explosives, produced from these AN, increased. Such course of relationship between detonation velocity and density is different than for typical explosives, for which accordingly with decreasing of density monotonically decreases detonation velocity. That phenomenon, observed also for other mixtures, should be explained by dominant influence of physical structure of material on detonation process, prevailing over influence of decreasing density.

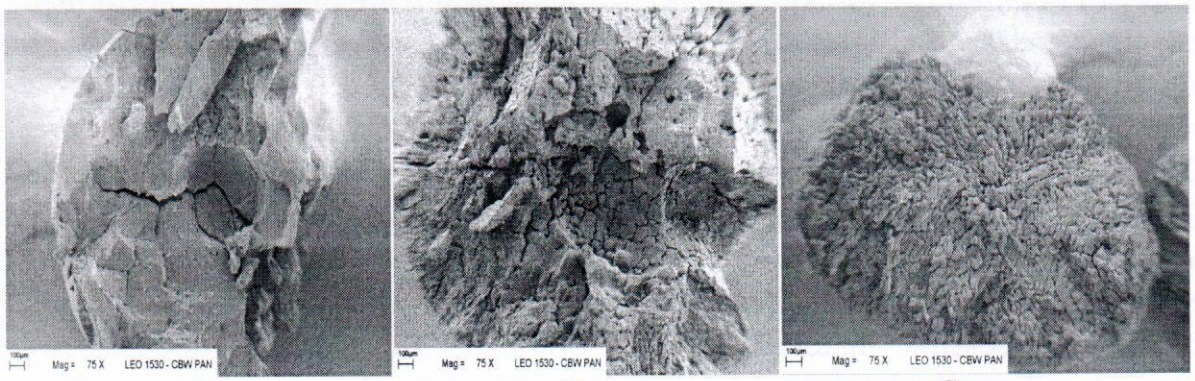
Second part of the paper are, important from practical point of view, examinations of influence of ratio between ingredients and detonation velocity, because such cases may occur, e.g. as an effect of improper dosing of ingredients. Two kinds of ANFO explosives, performed from AN of low and high porosity were tested. It was stated that if there were large discrepancy from stoichiometric composition of ANFO explosives, performed from AN of high density, decreasing of detonation velocity was big. However difference was slight if ANFO performed from AN of low porosity was tested. Probable reason of different behavior is difference of possibility of absorption of oil by AN. In case of ANFO explosives about stoichiometric composition, AN prills of low porosity can't absorb all dosed oil. Oil remaining outside prills takes part only in slight degree in chemical reactions run in zone of detonation wave and its influence on detonation velocity is small. In mixtures containing smaller content

of oil, its amount inside prills is almost the same; smaller amount is only on the surface and that influence on detonation velocity is slight. If prills of high porosity are used for manufacturing ANFO explosive, all oil is absorbed by the prills and takes art in above mentioned chemical reactions. Decreasing of amount of oil causes that products of decomposition of AN may not fully react with oil and consequently heat of explosion and detonation velocity are smaller.

Examinations on influence of dimensions and form of AN on detonation velocity of manufactured from them ANFO explosives were also carried out. Results proved that detonation velocity of ANFO explosives depends not only on dimensions of prills, grains, particles etc., but also from their form. It was measured that although of using AN of same fineness, with larger velocity detonated ANFO explosive manufactured from milled than from prilled AN. The cause of the difference is significantly bigger surface of milled than prilled AN, which causes better contact between ingredients (better mixing). The effect of better contact is quicker and fuller reaction of ingredients and higher detonation velocity.

In next paper written by professor B. Zygmunt and me [I.3] examinations of physical structure and detonation velocity of different kinds of porous AN were presented. Porous AN was manufactured by thermal treatment of fertilizer product or immediately by tower granulation of a solution containing a few percent of water. Apart from typically performed tests like: density, absorption of oil or grain size distribution also photos made by SEM were analyzed. The photos revealed that accordingly with increasing amount of thermal cycling ran changes in structure of fertilizer AN: initially compact, cast and characterized with relatively smooth and glossy surface transformed into cracked, consisting from many small crystals and their surfaces were uneven and mat. Visible on the photos lattice of capillary cracks, ending on the outer surface of the prills is undoubtedly a reason of absorption and lasting retaining of liquid hydrocarbons. Performed measurements of physical properties indicated on decreasing density and increasing of oil absorption of subjected cycles of thermal treatment AN. The photos of porous AN manufactured immediately by method of tower granulation showed, that their structure is different. The prill of such AN is a polycrystal, consisting from many, slightly elongated crystals, length about a few tens micrometer, tightly framed and partially together connated. All prill is penetrated with lattice of jointed pores and crevices causes that prill is able to absorb liquid. Dimensions of these prills were also significantly smaller than prills of fertilizer AN and prills of porous AN obtained by processing of fertilizer product. Because that factor influences significantly on explosive properties of AN and ANFO explosives it may be assessed that similarly like porous structure of prills, it is an effect of specially elaborated and carried out technological process.

