MANUFACTURING TECHNOLOGY
August 2016, Vol. 16, No. 4

Content

Editorial Office Address
J. E. Purkyne University in Usti n. Labem
FVTM, Campus UJEP, Building H
Pasteurova 3334/7, 400 01 Usti n. Labem
Czech Republic
Tel.: +420 475 285 534
e-mail: editors@fvtm.ujep.cz

Print
PrintPoint Ltd, Prague

Publisher
J. E. Purkyne University in Usti n. Labem
Pasteurova 1, 400 96 Usti n. Labem
Czech Republic
VAT: CZ44555601

Published 6 p. a., 300 pcs.
published in August 2016,
186 pages

Permission: MK CR E 20470

ISSN 1213–2489

indexed on: http://www.scopus.com

MANUFACTURING TECHNOLOGY

August 2016, Vol. 16, No. 4

Content

MTAA
Manufacturing Technology
Article Administration

New web portal of Manufacturing Technology Article Administration. More information on home page of the journal.

home page
http://journal.strojirenskatechnologie.cz/

indexed on databases
[SC] http://www.scopus.com
[IET] http://www.theiet.org

Mechanical Properties of Titanium-Aluminium Base Nanomultilayer Coatings

Totka Bakalova[1], Nikolay Petkov[2], Tetiana Cholakova[2], František Kaván[1], Hristo Bahchedzhiev[2]
[1]Institute for Nanomaterials, Advanced Technologies and Innovation, Technical University of Liberec, Studentská 2, 461 17 Liberec, Czech Republic, E-mail: totka.bakalova@tul.cz, frantisek@kavan.eu
[2]Central Laboratory of Applied Physics, Bulgarian Academy of Sciences, 61, St. Peterburg Blvd. 4000 Plovdiv, Bulgaria. E-mail: petkovnik@gmail.com, ipfban-dve@mbox.digsys.bg, hristo_bah@abv.bg

Titanium-aluminium base nanomultilayer (NML) coatings are deposited by cathodic arc evaporation using pure titanium and aluminium with eighteen percent silicon cathodes. Each multilayer Ti-Al-Si-N structure consists of 49 bi-layers with different thickness. The external deposited layer is with five times longer growing period. The coatings are deposited at the pressure of 2 Pa and the substrate temperature of 400 °C. Polished steel discs (Ø 20 mm × 5 mm thick) are used as the substrate material.
This article presents an investigation of the surface morphology and mechanical properties of the coatings, particularly the adhesion and nanohardness. The AFM analysis indicates that the coatings are dense, with an average surface roughness in the range of 33 ÷ 58 nm. The coating with the smaller value of average surface roughness exhibited a maximum hardness of 43 GPa. High calculated value of plasticity index (*H/E*) is 0.104. The scratch test results revealed that all the investigated coatings have very good adhesion in the normal loading interval from 1 N to 40 N.

Keywords: cathodic arc evaporation, Ti-Al-Si-N, surface morphology, multilayer, hardness, adhesion.

Acknowledgement

The paper was supported in part by the project LO1201 through the financial support of the Ministry of Education, Youth and Sports in the framework of the targeted support of the "National Programme for Sustainability I" and the OPR&DI project "Centre for Nanomaterials, Advanced Technologies and Innovation" registration number CZ.1.05/2.1.00/01.0005.

References

[1] BARSHILIA, H. C., DEEPTHI, B., RAJAN, K. S. (2006). *Vacuum*, Vol. 81, pp. 479 – 488.

[2] BUDZYNSKI, P., SIELANKO, J., SUROWIEC, Z. (2008). *Intermetallics*, Vol. 16, pp. 987 – 994.

[3] SURESHA, S. J., BHIDE, R., JAYARAM, V., BISWAS, S. K. (2006). *Materials Science and Engineering A*, Vol. 429, pp. 252 – 260.

[4] TENTARDINI, E. K., KWIETNIEWSKI, C., PERINI, F., BLANDO, E., HÜBLER, R., BAUMVOL, I. J. R. (2009). *Surface & Coatings Technology*, Vol. 203, pp. 1176 – 1181.

[5] JIANG, N., SHEN, Y. G., ZHANG, H. J., BAO, S. N., HOU, X. Y. (2006). *Materials Science and Engineering B*, Vol. 135, pp. 1 – 9.

[6] CHEN, L., DU, Y., WANG, She. Q., WANG, Ai. J., XU, H. (2009). *Materials Science and Engineering A*, Vol. 502, pp. 139 – 143.

[7] SINGH, K., LIMAYE, P. K., SONI, N. L., GROVER, A. K., AGRAWAL, R. G., SURI, A. K. (2005). *Waer*, Vol. 258, pp. 1813 – 1824.

[8] MARQUES, L., CARVALHO, S., VAZ, F., RAMOS, M. M. D., REBOUTA, L. (2009). *Vacuum*, Vol. 83, pp. 1240 - 1243.

[9] LI, Y., SHIMADA, S., KIYONO, H., HIROSE, A. (2006). *Acta Materialia*, Vol. 54, pp. 2041 – 2048.

[10] MEI, F., SHAO, N., WEI, L., LI, G. (2005). *Materials Letters*, Vol. 59, pp. 2210 – 2213.

[11] CHEN, L., DU, Y., WANG, S. Q., J. Li. (2007). *Int. Journal of Refractory Metals & Hard Materials*, Vol. 25, pp. 400 – 404.

[12] CARVALHO, S., REBOUTA, L., RIBEIRO, E., VAZ, F., TAVARES, C. J., ALVES, E., BARRADAS, N. P., RIVIERE, J. P. (2009). *Vacuum*, Vol. 83, pp. 1206 – 1212.

[13] TUILIER, M.-H., PAC, M.-J., COVAREL, G., ROUSSELOT, C., KHOUCHAF, L. (2007). *Surface & Coating Technology*, Vol. 201, pp. 4536 – 4541.

[14] CHEN, L., DU, Y., WANG, Ai J., WANG, S. Q., ZHOU, S. Z. (2009). Int. Journal of Refractory Metals & Hard Materials, Vol. 27, pp. 718 – 721.

[15] OLIVEIRA, J. C., MANAIA, A., CAVALEIRO, A., VIEIRA, M. T. (2006). *Surface & Coating Technology*, Vol. 201, pp. 4073 – 4077.

[16] ZHAO, W., MEI, F., DONG, Y., LI, G. (2006). *Journal of Materials Processing Tachnology*, Vol. 176, pp. 179 – 182.

[17] OLIVEIRA, J. C., MANAIA, A., CAVALEIRO, A. (2008). *Thin Solid Films*, Vol. 516, pp. 5032 – 5028.

[18] OLIVEIRA, J. C., MANAIA, A., DIAS, J. P., CAVALEIRO, A., TEER, D., TAYLOR, S. (2006). *Surface & Coating Technology*, Vol. 200, pp. 6583 – 6587.

[19] FERNANDES, C., CARVALHO, S., REBOUTA, L., VAZ, F., DENANNOT, M. F., PACAUD, J., RIVIERE, J. P., CAVALEIRO, A., (2008). *Vacuum*, Vol. 82, pp. 1470 – 1474.

[20] APERADOR, W., CAICEDO, J., ESPANA, C., CABRERA, G., AMAYA, C. (2010). *Journal of Physics and Chemistry of Solids*, Vol. 71, pp. 1754 – 1759.

[21] PETKOV, N., BAHCHEDZHIEV, Hr., CHOLAKOVA, T. (2015). *Eur. Phys. J. Appl. Phys*., Vol. 70, 30801.

[22]]NOVAK, M. (2012). Surface with High Precision of Roughness after Grinding. *In: Manufacturing Technology*, Vol. 12, No. 12, pp. 66-70, ISSN 1213-2489.

[23] SVOBODOVÁ, J., KRAUS, P. (2015). Influence of Chemical Pre-treatments Nanotechnology Based Applied to the Al Sheet on the Roughness and Morphology of the Surface. *In: Manufacturing Technology*, Vol. 15, No. 4, pp. 714 – 720, ISSN 1213-2489.

[24] CHEN, L., DU, Y., YIN, F., LI, J. (2007). *Int. Journal of Refractory Metals & Hard Materials*, Vol. 25, pp. 72 – 76.

[25] CHEN, L., DU, Y., MAYRHOFER, P. H., WANG, Sh. Q., LI, J. (2008). *Surface & Coating Technology*, Vol. 202, pp. 5158 – 5161.

[26] LEYLAND, A., MATTHEWS, A. (2000). Wear, Vol. 246, pp. 1 – 11.

[27] WANG, Sh., CHEN, L., YANG, B., CHANG, K., DU, Y., LI, J., GANG, T. (2010). *Int. Journal of Refractory Metals and Hard Materials*, Vol. 28, pp. 593 – 596.

[28] CARVALHO, P. (2008). Development of new decorative coatings based on zirconium oxynitrides, *Ph.D. Thesis*, University of Minho, Portugal, http://hdl.handle.net/1822/8949.

Paper number: M2016124

Resistance Spot Welding of Steel Sheets

Milan Brožek
Department of Material Science and Manufacturing Technology, Faculty of Engineering, Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Praha 6 – Suchdol, Czech Republic, E-mail: brozek@tf.czu.cz

Resistance welding ranks among progressive and in practice often used manufacturing techniques of rigid joints. The basis of this method is in the utilization of the Joulean heat, which arises at the passing of current through jointed sheets at collective influence of compressive force. The aim of the carried out tests has been to evaluate the rupture force of spot welded steel sheets of various thickness using short-time spot welding and long-time spot welding. For test specimens welding the parameters recommended by the spot welder producer were used. After welding all assemblies were loaded using the universal test machine up to their rupture. The rupture force was written down. From the carried out tests it follows that welding of sheets of the thickness 1 + 1 mm, 1 + 2 mm, 1 + 3 mm, 1 + 4 mm and 2 + 2 mm the rupture force value differences of short-time spot welding compared to long-time spot welding are practically negligible. But at the specimens of thickness 2 + 3 mm, 2 + 4 mm, 3 + 3 mm, 3 + 4 mm and 4 + 4 mm considerable differences were determined. The part of this tests evaluation was also the assessment of the tested assemblies failed pieces.

Keywords: resistance welding; steel sheet; laboratory test; spot welds shear testing

Acknowledgement

Supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Prague, Czech Republic; Project No. 2014:31140/1312/3133 titled "Influence of environmental conditions on constructional bonds".

References

[1] BROŽEK, M., NOVÁKOVÁ, A. (1995). Porovnání jednostranných nýtů s trnem různých výrobců (Comparison of blind rivets of different producers). In.: *XXXVI. konference kateder částí a mechanismů strojů* (díl 1). VUT, 13.-14. June. Brno. 37-40.

[2] BROCKMANN, W. et al. (2009). *Adhesive bonding: materials, applications and technology*. Weinheim, Wiley-VCH.

[3] BROŽEK, M. (2014). Technical-economical evaluation of beech plywood bonding. In.: *13th International Scientific Conference Engineering for Rural Development*. 29.-30. May, Latvia, Jelgava, 168-173.

[4] BROŽEK, M. (2013). Technical-economical evaluation of plywood bonding. In.: *5th International Conference "Trends in Agricultural Engineering"*. 3.-6. September. Czech University of Life Sciences Prague. 100-105.

[5] BROŽEK, M. (2013). Optimization of adhesive layer thickness at metal bonding using quick-setting adhesives. *Manufacturing Technology*. 13. 4. 419-423.

[6] BROŽEK, M. (2013). Soldering steel sheets using soft solder. *Research in Agriculture Engineering*. 59. 4. 141-146.

[7] BROŽEK, M. (2013). Soldering sheets using soft solders. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 61. 6. 1597-1604.

[8] NIPPES, E. F. (1983). *Metals Handbook*. Vol. 6., Welding, Brazing, and Soldering. Metal Park, ASM International. 1152.

[9] RUŽA, V. (1988). *Pájení*. (Soldering). Prague. SNTL. 456.

[10] BLAŠČÍK, F. et al. (1987). *Technológia tvárnenia, zlievárenstva a zvárania*. (Technology of Forming, Founding and Welding). Bratislava. ALFA. 832.

[11] BROŽEK, M. (2012). Wear resistance of multi-layer overlays. In.: *11th International Scientific Conference Engineering for Rural Development*. 24.-25. May. Latvia. Jelgava. 210-215.

[12] BROŽEK, M. (2011). Layer number influence on weld deposit chemical composition. In.: *10th International Scientific Conference Engineering for Rural Development*. 26.-27. May. Latvia. Jelgava. 393-397.

[13] HUDEC, Z. (2012). Gas Metal Rapid Arc Welding Potential. *Manufacturing Technology.* 12. 13. 113-118.

[14] KOLAŘÍKOVÁ, M., KOLAŘÍK, L., KOVANDA, K., HRABINA, R. (2013). Welding of Normalized Heat Treated Steels S355NL Large Thicknesses by Method FCAW. *Manufacturing Technology.* 13. 2. 181-188.

[15] KOVANDA, K., HOLUB, L., KOLAŘÍK, L., KOLAŘÍKOVÁ, M., VONDROUŠ, P. (2012). Experimental Verification of FEM Simulation of GMAW Bead on Plate Welding. *Manufacturing Technology.* 12. 12. 30-33.

[16] KRAMÁR, T., KOLAŘÍK, L., KOLAŘÍKOVÁ, M., SAHUL, M., POSPÍŠIL, D. (2014). Capacitor Discharge Welding of Aluminium Studs. *Manufacturing Technology.* 14. 2. 199-206.

[17] MEŠKO, J., ZRAK, A., MULCZYK, K., TOFIL, S. (2014). Microstructure Analysis of Welded Joints after Laser Welding. *Manufacturing Technology.* 14. 3. 355-359.

[18] NOVOTNÝ, J., HONZÍKOVÁ, J., PILOUS, V., STRÁNSKÝ, K. (2015). Properties of Welded Joints in Power Plant. *Manufacturing Technology.* 15. 6. 1028-1032.

[19] PODREZ-RADZISZEWSKA, M. (2011). Weldability problems of the technical AW7020 alloy. *Manufacturing Technology.* 11. 11. 59-66.

[20] ČSN EN ISO 4063 (2010). *Svařování a příbuzné procesy - Přehled metod a jejich číslování* (Welding and allied processes - Nomenclature of processes and reference numbers). ČNI.

[21] LIU, H., WANG, H., ZHANG, X., LI, C. (2012). Optimization of parameters and research on joint microstructure of resistance spot welding of 201stainless steel. Advanced Materials Research. Volume 418-420, 1359-1363. 2nd International Conference on Advances in Materials and Manufacturing, ICAMMP 2011. Guilin. China. 16.-18. December, 2011.

[22] LIU, H., XU, X., ZHANG, X. (2013). Optimization of parameters and research on joint microstructure of resistance spot welding for 316 stainless steel. Advanced Materials Research. Volume 652-654, 2326-2329. 2012. *3rd International Conference on Advances in Materials and Manufacturing Processes*, ICAMMP 2012. Beihai. China. 22.-23. December, 2012.

[23] PEASURA, P. (2011). The influence of welding parameters on effected the complete for resistance spot welding on mild steel. Advanced Materials Research. 214. 113-117. *International Conference on Key Engineering Materials*, ICKEM 2011. Sanya. China. 25.-27. March, 2011.

[24] Pouranvari, M. (2011). Effect of resistance spot welding parameters on the HAZ softening of DP980 ferrite-martensite dual phase steel welds. *World Applied Sciences Journal*. 15. 10. 1454-1458.

[25] TYLECOTE, R. F. (1941). *The Spot Welding of Light Alloys*.

[26] Tentative Standards and Recommended Practices and Procedures for Spot Welding of Aluminium Alloys (1942). New York. American Welding Society. 48.

[27] HAYAT, F., SEVIM, I. (2012). The effect of welding parameters on fracture toughness of resistance spot-welded galvanized DP600 automotive steel sheets. *International Journal of Advanced Manufacturing Technology*. 58. 9.-12. February. 1043-1050.

[28] SVÍTIL, A. (1980). *Odporové bodové svařování tenkých pozinkovaných ocelových plechů* (Resistance spot welding thin galvanised steel sheets). Praha, b.t. 210. In Czech.

[29] WANG, Z., WANG, Y., ZHANG, D. (2013). Optimization on parameters of resistance spot welding process for galvanized steel plate. Advanced Materials Research. 658, 178-181. 2012 *International Conference on Materials and Manufacturing Research*. ICMMR 2012. 19.-20. December, 2012.

[30] LI, R. X. (2012). Quality monitoring of resistance spot welding based on process parameters. *Energy Procedia*. 14, 925-930. 2011, ICAEE 2011. Bangkok. Thailand. 27.-28. December, 2011.

[31] YOUNGER, A., GOURD, L. M., JUBB, J. E. M. (1966). *An Investigation into the Fatigue Properties of a Single Spot Weld Lap Joint Cranfield. College of Aeronautics*. 18.

[32] ČSN EN ISO 4063 (2010). *Svařování a příbuzné procesy - Přehled metod a jejich číslování* (Welding and allied processes - Nomenclature of processes and reference numbers). ČNI.

[33] HIPPERSON, J., WATSON, T. (1950). *Resistance Welding*.

[34] HIPPERSON, J. *Recommended Machine Settings for Resistance Welding*.

[35] HOLÁSEK, J. (1968). *Odporové zváranie* (Resistance welding). Bratislava. Slov. vydav. technické literatury.

[36] ZHANG, H., SENKARA, J. (2012). *Resistance Welding: Fundamentals and Applications*. 2nd Edition. Boca Raton. CRC Press.

[37] BROŽEK, M. (2015). Resistance spot welding of steel sheets of different thickness. In.: *14th International Scientific Conference on Engineering for Rural Development*. 20.-22. May. Latvia. Jelgava. 72-77.

[38] BROŽEK, M. (2014). Working variables optimization of resistance spot welding. Manufacturing Technology. 14. 4. 522-527.

[39] ČSN EN ISO 14273 (2003). Rozměry vzorku a postup zkoušení střihem odporových bodových, švových a výstupkových svarů (Specimen dimensions and procedure for shear testing resistance spot, seam and embossed projection welds). ČNI.

[40] ČSN EN 1465 (2009). Lepidla – Stanovení pevnosti ve smyku při tahovém namáhání přeplátovaných lepených soustav (Adhesives – Determination of tensile lap-shear strength of bonded assemblies). ČNI.

Paper number: M2016125

Analysis of a Goods Wagon Running on a Railway Test Track

Ján Dižo
Faculty of Mechanical Engineering, University of Žilina. Univerzitná 8215/1, 010 26 Žilina. Slovak republic. E-mail: jan.dizo@fstroj.uniza.sk

An intermodal transport is nowadays an inseperable part of a transport system. Designs of longer wagons are the result of efforts to achieve universality, transport capacity increase, reducing of noise and maintenance needs. In this paper are presented results of selected parametres of a long goods wagon driving on a test track. The long goods wagon and test rings models have been created by using the ADAMS/Rail software. The analysed wagon has been equipped by the Y25 bogie. Simulations of the long goods wagon running have been performed on the model of railway test rings – VÚŽ Velim, Cerhenice. For the dynamic analysis of the long goods wagon have been selected two sections of the railway test rings. For the ride properties wagon assessemnt have been selected output signals of vertical forces Q, guiding forces Y and the Y/Q ratio. There have been detected, values of assessed parametes have not been exceeded the limited values and therefore wagon runnings have been safety.

Keywords: Goods wagon, Y25 bogie, Railway test track, Ride properties

Acknowledgement

This paper was created during the processing of the project "RAILBCOT - RAIL Vehicles Brake Components Test Stand", ITMS Code 26220220011 based on the support of Research and Development Operational Program financed by European Fund of a Regional Development.

References

[1] BLATNICKÝ, M. (2015). Checks Crane Hooks. In: *Manufacturing Technology*. Vol. 15, No 5 (2015). ISSN 1213-2489. Pp. 766-771.

[2] BOSSO, N., GUGLIOTTA, A., SOMÁ, A. (2000). Simulation of a freight bogie with friction dampers. *5th ADAMS/Rail User's Conference Haarlem*, The Netherlands – May 10th – 11th, 2000.

[3] CHALUPA, M. (2015). The Using of Vehicle Moving Simulation to Proposal of Construction Work. In: *Manufacturing Technology*. Vol. 15, No 5 (2015). ISSN 1213-2489. Pp. 845-850.

[4] DIŽO, J., GERLICI, J., LACK, T. (2013). The goods wagon equipped by Y25 bogies computer simulation analysis. In: *TRANSCOM 2013, section 6*, EDIS – Žilina University Publisher. ISBN 978-80-554-0695-4. Pp. 63 – 66.

[5] FABIÁN, P., GERLICI, J., MAŠEK, J., MÁRTON, P. (2013). Versatile, efficient and long wagon for intermodal transport in Europe. In: *Communications: scientific letters of the University of Žilina*. - Vol. 15, No. 2. ISSN 1335-4205. Pp. 118-123.

[6] GERLICI, J., LACK, T., HARUŠINEC, J. (2014). Realistic simulation of railway operation on the RAILBCOT test stand. In: *Applied mechanics and material*. Vol. 486. ISSN 1660-9336. Pp. 387-395.

[7] JAKUBOVIČOVÁ, L., SÁGA, M., VAŠKO, M. (2013). Impact Analysis of Mutual Rotation of Roller Bearing Rings on the Process of Contact Stresses in Rolling Elements. In: *Manufacturing Technology*. Vol. 13, No 1 (2013). ISSN 1213-2489. Pp. 50-54.

[8] LACK, T., GERLICI, J. (2014). Modified strip method specification for wheel/rail contact stress evaluation. In: *Prace Naukowe. Transport: Analiza I ocean elementów systemów transportowych*. Z. 101. ISSN 1230-9265. Pp. 63-82. Online: http://www.wt.pw.edu.pl/var/ezflow_site/storage/original/application/83bbe4bc0bf7c4c4b704e53b9637c3a6.pdf.

[9] LACK, T., GERLICI, J. (2014). A modified strip method to speed up the calculation of normal stress between wheel and rail. In: *Applied mechanics and material*. Vol. 486 (2014). ISSN 1660-9336. Pp. 359-370.

[10] POLÁCH, P. (2015). Influence of the Shock Absorbers Type Change at Stress of the Troleybus Chassis. In: *Manufacturing Technology*. Vol. 15, No 1 (2015). ISSN 1213-2489. Pp. 77-86.

[11] SKOČILASOVÁ, B., SKOČILAS, J., SOUKUP, J. (2008). *Experimental determination of natural frequencies and stiffness of suspension of flexible mounted body, aplication on road and railway vehicles* (In Czech). Acta Mechanica Slovaca, No. 3-B/2008, CD ROM, vol. 12, Košice, 2008. ISSN 1335-2393. Pp. 715 – 726.

[12] SUCHÁNEK, A., HARUŠINEC, J. (2015). The Downhill Braked Railway Wheel Structural Analysis by Means of the ANSYS Multiphysics Program System Package. In: *Manufacturing Technology*. Vol. 15, No 5 (2015). ISSN 1213-2489. Pp. 945-950.

[13] SVOBODA, M., SKOČILASOVÁ, B. (2010). *Analytical analysis of vertical vibration of mechanical system of bodies*. Presentation of Proceedings of Extended Abstracts of 26th Conference with International Participation Computational Mechanics 2010, University of West Bohemia in Plzeň, Hrad Nečtiny, November 2010.

