



ACTUAL PROBLEMS
OF MODERN SCIENCE

2017

ACTUAL PROBLEMS OF MODERN SCIENCE

Edited by

Musial Janusz

UTP University of Science and Technology,
Bydgoszcz, Poland

Polishchuk Oleh

Khmelnyskyi National University, Ukraine

Sorokatyi Ruslan

Khmelnyskyi National University, Ukraine

Bydgoszcz – 2017

Actual problems of modern science. Monograph: edited by Musial Janusz, Polishchuk Oleh, Sorokatji Ruslan – 2017. – 921 p.

Monograph is prepared at the Khmelnytskyi National University in cooperation with UTP University of Science and Technology, Bydgoszcz, Poland. Article in monograph are presented in the author's original version. Authors are responsible for materials and interpretation.

EDITORIAL BOARD

Bonek M. (Poland, Gliwice), **Buratowski T.** (Poland, Krakow), **Fabian P.** (Slovakia, Zilina), **Cherep A.** (Ukraine, Zaporizhyya), **Giergel M.** (Poland, Krakow), **Grishchenko I.** (Ukraine, Kyiv), **Gonchar O.** (Ukraine, Khmelnytskyi), **Januszewski A.** (Poland, Bydgoszcz), **Kaliński K.** (Poland, Gdańsk), **Kalaczyński T.** (Poland, Bydgoszcz), **Karmalita A.** (Ukraine, Khmelnytskyi), **Karvan S.** (Ukraine, Khmelnytskyi), **Krotofil M.** (Poland, Toruń), **Kwiatkiewicz P.** (Poland, Warszawa), **Landowski B.** (Poland, Bydgoszcz), **Lenik K.** (Poland, Lublin), **Macko M.** (Poland, Bydgoszcz), **Mania T.** (Poland, Gdańsk), **Matiukh S.** (Ukraine, Khmelnytskyi), **Mazurkiewicz A.** (Poland, Bydgoszcz), **Mironova N.** (Ukraine, Khmelnytskyi), **Misiats V.** (Ukraine, Kyiv), **Moravec J.** (Slovakia, Zilina), **Mroziński A.** (Poland, Bydgoszcz), **Muślewski Ł.** (Poland, Bydgoszcz), **Polasik R.** (Poland, Bydgoszcz), **Pyryev Y.** (Poland, Warszawa), **Skyba M.** (Ukraine, Khmelnytskyi), **Szczutkowski M.** (Poland, Bydgoszcz), **Śniadkowski M.** (Poland, Lublin), **Synyuk O.** (Ukraine, Khmelnytskyi), **Topoliński T.** (Poland, Bydgoszcz), **Voynarenko M.** (Ukraine, Khmelnytskyi), **Yochna M.** (Ukraine, Khmelnytskyi), **Żółtowski B.** (Poland, Bydgoszcz), **Zhurba I.** (Ukraine, Khmelnytskyi).

REVIEWERS:

Bromberek F. (Poland, Bydgoszcz), **Bojar P.** (Poland, Bydgoszcz), **Brytan Z.** (Poland, Gliwice), **Dyha O.** (Ukraine, Khmelnytskyi), **Horiashchenko S.** (Ukraine, Khmelnytskyi), **Kawa J.** (Poland, Gdańsk), **Matuszewski M.** (Poland, Bydgoszcz), **Musial J.** (Poland, Bydgoszcz), **Muślewski Ł.** (Poland, Bydgoszcz), **Paraska O.** (Ukraine, Khmelnytskyi), **Podlewska N.** (Ukraine, Khmelnytskyi), **Radek N.** (Poland, Kielce), **Smutko S.** (Ukraine, Khmelnytskyi), **Sorokatyi R.** (Ukraine, Khmelnytskyi), **Zashchepkina N.** (Ukraine, Kyiv),

Responsible Secretary: Marina Shalapko

Technical Secretariat: Slashchuk Oleksandr, Slashchuk Viktor

ISBN 978-83-938655-3-6

© Copyright by the UTP University of Science and Technology, 2017
85-790 Bydgoszcz, Al. prof. S. Kaliskiego 7. <http://utp.edu.pl/>

CONTENT

1 UKRAINE - EUROPEAN UNION: STATE, PROBLEMS AND PROSPECTS	9
1.1 CAPITALIZATION OF BUSIN SKOROBOGATA L. MISHCHUK M. ESS IN THE CONTEXT OF DEVELOPING AN ENTREPRENEURIAL ENVIRONMENT (<i>Skorobogata L., Mishchuk M.</i>).....	9
1.2 CLUSTERS AS SOURCES OF ADDED VALUE AND ECONOMIC GROWTH (<i>Voynarenko M.</i>)	19
1.3 CONTENT AND NATURE OF INNOVATIVE BUSINESS-PROCESSES: ADMINISTRATIVE ASPECT (<i>Menchinska O.</i>).....	27
1.4 DEVELOPMENT FEATURES OF NATIONAL ECONOMIC SPACE IN THE CONTEXT OF GLOBALIZATION (<i>Matiukh S., Dziuba M.</i>)	37
1.5 ECONOMIC-MATHEMATICAL MODELS IN THE FUNDAMENTAL FORGEROUS OF THE CLUSTER STRUCTURES (<i>Barmak O., Dzhuliy V.</i>)	45
1.7 INTANGIBLE ASSETS IN THE CONTEXT OF ECONOMICS KNOWLEDGE DEVELOPMENT (<i>Dzhuliy L.</i>)	50
1.8 INVESTMENT POTENTIAL OF THE ENTERPRISE: CONCEPT, FEATURES OF FORMATION AND DEVELOPMENT (<i>Kvasnitska R., Tarasiuk M.</i>).....	59
1.9 MODELLING OF PERIODIC ECONOMIC PROCESSES DISCRETE IN TIME (<i>Bilyi L., Tsyhanchuk R.</i>).....	68
1.10 MODERN UKRAINIAN PRACTICE OF TAX AUDIT IMPLEMENTATION (<i>Voynarenko M., Gurochkina V.</i>).....	80
1.11 ORGANIZATIONAL ASPECTS OF ACCOUNTING FOR FIXED ASSETS IN UKRAINIAN AND INTERNATIONAL ACCOUNTING STANDARTS (<i>Tseben R., Humeniuk A., Tarashevskia O.</i>)	91
1.12 POLITICAL CONFLICT BETWEEN THE POLISH MINORITY AND AUTHORITIES IN THE TOTALITARIAN SYSTEM IN THE 1920 AND 1930 (IN PODILLIA REGION) (<i>Posvistak O.</i>)	99
1.13 PREMISES FOR CREATION AND DEVELOPMENT OF INNOVATION CLUSTER STRUCTURES UNDER CONDITIONS OF INSTITUTIONAL ECONOMIC DEVELOPMENT (<i>Ponomaryova N., Trocikowski T.</i>)	110
1.14 PROEUROPEJSKA POLITYKA UKRAINY (<i>Szyborski W.</i>).....	120
1.15 STIMULATING THE INVESTMENT ACTIVITY OF AGRARIAN ENTERPRISES AS A WAY OF INCREASING THE COMPETITIVENESS OF UKRAINE (<i>Shcherbakova A., Suduk O.</i>).....	130
1.16 THE CREATION AND DISTRIBUTION OF VALUE IN THE CLUSTER UNIONS OF ENTERPRISE STRUCTURES (<i>Belyakova N.</i>).....	138
1.17 THE MAJOR SUBJECTS OF THE ELECTION PROCESS (<i>Liutko N.</i>).....	147
1.18 THE PROBLEMS OF GOVERNMENT CONTROL REGULATION IN THE SPHERE OF ECONOMIC ACTIVITY (<i>Nykytchenko N.</i>).....	157

