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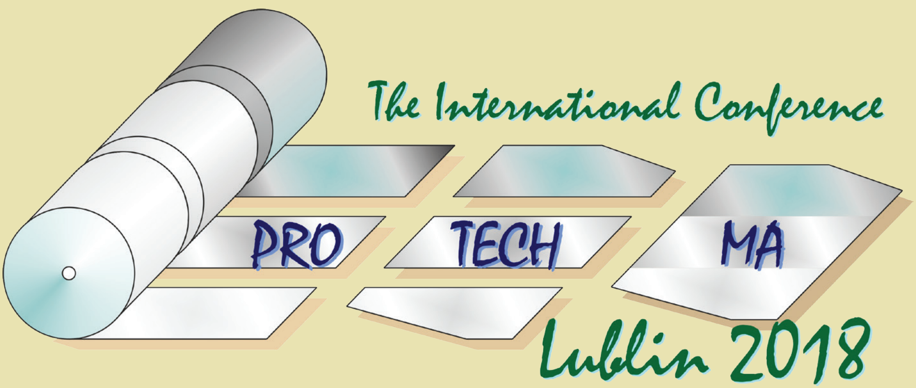
PRO-TECH-MA 2018

The Progressive Technologies and Materials

edited by
Grzegorz Samołyk



Lublin 2018

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Konferencje – Politechnika Lubelska

Politechnika Lubelska
Wydział Mechaniczny
ul. Nadbystrzycka 36
20-618 LUBLIN

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Publikacja wydana za zgodą Rektora Politechniki Lubelskiej

ISBN: 978-83-7947-313-7

Wydawca: Politechnika Lubelska
ul. Nadbystrzycka 38D, 20-618 Lublin
Realizacja: Biblioteka Politechniki Lubelskiej
Ośrodek ds. Wydawnictw i Biblioteki Cyfrowej
ul. Nadbystrzycka 36A, 20-618 Lublin
tel. (81) 538-46-59, email: wydawca@pollub.pl
www.biblioteka.pollub.pl
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Elektroniczna wersja książki dostępna w Bibliotece Cyfrowej PL www.bc.pollub.pl
Nakład: 50 egz.

Contents

Preface 9

1. **Unconventional material from sewage sludge with a potential application in a road construction** 11
M. Wójcik, Ł. Bąk, F. Stachowicz

2. **The analysis of forming loads of friction stir welding joint** 14
P. Myśliwiec, T. Balawender, R. E. Śliwa

3. **The influence of joining parameters on mechanical properties of friction stir welding joint** 17
T. Balawender, P. Myśliwiec, Ł. Micał

4. **Manufacturing technology of the thin-walled integral aircraft constructions** 20
P. Bałon, E. Rejman, R. Smusz, B. Kiełbasa, J. Szostak

5. **Comparative analysis of the impact of die design on its load and distribution of stress during extrusion** 22
I. Nowotyńska, S. Kut

6. **Effect of thickness and sheet material properties on loading the bending tool** 25
S. Kut

7. **Investigation of die oscilation effect in KOBO extrusion process** 28
M. Zwolak, T. Balawender, R. E. Śliwa

8. **Mechanical properties of chips from magnesium alloy after consolidation using the KOBO method** 31
B. Pawłowska

9. **Analysis of friction condictions in in hot ring rolling process** 34
P. Surdacki, A. Gontarz

10. **Analysis of friction conditions for commerical plasticine – copolimer ABS friction pair** 36
Ł. Wójcik, Z. Pater

11. **The effect of thermal treatment and hot forming on the structure and properties of magnesium alloy AZ91** 38
A. Dziubińska, K. Majerski, G. Winiarski, M. Szucki, K. Drozdowski

12. **Investigation of the deformability of aluminium – copper casting alloys** 40
G. Winiarski, A. Dziubińska, K. Majerski, M. Szucki, K. Drozdowski

13. **Creating the structure and properties of 7075 alloy casts by thermal and forming processes** 43
K. Majerski, A. Dziubińska, G. Winiarski, M. Szucki, K. Drozdowski

14. **Analysis of the possibility of using cast 2xxx and 7xxx series Al alloys in the forging process** 45
M. Szucki, A. Dziubińska, G. Winiarski, K. Majerski, K. Drozdowski, M. Górny, J. Buraś

15. **Investigation of the effect of the forming angle on force parameters in a skew rolling process for a stepped shaft** 48
K. Lis, Z. Pater

16. **Evaluation of fibers orientation effect in the polymer matrix on strength properties of wood-polymer composites (WPC)** 51
W. Frącz, G. Janowski

17. **Analysis of the change in thickness of the thin double reduced steel sheets by drawing of cups** 54
J. Majerníková, E. Spišák, Ľ. Kaščák, J. Slota

18. **Forming analysis of continuosly annealed, double reduced steel sheets** 57
E. Spišák, J. Majerníková, P. Mulidrán, Ľ. Kaščák, J. Slota

19. **The influence of nanofillers on LDPE mechanical properties** 60
Ľ. Dulebová, J.W. Sikora, F. Greškovič, B. Kiszka

20. **Radiation crosslinking of plastics in the automotive industry** 63
F. Greškovič, E. Spišák, Ľ. Dulebová

21. **Weldability analysis of combination of dual-phase steels DP600 and DP780** 66
Ľ. Kaščák, E. Spišák, J. Slota, J. Majerníková

22. **Options of use recycled materials in constructions of anti-sound clone (walls)** 69
M. Badida, L. Sobotová, T. Dzuro, A. Badidová, A. Mikulová

23. **Creation of al joins by thermal drilling little-waste technology** 72
L. Sobotova, M. Badida, A. Badidova, A. Mašlejová

24. **Possibilities of renovation functional surfaces of equipments in the steel industry** 75
J. Brezinová, J. Viňáš, D. Draganovská, A. Guzanová, J. Brezina

25. **Application possibilities of ceramic coatings for the restoration of functional surfaces** 78
J. Viňáš, J. Brezinová

26. **Investigations of hydromechanical forming technology for sheet blanks and tubes made of nickel superalloys inconel type** 81
M. Hyrcza-Michalska

27. **Homogenization of honeycombs structures by microplar elasticity approach** 83
A. Skrzat, F. Stachowicz, V. Eremeyev

28. **Numerical and experimental analysis of the strength of tanks dedicated to hot utility water** 85
P. Bałon, E. Rejman, R. Smusz, B. Kiełbasa, J. Szostak

29. **Effect of parameters of reduction and mixing on brake properties** 86
R. Moszumański, A. Waśko

30. **Research of the influence of the initial deflection on the product radius in the equal angle bar bending process on three-roller bending machine** 87
I. Usydus, A. Tofil, A. Gontarz

Authors Index 89

Preface

Pro-Tech-Ma (i.e. "*Progressive Technologies and Materials*") is the name of a cyclical international scientific conference where academic workers mainly from Poland and Slovakia handling primarily issues concerning the technology of processing metals and polymer materials, as well as processes directly related to these technologies, meet for more than 25 years now. The first meeting took place in Herľany near Košice, while the following conferences were held in turns – in Poland and Slovakia. The conferences took place for example in such locations as Bezmiechowa near Lesko (Bieszczady) and the picturesque Kazimierz Dolny (a town located by king Casimir the Great in the surroundings of a great terrain interlaced with mysterious gullies). For a few years now the Pro-Tech-Ma conference is being organized also by the Lublin University of Technology. This year, which constitutes an anniversary year for the university (65 years of the Lublin University of Technology), the conference took place in Lublin. Three research facilities constitute the event's organizers, i.e. Lublin University of Technology (*Faculty of Mechanical Engineering, The Department of Computer Modelling and Metal Forming Technologies*), Rzeszow University of Technology (*Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing*) and Technical University of Košice (*Faculty of Mechanical Engineering, Department of Mechanical Engineering Technology and Materials*).

The aim of the conference is to present the academic output of the cooperating academic and industrial centers, as well as an exchange of information concerning the currently conducted research works, especially in terms of developmental research. Papers presented by the participants concern the achieved results both in theoretical terms, taking advantage of numerical modelling, as well as those obtained in the course of experimental research.

Exchanging scientific experiences includes terms primarily concerning the newest construction and technological solutions.

This monograph constitutes the conference material, in which contents of the papers have been presented in the form of comprehensive summaries. I hope that the description form, which has been diligently prepared by specific authors, will result in that reading this work is going to be highly educating and inspiring, for example to undertake an academic cooperation with the authors in the nearest future. The subject matter of the conference includes the scope:

- method of determining the property of technological modern engineering materials (metals alloys, polymers and composites);
- theoretical analysis of technological processes from the scope of metal forming processing, welding, surface treatment, machining and the other processing, especially of polymer materials;
- tribological aspects of technological processes;
- modern mechanical engineering technologies;
- experimental investigations and analysis with using the numerical simulation of technological processes;
- tool and instrumentation used in the manufacturing processes;
- products design, as well as including designing production processes;
- environmental aspects of the production;
- production technologies in the aviation and automotive industry.

At this point I would like to sincerely thank (on behalf of the conference's organizers and myself) all of the authors and participants of the conference, as without them this monograph would never be created. I also address my thanks to the Scientific Committee which factual contribution and valuable remarks had an impact on creating the monograph in its current form. Special thanks to Professor Emil Spišák, Professor Feliks Stachowicz, and Professor Zbigniew Pater. Their commitment and promotion of the Pro-Tech-Ma conference results in that each year it becomes more significant within our academic environment and attracts a grand group of scientists who willingly participate in this special event.

Grzegorz Samołyk, Ph.D., D.Sc. (Eng.)
Chairman of the Organizing Committee

Marta Wójcik[1*], Łukasz Bąk[1], Feliks Stachowicz[1]

Unconventional material from sewage sludge with a potential application in a road construction

Keywords: sewage sludge, glass waste, recycling, road construction, civil engineering, utilization.

Abstract

Among all problematic types, sewage sludge is a waste that has to be properly managed in compliance with waste management requirements. According to the Central Statistical Office Report, 568 thousand Mg municipal sewage sludge was produced in Poland in 2015. The limited possibilities of agricultural utilization of sewage sludge results in the development of unconventional methods of its final management, for example, in a construction sector.

In this paper, the proposition of the use of sewage sludge in the production of unconventional material for a road construction is presented. In laboratory tests, dewatered sewage sludge with the moisture content at the level of 62%, glass powder and quartz sand were applied. The weight ratio of sewage sludge, glass powder and quartz sand was 1:0.5:0.5, respectively. The dosages were established on the basis of an initial research and literature review. Glass powder and quartz sand were mixed together and added to sewage sludge. Obtained mixture was placed into cylindrical forms with a diameter of approximately 25 mm and sintered for 1 hour at the temperature 1100°C. For obtained product, selected physical, chemical and mechanical properties were examined.

Unconventional material produced from sewage sludge, glass powder and quartz sand has a porous structure, which was shown on images (Fig. 1). The high porosity of material is closely related with the burning of organic compounds which were in sewage sludge [1]. The analysis of the chemical

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Poland
* Corresponding author: e-mail:m.wojcik@prz.edu.pl, Phone.:+48 17 865 15 07

composition also showed that the material derived from sewage sludge, glass powder and quartz sand comprises oxygen, calcium, sodium and silica among which oxygen and silica are dominant.

Fig. 1. Images of material derived from sewage sludge and other waste

Selected physical parameters of a material are presented in Table 1. The specific density of material containing sewage sludge and other waste was 2.84 g/cm^3. In comparison to other materials which are commonly applied in a construction sector, the specific density of samples is similar to concrete (approximately 2.80 g/cm^3). The bulk density of samples was 1.30 g/cm^3 and was similar to expanded clay aggregate (0.9 – 1.5 g/cm^3). In terms of the bulk density, the material might be classified as a lightweight aggregate with a bulk density below 2.0 g/cm^3. The obtained material was also characterized by the tightness and the porosity at the level of 45.8 and 54.2%, respectively. The water adsorption of tested material was approximately 18 – 30%, depending on time of the action of water.

Table 1. Selected parameters of material produced from sewage sludge and other waste

No.	Parameter	Unit	Mean value
1.	specific density	g/cm^3	2.84
2.	bulk density	g/cm^3	1.30
3.	tightness	%	45.78
4.	porosity	%	54.22
5.	water adsorption	%	18 - 30

Due to the high porosity of the material, the hardness was assessed with the use of Mohs hardness test. On the basis of Mohs scale, the hardness of samples was 3.5 Hardness of Mohs (HM). It means that the material is a medium hard and might be cracked by means of a copper wire. The mean compressive strength for tested material was 2.93 MPa. In comparison to other materials, the aforementioned parameter is similar to expanded clay aggregate, for which compressive strength is approximately 0.75 – 5.00 MPa.

In line with WT-42010 [2], PN-EN 13242+A1:2010 [3] and PN-S-96012:1997 [4], the aggregate obtained from sewage sludge, glass powder and quartz glass might be considered as a layer in a road construction.

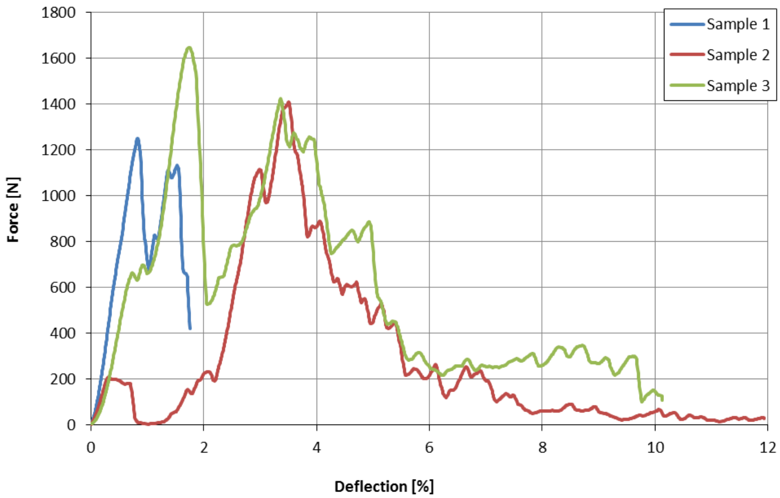

Fig. 2. The stress-strain relationship for material obtained from sewage sludge

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[3] PN-EN 13242+A1:2010 Kruszywa do niezwiązanych i związanych hydraulicznie materiałów stosowanych w obiektach budowlanych i budownictwie drogowym (in Polish)

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Piotr Myśliwiec[1*], Tadeusz Balawender[1], Romana E. Śliwa[1]

The analysis of forming loads of friction stir welding joint

Keywords: friction stir welding, aluminium 2024, AZ31B alloy.

Abstract

Friction stir welding developed in early 90's is a refreshing approach to the joining of different kinds of metals. FSW has become increasingly popular and provides excellent alternative to conventional welding or riveting sheets of various metals.

FSW is performed in three steps [1]. The first step is when the tool's pin is plunged into the joint formed by two sheets to be welded, until the shoulder gets in contact. Because the tool rotates at a high velocity, the sheets are heated up by plastic deformation and friction. In the second step the tool keeps rotating without any translation, so the material heating due to friction increases. During the third step the tool moves along the joint line, heating the material further, moving it from the front of the tool and depositing it behind its trailing edge and producing the weld.

