ABSTRACT AND REFERENCES

MATERIALS SCIENCE

DOI: 10.15587/1729-4061.2019.165408

IMPROVING A PROCEDURE FOR DETERMINING THE ASSAY OF GOLD IN A PRECIOUS ALLOY OF DIFFERENT COMPOSITION USING A TOUCHSTONE (p. 6-19)

Tatyana Artyukh
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-3541-6690

Galyna Kupalova
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-4486-8349

Viktor Bazylevych
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-8030-8651

Inna Hryhorenko
Vinnytsia Institute of Trade and Economics of Kyiv National University of Trade and Economics, Vinnytsia, Ukraine
ORCID: http://orcid.org/0000-0002-6175-9067

Alla Ternova
Vinnytsia Institute of Trade and Economics of Kyiv National University of Trade and Economics, Vinnytsia, Ukraine
ORCID: http://orcid.org/0000-0002-7447-137X

We report testing the yellow and white jewelry alloys based on gold that contains nickel, zinc, palladium, using a touchstone by applying various chemical reagents and XFA (X-ray fluorescence analysis).

We have improved the procedure for assessing the conformity of assay of the precious alloys based on gold, considering the content of component composition by using the results from rubbing the alloys on a touchstone.

It was established that the magnitude of gold assay for precious alloys in the system AuAgZnCu, determined under the action of the reagent "chloric gold" on the touchstone, depends on the manifestation of contrast in the course of quality reaction against a standard sample (touch-needle).

Under the influence of the reagent, the "yellow" gold alloys demonstrate chloride compounds with silver and copper, being reduced to a metal powder of black and brown color. In this case, copper dissolves while gold, together with silver, forms an intensive residue on a strip that depends on the ligature composition of the alloy. It was established that the lower the assay of a tested sample, the greater the amount of "chlorine gold" that decomposes, the larger the sediment of silver chloride and the pure gold reduced from the reagent, and hence the darker the sediment.

It has been proven that testing the precious alloys of red color from the system AuAgZnCu 585 with a content of zinc (over 2 %), nickel, indium by using a reagent based on potassium dichromate and copper chloride is not effective.

The results of our analysis indicate the increased gold assay compared with a standard touch-needle.

To eliminate this phenomenon, it is recommended that one should first determine the composition of an alloy by the XFA method and construct an algorithm for testing in accordance with the content of the alloy by other reagents.

It was determined that the gold assay defined on a touchstone for alloys from the system AuAgZnCu 585 (a content of zinc is over 2 %) is more contrast under the influence of acidic reagents and depends on the component composition of the alloy.

It has been proven that the alloy of "white gold", composed of palladium and silver (AuAgPd585), is not affected by the acid reagent for gold assay 585.

Testing the alloy of "white gold" (AuAgPd585) using an acid reagent for gold assay 750 yields the dark sediment of a bluish tint.

We have established a more contrast effect on the alloys of "white gold" and "yellow gold" of assay 750 from the acid reagent for gold alloys of assay 750.

Keywords: gold alloys, touchstone, "chlorine gold", potassium dichromate, copper sulphate, assay control.

References

1. Pro zakhyst prav spozhyvachiv: Zakon Ukrainy vid 12.05.1991 No. 1024-XII. Available at: https://zakon.rada.gov.ua/laws/show/1023-12/print
2. Pro derzhavne rehuliuvannia vydobutku, vyrobnytstva i zastosuvannia dorohotsinnykh metaliv i dorohotsinnoho kaminnia ta kontrol za operatsiyamy z nymy: Zakon Ukrainy vid 08.11.1997 No. 637/97-BP. Available at: https://zakon.rada.gov.ua/laws/show/995-16
3. DSTU 3527-97. Vyroby zolotarski z koshtovnykh metaliv. Zahalni tekhnichni umovy (1997). Kyiv, 31.
4. Pro Pravyla torhivli dorohotsinnymy metalamy (krim bankivskykh metaliv) i dorohotsinnym kaminniam, dorohotsinnym kaminniam orhanohennoho utvorennia ta napivdorohotsinnym kaminniam u syromu ta obroblenomu vyhliadi i vyrobamy z nykh, shcho nalezhat subiektam hospodariuvannia na pravi vlasnosti: Postanova Kabinetu Ministriv Ukrainy vid 04.06.1998 No. 802. Available at: https://zakon.rada.gov.ua/laws/show/802-98-%D0%BF
5. Document 31994L0027. Eur-Lex. Available at: https://eur-lex.europa.eu/legal-content/LV/NIM/?uri=CELEX:31994L0027
6. Artyukh, T., Hryhorenko, I., Ternova, A., Yaheliuk, S., Cernavca, M. (2018). Influence of the alloy composition on determining the millesimal fineness of gold by X-ray fluorescent and assay analysis. Eastern-European Journal of Enterprise Technologies, 5 (12 (95)), 6–18. doi: https://doi.org/10.15587/1729-4061.2018.142730
7. Nazymok, M. M., Borovykov, O. Ya., Artiukh, T. M. (2010). Probirnyi kontrol. Metody analizu dorohotsinnykh metaliv. Kyiv, 368.
8. Pro zatverdzhennia Instruktsiyi pro zdiysnennia derzhavnoho ekspertno-probirnoho kontroliu za yakistiu yuvelirnykh ta pobutovykh vyrobiv z dorohotsinnykh metaliv: Nakaz Ministerstva finansiv Ukrainy vid 20.10.1999 No. 244. Available at: https://zakon.rada.gov.ua/laws/show/z0874-99
9. HSTU 47-083-02.8-2018. Splavy dorohotsinnykh metaliv yuvelirni. Metody vyprobuvannia na probirnomu kameni yuvelirnykh ta pobutovykh vyrobiv z dorohotsinnykh metaliv, vyrobiv ta materialiv, shcho mistiat dorohotsinni metaly (2018). Kyiv, 27.
10. Bredihin, V. N., Kozhanov, V. A., Manyak, N. A., Kushnerova, E. Yu. (2009). Blagorodnye metally. Doneck: GVUZ «DonNTU», 525.
11. Finkelstein, N. P. (1962). A critical review of methods for the assay and analysis of high purity gold bullion. Journal of the Southern African Institute of Mining and Metallurgy, 62 (12), 700–711.
12. Oddy, W. A. (1986). The touchstone: the oldest colorimetric method of analysis. Endeavour, 10 (4), 164–166. doi: https://doi.org/10.1016/0160-9327(86)90089-x
13. Ježek, M. (2013). Touchstones of archaeology. Journal of Anthropological Archaeology, 32 (4), 713–731. doi: https://doi.org/10.1016/j.jaa.2013.04.004
14. Marucco, A. (2004). Low-energy ED-XRF spectrometry application in gold assaying. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 213, 486–490. doi: https://doi.org/10.1016/s0168-583x(03)01608-2

