ACTUAL PROBLEMS OF MODERN SCIENCE

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CONTENT

1 UKRAINE - EUROPEAN UNION: STATE, PROBLEMS AND PROSPECTS 8

1.1 UKRAINE'S GREEN DEAL TO THE EUROPEAN UNION *(**Mezentseva M., Kazakova N, Zhuravlova Y.**)* 8

1.2 ANALYSIS OF PLANT MARKET PRODUCTS OF UKRAINE ***(Kutsyk V.)*** 16

1.3 MOTIVATIONAL POTENTIAL OF A LEADER IN ENTERPRISE DEVELOPMENT MANAGEMENT (***Stadnyk V., Khomych L.***) 26

1.4 RAW MATERIAL AND RESOURCE POTENTIAL OF FORMATION OF LOCAL INTEGRATED SYSTEMS IN THE AGRO-INDUSTRIAL COMPLEX ***(Mitsenko N.)*** 36

1.5 MANAGEMENT OF AN INNOVATIVE PROJECT TAKING INTO ACCOUNT RISK FACTORS ***(Mykytyuk P., Mykytyuk Y., Trush I.)*** 47

1.6 ANALYSIS OF THE FINANCIAL STABILITY OF INDUSTRIAL ENTERPRISES AS A PREREQUISITE FOR SUCCESSFUL OPERATION IN AN UNSTABLE MARKET ENVIRONMENT ***(Ohrenych Yu.)*** 58

1.7 ANALYSIS OF THE LNG MARKET AS AN ESSENTIAL PART OF THE STRATEGY FOR TRANSFORMING WORLD ECONOMIES AND AN ENVIRONMENTALLY FRIENDLY ECONOMY ***(Grzybowski M.)*** 71

1.8 JUVENILE DELINQUENCY IN POLAND - A STUDY OF CRIMINAL LAW AND CRIMINOLOGY ***(Ożóg Ju.)*** 82

1.9 RESOURCE POTENTIAL MANAGEMENT AS A COMPONENT OF THE SYSTEM FOR ENSURING ENTERPRISES' ECONOMIC SECURITY ***(Hryhoruk P., Khrushch N., Grygoruk S.)*** 96

1.10 COMPENSATION TOOLS IN PROACTIVE ENTERPRISE MANAGEMENT ***(Slobodyan T.)*** 103

1.11 KAPITAŁ INTELEKTUALNY I SMART-TECHNOLOGIE W ZARZĄDZANIU NOWOCZESNYM PRZEDSIĘBIORSTWEM ***(Riepina I., Gonchar A.)*** 110

1.12 NARZĘDZIA MARKETINGOWE W ZAPEWNIENIU ROZWOJU INNOWACYJNEGO POTENCJAŁU PRZEDSIĘBIORSTWA I WZROSTU KONKURENCYJNOŚCI ***(Berdychevskyi A., Pushkina Yu.)*** 121

1.13 ZASADY ORGANIZACJI ZAOPATRZENIA ODDZIAŁÓW I ZWIĄZKÓW TAKTYCZNYCH WOJSK UKŁADU WARSZAWSKIEGO W AMUNICJĘ WEDŁUG POGLĄDÓW Z LAT 70. I 80. XX WIEKU ***(Wojcieszak A.)*** 129

1.14 MARKETING RESEARCH IN ENTERPRISE POTENTIAL MANAGEMENT IN CONDITIONS OF COMPETITION AND EUROPEAN INTEGRATION ***(Gonchar O., Zakryzhevska I., Bitiy A.)*** 137

1.15 THE INFLUENCE OF REPRESENTATIVES OF THE POLISH NOBILITY ON THE ART OF PARK BUILDING IN PODILLYA ***(Khalaytcan V., Strelbitska N., Bromberek F.)*** 150

1.16 PRACTICE AS AN ESSENTIAL PART OF PROFESSIONAL TRAINING OF FUTURE SOCIAL WORKERS ***(Nahorna O., Nahornyi Ya.)*** 160