[14] SVOBODA, M., SOUKUP, J. (2013). Verification of Numeric Solution by Experiment for Examination Vertical Oscillation of a Mechanical System. In: *Manufacturing Technology*. Vol. 13, No 4 (2013). ISSN 1213-2489. Pp. 559-563.

[15] ŠŤASTNIAK, P., HARUŠINEC, J. (2013). Computer aided simulation analysis for computation of modal analysis of the fright wagon. In: *Communications: scientific letters of the Universtity of Žilina*, Vol. 15, April 2013. ISSN 1335 – 4205. Pp. 73 – 79.

[16] ADAMS/Rail, *User manual*, 2005: MSC.Software\MSC.ADAMS\2005r2

[17] Railway Research Institute, j.s.c.: http://www.cdvuz.cz/zkusebni-centrum-vuz-velim/

Paper number: M2016126

Assessment of Complex Free Form Surfaces with Surface Profile Deviation

Miroslav Dovica[1], Ján Buša[2], Emil Spišák[1], Michal Fabian[1], Peter Ižol[1], Jana Fabianová[3]
[1]Faculty of Mechanical Engineering, Technical University of Košice, Letná 9, Košice, 040 01, Slovakia. E-mail: miroslav.dovica@tuke.sk, emil.spisk@tuke.sk, michal.fabian@tuke.sk, peter.ižol@tuke.sk
[2]Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, Košice, 040 01, Slovakia. E-mail: jan.busa@tuke.sk
[3]Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Košice, Letná 9, Košice, 040 01, Slovakia. jana.fabianova@tuke.sk

Accuracy of work-pieces of complex free form surfaces is achieved by tolerancing, producing and metrology of workpieces. The tolerance zone is defined by form tolerances, their orientation and location on the work-pieces. Tolerances for complex form surfaces are specified by line profile tolerance or surface profile tolerance. These tolerances control form or combination of size, form, orientation and location. In a machining process the impact of machining parameter settings on the final surface quality will be researched. The influence of toolpaths in connection with the SH (Scallop Height) parameter setting on production accuracy and quality of machined surface will be compared. For geometry verification of the complex form surfaces are coordinate measurements used. The measurement area is modeled with the equations in CATIA V5. The data of machined surface obtained through the contact coordinate measurement are processed using the coordinate system adjustment via the RSS minimization by the Newton method in Matlab/Octave. Calculated values of surface profile deviations at individual machining strategies are used to achieve the required quality of machined surface through optimization of the machining parameters.

Keywords: coordinate measurement, form tolerances, complex surfaces, Newton method, orthogonal deviation

Acknowledgements

This work is a part of these projects VEGA 1/0182/15, VEGA 1/0198/15, KEGA 014STU-4/2015, KEGA 021TUKE-4/2015.

References

[1] MEHRAD, V., XUE, D., GU, P. (2013). Prediction of surface reconstruction uncertainties for freeform surface inspection, *Measurement*, vol. 46, no. 8, pp. 2682–2694, Oct.

[2] OHARA, M., HIGASHI, M. (1983). Integration of CAD/CAM systems in automotive body engineering, *Computers & Graphics*, vol. 7, no. 3–4, pp. 307–314, 1983.

[3] SITNIK, R., BŁASZCZYK, P. M. (2012). Segmentation of unsorted cloud of points data from full field optical measurement for metrological validation, *Computers in Industry*, vol. 63, no. 1, pp. 30–44, Jan. 2012.

[4] KRUTH, J. P., KERSTENS, A. (1998). Reverse engineering modelling of free-form surfaces from point clouds subject to boundary conditions," Journal of Materials Processing Technology, vol. 76, no. 1–3, pp. 120–127, Apr. 1998.

[5] OE, T., SHIZUKI, B., TANAKA, J. (2012). Scan modeling: 3D modeling techniques using cross section of a shape, in 1*0th Asia-Pacific Conference on Computer-Human Interaction*, APCHI 2012, 2012, pp. 243–250.

[6] WU, N., YANG, C., GUO, R., ZHANG, Z., ZHOU, C., CHEN, W., TAO, L. (2011). Reverse design and manufacture of the car door using reverse engineering methods, in I*CCTP 2011: Towards Sustainable Transportation Systems - Proceedings of the 11th International Conference of Chinese Transportation Professionals*, 2011, pp. 3849–3854.

[7] VARADY, T., MARTIN, R. (2002). Chapter 26 - Reverse Engineering, in *Handbook of Computer Aided Geometric Design*, G. Farin, J. Hoschek, M.-S. Kim, and M.-S. B. T.-H. of C. A. G. D. Kim, Eds. Amsterdam: North-Holland, 2002, pp. 651–681.

[8] D. HANSFORD, D., FARIN, G. (2002). Chapter 7 - Curve and Surface Constructions, in *Handbook of Computer Aided Geometric Design*, G. Farin, J. Hoschek, M.-S. Kim, and M.-S. B. T.-H. of C. A. G. D. Kim, Eds. Amsterdam: North-Holland, 2002, pp. 165–192.

[9] CHOI, B. K., KIM, B. H., JERARD, R. B. (2002). Chapter 22 - Sculptured Surface NC Machining, in *Handbook of Computer Aided Geometric Design*, G. Farin, J. Hoschek, M.-S. Kim, and M.-S. B. T.-H. of C. A. G. D. Kim, Eds. Amsterdam: North-Holland, 2002, pp. 543–574.

[10] ALTAN, T., LILLY, B., YEN, Y. C. (2001). Manufacturing of Dies and Molds, *CIRP Annals - Manufacturing Technology*, vol. 50, no. 2, pp. 404–422, 2001.

[11] LO, C. C. (2000). CNC machine tool surface interpolator for ball-end milling of free-form surfaces, *International Journal of Machine Tools and Manufacture*, vol. 40, no. 3, pp. 307–326, Feb. 2000.

[12] WEI, E. J., LIN, M. C. (2005). Study on general analytical method for CNC machining the free-form surfaces, *Journal of Materials Processing Technology*, vol. 168, no. 3, pp. 408–413, Oct. 2005.

[13] YOO, D. J. (2011). Three-dimensional surface reconstruction of human bone using a B-spline based interpolation approach, *CAD Computer Aided Design*, vol. 43, no. 8, pp. 934–947, 2011.

[14] KALRA, A. (2011). Three-dimensional modeling of femoral bone of human body and its failure analysis for hip resurfacing, *International Journal of Applied Engineering Research*, vol. 6, no. 4, pp. 445–451, 2011.

[15] SALMI, M., TUOMI, J., PALOHEIMO, K. S., BJÖRKSTRAND, R., PALOHEIMO, M., SALO, J., KONTIO, R., MESIMÄKI, K., MÄKITIE, A. A. (2012). Patient-specific reconstruction with 3D modeling and DMLS additive manufacturing, *Rapid Prototyping Journal*, vol. 18, no. 3, pp. 209–214, 2012.

[16] FANG, D., ZHANG, A., QIU, Y. (2013). Research and practice on new measuring and drafting mode of mechanical drawing based on reverse engineering, *2012 International Conference on Measurement, Instrumentation and Automation, ICMIA 2012*, vol. 239–240. School of Mechanical Engineering, Zhengzhou University, Zhengzhou, 450001, China, pp. 645–648, 2013.

[17] HERLIN, C., DOUCET, J. C., BIGORRE, M., KHELIFA, H. C., CAPTIER, G. (2013). Computer-assisted midface reconstruction in Treacher Collins syndrome part 1: Skeletal reconstruction, *Journal of Cranio-Maxillofacial Surgery*, vol. 41, no. 7, pp. 670–675, 2013.

[18] LI, J., LI, P., LU, H., SHEN, L., TIAN, W., LONG, J., TANG, W. (2013). Digital design and individually fabricated titanium implants for the reconstruction of traumatic zygomatico-orbital defects, *Journal of Craniofacial Surgery*, vol. 24, no. 2, pp. 363–368, 2013.

[19] PONIATOWSKA, M. (2012). Deviation model based method of planning accuracy inspection of free-form surfaces using CMMs, *Measurement: Journal of the International Measurement Confederation*, vol. 45, no. 5, pp. 927–937, 2012.

[20] LEE, R. T., SHIOU, F. J. (2011). Multi-beam laser probe for measuring position and orientation of freeform surface, *Measurement: Journal of the International Measurement Confederation*, vol. 44, no. 1, pp. 1–10, 2011.

[21] KALE, K. B., GURUMOORTHY, B. (2013). Profile Tolerance Verification for Free-form Surfaces Using Medial Axis Transform, *Procedia CIRP*, vol. 10, no. 0, pp. 133–141, 2013.

[22] Dimensional metrology portal, In: www.tuke.sk/smetrologia [Online], Available: <http://web.tuke.sk/smetrologia/l5.html>, [Accessed: 18-March-2016]

[23] FARIN, G., HOSCHEK, J., KIM, M. S. (2002). *Handbook of Computer Aided Geometric Design*, North-Holland, Amsterdam, 2002.

[24] DVOŘÁČKOVÁ, Š. (2016). Gauge Block Calibration by Interferometry, In: *Manufacturing Technology*, 2016, Vol. 16, No. 1. pp. 58 – 63, ISSN 1213-2489

[25] JENČURÁKOVÁ, D., PALENČÁR, R. (2016). Optimizing Management of the Measurement System of the Technological Process“, Š. Dvořáčková, “Gauge Block Calibration by Interferometry, In: *Manufacturing Technology*, 2016, Vol. 16, No. 1. pp. 107 – 113, ISSN 1213-2489

[26] TICHÁ, Š., SRBA, O., VAVŘINA, J. (2016). A Measuring Device for the Checking of 3D Indicators, In: *Manufacturing Technology*, 2016, Vol. 16, No. 1. pp. 280 – 284, ISSN 1213-2489

Paper number: M2016127

Preparation of WE43 Using Powder Metallurgy Route

Drahomir Dvorsky, Jiri Kubasek, Dalibor Vojtěch, Filip Prusa, Katerina Nova
Faculty of chemical technology, Department of metals and corrosion engineering, University of chemistry and technology Prague, Technická 5 166 28 Praha 6 – Dejvice, Czech Republic. E-mail: dvorskyd@vscht.cz, Jiri.Kubasek@vscht.cz, Dalibor.Vojtech@vscht.cz

Magnesium alloy WE43 is well known for its low density and good mechanical properties. It has also fair corrosion resistance and relative usability up to 300 °C. All those properties are connected with the content of rare earth elements and determine this alloy not only for automotive and aviation industry, but also for applications as biodegradable materials. In this work, WE43 alloy prepared by powder metallurgy methods is characterized. Final products are prepared by cold uniaxial pressing with subsequent extrusion or spark plasma sintering (SPS). Present paper deals with the characterization of processing methods used for the WE43 alloy preparation and also the characterization of prepared WE43 products as themselves.

Keywords: WE43, powder metallurgy, spark plasma sintering, extrusion.

Aknowledgement

Authors wish to thank the Czech Science Foundation (project no. P108/12/G043) and specific university research (MSMT No 20-SVV/2016) for the financial support of this research.

References

[1] RZYCHOŃ, T., A. K. (2007). Microstructure of WE43 casting magnesium alloy. *Journal of achievements in materials and manufacturing engineering* 2007, *21* (1).

[2] DYBOWSKI, B., KIELBUS, A., JARSZ, R., PAŚKO, J. (2013). The Microstructure of Elektron21 and WE43 Magnesium Casting Alloys After Subsequent Melting Process Operations. *Solid State Phenomena* 2013, *211*, 65-70.

[3] ČAPEK, J., VOJTĚCH, D. (2015). Powder Metallurgical Techniques for Fabrication of Biomaterials. *Manufacturing Technology* 2015, *15* (6), 964-969.

[4] ZHENG, Y. F., GU, X. N., WITTE, F. (2014). Biodegradable metals. *Materials Science and Engineering: R: Reports* 2014, *77* (0), 1-34.

[5] VOJTĚCH, D., B. B., VEMER, J., ŠERÁK, J. (2004). Rychlé chlazení kovů - význam, technologie a využití. *Chemické Listy* 2004, *98*, 180-184.

[6] DVORSKÝ, D., KUBÁSEK, J., VOJTĚCH, D. (2015). Hydroxyapatite in Materials for Medical Applications *Manufacturing Technology* 2015, *15* (6), 969-973.

[7] HAO, L., LU, Y., SATO, H., ASANUMA, H., GUO, J. (2013). Analysis on energy transfer during mechanical coating and ball milling—Supported by electric power measurement in planetary ball mill. *International Journal of Mineral Processing* 2013, *121* (0), 51-58.

[8] HAO. L., LU, Y., SATO, H., ASANUMA, H. (2012). Fabrication of zinc coatings on alumina balls from zinc powder by mechanical coating technique and the process analysis. *Powder Technology* 2012, *228* (0), 377-384.

[9] VOJTĚCH, D. (2006). *Kovové materiály*. 1 ed.; VŠCHT Praha: Praha, 2006; p 185.

[10] LARGILLER, G., DONG, L., BOUVARD, D., CARRY, C. P., GABRIEL, A. (2012). Deformation and cracking during sintering of bimaterial components processed from ceramic and metal powder mixes. Part II: Numerical simulation. *Mechanics of Materials* 2012, *53* (0), 132-141.

[11] PEREVOSHCHIKOVA, N., HUTCHINSON, C. R., WU, X. (2016). The design of hot-isostatic pressing schemes for Ti–5Al–5Mo–5V–3Cr (Ti-5553). *Materials Science and Engineering: A* 2016, *657*, 371-382.

[12] KUBÁSEK, J., VOJTĚCH, D., DVORSKÝ, D. (2015). Preparation and Properties of Composite Materials with Magnesium Matrix and Hydroxyapatite Reinforcement *Manufacturing Technology* 2015, *15* (4).

[13] TAVIGHI, K.., EMAMI, M., EMAMI, A. R. (2013). Effects of extrusion temperature on the microstructure and tensile properties of Al–16wt% Al4Sr metal matrix composite. *Materials & Design* 2013, *46* (0), 598-604.

[14] PRŮŠA, F., VOJTĚCH, D., BLÁHOVÁ, M., MICHALCOVÁ, A., KUBATÍK, T. F., ČÍŽEK, J. (2015). Structure and mechanical properties of Al–Si–Fe alloys prepared by short-term mechanical alloying and spark plasma sintering. *Materials & Design* 2015, *75*, 65-75.

[15] ZHANG, Z.-H., LIU, Z.-F., LU, J.-F., SHEN, X.-B., WANG, F.-C., WANG, Y.-D. (2014). The sintering mechanism in spark plasma sintering – Proof of the occurrence of spark discharge. *Scripta Materialia* 2014, *81*, 56-59.

[16] TOKITA, M. (2013). Chapter 11.2.3 - Spark Plasma Sintering (SPS) Method, Systems, and Applications. In *Handbook of Advanced Ceramics (Second Edition)*, Somiya, S., Ed. Academic Press: Oxford, 2013; pp 1149-1177.

[17] MUHAMMAD, W. N. A. W., SAJURI, Z., MUTOH, Y., MIYASHITA, Y. (2011). Microstructure and mechanical properties of magnesium composites prepared by spark plasma sintering technology. *Journal of Alloys and Compounds* 2011, *509* (20), 6021-6029.

[18] GHOSH, N. C., HARIMKAR, S. P. (2012). 3 - Consolidation and synthesis of MAX phases by Spark Plasma Sintering (SPS): a review. In *Advances in Science and Technology of Mn+1axn Phases*, Low, I. M., Ed. Woodhead Publishing: 2012; pp 47-80.

Paper number: M2016128

Evaluation of Selected Properties of Steel 100Cr6 at Different Ways of Heat Treatment

Peter Fabian, Andrej Zrak
Faculty of Mechanical Engineering, University of Žilina, Univerzitná 1, 010 08 Žilina. Slovak Republic. E-mail: peter.fabian@fstroj.uniza.sk, andrejzrak@gmail.com

This study discusses the impact of heat treatment conditions on the final properties of quenched and low-tempered bearing components in terms of microstructure, hardness and impact strength. Technological process of heat treatment must be done rationally and in addition to the required hardness must also ensure the dimensional precision of bearings components. Different austenitization conditions have a great influence on the phenomena which takes place in the material during the austenitizing. Heat treatment of rolling bearing components is an indispensable part of their production and it is also an unavoidable item of the price calculation of bearings. The aim of a competitive struggle for the rolling bearings market is an offer of the best quality bearings (dimensional accuracy, stability and durability) at a reasonable price.

Keywords: austenitizing, bearing steel, quenching, heat treatment

Acknowledgement

This contribution was made with the financal assistance of KEGA agency, project No. 042ŽU-4/2015 and APVV SK-PL-2015-0008

References

[1] DURAND-CHARE, M. (2004). *Microstructure of Steels and Cast Irons*, Springer, Berlin.
[2] LIŠČIĆ, B et al. (2010). *Quenching Theory and Technology* 2nd edition, Taylor & Francis Group LLC, Boca Raton.
[3] PUTGEN, W. (2007). On the microstructure and properties of 100Cr6 steel processed in the semi-solid state, *Acta Materialia* 55 (19): 6553-6560, Elsevier, Amsterdam.
[4] KOŇÁR, R., MIČIAN, M., HLAVATÝ, I. (2014). Defect detection in pipelines during operation using Magnetic Flux Leakage and Phased Array ultrasonic method. In: *Manufacturing technology,* Vol. 14, No. 3, pp. 337-341. J. E. Purkyne University, Ústi nad Labem.
[5] KOŇÁR, R., MIČIAN, M. (2014). Non-destructive testing of welds in gas pipelines repairs with Phased Array ultrasonic technique. In: *Manufacturing technology*, Vol. 14, No. 1, pp. 42-47. J. E. Purkyne University, Ústi nad Labem.
[6] DOPJERA, D., KOŇÁR, R., MIČIAN, M. (2014) Ultrasonic testing of girth welded joint with TOFD and Phased Array. In: *Manufacturing technology*, Vol. 14, No. 3, pp. 281-286.
[7] DOPJERA, D., MIČIAN, M. (2014) The detection of articullary made defects in welded joint with ultrasonic defectoscopy Phased Array. In: *Manufacturing Technology*, Vol. 14, No. 1, pp. 12-17, ISSN 1213-2489
[8] PASTIRČÁK, R. (2014) Effect of low pressure application during solidification on microstructure of AlSi alloys In: *Manufacturing Technology*, Vol. 14, No. 3, pp. 397- 402, ISSN 1213-2489
[9] PATEK, M., KOŇÁR, R., SLÁDEK, A., RADEK, N. (2014) Non-destructive testing of split sleeve welds by the ultrasonic TOFD method In: *Manufacturing technology*. ISSN 1213-2489. - Vol. 14, No. 3 (2014), s. 403-407.
[10] KOŇÁR, R., MIČIAN, M., MEŠKO, J., SVENTEK, M. (2015). Identification of lack of fusion and penetration in circumferential fillet weld by phased array ultrasonic method in gas industry In: *Communications : scientific letters of the University of Žilina*. - ISSN 1335-4205. - Vol. 17, No. 3 (2015), s. 98-102.
[11] NOVÁK, P., MEŠKO, J., ŽMINDÁK, M. (2013) Finite element implementation of multi-pass fillet weld with phase changes In: *Manufacturing technology*. - ISSN 1213-2489. - Vol. 13, No. 1 (2013), s. 79-85.
[12] PODPROCKÁ, R., BOLIBRUCHOVÁ, D., MALIK, J. (2015) Defects in high pessure die casting process [Defekty pri procese vysokotlakového liatia] / Radka Podprocká, Jozef Malik, Dana Bolibruchová. In: *Manufacturing technology*: journal for science, research and production. - ISSN 1213-2489. - Vol. 15, No. 4, s. 674-678.
[13] ŽIHALOVÁ, M., BOLIBRUCHOVÁ, D., CAIS, J. (2015). Microstructural analysis of nickel influence in Alsi10MgMn alloy with increased iron level [Mikroštruktúrna analýza vplyvu niklu v zliatine so zvýšenou úrovňou železa AlSi10Mg. In: *Manufacturing technology*. ISSN 1213-2489. - Vol. 15, No. 4, s. 743-748.
[14] RICHTÁRECH, L. BOLIBRUCHOVÁ, D. (2014) Effect of selected elements on the microstructure of secondary Al-Si alloys In: *Manufacturing technology*. ISSN 1213-2489. - Vol. 14, No. 3, s. 431-437.

Paper number: M2016129

Titanium Alloy Ti-6Al-4V Prepared by Selective Laser Melting (SLM)

Michaela Fousová, Dalibor Vojtěch, Jiří Kubásek
Department of Metals and Corrosion Engineering, Faculty of Chemical Technology, University of Chemistry and Technology Prague, 166 28 Prague 6. Czech Republic. E-mail: fousovam@vscht.cz, dalibor.vojtech@vscht.cz, jiri.kubasek@vscht.cz

Selective laser melting (SLM) as a representant of additive manufacturing technology brings about many advantages into production, which are appreciated especially in the field of biomedical applications and implantology. Our paper is focused on characterization of titanium alloy Ti-6Al-4V (Ti Grade 5) widely used for orthopaedic implants produced by this novel method. Microstructure and mechanical properties are compared with the same material prepared by conventional way of casting, forging and machining. Results show these are almost equivalent. Microstructure is in both cases formed by two phases α+β, but possesses different morphology. Yield strength and ultimate tensile strength of SLM material slightly overpassed values obtained by conventional commercial production (950 MPa and 1000 MPa vs. 877 MPa and 985 MPa). Only elongation was reduced resulting from the presence of some porosity. However, by future optimalization of SLM process parameters, porosity is expected to decrease.

Keywords: titanium alloy, SLM, 3D printing, mechanical properties

Acknowledgement

Authors wish to thank the Czech Science Foundation (project no. P108/12/G043) and specific university research (MSMT No 20-SVV/2016) for the financial support of this research. Furthermore, authors thank to Prospon spol. s.r.o. for providing the test material.

References

[1] BANDYOPADHYAY, A., ESPANA, F., BANNA, V. K., ET AL. (2010). Influence of porosity on mechanical properties and in vivo response of Ti6Al4V implants. In: *Acta Biomaterialia*, Vol. 6, No. 4, pp. 1640-1648. Elsevier Ltd.

[2] ÖZCAN, M., HÄMMERLE, C. (2012). Titanium as a reconstruction and implant material in dentistry: advantages and pitfalls. In: *Materials*, Vol. 5, No. 9, pp. 1528-1545. MDPI AG, Basel, Switzerland.

[3] KRISHNA, B. V., BOSE, S., BANDYOPADHYAY, A. (2007). Low stiffness porous Ti structures for load-bearing implants. In: *Acta Biomaterialia*, Vol. 3, No. 6, pp. 997-1006. Elsevier Ltd.

[4] PETERS, M., HEMPTENMACHER, J., KUMPFERT J., LEYENS, C. (2003). Structure and Properties of Titanium and Titanium Alloys. In: *Titanium and Titanium Alloys: Fundamentals and Applications* (Leyens C., Peters, M. (Ed.)), pp. 1-35. Wiley-WCH GmbH & Co. KGaA: Weinheim.