The paper present the results of research work on linear FSW joining of aluminium 2024 and magnesium AZ31B alloys. All sheet materials used in this work were 1 mm in thickness. The blank sheet dimensions were 180 x 100 mm. A backing plate with two holders constituted the fixture to firmly hold the workpiece. Fixing device with workpiece was installed on the plate of piezoelectric Kistler dynamometer. The FSW experiments were carried out on a special adopted CNC milling machine using non consumable cylindrical tool made from tungsten carbide. Tool dimensions were adjusted to the material sheet thickness according to algorithm shown in literature [2]. Generally it was

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Poland
* Corresponding author: p.mysliwiec@prz.edu.pl

assumed that the ratio of shoulder diameter to pin diameters is about 3. Both the pin and the shoulder of the tool have smooth cylindrical shape. Tool worked without a tilt angle; it was set in perpendicular direction to the surface of the welded material. The butt joint configuration was prepared to produce the joints. Welding has been done on the 175 mm long section. The welding condition was systematically adjusted until defect-free process zones were obtained. Setup of the tool shoulder was chosen as 0.02 mm above the workpiece surface. FSW welding experiments were carried out with constant values of rotational speed and welding speed and were equal 2000 rev/min and 280 mm/min respectively. The dwell time was the same for all joints and was 10 s. Tool plunging in and out stages were realized with tool feed rate equal 5 mm/min. Visual evaluation of FSW joints showed that they were done properly, have no visible defects, face and root surfaces were smooth and uniform. No flash means more plastic material flows into the joint.

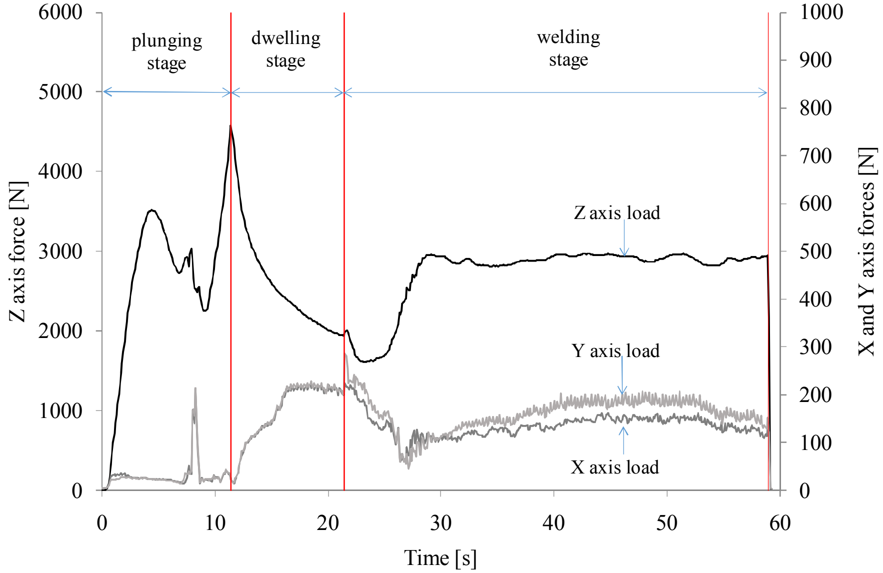

Fig. 1. Forces recorded during FSW joining of AZ31B magnesium alloy

The vertical (Z axis) and horizontal (X,Y axis) forces occurring during linear FSW process (Figure 1) were measured by high sensitive piezoelectric dynamometer developed by Kistler. It consist of four piezoelectric force sensor calibrated in range from 0 to 60 kN. Sensors were fitted between two rigid plates

(500 mm long, 500 mm width and 50 mm in thickness each). All sensors were connected via adder to a single charge amplifier. The force data were acquired with a maximum sample rate per channel of 200 kS/s and 16-bit resolution. The actual sample rate used during the data recording was 1 kHz.

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Tadeusz Balawender[1*], Piotr Myśliwiec[1], Łukasz Micał[1]

The influence of joining parameters on mechanical properties of friction stir welding joint

Keywords: friction stir welding, aluminum alloy, magnesium alloy.

Abstract

Friction stir welding (FSW) is energy efficient, environment friendly and versatile solid-state joining process. This joining technique can be applied to joining different materials, even such as not weldable light metals. Application of this method to aerospace industry is very attractive because of low temperature of the process (beneath melting point of joined materials) and lack of any filler metal. During the process, rotating tool with a pin and a shoulder is put into the abutting edges of sheets to be joined and moved along the weld line. The tool movements result in a heating of joined sheets and in a movement of material to produce the joint. The heating is obtained by friction between the tool and the material and by plastic deformation. The localized heating softens the material of joined sheets around the pin and combination of the tool rotation and translation leads to shift the material from the front to the back of the pin. As a result of this process a joint is produced in 'solid state' without melting joined materials.

In this work, the experimental investigations of friction stir welding process were described. The test FSW butt joints were carried out on aluminum 2024 and magnesium AZ31 alloys sheets with thickness of 1 mm. The joining process was realized on numerical controlled 3 axis milling machine using own made tools and fastening device. The processing tool used in the tests was made of carbide and has a shoulder with 10 mm diameter, and a cylindrical pin with 3.0 mm diameter and 0.95 mm height. The angle of tool tilt was equal to 0° in all

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Poland
* Corresponding author: tbalaw@prz.edu.pl

experiments. The changeable process parameters were tool plunging depth, tool rotation speed and its rate of feed.

All joints were made of end-to-end (butt) configuration under different process parameters. The effect of selected technological parameters on the quality of the joint was analyzed. Produced butt joints have been subjected to a static tensile testing to identify mechanical features of the joints and compared to the properties of parent materials. Axial and radial welding forces in the joining region were recorded during the tests and their dependency from the welding parameters was studied. Based on results of strength tests the efficiency of joints for sheets of 1 mm was compared to the parent sheet material. It has been found that for given parameters the correct, free of defects joints were obtained. The results suggests that FSW can be effectively applied to aluminium and magnesium alloys.

To date, the challenge remains in the fundamental understanding of the governing mechanisms for the joint formation and the resulting mechanical behavior of the joint after FSW [1]. In this study, the general objective was to investigate the influence of FSW process conditions (by varying the rotation and travel speed of the tool) on the forming load and the load capacity of the joint.

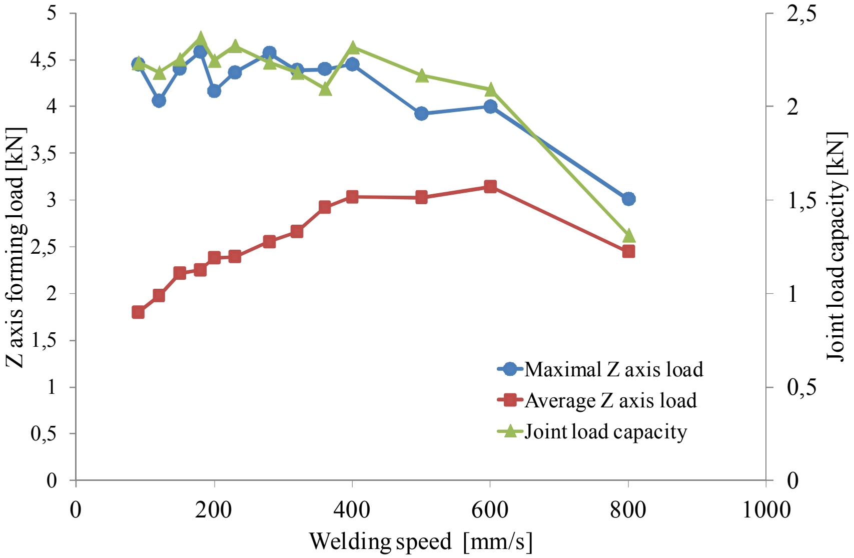

Fig. 1. FSW joint process loads and joint load capacity versus rate of tool feed

The tests results show a good coincidence between maximal forming load (recorded in Z axis at the end of the pin plunging step) and the load capacity of the joint (Fig.1); the fluctuation of the first one results in the same fluctuation of the second one. The increase of the welding speed causes increase in average Z-axis welding load but it is correlated with decrease of the load capacity of the joint.

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Paweł Bałon[1*], Edward Rejman[2], Robert Smusz[2],
Bartłomiej Kiełbasa[1], Janusz Szostak[3]

Manufacturing technology of the thin-walled integral aircraft constructions

Keywords: high speed machining, milling, thin-walled constructions.

Abstract

In this paper the authors present the innovative machining method of thin-walled elements dedicated to the aviation industry. The developed manufacturing technology of the complex aircraft structure was based on the example of the front beam of the Commuter aircraft. The method of manufacturing of the thin-walled structural elements creates a number of technological problems related to the occurrence of deformations and elastic and plastic movements of the workpiece. Due to displacements of the milled workpiece, vibrations can occur, and thus, geometric structure of the surface can be affected – roughness, waveness. Furthermore, plastic deformation can also cause shape problems and be a source of internal stresses in the surface layer which are highly difficult to remove and can lead to deformation of the workpiece after machining. Consequently, this leads to an increase in the manufacturing costs of machining operations, especially of thin-walled elements, due to shortages and increased manufacturing time. In order to improve the quality of thin-walled elements, many methods of minimizing the machining errors were implemented, such as:

- optimization of the machining strategy;
- optimization of cutting parameters, especially feed per tooth f_z, and the thickness of the cut layer a_e due to the minimization of the cutting force component perpendicular to the surface of the milled wall;

[1] SZEL-TECH Szeliga Grzegorz, Soltyka 16, 39-300 Mielec, Poland
[2] Rzeszow University of Technology, Rzeszow, Poland
[3] AGH University of Science and Technology, Kraków, Poland
* Corresponding author: balonpawel@gmail.com

- increasing the cutting speed v_s.

Acknowledgment

The works were carried out within the project "699757/SAT-AM" – Work programme topic: JTI-CS2-2015-CPW02-AIR-02-07. More Affordable Small Aircraft Manufacturing; Airframe itd. Grant Agreement No: CS2-AlR-GAM-2014-2015-01 (annex III) co-financed by Horizon 2020 Clean Sky 2. Special thanks go to the teams from: Instytut Lotnictwa, SZEL-TECH Szeliga Grzegorz, Zakłady Lotnicze Margański&Mysłowski, PZL Mielec, CIRA, Eurotech, Metrol and Ultratech.

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Irena Nowotyńska[1], Stanisław Kut[2]

Comparative analysis of the impact of die design on its load and distribution of stress during extrusion

Keywords: extrusion, FEM simulation, compressed die.

Abstract

Punches and dies for the extrusion are the most loaded tools from those used in the process of forming. This results in high requirements for tool materials, their heat treatment as well as construction and accuracy of workmanship. An important parameter for optimizing the durability of the tool is the introduction of initial compressive stress in the die insert by using a single ring, or a greater number of concentric rings between which there are contraction or press connections of the compression ring.

The paper presents numerical comparative analysis of stresses in the non-compressed (normal) and compression molded during extrusion. Numerical calculations were made using commercial MARC/Mentat from MSC Software. The extrusion process was modeled for a non-compressed die and compressed with a single steel ring using different mounting pressures. This made it possible to determine the places and the amount of wear, depending on the press used. The die pattern with dimensions is shown in Figure 1. The angle of the work cone is assumed to be $\alpha = 30^o$, while the length of the calibration bar $l_k = 5$mm.

Compression die testing was performed for seven selected push values that were 0.0015; 0.003; 0.006; 0.009; 0.012; 0.015 and 0.019 mm. Stress readings were made at 7 measuring points for all applied dies and inserts in the die insert and ring regions. Figure 2 shows the calculated relationship of circumferential stress at selected monolithic measuring points and compressed with one ring

[1] Rzeszow University of Technology, The Faculty of Management, Department of Computer Engineering in Management, Rzeszów, Poland

[2] Rzeszow University of Technology, The Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Rzeszów, Poland.

* Corresponding author: i_nowot@prz.edu.pl, Phone: +48 17 865 1894

using seven mounting pressure values. It was found that the use of the steel ring significantly influences the value of circumferential stresses. As shown in the graph (Fig. 2), the use of a pre-compressed die significantly reduced the peripheral stresses in the tool during extrusion.

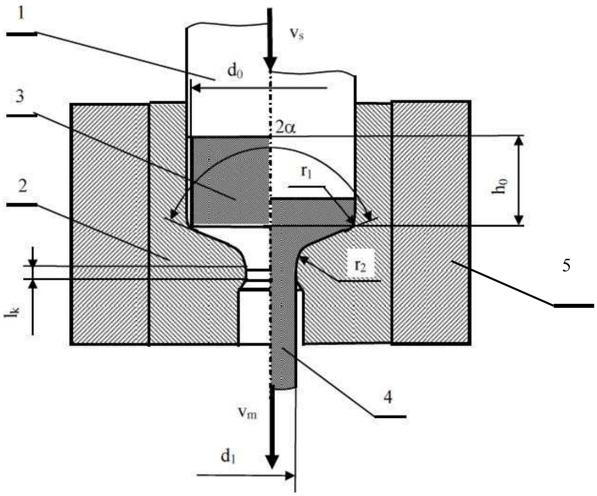

Fig. 1. Scheme of the extrusion process: 1 - punch, 2 - die, 3 – billet, 4 - extruded material; 5- compression ring; punch speed vectors (v_s) and material to flow from the die (v_m)

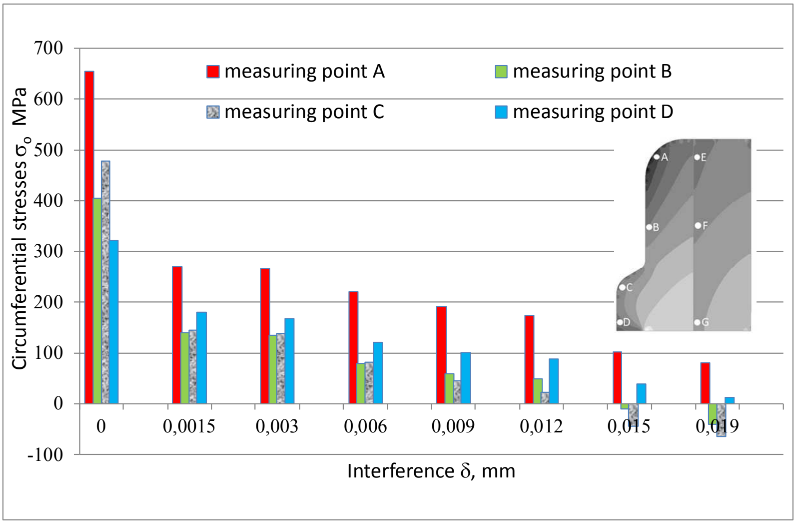

Fig. 2. Calculated values of circumferential stresses in the loaded monolithic die (δ = 0) and the compression molded inserts depending on the press used

Thanks to the use of numerical modeling in industrial practice, the best design of tools and tooling can be selected, as well as a technological process that ensures the longest possible tool life and high dimensional accuracy and dimensional accuracy of the products while reducing costly experiments. The calculation method used in the work permits the determination of the stress values in the tool of any profile, taking into account differential loads from the extruded material and friction conditions. On the basis of the results obtained, for the case of the die loads, the optimum size of the mounting bracket can be selected for operational use, premature destruction, and the technological possibilities of applying the appropriate size of the pressing in industrial practice.