1.19 THE ROLE OF CLUSTERS IN SOCIO-ECONOMIC DEVELOPMENT OF THE STATE (<i>Yemchuk L.</i>).....	165
1.20 TRANSFORMATION OF UKRAINE IN THE GLOBAL INSTITUTIONALIZATION SYSTEM (<i>Dykha M.</i>).....	173
1.21 TRANSPORT FACTOR IN THE SYSTEM OF INTERNATIONAL TRADE (<i>Kholodenko A.</i>).....	184
1.22 USE OF MARKETING INNOVATIONS IN BUILDING LOGISTIC SUPERVISORS NETWORK (<i>Vasylkivskiy D., Matiukh S.</i>).....	193
2 MODERN ENGINEERING AND TECHNOLOGY	200
2.1 ANALIZA METOD OCENY TRWAŁOŚCI POWŁOK OCHRONNYCH (<i>Kalaczynski T., Łukasiewicz M., Wilczarska J., Sadowski A., Kuliś E., Musiał J., Podgórski J.</i>).....	200
2.2 ANALYSIS OF CORRUGATED BOARD FLAT CRUSH RESISTANCE (<i>Foryś M., Pyryev Y.</i>).....	210
2.3 ANALYSIS OF THE EFFICIENCY OF ANTIMICROBIAL PREPARATIONS FINISHING OF TEXTILES (<i>Paraska O., Karvan S., Rak T., Kovalska V.</i>).....	218
2.4 ANALYTICAL GROUNDING OF THE TRANSFORMATION PROCESS OF TRANSFORMABLE GARMENTS (<i>Zakharkevich O.</i>).....	229
2.5 APPLICATION OF MULTIFRACTAL FLUCTUATION ANALYSIS FOR FABRIC ROUGHNESS DETERMINATION (<i>Shuda I., Zhylenko T.</i>).....	240
2.6 APPLICATION OF THE METHOD <i>IN SITU</i> IN THE PROCESS OF NANOTREATMENT FOR THE OBTAINING OF FUNCTIONAL TEXTILE MATERIALS (<i>Redko Ya.</i>).....	249
2.7 APPLICATIONS OF KANSEI ENGINEERING IN CLOTHING DESIGN (<i>Kuleshova S.</i>).....	258
2.8 BADANIA WPŁYWU ROZREGULOWAŃ SILNIKA WYSOKOPRĘŻNEGO NA EMISJĘ SZKODLIWYCH SKŁADNIKÓW SPALIN (<i>Kuliś E., Musiał J., Wilczarska J., Kalaczyński T., Łukasiewicz M., Sadowski A., Dziubek N.</i>).....	267
2.9 BRITTLE FRACTURE APPEARANCE TRANSITION TEMPERATURE OF SELECTED STRUCTURAL STEELS (<i>Kalinowska-Ozgowicz E., Lenik K., Barszcz M.</i>).....	278
2.10 CALCULATION OF STRESS AND DEFORMATION OF POLYMERIC PARTS (<i>Kulik T., Zlotenko B.</i>).....	289
2.11 CAVITATIONAL RESISTANCE OF POLYOLEFINS IN NEUTRAL, ACIDIC AND ALKALINE MODEL ENVIRONMENTS (<i>Stechyshyn M., Martyniuk A., Bilyk Yu.</i>).....	299
2.12 COGNITIVE GRINDING OF RECYCLED AND REUSE MATERIALS (<i>Flizikowski J., Macko M., Mroziński A., Tomporowski A.</i>).....	309
2.13 COMMUNICATION ENVIRONMENT AS A FACTOR OF DEVELOPMENT OF INFORMATIONAL SOCIETY (<i>Mikhalevska G., Mikhalevskiy V.</i>).....	318

2.14 CREATION OF ENVIRONMENTALLY FRIENDLY MULTIFUNCTIONAL POLYMER COATINGS ON TEXTILE MATERIALS (<i>Asaulyuk T., Semeshko O., Saribyekova Y., Myasnykov S.</i>).....	325
2.15 DETERMINATION OF DUST HOLDING CAPACITY AND DUST PERMEABILITY OF MATERIALS BY MEANS OF TELEVISION MEASURING METHODS (<i>Zashchepkina N., Poriev V., Melkonian A., Korotych O., Zdorenko V.</i>).....	334
2.16 DEVELOPMENT AND RESEARCH OF VACUUM-DIFFUSION GAS-RADIOLOGICAL TECHNOLOGIES IN KHMELNYTSKYI NATIONAL UNIVERSITY (<i>Stechyshyn M., Oleksandrenko V., Sokolova G., Bilyk Yu.</i>).....	349
2.17 DISCRETE MODEL OF MOISTURE SPREADING IN TEXTILE MATERIALS FOR MEDICAL USE (<i>Schutskaya A., Suprun N.</i>).....	356
2.18 EFFECT OF DIODE LASER SURFACE ALLOYING OF COMMERCIAL TOOL STEEL (<i>Bonek M.</i>).....	372
2.19 ELECTRICAL DISCHARGE TREATMENT AS AN ENERGY-EFFICIENT WAY OF COARSE WOOL MODIFICATION (<i>Asaulyuk T., Semeshko O., Saribyekova Y., Myasnykov S.</i>).....	386
2.20 FORMATION OF THE MODEL OF THE POLYMER MATERIAL STRUCTURE DURING ORIENTATIONAL DRAWING (<i>Synyuk O., Skyba M., Romanets T.</i>).....	395
2.21 GENERAL CLASSIFICATION OF 3D PRINTING (<i>Zozulia P., Pyscheniuk N., Skyba M., Polishchuk O., Malec M.</i>).....	413
2.22 HIGH FREQUENCY SEPARATION OF SUSPENDED BY MICROPARTICLES (<i>Ostaševičius V., Golinka E., Jūrėnas V., Gaidys R.</i>).....	422
2.23 IMPROVED TRIBOTECHNOLOGY OF RUNNING-IN (<i>Aulin V., Zamota T., Lysenko S., Hrinkiv A.</i>).....	431
2.24 INCREASING THE ACCURACY OF INFORMATION MEASUREMENT SYSTEMS (<i>Markina O.</i>).....	441
2.25 INVESTIGATION OF THE FRICTION CHARACTERISTICS IN THE CYLINDRICAL SLIDING TRIBOSYSTEMS (<i>Dykha O., Sorokatyi R., Makovkin O., Posonskiy S.</i>).....	451
2.26 MATHEMATICAL ASPECTS OF INFORMATION SECURITY (<i>Kravchuk O., Dlugunovich N., Synyuk O.</i>).....	466
2.27 METHODOLOGICAL BASIS FOR CHILD STATURE STUDY IN RESPECT OF SIZE PARAMETERS ABSOLUTE VALUES (<i>Ditkovska O.</i>).....	476
2.28 OCENA NIEWŁAŚCIWYCH ODDZIAŁYWAŃ LUDZI NA BEZPIECZEŃSTWO W TRANSPORCIE SZYNOWYM (<i>Bojar P.</i>).....	486
2.29 OPTIMIZATION OF CLAMPING STIFFNESS DURING MILLING OF HIGH-DIMENSIONAL STRUCTURES WITH THE USE OF TECHNIQUES OF EXPERIMENT-AIDED VIRTUAL PROTOTYPING (<i>Kaliński K., Galewski M., Mazur M., Morawska N.</i>).....	495
2.30 POMIARY EMISJI HAŁASU WYBRANYCH ŚRODKÓW KOMUNIKACJI PUBLICZNEJ (<i>Sadowski A., Musiał J., Wilczarska J., Kalaczyński T., Łukasiewicz M., Kasprowicz T., Kuliś E., Kmieć S.</i>).....	503