[5] STANCEKOVA, D., SEMCER, J., RUDAWSKA, A., CEP, R. (2015). Identification of drilling of biocompatible materials based on titanium. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 699-704. Czech Republic.

[6] ZHANG, L. C., ET AL. (2011). Manufacture by selective laser melting and mechanical behavior of a biomedical Ti–24Nb–4Zr–8Sn alloy. In: *Scripta Materialia*, Vol. 65, No. 1, pp. 21-24. Elsevier Ltd.

[7] KURODA, D., ET AL. (1998). Design and mechanical properties of new β type titanium alloys for implant materials. In: *Materials Science and Engineering: A*, Vol. 243, No. 1–2, pp. 244-249. Elsevier Science S. A.

[8] WANG, Y., ET AL. (2010). Development of highly porous titanium scaffolds by selective laser melting. In: *Materials Letters*, Vol. 64, No. 6, pp. 674-676. Elsevier B. V.

[9] RYAN, G., PANDIT, A., APATSIDIS, D. P. (2006). Fabrication methods of porous metals for use in orthopaedic applications. In: *Biomaterials*, Vol. 27, No. 13, pp. 2651-2670. Elsevier Ltd.

[10] FOUSOVÁ, M., VOJTĚCH, D., KUBÁSEK, J., DVORSKÝ, D., MACHOVÁ, M. (2015). 3D Printing as an Alternative to Casting, Forging and Machining Technologies? In: *Manufacturing Technology*, Vol. 15, No. 5, pp. 809-814. Czech Republic.

[11] HOLLANDER, D. A., ET AL. (2006). Structural, mechanical and in vitro characterization of individually structured Ti–6Al–4V produced by direct laser forming. In: *Biomaterials*, Vol. 27, No. 7, pp. 955-963. Elsevier Ltd.

[12] LI, J. P., ET AL. (2005). Porous Ti6Al4V scaffolds directly fabricated by 3D fibre deposition technique: Effect of nozzle diameter. In: *Journal of Materials Science: Materials in Medicine*, Vol. 16, No. 12, pp. 1159-1163. Kluwer Academic Publishers.

[13] OSAKADA, K., SHIOMI, M. (2006). Flexible manufacturing of metallic products by selective laser melting of powder. In: *International Journal of Machine Tools and Manufacture*, Vol. 46, No. 11, pp. 1188-1193. Elsevier Ltd.

[14] CHLEBUS, E., KUZNICKA, B., KURZYNOWSKI, T., DYBAŁA, B. (2011). Microstructure and mechanical behaviour of Ti—6Al—7Nb alloy produced by selective laser melting. In: *Materials Characterization*, Vol. 62, No. 5, pp. 488-495. Elsevier Inc.

[15] VRANCKEN, B., ET AL. (2012). Heat treatment of Ti6Al4V produced by Selective Laser Melting: Microstructure and mechanical properties. In: *Journal of Alloys and Compounds*, Vol. 541, pp. 177-185. Elsevier B. V.

[16] MERTENS, A., ET AL. (2014). Mechanical properties of alloy Ti-6Al-4V and of stainless steel 316L processed by selective laser melting: influence of out-of-equilibrium microstructures. In: *Powder Metallurgy*, Vol. 57, No. 3, pp. 184-189. Maney Publishing.

[17] QIU, C., ADKINS, N. J. E., ATTALLAH, M. M. (2013). Microstructure and tensile properties of selectively laser-melted and of HIPed laser-melted Ti–6Al–4V. In: *Materials Science and Engineering: A*, Vol. 578, pp. 230-239. Elsevier B. V.

[18] MICHALCOVÁ, A., ET AL. (2015). Microstructures of iron aluminides processed by additive layer manufacturing and spark plasma sintering. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 610-614. Czech Republic.

[19] MURR, L.E., ET AL. (2009). Microstructure and mechanical behavior of Ti–6Al–4V produced by rapid-layer manufacturing, for biomedical applications. In: *Journal of the Mechanical Behavior of Biomedical Materials*, Vol. 2, No. 1, pp. 20-32. Elsevier Ltd.

Paper number: M2016130

Distortion after Case Hardening of Steels

Jiří Hájek, Antonin Kříž, Tomáš Jirka
University of West Bohemia, Univerzitní 22, 306 14 Plzeň, Czech Republic, E-mail: hajek@kmm.zcu.cz, kriz@kmm.zcu.cz, jirka@kmm.zcu.cz

Dimensional changes, or distortion, play a very important role in carburizing. To keep carburizing process productive and profitable, it is crucial that the resulting distortion is minimized. The purpose of this experiment was to carry out low-pressure carburizing and measure dimensional changes, residual stresses, characterize the resulting microstructures, and determine hardness in the specimens. These are the most important clues to the quality of the carburized layer. Experimental materials were the most widely-used carburizing steels: C15, 16MnCr5 and 15NiCr13. Residual stresses in the surface were determined by X-ray stress measurement.

Keywords: Distortion, Carburizing, Low pressure carburising (LPC)

Acknowledgement

The assistance of the PILSEN TOOLS s .r. o. company with the experiments carried out for this paper is gratefully acknowledged.
This work was undertaken as part of the SGS-2015-016 project "Analysis of Surfaces of Assemblies and Tools by Surface Integrity Method and Impacts on End-Use Properties".

References

[1] HERRING, D. H., GERALD D. (2004). *Reducing distortion in heat-treated gears*., 35 pages. http://www.gear-solutions.com/article/detail/5655/reducing-distortion-in-heat-treated-gears

[2] LINDE GAS. *Furnace Atmospheres No. 1: Gas Carburizing and Carbonitriding* [online]. [Accessed 2015-05-12]. http://www.linde-gas.com/en/processes/heat_treatment/carburising_carbonitriding/index.html

[3] KŘÍŽ, A. *Tribologická analýza Pin on Disk* [online]. [Accessed 2015-05-19]. http://www.ateam.zcu.cz/TRIBOLOGICKA_ANALYZA_PIN-ON-DISC.pdf

[4] SALABOVÁ, P. (2013). Podtlaková cementace. *Tribotechnika: Časopis o tření, opotřebování a mazání*., No. 3.https://www.scribd.com/embeds/144596602/content?start_page=1&view_mode=book&access_key=key-24msy9xmeorm0d9f2j8&show_recommendations=false

[5] KARABELCHTCHIKOVA, O. (2007). *Fundamentals of Mass Transfer in Gas Carburizing*. Worcester, USA, Doctoral thesis. WORCESTER POLYTECHNIC INSTITUTE

[6] NOVA, I., MACHUTA, J. (2016). Monitoring of the Diffusion Processes during Carburizing Automotive Steel Parts, *Manufacturing Technology,* Volume 16, pages 225-230

[7] WENQUAN, S., JIAN, S., ANRUI, H., PUJUN, H. N.(2015). Research on Distribution of Residual Stresses of Cold Rolled Sheet Distorted Area Based on ANSYS, *Manufacturing Technology*, Volume 15, pages 220-226

[8] HÁEK, J., KŘÍŽ, A., HRDLIČKA, V. (2015). The Heat Treatment of Aluminium Bronzes, *Manufacturing Technology*, Volume 15, pages 35-41

[9] NOVÁK, M. (2011). Surface quality of hardened steels after grinding, *Manufacturing Technology*, Volume 11, pages 55-59

[10] VASILKO, K. (2011). Identification of „natural" breaker cut during the machining of carbon steels, *Manufacturing Technology*, Volume 11, pages 77-84

Paper number: M2016131

Influence of the Welding Process on the Martensitic and Dual Phase High Strength Steels

Petr Hanus, Eva Schmidová
Jan Perner Transport Faculty, University of Pardubice, Studentská 95, 532 10, Pardubice, Czech Republic, petr.hanus@upce.cz

The subject of the study are martensitic 22MnB5 steel and dual phase steel with the ferrite-martensitic structure, which are used in the automotive industry. The main purpose of the performed analyses is a study of strength differences in heat affected zones of the spot welding. For the needs of the strength decrease assessment, the critical layer of the heat affected area was experimentally simulated by different thermal influence procedures. The aim of the work is to determine the most suitable methodology for evaluating the local changes of the elastic-plastic material response. The yield strength and the deformation hardening are required constructions of safety carbody parts.

Keywords: Martensitic steel, dual phase steel, heat affected zones, yield strength, weld-joint fractures, indentation

References

[1] TICHÝ, J. (2006). Svařování v automobilovém průmyslu - 2. část. Časopis *Svět svaru*, Ostrava, 2006, s. 14-15.

[2] KARBASIAN, H., TEKKAYA, A. E. (2010). A review on hot stamping. *Journal of Materials Processing Technology* 210, 2010, 2103–2118.

[3] SAHUL, M., TURŇA, M., ŠUGÁROVÁ, J., SAHUL, M. (2013). Influence of Laser Welding Aluminium Alloy on Mechanical Properties of Welded Joints. *Manufacturing Technology Journal* [online]. Usti nad Labem, 2013, 2013(4), 5 [cit. 2016-04-12]. ISSN 1213-2489.

[4] SONG, R., DAI, Q. (2013). Dynamic Deformation Behavior of Dual Phase Ferritic-Martensitic Steel at Strain Rates From 10-4 to 2000 s-1, INTERNATIONAL, 2013.

[5] SVOBODA, M., SOUKUP, J. (2013). Dynamic Measurement of Four-Axle Railway Wagon. *Manufacturing Technology Journal* [online]. Usti nad Labem, 2013, 2013(4), 7 [cit. 2016-04-12]. ISSN 1213-2489.

[6] SCHMIDOVÁ, E., HANUS, P. (2013). Problems of Spot Welding of Al-Si Coated Martensitic Low Alloyed Steels, *30th Intermational Colloquium on Advanced Manufacturing and Repairing Technologies in Vehicle Industry*, Visegrád, Hungary, 22-24 May 2013, ISBN 978-963-313-079-7.

[7] PODREZ-RADZISZEWSKA, M. (2011). Weldability problems of the technical AW7020 alloy. *Weldability problems of the technical AW7020 alloy* [online]. Usti nad Labem, 2011, (11), 7 [cit. 2016-04-12]. ISSN 1213-2489.

[8] KOŇÁR, R., MIČIAN M. (2014). Non-destructive Testing of Welds in Gas Pipelines Repairs with Phased Array Ultrasonic Technique. Weldability problems of the technical AW7020 alloy [online]. Usti nad Labem, 2014, 2014(1), 6 [cit. 2016-04-12]. ISSN 1213-2489.

[9] BOWMAN, K. J. (2004). *Mechanical behavior of materials*. Hoboken, NJ: John Wiley, 2004, xi, 334 p. ISBN 0471241989.

Paper number: M2016132

Numerical Optimization of Large Shade Sail Support

Jakub Javorik
Faculty of Technology, Tomas Bata University in Zlín, Vavrečkova 275, 762 72 Zlín, Czech Republic. E-mail: javorik@ft.utb.cz

To design an optimal support of a large shade sail it is necessary to determine forces in wire ropes that support the sail. Relations between a sail loading and ropes reaction forces, rope diameters and sail stresses were investigated. To simulate the sail behavior and set up these relations, numerical (FEM) models were created and analyzed. Most of the results show nonlinear relations between above mentioned parameters and they depend on the sail geometry, applied loads and the rope diameter. It means that for every specific geometry and loading of particular sail an optimal rope diameter and support should be designed. The nonlinear numerical analysis is very suitable tool for this purpose and thus specialized systems based on the Finite Element Method (FEM) should be used to simulate and analyze such problems.

Keywords: Awnings, Numerical Model, Sail, Shade Sail, Wire Rope

References

[1] JUANICÓ, L. E. (2009). A new design of configurable solar awning for managing cooling and heating loads. In: *Energy and Buildings*. Vol. 41, No. 12, pp. 1381 – 1385. Elsevier BV.

[2] BRODERICK, R. (2003). The arts of fabric. In: *Fabric Architecture*. Vol. 15, No. 2, pp. 46 – 50. Industrial Fabrics Association International. Minnesota.

[3] EILAM, I. (2006). An awning on every home. In: *Industrial Fabric Products Review*. Vol. 91, No. 4, pp. 20 – 26. Industrial Fabrics Association International. Minnesota.

[4] YIMIN, L., JIE, W. (2014). Design and calculation of multi-angel and stepping transmission of sucker rod forging. In: *Manufacturing Technology*. Vol. 14, No. 4, pp. 650 – 657. Univerzita J. E. Purkyne. Czech Republic.

[5] RUSNAKOVA, S., FOJTL, L., ZALUDEK, M., RUSNAK, V. (2014). Design of material composition and technology verification for composite front end cabs. In: *Manufacturing Technology*. Vol. 14, No. 4, pp. 607 – 611. Univerzita J. E. Purkyne. Czech Republic.

[6] JAVORIK, J. (2014). Simulation and Numerical Analysis of Pneumatic Actuator Behavior. In: *International Journal of Mathematics and Computers in Simulation*. Vol. 8, No. 1, pp. 189 – 196. North Atlantic University Union. Oregon.

[7] SAMEK, D., JAVORIK, J. (2013). Numerical analysis of shape stability of rubber boot. In: *International Journal of Mechanics*. Vol. 7, No. 1, pp. 293 – 301. North Atlantic University Union. Oregon.

[8] ŽMINDÁK, M., MĚŠKO, J., PELAGIČ, Z., ZRAK, A. (2014). Finite element analysis of crack growth in pipelines. In: *Manufacturing Technology*. Vol. 14, No. 1, pp. 116 – 122. Univerzita J. E. Purkyne. Czech Republic.

[9] DELYOVÁ, I., HRONCOVÁ, D., FRANKOVSKÝ, P. (2014). Analysis of simple mechanism using MSC Adams. In: *Manufacturing Technology*. Vol. 14, No. 2, pp. 141 – 145. Univerzita J. E. Purkyne. Czech Republic.

[10] JAVORIK, J., BILEK, O. (2014). Numerical analysis of bushing of car stabilizer. In: *International Journal of Mechanics*. Vol. 8, No. 1, pp. 289 – 297. North Atlantic University Union. Oregon.

[11] JAVORIK, J., STANEK, M. (2011). The shape optimization of the pneumatic valve diaphragms. In: *International Journal of Mathematics and Computers in Simulation*. Vol. 5, No. 4, pp. 361 – 369. North Atlantic University Union. Oregon.

[12] Creative Commons licensed picture *Blue aerodynamic modern awnings* from author Wonderlane is available at https://www.flickr.com/photos/wonderlane/4648749377/in/photostream/ and is licensed under the CC BY 2.0 license, terms and conditions are available at https://creativecommons.org/licenses/by/2.0/.

[13] TAYYAR, A. E., ALAN, G. (2015). Outdoor usage performances of woven fabrics dyed with self-cleaning dyes. In: *Journal of the Textile Institute*. Vol. 106, No. 3, pp. 303 – 310. Taylor and Francis Ltd.

[14] FEYRER, K. (2007). *Wire Ropes, Tension, Endurance, Reliability*. Springer, Berlin, Heidelberg, New York.

Paper number: M2016133

Cr_2N – Ag Thin Films – a Short Review

Peter Jurči, Pavel Bílek
Department of Materials, Faculty of Materials and Technology of the STU, Trnava, Paulínská 16, 917 24 Trnava, Slovak Republic, p.jurci@seznam.cz

The current paper summarizes briefly the results obtained by comprehensive investigations of magnetron sputtered Cr_2N thin films with small additions of silver, whereas the pure Cr_2N is used as a reference material. The main aspects reported here are: growth rate of the films, their growth manner, phase constitution, mechanical properties being represented by Young modulus and nanohardness, adhesion on the substrate made from Cr-V ledeburitic steel having a hardness of 60 HRC, tribological performance and effect on the mechanical properties of the substrate.

Keywords: Magnetron sputtering, Cr_2N-Ag thin films, microstructure, mechanical properties, tribological performance

Acknowledgement

This paper is the result of the project implementation: CE for the development and application of diagnostic methods in the processing of metallic and non-metallic materials, ITMS:26220120048. This research was also supported by the grant project VEGA 1/0876/15.

References

[1] AOUADI, S. M., LUSTER, B., KOHLI, P., MURATORE, C., VOEVODIN, A. A. (2009). Progress in the development of adaptive nitride-based coatings for high temperature tribological applications. *Surface and Coatings Technology*, Vol. 204, pp. 962 – 968.

[2] MURATORE, C., VOEVODIN, A. A. (2009). Chameleon Coatings: Adaptive Surfaces to Reduce Friction and Wear in Extreme Environments. *Annu. Rev. Mater. Res*., Vol. 39, pp. 297 – 324.

[3] MURATORE, C., HU, J. J., VOEVODIN, A. A. (2007). Adaptive nanocomposite coatings with a titanium nitride diffusion barrier mask for high-temperature tribological applications. *Thin Solid Films*, Vol. 515, pp. 3638 – 3643.

[4] JAROS, A., SEDLÁK, J., FIALA, Z., CHLADIL, J., DVORACEK, J. (2016). Investigation of the Influence of PVD Coatings Deposited on HSS Milling Cutter. *Manufacturing Technology*, Vol. 16, pp. 506 – 512.

[5] HANES, T., HVIZDOŠ, P., ŤAVODOVÁ, M., KALINCOVÁ, D. HRICOVÁ, J., BEŇO, P. (2014). Coating Surface Roughness Measurement Made On Coining Dies. *Manufacturing Technology*, Vol. 14, pp. 309 - 317

[6] KASINA, M., VASILKO, K. (2012). Experimental Verification of the Relation between the Surface Roughness and the Type of Used Tool Coating. *Manufacturing Technology*, Vol. 12, pp. 27 – 30.

[7] KEJZLAR, P., ANDRSOVA, Z. (2015). Structure of Al-targets Used for PVD Coating in Jewellery. *Manufacturing Technology*, Vol. 15, pp. 553 - 557.

[8] YAO, S. H., SU, Y. L., KAO, W. H., CHENG, K. W. (2006). Evaluation on wear behaviour of Cr-Ag-N and Cr-W-N PVD nanocomposite coatings using two different types of tribometer. *Surface and Coatings Technology*, Vol. 201, pp. 2520 – 2526.

[9] MULLIGAN, C. P., BLANCHET, T. A., GALL, D. (2008). CrN-Ag nanocomposite coatings: Effect of growth temperature on the microstructure. *Surface and Coatings Technology*, 203, pp. 584 – 587.

[10] [MULLIGAN, C. P., BLANCHET, T. A., GALL, D. (2010). CrN-Ag nanocomposite coatings: Tribology at room temperature and during temperature ramp. *Surface and Coatings Technology*, Vol. 204, pp. 1388 – 1394.

[11] MULLIGAN, C. P., GALL, D. (2005). CrN-Ag self-lubricating hard coatings. Surface and Coatings Technology, Vol. 200, pp. 1495 – 1500.

[12] MULLIGAN, C. P., BLANCHET, T. A., GALL, D. (2010). Control of lubricant transport by a CrN diffusion barrier layer during high-temperature sliding of a CrN-Ag composite coating. *Surface and Coatings Technology*, Vol. 205, pp. 1350 – 1355.

[13] MURATORE, C., VOEVODIN, A. A., HU, J. J., ZABINSKI, J. S. (2006). Tribology of adaptive nanocomposite yttria-stabilized zirconia coatings containing silver and molybdenum from 25 to 700°C. *Wear*, Vol. 261, pp. 797 - 805.

[14] HU, J. J., MURATORE, C., VOEVODIN, A. A. (2007). Silver diffusion and high-temperature lubrication mechanisms of YSZ-Ag-Mo based nanocomposite coatings. *Composites Science and Technology*, Vol. 67, pp. 336 - 347

[15] AOUADI, S. M., SINGH, D.P., STONE, D.S., POLYCHRONOPOULOU, K., NAHIF, F., REBHOLZ, C., MURATORE, C., VOEVODIN, A.A. (2010). Adaptive VN/Ag nanocomposite coatings with lubricious behavior from 25 to 1000 °C. *Acta Mater*. Vol. 58, pp. 5326 – 5331.

[16] AOUADI, S. M., BOHNHOFF, A., SODERGREN, M., MIHUT, D., ROHDE, S. L., XU, J., MISHRA, S. R. (2006). Tribological investigation of zirconium nitride/silver nanocomposite structures. *Surface and Coatings Technology*, Vol. 201, pp. 418 – 422.

[17] BASNYAT, P., LUSTER, B., KERTZMAN, Z., STADLER, S., KOHLI, P., AOUADI, S., XU, J., MISHRA, S. R., ERYILMAZ, O. L., ERDEMIR, A. (2007). Mechanical and tribological properties of CrAlN-Ag self-lubricating films. *Surface and Coatings Technology*, Vol. 202, pp. 1011 – 1016.

[18] JURCI, P., BOHOVICOVA, J., HUDAKOVA, M., BILEK, P. (2014). Characterization and wear performance of CrAgN thin films deposited on Cr-V ledeburitic tool steel. *Materiali in technologije/Materials and technology*, Vol. 48, pp. 159 – 170.

[19] JURCI, P., DLOUHY, I. (2011). Coating of Cr-V ledeburitic steel with CrN containing a small addition of Ag. *Appl. Surf. Sci*., Vol. 257, pp. 10581 – 10589.

[20] JURČI, P., KUSÝ, M., PTAČINOVÁ, J., KURACINA, V., PRIKNEROVÁ, P. (2015). Long-term Sub-zero Treatment of P/M Vanadis 6 Ledeburitic Tool Steel – a Preliminary Study. *Manufacturing Technology*, Vol. 15, pp. 41 - 47.

[21] BÍLEK, P., JURČI, P., HUDÁKOVÁ, M., PAŠÁK, M., KUSÝ, M., BOHOVIČOVÁ, J. (2014). Cr_2N-7Ag nanocomposite thin films deposited on Vanadis 6 tool steel. *Appl. Surf. Sci*., Vol. 307, pp. 13 – 19.

[22] BÍLEK, P., JURČI, P., PODGORNIK, B., JENKO, D., HUDÁKOVÁ, M., KUSÝ, M. (2015). Study of Ag transport in $Cr_2N_{0.61}$-7Ag nanocomposite thin film due to thermal exposition, *Appl. Surf. Sci*., Vol. 357, pp. 317 – 327.

[23] BÍLEK, P., JURČI, P., NOVÁK, M., HUDÁKOVÁ, M., ČAPLOVIČ, L. (2015). Tribological and mechanical properties of Cr_2N–11Ag-coatings deposited on Cr–V ledeburitic steel, *Wear*, Vol. 340 - 341, pp. 47 – 52.

[24] BÍLEK, P., JURČI, P., DULOVÁ, P., HUDÁKOVÁ, M., PTAČINOVÁ, J., PAŠÁK, M. (2015). Interaction of Cr_2N and Cr_2N/Ag thin films with CuZn-brass counterpart during ball-on-disc testing. *Materiali in Tehnologije/Materials and Technology*, Vol. 49, pp. 429 – 433.

[25] MILLER, D. L., KUBISTA, K. D., RUTTER, G. M., RUAN, M., De HEER, W. A., FIRST, P. N., STROSCIO, J. A. (2010). Structural analysis of multilayer graphene via atomic moiré interferometry. *Physical Review B*, Vol. 81, pp. 125427-1 – 125427-6.