1.17 DEMOGRAPHIC SITUATION IN UKRAINE AND POLAND ***(Tsvihun I.)***..... 167

1.18 THE ROLE OF DIGITAL TRANSFORMATION IN THE MANAGEMENT OF THE ENTERPRISE ***(Mykoliuk O., Bobrovnyk V.)*** 173

1.19 ASSESSMENT OF CLUSTER TOOLS FOR THE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS IN THE CONTEXT OF FORMING A MODEL OF THEIR SECURITY-ORIENTED MANAGEMENT ***(Bohatchyk L.)*** 181

1.20 KEY TRENDS AND ACTUAL PROBLEMS OF DEVELOPMENT OF THE DOMESTIC INSURANCE SECTOR ***(Khrushch N., Prystupa L.)*** 191

1.21 PROBLEMATIC ASPECTS AND STRATEGIC GUIDELINES FOR STRENGTHENING THE TECHNOLOGICAL COMPETITIVENESS OF UKRAINE'S ECONOMY IN THE MARKETS OF THE EUROPEAN UNION ***(Zaychenko V., Kunytska-Iliash M., Berezivskyi Y.)*** 201

1.22 PRACTICE AS AN ESSENTIAL PART OF PROFESSIONAL TRAINING OF FUTURE SOCIAL WORKERS ***(Lupak R., Vasyltsiv T., Nakonechna N.)*** 206

1.23 MARKET ANALYSIS AND NUTRITIONAL VALUE OF TECHNICAL HEMP PRODUCTS ***(Dombrovska O. Chursina L., Tikhosova H.)*** 214

1.24 DIGITALIZATION OF UKRAINIAN ECONOMY: TRENDS, CHALLENGES AND THREATS TO THE DEVELOPMENT OF THE SOCIETY ***(Luchyk S., Luchyk V., Semykina M.)*** 227

1.25 THE IMPACT OF COVID-19 PANDEMIC ON LITHUANIAN BUSINESS ***(Kazlauskiene V., Christauskas C.)*** 236

1.26 MARKETING MANAGEMENT OF ENTERPRISES AND ITS TOOLS ***(Dovhan Yu.)***..246

1.27 CREDIT RATING AS AN INDICATOR OF THE FINANCIAL POLICY DEVELOPMENT OF EU COUNTRIES ***(Kazakova N., Maiboroda O., Korzh E.)*** 255

1.28 FEATURES OF STOCK MARKET DEVELOPMENT IN THE WORLD AND IN UKRAINE ***(Horbanevych V., Ivaniuta P.)*** 264

1.29 DIGITIZATION OF PERSONNEL MANAGEMENT PROCESSES ***(Pererva P., Kuchynskyi V.)*** 275

1.30 PSYCHOLOGICAL PECULIARITIES OF MOTIVATION IN MASTERING A FOREIGN LANGUAGE ***(Kharzhevska O.)*** 286

1.31 DUAL EDUCATION AT THE NUWEE: SUCCESSES AND PROBLEMS (ON THE EXAMPLE OF THE SPECIALTY "AGRICULTURAL ENGINEERING") ***(Nalobina O., Holotiuk M., Bundza O.)*** 296

1.32 CURRENT TRENDS AND FEATURES OF TOURISM DEVELOPMENT AMID PANDEMIC ***(Liubchuk O., Sharko M.)*** 306

2 MODERN ENGINEERING AND TECHNOLOGY 315

2.1 ROBOTICS IN UKRAINE ***(Zinko R., Polishchuk O., Polishchuk A., Bromberek F.)***315

2.2 FRICTION BRAKE UNITS IN RAIL VEHICLES - ASPECTS OF OPERATION ***(Szyca M., Musiał Ja.)*** 324

2.3 PROCESSING MAPS AND CONSTITUTIVE MODELLING THE HOT WORKING BEHAVIOUR OF HIGH MANGANESE AUSTENITIC STEELS ***(Borek W., Polishchuk A., Skyba M., Polishchuk O.)*** 335

2.4 GRAIN REFINEMENT OF MAGNESIUM ALLOYS ***(Król M., Skyba M., Polishchuk O.)*** 341

2.5 THE USAGE OF SOLIDWORKS CAD/CAM/CAE TECHNOLOGIES IN KHMELNYTSKYI NATIONAL UNIVERSITY ***(Kharzhevskyi V., Marchenko M.)*** 347