2.31 PROPOSAL CALCULATIONS OF STRESSES IN THE TWO-PHASE MODEL OF TRABECULAR BONE WITH USING FINITE ELEMENTS METHODS (<i>Nowicki K., Mazurkiewicz A., Andrzejewska A.</i>)	513
2.32 PRZYKŁADY ZASTOSOWANIA TEORETYCZNEJ ANALIZY MODALNEJ W APLIKACJACH INŻYNIERSKICH WSPOMAGAJĄCYCH PROCES DIAGNOZOWANIA POJAZDÓW (<i>Łukasiewicz M., Kalaczyński T., Musiał J., Wilczarska J., Kasprowicz T., Liss M., Sadowski A., Kuliś E.</i>).....	519
2.33 RESEARCH OF MATERIALS' ELECTROMAGNETIC COMPATIBILITY OF ORTHOPEDIC SEAT CUSHION WITH THE HUMAN ORGANISM (<i>Yanenko A., Paraska S., Pidchenko S., Taranchuk A., Lushevskaya E.</i>)	530
2.34 SIŁY SZLIFOWANIA PODCZAS OBRÓBKI W WARUNKACH ZASTOSOWANIA ŚCIERNIC O RÓŻNYCH CHARAKTERYSTYKACH (<i>Polasik R., Kalaczyński T., Musiał J., Szczutkowski M., Siegert M.</i>)	540
2.35 SKANOWANIE 3D W PROCESIE INŻYNIERII ODWROTNEJ (<i>Kalaczyński T., Kasprowicz T., Łukasiewicz M., Musiał J., Wilczarska J., Sadowski A., Liss M.</i>)	547
2.36 TECHNOLOGY AND APPLICATION OF THE ANTI-GRAFFITI COATING SYSTEMS FOR ROLLING STOCK (<i>Radek N., Pasieczński Ł.</i>)	554
2.37 TECHNOLOGY AND EQUIPMENT FOR MODIFICATION OF THE CUTTER KNIVES SET BY NITRIDING IN GLOW DISCHARGE (<i>Stechyshyn M., Lukyanyuk M., Lukyanyuk M.M.</i>).....	567
2.38 TELEVISION PYROMETRY: CONCEPT AND FUTURE (<i>Porev V., Porev G.V.</i>)	581
2.39 TELEVISION PYROMETRY IMPROVEMENT (<i>Markin M.</i>)	591
2.40 TEST METHOD FOR MONITORING IN AGRICULTURAL AREAS USING UNMANNED AERIAL VEHICLES (UAVS) AS A DOCUMENTED PROCEDURE IN AN ACCREDITED LABORATORY – METHODOLOGY FOR THE ELABORATION OF THE DOCUMENT (<i>Szczutkowski M., Kacprzak K., Kurek D., Musiał J., Siegert M.</i>)	606
2.41 THE INVESTIGATION OF CHANGES IN THE HEAT-PROTECTIVE PROPERTIES OF CLOTHING IN THE PROCESS OF EXPLOITATION (<i>Zasornov O., Zasornova I.</i>)	615
2.42 THE PREMISE OF CHOOSING A DEDICATED IT PLATFORM FOR AN ONLINE STORE ON THE EXAMPLE OF COMPANIES X AND Y OPERATING E-COMMERCE (<i>Buraczyńska B.</i>).....	625
2.43 THE PROBLEMS OF ENSURING OF GEOMETRIC ACCURACY OF METAL PRODUCTS FROM COLD-ROLLED SHEET (<i>Prysiashnyi A., Kukhar V., Balalayeva E., Anishchenko O., Gurkovs'ka S.</i>)	635
2.44 THE STRUCTURE AND MECHANICAL PROPERTIES OF ALMG2B AND ALMG5 ALUMINIUM ALLOY PLATES FOR PLASTIC WORKING (<i>Kalinowska-Ozgowicz E., Lenik K., Barszcz M.</i>).....	649
2.45 THE WEAR MODELS OF CYLINDRICAL SLIDING TRIBOSYSTEMS (<i>Dykha O., Babak O., Dykha M.O.</i>).....	657
2.46 TRIBOLOGICAL BEHAVIOR OF BIOMATERIALS IN SIMULATED BIOLOGICAL FLUIDS CONDITIONS (<i>Andrzejewska A., Mazurkiewicz A., Nowicki K.</i>)...678	

2.47 USING OF ACOUSTIC-EMISSIONS METHOD FOR ANALYSIS OF SYSTEMS WITH NON-STATIONARY VIBRATIONS (<i>Slashchuk O., Slashchuk V.</i>).....	682
2.48 WEAR OF THE IMPACT MILL OPERATING ELEMENTS AND WAYS OF MINIMIZING OF THIS PROCESS EFFECTS (<i>Lipiński T., Matuszewski M., Oborski I., Styp-Rekowski M.</i>).....	690
2.49 ZARZĄDZANIE PRZEDSIĘBIORSTWEM TRANSPORTU WODNEGO W POLSCE (<i>Wilczarska J., Kałaczyński T., Łukasiewicz M., Sadowski A., Kuliś E., Musiał J., Kasprowicz T., Winek K.</i>).....	709
3 ENVIRONMENT AND MODERN ENERGY.....	719
3.1 AGROECOLOGICAL INNOVATIONS IN GROWING AND RECYCLING THE RESTORATIVE BIOMASS AND ENERGY CULTURES (<i>Skrypchuk P., Rybak V., Trokhliuk T.</i>).....	719
3.2 ANALYSIS OF METHODOLOGICAL APPROACHES TO ASSESSMENT OF ENERGY SECURITY OF THE STATE (<i>Mykoliuk O.</i>).....	726
3.3 BASIS OF INTELLIGENT MONITORING SYSTEM IN BIOMASS COMMUNITION PROCESS (<i>Kruszelnicka W.</i>).....	736
3.4 ENHANCING ENERGY EFFICIENCY OF KHMELNYTSKYI NATIONAL UNIVERSITY (<i>Martynyuk V. Boiko J.</i>).....	748
3.5 INVESTIGATION OF HEAT EXCHANGERS FOR HEAT ACCUMULATING SYSTEM (<i>Horiashchenko S., Uspalenko S., Golinka E.</i>).....	754
3.6 METODY INTENSYFIKACJI WYMIANY CIEPŁA "PO STRONIE PŁASZCZA" W KOMPAKTOWYM WĘŻOWNICOWYM WYMIENNIKU CIEPŁA (<i>Andrzejczyk R., Mania T.</i>).....	764
3.7 METODY INTENSYFIKACJI WYMIANY CIEPŁA W KOMPAKTOWYM WYMIENNIKU CIEPŁA TYPU RURA W RURZE (<i>Andrzejczyk R., Mania T.</i>).....	772
3.8 MONITORING OF PHOTOVOLTAIC INSTALLATION WITH ELECTRIC ENERGY STORAGE (<i>Kruszelnicka W., Mroziński A., Polishchuk O., Polishchuk A.</i>).....	781
3.9 PROCES INWESTYCYJNY Z ANALIZĄ FAZY PRZYGOTOWANIA, PROJEKTOWANIA I WYKONANIA SYSTEMÓW POMP CIEPŁA W POLSKIM PROCESIE USTAWODAWCZYM (<i>Kawa. J., Mania T.</i>).....	793
3.10 STUDY OF PV MODULES UNDER REAL ENVIRONMENTAL CONDITIONS (<i>Kruszelnicka W., Mroziński A., Dutka M., Bałdowska P.</i>).....	811
3.11 SYSTEMY MAGAZYNOWANIA I REDUKCJI ZUŻYCIA ENERGII PIERWOTNEJ W BUDYNKACH MIESZKALNYCH (<i>Gosz M.</i>).....	821
3.12 UKRAINA – ZAOPATRZENIE W GAZ ZIEMNY A UWARUNKOWANIA MIĘDZYNARODOWE (<i>Kwiatkiewicz P.</i>).....	828
3.13 UKRAINA – ZAOPATRZENIE W ROPEŃ NAFTOWĄ A UWARUNKOWANIA MIĘDZYNARODOWE (<i>Kwiatkiewicz P.</i>).....	836

4. DEVELOPMENT OF EDUCATION	846
4.1 DIALECTICS OF THEORY AND PRACTICE IN THE VALUE-SEMANTIC COMPETENCE OF THE FUTURE TEACHER (<i>Kozachenko S.</i>)	846
4.2 FROM THE EXPERIENCE OF HARMONIZATION OF EDUCATIONAL PROGRAMS OF KHMELNYTSKYI NATIONAL UNIVERSITY AND LUBLIN UNIVERSITY OF TECHNOLOGY (<i>Krasylnykova G., Śniadkowski M., Pidgaichuk S.</i>).....	854
4.3 GAMIFICATION AS A TOOL IN MODERN HIGHER EDUCATION – DEVELOPMENT STAGE OF THE INSTRUMENTATION PLAN (<i>Szczutkowski M., Jachimowicz – Gawel D., Musiał J., Kurek D., Siegert M.</i>)	860
4.4 PECULIARITIES OF TEACHING WORKPLACE COMMUNICATION IN <i>ESP/EAP</i> COURSE (<i>Klochko S.</i>)	870
4.5 PROBLEMS WITH EDUCATION IN THE AGE OF INFORMATION SOCIETY (<i>Śniadkowski M., Krasylnykova G.</i>)	880
4.6 THE DEVELOPMENT OF THE FOREIGN LANGUAGE MOTIVATION AMONG THE STUDENTS OF ENGINEERING SPECIALTIES IN THE PROCESS OF PROFESSIONALLY ORIENTED LEARNING (<i>Kharzhevska O.</i>).....	890
4.7 THE MAIN FACTORS OF FUTURE HANDICRAFT AND TECHNOLOGY TEACHERS' TRAINING FOR PEDAGOGICAL INTERACTION (<i>Androshchuk I.V., Androshchuk I.P.</i>)	900
4.8 THE STRUCTURE OF THE DESIGN COMPETENCE OF FUTURE ENGINEER- TEACHERS OF THE SEWING PROFILE (<i>Bilyk V., Bilyk Y.</i>)	909
4.9 THE PECULIARITIES OF ENTERPRISE POTENTIAL MANAGEMENT IN CONDITIONS OF RISKINESS (<i>Gonchar O., Cherep A.</i>).....	915