[26] BÍLEK, P., JURČI, P., ČAPLOVIČ, L., HUDÁKOVÁ, M., PTAČINOVÁ, J. (2015). Microstructure of Cr_2N-11Ag nanocomposite thin film ddeposited on Vanadis 6 tool steel. *Key Engineering Materials*, Vol. 647, pp. 121 – 128.

[27] EHIASARIAN, A. P., MUNZ, W.D., HULTMAN, L., HELMERSSON, U., PETROV, I. (2003). High power pulsed magnetron sputtered CrNx films. *Surface and Coatings Technology*, Vol. 163-164, pp. 267 - 272.

[28] CUNHA, L., ANDRITSCHKY, M., PISHOW, K., WANG, Z. (1999). Microstructure of CrN coatings produced by PVD techniques. *Thin Solid Films*, Vol. 355-356, pp. 465 – 471.

[29] LAMASTRA, F. R., LEONARDI, F., MONTANARI, R., CASADEI, F., VALENTE, T., GUSMANO, G. (2006). X-ray residual stress analysis on CrN/Cr/CrN multilayer PVD coatings deposited on different steel substrate. *Surface and Coatings Technology*, Vol. 200, pp. 6172 – 6175.

[30] DJOUADI, M. A., NOUVEAU, C., BEER, P., LAMBERTIN, M. (2000). Cr_xN_y hard coatings deposited with PVD method on tools for wood machining, *Surface and Coatings Technology*, Vol. 133-134, pp. 478 - 483.

[31] KÖSTENBAUER, H., FONTALVO, G. A., KECKES, J., MITTERER, C. (2008). Intrinsic stresses and stress relaxation in TiN/Ag multilayer coatings during thermal cycling. *Thin Solid Films*, Vol. 516, pp. 1920 - 1924

[32] VILLAR, P. CALVERT, L. D. (1989). *Pearson's Handbook of Crystallographic Data for Intermetallic Phases*. Vol. 1. Metals Park, Ohio, American Society for Metals.

[33] KUTSCHEJ, K., MITTERER, Ch., MULLIGAN, C. P., GALL, D. (2006). High-temperature tribological behaviour of CrN-Ag Self-lubricating Coatings. *Advanced Engineering Materials*, Vol. 8, pp. 1125 – 1129.

Paper number: M2016134

Nonlinear Dynamic Analysis of the Aircraft Impact to the NPP Structures

Juraj Králik[1], Juraj Králik jr.[2]
[1]Faculty of Civil Engineering, STU in Bratislava, Radlinského 11, 810 05 Bratislava, Slovakia, e-mail: juraj.kralik@stuba.sk
[2]Faculty of Architecture, STU in Bratislava, Námestie Slobody 19, 812 45 Bratislava, Slovakia, e-mail: kralik@fa.stuba.sk

This paper presents the nonlinear analysis of the reinforced concrete buildings of nuclear power plant under the aircraft attack. The response from the nonlinear analysis was considered taken the deterministic calculation procedures. The dynamic load is defined in time on base of the airplane impact simulations considering the real stiffness, masses, direc-tion and velocity of the flight. The dynamic response is calculated in the system ANSYS using the transient nonlinear analysis solution method. The damage of the concrete wall is evaluated in accordance with the standard NDRC consid-ering the spalling, scabbing and perforation effects. The simple and detailed calculations of the wall damage are compared.

Keywords: Nonlinear, Dynamic, Aircraft, NPP, ANSYS

Acknowledgement

The project was performed with the financial support of the Grant Agency of the Slovak Republic (VEGA 1/0265/16).

References

[1] ADAMÍK, V. (2013). *Aircraft load function from the impact of JAS 39 GRIPEN, LEAR JET 25 and AIRBUS A 320*, Research report No. 5090, Pardubice - April.

[2] BANGASH, M. Y. H. BANGASH, T. (2006) *Explosion-Resistant Buildings. Design, Analysis, and Case Studies*, Springer Berlin Heidelberg New York.

[3] BAŽANT, Z. P. PANG, S. D. VOŘECHOVSKÝ, M. AND NOVÁK. D. (2007). Energetic-statistical size effect simulated by SFEM with stratified sampling and crack band model. *International Journal for Numerical Methods in Engineering* (Wiley), 71(11):1297-1320, Rep. Dept. of Civil Eng., Northwestern University, Evanston, Illinois.

[4] BEZECNÝ,J. ŠTRBA, J. DUBEC, A. (2015). Material analysis of Projectile Hard Core, *Manufacturing Technology Journal*, p. 762-765, V.15, No. 5, M2015138.

[5] DOE STANDARD. (2006). *Accident Analysis for Aircraft Crash into Hazardous Facilities*, Appendix C, DOE – STD3014 – 2006, October 1996, Riaffirmation May 2006, USA Department of Energy, Washington, DC 20585.

[6] ERIN, (2003) *Resistance of Nuclear Power Plant Structures Housing Nuclear Fuel to Aircraft Crash Impact*, (Safeguards Material), Final Report by ABS Consulting, Anatech, and ERIN Engineering, Electric Power Research Institute, Paolo Alto, CA, February.

[7] IAEA Safety Standards, (2006) *Advanced Nuclear Plant Design Options to Scope with External Events*, IAEA-TECDOC-1487, Vienna, February.

[8] KOHNKE, P. (2008). *ANSYS, Theory*, SAS IP Inc. Canonsburg.

[9] KRÁLIK, J. (2009). *Safety and Reliability of Nuclear Power Buildings in Slovakia. Earthquake-Impact-Explosion*. Published by STU Bratislava, 307pp.

[10] KRÁLIK, J. (2014). Safety of Nuclear Power Plants under the Aircraft Attack, In: *Applied Mechanics and Materials* Vols. 617 pp 76-80, © Trans Tech Publications, Switzerland, DOI:10.4028/www.scientific.net/AMM.617.76, ISSN 1662-7482.

[11] MONOTTI, M. N. (2004). Reinforced Concrete Slabs - Compatibility Limit Design, *Ph.D. thesis*, Swiss Federal Institute of Technology Zurich.

[12] NEI 07-13, (2011). *Revision 8P, Methodology for Performing Aircraft Impact Assessments for New Plant Designs*, ERIN, Palo Alto, CA, April.

[13] NEA/CNRA/.R (2011). *12. Proceedings of the Forum on the Fukushima Accident: Insights and Approaches*, JT03312480, Nov. 2011, OECD.

[14] NĚMEC, I. SYCHROVÁ, Š. ŠEVČÍK, I. KABELÁČ, J. (2012). Study of a Nuclear Power Plant Containment Damage Caused by Impact of a Plane, In: *International Refereed Journal of Engineering and Science (IRJES)*, ISSN (Online) 2319-183X, (Print) 2319-1821, Vol. 1, Issue 4. December, 2012, pp. 48-53 www.irjes.com.

[15] RIERA, J. D. (1968). On the Stress Analysis of Structures Subjected to Aircraft Crash on Building Structures. *Nuclear Engineering and Design*. Vol. 8. pp. 415–426.

[16] RIERA, J. D. (1982). An approach to evaluate the Design Load Time History for Normal Engine Impact taking into account the crash-Velocity Distribution, *Nuclear Engineering and Design*, 71, pp. 311-316.

[17] SIEFERT A., HENKEL F. O. (2011). Nonlinear Analysis of Commercial Aircraft Impact on A Reactor Building – Comparison Between Integral And Decoupled Crash Simulation, - *Transactions SMiRT 21,* Div-III: Paper ID# 144.

[18] SUGANO,T. (1993). Local Damage to Reinforced Concrete Structures Caused by Aircraft Engine Missiles: Part 2, Evaluation of Test Results, *Nuclear Engineering and Design*, Vol. 140, pp. 407-423.

[19] SUCHARDA, O., BROŽOVSKÝ, J., MIKOLÁŠEK, D. (2014). Numerical Modelling and Bearing Capacity of Reinforced Concrete Beams. *Key Engineering Materials*, pp. 281-284.

[20] ŽMINDÁK, M., PELAGIČ, Z., SOUKUP, J. (2015). Analysis of Fibre Orientation Influence to Dynamic Properties of Composite Structures, *Manufacturing Technology Journal*, p.490-494, V.15, No.3, M201584.

Paper number: M2016135

Processing of Al-Fe Scraps by Powder Metallurgy

Vojtěch Kučera, Filip Průša, Dalibor Vojtěch
Department of Metals and Corrosion Engineering, University of chemistry and technology Prague, Technická 5, 16628 Prague 6, Czech Republic. E-mail: kucerao@vscht.cz

Iron has a low solubility in aluminium solid solution even at elevated temperatures and forms brittle intermetallic phases with needle-like or platelets-like morphology when it is produced by conventional casting technologies. These phases have a detrimental effect on mechanical properties. Therefore with increasing significance of recycling and also amount of aluminium scrap that needs to be recycled, it is necessary to find a promising ways of processing such waste materials. Powder metalurgy leads to intensive microstructural refinement, increases solid solubility of alloying elements and overall to improvement of mechanical properties. Hence, it belongs to promising alternatives for proccesing aluminium materials with increased amount of iron. Aluminium alloy with 17 wt. % iron was prepared by centrifugal atomization and consolidated by spark plasma sintering followed by hot extrusion. The microstructure and phase composition of compact samples as well as mechanical properties were studied. Fine microstructure has been achieved by centrifugal atomization and consolidation by spark plasma sintering in combination with hot extrusion. Compression strength was 565 MPa with remarkable ductility reaching almost 35 %.

Keywords: AlFe alloy, centrifugal atomization, spark plasma sintering, hot extrusion

Acknowledgement

The authors wish to thank the Czech Science Foundation (project no. P108/12/G043) for its financial support of this research.
The authors wish to thank the Financial support from specific university research (MSMT No 20-SVV/2016) for its financial support of this research.

References

[1] PRUSA, F., D. VOJTECH, DAM, K. (2012). Characterization of the Al-13Si-10Fe alloy produced by centrifugal atomization and ultra-high-pressure compaction. *Kovove Materialy*, 2012. 50(6): p. 399-406.

[2] DAM, K., PRUSA, F., VOJTECH, D. (2014). Structural and mechanical characteristics of the Al–23Si–8Fe–5Mn alloy prepared by combination of centrifugal spraying and hot die forging. *Materials Science and Engineering*: A, 2014. 610: p. 197-202.

[3] SASAKI, T. T., T. OHKUBO, HONO, K. (2009). Microstructure and mechanical properties of bulk nanocrystalline Al–Fe alloy processed by mechanical alloying and spark plasma sintering. *Acta Materialia*, 2009. 57(12): p. 3529-3538.

[4] VOJTECH, D., PRUSA, F., MICHALCOVA, A. (2010). Structural and mechanical characterization of rapidly solidified Al95Ni5 and Al93Ni5Mm2 alloys prepared by centrifugal atomization. *Journal of Alloys and Compounds*, 2010. 506(2): p. 581-588.

[5] SKOLAKOVA, A., et al. (2014). Production of Al-Si-Fe-X alloys by powder metallurgy. *Manufacturing Technology*, 2014. 14(3): p. 437-441.

[6] SASAKI, T. T., MUKAI, T. HONO, K. (2007). A high-strength bulk nanocrystalline Al–Fe alloy processed by mechanical alloying and spark plasma sintering. *Scripta Materialia*, 2007. 57(3): p. 189-192.

[7] SCHMITZ, C., DOMAGALA, J., HAAG, P. (2006). *Handbook of Aluminium Recycling*. 1 ed, ed. C. Schmitz. 2006: Vulkan-Verlag GmbH. 510.

[8] DOLEZAL, J., BRYKSI STUNOVA, B., KUCERA, V. (2015). Současné poznatky o vlivu doprovodných prvků ve slitinách Al-Si. *Slévarenství*, 2015. 63 (9-10): p. 345–348.

[9] KŘÍŽ, J. and P. NOVÁK, Thermally stable Al-Fe based alloys produced from secondary materials. Manufacturing Technology, 2015. 15(2): p. 155-161.

[10] MICHNA, S., MAJRICH, P. (2012). Possible ways of obtaining an aluminium alloy by non-traditional waste processing of aluminium beverage containers. *Manufacturing Technology*, 2012. 12(13).

[11] Sběrné suroviny D. F. [cited 2016 5.3.]; Available from: http://www.centrum-odpadu.cz/ceniky/.

[12] BELOV, N. A., AKSENOV, A. A., ESKIN, D. G. (2002). *Iron in Aluminium Alloys: Impurity and Alloying Element*. Vol. 2. 2002, London: Taylor and Francis. 360.

[13] TAYLOR, J. A. (2012). Iron-Containing Intermetallic Phases in Al-Si Based Casting Alloys. *Procedia Materials Science*, 2012. 1: p. 19-33.

[14] SERAK, J., et al. (2008). Snížení obsahu železa ve slitinách AlSiCuMgFe, in *METAL 2008*. p. 6.

[15] PRUSA, F., VOJTECH, D. (2013). Mechanical properties and thermal stability of Al-23Si-8Fe-1Cr and Al-23Si-8Fe-5Mn alloys prepared by powder metallurgy. Materials Science and Engineering: A, 2013. 565: p. 13-20.

[16] OZAKI, H., KUTSUNA, M. (2012). Dissimilar Metal Joining of Zinc Coated Steel and Aluminum Alloy by Laser Roll Welding. Welding Processes 2012; Available from: http://www.intechopen.com/books/howtoreference/welding-processes/dissimilar-metal-joining-of-zinc-coated-steel-and-aluminum-alloy-by-laser-roll-welding.

[17] HO, K. H., ZHAO, Y. Y. (2004). Modelling thermal development of liquid metal flow on rotating disc in centrifugal atomisation. *Materials Science and Engineering*: A, 2004. 365(1–2): p. 336-340.

[18] ZHAO, Y. Y., JACOBS, M. H. DOWSON, A. L. (1998). Liquid flow on a rotating disk prior to centrifugal atomization and spray deposition. Metallurgical and Materials Transactions B, 1998. 29(6): p. 1357-1369.

[19] NEIKOV, O. D., (2009). Chapter 5 - Atomization and Granulation, in *Handbook of Non-Ferrous Metal Powders*, O.D.N.S.N.V.M.G.G.V.F.V. Lotsko, Editor. 2009, Elsevier: Oxford. p. 102-142.

[20] PRUSA, F., et al., (2014). Mechanical properties and thermal stability of Al–Fe–Ni alloys prepared by centrifugal atomisation and hot extrusion. *Materials Science and Engineering*: A, 2014. 603: p. 141-149.

[21] PRUSA, F., et al., (2015). Structure and mechanical properties of Al–Si–Fe alloys prepared by short-term mechanical alloying and spark plasma sintering. *Materials & Design*, 2015. 75: p. 65-75.

Paper number: M2016136

Freight Car Bogie Properties Analysis by Means of Simulation Computations

Tomas Lack, Juraj Gerlici, Maria Manurova
Faculty of Mechanical Engineering, Department of Transport and Handling Machines, University of Zilina. Univerzitná 8215/1, 010 26 Zilina. Slovak Republic. E-mail: tomas.lack@fstroj.uniza.sk, juraj.gerlici@fstroj.uniza.sk, maria.manurova@fstroj.uniza.sk

The article deals with the results of the simulation analysis of a railway wagon bogie model. We analysed four freight wagon bogie variants for its dynamics properties research. The bogie models correspond in general to the Y25 bogie concept. The models were created in SIMPACK software enhanced by the RAIL module. From the research results depicted in the graphs we found out, that the newly designed bogie variant gives the best results when compared to the other analysed versions. The newly designed model consists of a standard Y25 bogie frame with two Lenoire friction dampers. This bogie is equipped with longitudinal linkages on both sides. These linkages are completed with a radial torsion binding, torsion rod, between side bogie parts. The contact of railway wheels and rails generates active forces affecting the surface contact, affecting the size of the normal and tangential stress, wear surfaces of the wheel/rail, or directly the size of the derailment.

Keywords: Chassis, Lenoir, Damper, Coupling, Simulation

Acknowledgement

This paper was created during the processing of the project "RAILBCOT - RAIL Vehicles Brake COmponents Test Stand", ITMS Code 26220220011 based on the support of Research and Development Operational Program financed by European Fund of a Regional Development. The work was also supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic in project No. APVV-0842-11: "Equivalent railway operation load simulator on the roller rig.

Research-Educational Center of Rail Vehicles (VVCKV)

References

[1] IWNICKI, S., BEZIN, Y., ORLOVA, A., JOHNSSON, P.-A., STICHEL, S., SCHELLE, H. (2013). The 'SUSTRAIL' High Speed Freight Vehicle: Simulation of Novel Running Gear Design. *Proc. of the 23rd Intern. Symposium on Dynamics of Vehicles on Roads and Tracks*, p. 11. IAVSD. August 2013 Qingdao, China.

[2] LACK, T., GERLICI, J. (2014) Modified HHT method for vehicle vibration analysis in time domain utilisation. *Applied mechanics and materials.* - ISSN 1660-9336. - Vol. 486 (2014), s. 396-405.

[3] LACK, T., GERLICI, J., MAŇUROVA, M. (2014). Analysis of Dynamic Properties of Freight Bogie Model 1 (In Slovak), *Innovations in the concept, design, manufacturing and testing of freight II:* January 2015, Zilina: University of Zilina, ISBN 978-80-554-0955-9. S. 65-74.

[4] LACK, T., GERLICI, J., MAŇUROVA, M. (2015). Analysis of Dynamic Properties of Freight Bogie Model 2 (In Slovak), *Innovations in the concept, design, manufacturing and testing of freight II:* January 2015, Zilina: University of Zilina, ISBN 978-80-554-0980-1. S. 51-56.

[5] DIŽO, J., HARUŠINEC, J., BLATNICKÝ, M. (2015) Multibody System of a Rail Vehicle Bogie with a Flexible Body. *Manufacturing Technology: Journal for Science, Research and Production.* - ISSN 1213-2489. - Vol. 15, no. 5 (2015), pp. 781-788.

[6] DIŽO, J., (2015) Evaluation of Ride Comfort for Passengers by Means of Computer Simulation. *Manufacturing Technology: Journal for Science, Research and Production.* - ISSN 1213-2489. - Vol. 15, no. 1 (2015), pp. 8-14.

[7] DIŽO, J., BLATNICKÝ, M., SKOČILASOVÁ, B. (2015) Computational Modelling of the Rail Vehicle Multibody System Including Flexible Bodies. *Communications: scientific letters of the University of Žilina.* - ISSN 1335-4205. - Vol. 17, no. 3 (2015), pp. 31-36.

[8] LACK, T., GERLICI, J. (2015). Freight Car Bogie Analysis by Means of Simulation Computations (In Slovak), *PRORAIL 2015 Current problems in rail vehicles*, 22nd intern. conference, Zilina, September 2015. ISBN 978-80-89276-48-6.

[9] LACK, T., GERLICI, J. (2015). Railway Bogie Properties Analysis by Means of Simulation Computations (In Slovak). *Railway transport and logistics.* ISSN 1336-7943. - Vol. 11, č. 2 (2015), online, pp. 54-60.

[10] MAŇUROVÁ, M., SUCHÁNEK, A. (2016). Determination of Stiffess of Triple Spring Built in a Bogie of a Rail Vehicle. *Manufacturing Technology: Journal for science, research and production*. Univerzita J. E. Purkyně in Ústí n. Labem. April 2016, Vol. 16, No. 2 Pp. 390 - 396. ISSN 1213-2489.

[11] ŠŤASTNIAK, P. GERLICI, J., LACK, T., HARUŠINEC, J. (2013)., Computer aided simulation analysis for computation of modal analysis of the freight wagon *TRANSCOM 2013 : 10-th European conference of young researchers and scientists* : Žilina, June 24-26, 2013, Slovak Republic. Section 6: Machines and equipment. Applied mechanics. - Žilina: University of Žilina, 2013. - ISBN 978-80-554-0695-4. - S. 297-300.

[12] NANGOLO, F., SOUKUP, J. (2014). The Effect of Asymmetry on Vertical Dynamic Response of Railway Vehicles. In: *Manufacturing Technology: Journal for science, research and production*. Univerzita J. E. Purkyně in Ústí n. Labem. October 2014, Vol. 14, No. 3 Pp. 375-380. ISSN 1213-2489.

[13] SVOBODA, M., SOUKUP, J. (2013). Dynamic measurement of four-axle railway wagon. In: *Manufacturing Technology*. 2013, vol. 13, iss. 4, (pp. 552-558). ISSN 1213-2489.

[14] SKOČILAS, J., SKOČILASOVÁ, B., SOUKUP, J. Determination of the rheological properties of thin plate under transient vibration. *Latin American Journal of Solids and Structures.* Brasil society for mechanics and engineering. ISSN 1679-7817 (print), 1679-7825 (online).

Paper number: M2016137

Occupational Health and Safety Hazards in Machining

Danuse Madlova[1], Vlastislav Gebhart[2]
[1]Faculty of Production Technology and Management, J. E. Purkyne University in Usti nad Labem. Pasteurova 3334/7, 400 01 Usti nad Labem. Czech Republic. E-mail: madlova@fvtm.ujep.cz
[2]Gebhart. Skrivan 78, 270 21 Pavlikov. Czech Republic. E-mail: gebhart.vl@seznam.cz

This paper is focused on occupational health and safety hazards in machining processes. Problem is specified on employs and employers. Occupational health and safety is based on legislative regulations. Safety rules are usually formulated generally. But it is necessary to formulate safety rules more precisely for different production processes and even for different production machines. And this has not been fully satisfactory solved, especially from the point of view of the development of machine tools, their automation and also from the viewpoint of the development of cutting materials. In the paper principal occupational health and safety hazard in machining will be formulated on the base of laws, regulations and personal findings of the paper´s authors in different enterprises. As an example safety hazards and safety rules will be in depth formulated for turning. Similar health and safety rules and hazards must be formulated for other cutting processes. But occupational health and safety problems relate not only to persons but also to enterprise economy.

Keywords: Risk, Occupational health and safety, Legislation, Employer, Employee

References

[1] VASILKO, K., PILC, J. (2013). New Technological Knowledge of the Rotary Turning Tool. In: *Manufacturing Technology*, Vol. 13, No. 4, pp. 571 – 575.

[2] KOCMAN, K., PROKOP. J. (2001). *Techologie obrábění*, 271 p., CERM, Brno.

[3] HOLESOVSKY, F., NAPRSTKOVA, N., NOVAK, M. (2013). GICS for Grinding Process Optimization. In: *Manufacturing Technology*, Vol. 12, No. 12, pp. 22 – 26.

[4] http://makezine.com/2011/04/14/yale-student-killed-in-lathe-accident/.

[5] http://www.hse.gov.uk/press/2010/coi-nw-34autoy.htm.

[6] http://press.hse.gov.uk/2015/internationl-tyre-firm-fined-after-17-year-old-apprentice-injured-in-lathe/

[7] 262/2006 Sb. Zakonik prace (CZ Labour code).

[8] Zakon 309/2006 Sb. (CZ law related to occupational safety and inspection), ,

[9] Zakon 251/20065 Sb. (CZ law related to labour inspection).

[10] Zakon 372/2011 Sb. (CZ law related to health services).

[11] Vyhlaska 432/2003 Sb. (CZ government ordinance).

[12] Narizeni vlady 378/2001 Sb. (CZ government order).

[13] Narizeni vlady 201/2010 Sb. (CZ government order).

[14] Narizeni vlady 495/2001 Sb. (CZ government order).

