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# Methods of Ensuring the Quality of Assembly of Non-removable Joints from Dissimilar Materials

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*ABSTRACT*

This article addresses the critical challenge of achieving high-quality surface finishing for dissimilar material joints, which is essential for aerospace, energy, and precision engineering applications. Conventional methods often fail to deliver consistent results due to material property differences. We developed an optimized magnetic-abrasive treatment (MAT) process using NdFe permanent magnets 0.6-1.2 T and composite abrasives Fe/SiC. Experimental results demonstrate that our method achieves superior surface uniformity Ra 0.6-1.0 µm with 2-3 times higher productivity compared to manual grinding. Key findings include the determination of optimal parameters B = 1.0 T, n = 460 min$^{-1}$. The novelty of this work lies in the systematic optimization of MAT for dissimilar material joints and the first demonstration of industrial scalability for components up to 0.5 m². These results expand MAT applications, offering a cost-effective alternative to exist finishing methods.

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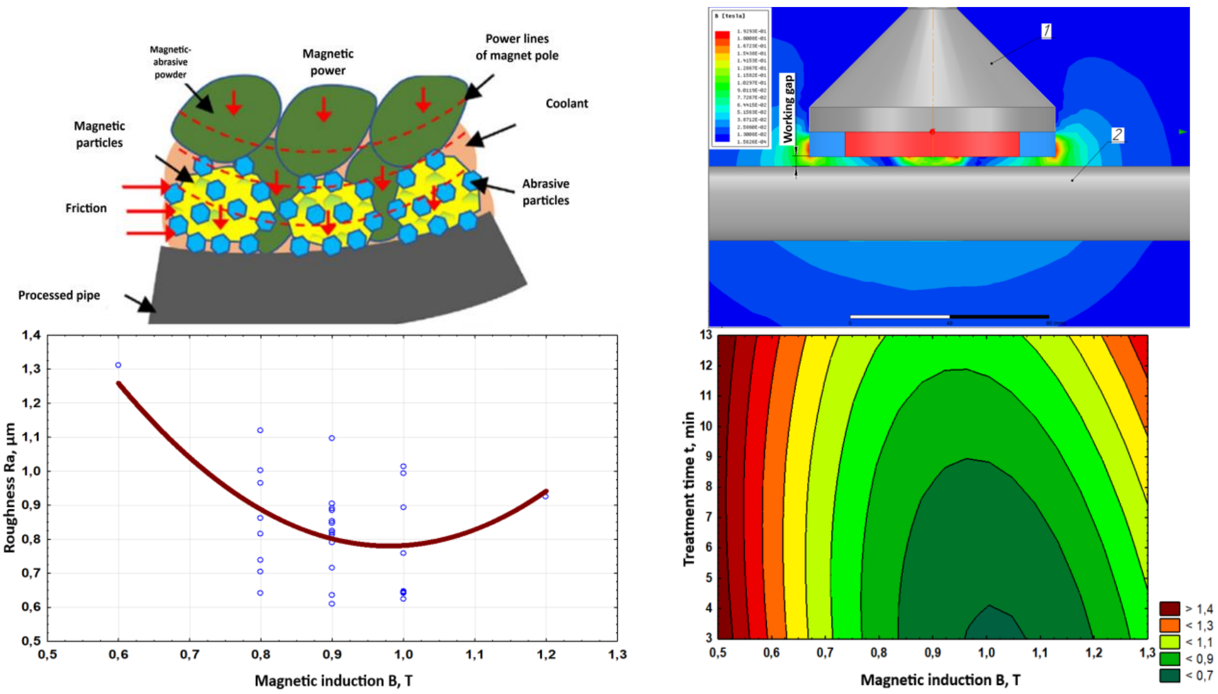
**Graphical Abstract**

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**NOMENCLATURE**

| | | | |
|---|---|---|---|
| B | Magnetic induction (T) | t | Treatment time (min) |
| n | Rotation speed ($min^{-1}$) | S | Longitudinal feed (mm/min) |
| Ra | Surface roughness (μm) | | |

## 1. INTRODUCTION

The magnetic-abrasive treatment (MAT) method is a technology that does not apply the traditional principles of chip removal. Turning, drilling holes, milling, and grinding are traditional chip removal techniques that use turning tools, milling cutters, grinding wheels, and other cutting tools to remove material from the workpiece. Tool wear is inevitable when using these methods, and the tool material must be harder than the material being processed (1). Processing high-strength materials requires significant shear forces, and the processing speed is inversely proportional to the strength of the material (2). At the same time, the release of a significant amount of heat in the cutting area limits the processing speed. Manufacturing of small-size cutting tools is difficult, which, in turn, limits the processing capabilities of small parts. Therefore, it is difficult or impossible to process small parts using traditional methods.