Performed next measurements of detonation velocity of ANFO explosives showed that accordingly with increasing amount of thermal cycles of AN, detonation velocity of ANFO explosives manufactured from thermally treated AN increased. Such results are effect, of revealed on the photos, structure of prills, which became more and more porous accordingly to increasing number of cycles of thermal treatment. A macroscopic effect of that was decreasing of density and increasing of oil absorption. The biggest detonation velocity was registered for ANFO explosive performed from porous AN, manufactured by tower granulation, what should be connected with, described above, structure and small dimensions of prills. Small dimensions commonly with high porosity cause to significant development of surface of prills and good contact (mixing) between ingredients of ANFO explosive. Photos of different kinds of AN: fertilizer, porous manufactured by thermal treatment of fertilizer and porous manufactured by tower granulation are showed below.



A B C

Fig.3. Microscopic photos of breaks of AN prills: fertilizer (A), after thermal treatment (B), making porous by tower granulation (C) – magnification 75x

Next paper titled *Agriculture Grade Ammonium Nitrate as the Basic Ingredient of Massive Explosive Charges* [I.6], published together with prof. B. Zygmunt in *Propellants, Explosives, Pyrotechnics* showed results of examinations of explosive properties of production batch of AN manufactured in all mills in Poland and performed from these AN explosives – ANFO explosives and ammonals. Tests with using liquid materials, which improve detonation ability of AN: 2-ethylhexyl nitrate(V) and nitromethane were also carried out. It was stated that detonation velocity of modified ANFO explosives, containing active liquid ingredient, underwent significant increasing. It was also occurred that proper thermal treatment improves detonation ability of all tested production batches of AN originated from all mills.

Considering explosive properties of AN in aspect of public safety, it was experimentally proved that only when addition of inert substance, i.e. dolomite, in amount exceeding 30% mass of the fertilizer (calcium ammonium nitrate,

which is a mixture of AN and mineral meal) carry to practical loss of detonation ability of explosives manufactured from AN.

In described above jointed with professor B. Zygmunt papers, I fully and by oneself performed tests of detonation properties of AN and manufactured on its base explosives. Together with my professor conferring a degree I elaborated plans of examinations, analyzed their results and stated final conclusions.

Following, written by oneself publications, are devoted to dependence among detonation properties of mixtures based on AN and kind of added solid combustible ingredient, which was products of plant origin.

At written by oneself paper *Explosive Properties of Mixtures of Ammonium Nitrate(V) and Materials of Plant Origin – Danger of Unintended Explosion* [I.9] published at *Central European Journal of Energetic Materials* results of tests of detonation properties and behavior during heating of mixtures of AN and variety of commonly available products of plant origin are presented. Performed tests revealed that all tested mixtures detonated if were initiated only with mining detonator. Detonation velocities of some of them *exceeding 3 km/s and critical diameters were on a level of 20 mm. Tests of behavior during heating (DTA method) proved that all tested mixtures decomposed in temperatures significantly lower than AN and ANFO explosives and decomposition some them was violent.* Obtained results are important from the view point of public and technical safety. Results indicate that mixtures manufactured from AN and commonly accessible materials of plant origin as: flour, coal, wood etc. are sensitive and relatively strong explosives, which may be used for carrying out terroristic attacks. Stated low temperatures and violent run of decomposition of such kind of mixtures show, that pollution of AN by commonly accessible materials of plant origin, may run to uncontrolled decomposition of the mixture and effect of that may be explosion of material present in technological installation.

Examinations of detonation properties of AN and solid combustible ingredient in aspect of industrial applications was dedicated next, written by oneself paper, titled *Cheaper than ANFO explosive, containing ammonium nitrate and material of plant origin* [II.8] published in proceedings from Conference "Safety of Works with Explosives in Mining" organized by Central Mining Institute in 2014 y. Results of tests of detonation properties of many mixtures, which may be used as industrial explosives was presented in that paper. Taking into account that in line of industrial explosives pressure on price, which should be as low as possible, is very strong, mixtures containing cheap, commonly accessible materials, like: barley, turnip, soya or lupine were tested. All tested mixtures detonated if were initiated only with mining detonator, detonation velocities many of them were on a level of 3,5 km/s and the lowest

critical diameter was 20 mm. Apart from results of tests, idea of a lorry – similar to MEMU vehicles - for manufacturing and charging into blasting holes manufactured mixtures was presented. Because producing mixtures from milled AN, which would be carry on site of performing blasting works, would be connected with serious drawbacks caused among others by tendency to caking and hygroscopicity of AN, proposed vehicle would be equipped, different to existing lorries, with mill used for milling prilled AN.