THE PROBLEMS OF ENSURING OF GEOMETRIC ACCURACY OF METAL PRODUCTS FROM COLD-ROLLED SHEET

Prysiashnyi A.¹, Kukhar V.¹, Balalayeva E.¹, Anishchenko O.¹, Gurkovs'ka S.²

¹ Pryazovskyi State Technical University, Ukraine

² Donbass State Engineering Academy, Ukraine

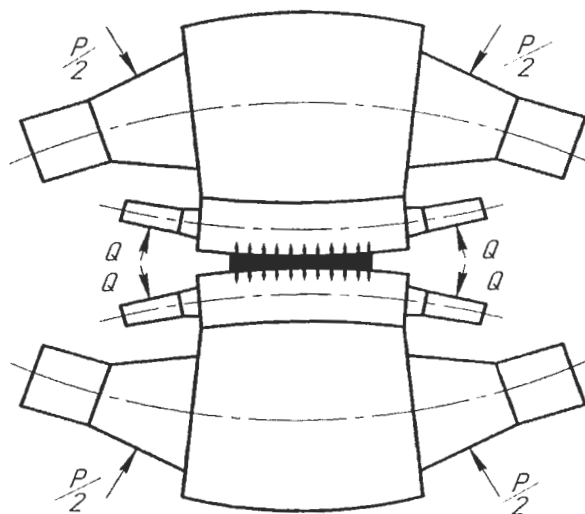
Introduction

High level of consumers' requirements for geometric precision of cold rolled strips stipulates the necessity of application for cold rolling the systems of automatic adjustment of shape and profile (hereinafter AASPS) of finished rolled stock at continuous and reverse mills [1, 2]. At that, improved efficiency of the aforesaid systems can be reached by refinement of mathematic models ensuring their operation, it allowing to increase their reliability and prediction of such indices, like, for instance, transverse polythickness, or the degree of flatness of cold rolled strips. Such indices, together with indices of precision, ensured as a result of shape-transforming operations of sheet stamping (like draw-forming, shaping and others) determine overall indices of precision of metal products, made of cold rolled sheets. To compensate errors of the "stand-tool-blank" system, eliminate unevenness of metal forming at manufacturing of sheet-metal stamping on pressing machines of open type and a consequence improvement of geometric precision of metal products it is advisable to use elastic compensators on the basis of polyurethanes. It would be necessary, at that, to improve the methods of design of elastic compensators of "press-stamp" system with the objective of obtaining high indices of metal products precision. With due regard to all aforesaid this work deals with the analysis of the problem of determination of optimal values of the force of counter-flexure of working rolls of continuous and reverse rolling mills, ensuring improvement of geometric precision of cold rolled strips, as well as the problems of designing appliances for compensating elastic deformation and increasing precision of metal production, obtained from cold rolled sheets, by means of sheet stamping.

Ensuring of geometric accuracy of cold-rolled sheet

For adjustment of the degree of flatness of steel sheets at cold rolling on continuous and reverse rolling mills the systems in which counter-flexure of working rolls are most widely used (see Fig. 1) [1, 2]. To ensure the proper operation of these systems it is advisable to set the target of specifying optimal values of the force of

counter-flexure, ensuring constant constancy or minimal differences of overall elastic displacements of the unit of working and back up rolls, irrespective of fluctuations of the rolling force, emerging due to directed or stochastic changes in the original operational parameters of the cold rolling process.



Q – the force of counter-flexure of working rolls; P – the rolling force

Fig. 1. The scheme of counter-flexure of working rolls [2]

The analysis of the methods of evaluation of elastic deformation of rolls units of quarto-stands, described in [3–5] showed that such methods did not correspond fully to actual conditions of cold rolling of thin strips. Particularly, A.I. Tselikov's mathematical model is designated for evaluation elastic deformation of flexure of back up rolls of working stands of sheet rolling mills only, having been obtained at conditions of uniform distribution of inter-rolls linear load and could not take into account the influence of trimming and forces of counter-flexure of working rolls. V.P. Poloukhin's engineering method [4, 5] is devoid of the distinguished flaws, still due to alternations in rolling facilities and technology, implemented lately and wide application of AASPS [1, 2] this method requires some additional correction. The authors of [6, 7] suggested a modified method of evaluation of elastic deformation of rolls units of quarto-mills stands, that takes into account unevenness of distribution of inter-rolls linear load, as well as the rolls profile and allowing to ensuring to raise precision of evaluating optimal values of counter-flexure force of the working rolls. For these reasons development of the method of evaluating optimal values of the force of counter-flexure of working rolls, ensuring an increase in the degree of

flatness of cold rolled strips, seems to be a problem of paramount scientific and engineering importance.

Determination of optimal values of the force of counter-flexure of working rolls was numerically formed on the basis of purposeful enumeration of possibilities, according to the following algorithmic diagram:

$$Q_{(t+1)} = Q_t + A_Q \text{sign}\{\Delta\delta_t - \Delta\delta^*\}, \quad (1)$$

where t – a number of the next in turn cycle of iteration solution procedure;

A_Q – a step of increment of the force of counter-flexure, set to be equal to $A_Q = 0.01P_n$;

$\text{sign}\{\Delta\delta_t - \Delta\delta^*\}$ – sign function, corresponding to:

$$\text{sign}\{\Delta\delta_t - \Delta\delta^*\} = \begin{cases} 1 \text{ if } \Delta\delta_t > \Delta\delta^*; \\ -1 \text{ if } \Delta\delta_t < \Delta\delta^*, \end{cases} \quad (2)$$

where $\Delta\delta_t$ – rated values of differences of overall elastic displacements in the middle and on the edges of bodies of working and back up rolls, determined within t_{th} cycle of iteration procedure solution procedure, depending upon the corresponding values of the rolling force P and the force of counter flexure Q_t ;

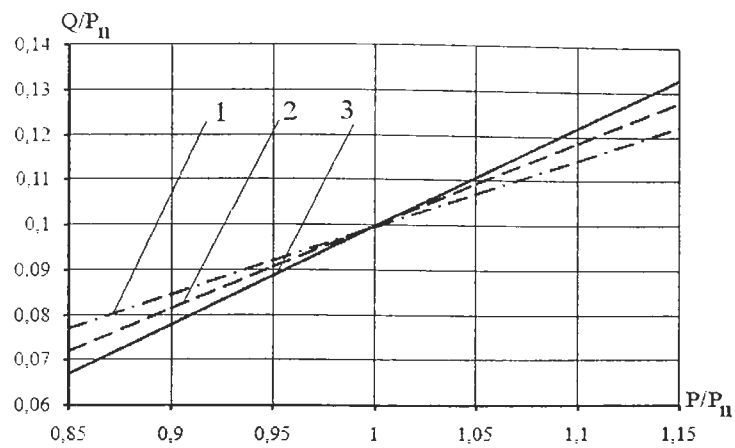
$\Delta\delta^*$ – maximum permissible or nominal values of overall elastic displacements, determined at nominal values of the rolling force P_n and the counter flexure force, taken as equal to $Q_n = 0.1P_n$.

The values of differences in overall elastic displacements of the unit of working and back up rolls were calculated in strict accordance with recommendations prescribed by the authors of [6, 7], with due regard to uneven distribution of inter-rolls linear load and trimming of working rolls. The rated determination of the rolling force was carried out in accordance with the modified numerical one-dimensional mathematical model [8], that takes into account the actual character of distributions of mechanical properties of metal along the length of the area of deformation, as well as geometric parameters and coefficient of external contact friction. There, in the first

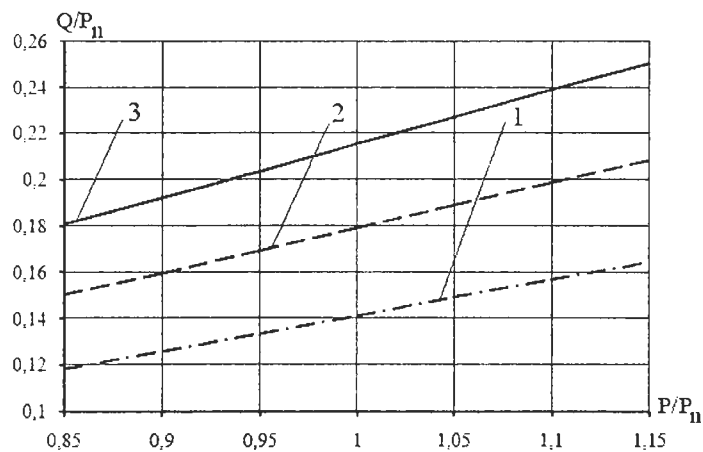
cycle of iteration procedure of solution ($t=1$) the original value of the force of counter flexure $Q|_{t=1}$ was taken as equal to its nominal value, i.e. $Q|_{t=1} = Q_n$, then the value of $\Delta\delta^*$ was determined, after that according to expression (1) an increment of the force of counter flexure $Q_{(t+1)}$ was performed, and then we passed to the following ($t+1$) cycle of iteration procedure of the solution. This procedure was stopped in case of alternation of the sign of the original difference of $\Delta\delta_t - \Delta\delta^*$. The obtained values of the force of counter flexure should not exceed the values, admissible by conditions of necks strength, as well as bearings units of the working rolls.