[15] European occupational health and safety regulation EHS 89/391.

[16] KOUBEK, J. (2007). *Rizeni lidskych zdroju.* 399 p., Management Press, Praha.

[17] http://www.suip.cz/_files/suip- b110a5cb403edcb12e206b5aebd1242/bezpecny_podnik_cj.pdf.

Paper number: M2016138

Electron Beam Surface Quenching of X37CrMoV51 Tool Steel Swages

Jiří Matlák, Pavel Doležal, Josef Zapletal, Filip Vančura, Ivo Dlouhý
Institute of Materials Science and Engineering, NETME centre, Brno University of Technology, Czech Republic

X37CrMoV51 tool steel for plastic working and heat cutting is usually used in whole volume quenched state for secondary hardness. Using high-energetic sources like electron beam or laser is possible repeated surface quenching of chosen surface localities with complicated geometry. The treatment leads to local hardness improvement which results in local wear damage decrease.
Delivered specimens were surface quenched using electron beam technology. The paper deals with influence of individual technological parameters of the treatment on final properties of treated localities. Final properties of treated surface were examined by light and electron microscopy and microhardness testing.

Keywords: electron beam, swage, X37CrMoV51, tool steel

Acknowledgments

The works have been supported by the project NETME centre plus (Lo1202), project of Ministry of Education, Youth and Sports under the "national sustainability programme". Support of Czech Science Foundation project Nr. 13-35890S is further acknowledged.

References

[1] ZENKER, R. (2009). Modern thermal electron beam processes: Research and industrial application. *La Metallurgia Italiana*. 2009, Aprile, s. 8.

[2] MEŠKO, J., ZRAK, A., MULCZYK, K., TOFIL, S. (2014). Microstructure Analysis of Welded Joints after Laser Welding. *Manufacturing Technology*. 2014, 2014(3), 355-359. ISSN 1213-2489.

[3] DIMITROV, D., APRAKOVA, M., VALKANOV, S. PETROV, P. (1998). Electron beam hardening of ion nitrided layers (1998) *Vacuum*, 49 (3), pp. 239-246.

[4] RADEK, N., MEŠKO, J., ZRAK, A. (2014). Technology of Laser Forming. *Manufacturing Technology*. 2014, 2014(3), 428-431. ISSN 1213-2489.

[5] ZENKER, R., SPIES, H. J., BUCHWALDER, A., SACHER, G. (2006). Combination of thermal surface treatment by high energy beams with thermochemical treatment and hard protective coating - State of the art (2006) "*Proceedings - 15th IFHTSE - International Federation for Heat Treatment and Surface Engineering Congress 2006*", pp. 214-219.

[6] IVANOV, Y. F., BESSONOV, D. A., VOROB'EV, S. V., GROMOV, V. E., IVANOV, K. V., KOLUBAEVA, Y. A., TSELLERMAER, V. Y. (2013). On the fatigue strength of grade 20Cr13 hardened steel modified by an electron beam (2013) *Journal of Surface Investigation*, 7 (1), pp. 90-93.

[7] DUAN, S., QIN, C., LI, B. (2015). Microstructure and properties of semi-HSS treated by laser quenching (2015) *Jinshu Rechuli/Heat Treatment of Metals*, 40 (9), pp. 76-78.

[8] ZENKER, R, BUCHWALDER, A. (2010). *Elektronenstrahl-Randschichtbehandlung: Inovative Technologienfür höchste industrielle Ansprüche*. 2nd edition. Germany: pro-beam AG&Co. KGaA, 2010.

[9] BREZNIČAN, M., FABIAN, P., MEŠKO, J., DRBÚL, M. (2013). The Simulation of Influence of Quenching Temperature on Properties of Bearing Rings. *Manufacturing Technology*. 2013, 2013(1), 20-25. ISSN 1213-2489.

[10] FRIEDEL, K. P., FELBA, J., POBOL, I. WYMYSLOWSKI, A. (1996). A systematic method for optimizing the electron beam hardening process (1996) *Vacuum*, 47 (11), pp. 1317-1324.

[11] VUTOVA, K., DONCHEV, V., VASSILEVA, V., MLADENOV, G. (2014). Thermal processes in electron-beam treatment of metals (2014) *Metal Science and Heat Treatment*, 55 (11-12), pp. 628-635.

[12] JURČI, P., KUSÝ, M., PTAČINOVÁ, J., KURACINA, V., PRIKNEROVÁ, P. (2015). Long-term Sub-zero Treatment of P/M Vanadis 6 Ledeburitic Tool Steel – a Preliminary Study. *Manufacturing Technology*. 2015, 2015(1), 41-47. ISSN 1213-2489.

[13] SONG, R. G., ZHANG, K., CHEN, G. N. (2003). Electron beam surface treatment. Part I: Surface hardening of AISI D3 tool steel (2003) *User Modeling and User-Adapted Interaction*, 69 (4), pp. 513-516.

[14] DOAN, V. T., KUSMIC, D., POSPICHAL, M. (2014). Surface Treatment Technologies for Wear Resistance Increasing of 42CrMo4 Steel. *Manufacturing Technology*. 2014, 2014(3), 303-307. ISSN 1213-2489.

Paper number: M2016139

Effect of Wirefeed Rate On The Morphology Of A Surface Machined Using WEDM

Katerina Mouralova[1], Jiri Kovar[1], Libor Benes[2], Karel Osicka[1]
[1]Faculty of Mechanical Engineering, Brno University of Technology. Technicka 2896/2, 616 69 Brno. Czech Republic. E-mail: mouralova@fme.vutbr.cz, kovar@fme.vutbr.cz, osicka@fme.vutbr.cz
[2]Faculty of Production Technology and Management, J. E. Purkyne University in Usti nad Labem. Pasteurova 3334/7, 400 01 Usti nad Labem. Czech Republic. E-mail: benes@fvtm.ujep.cz

Wire electrical discharge machining (WEDM) is an unconventional technology of machining that uses physical phenomena for material cutting. During wire electrical discharge machining craters are formed on the workpiece surface, and blended and molten material of both workpiece and wire electrode get stuck here due to diffusion processes. The study deals with the assessment of the influence of wire feed rate on quantitative and qualitative evaluations of craters on the workpiece made of X155CrVMo12-1 alloy tool steel. The diffusion phenomena that had occurred on the surface during the process of cutting were studied using light microscopy. Attention was also given to the detail study of the used brass electrode where the level of wear and degradation in terms of the quality of morphology were studied after the process of cutting.

Keywords: WEDM, Electrical Discharge Machining, steel X155CrVMo12-1, surface layer, wire feed

Acknowledgement

This work is an output of research and scientific activities of NETME Centre, supported through project NETME CENTRE PLUS (LO1202) by financial means from the Ministry of Education, Youth and Sports under the „National Sustainability Programme I“.
This Part of work was carried out with the support of core facilities of CEITEC - Central European Institute of Technology under CEITEC - open access project, ID number LM2011020, funded by Ministry of Education, Youth and Sports of the Czech Republic under the activity Projects of major infrastructures for research, development and innovations.
This work was supported by the Ministry of Education, Youth and Sport of the Czech Republic, the program NPU1, project No. LO1207.

References

[1] KNIGHT, A., BOOTHROYD, G. (2005). *Fundamentals of metal machining and machine tools*. Third Edition, CRC Press, ISBN 1574446592.

[2] JAIN., V. (2009). *Advanced machining processes*. Allied Publishers, ISBN 8177642944.

[3] OSIČKA, K., FIŠEROVÁ, Z., OTOUPALÍK, J. (2015). Influence of cutting tool overhangs at machining of hardened steels. In: *Manufacturing TECHNOLOGY, pp*. 188-191.

[4] MOURALOVÁ, K.; BEDNÁŘ, J.; KOVÁŘ, J.; MACH, J. (2016). Evaluation of MRR after WEDM depending on the resulting surface. In: *Manufacturing TECHNOLOGY,* pp. 396-401.

[5] BLECHA, P.; BLECHA, R.; BRADÁČ, F. (2011). Integration of Risk Management into the Machinery Design Process. In *Mechatronics Recent Technological and Scientific Advances.* Varšava: Springer- Verlag Berlin Heidelberg, pp. 473-482.

[6] BLECHA, P.; PROSTREDNIK, D. (2011). Influence on the failure probability. *Inteligent Manufacturing and Automation: Focus on Young Researches and Scientists*, pp. 11-12.

[7] BLECHA, P. (2006). Integration of risk management into Meta- Quality Deployment method. In *AEDS 2006 Workshop Proceedings.* Plzeň: Západočeská univerzita v Plzni, pp. 23.

[8] MIČIETOVÁ, A., NESLUŠAN, M., ČILLIKOVÁ, M. (2013). Influence of surface geometry and structure after non-conventional methods of parting on the following milling operations. In: *Manufacturing TECHNOLOGY, pp*. 199-204.

[9] MAŇKOVÁ, I., VRABEC, M., KOVAC, P. (2013). Artificial Neural Network Application for Surface Roughness Prediction when Drilling Nickel Based Alloy. In: *Manufacturing TECHNOLOGY, pp*. 193-199.

[10] NOVAK, M., DOLEZAL, R. (2012). G–Ratio in hardened steel grinding with different coolants. In: *Manufacturing TECHNOLOGY, pp*. 192-197.

[11] LIAO, Y. S., CHEN, S. T., & LIN, C. S. (2004). Development of a high precision tabletop versatile CNC wire-EDM for making intricate micro parts. *Journal of micromechanics and microengineering*, 15(2), pp. 245.

[12] MATOUSEK, R., BEDNAR, J. (2009). Grammatical Evolution: Epsilon Tube in Symbolic Regression Task. *Mendel Journal series. MENDEL*. Brno, BUT, pp. 9 – 15.

[13] MATOUSEK, R., BEDNAR, J. (2010). Grammatical evolution and STE criterion: Statistical properties of STE objective function.*Lecture Notes in Electrical Engineering*, vol 68, pp. 131–142.

[14] LUO, Y. F. (1995). An energy-distribution strategy in fast-cutting wire EDM. *Journal of materials processing technology*, 55(3), pp. 380-390.

[15] DAUW, D. F., & ALBERT, L. (1992). About the evolution of wire tool performance in wire EDM. *CIRP Annals-Manufacturing Technology*, 41(1), pp. 221-225.

[16] SCOTT, D., BOYINA, S., & RAJURKAR, K. P. (1991). Analysis and optimization of parameter combinations in wire electrical discharge machining. *THE INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH*, 29(11), pp. 2189-2207.

[17] LIAO, Y. S., HUANG, J. T., & SU, H. C. (1997). A study on the machining-parameters optimization of wire electrical discharge machining. *Journal of Materials Processing Technology*, 71(3), pp. 487-493.

[18] GÖKLER, M. I., & OZANÖZGÜ, A. M. (2000). Experimental investigation of effects of cutting parameters on surface roughness in the WEDM process. *International journal of Machine tools and manufacture,* 40(13), pp. 1831-1848.

[19] TOSUN, N., COGUN, C., & INAN, A. (2003). The effect of cutting parameters on workpiece surface roughness in wire EDM. *Machining science and technology*, 7(2), pp. 209-219.

[20] OBARA, H., IWATA, Y., & OHSUMI, T. (1995). An attempt to detect wire temperature distribution during wire EDM. In *Proceedings of the Eleventh International symposium for Electro-Machining (ISEM-11), Lausanne, Switzerland.*

[21] DEKEYSER, W., SNOEYS, R., & JENNES, M. (1985). A thermal model to investigate the wire rupture phenomenon for improving performance in EDM wire cutting. *Journal of Manufacturing Systems*, 4(2), pp. 179-190.

[22] MOURALOVA, K., (2015). Modern technologies for wire electrical discharge cutting of metal alloys. Thesis. Brno: CERM, pp. 98.

[23] YANG, X., FENG, G., & TENG, Q. (2012). Temperature field simulation of wire electrode in high-speed and medium-speed WEDM under moving heat source. *Procedia CIRP*, 1, pp. 633-638.

[24] KUMAR, A., KUMAR, V., & KUMAR, J. (2013). Experimental Investigation on material transfer mechanism in WEDM of pure titanium (Grade-2). *Advances in Materials Science and Engineering*, 2013.

[25] KUMAR, A., KUMAR, V., & KUMAR, J. (2013). Multi-response optimization of process parameters based on response surface methodology for pure titanium using WEDM process. *The International Journal of Advanced Manufacturing Technology*, 68(9-12), pp. 2645-2668.

[26] HUANG, C. A., HSU, F. Y., & YAO, S. J. (2004). Microstructure analysis of the martensitic stainless steel surface fine-cut by the wire electrode discharge machining (WEDM). *Materials Science and Engineering*: A, 371(1), pp. 119-126.

[27] HUANG, C. A., HSU, C. C., & KUO, H. H. (2003). The surface characteristics of P/M high-speed steel (ASP 23) multi-cut with wire electrical discharge machine (WEDM). *Journal of Materials Processing Technology,* 140(1), pp. 298-302.

Paper number: M2016140

Effect of Nickel Particle Size on Eactive Sintering Production of Niti Shape Memory Alloy

Pavel Novák, Ivo Marek, Petr Dvořák, Tomáš Veselý, Vladimír Vojtěch, Andrea Školáková, Adriana Bernatiková
Department of Metals and Corrosion Engineering, University of Chemistry and Technology Prague, Technicka 5, 166 28 Prague 6 – Dejvice, Czech. E-mail: panovak@vscht.cz, ivo.marek@vscht.cz, petr.dvorak@vscht.cz, tomas.vesely@vscht.cz, vladimir.vojtech@vscht.cz, andrea.skolakova@vscht.cz, adriana.bernatikova@vscht.cz

This work is focused on the description of the influence of the particle size of nickel on the synthesis of NiTi shape memory alloy by reactive sintering with high heating rate (300 °C.min-1). It was found that coarse nickel powders undergo only a limited thermally-activated reaction. On the other hand, too fine powders support the low-temperature (500-800 °C) diffusional formation of Ni-Ti intermetallics which could then suppress the rapid thermally-activated reaction. The optimum powder fraction of nickel to obtain the material with the lowest porosity and fraction of undesirable Ti_2Ni phase is 25-45 µm.

Keywords: powder metallurgy, NiTi, reactive sintering

Acknowledgement

This research was financially supported by Czech Science Foundation, project No. 14-03044S and from Specific University Research (MSMT No. 20/2015).

References

[1] KRISTIANOVA, E., NOVAK, P. (2015). Properties, Production and Applications of NiTi Shape Memory Alloy. In: *Manufacturing Technology*, Vol. 15, No. 6, pp. 995 – 998.

[2] NOVAK, P., SKOLAKOVA, A., VOJTECH, V., KNAISLOVA, A., POKORNY, P., MORAVEC, H., KOPECEK, J., KARLIK, M., KUBATIK, T. F. (2014). Application of Microscopy and X-ray Diffraction in Optimization of the Production of NiTi Alloy by Powder Metallurgy. In: *Manufacturing Technology*, Vol. 14, No. 3, pp. 387 – 392.

[3] NOVAK, P., KRIZ, J., MICHALCOVA, A., SALVETR, P. (2015). Role of Reactive Sintering in Production of Technically Important Intermetallics. In: *Manufacturing Technology*, Vol. 15, No. 1, pp. 74 – 77.

[4] SUZUKI, Y., UNUMA, H. (1988). US Patent 4,719,077.

[5] WHITNEY, M., CORBIN, S. F., GORBET, R. B. (2008). Investigation of the mechanisms of reactive sintering and combustion synthesis of NiTi using differential scanning calorimetry and microstructural analysis. In: *Acta Materialia*, Vol. 56, No. 3, pp. 559-570.

[6] NOVAK, P., POKORNY, P., VOJTECH, V., KNAISLOVA, A., SKOLAKOVA, A., CAPEK, J., KARLIK, M., KOPECEK, J. (2015). Formation of Ni-Ti intermetallics during reactive sintering at 500-650 °C. In: *Materials Chemistry and Physics*, Vol. 155, pp. 113-121.

[7] NOVAK, P., MEJZLIKOVA, L., MICHALCOVA, A., CAPEK, J., BERAN, P., VOJTECH, D. (2013). Effect of SHS conditions on microstructure of NiTi shape memory alloy. In: *Intermetallics*, Vol. 42, pp. 85-91.

[8] MICHALCOVA, A., SVOBODOVA, P., NOVAKOVA, R., LEN, A., HECZKO, O., VOJTECH, D., MAREK, I., NOVAK, P. (2014). Structure and magnetic properties of nickel nanoparticles prepared by selective leaching. In: *Materials Letters*, Vol. 137, pp. 221-224.

[9] NOVAK, P., MICHALCOVA, A., SKOLAKOVA, A., PRUSA, F., KRIZ, J., MAREK, I., KUBATIK, T. F., KARLIK, M., HAUSILD, P., KOPECEK, J. (2015). Effect of heating rate on the formation of intermetallics during SHS process. In: *Acta Physica Polonica A*, Vol. 128, pp. 561-563.

Paper number: M2016141

Investigation of the Effects of Smart Ultrasound Wave on Surface Roughness during Turning Operation of Mild Steel

Anayet Ullah Patwari, Md. Shariful Islam Chowdhury, Mohammad Ahsan Habib, Afzal Hossain Neelav, Md. Sharfat Latif, T. M. Moniruzzaman Sunny
Department of Mechanical and Chemical Engineering, Islamic University of Technology (IUT), Dhaka, Bangladesh E-mail: aupatwari@hotmail.com, shemon00@gmail.com, m.ahsan.habib@gmail.com, neelav.hellboy@gmail.com, sejan101411@gmail.com, tmmsunny@gmail.com

Turning is one of the most widely accepted metal cutting processes in manufacturing industry. Due to global competitiveness, there is an increasing demand for product quality. Surface roughness represents the dimensional accuracy of the finished product and is one of the most important quality requirements of the finished product. Surface roughness is generally detrimental to the efficient performance of machined parts, especially where relative motion between parts is concerned. In this paper, a new novel technique has been proposed and adopted with an aim to reduce surface roughness of the machined surface. External ultrasonic sound waves were applied during the turning process of mild steel and its effect on surface quality was studied. Detailed experimentations were carried out under different ultrasonic frequencies to determine the effective frequency range which optimizes surface roughness to the best degree possible. The experimental results showed significant improvements in surface roughness in machined products. In addition to these, the effect of orientation of the application of the ultrasonic sound waves and the amplitude of the waves were studied in detail.

Keywords: Ultrasound, Surface Roughness, Vibration, Orientation, Amplitude

References

[1] KALPAKJIAN, S., SCHMID, S.R. (2009) Manufacturing Processes for Engineering Materials, In: 5th ed., *India: Dorling Kindersley Pvt. Ltd.* (under license from Pearson Education in South Asia), pp. 440-447.

[2] CEPOVA, L., SOKOVA, D., MALOTOVA, S., GAPINSKI, B., CEP, R. (2016). Evaluation of Cutting Forces and Surface Roughness after Machining of Selected Material. In: *Manufacturing Technology*, Vol. 16, No. 1, pp. 45-48.

[3] BAČA, A., KONEČNÁ, R., NICOLETTO, G., KUNZ, L. (2015). Effect of Surface Roughness on the Fatigue Life of Laser Additive Manufactured Ti6Al4V Alloy. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 498-502.

[4] HRICOVA, J., NAPRSTKOVA, N. (2015). Surface Roughness Optimization in Milling Aluminium Alloy by Using the Taguchi´s Design of Experiment. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 541-546.

[5] SILBERSCHMIDTA, V. V, MAHDYB, S. M. A., GOUDAB, M. A., NASEERA, A., AGOSTINO MAUROTTOA, A. ROYA, A. (2014). Surface-roughness improvement in ultrasonically assisted turning. In: *2nd CIRP Conference on Surface Integrity (CSI)*, Procedia CIRP, Vol. 13, pp. 49 – 54.

[6] MAHDY, S. M. A., GOUDA, M. A., SILBERSCHMIDT, V. V. (2013). Study of ultrasonically assisted turning of stainless steel and brass alloys. In: *Journal of Physics: Conference Series 451*, paper 012037.

[7] MUHAMMAD, R., MAUROTTO, A., ROY, A., SILBERSCHMIDT, V. V. (2012). Ultrasonically assisted turning of Ti-6Al-2Sn-4Zr-6Mo. In: *Journal of Physics: Conference Series 382*, paper 012016.

[8] RIMKEVIČIENĖ, J., OSTAŠEVIČIUS,V., JŪRĖNAS, V., GAIDYS, R. (2009). Experiments and simulations of ultrasonically assisted turning tool. In: *MECHANIKA,* ISSN 1392 – 1207, Volume 1, No. 75.

[9] MAUROTTO, A., MUHAMMAD, R., ROY, A., SILBERSCHMIDT, V. V. (2013). Enhanced ultrasonically assisted turning of a β-titanium alloy. In: *Ultrasonics 53*, pp. 1242.

[10] PATIL, S., JOSHI, S., TEWARI, A., JOSHI, S. S. (2014). Modelling and simulation of effect of ultrasonic vibrations on machining of Ti6Al4V. In: *Ultrasonics*, Vol. 54, No. 2, pp. 694–705.

[11] EZE, S.C., IZELU, C.O., OREKO, B.U., EDWARD, B.A. (2013). Experimental Study of Induced Vibration and Work Surface Roughness in the Turning of 41Cr4 Alloy Steel using Response Surface Methodology. In: *International Journal of Innovative Research in Science, Engineering and Technology*, ISSN: 2319-8753, Vol. 2, No. 12.

[12] KUMAR, K.A., RATNAM, C., MURTHY, B.S.N., BEN, B.S., REDDY, K.R.R.M. (2012). Optimization of Surface Roughness in Face Turning Operation in Machining Of En-8. In: *International Journal of Engineering Science & Advanced Technology*, ISSN: 2250–3676, Vol. 2, No. 4, pp. 807 – 812.

[13] RODRIGUES, L.L.R., KANTHARAJ, A.N., KANTHARAJ, B., FREITAS, W.R.C., MURTHY, B.R.N. (2012). Effect of Cutting Parameters on Surface Roughness and Cutting Force in Turning Mild Steel. In: *Research Journal of Recent Sciences,* ISSN 2277-2502, No. 10, pp. 19-26.

[14] REDDY, B.S., PADMANABHAN, G., REDDY, K.V.K. (2008). Surface Roughness Prediction Techniques for CNC turning. In: *Asian Journal of Scientific Research*, Vol. 1, No. 3, pp. 256-264.

[15] THAMMA, R. (2008). Comparison between Multiple Regression Models to Study Effect of Turning Parameters on the Surface Roughness. In: Proceedings of the 2008 IAJC-IJME International Conference, ISBN 978-1-60643-379-9, Paper 133, ENG 103, pp. 1-12.

Paper number: M2016142

Biaxial Test of Tubes Using Elastomer

Eva Peterkova
Faculty of Mechanical Engineering, Brno University of Technology. Technicka 2896/2, 616 69 Brno. Czech Republic.
E-mail: peterkova@fme.vutbr.cz

To obtain the values of material characteristics of tubes such as the strain hardening exponent n and the strength coefficient K is most frequently used the hydraulic bulge test. The tool and an additional equipment are often complicated and very expensive for this test. This article deals with the question whether it would be possible to obtain the corresponding values n and K by the simple biaxial test of tube using elastomer. To solve this problem, a simple tool was designed and the verification tests were realized for thin-walled tubes from material AISI 321. The results showed that it's not possible to obtain real values n and K by biaxial test of tubes using elastomer. The reason is the elastic forming medium, which complicates the evaluation of these material characteristics, because the elastomer introduces many additional factors into the forming process.