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Stanisław Kut[1]

Effect of thickness and sheet material properties on loading the bending tool

Keywords: bending, tools load, numerical simulation, stress distribution.

Abstract

Currently, the prevailing trends to reduce the weight of structures, including sheet metal structures, force the manufacturers of machines and devices to use more durable materials. Until recently, the yield point of plates shaped on bending machines rarely exceeded 300 MPa. Currently, sheet metal is increasingly being formed on bending machines, whose yield strength exceeds 700 MPa. For this reason, most of the tools produced in traditional technologies no longer meet the requirements and expectations of customers mainly due to the low durability of these tools.

Effective design and production of bending tools that meet the requirements of today require knowledge of forces acting on the tools and distributions and values of stress occurring in the material during the implementation of the technological process. These data, taking into account the specificity of the technological process, the properties of shaped materials and tool material, can be obtained at the design stage using numerical modeling based on non-linear MES. The data obtained in this way allows such a selection of materials for tools and technologies for their production (including heat treatment) to fully meet the requirements imposed on them today, also in the economic aspect, i.e. maintaining a high quality/price ratio.

The paper presents the results of numerical analyzes aimed at determining the effect of bent band thickness and the properties of the bent sheet material on the load of the bending tool. The calculations were carried out with

[1] Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Poland,
* Corresponding author: stan_kut@prz.edu.pl, Phone.:+48 17 8651558

the assumption of six thicknesses of bent sheets, i.e. 0,5; 1; 1,5; 2; 3 and 4 mm. Five steel grades with different properties, i.e. S185, S355J2G3, S500MCD, INCONEL 625 and S700MCD were selected as representative sheet materials for testing. Numerical calculations for 26 bending cases were carried out using commercial software for nonlinear and contact issues MARC/Mentat. The process geometric model together with finite element mesh is shown in fig.1.

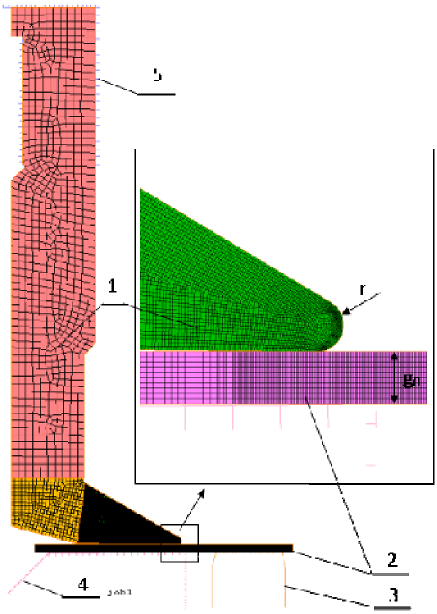

Fig. 1. Geometric model of the bending process with the finite element mesh: 1 – tool (template), 2 – bending plate, 3 – bending arm, 4 – table, 5 – tool holding socket

The surface analysis (fig. 2 a), stress intensity (fig. 2 b) and displacement of the tool tip (so-called stencil or knife) were subjected to a comparative analysis. As the thickness of the bent sheet increases, both the maximum pressure and the intensity of the stress go up. This increase can be described with good approximation using the second degree polynomial. In addition, the type of shaped material, specifically its yield point and the ability to reinforce strain, have a fundamental influence on the pressure and stress intensity.

The research shows that both the thickness of the bent sheet and the material grade significantly affect the load of bending tools. Both the surface pressure and the stress intensity as well as the displacement of the corner tip of the tool are a function of the thickness of the bent sheet. The course of these functions can be described with a sufficiently good approximation by means of a second degree polynomial. Knowledge of the numerical values of tension and pressure is the basis for the selection of material for the tool and its technological process including heat treatment. In this respect, the benefits of MES modeling using commercial software to analyze non-linear and contact issues of mechanics of deformable bodies cannot be overestimated both at the design stage of the tool and the technological process.

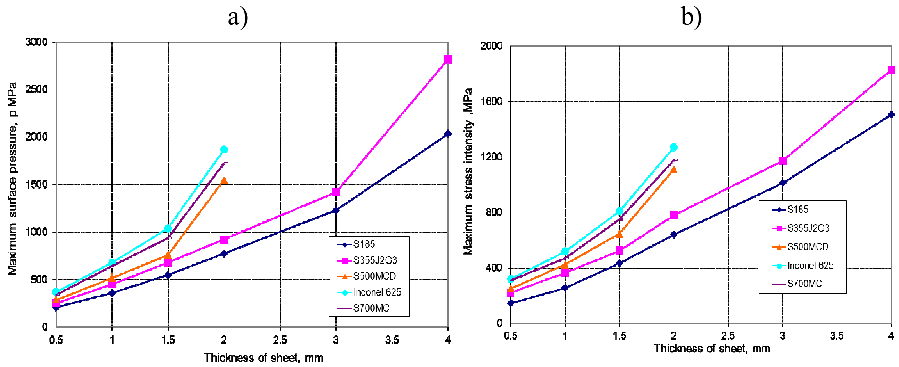

Fig. 2. Influence of sheet thickness and steel grade on: a) maximum surface pressures, b) maximum Huber-Mises stresses

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Marek Zwolak[1*], Tadeusz Balawender[1], Romana E. Śliwa[1]

Investigation of die oscilation effect in KOBO extrusion process

Keywords: extrusion, KOBO method, aluminium alloys.

Abstract

The KOBO method is an unconventional method of metallic materials extrusion. This method is based on phenomenon of changing the path of plastic deformation with use of cyclic oscillation of the tool (die) by a given angle and frequency (Fig. 1) [1].

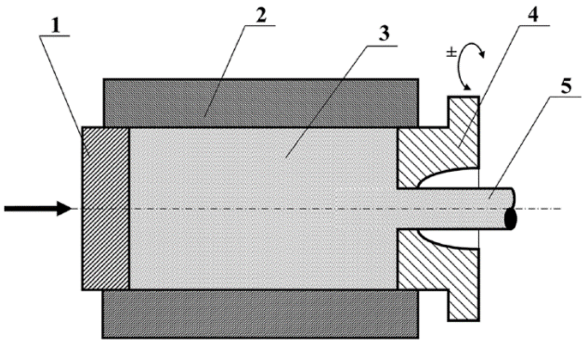

Fig. 1 KOBO extrusion pattern, 1 – ram, 2 – container sleeve, 3 – billet, 4 – cyclic rotating die, 5 – extruded product [1]

KOBO can be recognized as an SPD (Severe plastic deformation) method that are used to change materials properties by grain fragmentation. Introduction of die oscillating movement changes the plastic deformation scheme from axial-radial like in conventional extrusion into layer like radial flow. In addition,

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Poland
* Corresponding author: m.zwolak@prz.edu.pl

unlike the most of SPD methods, it allows to obtain the product with complex cross section geometry like conventional extrusion processes.

The biggest advantage of KOBO method is that it allows to extrude metallic materials without billet and press parts preheating with significant extrusion force lowering. What is more, it makes possible to extrude hardly-deformable metallic materials with high extrusion ratio.

The investigations presented in this work were realized using 2.5 MN forward extrusion press equipped with the KOBO device. The die oscillation angle was equal $\pm 8^0$ and the oscillation frequency was changeable in range from 2 to 8 Hz during realized tests. Ingots, 59.5 mm diameter and 60 mm length, were cut from as delivered rods. The extrusion ratio was equal $\lambda = 36$ and round rods 10 mm diameter were extruded. Initial temperature of the ingots was room temperature (without preheating) and extrusion rate, i.e. velocity of the stem displacement was 0.2 mm/s. The die was water cooled during processing; extrudate was air-cooled. During the process such process parameters as: stem position, stem speed, extrusion load and die oscillation were recorded. Mechanical properties of extruded rods were tested by means of Zwick / Roell Z100 testing machine.

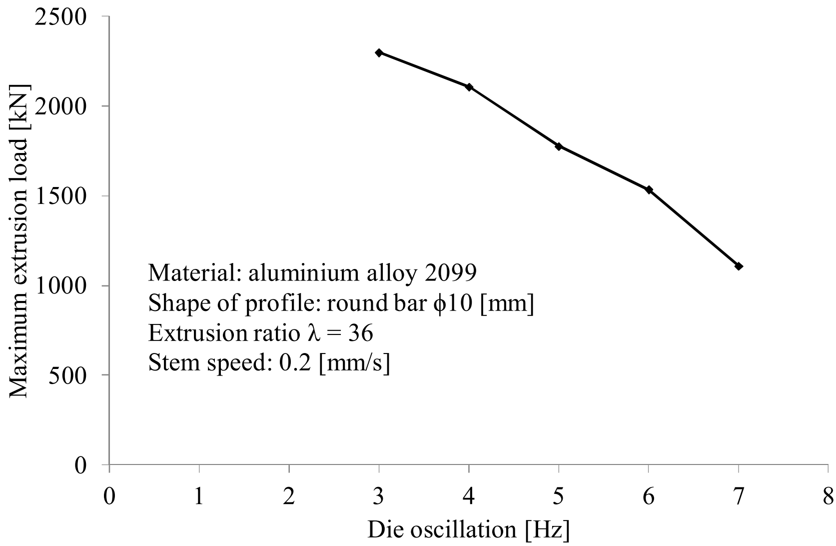

Fig. 2. Extrusion of 2024 aluminium alloy with constant extrusion velocity and load

The main aim of investigations was determination of relationship between extrusion load and extrudate strength with the die oscillation (Fig. 2). The essential effect of die oscillation on extrusion load and extruded rod strength was observed, e.g. increasing the die oscillation from 3 to 7 Hz caused the extrusion load to be twice decreased for aluminium alloy 2099.

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Beata Pawłowska[1]

Mechanical properties of chips from magnesium alloy after consolidation using the KOBO method

Keywords: KoBo, extrusion, recycling of chips, magnesium alloys.

Abstract

Manufacturing metal objects leads to a great amount of scrap material, such as: chips, cuttings or defective components. Most often, such scrap material goes back to ironworks, where it is recycled and some part of it can be used again in manufacturing processes. However, the recycling methods, which have been applied so far, are hardly effective considering large metal waste due to oxidation when heating the chips to the melting temperature.

However, there exists another method of metal waste management, which involves its direct conversion into solid material. That method involves refinement of metal waste, its preliminary cold moulding, which is followed by extrusion.

This paper presents an analytical study of recycling aluminum chips, on the example of chips of AZ80 magnesium alloy, by plastic consolidation with the use of KoBo method

KoBo method is an interesting technical and technological solution allowing for controlling the process of plastic flow of metallic materials, but also an effective method of forming the structure and properties of materials. The application of additional reversible torsion of die by a given angle, at specific frequency (Fig. 1) results in some strain caused by die torsion leading to the existence of viscoplasticity effect of the material.

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing, Poland
* Corresponding author: bpaw@prz.edu.pl

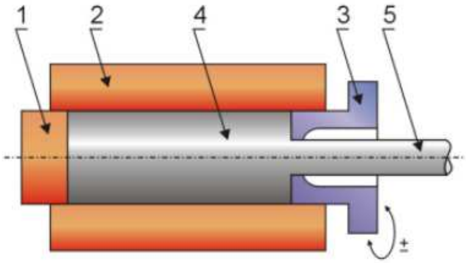


Fig. 1. Scheme of extrusion by KoBo method: 1 – punch, 2 – container, 3 – reversibly rotating die, 4 – extruded metal/billet, 5 – product

In general, recycled materials are characterized by worse plastic and mechanical properties compared to the original solid material. The research has shown that the consolidation process of plastic materials based on Mg alloys is able to provide very high quality and desired properties of the output product, in some cases even better than for solid material.

The proposed method is based on cold compaction of chips into briquettes (Fig. 2), and then extrusion by KoBo method at room temperature (Fig. 3). The extruded wires were tested for mechanical properties (uniaxial tensile test and Vickers hardness test), and compared with specific mechanical properties of solid material.


Fig. 2. Chips of AZ80 alloy and magnesium briquette made of them

A very good effect of chips compaction has been proved by KoBo method, which has been confirmed by relatively slightly different mechanical properties of the material after recycling compared with the solid one. In comparison to other recycling methods, chip extrusion by KoBo method is an innovative and energy-efficient solution. The application of that method on specially designed hydraulic presses allows for obtaining products of larger cross-sections as well as larger scale of chip processing. It will also allow for controlling the product properties by proper selection of process parameters and possible heat treatment.

Fig. 3. Hydraulic press used in the experiment

The above suggested methods, which do not use melting processes, seem to be highly attractive from the economical point of view. The use of plastic consolidation should limit the waste of metallic material almost completely, and the estimated amount of work and energy is from two up to five times lower compared with recycling by melting method. The recycling method is an alternative solution to conventional method of recovering metals by melting processes.

Piotr Surdacki[1*], Andrzej Gontarz[1]

Analysis of friction condictions in the hot ring rolling process

Keywords: ring rolling, friction, plastic forming, FEM.

Abstract

An effective method of producing ring products with large diameters in relation to the dimensions of the cross-section is hot rolling. This process is a typical incremental metal forming process. The scheme of ring rolling process using a main roll and a mandrel is shown in Fig.1. The main roll 1 moves radially with the speed V_1 towards the mandrel 2, causing a change in the cross section of the blank. It also rotates at the speed n_1 causing rotation of the ring 3. The mandrel on which the rolled element is placed rotates in relation to its own axis. It should be mentioned that the guide rolls are also used in the process, however, they have not been used for the discussed tests because the friction factor between the main roll and the rolled ring was determined.

Due to the complexity of the design process, numerical simulations are very helpful. An important issue is an adequate description of the friction conditions. Most often, in the calculations, a shear friction model is used, in which the friction factor is characterized by a rubbing pair: tool - a deformed material. In the specialist literature there are discrepancies in the value of this factor. It prompted the authors to undertake research aimed at determining the friction factor for a rubbing pair: tool – rolled ring, that when used in simulations, will ensure the best convergence of calculation with experience results.

Steel samples with initial dimensions: external diameter 110 mm, internal diameter 50 mm, height 15 mm, heated to a temperature of 1100 °C, were used for the tests. A main roll and a mandrel with special technological undercuts

[1] Department of Computer Modelling and Metal Forming Technologies, Mechanical Engineering Faculty, Lublin University of Technology, Poland
* Corresponding author: piotr.surdacki@pollub.pl

were used in the process to prevent the rolled ring from moving in the axial direction. Laboratory tests were carried out on a vertical mill with a constant rotational speed of the main roll n_1 = 92 rpm, only its feed speed V_1 was changed. It was assumed that the rolling process will last until the rolled ring reaches a thickness of 14 mm.

On the basis of experimental tests, it was found that the critical feed speed of the main roll, conditioning the correct course of the process, is V_1 = 35 mm/s. At higher speeds the blank crumpled, the friction forces were too small to rotate.

The next stage of the research was to conduct a series of numerical simulations using a commercial programme dedicated to the analysis of plastic metal forming processes – Simufact.forming v.13.3. In numerical calculations, parameters were used, consistent with the parameters of the real process. Changing the value of the friction factor, the aim was to obtain compatibility between the results of the simulation and the experimental results in the extent of the impact of the feed speed of the main roll on the process. On the basis of the applied research methodology, the friction factor m = 0.6 was determined as the most suitable for numerical analysis using the programme Simufact.forming v.13.3. With this factor, the best compatibility between the results of the simulation and the results of experimental test was obtained (Fig. 2).