Magnetic-abrasive treatment is one of the modern methods of finishing materials, which is actively used to improve surface quality (3, 4). This method is based on the use of a magnetic field to control abrasive particles, which allows for high precision and uniformity of processing. Permanent magnet devices play a key role in this process, providing a stable magnetic field necessary for effective control of abrasive particles (5, 6).

Magnetic-abrasive treatment plays an important role in ensuring the quality of, for example, soldered joints of flat-oval finned pipes, which are widely used in heat exchangers. Heat exchangers are used in various industries, including the energy sector, the chemical industry, the oil and gas industry, and heating, ventilation, and air conditioning systems (7-9). It is especially important to ensure the quality of heat exchange devices in harsh climatic conditions (10-12). Their main function is to efficiently transfer heat between two or more media, which optimizes heating or cooling processes (13).

Flat-oval finned pipes, due to their design, provide a large heat exchange surface, which helps to increase the efficiency of heat exchangers (14, 15). However, the quality of the soldered joints of such pipes is critically important to ensure the reliability and durability of the heat exchanger. The use of the magnetic abrasive treatment method makes it possible to improve the surface quality in the area of the soldered joint by removing oxides and smoothing out irregularities that negatively affect the strength and tightness of the soldered or welded joint (16).

Soldering of products made of aluminum and its alloys is also complicated by the presence of an oxide film on the surface of the products, which has a melting point several times higher than the metal itself and remains as non-metallic inclusions at the root of the seam. When the aluminum surface that has just been processed on a milling machine interacts with the atmosphere, it is immediately covered with an oxide film, which tends to recover. To create a reliable welded joint, it is necessary to carefully choose the operation of pre-preparation of products before welding (17, 18).

## 2. LITERATURE REVIEW

Today, with the development of technology, expectations of precision products and their processing methods are growing (19, 20). To meet this need, researchers are developing new surface treatment methods, especially in the mining, aerospace, electronics, and medical industries (21). The treatment of abrasive particles in a magnetic field is a new and developing method that removes an allowance from the surface using abrasive and magnetic particles under the influence of a magnetic field applied to the treatment site (Figure 1) (22-24). This method ensures a high level of surface quality. In the MAT method, shear forces are controlled using a magnetic field, and the abrasive powders that polish the surface have a flexible structure, unlike the one-piece cutting tools used in traditional methods such as grinding and honing (25-27). This avoids the occurrence of stresses on the surface and eliminates microcracks, which can significantly reduce the strength of the material.

As a result of the development of technological requirements, Erden and Cerit drew the attention of engineers to more modern production methods (3). After World War II, significant efforts were made to develop new methods of final surface treatment, and the first non-traditional methods appeared between 1950 and 1970. The development of the MAT method, as an unconventional method, began in the specified period of time. Thanks to advances in materials science, materials with exceptional properties have been created that could not be processed by traditional methods due to their high strength (28). Therefore, there was a need for the MAT method (3, 29).

MAT method was first developed and applied in the Soviet Union, and then it was developed in Japan, which is still happening today (16, 30, 31). A flexible surface treatment tool is created by mixing ferromagnetic and abrasive particles in certain proportions (Figure 2). The ferromagnetic particles in the mixture keep the abrasive particles under pressure, allowing them to penetrate into the processing area and remove a certain layer of metal

(31, 32). Iron powder is usually used as magnetic particles, and materials such as silicon carbide (SiC), aluminum oxide ($Al_2O_3$), and boron nitride are used as abrasives (32, 33).

Chang et al. (32) added a lubricant that leaves a visible trace to ferromagnetic abrasive powders by mixing them mechanically, and investigated the effect of the prepared mixture during processing of stainless steels by tracking the path of particles. As a result, it was found that the most significant factors affecting the degree of chip removal and surface roughness are the working clearance during processing and the speed of rotation of the workpiece (32). Khairy (25) studied the change in surface roughness during the processing of steels using a mixture of sintered aluminum oxide ($Al_2O_3$) and iron powders. Kwak (33) investigated the effect of a mixture consisting of silicon carbide abrasives and ferromagnetic particles together with SAE 30 lubricant on the quality of cylindrical outer surfaces after MAT (34).