As an example of numerical realization of algorithmic diagram (1)–(2) at Fig. 2a represents the rated values of distribution of Q/P_n values of the force of counter flexure, ensuring the constancy of the difference in overall elastic displacements in the middle and on the edges of the bodies of working and back up rolls, irrespective of the value of the rolling force, the data were obtained for one of the working stands of 1700 continuous 4-stand cold rolling mill of “Ilyich” Iron and Steel Works PrJSC (Mariupol). There, the range of alternations of this force was considered to be equal to $P=0.85P_n\dots1.15P_n$ ($P/P_n=0.85\dots1.15$), while nominal values of $\Delta\delta^*$ difference of elastic displacements of $\Delta\delta_t$ were determined in accordance with recommendations, specified by the authors of [6, 7], differentially, in accordance with width of the rolled strip b at nominal values of the rolling force P_n and the force of counter flexure $Q_n=0.1P_n$. Similar rated distributions (see Fig. 2b) were obtained for the condition of minimization of the difference of overall elastic displacements in the middle and on the edges of the bodies of the working and back up rolls, it ensuring obtaining of cold rolled strips with minimal transverse polythickness.

The analysis of the obtained result showed that the required values of the force of counter flexure of the working rolls depended largely upon the width of the rolled strips and they increased linearly with the growth of the rolling force (see Fig. 2b), it allowing approximation of these rated functions with linear functions of the type:



a



b

1 - $P_n = 16.2$ MN, $b = 1350$ mm; 2 - $P_n = 15.0$ MN, $b = 1250$ mm;
3 - $P_n = 13.8$ MN, $b = 1150$ mm

Fig. 2. Rated distributions of the corrected values of the force of counter flexure, ensuring constancy of the difference of overall elastic displacements in the middle and on the edges of the bodies of working and back up rolls (a) and minimal transverse polythickness of cold rolled strips (b), irrespective of alternations in the rolling force

$$Q = Q_n + k_{QP}(P - P_n), \quad (3)$$

where k_{QP} is the transmission coefficient, characterizing functional connection between increments of the force of counter flexure Q and the force of rolling P and determined on conditions of ensuring continuity of the difference of overall elastic displacements in the middle and on the edges of the bodies of the working and back up rolls or on condition of ensuring minimal transverse polythickness of cold rolled strips.

The advantage of linear functions (3) is in the possibility of their application with the objective of determining the values of the force of counter flexure of the

working rolls in real time mode, corresponding to minimal polythickness of strips and also required for obtaining minimal longitudinal polythickness of rolled stock, alternations of inter-rolls gap, directly in the process of rolling. Particularly, for Fig. 1a it was obtained that for $k_{QP} = 0.051$ at $b = 1350$ mm, $k_{QP} = 0.088$ at $b = 1250$ mm and $k_{QP} = 0.123$ at $b = 1150$ mm, as for Fig. 1b – $k_{QP} = 0.151$ at $b = 1350$ mm, $k_{QP} = 0.186$ at $b = 1250$ mm and $k_{QP} = 0.221$ at $b = 1150$ mm.

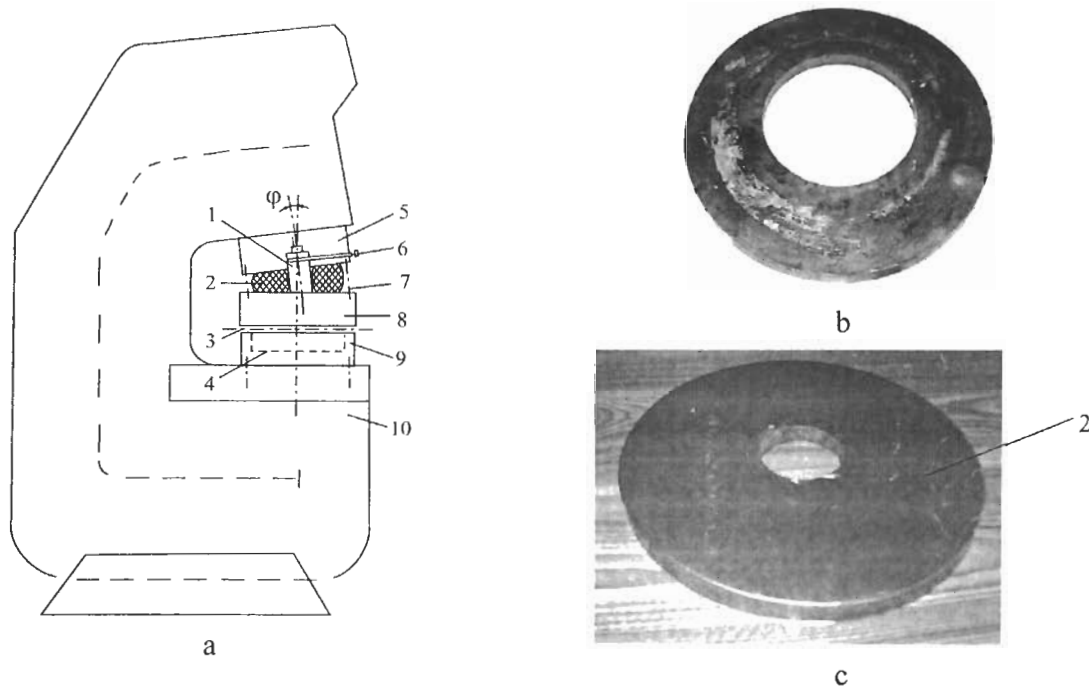
It is worthwhile mentioning that beside AASPS, contemporary rolling mills are equipped with the systems of automatic regulation of strips widths (SARSW) [1, 2]. The main element of these systems is hydraulic screw-down device, ensuring fine regulation of the required value of preliminary rolls gap and its high precision adjustment in the process of rolling. There, in the process of adjustment of the rolls gap the range of alternations in the rolling force is raised, it eventually leading to an increase in alternations in the shape of active generating working rolls and, as a consequence, leading to an increase in transverse polythickness and in probability of defects formation in indices of flatness of the rolled strips. This call for changes in the force of counter flexure of working rolls to be applied without delay. Thus operation of AASPS and SARSW should not be considered separately, in other words, the values calculated by algorithmic scheme (1)–(2) of the value Q must be taken into account for designating of the process mode of SARSW of a particular rolling mill.

Ensuring of geometric accuracy of metal products from cold-rolled sheet

The accuracy of “press-and-die” systems are affected from misalignment of the slide axis to press table surface in the loaded state, from distortion in the gaps between press and slide guides, as well as cumulative errors of the punching unit [9–12]. Mechanical and elastic compensators are widely used to reduce errors in the “press-and-die” system of open-crank presses and ring compensators of elastomeric materials has not been studied enough. This makes it difficult to calculate their design parameters.

There are two basic approaches to eliminate the influence of deformation of the C-frame presses on the alignment of “press-and-die” system. The first approach is the closure of open C-frame press with using the ties [13], which greatly reduces its deformation. A second approach for solving the skew problem is to eliminate the misalignment between the upper and lower basing plates with various additional devices

or elements (Fig. 3a). These devices or parts are called “compensators”. A further alternative approach to reducing of errors of the “press-and-die” system can be die-free [14] and impression-free [15, 16] methods of metal-forming.



1 – shank; 2 – compensator; 3 – die line connector; 4 – circuit of a formed product; 5 – slider; 6 – fixing pin; 7 – fasteners; 8 – upper plate; 9 – lower plate; 10 – frame; φ – skew angle of the slider

Fig. 3. The opening of the C-frame press (a), the design of the elastic ring compensator (b), and its upgrading design (c)

The main purpose of installing a skew compensator in forging equipment is to ensure the transfer of the operating force from basic die elements, which have lost alignment as a result of deformation of the frame, to coaxial (parallel) basic die surfaces (see Fig. 3a).