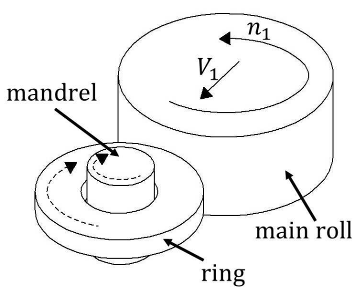


Fig. 1 Scheme of ring rolling process

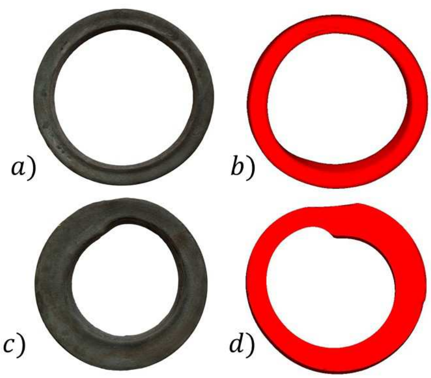


Fig. 2 Shape of rings after the ring rolling process: a) experimental test with 35 mm/s speed, b) numerical symulation with 35 mm/s speed, c) experimental test with 40 mm/s speed, d) numerical symulation with 40 mm/s speed

Łukasz Wójcik[1*], Zbigniew Pater[1]

Analysis of friction conditions for commerical plasticine – copolimer ABS friction pair

Keywords: physical modelling, plasticine, friction.

Abstract

The paper presents the results of laboratory tests on the basis of which the friction conditions between the model material and tools made of ABS material were determined. The Coulomb friction model was used in the research.

As a model material, commercial plasticine based on the PRIMO company was adopted, while the tools were made using the 3D FDM / FFF method on the uPRINT SE printer. The building material used for printing is ABS P430. Fig.1 presents the tools used for testing (the base and the holder allowing for mounting the sample and the weight).

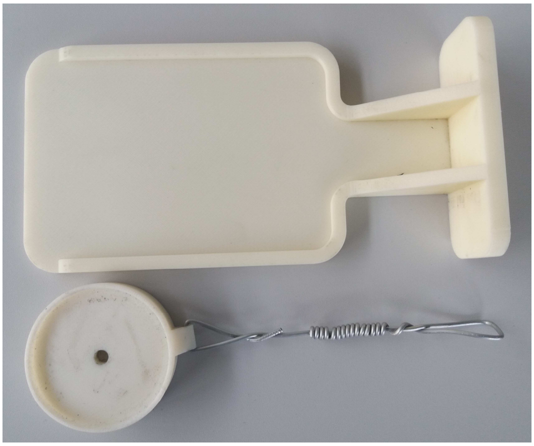


Fig.1. Prints of tools used for laboratory tests

[1] Department of Computer Modelling and Metal Forming Technologies, Mechanical Engineering Faculty, Lublin University of Technology, Poland
* Corresponding author: l.wojcik@pollub.pl

Laboratory tests were carried out for five temperatures (0, 5, 10, 15, 20˚C) under dry friction and lubrication conditions (PTFE oil). For laboratory analysis, samples of model material in the shape of discs with a diameter of 50 mm and a thickness of 5 mm in black and white (Fig.2) were used. The tests were carried out on a test bench based on the CGD-E 2000 laboratory chain saw (Fig.3). The laboratory stand consists of tools, a force sensor (AXIS 1kN) and a computer with software allowing to import on-line measurement results along with the possibility of their subsequent processing.

Based on the collected information, it was observed that in conditions of dry friction in the range of the tested temperatures, the values of dynamic friction coefficients for both colors of plasticine are out of range. After applying Teflon oil lubrication results were obtained for white plasticine, respectively: 0˚C – 0.454; 5˚C – 0.411; 10˚C – 0.376; 15˚C – 0.319; 20˚C – 0.223, while for black plasticine: 0˚C – 0.44; 5˚C – 0.365; 10˚C – 0.362; 15˚C – 0.382; 20˚C – 0.196. The use of appropriate lubrication during physical modeling allows to obtain more accurate results of physical simulation of plastic forming processes.

Fig. 2. Tested samples of commercial plasticine

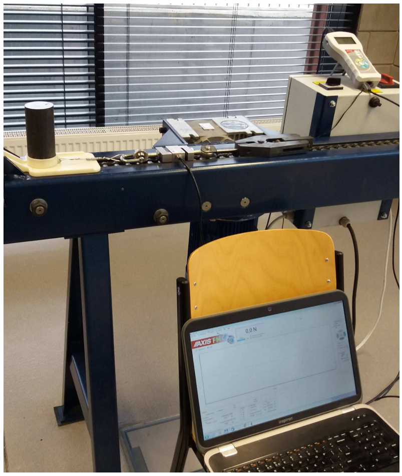


Fig.3. Stand for laboratory tests

Anna Dziubińska[1*], Krzysztof Majerski[1], Grzegorz Winiarski[1],
Michał Szucki[2], Krzysztof Drozdowski[3]

The effect of thermal treatment and hot forming on the structure and properties of magnesium alloy AZ91

Keywords: magnesium casting alloys; AZ91; open die forging; microstructure examination; hardness tests.

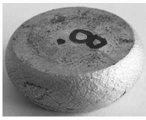
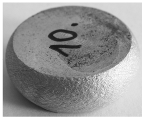
Abstract

The objective of this study was to determine the effect of thermal treatment and hot forming on the structure and properties of magnesium alloy AZ91. A growing interest in the application of magnesium alloys in the aircraft and automotive industry results from their unique properties such as low density and very high mechanical properties. One of the manufacturing priorities in the above industrial branches is to decrease the weight of transportation means. As a result, components made of magnesium-based light metal alloys are more and more widely used in the aircraft and automotive design [1-2]. The first part of the study describes general characteristics of magnesium casting alloys and provides a survey of the literature on the thermal treatment and metal forming techniques for these alloys. A subsequent part of the study describes tests of thermal treatment and hot forming of magnesium alloys of grade MgAlZn. The tests were performed on magnesium casting alloy AZ91 which is widely available on the market. Two forming methods were employed. In the first method, alloy AZ91 was hot formed from a billet delivered in the form of annealed cast. The other method consisted in subjecting the billet first to solution heat treatment and then to metal forming [3]. Magnesium alloy AZ91 as formed by open die forging on a hydraulic press in a temperature range

[1] Lublin University of Technology, Faculty of Mechanical Engineering, Poland
[2] AGH University of Science and Technology in Cracow, Faculty of Foundry Engineering, Poland
[3] ZOP Co. Ltd Forging Plant, Świdnik, Poland
* Corresponding author: a.dziubinska@pollub.pl, phone: +48 (81) 5384364

of 250°C÷450°C. Examples of produced forgings are shown in Table 1. Next, the paper reports the results of microstructure examination and the properties of alloy AZ91 after the forging process. The experimental results were used to determine optimum hot forming conditions for magnesium alloy AZ91 with respect to obtaining the best microstructure and properties.

Table 1. Photographs of selected samples of magnesium alloy AZ91 after open die forging

Research methods	Forging temperature [˚C]				
	250	300	350	400	420
1. Forging of billet in the form of cast after annealing.					
2. Solution heat treatment of cast. 2. Forging of billet in the form of cast after heat treatment.					

Acknowledgment

Project “The Design and Implementation of an Innovative Low-Waste Metal Forming Technology for High-Strength Light Metal Alloys Used in the Aircraft and Automotive Industry”; No. LIDER/10/0058/L-8/16/NCBR/2017. Total cost of the Project: 1,200,000 PLN. The project is financed by the National Centre for Research and Development under the 8th edition of the LIDER Programme.

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Grzegorz Winiarski[1], Anna Dziubińska[1], Krzysztof Majerski[1],
Michał Szucki[2], Krzysztof Drozdowski[3]

Investigation of the deformability of aluminium – copper casting alloys

Keywords: aluminium alloy, metal forming, upsetting test, qualitative research.

Abstract

This paper presents the results of a study investigating the deformability of casts made of two grades of aluminium-copper alloys: EN AW-2017A and EN AW-2024. It is worth mentioning that the above grades of Al alloys are part of 2XXX (Al-Cu) alloys and thus exhibit very high mechanical properties. As a result, they are widely used for producing high-loaded components of mechanical, building, aircraft or automotive structures. Nonetheless, the formation of machine components of complex geometry from the above alloys by metal forming techniques can be difficult due to relatively low workability of these alloys, which may lead to various failure modes such as material cohesion loss, die underfill, overlap, crack occurrence in the parting plane of the dies and the formation of coarse-grained structures. To prevent the occurrence of these failure modes, wrought billet materials made of these alloys are subjected to multi-treatment deformation and thermal treatment.

The investigation of the deformability of EN AW-2017A and EN AW-2024 involved performing an upsetting test in compliance with the standard PN-H-04411 [1]. Test samples were produced by two casting methods for sand moulds and a casting method for permanent moulds. Cast rods were first skinned and then cut into cylindrical samples. After that, they were subjected to homogenizing annealing. The upsetting test of 2XXX aluminium alloys were

[1] Lublin University of Technology, Faculty of Mechanical Engineering, Poland
[2] AGH University of Science and Technology in Cracow, Faculty of Foundry Engineering, Poland
[3] ZOP Co. Ltd Forging Plant, Świdnik, Poland
* Corresponding author: g.winiarski@pollub.pl, phone: +48 (81) 5384679

carried out on the Nargesa MX 700 hydraulic press equipped with a specially designed device for upsetting. Samples of the tested aluminium alloys were subjected to hot upsetting to 1/3 of their height in the range of 420-500 ºC changed every 20ºC [2, 3]. During upsetting, the flat tools were heated to 250 ºC.

Examples of samples after upsetting are shown in Table 1. The experimental results demonstrate that the casting type has a significant effect on the workability of aluminium-copper alloys. The permanent-mould castings have higher deformability in the tested range of temperatures. In contrast, the samples of sand-mould castings made of EN AW-2017A and EN AW-2024 formed at a low temperature showed low workability properties and were prone to cracking. After upsetting, the alloy samples were examined for microstructure and hardness. The experimental findings helped determine the deformability of aluminium-copper casting alloys.

Table 1. Photographs of selected samples of Al-Cu alloys after upsetting

Grade of alloy	**Type of casting mould**	**Upset temperature, [˚C]**		
		420	**440**	**460**
2017A	Sand mould			
2017A	Steel permanent mould			
2024	Sand mould			

Acknowledgment

Project "The Design and Implementation of an Innovative Low-Waste Metal Forming Technology for High-Strength Light Metal Alloys Used in the Aircraft and Automotive Industry"; No. LIDER/10/0058/L-8/16/NCBR/2017. Total cost of the Project: 1,200,000 PLN. The project is financed by the National

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Krzysztof Majerski[1], Anna Dziubińska[1], Grzegorz Winiarski[1],
Michał Szucki[2], Krzysztof Drozdowski[3]

Creating the structure and properties of 7075 alloy casts by thermal and forming processes

Keywords: aluminum alloys, heat treatment, metal Forming, microstructure.

Abstract

Aluminium alloys are nowadays widely used in the industry owing to their properties and the availability of many forming techniques for these alloys, including casting, metal forming and machining [1]. Aluminium alloys have low density and high corrosion resistance. In addition, their mechanical properties can be shaped to a great extent due to the possibility of using a numerous group of alloying elements and the thermal workability of many of these alloys [2]. The objective of this study is to investigate the hot workability of alloy EN AW7075 in the form of sand mould cast in terms of obtaining a advantageous microstructure.

Experiments were performed on casts made of alloy EN AW7075 in sand moulds. Ingots were skinned and cut into cylindrical samples. After that, they were subjected to homogenization at 475°C for 24h in order to obtain a homogenous chemical composition. The forging temperature was set to 420, 440, 460, 480 and 500°C in order to determine the range of workability of alloy 7075. The forging tests were performed in accordance with the standard PN-H-04411:1983 by open-die hot forging on a hydraulic press, Nargesa MX-700. The analysis involved investigation of alloy work-ability, its susceptibility to crack occurrence, the hardness and changes of alloy microstructure during the forming process. To enhance their mechanical

[1] Lublin University of Technology, Faculty of Mechanical Engineering, Poland
[2] AGH University of Science and Technology in Cracow, Faculty of Foundry Engineering, Poland
[3] ZOP Co. Ltd Forging Plant, Świdnik, Poland
* Corresponding author: k.majerski@pollub.pl:, phone: +48 81 5384218

properties, the forgings were subjected to further thermal treatment by solutioning and artificial ageing.

The results of examination of the alloy 7075 microstructure after casting reveal the presence of both the primary α phase in Al and eutectic compositions of Mg (Zn, Cu, Al)2 located on the grain boundary. As a result of homogenization, the microstructure exhibits total dissolution of the eutectic compositions and a considerable increase in its homogeneity.

The results of the forging tests demonstrate that there structural defects such as workpiece surface cracking strongly depends on the forging temperature. A further thermal treatment of forgings free from visible forging defects has a significant effect on their microstructure and leads to their increased hardness.

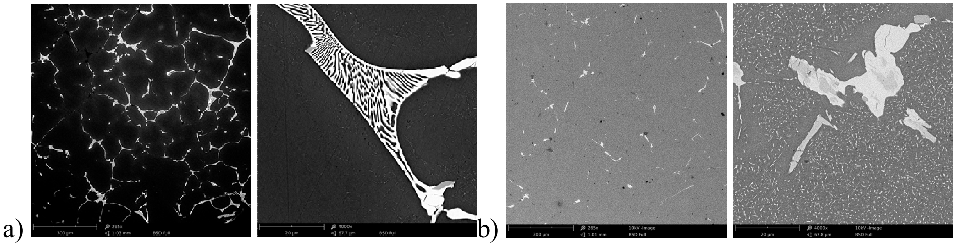

Fig. 1. Microstructure of EN AW7075 – a) after casting, b) after homogenization

Acknowledgment

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The National Centre for Research and Development
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Michał Szucki[1*], Anna Dziubińska[2], Grzegorz Winiarski[2], Krzysztof Majerski[2], Krzysztof Drozdowski[3], Marcin Górny[1], Janusz Buraś[1]

Analysis of the possibility of using cast 2xxx and 7xxx series Al alloys in the forging process

Keywords: cast into green sand moulds, cast into steel permanent mould, 2XXX series Al alloys, 7XXX series Al alloys, forgings.

1. Introduction

At present, casting and forging are two of most commonly used production methods of metal objects. Casting is a less expensive and more efficient technology, but its main disadvantage is the heterogeneity of the obtained material structure. In turn, forging allows for high dimensional accuracy and homogenization of the microstructure which, however, are associated with the need to incur greater financial and work effort. An interesting alternative seems to be the combination of these methods so that the prefabricates can be made by casting and then the final shape and properties of the objects are obtained by forging [1, 2]. The aim of the work is to analyse the possibilities of using aluminium alloys for forming as materials for casting prefabricates in forging process.