Lack of automatization in the MAT process is the reason that MAT is not used in industry on a large scale. MAT requires a closed control loop with a feedback system, which will provide better control of output variables by adjusting the operating parameters of the process based on feedback signals (35).

Based on the results of the analysis of scientific literature, it becomes clear that the efficiency of MAT for finishing and the rate of material removal for difficult-to-process materials such as ceramics, superalloys and glass is low. Therefore, it is necessary to consider increasing the efficiency of MAT for these materials by hybridization with other processes, for example, electrochemical and chemical.

The effectiveness of magnetic abrasive treatment depends on many physical and chemical factors. These include, for example, the force acting on individual abrasive grains (Figure 3). One of the important aspects of magnetic abrasive finishing is the creation of a high magnetic flux density in the finishing area, which significantly affects the force acting on individual ferromagnetic abrasive grains and helps to improve the finishing process (33).

## 3. PROBLEM STATEMENT

The main task in magnetic abrasive processing is to achieve an optimal combination of magnetic field parameters and abrasive particle characteristics to ensure maximum process efficiency.

Preparation for magnetic abrasive treatment includes the choice of the strength of the magnetic field, the speed of movement of the particles of the mixture and the processing time. An important aspect is also the study of the influence of various parameters on the final surface quality, including roughness and structural changes of the material (35).

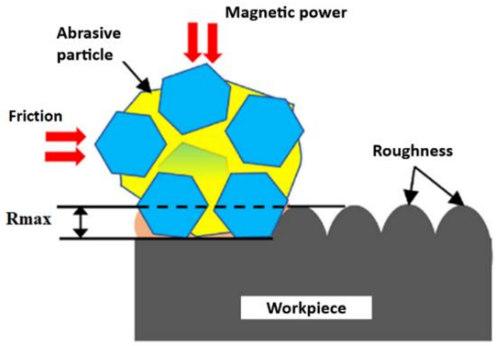


**Figure 1.** Removal of the material during magnetic abrasive treatment

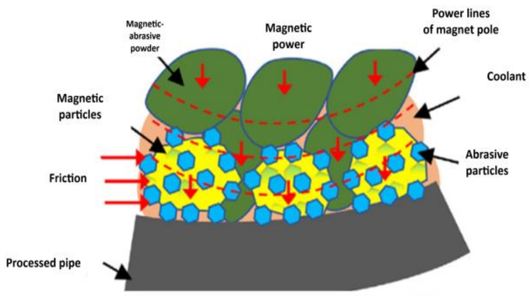


**Figure 2.** Interaction of grain groups

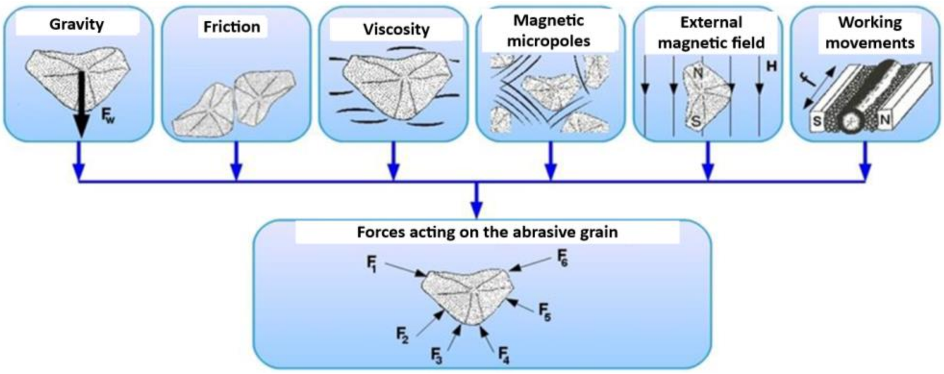


**Figure 3.** Forces acting on abrasive grain

To assess the effect of the processing mode parameters: magnetic induction B, the rotation speed of the device n, the processing time t and the feed of the workpiece S, the task was set to carry out magnetic abrasive treatment of a flat-oval tube made of aluminum alloy A93003 (AlMn).