2.6 DIFFERENTIAL ACTIVE EMG ELECTRODE IN PROSTHETICS – PERFORMANCE ANALYSIS ***(Dziemianowicz M.1, Tomaszuk A.)*** 356

2.7 THE IMPORTANCE OF POST WELDING CLEANING AND ITS INFLUENCE ON THE CORROSION RESISTANCE OF WELDED DSS ***(Brytan Z.)*** 366

2.8 ANALYSIS OF ENERGY DISSIPATION USING A MATHEMATICAL MODEL UNDER CYCLIC LOADS OF AN ALUMINUM ALLOY ***(Karasiewicz T., Polański Ju.)*** ... 381

2.9 PROSPECTS OF USING COMPOSITE FILAMENTS WITH HIGH METAL CONTENT FOR MANUFACTURE OF INDUSTRIAL MACHINE BUILDING PRODUCTS METHOD OF 3D PRINTING ***(Polishchuk O., Bonek M., Skyba M., Polishchuk A., Lisevich S.)*** 390

2.10 SYSTEM RESEARCH «SHAPING FABRIC – LOADING DEVICE» ***(Kushchevskiy N., Koshevko J.)*** 397

2.11 EFFECT OF LASER HPDL SURFACE MODIFICATION OF X40CRMOV5-1 HOT-WORK TOOL STEEL ***(Bonek M., Polishchuk O.)*** 408

2.12 THE INFLUENCE OF THE MILL-TURNING TECHNOLOGICAL CONDITIONS ON THE SURFACE QUALITY ***(Słomion M., Matuszewski M., Wojciechowski A.)*** 415

2.13 EVALUATION OF ACCURACY OF THE METHOD OF CALCULATION OF THE EFFECTIVE LEVEL OF DEFORMATION OF CONTACTING SURFACES OF CYLINDER-PISTON SEALS ***(Tymoshchuk O.)*** 425

2.14 PROBLEMS OF DESIGNING ROBOTS INTENDED TO WORK IN EXTREME ENVIRONMENT AND TEMPERATURES ***(Giergiel M., Szczepkowicz T., Wójcik J.)*** 431

2.15 BaTiO3-DOPED PVP NANOFIBERS FABRICATED BY ELECTROSPINNING METHOD ***(Matysiak W., Zaborowska M., Polishchuk O.)*** 437

2.16 AUTOMATIC CONTROL SYSTEM FOR THIN POLYMER APPLICATION DEVICES WITH EVALUATION OF QUALITY AND ECONOMIC EFFICIENCY OF COATING ***(Horiashchenko S., Horiashchenko K., Kravchik Yu.)*** 444

2.17 DESIGN METHODS FOR REDUCTION OF FORCED VIBRATIONS OF HORIZONTAL ROTARY MACHINES ***(Drach I., Goroshko A.)*** 451

2.18 DETERMINATION OF BULK DENSITY OF MIXTURES OF FRACTIONS OF CRUSHED POLYMERIC MATERIALS ***(Misiats O., Misiats V., Rubanka M., Polishchuk A., Skyba M.)*** 462

2.19 INFORMATION TECHNOLOGIES FOR VISUALIZATION OF THE DIAGNOSTIC RESULTS OF THE FORMATION OF THE COMPETENCIES OF FUTURE ENGINEERS IN MULTIDIMENSIONAL NON-METRIC SPACES ***(Chornyi O., Herasymenko L., Tytiuk V., Busher V.)*** 467

2.20 FORMATION OF QUALITATIVE PROPERTIES OF TEXTILE SHOES BASED ON TECHNICAL HEMP ***(Boyko G., Kalinsky E., Tikhosov A.)*** 478

2.21 PHYSICO-CHEMICAL AND TRIBOLOGICAL PROPERTIES OF NITROGENED LAYERS OF STRUCTURAL STEEL ***(Skyba M., Stechyshyn M., Stechyshyna N., Martynyuk A., Lyukhovets V.)*** 488

2.22 MODELING OF INFORMATION AND ANALYTICAL SYSTEMS BASED ON THE THEORY OF FUZZY LOGIC ***(Mikhalevskyi V., Mikhalevska G.)*** 500