2. Methodology

The authors analysed two alloys of the 2xxx series and two of 7xxx series: 2017A, 2024 and 7022, 7075 respectively. Commercial alloys were remelted and cast into green sand moulds (Fig. 1) and steel permanent mould. In this way, cylindrical samples of the dimension of ∅32x75 mm were obtained. Next, LM

[1] AGH University of Science and Technology in Cracow, Faculty of Foundry Engineering, Poland
[2] Lublin University of Technology, Faculty of Mechanical Engineering, Poland
[3] ZOP Co. Ltd Forging Plant, Świdnik, Poland
* Corresponding author: m mszucki@agh.edu.pl, phone: +48 12 6174718

and SEM analysis were performed. These studies included the impact of the selected alloy and mould type on the casting microstructure.

Fig. 1. Casting process in green sand moulds: mould scheme (a), mould before pouring (b), ready castings after shakeout (c)

3. Result and discussion

In each of analysed cases the mould cavity was properly filled and the shrinkage did not deform the castings. Despite the lack of feeders, no large shrinkage cavities were observed. Light microscopy also indicated the lack of gas-related porosity in all castings. However, a small shrinkage micro-porosity was detected. The higher number of pores was observed in the 7075 alloy in contrast to 2017A alloy with almost no micro-porosity. Obviously, type of mould significantly influenced the microstructure of the castings. In the case of permanent mould, higher number of primary dendrites (α-Al) was observed (Fig. 2).

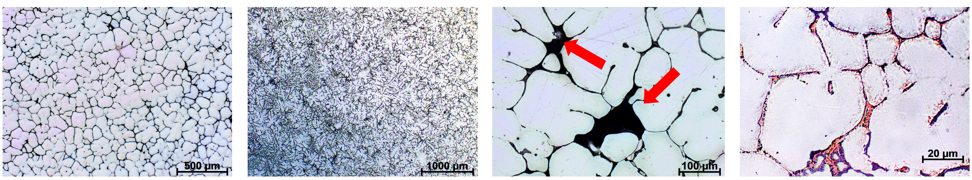

Fig. 2. Example results for 2017A alloy: (a) microstructure (sand mould), (b) microstructure (permanent mould), (c) microstructure with visible micro-porosity, (d) eutectic in interdendritic regions

4. Conclusions

Thanks to the use of base alloys of high purity and proper casting technique, the potential problem of gas porosity has been eliminated. Castings from sand moulds had coarser structure and a greater tendency to shrinkage porosity. The elimination of these defects, however, can be obtained by forging.

In turn, the problem at the stage of forming may be microsegregation and eutectic located in interdendritic regions of the primary phase grains. Therefore, it is necessary to conduct a thermal homogenization treatment before forging as it is proposed in e.g. [3].

Acknowledgment

Project "The Design and Implementation of an Innovative Low-Waste Metal Forming Technology for High-Strength Light Metal Alloys Used in the Aircraft and Automotive Industry"; No. LIDER/10/0058/L-8/16/NCBR/2017. Total cost of the Project: 1,200,000 PLN. The project is financed by the National Centre for Research and Development under the 8th edition of the LIDER Programme.

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Konrad Lis[1*], Zbigniew Pater[1]

Investigation of the effect of the forming angle on force parameters in a skew rolling process for a stepped shaft

Keywords: FEM, forming angle, skew rolling, load, torque.

Abstract

Stepped axles and shafts used in the automotive, aerospace and engineering industry are produced by metal forming processes such as rotary forging, open die forging, die forging and cross wedge rolling [1 - 5].

One alternative method for producing axisymmetric parts is skew rolling, as shown schematically in Fig. 1 [6, 7]. This method consists in the use of three tapered rolls that are located every 120° on the circumference of the workpiece. The rolls are set askew at an angle θ relative to the axis of the workpiece. The rolls are rotated in the same direction at the same speed. In addition, they can be moved closer or apart to enable the cross-sectional reduction of the billet. The spacing of the rolls is synchronized with an axially-moving chuck in which the workpiece is fixed at one end.

A numerical analysis was performed to investigate the effects of the forming angle α on force parameters and torque acting on the tapered rolls in a skew rolling process for producing a stepped shaft.

In the created numerical model, the translational motion of the chuck was replaced with the axial feed of the rolls, which did not affect the kinematics of the skew rolling process. The rolls were rotated at the same rotational speed set equal to 60 revolutions per minute and their sequence of motion in axial and radial directions was defined. As for other parameters applied in the numerical simulation, the friction factor on the material-tool surface was set

[1] Department of Computer Modelling and Metal Forming Technologies, Mechanical Engineering Faculty, Lublin University of Technology, Poland

* Corresponding author: k.lis@pollub.pl

to 0.95, the heat exchange coefficient between the rolls and the material was set equal to 10 kW/m^{2}K, the temperature of the billet was 1150 °C while the temperature of the tools was set to 100 °C.

The numerical analysis provided information about the variations in the radial and axial loads as well as the distribution of torque on the tapered roll depending on the applied value of the forming angle α.

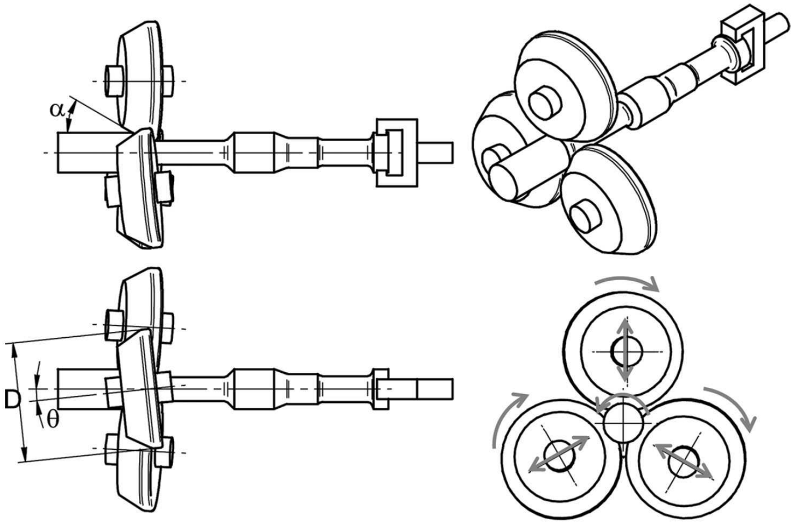

Fig. 1. Schematic design of the skew rolling process by three tapered rolls

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Wiesław Frącz[1*], Grzegorz Janowski[1]

Evaluation of fibers orientation effect in the polymer matrix on strength properties of wood-polymer composites (WPC)

Keywords: wood-polymer composites.

Abstract

This research work was carried out the effect of fibers orientation cases on strength properties for products made of wood-polymer composites based on micromechanical analysis. For this purpose the numerical analysis of uniaxial tensile test for wood-polymer composite (WPC) specimen made by injection molding process was performed. To determine the actual fibers orientation after manufacturing process, the orientation tensor values were obtained using Autodesk Moldflow Insight 2016 software. The micromechanical calculations were performed using Digimat FE commercial code. In order to carry out advanced micromechanical analysis, the geometric data of fibers as curved cylinder were defined in this software. Based on the input data the micromechanical analysis were performed for six different types of fiber orientation (Fig. 1):

- based on the numerical simulation of manufacturing process;
- for Theta= 90° and Phi = 90°;
- for Theta =180° and Phi = 90°;
- for Theta = 90° and Phi = 180°;
- for random 2D orientation;
- for random 3D orientation.

[1] Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Poland
* Corresponding author: wf@prz.edu.pl

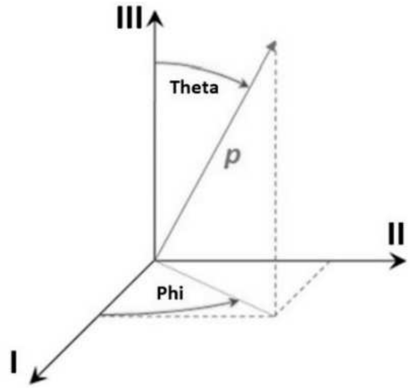

Fig. 1. The definition of fiber orientation vector *p*

The results (a stress-strain characteristics) of numerical simulations, taking into account a calculated fiber orientation tensor, were compared to the experiment. Moreover, the mechanical properties of the same composites product were predicted for hypothetical fiber orientation types. It was noted that selection of fiber orientation has a significant impact on the quality of obtained results compared to experiment.

One of the most important results were the stiffness matrices (Fig. 2.).

a)

	11	22	33	12	23	13
11	3788.59	2350.88	2315.22	-12.1463	-9.75874	23.7813
22	2350.88	3624.89	2281.07	7.3617	-0.0361329	-4.63391
33	2315.22	2281.07	3624.67	0.574974	7.86392	1.61387
12	-12.1463	7.36171	0.574978	649.093	-11.4478	-8.87849
23	-9.75874	-0.036134	7.86392	-11.4478	650.194	1.97659
13	23.7813	-4.6339	1.61388	-8.87849	1.97659	622.652

b)

	11	22	33	12	23	13
11	3610.17	2278.3	2258.66	0.0021396	-0.0039939	-0.608111
22	2278.3	4064.58	2290.1	0.0171475	-0.055099	-0.982372
33	2258.66	2290.1	3618.12	0.00155673	-0.0107647	0.533724
12	0.0021396	0.0171475	0.00155673	576.007	-2.26163E-005	-0.00314799
23	-0.0039939	-0.055099	-0.0107647	-2.26163E-005	576.007	0.00130151
13	-0.608112	-0.982372	0.533723	-0.00314799	0.00130151	668.467

Fig. 2. Examples of calculated stiffness matrices for WPC composite (with 10% of fibres) with different fiber orientation: a) on the base of simulation using Autodesk Modflow Insight software, b) for Theta = 90° and Phi = 90°

The use of simplifications in polymer composites models during strength analyzes of products allows to omit expensive and time consuming analysis of plastic flow in mold cavities (taking into account the effect of fiber orientation) only if an appropriate case of fiber orientation is chosen.

Simplifications in fiber orientation modeling help to reduce computational problems and calculation time. This is particularly important in the strength analysis of products with large dimensional dimensions.

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Janka Majerníková[1*], Emil Spišák[1], Ľuboš Kaščák[2], Ján Slota[2]

Analysis of the change in thickness of the thin double reduced steel sheets by drawing of cups

Keywords: double reduced steel sheets, deep drawing, earring test.

1. Introduction

General opinion is that the continuously annealed materials are used for the production of less demanding cups. Apart from the change in the material thickness of the packaging sheets, thickness of the tin layer has been considerably reduced in the recent years as well. This reduction has been a consequence of the scarce tin resources in the world. In the case of many types of sheets, thickness of the tin layer has decreased down to approximately $1 g/m^2$. Tin layer plays a very important role in the protection of the packaging sheets. It protects main material with its entirety. Entirety of the tin layer can be violated by the deformation of main material (steel sheet). During the processing of the thin packaging sheets by drawing, various stress-strain states occur. From the point of view of the tin layer entirety, the tensile stress is the most favourable one. It is assumed that the thickness of the protection tin layer should correspond with the change in the material thickness. That is why it is very important to analyse the change in the material thickness during the drawing.

That is the reason why this contribution focuses on the examination of the change in the material thickness during the drawing of cylindrical cups. Cupping test was performed on the selected experimental materials produced by continuous annealing. Earring and the change in the thickness of the main material of the cups were evaluated after the cupping test.

[1] Department of Mechanical Technology and Materials, Faculty of Mechanical Engineering, Technical University of Košice, Slovaki
[2] Department of Computer Support of Technology, Faculty of Mechanical Engineering, Technical University of Košice, Slovakia
* Corresponding author: janka.majernikova@tuke.sk

2. Experimental material

The four grades of the thin tin coated double reduced continuously annealed packaging sheets of the nominal thickness 0.17 mm have been used for the experimental research. Specimens for the cupping test have been taken from the plates of individual grades of sheets. The ten specimens from each grade have been evaluated. Individual grades of sheets have been labelled – **A, B, C, D.**

3. Experimental method

During the drawing of the cups, the punch with the diameter of 33.00 mm and the corresponding die with the appropriate tolerance $33.49^{+0.01}$ mm were chosen. Diameter of the blank was 55.00 mm, which corresponded with the drawing degree 1.66. Semi-diameter of the drawing edge radius of the punch r_p was 4.75 mm and the semi-diameter of the drawing edge radius of the die r_t was 2.20 mm.

Measuring of the change in the thickness was done in three directions, perpendicularly to the rolling direction, in the rolling direction, and at 45° according to the rolling direction. Directions and positions of the sections are shown in the Fig. 1.

Fig.1 Illustration of the directions on the cup and the position of measured areas of the cup

Before the deformation of the specimen, thickness a_0 was measured at each measurement point and in each direction, using the micrometer (micrometer screw gauge). Consequently, cupping test was carried out, during which cylindrical cups with flat bottoms were pulled out with a certain tensile strength F. After the cupping test, thickness of the cup specimens was measured again (at the same measurement points and in the same directions). Thickness of the specimens and cups was measured with accuracy the 0.001 mm.

Relative thinning was calculated according to this relation:

$$a_p = \left(\frac{a_0 - a_i}{a_0} \right) \cdot 100 \quad [\%] \tag{1}$$

4. Conclusions

From all the measured results of the change in the material thickness during the cupping test, it can be clearly concluded that all the examined materials experienced only minimal thinning of the cup. This change in the thickness (less than 2%) does not cause any considerable change in the thickness of the tin layer, thus it does not influence the corrosion resistance.

Acknowledgment

The authors are grateful to APVV for support of experimental work under grant APVV-14-0834 and the project VEGA No. 1/0441/17.

Emil Spišák[1*], Janka Majerníková[1], Peter Mulidrán[1],
Ľuboš Kaščák[2], Ján Slota[2]

Forming analysis of continuosly annealed, double reduced steel sheets

Keywords: double reduced steel sheets, uniaxial tensile test, bulge test, springback test

1. Introduction

The production of thin sheets has undergone significant changes over the years. These changes include, in particular, a significant change in the thickness of the packaging sheets from the original thickness from 0.24-0.22 mm to a thickness of 0.14-0.16 mm. These thicknesses are achieved by introducing a second reduction. In the case of such packaging sheets, higher strength properties, in particular the Yield strength, are achieved with sufficient (for further processing by forming) plastic properties. In view of the significant changes in production of packaging steel sheets and the increasing requirements for determining their properties, it is also necessary in the area of their evaluation to seek objective, rapid and cost-effective test methods to determine their mechanical and plastic properties. Due to the fact that many different methods of mechanical properties evaluation are used by the sheet metal manufacturers and processors, the results of the mechanical properties determined by the uniaxial test, the biaxial test (bulge test) and the springback test are compared in this paper. In the paper, sheets produced by the second reduction, continuously annealed will be compared.

Results should lead to the optimization of the test method for determining the objective mechanical properties of the sheets and thus to create the conditions for their trouble-free processing by drawing.