A promising direction to reduce of distortions in the “press-and-die” system is the using of different constructions of compensators, which are made, for example, of different brands of polyurethane. The choice of polyurethane is complicated by wide range of functional properties of the polyurethanes from various manufacturers. Recommendations for optimization of this choice are given in [17]. The method of calculating the optimum design parameters is discussed in [18]. Also, an automated method of calculation for the reconfigurable polyurethane compensators, taking into account the errors of “press-and-die” system, is proposed [19].

Polyurethane elements are widely used for compensation of power and geometric deviations in metal forming technologies [18–21].

The method of fastening the upper plate to the press slider through an elastic compensator (see Fig. 3a) is considered in [18, 19]. The example of the design of the ring elastic compensator is shown on Fig. 3b. However, the work of the ring compensator can be accompanied by cracking of the elastic plate because during the influence of deformation force the material can flow into non-technological openings, forming regions of increased concentration of stresses and unregulated deformations.

To solve this problem, the variant of the upgrading design of the compensator (see Fig. 3c) was developed, according to which the ring elastic compensator is placed between two ground metal plates with a central hole and connected to them using an adhesive bond.

The disadvantage of the above-described method is the lack of optimal bonding conditions (the glue is applied to the entire surface area of the contact surfaces of the protective plates and the elastic element), which should be determined on the basis of the structural and technological features of the ring compensator and the physical and mechanical characteristics of the glue.

The purpose of this work is to develop a mathematical model and study the deformations of the ring elastic compensator for modeling its shaping under the conditions of the "press-and-die" system work with slider skewing, as well as the calculation of tangential stresses in the adhesive bond with protective plates to determine the optimum gluing parameters, which will help to reduce adhesive consumption, tangential stresses, increase the reliability of fastening the compensator and improve the working conditions.

The compression pre-tests were carried with different shape samples from polyurethane brand SKU-PFL-100 (CKY-ΠΦЛ-100, 100 Shore hardness). The approximating dependence between the pressures during compression of polyurethane q and the degree of upsetting $\varepsilon = (H_0 - h) / H_0$ (where H_0 is the initial height of the compensator, h is the height of the deformed compensator) for $\varepsilon \leq 0.3$ is received as the result of studying the influence of the shape of the compensator on its elastic properties [18, 19]:

$$q = 52\varepsilon + 1.92. \quad (4)$$

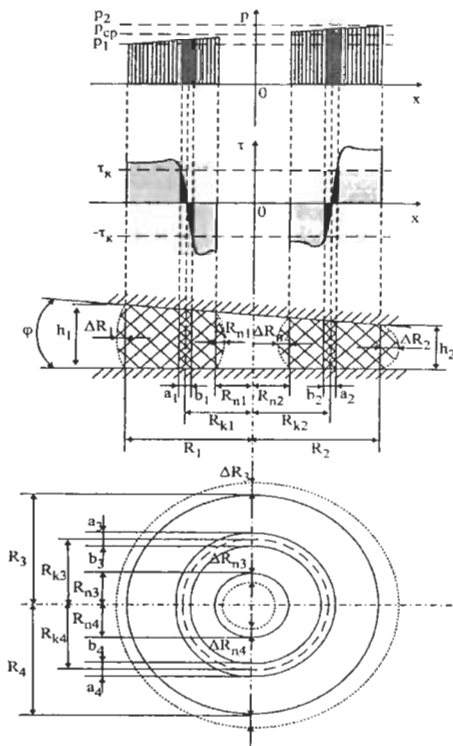


Fig. 4. Uneven deformation of the ring elastic compensator

and ΔR_n by analogy with the flow of a deformed ring metal preform at four characteristic points were considered. Without considering the shear strain, we had: $\Delta R_3 = \Delta R_4$ and $\Delta R_{n3} = \Delta R_{n4}$. Based on the accepted assumptions, only three characteristic points were considered.

The deformation of the ring elastic compensator is characterized by the presence of a neutral flow line of the material. The boundary of the material flow is the surface defined by the radius R_k . The contact tangential stress τ at points with radius R_k is equal to zero. At the same time, its average value was determined as:

$$\tau = \psi \tau_s; \tau_s = q/\sqrt{3}; \psi = \mu + (1/8) \cdot (R - R_n)/H_0 \cdot (1 - \mu) \cdot \sqrt{\mu}, \quad (5)$$

where μ is the coefficient of friction.

The radius of the critical surface R_k , as well as the change in the outer radius ΔR and the inner radius ΔR_n at the i -point not taking into account the barrel shape and taking into account the unevenness of the radial deformation along the height were determined by the methods [I.Ya. Tarnovskiy (1963), L.A. Shofman (1961)]. However, preliminary calculations showed a significant difference in the values of R_k

A ring polyurethane element (see Fig. 4) with an outer radius R , an inner radius R_n and a height H_0 was considered. The support area of the compensator was determined as $F = \pi (R^2 - R_n^2)/4$. Misalignment of the slide at an angle φ causes the uneven deformation along the height of the compensator (see Fig. 4). Moreover, the maximum of angle deviation should not exceed $\varphi \leq \arctg(H_0/2R)$.

The upsetting of the ring elastic compensator is accompanied by a simultaneous increase in the outer radius R and a decrease in the inner radius R_n . The changes in the radii ΔR

which showed the need to refine the dependence to determine the dimensions of the ring element with respect to barrel shape:

$$R_{k_i} = 63.25 \cdot \sqrt{\frac{R^2 \cdot R_n^2 \cdot (R^2 - R_n^2)}{8000 \cdot R^2 \cdot R_n^2 \cdot \ln(R/R_n) + 1599 \cdot h_i^2 \cdot (R^2 - R_n^2)}} \quad (6)$$

The change in the outer radius ΔR and the outer radius ΔR_n at the i -point was calculated as:

$$\Delta R_i = 0.375 \cdot R \cdot (H_0 - h_i) / H_0 \cdot \left(1 - R_{k_i}^2 / R^2\right); \quad (7)$$

$$\Delta R_{n_i} = -0.375 \cdot R_n \cdot (H_0 - h_i) / H_0 \cdot \left(1 - R_{k_i}^2 / R_n^2\right). \quad (8)$$

The compression pressure p_i at the upsetting of the ring polyurethane compensator is distributed unevenly along its diameter, so the calculation was applied for each deformable part on the four sides of the ring compensator taking into account the unevenness of deformation of the elastic element.

In order to achieve optimum bonding characteristics, the application of glue (diagum FL, diagum P, diaflex) [22] should be carried out only on areas limited by the shear stress zone τ with values not exceeding the critical shear stresses τ_k (see Fig. 4). According to the proposed method, a number of diagrams of tangential stresses are constructed depending on the geometric parameters of the compensator and zones are defined for which $\tau < \tau_k$ (see Fig. 4). The tangential stress in the adhesive layer of the polyurethane ring compound with metal protective plates is calculated by the method of Lamé, described, for example, in work [23].

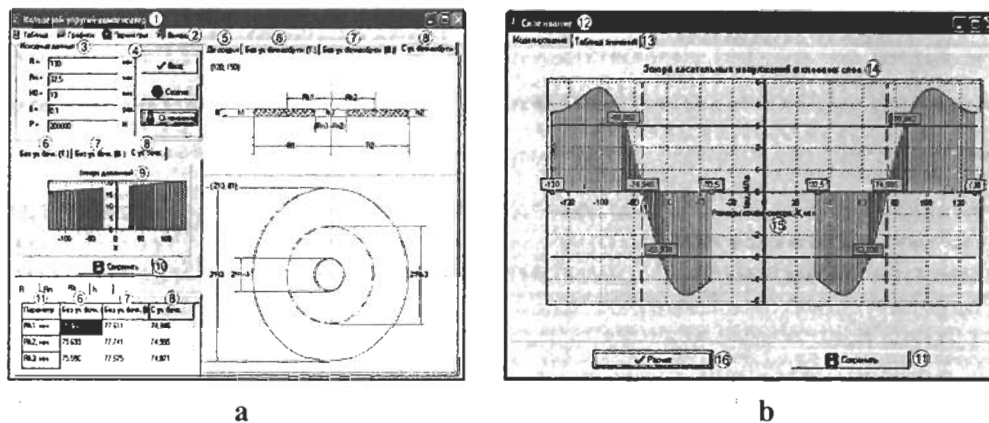
The dependence of the distances from the flow separation line R_k to the outer edge (a) and the inner edge (b) of the compensator from three factors (S/D , S/H_0 , ε) was established using the method of experiment planning (2^3):

$$a = 10.283 + 0.034 \cdot S/D + 0.46 \cdot S/H_0 - 1.109 \cdot \varepsilon + 0.135 \cdot S/D \cdot S/H_0 - 0.073 \times \\ \times S/H_0 \cdot \varepsilon - 0.034 \cdot S/D \cdot \varepsilon - 0.015 \cdot S/D \cdot S/H_0 \cdot \varepsilon; \quad b = 0.929a, \quad (9)$$

where S is the wall thickness of the compensator; D is outer diameter of the compensator.