2.23 MODERNIZATION OF ENERGY BLOCKS AS AN ALTERNATIVE IN PRO-ECOLOGICAL POWER SUPPLY PROCESSES ***(Gutsche J., Muślewski Ł., Dzioba A., Matiukh S.)*** 508

2.24 CREATION THE INNOVATIVE TECHNOLOGIES OF PRIMARY PROCESSING OF BAST CROPS ***(Berezovsky Yu., Kuzmina T.)*** 517

2.25 FORMATION OF THE MECHANISM OF COMMERCIALIZATION OF INTELLECTUAL TECHNOLOGIES ON THE BASIS OF THE FUNCTIONAL APPROACH ***(Pererva P.G., Maslak M.V., Kobielieva A.V.)*** 527

2.26 INNOVATIVE TRENDS IN INDUSTRIAL MACHINERY ENGINEERING AND EDUCATION ***(Berezin L., Oliinyk O. , Rubanka M.)*** 538

2.27 NEW CELLULOSE-CONTAINING MATERIALS FROM HEMP ***(Putintseva S., Tikhosova A., Fediakina N.)*** 549

2.28 STUDY OF A BIO-BASED FIRE RETARDANT FOR IMPARTING FIRE RESISTANCE TO COTTON TEXTILES ***(Horokhov I., Saribyekova Yu., Asaulyuk T., Lavrik V.)*** 558

2.29 OPERATIONS ANALISYS OF REAPER OPERATION FOR SUNFLOWER HARVESTING ***(Vasylchuk N., Puts V., Herasymchuk O., Martyniuk V.)*** 566

2.30 MODERN TECHNOLOGIES OF MOTOR VEHICLE BODYWORK AND PAINT REPAIRS ***(Kałaczyński T., Łukasiewicz M., Liss M.,Baranowski Sz., Dluhunovych N., Dykha O.)*** 573

2.31 YARN CLASSIFICATION BY APPEARANCE CRITERIA ***(Smykalo K., Zakora O., Yefimchuk H.)*** 583

2.32 FEATURES OF TECHNOLOGICAL PROCESS OF SCREEN PRINTING ON TEXTILE MATERIALS ***(Prybeha D., Smutko S., Skyba M.)*** 593

2.33 RESEARCH ON THE EFFECT OF COMPOSITIONS OF BIOSURFACTANTS ON THE STRUCTURAL-MORPHOLOGICAL AND MECHANICAL PROPERTIES OF TEXTILES ***(Paraska O., Radek N., Hes L.)*** 601

2.34 TECHNOLOGY OF FORMATION OF ANTIBACTERIAL PROPERTIES OF LINING LEATHERS ***(Kozar O., Zhiguts Yu.)*** 611

2.35 RATIONALE FOR IMPLEMENTING EUROPEAN MODULAR SYSTEMS IN EUROPE ***(Dzioba A, Muślewski Ł., Gutsche J., Polishchuk O.)*** 619

2.36 CHARACTERIZATION OF NANOCRYSTALLINE ZINC OXIDE SYNTHESIZED BY DIRECT PRECIPITATION METHOD ***(Asaulyuk T., Semeshko O., Saribyekova Yu.)*** 629

2.37 INTERNATIONAL JOURNAL OF ROTATING MACHINERYIMPROVING THE EFFICIENCY OF THE DARRIEUS ROTOR ***(Serilko L., Stadnyk O., Sasiuk Z., Serilko D.)*** 637

2.38 TRIBOTECHNICAL PROPERTIES OF NANOMODIFIED FLUOROPLASTIC MATERIALS ***(Dykha O., Svidersky V., Kirichenko L., Makovkin O., Posonsky S.)***..... 648

2.39 RESEARCH OF TRIBOTECHNICAL CHARACTERISTICS OF ORIENTED CARBON PLASTICS ***(Dykha O., Drobot O., Oleksandrenko V., Pidhaichuk S., Babak O.)*** 659