Subject matter of examinations of energetic properties of explosives, which are mixtures was devoted a paper titled *Examinations of energetic properties of ANFO explosives with using ballistic mortar and cylindrical test* [II.1]. That paper was lectured and published in proceedings from the conference organized by Central Mining Institute. The authors, apart me, are professors W. Trzciński i B. Zygmunt. In scope of that work we performed tests with using following methods: cylindrical test, ballistic mortar test and detonation velocity. Raw material, for manufacturing ANFO explosives was AN, originated from one production batch, which was processed in different manners: performing porous product or milled. The results disclosed that accordingly with increasing porosity and fineness of AN, detonation velocity and Guerney's energy of ANFO explosives increased, but determined with using ballistic mortar, ability to performing work was on constant level. Performed additionally measurements, with using ballistic mortar and charges of the same composition:

- mixtures of milled AN and coal dust,
- consisting of separated layers of milled AN and coal dust

showed that ability to performing work by charges of two kinds was similar.

Differences in results are caused by different conditions of performing the tests. During the test with using ballistic mortar, products of reaction relatively long stay in closed chambers, which enables their fully reaction, practically independently of degree of mixing of the ingredients. While during cylindrical test the tube, which is framing of the charge, is fast driven, undergoes fragmentation and only in small degree limits dispersing of products of reaction. A reason of such incidents are conditions significantly less advantageous for further reaction among products of reaction. Performed tests enabled assessment that using ballistic mortar for testing mixtures about weak explosive properties seems to have limited applying. However cylindrical test significantly better imitates conditions existing during blasting works and should be a standard test, used for evaluation of energetic characteristics of explosives applied in industry.

In my opinion, presented results of examinations show that subject matter described in above mentioned cycle of publication is current and of big practical importance. Moreover performed tests broaden knowledge about detonation properties of manufactured and applied on mass scale mineral fertilizers and explosives. Confirmation of that conclusion are numerous citations of my

publications in technical, scientific, world known fame journals (totally ca. 90 times in Scopus base, including only 7 selfcitations).

5. Describing of other scientific and research achievments

In 2005 y. I received, from the Ministry of Science and University Education, experimental, mentorship project **nr 0 T00C 026 28**, realized at Institute of Industrial Organic Chemistry, titled "*Influence of physical structure of ammonium nitrate prills on explosive properties of ANFO explosives*". I was the main performer of that project. In the scope of the project I performed significant part of experiments related to Ph.D. dissertation, mainly detonation properties of ANFO explosives.

In 2007 y. I received, from the Ministry of Science and University Education, experimental, own project **no. O N508 1192 33**, titled „*Identification of threat of public safety caused by mass production and accessibility of fertilizer ammonium nitrate – counteracting of bomb terrorism*"; I was the manager of the project. The project was realized in years 2007-2010 at Institute of Industrial Organic Chemistry. During realization the project I switched my interests on possibilities of manufacturing explosives from fertilizers which are mixtures of AN and inert substances. On base of performed examinations, I proved that addition of inert substances, like dolomite or anhydrite, to fertilizers do not prevent of possibility of relatively easy manufacturing from the fertilizers, ANFO explosives or ammonals. In some cases even from fertilizer containing a few tens percent of mineral meal it was succeeded to manufacture an explosive. Conclusions from realization of the project was presented to domestic producers of nitrogen fertilizers and was published in scientific journals [I.4,6] and on domestic and foreign conferences [II.5,6].

Started during performing the above mentioned project examinations of detonation properties of mixtures of AN and materials of plant origin were developed during realization an inner experimental project in scope of statutory activity of Institute of Industrial Organic Chemistry executed in 2012 y. Based on results of performed tests, I found that mixtures of AN and many materials of plant origin decompose in violent way at temperatures nearing to melting temperature of AN and have significantly detonation properties. Results obtained during realization of the project were presented on scientific-technological conferences and in journals [I.5,9 and II.8].

Carried out at Institute of Industrial Organic Chemistry experimental works caused to elaboration of two patents, which I am a coinventor:

- Patent PL 176297 B1, *Way of obtaining porous ammonium nitrate,* date of notification: 21.02.1995, patent granted: 31.05.1999;
- Patent PL 196449 B1, *Way of manufacturing granulated explosives,* date of notification: 29.04.2002, patent granted: 31.01.2008.