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[1] Department of Mechanical Technology and Materials, Faculty of Mechanical Engineering, Technical University of Košice, Slovakia
[2] Department of Computer Support of Technology, Faculty of Mechanical Engineering, Technical University of Košice, Slovakia
* Corresponding author: emil.spisak@tuke.sk

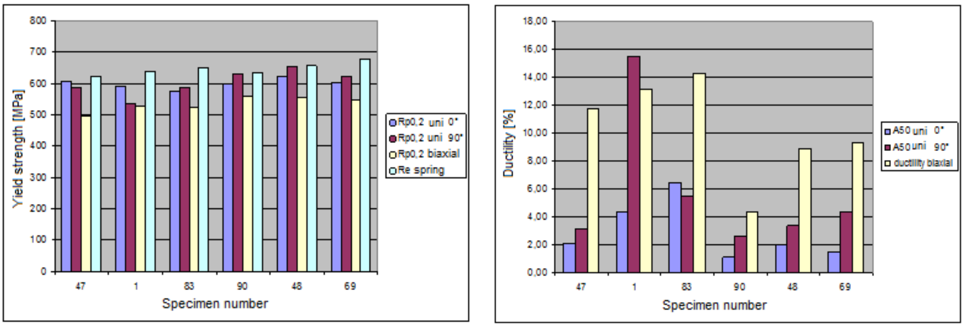
2. Experimental material

For experimental research of the formability of continuously annealed sheets, continuous annealed materials of different thicknesses and different melts were used. In total, 6 types of two kinds of TH 550 CA, TH 620 CA sheets, 0.15 to 0.175 mm thickness were used.

3. Experimental method

Uniaxial tensile test is currently the most widely used test that acquires the basic mechanical properties of the sheet metal. The test conditions and shape of the test specimen are specified in STN EN 10002-1 + AC1 and STN 42 0321. For tinsteel sheets we often determine the Ultimate tensile strength, Yield strength and ductility of the material, these properties are obtained from uniaxial tensile test. To assess the anisotropic properties of the material, samples were taken in a 0° and 90° direction relative to the rolling direction for the tensile test.

Biaxial tension is one of the most unfavorable types of stress schemes in plastic deformation of steel sheets. That is the reason, why it is suitable to use this type of stress for determination of plastic and mechanical properties of steel sheets. Specimen flange prevents drawing of the material with the use of bead, which is located in die. Sheet metal is bulged by the pressurized hydraulic fluid until specimen is fractured. The height of the fractured bulged specimen, shape of fracture and surface of specimen after fracture is evaluated in this test.



a) b)

Fig. 1 Comparison of the a) Yield strength and b) ductility obtained by realized tests

Sprinback test was developed for the purpose of simple determination of the Yield strength of tinsteel sheets while characterizing its certain plastic properties. The Yield strength values were based on the table recommended by the device manufacturer depending on the springback angle. A sample of 152.4 x 25.4 mm is used to perform the test, which is clamped at one end and the second free end is bent to 180 ° about a 25.4 mm diameter mandrel by means of a roller. The roller returns to the starting position and the springback angle is read off directly on the scale.

4. Conclusions

Based on the experiments, it can be concluded that the strength and plastic properties of the thin packaging sheets determined by the different tests cannot be compared. The results of the uniaxial tensile test achieve the closest values for Yield strength and tensile strength in terms of the results set by the standard. The ductility values obtained from this test achieve considerable scattering, which is caused, in particular, by fracturing of the samples out of the measured area and locating the plastic deformation without developing the deformation over the entire measuring range.

Acknowledgment

The authors are grateful to APVV for support of experimental work under grant APVV-14-0834 and the project VEGA No. 1/0441/17.

Ľudmila Dulebová[1*], Janusz W. Sikora[2], František Greškovič[1], Bogusław Kiszka[3]

The influence of nanofillers on LDPE mechanical properties

Keywords: Low-Density Polyethylene, nanofillers, injection molding, mechanical properties.

Abstract

Polymer nanocomposite has been known as one of the early success stories of realizing the potential of nanomaterial as reinforcement filler to improve the properties of neat polymers. By adding the nano sized organic compounds, the properties of polymers are improved. Properties of the produced nanocomposites depend on the inorganic materials present in the polymers matrix.

The polymer Low-Density Polyethylene (LDPE) marketed under the trade name Malen E, produced by Basell Orlen Polyolefins Company, was used in the experimental tests. This material was modified by Halloysite nanotubes (HNT). Halloysite is a naturally occurring member of the kaolin family of aluminosilicate clays. Halloysite nanotubes, produced by Sigma-Aldrich Company, in the form of powder of the grain diameter from 30 to 70 nm and length 1-3 μm was used as filler. Polyethylene grafted with maleic anhydride (PE-*graft*-MA), produced by Sigma-Aldrich Company, as a compatibilizer was used in the tests.

The article aims to investigate the influence of filler mass content HNT on the selected mechanical properties of polymer nanocomposites with LDPE matrix. The material LDPE was modified by HNT with a mass content of 2, 4, 6 wt%. Nanocomposites were filled with 5 wt% PE-graft-MA as a compatibilizer.

[1] Technical University of Košice, Faculty of Mechanical Engineering, Slovakia
[2] Lublin University of Technology, Mechanical Engineering Faculty, Poland
[3] ZAMAK Mercator Sp. z o.o., Skawina, Poland
* Corresponding author: ludmila.dulebova@tuke.sk

The specimens were prepared by injection molding on injection molding machine type Arburg Allrounder 320 C 500 – 170. Mechanical properties of specimens were tested by static tensile test (Young's modulus, tensile strength, tensile strain at strength), Charpy impact test and Shore hardness test according to standards. The surface of pure polyethylene without additives is shown on Fig.1. Figure 2 shows the structure of polyethylene with 2% addition of HNT and 5% of compatibilizer. The relationship between Charpy impact strength and the filler content of the HNT without the addition of compatibilizer and with the addition of a compatibilizer is shown on Fig.3.

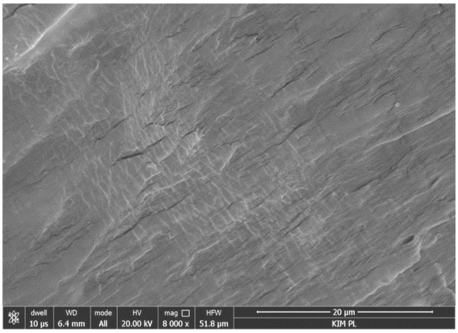


Fig.1 The surface of pure LDPE without additives

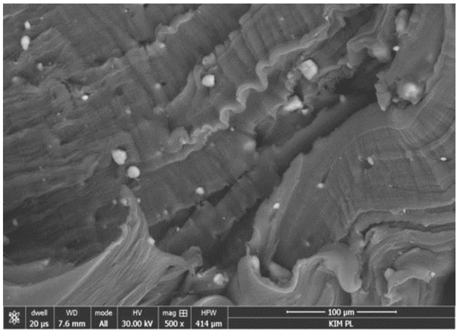
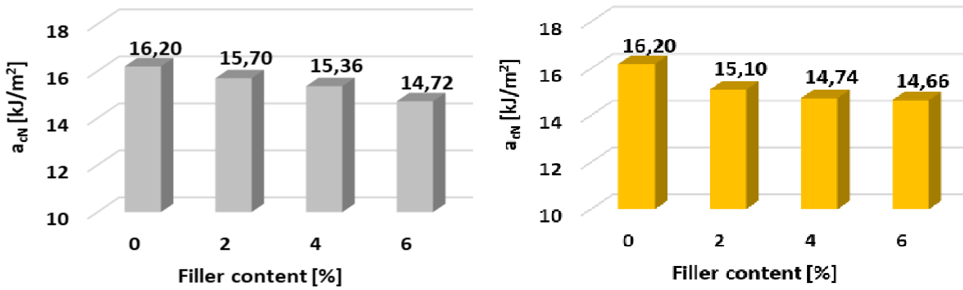


Fig.2 Structure LDPE with 2% addition of HNT and 5% of compatibilizer



a) b)

Fig.3 Charpy impact strength in dependence on nanofiller mass content without the addition of compatibilizer (a) and with the addition of 5% of compatibilizer (b)

Based on the research it can be concluded that the tensile strength was increased by adding the filler and PE-graft-MA and strain at strength was decreased by adding the fillers and PE-graft-MA. The hardness of the tested materials remained almost constant over the test but showed a tendency to decrease. The largest deterioration of the investigated properties was observed for the tested materials by the Charpy impact test.

Acknowledgment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 734205 – H2020-MSCA-RISE-2017.

František Greškovič[1*], Emil Spišák[1], Ľudmila Dulebová[1]

Radiation crosslinking of plastics in the automotive industry

Keywords: radiation crosslinking, automotive, polymer composite.

Abstract

The cross-linking is the most important reaction of polymers that significantly changes product properties. In the cross-linking, the molecules are joined to create a functional net. The radiation in cross-linking causes change of the thermoplastic into the thermoset. Increasing density of cross-linking increases rigidity and hardness, electric resistance and resistance to solvents; and decreases the degree of bulking. The cross-linking is carried out by peroxides, silanes, ionizing radiation (for example the radiation dose in PE is within the range 1 – 30 Mrad) and by vulcanization of sulphur (in caoutchouc).

Higher temperatures are usually used (polymer is melted) in cross-linking by peroxides (dibenzoylperoxide, butylperoxide). In the first step, peroxide (ROOR) is decomposed by heat into free radicals RO which further react with polymer string. In the recombination of polymer radicals, there occurs joining of string through the C-C bond.

The disadvantages of cross-linking is its low efficiency (side reactions of peroxides and free radicals) and necessity of using the big amount of relatively expensive peroxides as well as mixing the compound of polymers with peroxides and stabilizers in a special equipment (in PE - Engel process).

Peroxide is used to create a primary radical. Molecules of silane are then inoculated with primary radicals. Then Si-O-Si bridges are created. For the optimal speed of reaction, elevated temperature is used (in PE from 80°C to 90 °C) with the presence of catalyst. The advantage of cross-linking by silanes is in using conventional machines, and in addition, wider temperature range

[1] Technical University of Košice, Faculty of Mechanical Engineering, Slovakia
* Corresponding author: frantisek.greskovic@tuke.sk

is available in comparison to the cross-linking by peroxides. The problem is the by-products occurrence (methanol and water) during reaction.

The cross-linking includes the basic assumption, that the materials during ionising radiation are mainly cross-linked and do not degrade. It is a physical method and chemical ingredients are not needed (for example in PP a cross-linking reagent TAIC is used). The main condition is the presence of three or more functional monomers. The interaction of radiation and polymers causes the creation of polymer radicals (decomposition of bonds C-H), which create nets by recombination in strings. A net is created by bonding of two free radicals between adjacent strings with creation of a C-C bond. The cross-linking is performed mostly by beta or gamma radiation. Because of radiation, thermoplastics are transformed into the materials with the properties of elastomers in certain temperatures. The elastomers or partially non cross-linked systems have a sufficient number of cross-linked areas due to radiation. It is not necessary to use the elevated temperature during the radiation cross-linking process. The cross-linking is always used after processing. Electrons can be accelerated artificially in so-called electron accelerators, for example transformation type Betatron or electrostatic cathodic.

The properties of a composite filled with an element filler depend on the physical properties of components (matrix, filler). The coherence of the matrix with the filler has a significant influence on the transmission of stresses on reinforcement as well as on the mechanical properties. The radiation technology of beta or gamma rays is utilized to achieve joining of the matrix structure with the reinforcement to increase the material strength, as presented in the figure 1 and figure 2.

The evaluation of composite structure is usually based on the fracture area after tensile test. It is realized by REM RE-Detector with given magnification. The material filled with glass short fibres PA6 GF30 is shown in figure above. Its structure is irradiated by dose of 100 kGy.

Using of regrinds from irradiated material in a repeated process of injection prevents the irradiated material from melting, which can affect the properties, as well as the appearance of the component. The method of the injection cycle reduction or cooling time can be reduced in some cases by about 40%.

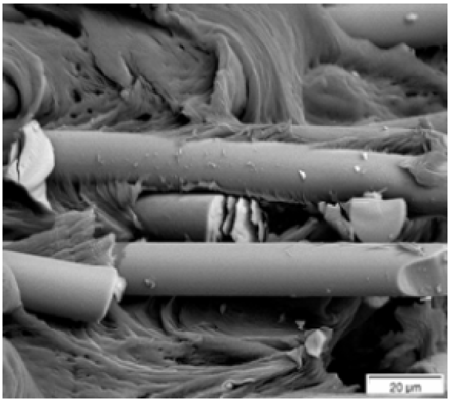


Fig. 1. Structure of unirradiated material

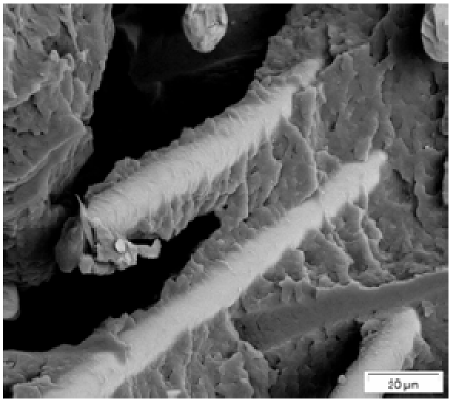


Fig. 2. Structure of irradiated material

Acknowledgment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 734205 – H2020-MSCA-RISE-2017.

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Ľuboš Kaščák[1*], Emil Spišák[2], Ján Slota[1], Janka Majerníková[2]

Weldability analysis of combination of dual-phase steels DP600 and DP780

Keywords: resistance spot welding, tesile test, metallography observation.

1. Introduction

Materials used in car body production are joined by resistance spot welding (RSW) as the dominant method of joining. Significant changes occur in mechanical and metallurgical properties of the weld nugget and heat affected zone during welding process. RSW is accomplished by passing an electrical current through coincident sheets via electrodes. The heat induced by the electrical current creates a molten nugget. The molten nugget grows until the electrical current ceases, at which point the nugget solidifies to create a bond between the sheets. The current requirement for car weight reduction has led to new types of advanced high-strength steels to automobile industry. These steels have been introduced into vehicle designs in an effort to increase the collision energy management and passenger safety, while maintaining or reducing vehicle weight, resulting in fuel economy. Dual-phase (DP) steel was developed specially for automotive industry as a high-strength steel with good formability and weldability. The tensile strength typically ranges from 450 to 980 MPa. The DP steel consists of hard martensitic formations dispersed in ferritic matrix; from 70 to 90% of ferrite and from 10 to 30% of martnesite. Except the above mentioned phases, the structure of DP steel can include small amount of bainite, perlite and residual austenite. The quality of spot welded joint is affected by several factors such as welding current, pressing force of welding electrodes, welding time, material of welding electrode tips, thickness

[1] Department of Computer Support of Technology, Faculty of Mechanical Engineering, Technical University of Košice, Slovakia
[2] Department of Mechanical Technology and Materials, Faculty of Mechanical Engineering, Technical University of Košice, Slovakia
* Corresponding author: lubos.kascak@tuke.sk

and material properties of the joined sheets. Investigation on weld nugget formation provide relevant information about the influence of different welding parameters on the weld properties. The influence of welding parameters of RSW on the properties of spot welds has been studied experimentally to improve the quality of the spot welds.

This research focused on the evaluation of influence of welding parameters on the quality of spot welds of combination of dual-phase steel sheets DP600 and DP780.

2. Experimental work

The materials for the study were the hot-dip galvanized dual-phase steel sheets DP600 and DP780, both with the thickness of a_0 = 0.8 mm. The basic mechanical properties and chemical composition of joined dual-phase steel sheets are shown in Tab.1 and Tab. 2. Next, the microstructure of the welded samples are shown in Fig. 1.