15. Stankiewicz, W., Bolibrzuch, B., Marczak, M. (1998). Gold and gold alloy reference materials for XRF analysis. Gold Bulletin, 31 (4), 119–125. doi: https://doi.org/10.1007/bf03214776
16. Young, R. S. (1980). Analysis for gold. Gold Bulletin, 13 (1), 9–14. doi: https://doi.org/10.1007/bf03215123
17. Jurado-López, A., de Castro, L., Pérez-Morales, R. (2006). Application of energy-dispersive X-ray fluorescence to jewellery samples determining gold and silver. Gold Bulletin, 39 (1), 16–21. doi: https://doi.org/10.1007/bf03215528
18. Mahr, C., Schowalter, M., Mitterbauer, C., Lackmann, A., Fitzek, L., Mehrtens, T. et. al. (2018). Nanoporous gold dealloyed from AuAg and AuCu: Comparison of structure and chemical composition. Materialia, 2, 131–137. doi: https://doi.org/10.1016/j.mtla.2018.07.014
19. Morcali, M. H., Zeytuncu, B., Ozlem, E., Aktas, S. (2015). Studies of Gold Adsorption from Chloride Media. Materials Research, 18 (3), 660–667. doi: https://doi.org/10.1590/1516-1439.005715
20. Henson, B. C., Harris, J. T., Homan, K. A. (2017). Synthesis of Gold Nanorods: Avoiding Common Pitfalls. Material Matters. Available at: https://www.sigmaaldrich.com/technical-documents/articles/material-matters/synthesis-of-gold-nanorods.html
21. Ali, R., Ali, H. R. H., Batakoushy, H. A., Derayea, S. M., Elsutohy, M. M. (2019). A reductant colorimetric method for the rapid detection of certain cephalosporins via the production of gold and silver nanoparticles. Microchemical Journal, 146, 864–871. doi: https://doi.org/10.1016/j.microc.2019.02.023
22. Hashmi, M. H., Rashid, A. (1966). Colorimetric Determination of Gold, Platinum, and Cerium. Analytical Chemistry, 38 (10), 1423–1424. doi: https://doi.org/10.1021/ac60242a041
23. TU U 27.4-00201514-010:2005. Splavy na osnovi dorohotsinnykh metaliv. Tekhnichni umovy (2005). Donetsk, 12.

DOI: 10.15587/1729-4061.2019.161292

ANALYSIS AND COMPARISON OF MECHANICAL AND CHEMICAL PROPERTIES OF PROTECTIVE COATINGS OBTAINED AT DIFFERENT COMBINATIONS OF "TARGET – SUBSTRATE" (p. 19-27)

Larisa Vasetskaya
Institute of Chemical Technologies of the Volodymyr Dahl East Ukrainian National University, Rubizhne, Ukraine
ORCID: http://orcid.org/0000-0002-4873-8835

The effect of different combinations of the "target-substrate" on the mechanical and chemical properties of protective coatings obtained by ion-plasma treatment has been studied. The widespread use of ion-plasma technology for strengthening products is constrained by the imperfection of equipment, the lack of sufficient theoretical and experimental research for control and regulates the physical properties and technical parameters of the process. Eliminating these problems is possible based on further research and new solutions in the field of strengthening technology. For research in this direction, an experimental ion-plasma setup was used with software for regulating and controlling energy, dose, concentration of implanted ions, working gas pressure, coating thickness. The effective technique to improve the quality of the steel tool working surface has been applied, which made it possible to carry out mass transfer of alloying elements by ion-plasma surface treatment. Due to the controlled low-temperature two-stage ionization of nitrogen atoms and alloying elements in the reaction volume, the iron crystal lattice was saturated with implanted ions and carbonitride phases of the alloying elements, which are responsible for increasing hardness, wear and corrosion resistance. The optimal parameters of the implantation process (U_s=25 kV, I_s=35 mA, D=4.01·10^{17} cm^{-2} per hour) were revealed, which made it possible to achieve an improvement in the surface properties of structural carbon, structural alloyed, tool steels. The relationship has been established between the service life of the products and the surface properties obtained after implantation. An increase in the service life of products with TiN coating (1.5–3 times), CrN (1.9–6 times) and ZrN (3–12 times) in comparison with uncoated products is shown. An analysis was conducted and the most effective variants of combinations "target – steel substrate" for practical application of protective coatings were determined. The use of relatively inexpensive steel products with enhanced strength characteristics has economic benefits for the manufacturer and is one of the trends in modern production.

Keywords: ion implantation, protective coating, steel substrate, wear resistance, service life.

References

1. Dragunov, Yu. G. et. al.; Dragunov, Yu. G., Zubchenko, A. S. (Eds.) (2014). Marochnik staley i splavov. Moscow, 1216.
2. Ba, Z., Dong, Q., Yin, J., Wang, J., Ma, B., Zhang, X.Wang, Z. (2017). Surface properties of Mg-Gd-Zn-Zr alloy modified by Sn ion implantation. Materials Letters, 190, 90–94. doi: https://doi.org/10.1016/j.matlet.2016.12.038
3. Schibicheski Kurelo, B. C. E., de Oliveira, W. R., Serbena, F. C., de Souza, G. B. (2018). Surface mechanics and wear resistance of supermartensitic stainless steel nitrided by plasma immersion ion implantation. Surface and Coatings Technology, 353, 199–209. doi: https://doi.org/10.1016/j.surfcoat.2018.08.079
4. Borisov, A. M., Krit, B. L., Kulikauskas, V. S., Semenova, N. L., Suminov, I. V., Tihonov, S. A. (2014). Issledovanie uprochneniya poverhnosti staley pri kombinirovannom ionnom i lazernom vozdeystvii. Izvestiya Tomskogo politekhnicheskogo universiteta, 324 (2), 137–142.
5. Bystrov, S. G., Pepelyaev, N. B., Reshetnikov, S. M., Kolotov, A. A., Bayankin, V. Ya. (2017). Vliyanie implantacii ionov argona na fiziko-himicheskoe stroenie i korrozionnoe povedenie vysokohromistoy stali. Himicheskaya fizika i mezoskopiya, 19 (2), 250–258.
6. Pogrebnyak, A. D., Kaverina, A. Sh., Kylyshkanov, M. K. (2014). Electrolytic plasma processing for plating coatings and treating metals and alloys. Protection of Metals and Physical Chemistry of Surfaces, 50 (1), 72–88.
7. Proskuryakov, V. I., Rodionov, I. V., Koshuro, V. A. (2019). Issledovanie izmeneniya mikrotverdosti poverhnosti cirkoniya posle lazernoy modificiruyushchey obrabotki. Zhurnal tekhnicheskoy fiziki, 45 (6), 20–22. doi: https://doi.org/10.21883/pjtf.2019.06.47493.17598
8. Semendeeva, O. V., Uchevatkina, N. V., Ovchinnikov, V. V. (2011). Analysis of implantation features for titanic alloys, 2, 36–47.
9. Yakupov, N. M., Giniyatullin, R. R. (2011). Corrosion deterioration of the thin-walled elements processed by a method of ionic implantation. Stroitel'naya mekhanika inzhenernyh konstrukciy i sooruzheniy, 3, 74–79.
10. Wang, F., Zhou, C., Zheng, L., Zhang, H. (2017). Corrosion resistance of carbon ion-implanted M50NiL aerospace bearing steel. Progress in Natural Science: Materials International, 27 (5), 615–621. doi: https://doi.org/10.1016/j.pnsc.2017.07.003
11. Vlcak, P., Fojt, J., Weiss, Z., Kopeček, J., Perina, V. (2019). The effect of nitrogen saturation on the corrosion behaviour of Ti-35Nb-7Zr-5Ta beta titanium alloy nitrided by ion implantation. Surface and Coatings Technology, 358, 144–152. doi: https://doi.org/10.1016/j.surfcoat.2018.11.004
12. Bratushka, S. N., Sokolov, S. V. (2012). Vliyanie plazmennoy obrabotki i ionnoy implantacii na svoystva i strukturno-fazovye izmeneniya v titanovyh splavah. Fizicheskaya inzheneriya poverhnosti, 10 (2), 138–161.