The special software is written on the base of the developed calculation method (see Fig. 5). This software allows to calculate the dimensions of the ring elastic compensator after the upsetting with and without taking into account the barrel shape and also determine the bonding areas of the ring compensator with protective plates.

The research of the work of the elastic ring compensator with parameters $R = 130$ mm, $R_n = 32.5$ mm, $H_0 = 13$ mm (see Fig. 5a) was carried out. The angle $\varphi = 0.1$ rad. and the force $P = 0.2$ MN (see Fig. 5a). According to the results of simulation (see Fig. 5b), it is advisable to apply the adhesive to the areas of the compensator surface limited by distances $a_1 = 14.01$ mm and $a_2 = 13.94$ mm to the outer edge, $b_1 = 13.01$ mm and $b_2 = 12.946$ mm to the inner edge of the neutral line, $R_{k1} = 74.95$ mm and $R_{k2} = 74.99$ mm; the width of the adhesive layer from the maximum deformation side is 27.02 mm and from the minimal deformation side is 26.9 mm. The consumption of the adhesive compound was reduced by 72 %.



- 1 – the ring elastic compensator; 2 – table, graphics, params, exit; 3 – initial data; 4 – input, upsetting, gluing; 5 – before upsetting; 6 – without taking into account the barrel shape (by I.Ya. Tarnovsky); 7 – without taking into account the barrel shape (by L.A. Shofman); 8 – with taking into account the barrel shape;
- 9 – diagram of the compression pressure; 10 – save; 11 – params; 12 – gluing; 13 – simulation, table of values; 14 – diagram of the tangential stresses in the adhesive layer; 15 – compensator sizes; 16 – calculation

Fig. 5. Software interface for modeling of the work of the ring elastic compensator taking into account the barrel shape (a) and plotting the shear stresses in the adhesive layer (b)

The upgraded design of the ring elastic compensator was tested during solving of the problem of increasing the accuracy of the dimensions of the stamped part "Bottom" of the washing machine "Donbas" (see Fig. 6) in the conditions of the enterprise "ElektroPobutPrylad" JSC (Mariupol). The compensator in the form of a

flat ring made of polyurethane of SKU-PFL-100 grade had an outer diameter of 260 mm, an inner diameter of 65 mm and a height of 13 mm (see Fig. 3b); the calculated thickness of two ground metal plates (see Fig. 3c) was 0.8 mm (X18N9T steel grade). The operation was carried out on a single-crank press of a single action with a C-frame with a nominal force of 1.0 MN (KE 2130A model).

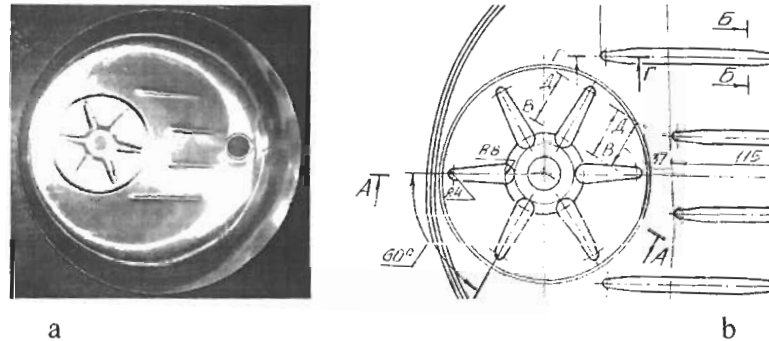


Fig. 6. The bottom of the washing machine "Donbas" (a) and a fragment of its drawing (b)

The depth of molded ribs of activator jack (steel X18N9T) was measured from the front and rear of the press with depth gauge at six points on the extreme edges of the axis. Measurements were carried out using the compensator and without it. The upgraded design of the compensator made it possible to reduce the difference in depth of the ribs of the opening under the activator by 64–73 %.

Conclusions

The method of determination of the force of counter flexure of the working rolls was designed, ensuring improvement of the degree of flatness of cold rolled strips with due regard to the influence of unevenness of distribution of inter-rolls linear load, as well as trimming of the working rolls. On the basis of the analysis of numerical realization of this method an essential influence of the width of the rolled strips upon the optimal value of the force of counter flexure was found out. Also, it was suggested to approximate the link between increments of the force of counter flexure with linear equations, the application of which is to promote improvement in efficiency of AASPS operation of cold sheet rolling mills. For the cold rolling mill of "Ilyich" Iron and Steel Works of Mariupol the values of transmission coefficients of the aforementioned equations, depending on widths of rolled strips were determined.

Based on the performed analysis of the ring elastic compensator work under conditions of the "press-and-die" system work with slider skewing, its design,

methodology and software for calculating its sizes after the upsetting were developed. This made it possible to evaluate the slider skew on the shaping of the elastic element, to determine the dimensions of the areas for bonding the elastic compensator to the protective plates, and to minimize shearing stresses in the adhesive layer by 72% and to improve the quality of the finished metal products from the sheet by 64–73%.

References

1. Konovalov, Ju.V. (2008). Spravochnik prokatchika [Reference book for rolling worker]. (Vols. 1–2; Vol. 2). Moskva: Teplotekhnika [in Russian].
2. Harber, E.A. (2007). Proizvodstvo prokata [Production of rolled products]. (Vol. 1). Moskva: Teplotekhnika [in Russian].
3. Tselikov, A.I., Nikitin, H.S., & Rokotian, S.Ye. (1980). Teoriia prodolnoi prokatki [Theory of longitudinal rolling]. Moskva: Metallurhiia [in Russian].
4. Tselikov, A.I., Polukhin, P.I., Hrebenik, V.M., Ivanchenko, F.K., Tylkin, M.A., & Korolev, A.A. et al. (1988). Mashiny i ahreaty metallurhicheskikh zavodov [Machines and units of metallurgical factories]. (Vols. 1–3; Vol. 3). Moskva: Metallurhiia [in Russian].
5. Polukhin, V.P. (1972). Matematicheskoe modelirovaniie i raschet na EVM listovykh prokatnykh stanov [Mathematical simulation and calculation of sheet rolling mills on a computer]. Moskva: Metallurhiia [in Russian].
6. Prisyazhnyi, A.H. (2012). Raschetnoie opredeleniie mezhvalkovoii pohonnoi nahruzki v kletiakh «kvarto» stanov kholodnoi prokatki s uchetom vliianiia profilirovki i protivozhiva rabochikh valkov [Calculation of linear load between rolls in the quarto-stands of cold rolling mills with due regard to the influence of trimming and counter-flexure of working rolls]. Vestnik NTU «KhPI» – Reporter of NTU «KhPI», 47 (953), 153–159 [in Russian].
7. Satonin, A.V., Nastoiaschaia, S.S., & Prisyazhnyi, A.H. (2012). Razvitiie inzhenernykh metodov rascheta napriazhenno-deformirovannogo sostoianiia valkovoho uzla chetyrekhvalkovykh rabochikh kletei shirokopolosnykh stanov [The development of engineering methods of calculating the stress-strain state of four-high roll assembly work stands wide strip]. Obrabotka materialov davleniim – Materials working by pressure, 4 (33), 266–272 [in Russian].
8. Satonin, A.V., Prisyazhnyi, A.H., Spaskaia, A.M., & Churukanov, A.S. (2012). Razvitiie chislennykh odnomernykh matematicheskikh modelei napriazhenno-deformirovannogo sostoianiia metalla pri kholodnoi prokatke otноситelno tonkikh polos [Development of numerical of one-dimensional mathematical models of the intense-deformed condition of metal at cold rolling concerning thin strips]. Obrabotka materialov davleniim – Materials working by pressure, 2 (31), 62–68 [in Russian].
9. Norton, R.L. (2006). Machine Design: An Integrated Approach. Upper Saddle River, NJ: Pearson Prentice Hall.
10. Smith, D.A. (1988). Why Press Slide out of Parallel Problems Affect Part Quality and Available Tonnage. Dearborn, MI: Society of Manufacturing Engineers.
11. Slide Out-of-Parallel Problems: Why they affect part quality and available tonnage, The Fabricator, The Fabricator's and Manufacturer's Association, International, Rockford, Illinois, April 1990.
12. Dasgupta, A., & Pecht, M. (1991). Material Failure Mechanisms and Damage Models. IEEE Transactions on Reliability, 40 (5), 531–536.
13. Cirek, M., & Kubec, V. (2006). Analysis of energy consumption of spindle presses. Tehnički vjesnik, 13 (1,2), 23–30.