2.40 AUTOMATED DESIGNING OF MECHANICAL PROCESSES BY SYNTHESIS METHOD ***(Savitskyi Y.)*** 669

2.41 COMPARATIVE ANALYSIS OF FUNCTIONALLY ADEQUATE PRODUCT MOVEMENT MANIPULATORS ON SEWING MACHINES ***(Orlovsky B.)*** 677

2.42 SELECTED ASPECTS OF TECHNICAL STATE GENESIS OF HYBRID MULTIMEDIA MOBILE SCENES ***(Kałaczyński T., Łukasiewicz M., Liss M., Kuliś E., Wilczarska J., Musiał J.)***..... 688

2.43 POSSIBILITIES OF USING A HYBRID PHOTOELECTRIC SYSTEM WITH A STORAGE BATTERY FOR THE NEEDS OF A LOCAL OBJECT ***(Shavolkin O., Shvedchykova I.)*** 698

2.44 NEW TECHNOLOGIES SYNTHESIS OF SPECIAL CAST IRONS FOR HIGH TEMPERATURES ***(Zhiguts Yu., Kozar O.)***..... 708

2.45 MECHANISMS WITH VARIABLE LENGTH OF LINKS FOR DRIVE GUIDE NEEDLES OF KNITTING MACHINES ***(Dvorzhak V., Polishchuk O., Rubanka M.)*** 715

2.46 IMPACT OF THE DYNAMIC LOADS OF A NEEDLE-WEDGE PAIR OF A KNITTING MACHINE FOR THE LONGEVITY OF THE WEDGES ***(Pleshko S., Kovalyov Y.)***726

2.47 WEAR RESISTANCE OF NITROGENED STRUCTURAL STEEL WITH LIMIT AND DRY FRICTION ***(Stechyshyn M., Oleksandrenko V., Lukyanyuk M.)*** 733

2.48 MICROSCOPY INVESTIGATION OF MULTILAYER PE FILMS ***(Bilewicz M., Gliński T., Polishchuk A., Polishchuk O.)***..... 741

2.49 LINEAR CURRENT SWEEP AND MEASURING THE CURRENT-VOLTAGE CHARACTERISTICS OF THE SOLAR PANEL ***(Zashchepkina N., Bozhko I.)*** 747

ALPHABETICAL INDEX OF AUTHORS 757

DETERMINATION OF BULK DENSITY OF MIXTURES OF FRACTIONS OF CRUSHED POLYMERIC MATERIALS

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1. Introduction

The purpose of the experimental study is to obtain the dependences of bulk density on the fractional composition of the crushed material.

Bulk density or bulk density of bulk material $\rho_н$ is called the mass of material that is per unit volume occupied by it. The value of $\rho_н$ is used in determining the required volume of hoppers, crushers, mixers in the calculation of energy consumption for the processing of bulk material [1, 2]. The bulk density of bulk material depends on the size of its constituent particles, their average density, humidity, the density of the particles in the layer [3, 4]. It does not remain constant even at rest of loose material. Under the influence of vibrations of walls of a vessel loose material in due course is condensed and its bulk density reaches some limiting value $\rho_{\max}$. In the process of movement, movement, mixing, on the contrary, there is a loosening of the material. The bulk density decreases, approaching the limit value $\rho_{\min}$. The $\rho_{\max} / \rho_{\min}$ ratio for some materials reaches values of 1,52 [1].

2. Research results

According to the particle size distribution of bulk material, the quantitative distribution of its constituent particles by linear dimensions is estimated. Most bulk materials have irregularly shaped particles, for which the conditional diameter d_i, calculated by three measurements of the particle (length, height and width of the particle) as the arithmetic mean or geometric mean.

Bulk material only in some cases consists of particles of the same size. More often in it the value of d_i changes discrete from some minimum size d_{min} to the maximum d_{max}. The d_{min}/d_{max} atio in some bulk materials can be very large. The particle size distribution of polydisperse materials can be characterized by a series

of distribution of the discrete random variable d_i in which the measured values of this random variable are listed: in which the measured values of this random variable are listed: d_1; d_2; d_n with the corresponding probability p_1, p_2 ..., p_n or frequencies n_1, n_2,... n_n. Determining the whole series of discrete random values of d_i for polydisperse materials with a large ratio d_{min}/d_{max} is difficult, so this series is replaced by a discrete series of classes (fractions) of values of d_i. To determine the particle size distribution of bulk materials used methods of direct measurement and sieve analysis [5].