13. Singh, O., Malik, H. K., Dahiya, R. P., Kulriya, P. K. (2017). Tuning of mechanical and structural properties of 20 MC 5 steel using N ion implantation and subsequent annealing. Journal of Alloys and Compounds, 710, 253–259. doi: https://doi.org/10.1016/j.jallcom.2017.03.097
14. Jie, J., Shao, T. (2017). Graded Microstructure and Mechanical Performance of Ti/N-Implanted M50 Steel with Polyenergy. Materials, 10 (10), 1204. doi: https://doi.org/10.3390/ma10101204
15. Budzynski, P., Youssef, A. A., Sielanko, J. (2006). Surface modification of Ti–6Al–4V alloy by nitrogen ion implantation. Wear, 261 (11-12), 1271–1276. doi: https://doi.org/10.1016/j.wear.2006.03.008
16. Sepitka, J., Vlcak, P., Horazdovsky, T., Perina, V. (2016). Nanomechanical Characterization of Titanium Alloy Modified by Nitrogen Ion Implantation. World Academy of Science, Engineering and Technology International Journal of Materials and Metallurgical Engineering, 10 (12), 1451–1454.
17. Carroll, M. P., Stephenson, K., Findley, K. O. (2009). Characterization of high energy ion implantation into Ti–6Al–4V. Journal of Nuclear Materials, 389 (2), 248–253. doi: https://doi.org/10.1016/j.jnucmat.2009.02.008
18. Budzynski, P., Youssef, A. A., Surowiec, Z., Paluch, R. (2007). Nitrogen ion implantation for improvement of the mechanical surface properties of aluminum. Vacuum, 81 (10), 1154–1158. doi: https://doi.org/10.1016/j.vacuum.2007.01.072
19. Vlcak, P., Sepitka, J., Drahokoupil, J., Horazdovsky, T., Tolde, Z. (2016). Structural Characterization and Mechanical Properties of a Titanium Nitride-Based Nanolayer Prepared by Nitrogen Ion Implantation on a Titanium Alloy. Journal of Nanomaterials, 2016, 1–7. doi: https://doi.org/10.1155/2016/9214204
20. Tian, X. B., Zeng, Z. M., Tang, B. Y., Fu, K. Y., Kwok, D. T. K., Chu, P. K. (2000). Properties of titanium nitride fabricated on stainless steel by plasma-based ion implantation/deposition. Materials Science and Engineering: A, 282 (1-2), 164–169. doi: https://doi.org/10.1016/s0921-5093(99)00756-x
21. Gabovich, M. D. (1972). Fizika i tekhnika plazmennyh istochnikov ionov. Moscow: Atomizdat, 304.
22. Vil'yams, Dzh. S., Pout, Dzh. M. (Eds.) (1988). Ionnaya implantaciya i luchevye tekhnologii. Kyiv: Naukova dumka, 360.
23. Pogrebnyak, A. D., Bratushka, S. N., Malikov, L. V., Levintant, N., Erdybaeva, N. K., Plotnikov, S. V., Gricenko, B. P. (2009). Vliyanie vysokih doz ionov N^+, N^++Ni^+, Mo^++W^+ na fiziko-mekhanicheskie svoystva TiNi. Zhurnal tekhnicheskoy fiziki, 79 (5), 65–72.
24. Belous, V. A., Nosov, G. I., Azarenkov, N. A. (2010). O vliyanii oblucheniya ionami Ar^+ na korrozionnuyu stoykost' metallov i splavov. Fizychna inzheneriya poverkhni, 8 (2), 161–168.
25. Sergeeva, M. H., Kohanovskiy, V. A. (2008). Surface nano level structural modification. Vestnik Donskogo gosudarstvennogo tekhnicheskogo universiteta, 8 (2), 192–197.
26. Dziuba, V. L., Kliakhina, N. P., Vasetska, L. O. (2010). Pat. No. 56823 UA. Method for nitride film producing. No. u201009062; declareted: 19.07.2010; published: 25.01.2011, Bul. No. 2.
27. Topolyanskiy, P. A., Ermakov, S. A., Sosnin, N. A. (2005). Tverdost' tonkoplenochnogo pokrytiya, nanosimogo metodom finishnogo plazmennogo uprochneniya. Tekhnologii remonta, vosstanovleniya i uprochneniya detaley mashin, mekhanizmov, oborudovaniya, instrumenta i tekhnologicheskoy osnastki: tezisy dokl. 7-oy mezhdunar. prakt. konf.-vystavki. Sankt-Peterburg, 274–298.
28. Belous, V. A., Lapshin, V. I., Marchenko, I. G., Neklyudov, I. M. (2003). Radiacionnye tekhnologi modifikacii poverhnosti. I. Ionnaya ochistka i vysokodozovaya implantaciya. Fizicheskaya inzheneriya poverhnosti, 1 (1), 40–48.
29. Gricenko, B. P., Kashin, O. A. (2004). Vliyanie vysokodoznoy ionnoy implantacii i akusticheskih kolebaniy v tribosisteme na deformacionnoe povedenie i iznosostoykost' stali 45. Izvestiya Tomskogo politekhnicheskogo universiteta, 307 (4), 121–125.

DOI: 10.15587/1729-4061.2019.164071

DETERMINING SPECIAL FEATURES IN THE TOPOGRAPHY OF PAPER WITH WATER MARKS AT THE MICRO AND NANOLEVELS (p. 28-35)

Tetiana Kyrychok
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-9639-5486

Tetiana Klymenko
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-2329-8359

Nadiia Talimonova
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-7162-859X

Katerina Svezhentsova
V. E. Lashkaryov Institute of Semiconductor Physics National Academy of Sciences of Ukraine
ORCID: http://orcid.org/0000-0002-4309-556X

We have studied the surface structure of tamper-proof paper with positive and negative watermarks at different scales – from a micrometer to a nanometer level, by using the methods of contact profilometry and atomic force microscopy. Experimental research has confirmed that the structural parameters of the tamper-proof paper's surface differ at regions with and without watermarks.

The results of measurements by a contact profilometer have made it possible to trace a correlation between values of the profile's mean arithmetic deviation and the presence of watermarks. It was determined that the value for the profile's largest height does not depend on a measurement region, which could be related to the chaotic arrangement of fibers and particles of the filler in the paper bulk that protrude above the profile's line.

By analyzing the value of the profile's mean arithmetic deviation obtained by using a method of atomic-force microscopy, it was found that for regions with negative watermarks it is larger than that for regions with positive watermarks. The dependence of the profile's largest height on measurement region is not clearly observed. This may be due to that the size of the examined region (3,000×3,000 nm) covers only part of the pulp fibers.