14. Kukhar, V. V. (2015). Producing of Elongated Forgings with Sharpened End by Rupture with Local Heating of the Workpiece Method. *Metallurgical and Mining Industry*, 6, 122–132.
15. Kukhar, V., Burko, V., Prysiashnyi, A., Balalayeva, E., & Nahnybeda, M. (2016). Development of Alternative Technology of Dual Forming of Profiled Workpiece Obtained by Buckling. *Eastern-European Journal of Enterprise Technologies*, 3(7(81)), 53–61.
16. Kukhar, V., Artiukh, V., Serduik, O., & Balalayeva, E. (2016). Form of Gradient Curve of Temperature Distribution of Lengthwise the Billet at Differentiated Heating before Profiling by Buckling. *Procedia Engineering*, 165, 1693–1704.
17. Artiukh, V., Karlushin, S., & Sorochan, E. Peculiarities of Mechanical Characteristics of Contemporary Polyurethane Elastomers International Scientific Conference Urban Civil Engineering and Municipal Facilities. *Procedia Engineering*, 117, 938–944.
18. Kukhar, V., Balalayeva, E., Tuzenko, A., & Burko, V. (2015). Calculation of Universal Elastic Compensator Applied to the Pressing-extrusion Operations. *Multidisciplinary Journal of Research in Engineering and Technology*, 2 (3), 593–604.
19. Balalayeva, E.Yu., Kukhar, V.V., & Hrushko, O.V. (2014). The Computer-Aided Method of Calculation of Universal Elastic Rotary Compensator for the “Press-and-Die” System Errors of Crank Press for Drawing-Forming Operations. *HCTL Open Science and Technology Letters (HCTL Open STL)*, 6.
20. Al-Quran, Firas M.F., Matarneh, M.E., & Artiukh, V.G. (2012). Choice of Elastomeric Material for Buffer Devices of Metallurgical Equipment. *Research Journal of Applied Sciences, Engineering and Technology*, 4 (11), 1585–1589.
21. Gharaibeh, Nabeel S., Matarneh, Mohammed I., & Artiukh, V.G. (2014). Loading Decrease in Metallurgical Machines. *Research Journal of Applied Sciences, Engineering and Technology*, 8 (12), 1461–1464.
22. Ishchenko, A.A., & Artiukh, G.V. (1997). Ispytaniia novykh kleiev dlia soiedineniia elastomerov s metallami [Tests of new glues for joint of elastomers with metals]. *Zakhyst metalurhiinykh mashyn vid polomok – Protecting of metallurgical machines from break-down*, 2, 159–166.
23. Kushnarenko, S.H. (1979). Issledovaniie napriazhenii v kleievom sloie kleieklepannykh soiedinenii [Research of tensions in the glue layer of adhesive joints]. *Obrabotka materialov davleniiem v mashinostroenii – Materials working by pressure in mechanical engineering*, 17, 55–58.

ALPHABETICAL INDEX OF AUTHORS

- Androshchuk I.V. 900
 Androshchuk I.P. 900
 Andrzejczyk R. 764, 772
 Andrzejewska A. 513, 677
 Anishchenko O. 635
 Asauljuk T. 325, 386
 Aulin V. 431
 Babak O. 657
 Balalayeva E. 635
 Bałdowska P. 811
 Barmak O., 45
 Barszcz M. 278
 Barszcz M. 649
 Belyakova N. 138
 Bilyk V. 909
 Bilyk Y. 909
 Bilyk Yu. 299, 349
 Boiko J. 748
 Bojar P. 486
 Bonek M. 372
 Buraczyńska B. 625
 Cherep A. 915
 Ditkowska O. 476
 Dlugunovich N. 466
 Dutka M. 811
 Dykha M. 173
 Dykha M.O. 657
 Dykha O. 451, 657
 Dzhuliy L. 50
 Dzhuliy V. 45
 Dziuba M. 37
 Dziubek N. 267
 Flizikowski J. 309
 Foryś M. 210
 Gaidys R. 422
 Galewski M. 495
 Golinka E. 422, 754
 Gonchar O. 915
 Gosz M. 821
 Gurkova'ska S. 635
 Gurochkina V. 90
 Horiashchenko S. 754
 Hrinkiv A. 431
 Humeniuk A. 91
 Jachimowicz -- Gawel D. 860
 Jūrēnas V. 422
 Kacprzak K. 606
 Kałaczyński T. 200, 267, 503,
 519, 540, 547, 709
 Kalinowska-Ozgowicz E. 278, 649
 Kaliński K. 495
 Karvan S. 218
 Kasproicz T. 503, 519, 547, 709
 Kawa. J. 793
 Kharzhevskaya O. 890
 Kholodenko A. 184
 Klochko S. 870
 Kmiec S. 503
 Korotych O. 334
 Kovalska V. 218
 Kozachenko S. 846
 Krasylnykova G. 854, 880
 Kravchuk O. 466
 Kruszelnicka W. 736, 781, 811
 Kukhar V. 635
 Kuleshova S. 258
 Kulik T. 289
 Kuliś E. 200, 267, 503, 519, 709
 Kurek D. 606, 860
 Kvasnitska R. 68
 Kwiatkiewicz P. 828, 836
 Lenik K. 277, 649
 Lipiński T. 690
 Liss M. 519, 547
 Liutko N. 147
 Łukasiewicz M. 200, 267, 503,
 519, 547, 709
 Lukyanyuk M.M. 567
 Lukyanyuk M. 567
 Lushevskaya E. 530
 Lysenko S. 431
 Macko M. 309
 Makovkin O. 451
 Malec M. 413
 Mania T. 764, 772, 793
 Markin M. 591
 Markina O. 441
 Martyniuk A. 299
 Martyniuk V. 748
 Matiukh S. 37, 193
 Matuszewski M. 690
 Mazur M. 495
 Mazurkiewicz A. 513, 678
 Melkonian A. 334
 Menchinska O. 27
 Mikhalevska G. 318
 Mikhalevskiy V. 318
 Mishchuk M. 9
 Morawska N. 495
 Mroziński A. 309, 781, 811
 Musiał J. 200, 267, 503, 519, 540,
 547, 606, 709, 860
 Myasnykov S. 325, 386
 Mykoliuk O. 726
 Nowicki K. 513, 678
 Nykytchenko N. 157
 Oborski I. 690
 Oleksandrenko V. 349
 Ostaševičius V. 422
 Paraska O. 218
 Paraska S. 530
 Pasieczyński Ł. 554
 Pidchenko S. 530
 Pidgaichuk S. 854
 Podgórski J. 200
 Polasik R. 540
 Polishchuk A. 781
 Polishchuk O. 413, 781
 Ponomaryova N. 110
 Porev G.V. 581
 Porev V. 334, 581
 Posonskiy S. 451
 Posvistak O. 99
 Prysiaznyi A. 635
 Pyryev Y. 210
 Pyscheniuk N. 413
 Radek N. 554
 Rak T. 218
 Redko Ya. 249
 Romanets T. 395
 Rybak V. 719
 Sadowski A. 200, 267, 503, 519,
 547, 709
 Saribyekova Y. 325, 386
 Schutskaya A. 356
 Semeshko O. 325, 386
 Shcherbakova A. 130
 Shuda I. 240
 Siegert M. 540, 606, 860
 Skorobogata L. 9
 Skrypchuk P. 719
 Skyba M. 395, 413
 Slashchuk O. 682
 Slashchuk V. 682
 Śniadkowski M. 854, 880
 Sokolova G. 349
 Sorokatyi R. 451
 Stechyshyn M. 299, 349, 567
 Styp-Rekowski M. 690
 Suduk O. 130
 Suprun N. 356
 Synyuk O. 395, 466
 Szczutkowski M. 540, 606, 860
 Szymborski W. 120
 Taranchuk A. 530
 Tarashevskaya O. 91
 Tarasiuk M. 68
 Tomporowski A. 309
 Trocikowski T. 110
 Trokhliuk T. 719
 Tseben R. 91
 Uspalenko S. 754
 Vasylykivskiy D. 193
 Voynarenko M. 19, 80
 Wilczarska J. 200, 267, 503, 519,
 547, 709
 Winek K. 709
 Yanenko A. 530
 Yemchuk L. 165
 Zakharkevich O. 229
 Zamota T. 431
 Zashchepkina N. 334
 Zasornov O. 615
 Zasornova I. 615
 Zdorenko V. 334
 Zhylenko T. 240
 Zlotenko B. 289
 Zozulia P. 413