Materials and equipment used in the study:

- measuring cup with a volume of 1000 cm3;

- laboratory scales with a weighing limit of 500 g and a weighing error of not more than 0.5 g;

- laboratory vibrator 028-M with a set of sieves.

In the sieve analysis, the powder residue on the sieves after sieving was quantified, followed by the calculation of its content as a percentage of the total weight of the sample taken for sieving.

A set of sieves with different hole sizes with shells with a diameter of 200 mm and a board height of 50 mm was used for sieve analysis. The value of the size class of the material fraction was determined by the size of the holes of adjacent sieves. For example, if the lower sieve has an opening equal to 0.5 and the upper 0.7 mm, then between these sieves after sieving will remain a fraction of bulk material of class (0.5 ... 0.7) mm.

The research was conducted in the following order.

Waste materials were ground on a rotary crusher using grids with different hole diameters. Using a set of sieves, the crushed materials were divided into fractions by particle size (Fig. 1).

A mixture of different fractions in a certain ratio was prepared. Using a measuring cup and a weight, the bulk density of each fraction of powder and mixture was determined.

Waste of polymeric materials of shoe production was used as the investigated material.

The study used the method of simplex-lattice planning of the experiment [6].

Mixtures of crushed rubber were formed by three sieved fractions (Table 1), the mass fraction of which varied at four levels: 0; 0.33; 0.66, 1.

A B C

Fig. 1. Fractions of crushed rubber: A - 10 mm; B - 5 mm; C - 2 mm

The bulk density of the investigated bulk material was calculated by the formula:

$$\rho_H = \frac{G_1 - G}{O_{cm}}, \quad (1)$$

where G_1 and G – respectively, the weight of the glass with the material and without it; O_{cm} is the volume of the glass.

The experiments were performed in triplicate. The results of the experiment to determine the bulk density of the crushed polymer waste are presented in tables 2.

Table 1. Particle size distribution of the fractions of the studied materials

Rubber particle size, mm	10	5	2
Denotation of quantity content	X1	X2	X3

As a result of processing the experimental data, it was found that the bulk density of mixtures of fractions of crushed materials with sizes from 10 to 2 mm varies within 15% (Fig. 2), so the obtained experimental data were approximated depending on the average particle size in the material mixture. by the formula:

$$\overline{d} = d_1 X_1 + d_2 X_2 + d_3 X_3, \qquad (2)$$

where d_1, d_2, d_3 - particle size in the fractions of the mixture, X_1, X_2, X_3 quantity content of fractions in the mixture.

Table 2 The results of the experiment

№	X1	X2	X3	Y1	Y2	Y3	Ymid
1	1	0	0	471	470	471	470,7
2	0	1	0	497	497	495	496,3
3	0	0	1	408	409	408	408,3
4	0.33	0.33	0.33	468	473	473	471,3
5	0.33	0.66	0	456	463	462	460,3
6	0	0.33	0.66	435	433	431	433
7	0.66	0.33	0	471	469	470	470
8	0.33	0	0.66	458	459	454	457
9	0.66	0	0.33	504	493	496	497,7
10	0	0.66	0.33	462	462	462	462