Thus, the results of our analysis allow us to argue that both methods are suitable for estimating the characteristics of paper's surface, and determine the character of interaction between a given type of paper and printing inks during printing process. In particular, it has been established that the method of profilometry makes it possible to determine parameters of the paper's surface profile, formed in a certain way, while the atomic force microscopy method allows analysis of the morphology of its components, located at the surface (fibers, filler's particles, etc.). The availability of information on the structural properties of paper makes it possible to predict the quality of printing reproduction, specifically clearness of reproduction of thin guilloche lines on watermarks, which is relevant because it prevents flaws in printing products for special purposes.

Keywords: tamper-proof paper, roughness, contact profilometry, atomic force microscopy, surface structure of paper.

References

1. TAPPI Standards–2012. TAPPI T 421. Qualitative (including optical microscopic) analysis of mineral filler and mineral coating of paper.

2. ISO 8791-4:2007. Paper and board. Determination of roughness/smoothness (air leak methods). Part 4: Print-surf method.
3. Habeger, C., Lyne, M. B., Mark, R., Borch, J. (Eds.) (2001). Handbook of physical testing of paper. Vol. 2. CRC Press, 560. doi: https://doi.org/10.1201/9780203910498
4. Security features integrated in banknote paper (2011). Billetaria. International Review on Cash Management, 9, 38–39.
5. Perron, M. (2010). Patenting of new banknote security features. Billetaria. International Review on Cash Management, 9, 22–23.
6. Kyrychok, P. O., Korostil, Yu. M., Shevchuk, A. V. (2008). Zakhyst tsinnykh paperiv ta dokumentiv suvoroho obliku. Kyiv: NTUU «KPI», 368.
7. Kyrychok, T., Shevchuk, A., Nesterenko, V., Kyrychok, P. (2014). Banknote Paper Deterioration Factors: Circulation Simulator Method. BioResources, 9 (1), 710–724. doi: https://doi.org/10.15376/biores.9.1.710-724
8. Kyrychok, T. Y., Kirilenko, V. M., Sukhina, E. G. (2013). Effect of wear on the electrophysical parameters of the banknotes. Proceedings of the universities. Problems of printing and publishing, 6, 3–12.
9. Kyrychok, T. (2014). Durability Banknote production. Kyiv: NTTU «KPI», 308.
10. Kyrychok, T., Havenko, S., Kyrychok, P., Sukhina, Y., Kazhmuratov, Z. (2016). Badanie elektrofizycznych właściwości papier u banknotowego i banknotów. Przegląd papierniczy, 1 (1), 52–56. doi: https://doi.org/10.15199/54.2016.1.2
11. Ionov, V. (2012). The method of expert evaluation in banknote quality assessment. Proceedings of 2nd Stochastic modeling techniques and data analysis Int. Conf. Chania, 315–324.
12. Kyrychok, T. Yu., Talimonova, N. L., Zaritska, V. I., Denysiuk, A. I. (2012). Modeliuvannia pronyknennia farby v papir z vodianymy znakamy pid chas ofsetnoho druku. Naukovi visti Natsionalnoho tekhnichnoho universytetu Ukrainy "Kyivskyi politekhnichnyi instytut", 5, 135–139.
13. Kyrychok, T., Klymenko, T., Malkush, N. (2012). Badanie szorstkosci powierzchni papierow ze znakami wodnynmi. The Investigation of Roughness for Paper with Watermarks. Przegland papierniczy, 414–417.
14. Medyak, D. M., Maslakova, I. A., Kulak, I. I. (2011). Fraktal'naya geometriya struktury poverhnosti bumagi s vodyanymi znakami. Trudy BGTU, 9, 51–56.
15. González, I., Alcalà, M., Chinga-Carrasco, G., Vilaseca, F., Boufi, S., Mutjé, P. (2014). From paper to nanopaper: evolution of mechanical and physical properties. Cellulose, 21 (4), 2599–2609. doi: https://doi.org/10.1007/s10570-014-0341-0
16. Zhukovb, M. (2014). Structure control for different types of paper by atomic force microscopy. Nauchno-tekhnicheskiy vestnik informacionnyh tekhnologiy, mekhaniki i optiki, 1 (89), 44–49.
17. Kirsankin, A. A., Mikhaleva, M. G., Nikol'skii, S. N., Musokhranova, A. V., Stovbun, S. V. (2016). Direct method of quality control surface coated types of paper. Chemistry of Plant Raw Material, 4, 159–163. doi: https://doi.org/10.14258/jcprm.2016041415
18. Chinga-Carrasco, G. (2012). Complementary microscopy techniques for surface characterisation of uncoated and mineral pigment coated paper. Current Microscopy Contributions to Advances in Science and Technology, 1448–1455.
19. Jurič, I., Ranđelović, D., Karlović, I., Tomić, I. (2014). Influence of the surface roughness of coated and uncoated papers on the digital print mottle. Journal of Graphic Engineering and Design, 5 (1), 17–23.
20. Ying, L., Beihai, H. (2011). Characterization of ink pigment penetration and distribution related to surface topography of paper using confocal laser scanning microscopy. BioResources, 6 (3), 2690–2702.
21. Maydanyuk, S. V., Plyvak, A. A., Bekmuradov, R. A. (2007). The module for measurement of shaped structures. Visnyk ZhDTU, 2 (41), 15–18.
22. Liashenko, M. Ya., Holovan, M. S. (1996). Chyselni metody. Kyiv, 285.
23. Kormen, T., Leyzerson, Ch., Rivest, R., Shtayn, R.; Krasikov, I. V. (Ed.) (2005). Algoritmy: postroenie i analiz. Moscow: «Vil'yams», 1296.
24. Filonov, A. S., Yaminskiy, I. V. (2008). Polniy programmniy paket upravleniya i obrabotki dannyh dlya skaniruyu shchey zondovoy mikroskopii FemtoSkan Onlayn. Moscow: Centr perspektivnyh tekhnologiy.

DOI: 10.15587/1729-4061.2019.164694

ANALYSIS OF CHANGE IN THE DECORATIVE PROPERTIES OF GRANITES UNDER THERMAL EXPOSURE (p. 35-43)

Valentyn Korobiichuk
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0002-1576-4025

Volodymyr Shlapak
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0002-4183-1922

Andrii Kryvoruchko
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0003-3332-2631

Ruslan Sobolevskyi
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0001-7489-8851

Natalia Zuievska
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-1716-1447

We investigated samples extracted in Ukraine from nine granite deposits experimentally. We performed tests of granite samples at high temperatures of 200, 400, 600, and 900 °C.

All presented granites showed a change in the color of surface at a temperature of 200 °C and higher. The behavior of granites under heating depends on their mineral composition, structure and texture.

Surfaces of all samples became lighter and some granite samples lost saturation of their color. The largest increase in L component (image of stone samples brightens) of the CIELab color system occurred on Cardinal Gray and Carpazi granite samples of natural stone under heating to 900 °C. The increase made up 42 and 44 %, respectively. The smallest increase in L component was on Gray Ukraine and L granites under heating to 900 °C. It made up 4 and 8.5 %, respectively.

The effect of temperature was less visible on red granite, since both fresh and heated samples had a similar red color. Flower of Ukraine granite samples acquired a uniform violet-pink color at the temperature of 900 °C due to the content of apatite and fluorite. Red spots appeared on gray granites under heating. The red spots located mainly around mica and other minerals, which were rich in Fe. Reddish-brown spots appeared at the temperature of 200 °C on green Verde Oliva granite. Red spots occupied 67 % of the sample area under heating to 900 °C.