A device similar to an end mill with permanent magnets arranged radially is usually positioned relative to the flat surface being processed by a working gap of about 2.5 mm (Figure 4). When the device passes along the processed plane of the flat-oval pipe, the surface is sanded, to which the fin plates (comb) will be soldered later.

Before carrying out magnetic abrasive treatment, it is necessary to simulate the distribution of the magnetic field, since with the help of modeling it is possible to determine the optimal parameters of the magnetic field, such as its intensity and distribution, which contributes to the implementation of processing for a specific selected device.

The uniform distribution of the magnetic field helps to avoid defects such as uneven machining or surface damage, which is especially important for difficult-to-process materials such as aluminum A93003 (AlMn).

Modeling makes it possible to minimize the cost of materials and the time required for experiments by first determining the best processing conditions (2, 29, 36).

The described device and the flat-oval tube were modeled in the KOMPAS 3D software package, then the models were placed in the workspace of the ANSYS Maxwell software package to evaluate the uniformity of the magnetic field distribution in the working gap (Figures 5 and 6). In this case, the following boundary conditions are accepted: the material of the workpiece is aluminum alloy A93003 (AlMn); the material of the pole tips is steel AISI 1017; the material of the magnets is NdFe10 neodymium magnet; the working gap is 2.5 mm.

In this case, the magnetic field distribution was estimated; for these magnets, the induction value B reached only 0.1 T, which is a small value for magnetic abrasive treatment. However, taking into account the rotation of the device on the order of 200-300 min$^{-1}$, it is assumed that the field will be uniform and processing will be carried out using more powerful NdFe40 and NdFe45 magnets.

The developed MAT approach can benefit from recent methodologies in pipeline monitoring and thermal analysis (37) for enhanced quality control in dissimilar material joints.

## 4. RESULTS AND DISCUSSION

Experimental studies were carried out, according to the results of which sections of a flat-oval pipe were treated using a device for magnetic abrasive treatment with radially arranged permanent magnets of the NdFe30, NdFe35, NdFe40, NdFe45, NdFe50 grades. Thus, the following ranges of values were selected as controlled processing parameters: magnetic induction B from 0.6 to 1.2 T, processing time t from 4 to 12 minutes, rotation speed of the device n from 115 to 460 min$^{-1}$, longitudinal feed of the workpiece S from 25 to 225 mm/min. The controlled parameter was the roughness of the treated flat surface Ra. Combinations of operating parameters and roughness results for parameter Ra are shown in Table 1.

Based on the results of experimental studies, graphs of the dependence of surface roughness Ra on magnetic induction B, processing time t, device rotation speed n and longitudinal feed S are drawn (Figure 7). Response surfaces have also been compiled, demonstrating the

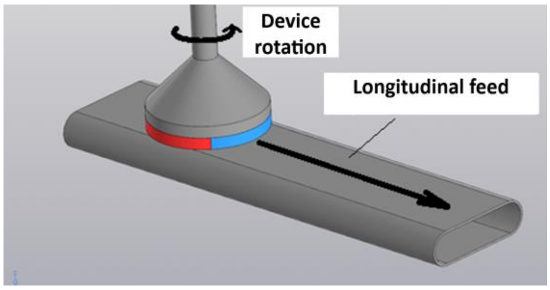


**Figure 4.** Device operation diagram

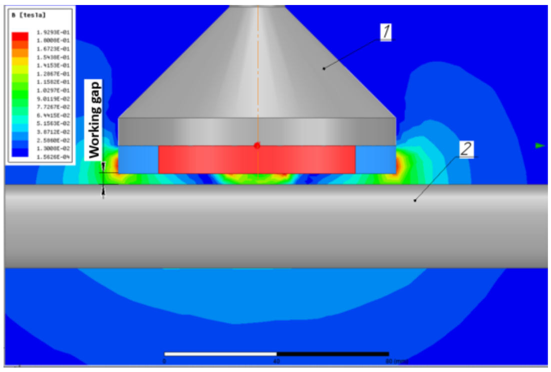


**Figure 5.** Distribution of the magnetic field in the working gap between the magnets of the device and the flat–oval tube: 1 - device; 2 – workpiece