Keywords: Biaxial test, Tube, Elastomer, Strain hardening exponent

Acknowledgement

This paper was elaborated with the support of specific research Faculty of Mechnical Engineering, Brno University of Technology relating to the grant no. FSI-S-14-2394. Thanks belong to all persons of the Department of metal forming, who helped with the solution of this research.

References

[1] SONG, W. J., KIM, J., KANG, B. S. (2007). Experimental and analytical evaluation on flow stress of tubular material for tube hydroforming simulation. In: *Journal of Materials Processing Technology*, Vol. 191, pp. 368-371. ISSN 0924-0136.

[2] BORTOT, P., CERETTI, E., GIARDINI, C. (2008). The determination of flow stress of tubular material for hydroforming applications. In: *Journal of Materials Processing Technology*, Vol. 203, pp. 381-388. ISSN 0924-0136.

[3] HWANG, Y. M., LIN, Y. K., ALTAN, T. (2007). Evaluation of tubular materials by a hydraulic bulge test. In: *International Journal of Machine Tools & Manufacture*, Vol. 47, pp. 343-351. ISSN 0890-6955.

[4] STRANO, M., ALTAN, T. (2004). An inverse energy approach to determine the flow stress of tubular materials for hydroforming applications. In: *Journal of Materials Processing Technology*, Vol. 146, pp. 92-96. ISSN 0924-0136.

[5] SOKOLOWSKI, T., GERKE, K., AHMETOGLU, M., ALTAN, T. (2000). Evaluation of tube formability and material characteristics: hydraulic bulge testing of tubes. In: *Journal of Materials Processing Technology*, Vol. 98, pp. 34-40. ISSN 0924-0136.

[6] SONG. W. J., HEO, S. CH., KU, T. W., KIM, J., KANG, B. S. (2010). Evaluation of effect of flow stress characteristics of tubular material on forming limit in tube hydroforming process. In: *International Journal of Machine Tools & Manufacture*, Vol. 50, pp. 753-764. ISSN 0890-6955.

[7] KOÇ, M., AUE-U-LAN, Y., ALTAN, T. (2001). On the characteristics of tubular materials for hydroforming - experimentation and analysis. In: *International Journal of Machine Tools & Manufacture*, Vol. 41, pp. 761-772. ISSN 0890-6955.

[8] LIANFA, Y., CHENG, G. (2008). Determination of stress-strain relationship of tubular material with hydraulic bulge test. In: *Thin-Walled Structures*, Vol. 46, pp. 147-154. ISSN 0263-8231.

[9] MARCINIAK, Z. (1964). Sheet Metal Forming Theory, pp. 112-195. State publishing of technical literature, Prague.

[10] ČSN EN ISO 604:2004. (2004). *Plastics - Determination of compressive properties*, pp. 1-20. Czech standards institute, Prague.

[11] SAMEK, R., ČALKOVSKÝ, A. (2000). New relationship defining the values of flow stress, tangent and secant modulus. In: *Proceedings of the 8th International Conference Sheet Metal 2000*. Ed. 1, pp. 381-386. University of Central England, Birmingham, ISBN 0-95276-643-4.

[12] BERKOVIČ, I. I., NIKIŠIN, V. E., NIKOLAJEVA, A. M. (1988). Assessment of the contact friction forces effect on a forming process by an elastic medium. In: *Kuznečno-štampovočnoe proizvodstvo*, No. 4, pp. 15-16.

[13] GIRARD, A. C., Y. J. GRENIER a B. J. MAC DONALD. Numerical simulation of axisymmetric tube bulging using a urethane rod. *Journal of Materials Processing Technology*. 2006, 172(3), 346-355. DOI: 10.1016/j.jmatprotec.2005.10.012. ISSN 09240136.

[14] THIRUVARUDCHELVAN, S. a F. W. TRAVIS. Tube bulging with a urethane rod. *Journal of Materials Processing Technology*. 1990, 23(2), 195-209. DOI: 10.1016/0924-0136(90)90157-P. ISSN 09240136.

[15] ŽMINDÁK, M., MEŠKO, J., PELAGIĆ, Z., ZRAK, A. (2014). Finite element analysis of crack growth in pipelines. In: *Manufacturing Technology*. Vol. 14, No. 1, pp. 116-122. ISSN 1213-2489.

[16] YOU, J. CH., LIN, J. D., XU, D. F., HAO, W. Y. (2016). Contact Analysis of Silicone Rubber Rectangular Ring in the Automatic Tighten Assembly. In: *Manufacturing Technology*. Vol. 16, No. 3, pp. 648-653. ISSN 1213-2489.

Paper number: M2016143

The Indentation Size Effect (ISE) and the Speed of the Indenter Penetration into Test Piece

Jozef Petrík, Pavol Palfy, Peter Blaško, Lenka Girmanová, Milan Havlík
Faculty of Metallurgy, Technical University of Košice. Letná 9, 042 00 Košice Slovakia. E-mail: jozef.petrik@tuke.sk

The aim of the submitted paper is to study the influence of the speed of the penetration of the indenter into the test piece ranging from 0.302 μm s^{-1} to 1.089 μm s^{-1} and applied load ranging from 10 g to 100 g on measured values of micro-hardness. Whereas certified reference material with defined specified hardness and its uncertainty was used as a test piece, the measurement involved indirect calibration of the tester. The influence of observed factors on measured value of the micro-hardness was evaluated by Meyer's index n, PSR method and by Analysis of Variance (ANOVA). The influence of the load on the measured value of micro-hardness is statistically significant and the relationship between applied load and micro-hardness manifests "reverse" ISE. The velocity has statistically significant effect on the micro-hardness. Meyer's index on average decreases with increasing of the speed.

Keywords: Micro-hardness, ISE, Speed of the indenter in the test piece, Load

Acknowledgements

This work was supported by the Slovak Grant Agency for Science VEGA 1/0595/16.

References

[1] MARTINOVSKÝ, M., MÁDL, J. (2015). Effect of Different Modifiers and Heat Treatment on Structure, Hardness and Microhardness of AlSi7Mg0.3 Alloy. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 604-610.

[2] ŤAVODOVÁ, M., KALINCOVÁ, D., KAŠTAN, R. (2016). The Research of Options for the Innovation Heat Treatment of the Tools for Coinage in Order to Increase their Lifetime. In: *Manufacturing Technology*, Vol. 16, No. 1, pp. 274-280.

[3] ŽIHALOVÁ, M., KALINCOVÁ, D., CAIS, J. (2015). Microstructural Analysis of Nickel Influence in Alsi10mgmn Alloy with Increased Iron Level. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 743-748.

[4] SANGWAL, K. SUROWSKA, B., BŁAZIAK, P. (2002). Analysis of the indentation size in the microhardness measurement of some cobalt-based alloys. In: *Materials Chemistry and Physics*, Vol. 77, No. 2, pp. 511-520.

[5] KORBA, P., PIĽA, J., FŐZŐ, L., CIBEREOVÁ, J. (2014). The use of visualization in aircraft design nodes by using CAX systems - 2014. In: *SGEM 2014* : 14th international multidiscilinary scientific geoconference : GeoConference on Informatics, Geoinformatics and Remote Sensing : conference proceedings : volume 1: 17-26, June, 2014, Albena, Bulgaria. - Sofia : STEF92 Technology Ltd., 2014 pp. 399-406.

[6] ŠČUREK, R., VÁLEK, D. (2014). Method of selecting the most important power lines in a transmission and distribution network, In: *Przeglad elektrotechniczny*, SIGMA-NOT, 11/2014, Poland, pp.152-1554.

[7] DAVID, J., ŠVEC, P., FRISCHER, R. (2013). Podpora údržby a řízení technologie bramového kontilití, In: *METAL 2013*, 22nd International Conference on Metallurgy and Materials, May 15th - 17th 2013, Hotel Voronez I, Brno Czech Republic, pp. 1650-1656.

[8] BUJNA, M., KOTUS, M., PRÍSTAVKA, M., FÖLDEŠIOVÁ, D. (2012). Analysis of hazard using FMEA. In: *Technika v technológiách agrosektora 2012*. Zborník vedeckých prác - Technics in agrisector Technologies, Nitra, SPU Nitra, pp. 32-35.

[9] KRÁLIKOVÁ, R., PAULIKOVÁ, A., WESSELY, E. (2006). Modelling of production cycle for mechanical engineering processes - 2006. In: *Industrial engineering - adding innovation capacity of labour force and entrepreneur*. - Tallinn : University of technology, 2006, pp. 203-206.

[10] ISO 10 012:2003 Measurement management systems - Requirements for measurement processes and measuring equipment.

[11] International Vocabulary of Basic and General Terms in Metrology (1993). ISO. Geneva.

[12] VELES, P. (1985). *Mechanical properties and testing of metals*. Alfa/SNTL, pp. 307-320.

[13] PETRÍK, J., ŠOLC, M., MIKLOŠ, V. Applied Load and Calibration of the Hardness Tester (2014) In: *Manufacturing Technology*, Vol. 14, No. 2, pp. 228-234.

[14] SANGWAL, K. (2000), On the reverse indentation size effect and microhardness measurement of solids. In: *Materials Chemistry and Physics*. Vol. 63, No. 2, pp. 145-152.

[15] STN EN ISO 6507-1:2005 Metallic materials. Vickers hardness test. Part 1: Test method.

[16] CHAKRABORTY, R. et al. (2010). Loading Rate Effect on Nanohardness of Soda-Lime-Silica, In: *Metallurgical and Materials Transactions A*, Vol. 41, No. 5, pp 1301-1312.

[17] GONG, J., WU. J., GUAN. ZH. (1999). Examination of the Indentation Size Effect in Low-load Vickers Hardness Testing of Ceramics, In: *Journal of the European Ceramic Society*. Vol. 19, No. 15, pp. 2625 – 2631.

[18] REN. X. J., HOOPER, R. M., GRIFFITHS, C. (2003). Indentation size effect in ceramics: Correlation with H/E, In: *Journal of Materials Science Letters*. Vol. 22 No. 15, pp. 1105-1106.

[19] NAVRÁTIL, V., NOVOTNÁ, J. (2009). Some problems of microhardness of metals. In. *Journal of Applied Mathematics*. Vol. 2, No. 3, pp. 241-244.

[20] EA-10/16 EA (2004) Guidelines on the Estimation of Uncertainty in Hardness Measurements. Annex Guideline to the Evaluation of the Uncertainty of the Brinell and the Vickers Measuring Method.

[21] STN EN ISO 6507-2:2005 Metallic materials. Vickers hardness test. Part 2: Verification and calibration of testing machines.

[22] CHANYA, CH., POJJANUT, B., PAITOON, D. (2009). Effect of Indentation Load and Time on Knoop and Vickers Microhardness Tests for Namel and Dentic, In: *Materials Research*, Vol. 12, No. 4, pp. 473-476.

[23] LI, H., BRADT, R. C. (1993). The microhardness indentation load/size effect in rutile and cassiterite single crystals. In: *Journal of Materials Science*. Vol. 28, No. 4, pp. 917-926.

[24] MICHELS, B. D., FRISCHAT, G. H. (1982). Microhardness of chalcogenide glasses of the system Se- Ge-As. In: *Journal of Materials Science*. Vol. 17, No. 2., pp. 329-334.

[25] KIM, H., KIM. T. (2002). Measurement of hardness on traditional ceramics. In: *Journal of the European Ceramic Society*, Vol. 22, No. 9-10, pp. 1437-1445.

[26] KONAR, R., PATEK, M. (2016) Prediction of Hardness and Residual Stresses of Dissimilar Weld Joint, In: *Manufacturing Technology*, Vol. 16, No. 2, pp. 365-371.

[27] MACHAKA, R. et al.. Advances in Materials Science and Engineering. 2011. [online]. [cited 29 November 2012]. Available from: http://www.hindawi.com/journals/amse/2011/539252/

[28] PETRÍK, J. (2014). Micro-hardness of heat treated carbon steel. In: *Materials Science* – Medžiagotyra, Vol. 20, No. 1, pp. 21-24.

[29] McDONALD, J. H. *Handbook of Biological Statistics*. [cited 07 May 2015]. Available from: http://www.biostathandbook.com/multipleregression.html

[30] AAKRE, A. (2004). *Statistical functions and tools in Microsoft Excel*. Trondheim, [cited 18 May 2015]. Available from: http://trafikk.info/evu_tt_oslo_2007/litteratur/excel_all_statistical_functions_and_tools_a5.pdf

Paper number: M2016144

Numerical Model Description of Fibres Winding Process for New Technology of Winding Fibres on the Frames

Michal Petru, Tomas Martinec, Jaroslav Mlynek
Technical University of Liberec, Studentská 2, 461 17, Liberec 1, Czech Republic. E-mail: michal.petru@tul.cz, tomas.martinec@tul.cz, jaroslav.mlynek@tul.cz

Currently, traditional materials are very often replaced by composite materials in many industrial areas. The advantages of these materials consist mainly in their lightweight, high strength and flexibility, corrosion resistance and a long lifespan. The use of composites reaches its large development in the field of aerospace. This article discusses quality of the manufacturing process technology of a specially shaped composite frame in 3D space. The used technology is based on a winding of carbon, glass, organic filament rovings on a polyurethane core. Polyurethane core which is a geometry of frame with and without a circular cross section. Quality production of said type of composite frame depends primarily on the correct winding of fibers on a polyurethane core. It is especially needed to ensure the correct angles of the fibers winding on the polyurethane core and the homogeneity of individual winding layers. The quality of fibers winding also depends on the material properties of polyurethane core and fibers. The article describes mathematical model for use an industrial robot in filament winding and how to calculate the trajectory of the robot. When winding fibers on the polyurethane core which is fastened to the robot-end-effector so that during the winding process goes through a fibre-processing head on the basis of the suitably determined robot-end-effector trajectory. We use for description numerical model and matrix calculus to enumerate the trajectory of the robot-end-effector to determine the desired passage of the frame through the fibre-processing head. The calculation of the trajectory was programmed in the Delphi development environment. Equations and relations of the numerical model are important for use a real solving of the passage of a polyurethane core through fibre-processing head.

Keywords: Numerical model, composite materials, technology of winding fibers, Denavit-Hartenberg method

Acknowledgements

The results of this project No. LO1201 were obtained through the financial support of the Ministry of Education, Youth and Sports, Czech Republic in the framework of the targeted support of the "National Programme for Sustainability I".

References

[1] RUSNAKOVA, S., ZALUDEK, M., BAKOSOVA, D. (2012). Processing engineering of large composites structures using low-pressure vacuum infusion. In: *Manufacturing Technology*, Vol. 12, June 2012, pp. 83-86.

[2] NOVAKOVA-MARCINCINOVA, L., NOVAK-MARCINCIN, J. (2014). Production of abs-aramid composite material by fused deposition modeling rapid prototyping system. In: *Manufacturing Technology*, Vol. 14, N.1, pp. 85-91.

[3] SCIAVICCO, L., SICILIANO, B. (2004). *Modelling and Control of Robot Manipulators*, p.378. Springer, London.

[4] JAZAR R., N. (2004). *Theory and applied robotics*, p.883. Springer, New York.

[5] SCIAVICCO, L., SICILIANO, B. (2004). *Modelling and Control of Robot Manipulators*, p.378. Springer, London.

[6] MARTINEC T, MLÝNEK J, PETRŮ, M. (2015). Calculation of the robot trajectory for the optimum directional orientation of fibre placement in the manufacture of composite profile frames, *Robotics and Computer-Integrated Manufacturing*, Vol. 35, pp. 42-54.

[7] SEVCIK, L., LEPSIK, P., PETRŮ, M., MAŠÍN, I., MARTONKA, R. (2014). *Modern Methods of Construction Design, Lecture Notes in Mechanical Engineering*, p. 631. Springer.

[8] BALOČKOVÁ, L. (2013). The method for solving kinematics of an industrial robot, In:*Applied Mechanics and materials*, Vol. 283, pp. 279–281.

[9] MÜLLER, M., VALÁŠEK, P. (2014). Optimization of Surface Treatment of Carbon Steel in Area of Adhesive Bonding Technology with Application of Quik-Setting Adhesives. In: *Manufacturing Technology*, Vol. 14 N.4, pp. 579-584.

[10] KUMIČÁKOVÁ, D., GÓRSK, F., MILECKI, A., GRAJEWSKI, D. (2013). Utilization of Advanced Simulation Methods for Solving of Assembly Processes Automation Partial Tasks. In: *Manufacturing Technology*, Vol. 13, N. 4, pp. 478-486.

[11] ŽMINDÁK, M., PELAGIĆ, Z., SOUKUP, J. (2015). Analysis of Fiber Orientation Influence to Dynamic Properties of Composite Structures. In: *Manufacturing Technology*, Vol. 15, N. 3, pp. 490-494.

Paper number: M2016145

Tensile Properties of AA6156-T4 Friction Stir Welded Joints in As-Welded and Post-Weld Aged Condition

Umberto Prisco, Fabio Scherillo
Department of Chemical, Materials and Production Engineering, University of Napoli Federico II, Piazzale Tecchio 80 – 80125 Napoli, Italy

The effect of the T62 post-weld heat treatment on the tensile strength of AA6156-T4 friction stir welded joints is studied. To this aim, the 0.2% proof stress and the tensile strength of as-welded and post-weld treated joints as function of the rotating and welding speed was analyzed performing a complete factorial design with three levels for each studied parameter. Statistical analyses were carried out to establish empirical models of the tensile properties of the joints as a function of the studied welding parameters. The obtained models were validated through statistical tools such as Mallow's *CP*, *S*, R^2 and $R^2(adj)$. The developed regression models can be effectively used to predict the mechanical proprieties of the joints at 95% confidence level.

Keywords: friction stir welding, AA6156, DOE, ANOVA, tensile properties

References

[1] LIBERINI, M., SCHERILLO, F., ASTARITA, A., PRISCO, U., BRUNO, M., MONETTA, T., BELLUCCI, F., SQUILLACE, A. (2016). Microstructure of a hot forged Ti 5-5-5-3 aeronautical component. *Metallography, Microstructure, and Analysis*, Vol. 5, No. 3, pp. 207–216.

[2] ASTARITA, A., PRISCO, U., SQUILLACE, A., VELOTTI, C., TRONCI, A. (2015). Mechanical characterization by DOE analysis of AA6156-T4 friction stir welded joints in as-welded and post-weld aged condition. *Materialpruefung/Materials Testing*, Vol. 57, No. 3, pp. 192–199.

[3] PRISCO, U., SQUILLACE, A., ASTARITA, A., VELOTTI, C. (2013). Influence of welding parameters and post-weld aging on tensile properties and fracture location of AA2139-T351 friction-stir-welded joints. *Materials Research*, Vol. 16, No. 5, pp. 1106–1112.

[4] PRISCO, U. (2015). Size-dependent distributions of particle velocity and temperature at impact in the cold-gas dynamic-spray process. Journal *of Materials Processing Technology*, Vol. 216, pp. 302–314.

[5] SQUILLACE, A., PRISCO, U. (2009). Influence of filler material on micro- and macro-mechanical behaviour of laser-beam-welded T-joint for aerospace applications. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, Vol. 223, No. 3, pp.103–115.

[6] PRISCO, U. (2014). Thermal conductivity of flat-pressed wood plastic composites at different temperatures and filler content. *Science and Engineering of Composite Materials*, Vol. 21, No. 2, pp. 197–204.

[7] VELOTTI, C., ASTARITA, A., BUONADONNA, P., DIONORO, G., LANGELLA, A., PARADISO, V., PRISCO, U., SCHERILLO, F., SQUILLACE, A., TRONCI, A. (2013). FSW of AA 2139 plates: influence of the temper state on the mechanical properties. *Key Engineering Materials*, Vol. 554-557, pp. 1065–1074.

[8] BITONDO, C., PRISCO, U., SQUILACE, A., BUONADONNA, P., DIONORO, G. (2011). Friction-stir welding of AA 2198 butt joints: Mechanical characterization of the process and of the welds through DOE analysis. International *Journal of Advanced Manufacturing Technology*, Vol. 53, No. 5-8, pp. 505–516.

[9] BITONDO, C., PRISCO, U., SQUILLACE, A., GIORLEO, G., BUONADONNA, P., DIONORO, G., CAMPANILE, G. (2010). Friction stir welding of AA2198-T3 butt joints for aeronautical applications. *International Journal of Material Forming*, Vol. 3(SUPPL. 1), pp. 1079–1082.

[10] PRISCO, U., POLINI, W. (2010). Flatness, cylindricity and sphericity assessment based on the seven classes of symmetry of the surfaces. *Advances in Mechanical Engineering*, Vol. 2010, article number 154287.

[11] SERRONI, G., SQUILLACE, A., PRISCO, U., BITONDO, C., PRISCO, A. (2011). Aircraft panels stiffened by friction stir welded extruded parts: mechanical characterization. *Metallurgia Italiana*, Vol. 103, No. 1, pp. 35–39.

[12] VITIELLO, A., PRISCO, U. (2009). Evaluation of drilling parameters effects on machinability of PM materials using ANOVA. *Powder Metallurgy*, Vol. 52, No. 2, pp. 164–171.

[13] CARRINO, L., CILIBERTO, S., GIORLEO, G., PRISCO, U. (2011). Effect of filler content and temperature on steady-state shear flow of wood/high density polyethylene composites. *Polymer Composites*, Vol. 32, No. 5, pp. 796–809.

[14] SQUILLACE, A., PRISCO, U., CILIBERTO, S., ASTARITA, A. (2012). Effect of welding parameters on morphology and mechanical properties of Ti-6Al-4V laser beam welded butt joints. *Journal of Materials Processing Technology*, Vol. 212, No. 2, pp. 427–436.

[15] VELOTTI, C., ASTARITA, A., SQUILLACE, A., CILIBERTO, S., VILLANO, M.G., GIULIANI, M., PRISCO, U., MONTUORI, M., GIORLEO, G., BELLUCCI, F. (2013). On the critical technological issues of friction stir welding lap joints of dissimilar aluminum alloys. *Surface and Interface Analysis*, Vol. 45, No. 10, pp. 1643–1648.

[16] PRISCO, U., D'ONOFRIO, M.C. (2008). Three-dimensional CFD simulation of two-phase flow inside the abrasive water jet cutting head. *International Journal of Computational Methods in Engineering Science and Mechanics*, Vol. 9, No. 5, pp. 300-319.

[17] SERRONI, G., BITONDO, C., ASTARITA, A., SCALA, A., GLORIA, A., PRISCO, U., SQUILLACE, A., BELLUCCI, F. (2011). A comparison between mechanical and electrochemical tests on Ti6Al4V welded by LBW. *AIP Conference Proceedings*, Vol. 1353, No. 1391–1396.

[18] HOCKING, R.R., LESLIE, R.N. (1967). Selection of the best subset in regression analysis. *Technometrics*, Vol. 9, pp. 531–540.

[19] SAHUL, M., TURŇA, M., ŠUGÁROVÁ, J., SAHUL, M. (2013). Influence of laser welding aluminium alloy on mechanical properties of welded joints. *Manufacturing Technology*, Vol. 13, No. 4, pp. 526-530.