We observed the greatest color change on granites, where the phase transition of dark-colored minerals (biotite and pyroxene) into polymorphic minerals took place. This gave granite samples a light color, as the minerals changed color from black to gray or white. Quartz provided the shades of white. White microcracks appeared under heating of quartz.

Noticeable aesthetic damage appears at temperatures from 200 to 400 °C at the surfaces of natural stone samples. Thus, one can

consider a fire with temperatures lower than this threshold as a "safe" fire in terms of aesthetic damage, if we take into consideration the heating coefficient of fire only and exclude ash and gases.

Keywords: granite, high temperatures, decorativeness of natural stone, mineral composition, granite structure.

References

1. Korobiichuk, V., Shamrai, V., Levytskyi, V., Sobolevskyi, R., Sydorov, O. (2018). Evaluation of the effectiveness of natural stone surface treatment from Ukraine by mechanical and chemical methods. Rudarsko-geološko-naftni zbornik, 33 (4), 15–21. doi: https://doi.org/10.17794/rgn.2018.4.2
2. Chakrabarti, B., Yates, T., Lewry, A. (1996). Effect of fire damage on natural stonework in buildings. Construction and Building Materials, 10 (7), 539–544. doi: https://doi.org/10.1016/0950-0618(95)00076-3
3. Freire-Lista, D. M., Fort, R., Varas-Muriel, M. J. (2015). Freeze–thaw fracturing in building granites. Cold Regions Science and Technology, 113, 40–51. doi: https://doi.org/10.1016/j.coldregions.2015.01.008
4. Vazquez, P., Acuña, M., Benavente, D., Gibeaux, S., Navarro, I., Gomez-Heras, M. (2016). Evolution of surface properties of ornamental granitoids exposed to high temperatures. Construction and Building Materials, 104, 263–275. doi: https://doi.org/10.1016/j.conbuildmat.2015.12.051
5. Prieto, B., Sanmartín, P., Silva, B., Martínez-Verdú, F. (2010). Measuring the color of granite rocks: A proposed procedure. Color Research & Application, 35 (5), 368–375. doi: https://doi.org/10.1002/col.20579
6. Korobiichuk, V., Shlapak, V., Sobolevskyi, R., Sydorov, O., Shaidetska, L. (2019). Change in the physicalmechanical and decorative properties of labradorite under thermal exposure. Eastern-European Journal of Enterprise Technologies, 1 (12 (97)), 14–20. doi: https://doi.org/10.15587/1729-4061.2019.157307
7. Kılıç, Ö. (2006). The influence of high temperatures on limestone P-wave velocity and Schmidt hammer strength. International Journal of Rock Mechanics and Mining Sciences, 43 (6), 980–986. doi: https://doi.org/10.1016/j.ijrmms.2005.12.013
8. Korobiichuk, V., Shamrai, V., Iziumova, O., Tolkach, O., Sobolevskyi, R. (2016). Definition of hue of different types of pokostivskiy granodiorite using digital image processing. Eastern-European Journal of Enterprise Technologies, 4 (5 (82)), 52–57. doi: https://doi.org/10.15587/1729-4061.2016.74849
9. Semenchenko, Yu. V., Agafonova, T. N., Soloninko, I. S., L'vova, T. V., Nazarenko, V. V. (1974). Cvetnye kamni Ukrainy. Kyiv, 186.
10. Kompaníková, Z., Gomez-Heras, M., Michňová, J., Durmeková, T., Vlčko, J. (2014). Sandstone alterations triggered by fire-related temperatures. Environmental Earth Sciences, 72 (7), 2569–2581. doi: https://doi.org/10.1007/s12665-014-3164-2
11. Dwivedi, R. D., Goel, R. K., Prasad, V. V. R., Sinha, A. (2008). Thermo-mechanical properties of Indian and other granites. Journal of Rock Mechanics and Mining Sciences, 45 (3), 303–315. doi: https://doi.org/10.1016/j.ijrmms.2007.05.008
12. De Argandoña, V. G. R., Calleja, L., Montoto, M. (1985). Determinación experimental del umbral de microfisuración térmica de la roca matriz o intact rock. Trabajos de geologia, 15 (15), 299–307.
13. Gillhuber, S., Lehrberger, G., Göske, J. (2010). Fire damage of trachyte: investigations of the Teplá monastery building stones. Geological Society, London, Special Publications, 333 (1), 73–79. doi: https://doi.org/10.1144/sp333.7
14. Hajpál, M., Török, A. (2004). Mineralogical and colour changes of quartz sandstones by heat. Environmental Geology, 46 (3-4), 311–322. doi: https://doi.org/10.1007/s00254-004-1034-z
15. Gómez-Heras, M., Smith, B. J., Fort, R. (2008). Influence of surface heterogeneities of building granite on its thermal response and its potential for the generation of thermoclasty. Environmental Geology, 56 (3-4), 547–560. doi: https://doi.org/10.1007/s00254-008-1356-3
16. Vázquez, P., Shushakova, V., Gómez-Heras, M. (2015). Influence of mineralogy on granite decay induced by temperature increase: Experimental observations and stress simulation. Engineering Geology, 189, 58–67. doi: https://doi.org/10.1016/j.enggeo.2015.01.026
17. Hajpál, M. (2006). Thermal Stresses. Fracture and Failure of Natural Building Stones, 439–445. doi: https://doi.org/10.1007/978-1-4020-5077-0_27

DOI: 10.15587/1729-4061.2019.164017

A STUDY OF THE STRUCTURE AND PROPERTIES OF MATERIAL BASED ON AN IRON – COPPER COMPOSITE POWDER (p. 44-50)

Anatoly Minitsky
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-5767-4071

Ievgen Byba
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-1696-300X

Nataliya Minitska
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-5156-7328

Sergey Radchuk
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-9232-1482

The study was conducted on the influence of chemical precipitation of copper on the change in the physical, chemical and technological properties of atomized powder based on iron. The kinetics of the copper deposition process from the solution of copper glycerate and the technological parameters of the deposition process have been established, helping obtain copper plating with adjustable thickness. The study of the physical properties of composite powders has shown that plating changes the shape, size, and morphology of the surface of particles of iron powder. Due to this, there are changes in the technological characteristics of iron powders, in particular their fluidity and bulk density increase. The study of the structure of composite powders has shown a difference in porosity at low pressures after compression, compared with the original iron powder, which is due to the best repositioning of particles at the stage of structural deformation. This allows the compression process to be carried out at lower pressures to obtain satisfactory porosity. Second pressing of briquettes based on composite powders results in a decrease in the total porosity of the material by 6–7 %, which is due to the effect of plastic copper, which is more easily deformed at a pressure of up to 800 MPa. The study of the physical and mechanical properties of composite powders has shown that plating with copper increases bending strength and toughness with hardness. The improvement of properties is due to the dissolution of copper in the iron after sintering and the formation of a solid copper solution in α–Fe. In addition, the introduction of copper by chemical precipitation allows obtaining a material with a uniform distribution of the alloying component throughout the volume of iron, which is confirmed by the results of metallographic analysis and measurement of specific electrical resistance.