Table 1. Basic mechanical properties of dual-phase steel sheets

Material	Rp0.2 [MPa]	Rm [MPa]	A80 [%]
DP600	375	600	20
DP780	330	780	14

Table 2. Chemical composition of dual-phase steel sheets (wt%)

Material	C	Mn	Si	P	S	Mo	Cr
DP600	0.086	1.857	0.022	0.018	0.002	0.178	0.203
DP780	0.093	1.415	0.200	0.011	0.002	0.103	0.057

Fig.1 Microstructure of the welded dual-phase steel sheets

3. Conclusions

The influence of the welding parameters such as welding current and welding time on the weld quality of combination of DP600 and DP780 steel sheets was investigated in this study. Only the fusion weld joints occurred in case of all observed parameters of resistance spot welding.

Increased values of the welding current resulted in an increase in load-bearing capacity. But in samples made with the maximum welding current, pores and cracks were observed. The increasing of welding time caused increasing the values of load bearing capacity, until value of $T = 25$ periods. Further increasing of welding time led to decreasing of the values of load-bearing capacity.

The resistance spot welding of dual-phase steel sheets requires consistent optimization of welding parameters whereas the appropriate welding parameters are only in a very narrow field.

Acknowledgment

The authors are grateful to APVV for support of experimental work under grant APVV-14-0834 and the project VEGA No. 1/0441/17.

Miroslav Badida[1*], Lýdia Sobotová[1], Tibor Dzuro[1],
Anna Badidová[1], Alžbeta Mikulová[1]

Options of use recycled materials in constructions of anti-sound clone (walls)

Keywords: recycled plastics, environment, construction, noise.

Abstract

Harmful effects of environmental noise are different and can be caused by different ways. In the European Union, about 80 million people are exposed to high levels of noise that are unacceptable. Approximately 170 million people live in so-called "gray zones" in which the noise is very annoying. Transport is one of the main sources of noise in the environment. Noise measures reduce the noise impact of traffic (road, rail and air) and may be passive or active. The active measures try to avoid noise. The passive measures are coming up until noise is created. The passive anti-noise measures prevent the spread of acoustic noise and include: noise wall (Fig. 2) and anti-noise barriers. The shapes of noise barriers can be structurally diverse (Fig. 3). In the construction is using sandwich structure, generally is employing different acoustically absorptive material. The authors present in the paper the results of their scientific research, which focuses on the development of acoustically absorbing materials usable in the construction of noise barriers. The attention is focused on materials obtained from cars over their lifetime. Specifically, these are polyurethane foams (PUR foam) of car seats and caravans from which ecomolitan material was produced (Fig. 1 a)) and the so-called " recycled rubber (Fig. 1 b)) made from used vehicle recycling products.

These materials have been shown to be suitable to use in a sandwich construction of noise barriers. The authors examined post optimal structure of developed materials that would be suitable for the needs of sound absorption.

[1] Technical University in Košice, Košice, Slovakia
* Corresponding author: miroslav.badida@tuke.sk, phone: +421 55 602 2716

Measurements of acoustic descriptors have been done, namely sound absorption coefficient (a) and transmission damping (TL). For the purpose of measurement was used impedance tube (Kundt tube) (Fig. 3).

a) Ecomolitan b) recycled rubber c) Nobasil

Fig. 1. Acoustically absorbed materials

Fig. 2. Noise wall

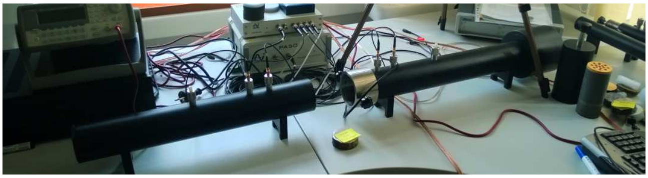
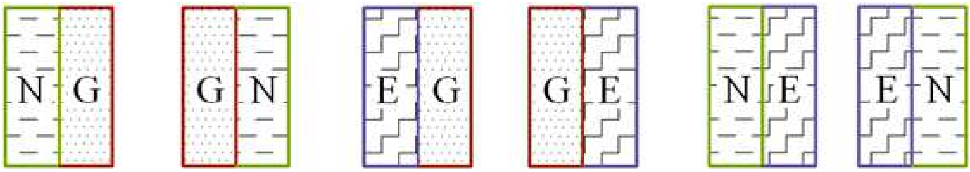


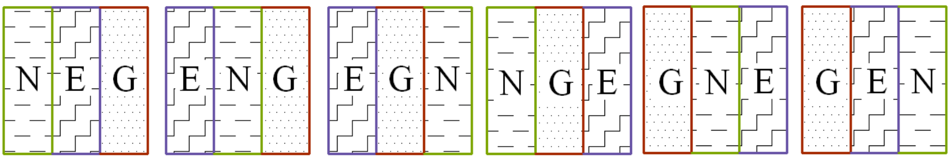
Fig. 3. Kundt tube

Measurements were made both on samples of base materials (Ecomolitan, recycled rubber and Nobasil (Fig. 1 c), as well as on samples of sandwich structures (two-layer and three-layer), see (Fig. 5).



Legend: N - Nobasil, G - recycled rubber, E - Ecomolitan

Fig. 4 Two-layer sandwich samples



Legend: N - Nobasil, G - recycled rubber, E - Ecomolitan

Fig. 5 Three-layer sandwich samples

Frequency spectrum of traffic noise has its maximum in the range of 500 Hz to 1 500 Hz, with the greatest noise causing a frequency of 1 000 Hz. The paper will present the results of individual measurements of selected acoustic descriptors for different material arrangement of sandwich structures of noise barrier Experimental measurements have demonstrated the suitability of developed materials for their applications in noise barrier constructions.

Acknowledgment

This work was supported by the Ministry of Education of the Slovak Republic under grant project APVV 0327-15.

Lydia Sobotova[1*], Miroslav Badida[1], Anna Badidova[1],
Alica Mašlejová[2]

Creation of al joins by thermal drilling little-waste technology

Keywords: join, thermal drilling, Al material.

Abstract

The contribution deals with the possibilities of thermal drilling technology of Al material and analysis of Al joins. By using of new friction joining technologies we can shortage the production time, provide automation in operations, increase the quality of joins, spare of economical expenses. We can protect the environment, because thermal drilling technology belongs to little waste technology.

The bushings created by thermal drilling operations and following thread joins increase the stiffness of automobile parts. They can be used in the pipe industry, in the civil engineering in the metal construction of buildings. The development of such mechanical joins accelerates the production and the utilization of new technologies. The thermal friction method is using in joining of materials such as sheets, pipes, hollow profiles from various types of ferrous and non-ferrous materials. We can compare this technology with production of smooth cylindrical and conical bushings and compare the production of threads in thin materials with classical technologies.

In the frame of experiments in the Department of Process and Environmental Engineering, Faculty of Mechanical Engineering, TU of Košice, there was verified the suitability of thermal drilling technology, it means Flowdrill method for chosen Al materials, for evaluation of quality of produced

[1] Technical University in Košice, Košice, Slovakia
[2] U.S. Steel Kosice, s.r.o., Vstupny areal U.S. Steel, Košice, Slovakia
* Corresponding author: lydia.sobotoval@tuke.sk

bushings, holes, threads at various conditions and for investigation of macro and micro structures of mentioned materials.

In the Fig. 1 is shown the tested Al semi-product from two parts of Al sheets. The cross-section of tested created bushings are in the Fig. 2, after dividing into two parts.

Fig. 1. Joined Al materials

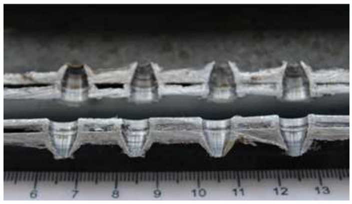


Fig. 2. The cross section of Al joins

There was made the metallographic evaluation with the macro and microstructures. The prepared sample is shown in the Fig. 3. The view of macrostructure of Al material join after thermal drilling is in the Fig. 4.

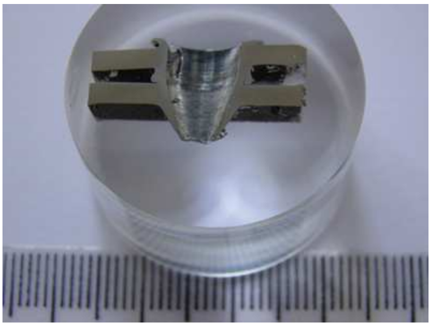


Fig. 3 Tested sample

4 The macrostructure of Al join

The detail of created collar is in the Fig. 5. and the mixed materials after thermal drilling from bushing is in the Fig. 6.

In the contribution will be more detailed shown the parts of created joins of Al material, together with the determination of material properties.

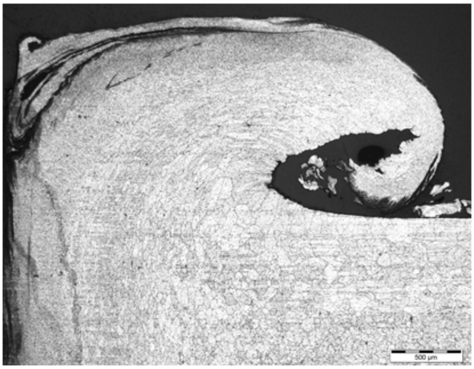


Fig. 5. The Al collar

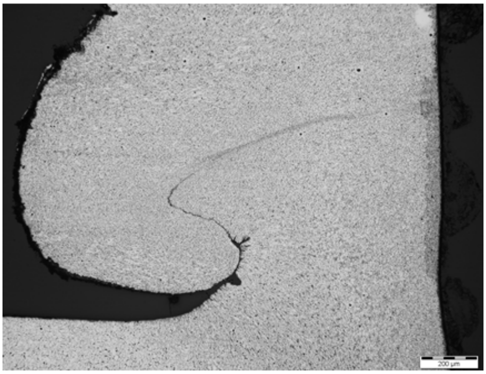


Fig. 6. The mixed Al material from bushing

Acknowledgment

This work was supported by the Ministry of Education of the Slovak Republic under grant project KEGA 041TUKE- 4/2018, Transfer of knowledge from scientific – research activities from field of products disasemby and recycling into processing of the university textbooks.

Janette Brezinová[1], Ján Viňáš[1], Dagmar Draganovská[1],
Anna Guzanová[1*], Jakub Brezina[1]

Possibilities of renovation functional surfaces of equipments in the steel industry

Keywords: renovation, continuous casting line, rollers, SAW, wear.

Abstract

The paper analyzes the possibilities of increasing the lifespan of rollers in continu-ous steel casting line. There are analyzed the causes of the surface rollers damage and the impact of degrading factors in metallurgical production. Three types of welding consuma-ble electrodes designed for restoration layers formation applied by SAW surfacing technol-ogy were analyzed. There were analyzed microstructure, microhardness and properties of weld clads in tribological conditions.

In the experimental part of work, the twice renovated roller with diameter of 180 mm, made from forged steel X20Cr13 EN 10088-3 was used.

Wear size of roller was assessed by visual check. Worn layer (with thickness of 7 mm) was removed from roller surface by turning. Turned surface was checked visually again. The presence of inner defects was checked by ultrasonic test. Considering chemical composition of roller, there was necessary to preheat it before cladding on temperature of 350°C - 400°C. Chemical composition of welding wires used is given in Table 1. For clad-ding was used universal flux AWS A5 17-89 EM 13K.

Welding wire W3 (W3-WLDC 3) is commercially used for cladding of continuous casting rollers. Welding wires W8 (W8-WLDC 8) and W5 (W5HT-WLDC 5) were still not used for cladding of continuous casting rollers. The roller was renovated using welding equipment Weldclad GU125LZ, COREWIRE. The parameters of cladding are listed in Table 2. After cladding,

[1] Technical University of Košice, Faculty of Mechanical Engineering, Košice, Slovakia
* Corresponding autor: anna.guzanova@tuke.sk, phone: +421556023515

roller was cooled down in electric furnace in isothermic wrap. Cool-ing speed was 40°C per hour up to room temperature. Then it was tempered in furnace at 500 °C / 8 hours. Quality of weld layers was assessed by non-destructive testing according to STN EN ISO 23277 and STN EN ISO 11666. Microhardness tests were realized by Vickers diamond pyramid.

Table 1. Chemical composition of weld wires [in wt. %], balance of Fe

Wire	C	Si	Mn	Ni	Cr	Mo	Nb	V
W 3	0.1	0.6	1.0	2.5	12.2	0.8	0.15	0.15
W 5	0.25	0.6	1.0	0.25	9.0	2.0	-	-
W 8	0.3	0.6	1.0	-	12.2	0.75	-	0.15

Tab. 2. Parameters of cladding

Wire	Diameter, [mm]	Voltage, [V]	Current, [A]	Oscillations, [mm]
W 3	3.2	28	450	45
W 5	3.2	26	600	47
W 8	3.2	26	450	50

Microstructure of cover layer, first cladding layer and HAZ are presented in Table 3. Fig. 1 shows the microhardness of particular weld layers and HAZ of weld deposits W3, W5 and W8. Higher microhardness was found in clads made using welding wires W5 and W8, from the cover layer to the base material the hardness decreased.

Table 3. Microstructure of weld clads

	Cover layer	First layer	HAZ
W 3	low-carbon high-tempered martensite (sorbite)	low-carbon high-tempered martensite, carbide phases	low-carbon tempered martensite without carbids
W 5	martensite with islands of ferrite	low-carbon tempered martensite	low-carbon tempered martensite
W 8	tempered martensite with small carbide particles	of low-carbon tempered martensite	low-carbon tempered martensite

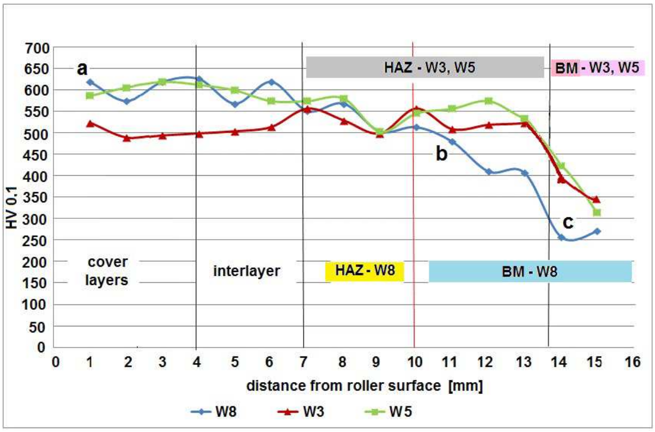


Fig. 1 Microhardness of particular layers of weld clads

Based on the realised experimental work can be concluded, that the highest value of microhardness before thermal cycles were found in the cover layer of weld deposit made of welding wire W8-WLDC 8, 620 HV 0.1. This value is consistent with the chemical composition of the welding wire used, especially with the highest carbon content among the assessed filler materials and also with high chromium content. Based on the evaluation of results obtained by simulation of degradation phenomena affecting the continuous casting rollers during their operation, newly developed welding wire W8-WLDC 8 can be designated as the best material for renovation of continuous steel casting rollers.

Acknowledgment

This work was supported by scientific grant agency of the Ministry of Education of the Slovak Republic VEGA No.1/0424/17.

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Ján Viňáš[1*], Janette Brezinová[1]

Application possibilities of ceramic coatings for the restoration of functional surfaces

Keywords: coatings, plasma, renovation, quality, surface.