[20] HUDEC, Z. (2012). Gas metal rapid arc welding potential. *Manufacturing Technology*, Vol. 12, no, 13, pp. 113-118.

[21] NOVÁ, I., MACHUTA, J. (2014). Monitoring of the structure and quality of aluminium castings in moulds of gypsum mixtures. *Manufacturing Technology*, Vol. 14, No. 3, pp. 381-387.

[22] NOVOTNÝ, J., CAIS, J., NÁPRSTKOVÁ, N. (2014). analysis of aluminium alloys alsi7mg0.3 and almg3 by means of x-ray diffraction. *Manufacturing Technology*, Vol. 14, No. 3, pp. 392-397.

[23] BOLIBRUCHOVÁ, D., RICHTÁRECH, L. (2014). Study of the gas content in aluminum alloys. *Manufacturing Technology*, Vol. 13, No. 1, pp. 14-20.

Paper number: M2016146

The Influence of Process Fluids on the Machining Process and Forming Internal Threads

Miroslav Rejzek, Jan Jersák, Jaroslav Votoček
Department of Machining and Assembly, Faculty of Engineering, Technical University of Liberec, Studentská 2, 461 17 Liberec, Czech Republic. E-mail: rejzek.mir@seznam.cz, jan.jersak@tul.cz, jaroslav.votocek@tul.cz

Using cutting or forming taps during the production of internal threads represents the basic method of manufacturing these coupling structural components, which - in the case of smaller dimension internal threads – can be encountered in many manufacturing processes. To optimize the cutting process and forming of internal threads, and in favour of the final results of these operations, the right choice of technological conditions, process fluids and methods of their application in areas where the technological process is realized, is needed. An important aspect of the use of process fluids are relatively large operating costs, and in some cases also the adverse environmental effects. Therefore, one of the current trends is reducing the amount of process fluids used during machining operations. At the Department of Machining and Assembly at the TU of Liberec experiments were conducted and various technological methods of production of internal threads during the use of various types of process fluids and methods of their application in the technological process were compared. During machining and molding, technological process, the parameters and properties of the produced internal threads were evaluated.

Keywords: thread machining, thread forming, process fluid, MQL method

Acknowledgement

This article was created thanks to the targeted support of specific university research, which is provided by the Ministry of Education, Youth and Sports (MŠMT) of the Czech Republic.

References

[1] BARTUŠEK, T., JERSÁK, J. (2009). Metoda MQL a její vliv na technologické parametry procesu broušení. *Strojírenská technologie*. Rec. prof. Mádl. 14. roč., č. 1. s. 12 - 18. ISSN 1211-4162.

[2] BÁTORA, B., VASILKO, K. (2000). *Obrobené povrchy – technologická dědičnosť*, *funkčnost*, Rec. K. Kocman, S. Adamczak, TU v Trenčíně a GC Tech, Trenčín, 184 s.

[3] BUMBÁLEK, B., OŠTÁDAL, B., ŠAFR, E. (1963). *Řezné kapaliny*, SNTL - Nakladatelství technické literatury, n. p., Praha, 136 s.

[4] ČSN EN ISO 4287. (1999). *Geometrické požadavky na výrobky (GPS) – Struktura povrchu: Profilová metoda – Termíny, definice a parametry struktury povrchu,* Český normalizační institut, Praha.

[5] ČSN ISO 724 (2005). *Metrické závity ISO pro všeobecné použití - Základní rozměry*, Český normalizační institut, Praha.

[6] ČSN ISO 8688 – 1 (1993). *Rezné nástroje – Testovanie trvanlivosti při frézovaní. Časť 1 : Rovinné frézovanie,* Český normalizační institut, Praha.

[7] DUGIN, A., JERSÁK, J., POPOV, A. (2014). Method for Determining of the Anti-adhesion Ability of Cutting Fluids. *Manufacturing Technology.* Vol. 14, No. 2. pp. 145 - 149. ISSN 1213-2489.

[8] DUGIN, A., VOTOCEK, J., POPOV, A. (2014). Method for Determining the Tribological Properties of the Cutting Fluid. *Manufacturing Technology.* Vol. 14, No. 2. pp. 149-153. ISSN: 1213-2489.

[9] JERSÁK, J., REJZEK, M. (2011). Účinek procesní kapaliny na proces soustružení a vybrané parametry integrity povrchu. S*trojírenská technologie*. Rec. prof. Vasilko, prof. Holešovský. roč. 16, č. 2. s. 17 - 23. ISSN 1211-4162.

[10] JERSÁK, J., VRKOSLAVOVÁ, L. (2013). The Influence of Process Fluids on the Properties of the Surface Layer of Machined Components. *Manufacturing Technology.* Vol. 13, No. 4. pp. 466 - 473. ISSN 1213-2489.

[11] SHAO, J., YAO, Ch., ANRUI HE, W., S. (2015). Setup System of Selective Roll Cooling Based on Profile Prediction in Aluminum Hot Strip Mill. *Manufacturing Technology*. Vol. 15, No. 2. pp. 204 - 209. ISSN 1213-2489.

[12] KREMANOVÁ, B., MÁDL, J., RÁZEK, V., KOUTNÝ, V. (2007). Vývoj nových technologických kapalin na bázi přírodních surovin. S*trojírenská technologie*. Rec. doc. Kvasnička. roč. 12, č. 2. s. 18 - 23. ISSN 1211-4162.

[13] MÁDL, J., KOUTNÝ, V. (2002). How to Select Suitable Cutting Fluid. *Manufacturing Technology.* Vol. 2, No. - . pp. 45 - 53. ISSN 1213-2489.

[14] MÁDL, J. (2002). Dry Machining Versus Cutting With Cutting Fluids. *Manufacturing Technology*. Vol. 2, No. -. pp. 42 - 45. ISSN 1213-2489.

[15] MEČIAROVÁ, J., JERSÁK, J. (2006). Humánní aspekty používání procesních kapalin. S*trojírenská technologie*. Rec. prof. Mádl. roč. 11, č. 4. s. 4 - 8. ISSN 1211-4162.

[16] POHOŘALÝ, M., JERSÁK, J. (2003). Výzkum vybraných parametrů jakosti brouseného povrchu v závislosti na povaze použitého chladicího média. *Strojírenská technologie.* Rec. F. Holešovský. 8, č. 4. s. 4 - 8. ISSN 1211-4162.

[17] RÁZEK, V., MÁDL, J., KOUTNÝ, V. (2003). Metody zkoušení vlastností řezných kapalin. S*trojírenská technologie*. Rec. doc. Kvasnička. roč. 8, č. 3. s. 21 - 24. ISSN 1211-4162.

[18] REJZEK, M. (2014). *Účinek procesních médií na technologie obrábění a tváření vnitřních závitů [Diplomová práce]*, TU v Liberci, Liberec, 85 s.

[19] ČILLÍKOVÁ, M., aj. (2008). *Top trendy v obrábaní - VI. časť - Procesné médiá*. Žilina: MEDIA/ST, s.r.o. ISBN 978-80-969789-3-9.

[20] VENZARA, P., POPOV, A., KAPLAN. F. (2012). Účinek procesních kapalin na trvanlivost nástroje a kvalitu povrchu při frézování konstrukční oceli. *Strojírenská technologie*. Rec. prof. Mádl, prof. Kocman. roč. 17, č. 3. s. 197 - 202. ISSN 1211-4162.

[21] VLACH, B. (1990). *Technologie obrábění a montáží*, SNTL - Nakladatelství technické literatury, n. p., Praha, 472 s.

Paper number: M2016147

Technology and Mold Design for Production of Hollow Carbon Composite Parts

Sona Rusnakova[1], Alexander Capka[1], Ladislav Fojtl[1], Milan Zaludek[1], Vladimir Rusnak[2]
[1]Department of Production Engineering, Faculty of Technology, Tomas Bata University in Zlín. Nad Stranemi 4511, 760 05 Zlín. Czech Republic. E-mail: rusnakova@ft.utb.cz, capka@ft.utb.cz, fojtl@ft.utb.cz, zaludek@ft.utb.cz
[2]Faculty of Metallurgy and Materials Engineering, VŠB-Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic. E-mail: vladimir.rusnak@form-composite.com

This essay aims to describe technology and mold design for production of hollow composite parts like carbon rims or sport rackets. Tested materials correspond to those used for composites in sport applications. Production technology called inflatable bladder molding (IBM) is describe with respect to used material, molds and process parameters. Furthermore, prototype mold for verification of flexible bladder, inner pressure and curing conditions is constructed and tested. Construction design of manufacturing mold together with description of technological steps is proposed.

Keywords: Mold, Carbon Composite, Carbon Rim, Compression Molding, Inflatable Bladder Molding, Prepreg

Acknowledgement

This work and the project is realized with the financial support of the internal grant of TBU in Zlín No. IGA/FT/2016/002 funded from the resources of specific university research.

References

[1] JOHNSON, J. H., KIEPURA, R., HUMPHRIES, D. (1998). *Engineered Materials Handbook*, Vol. 1, Composites, ASM International, Ohio, pp. 52-154, ISBN 978-0871702791.

[2] NOVAKOVA-MARCINCINOVA, L., NOVAK-MARCINCIN, J. (2014). Production of abs-aramid composite material by fused deposition modeling rapid prototyping system. *Manufacturing Technology*, Vol. 14, Issue 1, pp. 85-91, ISSN 1213-2489.

[3] MULLER, M., VALASEK, P. (2012). Abrasive wear effect on Polyethylene, Polyamide 6 and polymeric particle composites. *Manufacturing technology*. Vol 12, No. 13, pp. 55-59, ISSN 1213-2489.

[4] HOMOLA, P., KADLEC, M. (2011). Vyhodnocení rázového poškození uhlíkového kompozitu s termoplastovou matricí. *Strojírenská technologie.* roč. 16, č. 1, s. 11-15, ISSN 1211-4162.

[5] RUSNAKOVA, S., FOJTL, L., ZALUDEK, M., RUSNAK, V. (2014). Design of material composition and technology verification for composite front end cabs. *Manufacturing Technology*, Vol. 14, Issue 4, pp. 607-611, ISSN 1213-2489

[6] EHRENSTEIN, G. W. (2009). Polymerní kompozitní materiály. Praha: Scientia, 351 p. ISBN 978-80-86960-29-6

[7] SLOBODZINSKY, A. (1982). Bag Molding Processes, *Handbook of Composites*. Springer, New York, pp 368-390, ISBN 978-1-4615-7141-4

[8] ČSN EN ISO 4210-7. Cycles - Safety requirements for bicycles - Part 7: Wheels and rims test methods, Praha: UNMZ, 2014. 20 p. Classifications 309000.

[9] ISO 5775-2:1996 Bicycle tyres and rims - Part 2: Rims, ETRTO. 1996. 16 p.

[10] E.T.R.T.O. Recommendations, The European Tyre and Rim Techni-cal Organisation, B 1060 Brussels – Belgium. 2014, 96 p.

[11] HexPly® M49 [online]. [cit. 2015-8-17]. WWW: <http://www.hexcel.com/resources/datasheets>.

[12] FOJTL, L., RUSNAKOVA, S., ZALUDEK, M., CAPKA, A., RUSNAK, V. (2015). Characterization of Carbon Composites Properties for Application in Sport Industry, *Applied Mechanics and Materials.* Vol. 1120-1121, pp. 515-518. ISSN 1662-8985

[13] Bagging films [online]. [cit. 2015-8-17]. WWW: <http://catalogue.airtech.lu/category.php>.

Paper number: M2016148

Preparation of Ni-Ti Shape Memory Alloy by Spark Plasma Sintering Method

Pavel Salvetr[1], Tomáš František Kubatík[2], Pavel Novák[1]
[1]University of Chemistry and Technology, Department of Metals and Corrosion Engineering, Technicka 5, 166 28 Prague 6, Czech Republic
[2]Institute of Plasma Physics ASCR, v.v.i., Za Slovankou 1782/3, 182 00 Prague 8, Czech Republic
Email: salvetrp@vscht.cz, kubatik@ipp.cas.cz, panovak@vscht.cz

This paper aims to describe powder metallurgy methods of production Ni-Ti shape memory alloy - self-propagating high-temperature synthesis (SHS) and spark plasma sintering (SPS). There are compared microstructures and phase compositions of alloys produced by SHS and by a technology containing SHS, milling and SPS. At the same time there is determined the influence of the SPS sintering temperature on the structure of Ni-Ti alloy. Self-propagating high-temperature synthesis was initiated at 1100°C with process duration 20 minutes the heating rate of approx. 300 °C/min. The product is highly porous and contains undesirable Ti_2Ni phase. The SPS technique allows to obtain product with low porosity. The disadvantages of SPS technique are growing amount of Ti_2Ni phase and formation of other undesirable phases (Ni_4Ti_3 and Ni_3Ti).

Keywords: powder metallurgy, reactive sintering, spark plasma sintering, Ni-Ti alloy

Acknowledgement

This research was financially supported by Czech Science Foundation, project No. 14-03044S.

References

[1] ÖLANDER, A. (1932). An electrochemical investigation of solid cadmium-gold alloys. *Journal of the American Chemical Society*, Vol. 54, pp. 3819-3833.

[2] MOHD JANI, J., LEARY, M., SUBIC, A., GIBSON, M. A. (2014). A review of shape memory alloy research, applications and opportunities, *Materials & Design*, Vol. 56, pp. 1078-1113.

[3] BUEHLER, W. J., GILFRICH, J. V., WILEY, R. C. (1963). Effect of Low-Temperature Phase Changes on the Mechanical Properties of Alloys near Composition TiNi. *Journal of Applied Physics*, Vol. 34, pp. 1475-1477.

[4] A Historical Perspective. Nitinol Devices & Components, Inc.. http://www.nitinol.com/nu-category/nitinol-the-book (accessed Jan 11, 2016).

[5] Other Alloys Exhibiting Shape Memory Effects. Nitinol Devices & Components, Inc.. http://www.nitinol.com/nu-category/nitinol-the-book (accessed Jan 11, 2016).

[6] OTSUKA, K., REN, X. (2005). Physical metallurgy of Ti–Ni-based shape memory alloys, *Progress in Materials Science*, Vol. 50, pp. 511-678.

[7] NAYAN, N., GOVIND, SAIKRISHNA, C.N., RAMAIAH, K.V., BHAUMIK, S.K., NAIR, K.S., MITTAL, M.C. (2007). Vacuum induction melting of NiTi shape memory alloys in graphite crucible, *Materials Science and Engineering: A*, Vol. 465, pp. 44-48.

[8] FRENZEL, J., ZHANG, Z., NEUKING, K., EGGELER, G. (2004). High quality vacuum induction melting of small quantities of NiTi shape memory alloys in graphite crucibles, *Journal of Alloys and Compounds*, Vol. 385, pp. 214-223.

[9] FOROOZMEHR, A., KERMANPUR, A., ASHRAFIZADEH, F., KABIRI, Y. (2011). Investigating microstructural evolution during homogenization of the equiatomic NiTi shape memory alloy produced by vacuum arc remelting, *Materials Science and Engineering: A*, Vol. 528, pp. 7952-7955.

[10] ELAHINIA, M.H., HASHEMI, M., TABESH, M., BHADURI, S.B. (2012). Manufacturing and processing of NiTi implants: A review, *Progress in Materials Science*, Vol. 57, pp. 911-946.

[11] DUERIG, T., PELTON, A., TREPANIER, CH. (2011). Nitinol - PART I Mechanism and Behaviour, *SMST e-Elastic newsletter*, ASM International.

[12] KAIEDA, Y. (2003). Fabrication of composition-controlled TiNi shape memory wire using combustion synthesis process and the influence of Ni content on phase transformation behavior, *Science and Technology of Advanced Materials*, Vol. 4, pp. 239-246.

[13] NOVÁK, P., KŘÍŽ, J., MICHALCOVÁ, A., SALVETR, P. (2015). Role of Reactive Sintering in Production of Technically Important Intermetallics, *Manufacturing Technology*, Vol. 15, pp. 74-77.

[14] NOVÁK, P., MICHALCOVÁ, A., ŠERÁK, J., VOJTĚCH, D., FABIÁN, T., RANDÁKOVÁ, S., PRŮŠA, F., KNOTEK, V., NOVÁK, M. (2009). Preparation of Ti–Al–Si alloys by reactive sintering, *Journal of Alloys and Compounds*, Vol. 470, pp. 123-126.

[15] WISUTMETHANGOON, S., DENMUD, N., SIKONG, L. (2009). Characteristics and compressive properties of porous NiTi alloy synthesized by SHS technique, *Materials Science and Engineering: A*, Vol. 515, pp. 93-97.

[16] NOVÁK, P., MEJZLÍKOVÁ, L., MICHALCOVÁ, A., ČAPEK, J., BERAN, P., VOJTĚCH, D. (2013). Effect of SHS conditions on microstructure of NiTi shape memory alloy, *Intermetallics*, Vol. 42, pp. 85-91.

[17] SALVETR, P., MORAVEC, H., NOVÁK, P. (2015). Ni-Ti Alloys Produced by Powder Metallurgy, *Manufacturing Technology*, Vol. 15, pp. 689-694.

[18] CHU, C. L., CHUNG, C. Y., LIN, P. H., WANG, S. D. (2004). Fabrication of porous NiTi shape memory alloy for hard tissue implants by combustion synthesis, *Materials Science and Engineering: A*, Vol. 366, pp. 114-119.

[19] NOVÁK, P., MORAVEC, H., SALVETR, P., PRŮŠA, F., DRAHOKOUPIL, J., KOPEČEK, J., KARLÍK, M., KUBATÍK, T. F. Preparation of nitinol by non-conventional powder metallurgy techniques, *Materials Science and Technology*, DOI: 10.1179/1743284715Y.0000000041.

[20] CHEN, G., LISS, K. D., CAO, P. (2014). In situ observation and neutron diffraction of NiTi powder sintering, *Acta Materialia*, Vol. 67, pp. 32-44.

Paper number: M2016149

Influence of Elements with High Affinity to Oxygen on Microstructure and Phase Composition of Ni-Ti Alloy

Andrea Školáková, Pavel Novák, Pavel Salvetr
University of Chemistry and Technology in Prague, Department of Metals and Corrosion Engineering, Technická 5, 166 28 Prague 6, Czech Republic, E-mail: SkolakovaA@seznam.cz

Approximately an equiatomic alloy of nickel and titanium is known as nitinol. Nitinol possesses a lot of interesting properties such as shape memory, pseudoplasticity, superelasticity and corrosion resistance. NiTi alloys are usually industrially produced by melting process, but the products have not good quality and purity. Powder metallurgy with reactive sintering is considered as one of the route of production of NiTi alloys. However, the other phases are formed during this process (Ti_2Ni, Ni_3Ti). The presence of Ti_2Ni phase is unwanted in this alloy. It is stabilized by oxygen and its main disadvantage is brittleness. In this work we prepared NiTi shape memory alloys by Self-propagating High-temperature Synthesis (SHS). Results showed the possibility of modification of the phase composition by alloying with other elements, which have higher affinity to oxygen. Carbon was found to reduce the amount of undesirable Ti_2Ni phase, while in presence of zirconium this phase reduces its hardness which implies the loss of brittleness.

Keywords: NiTi alloy, Self-propagating High-temperature Synthesis, Ti_2Ni phase

Acknowledgement

This research was financially supported by Czech Science Foundation, project No. 14-03044S.

References

[1] NOVÁK, P., MEJZLÍKOVÁ, L., MICHALCOVÁ A., ČAPEK J., BERAN P., VOJTĚCH D. (2013). Effect of SHS conditions on microstructure of NiTi shape memory alloy. In: *Intermetallics*, Vol. 42, pp. 85 – 91. Elsevier. Netherlands.

[2] WU, M. H. (2002). Fabrication of nitinol materilas and components. In: *Materials Science Forum*, Vol. 394, pp. 285 – 292. Trans Tech Publications. Switzerland.

[3] NYAN, N., GOVIND, SAIKRISHNA, C. N., VENKATA RAMAIAH, K., BHAUMIK, S. K., SUSEELAN NAIR, K., MITTAL, M. C. (2007). Vacuum induction melting of NiTi shape memory alloys in graphite crucible. In: *Materials Science and Engineering: A*, Vol. 465, No. 1-2, pp. 44 – 48. Elsevier. Netherlands.

[4] YI, H. C., MOORE, J. J. (1988). A novel technique for producing NiTi shape memory alloy using the thermal explosion mode of combustion synthesis. In: *Scripta Metallurgica*, Vol. 22, No. 12, pp. 1889 – 1892. Elsevier. Netherlands.

[5] ITIN, V. I., GYUNTER, V. E., SHABALOVSKAYA, S. A., SACHDEVA, R. L. C. (1994). Mechanical properties and shape memory of porous nitinol. In: *Materials Characterization*, Vol. 32, No. 3, pp. 179 – 187. Elsevier. Netherlands.

[6] WHITNEY, M., CORBIN, S. F., GORBET, R. B. (2008). Investigation of the mechanism of reactive sintering and combustion synthesis of NiTi using differential scanning calorimetry and microstructural analysis. In: *Acta Materialia*, Vol. 56, No. 3,pp. 559 – 570. Elsevier. Netherlands.

[7] NOVÁK, P., VESELÝ, T., MAREK, I., DVOŘÁK, P., VOJTĚCH, V., SALVETR, P., KARLÍK, M., HAUŠILD, P., KOPEČEK, J. (2016). Effect of particle size of titanium and nickel on the synthesis of NiTi by TE-SHS. In: *Metallurgical and Materials Transactions B*, Vol. 47, No. 2, pp. 932 – 938. Springer. Germany.

[8] NOVÁK, P., SALVETR, P., PECENOVÁ, Z. (2015). Intermetallics – Synthesis, Production, Properties. In: *Manufacturing Technology*, Vol. 15, No. 6, pp. 1024 – 1028. UJEP. Czech Republic.

[9] NOVÁK, P., POKORNÝ, P., VOJTĚCH, V., KNAISLOVÁ, A., ŠKOLÁKOVÁ, A., ČAPEK, J., KARLÍK, M., KOPEČEK, J. (2015). Formation of Ni – Ti intermetallics during reactive sintering at 500 – 650 °C. In: *Materials Chemistry and Physics*, Vol. 155, pp. 113 – 121. Elsevier. Netherlands.

[10] NOVÁK, P., MICHALCOVÁ, A., ŠKOLÁKOVÁ, A., PRŮŠA, F., KŘÍŽ, J., MAREK, I., KUBATÍK, T. F., KARLÍK, M., HAUŠILD, P., KOPEČEK, J. (2015). Effect of heating rate on the formation of intermetallics during SHS process. In: *Acta Physica Polonica A*, Vol. 128, No. 4, pp. 561 – 564. Instytut Fizyki. Poland.

[11] NOVÁK, P., ŠKOLÁKOVÁ, A., VOJTĚCH, V., KNAISLOVÁ, A., POKORNÝ, P., MORAVEC, H., KOPEČEK, J., KARLÍK, M., KUBATÍK, T. F. (2014). Applications of microscopy and x-ray diffraction in optimization of the production of NiTi alloy by powder metallurgy. In: *Manufacturing Technology*. Vol. 14, No. 3, pp. 387 – 392. UJP. Czech Republic.