There are grounds to argue that it is possible to control the amount of copper in an iron powder with a given thickness of plating by a chemical precipitation method, which helps obtain powdered material with high performance characteristics.

Keywords: plating, chemical precipitation, composite powder, moulding, compaction, sealing, morphology, impact strength, electrical resistance.

References

1. Kocyuba, A. A., Bychkov, A. S., Nechiporenko, O. Yu., Lavrenko, I. G. (2016). Poroshkovye materialy dlya aviacionnoy i raketno-kosmicheskoy tekhniki. Kyiv: KVIC, 304.
2. Tan, L., He, G., Liu, F., Li, Y., Jiang, L. (2018). Effects of Temperature and Pressure of Hot Isostatic Pressing on the Grain Structure of Powder Metallurgy Superalloy. Materials, 11 (2), 328. doi: https://doi.org/10.3390/ma11020328
3. Simchi, A. (2006). Direct laser sintering of metal powders: Mechanism, kinetics and microstructural features. Materials Science and Engineering: A, 428 (1-2), 148–158. doi: https://doi.org/10.1016/j.msea.2006.04.117
4. Mori, K., Maeno, T., Suganami, T., Sakagami, M. (2014). Hot Semi-punching of Quenchable Steel Sheet. Procedia Engineering, 81, 1762–1767. doi: https://doi.org/10.1016/j.proeng.2014.10.228
5. Li, Y., La, P., Wei, Y., Lu, Y., Yang, Y. (2011). Effect of Hot Pressing on Microstructure and Mechanical Properties of Bulk Nanocrystalline Fe3Al Materials Containing Manganese Element. Journal of Iron and Steel Research International, 18 (3). 65–71. doi: https://doi.org/10.1016/s1006-706x(11)60039-3
6. Vinogradov, G. A. (2002). Theory and Practice of Rolling Metal Powders. Powder Metallurgy and Metal Ceramics, 41 (9-10), 517–525. doi: http://doi.org/10.1023/A:1022201410282
7. Kalkanli, A., Durmaz, T., Kalemtas, A., Arslan, G. (2017). Melt Infiltration Casting of Alumina Silicon Carbide and Boron Carbide Reinforced Aluminum Matrix Composites. Journal of Material Science & Engineering, 06 (04). doi: https://doi.org/10.4172/2169-0022.1000357
8. James, B. W. (2015). Powder metallurgy methods and applications. Vol. 7. ASM Handbook, 9–19. doi: https://doi.org/10.31399/asm.hb.v07.a0006022
9. Hlosta, J., Zurovec, D., Jezerska, L., Zegzulka, J., Necas, J. (2016). Effect of particle shape and size on the compressibility and bulk properties of powders in powder metallurgy. International Conference on Metallurgy and Materials METAL 2016. Brno.
10. Benson, J. M., Snyders, E. (2015). The need for powder characterisation in the additive manufacturing industry and the establishment of a national facility. The South African Journal of Industrial Engineering, 26 (2), 104–114. doi: https://doi.org/10.7166/26-2-951
11. Yasnickiy, Yu. G., Zhornyak, A. F., Radomysel'skiy, I. D., Popichenko, E. Ya. et. al. (1976). Vliyanie sposobov izgotovleniya i tekhnologicheskih harakteristik zheleznyh poroshkov na ih pressuemost'. Poroshkovaya metallurgiya, 5, 91–96.
12. Van Laar, J. H. (2016). Spheroidisation of iron powder in a microwave plasma reactor. Journal of the Southern African Institute of Mining and Metallurgy, 116 (10), 941–946. doi: https://doi.org/10.17159/2411-9717/2016/v116n10a8
13. Gay, D. E. (1996). High performance microencapsulated powders for various P/M applications. The international journal of powder metallurgy, 36 (1), 13–25.
14. Fedorchenko, I. M., Francevich, I. N., Radomysel'skiy, I. D. (1985). Poroshkovaya metallurgiya. Materialy, tekhnologiya, svoystva, oblasti primeneniya. Kyiv, 624.
15. Maslyuk, V. A., Panasyuk, O. A., Danninger, H., Lyulko, V. G., Apininska, L. M., Minitsky, A. V. (2004). Origination and investigation of properties of powder magnetic-soft materials, based on the iron powders, clad with metal and non-metal components. Euro PM 2004. Vienna, 4, 577–581.
16. Minitskyi, A. V. (2014). Rozrobka kompozytsiynykh poroshkovykh materialiv elektrotekhnichnoho pryznachennia. Physics and chemistry of solid state, 15 (4), 818–821.
17. Lyakishev, N. P. (1997). Diagrammy sostoyaniya dvoynyh metallicheskih sistem. Vol. 2. Moscow: Mashinostroenie, 241.

DOI: 10.15587/1729-4061.2019.161951

DETERMINING THE INFLUENCE OF CARBON BLACK IN OIL ON THE WEAR RESISTANCE OF ELEMENTS IN THE TRIBOLOGICAL SYSTEM "STEEL – OIL – BRONZE" (p. 51-58)

Serhii Voronin
Ukrainian State University of Railway Transport, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-8443-3222

Oleksii Suranov
Ukrainian State University of Railway Transport, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7515-8177

Dmytro Onopreichuk
Ukrainian State University of Railway Transport, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-6314-3936

Volodymyr Stefanov
Ukrainian State University of Railway Transport, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7947-2718

Serhii Kryvonogov
Institute for Single Crystals National Academy of Sciences of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-3626-2892

Viktor Pashchenko
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-6859-0700

Hennadii Radionov
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-1112-7456

Roman Gonchar
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-0948-5422

Lyudmila Safoshkina
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-6336-8919

Mykyta Horbachov
LLC «Steel-Service», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9048-4736

The results of experimental research into the influence of the concentration of carbon black in industrial oil I-30A and on wear resistance of the tribological system "steel-oil-bronze" are presented. It is assumed that carbon black, obtained by the electric arc method under laboratory conditions, consists of conglomerates and micro- and nanoparticles of carbon, which are found in a wide range from nanometers to tenths of millimeters.

The procedure, materials, and equipment for experimental studies of wear resistance of the parts of the tribosystem "steel-bronze" on the friction machine SMC-2 was shown. The research procedure methodology involved the variation by two independent factors: concentration of carbon black in industrial oil I-30A and external loading. Sliding velocity, contour area of the contact and initial temperature of the tribosystem remained constant factors.

The obtained experimental data made it possible to establish two main patterns that characterize the process of friction and wear in the studied tribological system. The first pattern reveals the influence of the concentration of carbon black in industrial oil I-30A and external load on friction torque in the couple "steel – bronze". The second pattern reveals the influence of the same factors on wear

resistance of the parts that were tested on the friction machine. The obtained patterns correlate among themselves and determine the scope of rational concentration of conglomerates of micro- and nanoparticles of carbon in industrial oil I-30A, which was applied as a lubricant in the tested tribological system.

At the final stage of the research, the surfaces of the parts of friction were studied at the atomic-force microscope "Solver P47-Pro" made by manufacturing company NT-MDT. These studies made it possible to reveal the mechanism of modification of the surface layer of steel and bronze by carbon nanoparticles in their interaction in the tribological system at friction.

Keywords: carbon conglomerate, carbon nanoparticles, friction pair, tribological system, industrial oil.