Abstract

Paper deals with the evaluation methods of plasma sprayed ceramic materials. The restoration possibilities of functional surfaces for tensometric roll were assessed. Plasma sprayed layers of WC-Co, Cr_2O_3 and Al_2O_3 + 5% TiO_2 were evaluated. The effects of the NiCr interlayer on the functional properties of the spray coatings have also been studied. Surfaces of rollers in production and processing of steel belong to the extremely stressed parts in metallurgical industry. Surfaces of rollers for continuous steel casting line, hot and cold rolling rollers as well as tensometric roller surfaces are renovated after reaching the specified wear level. The paper analyzes possibilities of restoration functional surfaces of tensometric rollers by means of plasma spraying technology (HVOF) [1]. Tensometric rollers are used to measure the tensile stress in the belt between mills. It is located between the roller mills closer to the previous mill. The rollers are mounted on pressure measuring blocks which measure the compressive force from which the belt tension is calculated based on the formula that is the sum of the two PillowBlock boxes (Fig.1).

The test samples for coatings deposition were made of steel C55 EN 10027-1. Chemical composition and mechanical properties of used steel are shown in Table 1.

[1] Department of Technology and Materials, Technical University of Košice, Košice, Slovakia
* Corresponding author: jan.vinas@tuke.sk, phone:+421556023510

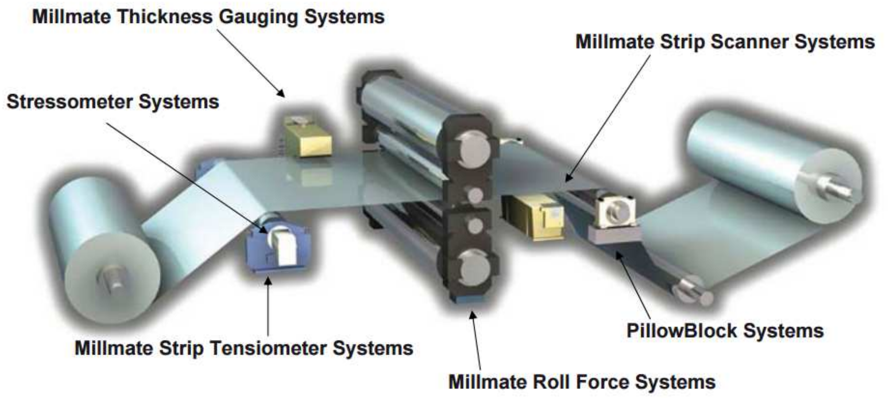

Fig. 1 Scheme of cold rolling process [2]

Table 1. Chemical composition (in % wt.) and mechanical properties (in MPa) of used steel

Composition							Properties	
C	**Mn**	**Si**	**P**	**S**	**Cr**	**Ni**	**Rm**	**Re**
0.522	0.611	0.254	0.011	0.009	0.14	0.12	820	492

Surface pre-treatment of test samples was realized by abrasive blasting using brown corundum (Al_2O_3). Granularity of blasting medium was characterized by mean particle size d_z = 0.75 mm. Blasting medium was accelerated by compressed air, air pressure was 0.4 MPa. Microgeometry of the blasted surfaces and applied coatings was evaluated according to STN ISO 4287 by stylus roughness tester Surftest SJ – 301, Mitutoyo. High-velocity Oxygen Fuel (HVOF) technology was used for spraying coatings of tensometric roller. Kerosene was used as fuel, spraying distance was 380 mm.Before deposition of all studied types of ceramic materials interlayer of composite NiCr (83% Ni +17% Cr, particle size 45±5mm) by flame spraying using the torch NPK2 on pretreated substrate was applied. NiCr interlayer provides better adhesion to the base material, balances the CTE substrate and ceramic layers.

The thickness, microhardness and adhesion of the individual coatings together were determined with their abrasion resistance and thermal cyclic loading. Based on experimental results, the possibilities of using selected types of plasma sprayed layers to define the functional surfaces of the rated components were defined.

Table 2. Physical properties of the powders used for the restoration

Powder type	WC-Co	Cr2O3	Al2O3 + 5% TiO2
Powder`s chemical constitution [% wt.]	83% WC 17% Co	Cr2O3	95% Al2O3 5% TiO2
Granulation [µm]	22 - 56	22 - 56	22 - 56
Density [g/cm^3]	14.00	5.22	3.90
Hardness HV0.3	1150	1100	1080
Coating`s porosity [%]	0.50	0.50	0.50
Max. work temperature [°C]	560	1120	1400

Acknowledgment

This work was supported by VEGA 1/0424/17 Research of properties of newly conceived layers and coatings in tribological systems.

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Monika Hyrcza-Michalska[1*]

Investigations of hydromechanical forming technology for sheet blanks and tubes made of nickel superalloys Inconel type

Keywords: hydromechanical forming, sheet blank, tube, nickel superalloy, Inconel, drawability.

Abstract

The article presents the results of research on the metal forming of heat-resistant and creep-resistant nickel alloys Inconel type. Semi-finished products in the form of sheets and tubes of Inconel 625 and Inconel 718 alloys were used as charge materials for the pressing process. Due to the properties of selected alloys, their forming process using conventional stamping methods, rigid cold tools, is very limited. The shapes of the products that we expect to produce are very complicated, as they are intended for use in the construction of aircraft, and specifically the areas of the engine, as housing, covers and elements of the exhaust system. The solution to the technological limitations of cold forming these alloys is the use of liquid as a working medium, which increases the possibility of shaping these charges, but becomes difficult to predict without the use of computer assistance and advanced simulation techniques. For the needs of simulations, the characteristics of the charge material properties are required, including advanced characteristics – forming limit curves. The article presents own experience from acquisition of such curves using the AutoGrid automatic strain analyzer. The paper presented their practical applications to solve simulation tasks carried out in the DYNAFORM software. As the subject of simulation tasks, the hydromechanical forming of a selected element from Inconel 625 alloy sheet (axial-symmetric turbo-compressor cover drawpiece) and the seamless tube element Inconel 718 (freely extruded tube, part of the flue

[1] Silesian University of Technology, Faculty of Materials Engineering and Metallurgy, Katowice, Poland
* Corresponding author: monika.hyrcza-michalska@polsl.pl

gas exhaust system) were chosen. As a result of the research, it was shown that the technology of liquid shaping of tested nickel superalloys is a good technological solution and provides the possibility of producing complex elements for the needs of aircraft constructions. The effective use of this technology is possible thanks to the use of the latest achievements in building the characteristics of material properties and modern simulation environments. The only practical limitation of this technology is the low-series production that the aviation industry is characterized by.

Andrzej Skrzat[1*], Feliks Stachowicz[1], Victor Eremeyev[2]

Homogenization of honeycombs structures by microplar elasticity approach

Keywords: honeycomb structure, FEM analysis, special finite elements.

Abstract

Cellular solids can be found in many natural or man-made structures – cancellous bone, wood, bees honeycombs, foams, sandwich structures, 3D prints etc. are some of examples. Detailed analysis of such structures performed beyond the representative volume element is computationally expensive. Usually honeycombs are modeled as 3D structures consisting of beam of shell elements. If the strain localization is not important, such structures can be replaced by continuous medias acquiring honeycombs effective properties (Fig. 1). In the micropolar elasticity not only displacements but also microrotations are considered as the degrees of freedom of the deformed body. Thus, this approach is compatible with bending-based analysis of beams or shells structures.

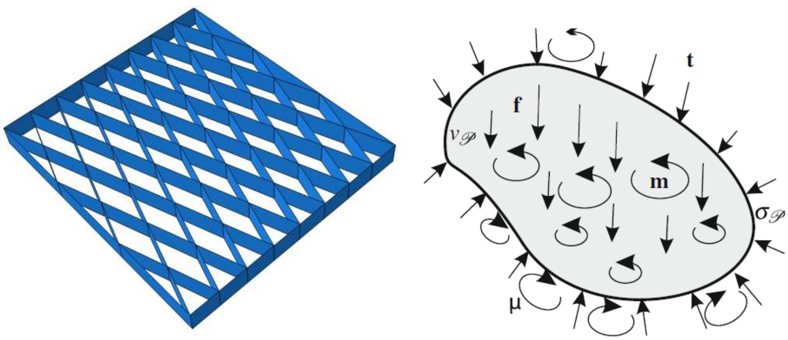

Fig. 1. Honeycomb structure and equivalent micropolar medium

[1] Rzeszow University of Technology, Rzeszów, Poland
[2] Gdansk University of Technology, Gdańsk, Poland
* Corresponding author: askrzat@prz.edu.pl

Micropolar material constants necessary for reliable analysis are found by the comparison of two different approximations of the strain energy. An analytical and numerical derivations are used here. Special 3D finite elements satisfying micropolar elasticity requirements are developed and linked with the commercial FEM software. Several benchmark tests and practical engineering examples solved by FEM analysis are included.

Acknowledgment

The research leading to these results has received funding from the People Programme (Marie Curie International Research Staff Exchange) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement n° PIRSES-GA-2013-610547

Paweł Bałon[1,2*], Edward Rejman[3], Robert Smusz[3],
Bartłomiej Kiełbasa[1], Janusz Szostak[2**]

Numerical and experimental analysis of the strength of tanks dedicated to hot utility water

Keywords: tank, FEM analysis, hot utility water.

Abstract

The aim of the paper are numerical and experimental strength tests of the accumulating tank dedicated to hot utility water. The tests concerned the verification of the minimum wall thickness for the assumed operating parameters while meeting all safety standards. The authors presented numerical and experimental analysis for the verification of strength parameters of axial cylindrical tanks due to the lack of methodological guidelines for this type of equipment.

The correct assessment of strength properties requires testing both numerical and experimental tank, including its critical nodes, i.e. welded joints.

In order to verify the conducted theoretical considerations and calculations, experimental tests of samples of front welds made of austenitic steel as well as a pressure test for the whole tank were made using a research test stand.

[1] SZEL-TECH Szeliga Grzegorz, Soltyka 16, 39-300 Mielec, Poland
[2] AGH University of Science and Technology, Kraków, Poland
[3] Rzeszow University of Technology, Rzeszow, Poland
* Corresponding author: balonpawel@gmail.com
** Corresponding author: szostak@agh.edu.pl

Ryszard Moszumański[1], Agnieszka Waśko[1]

Effect of parameters of reduction and mixing on brake properties of cement mixtures

Keywords: method for qualifying, grinding and mixing processes, pulsating pressing on heat, recuperative heating.

Abstract

The previous optimization studies of the grinding and mixing processes made it possible to set minimum times to obtain a homogeneous friction mixture. The subject of the article is exploratory research of a new method for qualifying the brake quality of a friction compound for subsequent pressing and soaking operations. This method consists in microscopic evaluation of the breakthrough and cross section of the green compact. A research station consisting of a set of components dosing scales, a prototype mill mixer on a semi-technical scale of a multi-cavity press was built. The research material was prepared at varying speeds and times of grinding and mixing. Breakthroughs and cross-sections of "green" moldings have been subjected to image analysis at 5-500 magnifications. The obtained internal surfaces of the compacts were compared with the external surfaces of the mixture (previously used to evaluate the quality of the grinding and mixing process). On this basis, mixtures were selected for further pulsating pressing on heat and recuperative heating.

[1] Cracow University of Technology, Faculty of Mechanical Engineering, Kraków, Poland
* Corresponding author: rysmos@mech.pk.edu.pl

Ireneusz Usydus[1*], Arkadiusz Tofil[1], Andrzej Gontarz[2]

Research of the influence of the initial deflection on the product radius in the equal angle bar bending process on three-roller bending machine

Keywords: bending, metal forming, three-roller bending machine, steel angle.

Abstract

The paper presents the results of research on the steel bending process of an equal angle bar with dimension of 25×25×3 mm on a three-roller bending machine. For example, on fig. 1 bent equal angle bars were shown. The deformation was get at different an initial deflection.

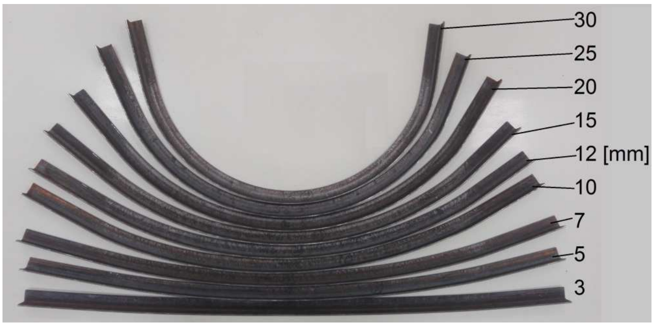

Fig. 1. The equal angle bars after deformation, where initial deflections of the blank were shown

The relationship between the initial deflection of the blank and the final radius that the rolled product achieves is determined. This relationship is described by a power function that can be used in the design of bending processes corresponding to the test conditions. It was also found that the initial

[1] The State School of Higher Education in Chełm, The Institute of Technical Scieces and Aviation, Chełm, Poland
[2] Lublin University of Technology, Mechanical Engineering Faculty, Lublin, Poland
* Corresponding author: iusydus@pwsz.chelm.pl

deflection can be used in the range of 5÷30 mm and that the minimum bend radius is around 290 mm.

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Autors Index

B

Badida Miroslav, 69, 72
Badidová Anna, 69, 72
Balawender Tadeusz, 14, 17, 28
Bałon Paweł, 20, 85
Bąk Łukasz, 11
Brezina Jakub, 75
Brezinová Janette, 75, 78
Buraś Janusz, 45

D

Draganovská Dagmar, 75
Drozdowski Krzysztof, 38, 40, 43, 45
Dulebová Ľudmila, 60, 63
Dziubińska Anna, 38, 40, 43, 45
Dzuro Tibor, 69

E

Eremeyev Victor, 83

F

Frącz Wiesław, 51

G

Gontarz Andrzej, 34, 87
Górny Marcin, 45
Greškovič František, 60, 63

Guzanová Anna, 75

H

Hyrcza-Michalska Monika, 81

J

Janowski Grzegorz, 51

K

Kaščák Ľuboš, 54, 57, 66
Kiełbasa Bartłomiej, 20, 85
Kiszka Bogusław, 60
Kut Stanisław, 22, 25

L

Lis Konrad, 48

M

Majerníková Janka, 54, 57, 66
Majerski Krzysztof, 38, 40, 43, 45
Mašlejová Alica, 72
Micał Łukasz, 17
Mikulová Alžbeta, 69
Moszumański Ryszard, 86
Mulidrán Peter, 57
Myśliwiec Piotr, 14, 17

N

Nowotyńska Irena, 22

P

Pater Zbigniew, 36, 48
Pawłowska Beata, 31

R

Rejman Edward, 20, 85

S

Sikora Janusz W., 60
Skrzat Andrzej, 83
Slota Ján, 54, 57, 66
Smusz Robert, 20, 85
Sobotová Lýdia, 69, 72
Spišák Emil, 54, 57, 63, 66
Stachowicz Feliks, 11, 83
Surdacki Piotr, 34
Szostak Janusz, 20, 85
Szucki Michał, 38, 40, 43, 45
Śliwa Romana E., 14, 28

T

Tofil Arkadiusz, 87

U

Usydus Ireneusz, 87

W

Waśko Agnieszka, 86
Winiarski Grzegorz, 38, 40, 43, 45
Wójcik Łukasz, 36
Wójcik Marta, 11

V

Viňáš Ján, 75, 78

Z

Zwolak Marek, 28