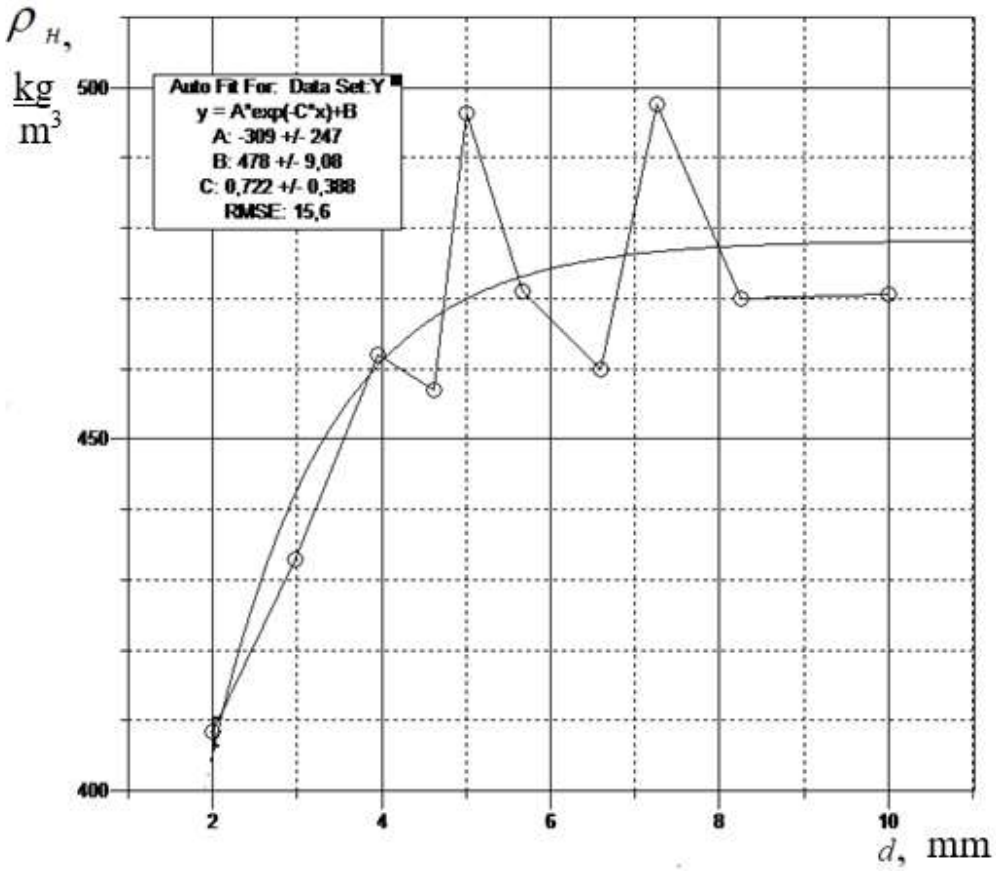

Fig. 2. The results of data processing of experimental research of forced rubbers from the average particle size of compatible fractions

3. Conclusion

The obtained functions for calculating the bulk density of polymeric materials depending on the average particle size are presented in table. 3.

Table 3 Functions for calculating bulk density depending on the average particle size of polymeric materials

Material	Density, kg /m^3	bulk density of the mixture of fractions 10…2 mm, kg/m^3
PVC plastic	1250	$\rho_н = 519 - 423\exp(0{,}834\bar{d})$
Rubber	1100	$\rho_н = 478 - 309\exp(0{,}722\bar{d})$
Polyethylene	950	$\rho_н = 398 - 257\exp(0{,}672\bar{d})$

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ALPHABETICAL INDEX OF AUTHORS