References

1. Remarchuk, M. P. (2013). Metodyka vyznachennia stanu hidrosystem budivelnykh i dorozhnikh mashyn v umovakh ekspluatatsiyi. Naukovyi visnyk budivnytstva, 73, 306–312.
2. Voronin, S. V., Safonyuk, I. Y., Onopreychuk, D. V., Stefanov, V. O., Suranov, O. O. (2016). Analysis of properties actuating fluidtrack equipment railroads of Ukraine. Zbirnyk naukovykh prats Ukrainskoho derzhavnoho universytetu zaliznychnoho transportu, 165, 90–98.
3. Panarin, V. Y., Svavil'nyy, M. Y., Khominych, A. I., Kindrachuk, M. V. (2017). Creation of a Diffusion Barrier at the Interphase Surface of Composite Coatings Reinforced with Carbon Nanotubes. Journal of Nano- and Electronic Physics, 9 (6), 06023-1–06023-5. doi: https://doi.org/10.21272/jnep.9(6).06023
4. Mikosyanchik, O. O. (2013). Kinetic change of microhardness surface layers of metal at adaptation of boundary adsorption layers of lubricant in contact zone. Problems of friction and wear, 2, 56–61.
5. Dmitrichenko, N. F., Mnatsakanov, R. G., Mikosyanchik, O. A., Kushch, A. I. (2009). Wear kinetics of contact surfaces with use of C60 fullerene additive to motor oil. Journal of Friction and Wear, 30 (6), 399–403. doi: https://doi.org/10.3103/s106836660906004x
6. Lee, C.-G., Hwang, Y.-J., Choi, Y.-M., Lee, J.-K., Choi, C., Oh, J.-M. (2009). A study on the tribological characteristics of graphite nano lubricants. International Journal of Precision Engineering and Manufacturing, 10 (1), 85–90. doi: https://doi.org/10.1007/s12541-009-0013-4
7. Voronin, S. V., Suranov, A. V., Suranov, A. A. (2017). The effect of carbon nanoadditives on the tribological properties of industrial oils. Journal of Friction and Wear, 38 (5), 359–363. doi: https://doi.org/10.3103/s1068366617050130
8. Tochil'nikov, D. G., Ginzburg, B. M. (1999). Vliyanie C60-soderzhashchih prisadok k smazochnomu maslu na optimizaciyu processov iznashivaniya pri granichnom trenii metallov. Zhurnal tekhnichekoy fiziki, 69 (6), 102–105.
9. Ginzburg, B. M., Baydakova, M. V., Kireenko, O. F., Tochil'nikov, D. G., Shepelevskiy, A. A. (2000). Vliyanie fullerena C60, fullerenovyh sazh i drugih uglerodnyh materialov na granichnoe trenie skol'zheniya metallov. Zhurnal tekhnicheskoy fiziki, 70 (12), 87–97.
10. Baklar', V. Yu., Kuskova, N. I., Tihonovich, V. V., Gripachevskiy, A. N. (2009). Trybologic properties of nanocarbon produced by electrodischarge method. Elektronnaya obrabotka materialov, 4, 30–37.
11. Rakov, E. G. (2000). Methods for preparation of carbon nanotubes. Russian Chemical Reviews, 69 (1), 35–52. doi: https://doi.org/10.1070/rc2000v069n01abeh000531
12. Voronin, S. V., Onopreychuk, D. V., Suranov, A. A., Aminov, D. A. (2013). Reviews and analisys of desings for receive of carbons nanoparticulars by electrical arc method. Zbirnyk naukovykh prats Ukrainskoi derzhavnoi akademiyi zaliznychnoho transportu, 141, 253–258.
13. Voronin, S. V., Suranov, A. V., Suranov, A. A., Kuts, V. (2014). Selections optimal parametries of desings for receive of carbons nanoparticulars. Zbirnyk naukovykh prats Ukrainskoi derzhavnoi akademiyi zaliznychnoho transportu, 148 (1), 74–78.
14. Gribachev, V. (2008). Tekhnologiya polucheniya i sfery primeneniya uglerodnyh nanotrubok. Komponenty i tekhnologii, 12, 135–138.
15. Tihomirova, G. V. (2011). Uglerodnye nanomaterialy. Ekaterinburg: Ural'skiy federal'niy universitet, Institut estestvennyh nauk, 70.
16. Kasumov, M. M., Pokropivniy, V. V. (2007). Povyshenie vyhoda fullerenov v dugovom razryade pod deystviem potoka gaza v polom elektrode. Zhurnal tekhnichskoy fiziki, 77 (7), 136–138.
17. Gruzinskaya, E. A., Keskinov, V. A., Keskinova, M. V., Semenov, K. N., Charykov, N. A. (2012). Fullerenovaya sazha elektrodugovogo sinteza. Nanosistemy: fizika, himiya, matematika, 3 (6), 83–90.
18. Stepnov, M. N. (1985). Statisticheskie metody obrabotki rezul'tatov mekhanicheskih ispytaniy. Moscow: Mashinostroenie, 232.
19. Vinarskiy, M. S., Lur'e, M. V. (1975). Planirovanie eksperimenta v tekhnologicheskih issledovaniyah. Kyiv: Tekhnika, 168.
20. Iijima, S. (1991). Helical microtubules of graphitic carbon. Nature, 354 (6348), 56–58. doi: https://doi.org/10.1038/354056a0
21. Ando, Y., Zhao, X., Sugai, T., Kumar, M. (2004). Growing carbon nanotubes. Materials Today, 7 (10), 22–29. doi: https://doi.org/10.1016/s1369-7021(04)00446-8
22. Bhushan, B., Gupta, B. K., Van Cleef, G. W., Capp, C., Coe, J. V. (1993). Sublimed C60films for tribology. Applied Physics Letters, 62 (25), 3253–3255. doi: https://doi.org/10.1063/1.109090
23. Gupta, B. K., Bhushan, B. (1994). Fullerene particles as an additive to liquid lubricants and greases for low friction and wear. Lubrication Engineering, 50 (7), 524–528.
24. Kindrachuk, M. V., Vol'chenko, D. A., Vol'chenko, N. A., Stebeletskaya, N. M., Voznyi, A. V. (2017). Influence of Hydrogen on the Wear Resistance of Materials in the Friction Couples of Braking Units. Materials Science, 53 (2), 282–288. doi: https://doi.org/10.1007/s11003-017-0073-z
25. Mordyuk, B. M., Mikosyanchyk, O. O. (2017). Influence of Shear Component of Load Under the Friction on a Structure–Phase State and Wear of Surface Layer of Steel 1045. Metallofizika i Noveishie Tekhnologii, 39 (6), 795–813. doi: https://doi.org/10.15407/mfint.39.06.0795
26. Dmitrichenko, N. F., Mnatsakanov, R. G., Mikosyanchik, O. A., Kushch, A. I. (2005). Increase of wear resistance of the steel surface layer by modifiers of friction at rolling with sliding. Trenie i Iznos, 26 (4), 391–396.