[12] NEVITT, M. V. (1960). Stabilization of certain amount Ti_2Ni-type phases by oxygen. In: *Transactions of the Metallurgical Society of AIME*, Vol. 218, pp. 327 – 331. American Institute of Mining, Metallurgical and Petroleum Engineers. USA.

[13] SALVETR, P., NOVÁK, P., MORAVEC, H. (2015). Ni-Ti alloys produced by powder metallurgy. In: *Manufacturing technology*, Vol. 15, No. 4, pp. 689 – 694. UJP. Czech Republic.

[14] KUČERA, V., ČAPEK, J., MICHALCOVÁ, A., VOJTĚCH, D. (2014). Preparation and characterization of NiTi shape memory alloy prepared by powder metallurgy. In: *Manufacturing Technology*, Vol. 14, No. 3, pp. 342 – 351. UJP. Czech Republic.

[15] NOVÁK, P., KRISTIÁNOVÁ, E., VALALÍK, M., DARME, C., SALVETR, P. (2015). New composite materials based on NiTi. In: *Manufacturing Technology*, Vol. 14, No. 3, pp. 644 – 647. UJP. Czech Republic.

[16] DU, J., WEN, B., MELNIK, R., KAWAZOE, Y. (2014). First-principles studies on structural, mechanical, thermodynamic and electronic properties of Ni-Zr intermetallic compounds. In: *Intermetallics*, Vol. 54, pp. 110 – 119. Elsevier. Netherlands.

[17] MASSALSKI, T. B. (1990). Binary Alloy Phase Diagrams, ASM, Materials Park.

Paper number: M2016150

Model of Unique Material Flow in Context with Layout of Manufacturing Facilities

Martin Straka[1], Peter Kačmáry[1], Andrea Rosová[1], Boris Yakimovich[2], Aleksander Korshunov[2]
[1]Institute of Logistics, Faculty of Mining, Ecology, Process Control and Geotechnology, Technical university of Kosice, Park Komenskeho 14, 043 84, Kosice. Slovak Republic. E-mail: martin.straka@tuke.sk, peter.kacmary@tuke.sk, andrea.rosova@tuke.sk
[2]Department of Higher Mathematics, Physics, Chemistry, Votkinsk Branch of Kalashnikov Izhevsk State Technical University, Studencheskaya 7, 4260 69 Izhevsk, Russia. E-mail: yakimovich@istu.ru, kai@istu.ru

The situation of analysis and finding solution of unique material flow managing and planning in production company allows increasing the competitiveness company on the market. The uniqueness of the material flows is in its combination of metallurgical and machinery character. There are continuous metallurgical and discrete mechanical material flow with even different speed which are joining at one place – aluminium casting. The research has brought also the recommendation of new layout of the company. Each company is original from the point of production processes. Application of standard enterprise information system (SAP, proAlpha, Baan, etc.) need difficult adaptation especially for conditions of small or medium enterprises and the price of that system is relatively high. Therefore, the proposed model of capacity planning is much more suitable for the conditions, requires and demands of this enterprisers.

Keywords: layout, material flow, manufacturing, production process

Acknowledgement

Publication has been created with the support of VEGA grant agency, in the framework of grant task VEGA 1/0216/13 „Methods and new approaches study to measurement, evaluation and diagnostic performance of business processes in the context of logistics management company".

References

[1] JOHNSON, J. C., WOOD, D. F. (1996). *Contemporary logistics*, sixth ed., Prentice Hall, Upper Saddle River.

[2] KHOURI, S., KAČMÁRY, P. (2009). Optimization of information flows in a model enterprise through the implementation of ERP system, *Transport and Logistics* Vol. 2009, No. 6, pp. 125-127.

[3] KOLLÁR, P., NIKITIN, Y., STRAKA, M. (2015). The determination of the shelf mass in the universal shelving stacker by measuring the frequency converter torque generating current of the main drive, *Manufacturing technology*, Vol. 15, No. 3, pp. 363-366.

[4] LASCSÁKOVÁ, M. (2015.). The analysis of the commodity price forecasting success considering different lengths of the initial condition drift, *Acta Logistica*, Vol. 2, No. 3, pp. 7-12.

[5] PEKARČÍKOVÁ, M., TREBUŇA, P., POPOVIČ, R., KLIMENT, M. (2015). Utilization of the software product Tecnomatix Jack in optimizing of working activities, *Acta Simulatio*, Vol. 1, No. 4, pp. 5-11.

[6] RAYWARD-SMITH, V. J., OSMAN, I. H., REEVES, C. R., SMITH, G. D. (1996). *Modern heuristic search methods*, UNICON John Wiley & Sons, Chichester.

[7] RAZZHIVINA, M. A., YAKIMOVICH, B. A., KORSHUNOV, A. I. (2015). Application of information technologies and principles of lean production for efficiency improvement of machine building enterprises, *Pollack Periodica*, Vol. 10, Issue 2, pp. 17-23.

[8] ROSOVA, A. (2010). The system of indicators of distribution logistics, logistic of transport and material flow as one of the tools of controlling in the enterprise logistics, *Acta Montanistica Slovaca*, Vol. 2010, No. 1, pp. 67-72.

[9] SANIUK, S., SANIUK, A., LENORT, R., SAMOLEJOVA, A. (2014). Formation and planning of virtual production networks in metallurgical clusters, *Metalurgija*, Vol. 53, No. 4, pp. 725-727.

[10] SĄSIADEK, M. (2015). Planning and analysis of mechanical assembly sequences in design engineering - part I: the method, *Tehnički Vjestnik*, Technical Gazette, Vol. 22, No. 2, pp. 337-342.

[11] SĄSIADEK, M. (2015). Planning and analysis of mechanical assembly sequences in design engineering - part II: application, *Tehnički Vjestnik*, Technical Gazette, Vol. 22, No. 3, pp. 643-648.

[12] STRAKA, M. (2011). Analysis and the conception proposal of manufacturing facilities layout, *Carpathian Logistics Congress CLC´2011*, TU of Kosice, pp. 1-4.

[13] STRAKA, M., ŽATKOVIČ, E., SCHRÉTER, R. (2014). Simulation as a means of activity streamlining of continuously and discrete production in specific enterprise, *Acta Logistica*, Vol. 1, No. 3, pp. 11-16.

[14] SZABO, S., FERENC, V., PUCHAR, A. (2013). Trust, Innovation and Prosperity, *Quality Innovation Prosperity*, Vol. 17, No. 2, pp. 1-8.

[15] PELAGRIĆ, Z., NÁGEĽ, M., ŽMINDÁK, M., RIECKY, D. (2015). Wear simulation modeling by using the finite element method, *Manufacturing technology*, Vol. 15, No. 2, pp. 191-195.

[16] BEZECNÝ, J., DUBEC, A., JANEKOVÁ, M. (2015). Brazing operation for aluminium semi-products by heat treatment, *Manufacturing technology*, Vol. 15, No. 1, pp. 3-7.

[17] PRAJOVÁ, V., PERMINOVA, O., FAIZULLIN, R. (2014). Principles of organizations interaction while forming mechatronics specialists professional competences in a regional industry cluster. Procedia Engineering: *The 6th International Conference on Modelling of Mechanical and Mechatronic Systems MMaMS 2014*, Vol. 96, online, pp. 370-373.

[18] BOŽEK, P., MORAVČÍK, O., ŠTOLLMANN, V., ŠURIANSKY, J., PRAJOVÁ, V., WALEKOVÁ, G. (2008). Virtual program imported into the real technological workplace. Vienna: *Annals of DAAAM and Proceedings of DAAAM Symposium*, pp. 0157-0158.

Paper number: M2016151

Reactive Resins Filled with Microparticles Based on Iron Powder

Petr Valášek
Department of Material Science and Manufacturing Technology, Faculty of Engineering, Czech University of Life Sciences Prague. Kamýcká 129, 165 21, Prague. Czech Republic. E-mail: valasekp@tf.czu.cz

Hard inorganics microparticles are added to the composite systems due to optimization of some mechanical properties among which is possible to rank hardness and resistance to abrasive wear. Advantage of interaction of metal powders with polymers is also their ferromagnetism which changes physical properties of resulting composite systems. This paper is focused on evaluation of mechanical properties of epoxy resin filled with microparticles on the basis of iron powder (20.6 μm), mainly on resistance to abrasive wear, hardness and on adhesive and cohesive characteristics. The experiment evaluates composite systems prepared without using controlled semi-layers and without using a vacuum technology. Such technology was chosen with regard to practise. It is possible to consider the adhesive and cohesive characteristics as key properties determining possible application areas of filled reactoplastics. For evaluation of fracture areas was used electronic microscopy. The experiment confirmed significant increase of resistance to abrasive wear with increasing concentration of iron powder. This property can be utilized in widening the application areas of reactoplastics resins, i.e. creating the new resistant layers.

Keywords: Abrasive wear, epoxy resin, hardness, tensile strength.

Acknowledgement

The results were supported by the grant IGA TF 2015 (31140/1312/3107).

References

[1] MÜLLER, M., VALÁŠEK, P. (2012). Abrasive wear effect on Polyethylene, Polyamide 6 and polymeric particle composites. In: *Manufacturing Technology*, 12, pp. 55 – 59.
[2] VALÁŠEK, P., MÜLLER, M. (2013). Polymeric composite based on glass powder - Usage possibilities in agrocomplex. In: *Scientia Agriculturae Bohemica*, No. 2, pp. 107 – 112.
[3] VALÁŠEK, P., MÜLLER, M. (2013). Polyurethane resins filled with inorganic waste particles. In: *Manufacturing Technology*, Vol. 13, No. 2, pp. 241 – 247.
[4] RUGGIERO, A., et al. (2015). Friction and wear behaviors of Al/Epoxy Composites during Reciprocating Sliding tests. In: *Manufacturing Technology*, Vol. 15, No. 4, pp. 684 – 689.
[5] SATAPATHY, B.K., BIJWE, J. (2002). Analysis of simultaneous influence of operating variables on abrasive wear of phenolic composites. In: *Wear*, 253, pp. 787 – 794.
[6] XUE QUNJI, WANG QUIHA. (1997). Wear mechanisms of polyetheretherketone composites filled with various kinds of SiC. In: *Wear*, 213, pp. 54 – 58.
[7] YU, Y.H. et al. (2014). Preparation, morphological, and microwave absorbing properties of spongy iron powders/epoxy composites. In: *Journal of the Taiwan Institute of Chemical Engineers*, Vol. 45, No. 2, pp. 674 – 680.
[8] CHOI, H. et al. (2008). Fracture behavior of carbon/epoxy laminated composite reinforced by iron powder. In: *Korean Journal of Chemical Engineering*, Vol. 25, No. 5, pp. 1208 – 1211.
[9] NOVÁK, M. (2012). Surfaces with high precision of roughness after grinding. In: *Manufacturing Technology*, 12, pp. 66 – 70.
[10] MÜLLER, M. (2014). Influence of adhesives storing temperature on adhesive bond strength. In: *Manufacturing Technology*, Vol. 14, No. 1, pp. 71 – 75.
[11] ŤAVODOÁ, M. (2013). The surface quality of materials after cutting by abrasive water jet evaluated by selected methods. In: *Manufacturing Technology*, Vol. 13, No. 2, pp. 236 – 241.
[12] KAHRAMANA, R., MEHMET SUNARB, BEKIR YILBAS. (2008). Influence of adhesive thickness and filler content on the mechanical performance of aluminum single-lap joints bonded with aluminum powder filled epoxy adhesive. In: *Materials Science Forum*, Vol. 205, pp. 183 – 189.
[13] KILIK, R., DAVIES, R. (1989). Mechanical properties of adhesive filled with metal powders. In: *International Journal of Adhesion and Adhesives*, Vol. 9, No. 4 pp. 224 – 228.
[14] KAVAK, N., ALTAN, E. (2012). Influence of filler amount and content on the mechanical performance of joints bonded with metal powder filled adhesive. In: *15th International Conference on Advances in Materials and Processing Technologies, Wollongong*, NSW; Australia, Vol. 773-774, pp. 226 – 233.

Paper number: M2016152

Theoretical and Practical Relationship $Rz = f(f;r_\varepsilon)$

Karol Vasilko, Zuzana Murčinková, Jozef Nosáľ
Faculty of Manufacturing Technologies Prešov, Technical University of Košice, 080 01 Prešov, Bayerova 1, SR. E-mail: karol.vasilko@tuke.sk, zuzana.murcinkova@tuke.sk, jozef.nosal@tuke.sk

Development of methods for machined surface identification has reached a stage when real surface shape can be visualised more precisely. Mechanical tools for measuring roughness have shown misrepresented profile considering the fact that the tip of diamond sensor is not „ideally sharp", it only follows the outline of actual profile. Profile details can be followed by optical scanning. During observation of profile records and theoretically defined rounded tool tip copying considerable disproportions can be found. This fact leads to incorrectly determination of feed with defined value of *Rz* and selected tool tip radius in practice. The aim of the paper is to identify the reasons of such differences and suggest a process of their elimination.

Keywords: machining, shift, machined surface

References

[1] BUMBÁLEK, B., ODVODY, V., OŠŤÁDAL, B. (1989). *Drsnost povrchu*. Praha, SNTL. 1989, p. 338.

[2] VASILKO, K., MÁDL, J. (2012). *Teorie obrábění*. UJEP Ústí nad Labem, 2012, p. 526.

[3] BUDA, J., BÉKÉS, J. (1977). *Teoretické základy obrábania kovov*. ALFA Bratislava, 1977, p. 565.

[4] BRAMMERTZ, P. H. (1961). Die Entstehung der Oberflächenrauhei beim Feindrehen. *Industrie Anzeiger*, Vol. 2, 1961

[5] GRZESIK, W. (2010). *Podstavy skrawania materialow konstrukcyjnych*. Wydawnictwo Naukowo-Techniczne, Warszawa, 2010.

[6] KOVAČ, P., MILIKIČ, D. (1998). *Rezanije metala*. Univerzitet u Novom Sadu, Serbia,1998, p. 210

[7] BETZ, F. (1971). Untersuchungen zur Entstehung der Schnittflächenrauheit. *Technische Rundschau* Nr. 34, August 1971.

[8] STANCEKOVA, D., KURNAVA, T., SAJGALIK, M., NAPRSTKOVA, N., STRUHARNANSKY, J., ŠČOTKA, P.: Identification of machinability of ceramic materials by turning. *Manufacturing Technology*, Mar 2014, Vol. 14, No.1, pp.

[9] HOLESOVSKY, F., NAPRSTKOVA, M., NOVAK, M. (2012). GICS for grinding process optimization. *Manufacturing Technology*, 2012, Vol. 12, No. 2, pp. 22-26

[10] LEGUTKO, S., KROLCZYK, G., KROLCZYK, J. (2014). Quality Evaluation of Surface Layer in Highly Accurate Manufacturing. *Manufacturing Technology*, Nr. 1, 2014, pp. 50-56.

[11] KLANICA, O., SVOBODA, E., JOSKA, Z. (2013). Changes of the Surface Texture after Surface Treatment HS6-5-2-5 Steel. *Manufacturing Technology*, Vol 15, No.1, 2013, pp. 47-53.

[12] JERSAK, J. et al. (2010). Surface integrity of hardened bearing steel after milling. *Manufacturing Technology*, Vol. 10, 2010, pp. 80-87.

[13] WINCZEK, J. (2011). New approach to modelling of temperature field in surfaced steel elements, *International journal of Heat and Mass Transfer*, Elsevier, Vol. 54, 2011, pp. 4702-4709

[14] MURČINKOVÁ, Z., MURČINKO, J. (2013). Machine-tool-workpiece system dynamic analysis approaches by use of CAE systems, *Technológ*. Vol. 5, No. 4 (2013), pp. 123-126.

Paper number: M2016153

Effect of Machined Surface Shape on Sound Reflection

Martin Vasina[1], Ondrej Bilek[2]
[1]Faculty of Mechanical Engineering, VSB-Technical University of Ostrava, Department of Hydromechanics and Hydraulic Equipment. 17. listopadu 15/2172, 708 33 Ostrava-Poruba. Czech Republic. E-mail: martin.vasina@vsb.cz
[2]Faculty of Technology, Tomas Bata University in Zlin, Department of Production Engineering. T. G. Masaryka 5555, 760 01 Zlin. Czech Republic. E-mail: bilek@ft.utb.cz

Sound reflection of materials is influenced by many factors, e.g. by material type, density, thickness, porosity, angle of sound incidence, surface shape and excitation frequency of acoustic wave. The aim of the paper is to investigate the surface shape effect of expanded polyvinylchloride material on sound reflection. For this reason polyvinylchloride samples of different surface shapes and perforations were produced on universal and CNC machine tool. The material ability to reflect sound of the investigated polyvinylchloride samples was experimentally measured by means of the transfer function method on Kundt´s impedance tube. The material samples were subsequently compared in terms of their sound reflection. It was verified that the highest sound reflection was obtained in case of the smooth surface polyvinylchloride sample.

Keywords: Sound Reflection, CNC Milling, Surface Shape, Excitation Frequency, Polyvinylchloride.

References

[1] NOVÝ, R. (2000). *Hluk a chvění*. 389 p. ČVUT, Praha (in Czech).

[2] BÍLEK, O., VAŠINA, M. CNC Milling and Manufacturing of Grove Shapes for Light Reflection Measurement. In: *Manufacturing Technology*. 2014, Vol. 14, No. 4, pp. 516–522. Elsevier. Netherlands.

[3] MADL, J., HOLEŠOVSKY, F. (2008). *Integrita obrobených povrchů z hlediska funkčních vlastností*. 230 p. UJEP, Usti nad Labem (in Czech).

[4] VASILKO, Karol. New experimental dependence of machining. In: *Manufacturing Technology*. 2014, Vol. 14, No. 1, pp. 111–116. Elsevier. Netherlands.

[5] LEGUTKO, S., KROLCZYK, G., KROLCZYK, J. Quality evaluation of surface layer in highly accurate manufacturing. In: *Manufacturing Technology*. 2014, Vol. 14, No. 1, pp. 50–56. Elsevier. Netherlands.

[6] SAEKI, Y., EMURA, T. Technical progresses for PVC production. In: *Progress in polymer science.* 2002, Vol. 27, No. 10, pp. 2055-2131. Pergamon Elsevier Science Ltd. England.

[7] ENDO, H., ETSUO, M. Small-hole drilling in engineering plastics sheet and its accuracy estimation. In. *International Journal of Machine Tools and Manufacture.* 2006, Vol. 46, No. 6, pp. 575-579. Elsevier. England.

[8] FETECAU, C., STAN, F., MUNTEANU, A., POPA, V. Machining and surface integrity of polymeric materials. In. *International Journal of Material Forming*. 2008 Vol. 1, No. 1, pp. 515-518. Springer. France.

[9] ISO 10534-2:1998 Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 2: Transfer function method.

[10] HAN, F. S., SEIFFERT, G., ZHAO, Y. Y., GIBBS, B. Acoustic absorption behaviour of an open-celled aluminium foam. In. *Journal of Physics D-Applied Physics*. 2003 Vol. 36, No. 3, pp. 294-302. IOP Publishing Ltd. England.

Paper number: M2016154

The Effect of Artificial Neural Network Architecture on Surface Roughness Parameter Prediction Capability when Turning Inconel 718

Marek Vrabeľ[1], Ildikó Maňková[1], Miroslav Paľo[1], Radek Lattner[2]
[1]Faculty of Mechanical Engineering, Technical University of Kosice, Masiarska 74, 040 01 Kosice, Slovakia. E-mail: marek.vrabel@tuke.sk, ildiko.mankova@tuke.sk, miroslav.palo@tuke.sk
[2]Faculty of Production Technology and Management, J. E. Purkyne University in Usti nad Labem. Pasteurova 3334/7, 400 01 Usti nad Labem. Czech Republic. E-mail: lattnerr@fvtm.ujep.cz

This paper investigates the influence of Artificial Neural Network (ANN) architectures on its prediction capability when machining nickel based super alloy. The ANN was employed to determine surface roughness parameter Ra through cutting conditions, tool wear and process monitoring indices such a cutting force components. The ANN structure was optimized by methods like a reduction of input vector parameters, dimensions of input data pattern, combined reduction and modification of hidden layers. Calculated and experimentally measured values were compared for each optimized ANN model. The work concludes that optimization of ANN has significant influence on prediction capability and accuracy for the task proposed.

Keywords: Artificial Neural Network, Optimization, Turning, Surface Roughness, Nickel Based Alloy

Acknowledgement

This work was supported by the bilateral project APVV SK-SRB-2013-0037 "Implementation of the artificial intelligence into optimisation of the selected advanced removal processes" as well as the project VEGA 1/0434/15 "Research on process dependent interface when milling with small diameter of end mill cutters"

References

[1] PONTES, F. J., DE PAIVA A. P., BALESTRASSI, P. P., FERREIRA, J. R., DA SILVA, M. B. F P. (2012). Optimization of radial basis function neural network employed for predictionof surface roughness in hard turning process using Taguchi's orthogonal arrays. In: *Expert Systems with Application*, Vol. 39, pp. 7776 – 7787.

[2] GARCÍA-PLAZA, E., NÚÑEZ, P. J., SALGADO, D. R., CAMBERO, I., HERRERA OLIVENZA, J. M., GARCÍA SANZ-CALCEDO, J. (2013). Surface finishmonitoring in taper turning CNC using artificial neural network and multiple regression methods. In: *Procedia Engineering*, The Manufacturing Engineering Society International Conference - MESIC 2013, Vol. 63, pp. 21 – 25.

[3] SEGRETO, T., SIMEONE, A., TETI, R. (2013). Multiple sensor monitoring in nickel alloy turning for tool wear assessment via sensor fusion. In: *Procedia CIRP*, Conference on Intelligent Computation in Manufacturing Engineering, Vol. 12, pp. 237 – 261.

[4] SIMEONE, A., SEGRETO T., TETI R. (2013). Residual stress condition monitoring via sensor fusion in turning of Inconel 718. In: *Procedia CIRP*, Conference on Intelligent Computation in Manufacturing Engineering, Vol. 12, pp. 67 – 72.

[5] JAWAHIR, I. S., BRINKSMEIER, E., M´SAOUBI, R. M, ASPINWALL, D. K., OUTEIRO, J. C., MEYER, D., UMBRELLO, D., JAYAL, A. D. (2011). Surface integrity in material removal processes: Recent advances, In: *CIRP Annals – Manufacturing Technology*, Vol. 60, pp. 603 – 626.

[6] MAŇKOVÁ, I., VRABEĽ, M., KOVAČ, P (2013). Artificial neural network application for surface roughness prediction when drilling nickel based alloy. In: *Manufacturing Technology*, Vol. 13, No. 2, pp. 193 – 199.

[7] NOVAK, M., NAPRSTKOVA, N. (2015). Grinding of the Alloy INCONEL 718 and Final Roughness of the Surface and Material Share. In: *Manufacturing Technology*, Vol. 15, No. 6, pp. 1015 – 1023.

[8] BELAN, J., KUCHARIKOVÁ, L., TILLOVÁ, E., UHRÍČIK, M. (2015). The Overview of Intermetallic Phases Presented in Nickel Base Superalloys after Precipitation Hardening. In: *Manufacturing Technology,* Vol. 15, No. 4, pp. 509 – 515.

Paper number: M2016155