Asaulyuk T. *558, 629*
Babak O. *659*
Baranowski Sz. *573*
Berdychevskyi A. *121*
Berezin L. *538*
Berezivskyi Y. *201*
Berezovsky, *517*
Bilewicz M. *741*
Bitiy A. *137*
Bobrovnyk V. *173*
Bohatchyk L. *181*
Bonek M. *390, 408*
Borek W. *335*
Boyko G. *478*
Bozhko I. *747*
Bromberek F. *150, 315*
Brytan Z. *366*
Bundza O. *296*
Busher V. *467*
Chornyi O. *467*
Christauskas C. *236*
Chursina L. *214*
Dluhunovych N. *573*
Dombrovska O. *214*
Dovhan Yu. *246*
Drach I. *451*
Drobot O. *659*
Dvorzhak V. *715*
Dykha O. *573, 648, 659*
Dziemianowicz M.1 *356*
Dzioba A. *508, 619*
Fediakina N. *549*
Giergiel M. *431*
Gliński T. *741*
Gonchar A. *110*
Gonchar O. *137*
Goroshko A. *451*
Grygoruk S. *96*
Grzybowski M. *71*
Gutsche J. *508, 619*
Herasymchuk O., *566*
Herasymenko L. *467*
Hes L. *601*
Holotiuk M. *296*
Horbanevych V. *264*
Horiashchenko K. *444*
Horiashchenko S. *444*
Horokhov I. *558*
Hryhoruk P. *96*
Ivaniuta P. *264*
Kałaczyński T. *573, 688*
Kalinsky E. *478*
Karasiewicz T. *381*
Kazakova N. 8, *255*
Kazlauskiene V. *236*
Khalaytcan V. *150*
Kharzhevska O. *286*
Kharzhevskyi V. *347*
Khomych L. *26*
Khrushch N. *96, 191*
Kirichenko L. *648*
Kobielieva A.V. *527*
Korzh E. *255*
Koshevko J. *397*
Kovalyov Y. *726*
Kozar O. 611, 708
Kravchik Yu. *444*
Król M. *341*
Kuchynskyi V.A. *275*
Kuliś E. *688*
Kunytska-Iliash M. *201*
Kushchevskiy N. *397*
Kutsyk V.I. *16*
Kuzmina T. *517*
Lavrik V. *558*
Lisevich S. *390*
Liss M. 573, *688*
Liubchuk O. *306*
Luchyk S. *227*
Luchyk V. *227*
Łukasiewicz M. *573, 688*
Lukyanyuk M . *733*
Lupak R. *206*
Lyukhovets V. *488*
Maiboroda O. *255*
Makovkin O. *648*
Marchenko M. *347*
Martyniuk V. *566*
Martynyuk A. *488*
Maslak M. *527*
Matiukh S. *508*
Matuszewski M. *415*
Matysiak W. *437*
Mezentseva M. *8*
Mikhalevska G. *500*
Mikhalevskyi V. *500*

Misiats O. *462*
Misiats V. *462*
Mitsenko N. *36*
Musiał Ja. *324, 688*
Muślewski Ł. *508, 619*
Mykoliuk O. *173*
Mykytyuk P. *47*
Mykytyuk Y. *47*
Nahorna O. *160*
Nahornyi Ya. *160*
Nakonechna N. *206*
Nalobina O. *296*
Ohrenych Yu. *58*
Oleksandrenko V.*659,733*
Oliinyk O. *538*
Orlovsky B. *677*
Ożóg Ju. *82*
Paraska O. *601*
Pererva P. *275*, *527*
Pidhaichuk S. *659*
Pleshko S. *726*
Polański Ju. *381*
Polishchuk A. *315, 335, 390, 462, 741*
Polishchuk O. *315,335,341, 390,408,437,619,715,741*
Posonsky S. *648*
Prybeha D. *593*
Prystupa L. *191*
Pushkina Yu. *121*
Putintseva S. *549*
Puts V. *566*
Radek N. *601*
Riepina I. *110*
Rubanka M. *462,538, 715*
Saribyekova Yu. *558, 629*
Sasiuk Z. *637*
Savitskyi Y. *669*
Semeshko O. *629*
Semykina M. *227*
Serilko D. *637*
Serilko L., *637*
Sharko M. *306*
Shavolkin O. *698*
Shvedchykova I. *698*
Skyba M. *335, 341, 390, 462, 488, 593*
Slobodyan T. *103*
Słomion M. *415*
Smutko S. *593*
Smykalo K. *583*
Stadnyk O. *637*
Stadnyk V. *26*
Stechyshyn M. *488, 733*
Stechyshyna N. *488*
Strelbitska N. *150*
Sviderskyi V. *648*
Szczepkowicz T. *431*
Szyca M. *324*
Tikhosov A. *478*
Tikhosova A. *549*
Tikhosova H. *214*
Tomaszuk A. *356*
Trush I. *47*
Tsvihun I. *167*
Tymoshchuk O. *425*
Tytiuk V. *467*
Vasylchuk N. *566*
Vasyltsiv T. *206*
Wilczarska J. *688*
Wojciechowski A. *415*
Wojcieszak A. *129*
Wójcik J. *431*
Yefimchuk H. *583*
Zabarowska M., *437*
Zakora O. *583*
Zakryzhevska I. *137*
Zashchepkina N. *747*
Zaychenko V. *201*
Zhiguts Yu. 611, *708*
Zhuravlova Y.8
Zinko R. *315*

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