DOI: 10.15587/1729-4061.2019.160755

STUDYING THE PHYSICAL-CHEMICAL TRANSFORMATIONS AT RESOURCESAVING REDUCTION MELTING OF CHROME-NICKEL-CONTAINING METALLURGICAL WASTE (p. 59-64)

Artem Petryshchev
Zaporizhzhya National Technical University, Zaporizhzhya, Ukraine
ORCID: http://orcid.org/0000-0003-2631-1723

Dmitry Milko
Tavria State Agrotechnological University, Melitopol, Ukraine
ORCID: http://orcid.org/0000-0002-0991-1930

Viacheslav Borysov
Donbass Institute of Technique and Management Private Higher Educational Establishment "Academician Yuriy Bugay Internationalscientific and Technical University", Kramatorsk, Ukraine
ORCID: http://orcid.org/0000-0002-3117-2118

Bohdan Tsymbal
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-2317-3428

Ihor Hevko
Donbass Institute of Technique and Management Private Higher Educational Establishment "Academician Yuriy Bugay Internationalscientific and Technical University", Kramatorsk, Ukraine
ORCID: http://orcid.org/0000-0003-1325-1434

Svitlana Borysova
Donbass Institute of Technique and Management Private Higher Educational Establishment "Academician Yuriy Bugay Internationalscientific and Technical University", Kramatorsk, Ukraine
ORCID: http://orcid.org/0000-0003-0610-644X

Andrii Semenchuk
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-6910-1868

We have investigated the physicochemical characteristics of chromium-nickel-containing waste from the production of corrosion-resistant steels and a doped alloy obtained by reduction smelting. This is necessary to determine the parameters that reduce the losses of Ni and Cr during the processing of doped oxide raw materials and using the resulting dopant. It was determined that the alloy with the O/C ratio in the charge in the range of 1.09–1.78 had the γ-Fe and Fe_3C phases with alloying elements as substitutional atoms. At O/C=1.78, the phase composition predominantly consisted of γ-Fe with a weak manifestation of Fe_3C. A phased O/C change in charge of 1.33 and 1.09 resulted in an increase in the emergence of Fe_3C on diffractograms. The microstructure of the chrome-nickel-containing corrosion-resistant steels scale mixture is disordered with the presence of particles of different sizes and shapes. The content of the alloying elements Ni and Cr was 7.65 % wt. and 14.26 % wt., respectively, at the oxygen content at the level of 29.70 % wt. The microstructure of the doped alloy with a different O/C ratio in the charge had a clear manifestation of several phases, characterized by differences in the content of the main alloying elements. The Ni content in the studied areas of different phases varied within 1.41–20.90 % wt., Cr – 1.27–32.90 % wt. According to research, the most acceptable O/C ratio in the charge is 1.78. In this case, reduction was achieved with predominance in the phase composition of γ-Fe with a relatively weak manifestation of residual carbon as the carbide component. In other words, we have determined the indicators for the processing of chromium-nickel-containing industrial wastes and the production of a doped smelting product with a relatively low carbon content. This expands the possibilities of resource saving using the obtained alloy with the replacement of a certain proportion of standard alloying materials in the smelting of carbon-limited steel grades.

Keywords: corrosion-resistant steel scale, alloyed technogenic waste, reduction smelting, X-ray phase studies.

References

1. Vojtov, V. A., Tsymbal, B. M. (2018). Study of Tribological Characteristics of Compatible Materials in Tribosystems of Extruders for Manufacturing Solid Fuel from Biomass. Journal of Friction and Wear, 39 (6), 500–504. doi: https://doi.org/10.3103/s1068366618060168
2. Ryabchikov, I. V., Belov, B. F., Mizin, V. G. (2014). Reactions of metal oxides with carbon. Steel in Translation, 44 (5), 368–373. doi: https://doi.org/10.3103/s0967091214050118
3. Mechachti, S., Benchiheub, O., Serrai, S., Shalabi, M. (2013). Preparation of iron Powders by Reduction of Rolling Mill Scale. International Journal of Scientific & Engineering Research, 4 (5), 1467–1472.
4. Shatokha, V. I., Gogenko, O. O., Kripak, S. M. (2011). Utilising of the oiled rolling mills scale in iron ore sintering process. Resources, Conservation and Recycling, 55 (4), 435–440. doi: https://doi.org/10.1016/j.resconrec.2010.11.006
5. Liu, S., Wu, H. B., Yu, W., Wang, L. D., Cai, Z. X., Tang, D. (2013). Influence of hot-rolling parameters on the microstructure and corrosion-resistance of oxide scales. Cailiao Kexue yu Gongyi/Material Science and Technology, 21 (6), 84–90.
6. Hryhoriev, S., Petryshchev, A., Shyshkanova, G., Zaytseva, T., Frydman, O., Sergienko, O. et. al. (2017). Research into recycling of nickelcobaltcontaining metallurgical wastes by the ecologicallysafe technique of hydrogen reduction. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 45–50. doi: https://doi.org/10.15587/1729-4061.2017.114348
7. Hryhoriev, S., Petryshchev, A., Shyshkanova, G., Zaytseva, T., Frydman, O., Krupey, K. et. al. (2018). A study of environmentally friendly recycling of technogenic chromium and nickel containing waste by the method of solid phase extraction. Eastern-European Journal of Enterprise Technologies, 1 (10 (91)), 44–49. doi: https://doi.org/10.15587/1729-4061.2018.121615
8. Zhang, Y., Wei, W., Yang, X., Wei, F. (2013). Reduction of Fe and Ni in Fe-Ni-O systems. Journal of Mining and Metallurgy, Section B: Metallurgy, 49 (1), 13–20. doi: https://doi.org/10.2298/jmmb120208038z
9. Huang, D. H., Zhang, J. L., Lin, C. C., Mao, R. (2011). Production of ferro-nickel granules from nickel laterite ore/coal composite briquettes by direct reduction. Beijing Keji Daxue Xuebao, 33 (12), 1442–1447.
10. Wang, L., Lü, X., Liu, M., You, Z., Lü, X., Bai, C. (2018). Preparation of ferronickel from nickel laterite via coal-based reduction followed by magnetic separation. International Journal of Minerals, Metallurgy, and Materials, 25 (7), 744–751. doi: https://doi.org/10.1007/s12613-018-1622-7
11. Pan, J., Zheng, G., Zhu, D., Zhou, X. (2013). Utilization of nickel slag using selective reduction followed by magnetic separation. Transactions of Nonferrous Metals Society of China, 23 (11), 3421–3427. doi: https://doi.org/10.1016/s1003-6326(13)62883-6
12. Zhao, L., Wang, L., Chen, D., Zhao, H., Liu, Y., Qi, T. (2015). Behaviors of vanadium and chromium in coal-based direct reduction of high-chromium vanadium-bearing titanomagnetite concentrates followed by magnetic separation. Transactions of Nonferrous Metals Society of China, 25 (4), 1325–1333. doi: https://doi.org/10.1016/s1003-6326(15)63731-1
13. Simonov, V. K., Grishin, A. M. (2013). Thermodynamic analysis and the mechanism of the solid-phase reduction of Cr_2O_3 with carbon: Part 1. Russian Metallurgy (Metally), 2013 (6), 425–429. doi: https://doi.org/10.1134/s0036029513060153
14. Simonov, V. K., Grishin, A. M. (2013). Thermodynamic analysis and the mechanism of the solid-phase reduction of Cr2O3 with carbon: Part 2. Russian Metallurgy (Metally), 2013 (6), 430–434. doi: https://doi.org/10.1134/s0036029513060165