In table 1 I have collected number of publications according to their kind with division on publications before and after obtaining Ph.D. degree.

Table 1. List of publications before and after obtaining Ph.D. degree

Kind of publication	Number of publications		
	before Ph.D. degree	after Ph.D. degree	totally
Authorship or coauthorship papers from list A	0	8	8
Authorship or coauthorship papers from list B	9	4	13
Granted patents	1	1	2
Authorship or coauthorship of scientific papers in others journals	1	0	1
Authorship or coauthorship of monographs	0	1	1
Authorship or coauthorship of scripts	0	0	0
Authorship or coauthorship of scientific papers in conference's proceedings	19	8	27

5.1. Total impact factor of publications according to list of Journal Citation Reports (JCR), accordingly with the year of publication

Total impact factor of publications, according to the year of edition amounts **6,527**, considering the paper from 2011 y. in Central European Journal of Energetic Materials on level of year 2012.

5.2. Number of citations of publications according to base Web of Science (WoS)

Number of citations of publications accordingly with base Web of Science amounts 87, including 80 without selfcitations.

5.3. Hirsch Index of published papers according to base Web of Science (WoS)

Hirsch Index of published papers according to base Web of Science (WoS) and Scopus **amounts 5.**

5.4. Prizes for scientific activity

Team prize awarded by the Rector of Military Academy of Technology for elaborating and issuing the monograph *Explosives of third generation*, 2008 y.

5.5. Lectures presented on conferences and seminars scientific-technological
Results of my works were presented during a few tens of seminars and conferences. The list of them is given below.

Conference *IPOEX*, organizer – Institute of Industrial Organic Chemistry, annually from 2004 to 2018 y., 15 times,

Conference *Safety of Works with Explosives in Mining*, organizer - Central Mining Institute - 1993, 1996, 1999, 2006, 2008, 2010, 2012, 2014, 2016 and 2018 y., 10times,

Conference *Scientific Aspects of Armament and Safety Technology*, organizers – Military Academy of Technology and Military Institute of Armament's Technology, 2002 and 2004 y., twice,

Seminar *New Trends in Research of Energetic Materials*, organizer - University of Pardubice (The Czech Republic), 1999, 2000, 2001, 2002, 2003, 2005 and 2010 y., 7 times,

Conference *Blasting Technique*, organizer – Slovak Society of Blasting Engineers, 2004 y., once,

Conference *Development and Technological Safety in Technology of Nitrogen Fertilizers* (later names *Nitrate and Granulation*), organizers – Wrocław University of Technology, Institute of Artificial Fertilizers and Association of Engineers and Technicians of Chemical Industry, 1994, 1995, 1999, 2013 and 2018 r., 5 times,

Scientific Congress of Polish Chemical Society, organizers – Polish Chemical Society and Association of Engineers and Technicians of Chemical Industry, 1999 and 2001 y., twice,

Congress of Chemical Technology, organizer – Szczecin University of Technology, 1994 y., once,

Conference *Rocky Mining – Current State and Perspectives*, organizers – Wrocław University of Technology, Association of Engineers and Technicians of Mining and Institute of Opencast Mining, 1996 y., once,

Conference *Mining of Rocky Raw Materials in Economy at the Beginning of the XXI Century*, organizers - Wrocław University of Technology and Institute of Opencast Mining, 2001 y., once.

6. Activity in the fields of development of technology, training and teaching

6.1.Standardization activity

I'm the author of the draft of the standard *PN-C-87082:2000, Artificial fertilizers, Simple nitrogen fertilizers of high nitrogen concentration containing ammonium nitrate, determination of resistance to detonation.*

6.2.Activity in the field of transport of dangerous goods

From 2004 y. I have advisor's power affairs of Safety in Transport of Dangerous Goods (DGSA advisor).

From 2015 y. I am the member of advisory Team affairs of transport of dangerous goods working at the Ministry of Infrastructure.

6.3.Activity for governmental organizations

From 2016 y. I am the member of the Qualifying Commission appointed by the Minister of Economy (now Minister of Development), confirming vocational training of people applying for permission of access to explosives for civil uses (demolitions with using explosives, demining of area, examinations of explosives, blasting works, pyrotechnic shows).

6.4. Teaching activity

Teaching of laboratory classes at subject *Dangerous substances* with students from Military Academy of Technology and Warsaw University of Technology during student's practice and auditorium classes.

Warszawa, 07.03.2019 .....

Signature