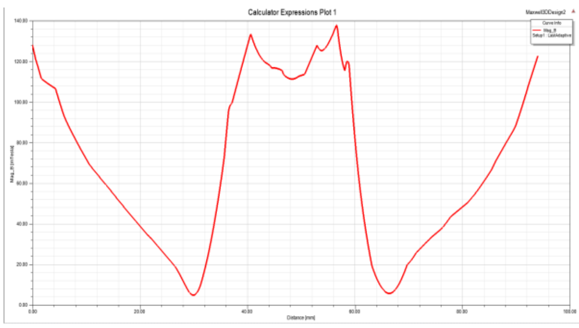


**Figure 6.** Graph of the magnetic induction distribution along the midline of the working gap

**TABLE 1.** Matrix of experimental research

| Experiment | Magnetic induction B, T | Treatment time t, min | Rotation speed n, min$^{-1}$ | longitudinal feed S, mm/min | Surface roughness Ra, µm |
|---|---|---|---|---|---|
| 1 | 0,8 | 10 | 460 | 75 | 1,002 |
| 2 | 1,0 | 6 | 460 | 75 | 0,642 |
| 3 | 0,8 | 6 | 460 | 75 | 0,815 |
| 4 | 1,0 | 10 | 190 | 75 | 0,994 |
| 5 | 0,8 | 10 | 190 | 75 | 0,965 |
| 6 | 1,0 | 6 | 190 | 75 | 1,013 |
| 7 | 0,8 | 6 | 190 | 75 | 1,12 |
| 8 | 1,2 | 8 | 300 | 125 | 0,923 |
| 9 | 0,6 | 8 | 300 | 125 | 1,31 |
| 10 | 0,9 | 12 | 300 | 125 | 1,095 |
| 11 | 0,9 | 4 | 300 | 125 | 0,635 |
| 12 | 0,9 | 8 | 750 | 125 | 0,608 |
| 13 | 0,9 | 8 | 115 | 125 | 0,715 |
| 14 | 0,9 | 8 | 300 | 225 | 0,818 |
| 15 | 0,9 | 8 | 300 | 25 | 0,889 |
| 16 | 0,9 | 8 | 300 | 125 | 0,884 |
| 17 | 0,9 | 8 | 300 | 125 | 0,852 |
| 18 | 0,9 | 8 | 300 | 125 | 0,791 |
| 19 | 0,9 | 8 | 300 | 125 | 0,903 |
| 20 | 0,9 | 8 | 300 | 125 | 0,848 |
| 21 | 0,9 | 8 | 300 | 125 | 0,824 |
| 22 | 0,9 | 8 | 300 | 125 | 0,814 |

effect of a combination of these parameters on surface roughness (Figure 8).

A comparative analysis was conducted between MAT and manual grinding for finishing aluminum alloy A93003 surfaces. The results indicate that MAT provides more consistent surface quality Ra 0.6-1.0 µm compared to manual grinding Ra 1.2-2.0 µm, while achieving 3-4 times higher productivity. Unlike manual grinding, MAT eliminates operator-dependent variability and ensures uniform treatment of complex geometries.

Our studies revealed that surface finish consistency varies by geometry complexity. For standard components flat/cylindrical surfaces, Ra variation remained within ±0.1 µm (94% consistency). However, in complex geometries (gears, internal grooves), field gradients caused localized under-treatment Ra up to 1.5 µm in concave areas versus 0.8 µm on convex surfaces. This was mitigated by implementing adaptive magnet arrays and dynamic gap control.

For industrial applications, the MAT system can be adapted in two ways: 1) integration into existing machine tool spindles for processing small-to-medium components (<0.5 m²), or 2) development of specialized machines with enhanced magnetic systems for large surfaces (>0.5 m²). While current NdFe magnets effectively handle typical industrial part sizes, scaling beyond 1 m² requires either electromagnet arrays or multi-head configurations to maintain uniform abrasive brush behavior across extended surfaces.

The study employed STATISTICA 12 for experimental design (rotatable central composite design) and data analysis, including regression modeling and ANOVA. All mathematical models (Figures 7 and 8, Table 2) were derived and validated using this software.

Most of the available scientific sources and technical literature that address MAT issues are devoted to the finishing of flat, internal and external curved surfaces of cylindrical workpieces. However, the processing of surfaces of arbitrary shape using MAT remains less studied insufficiently. The processing of machine-building industry parts with internal grooves and complex shapes, such as gears and molds, using MAT is

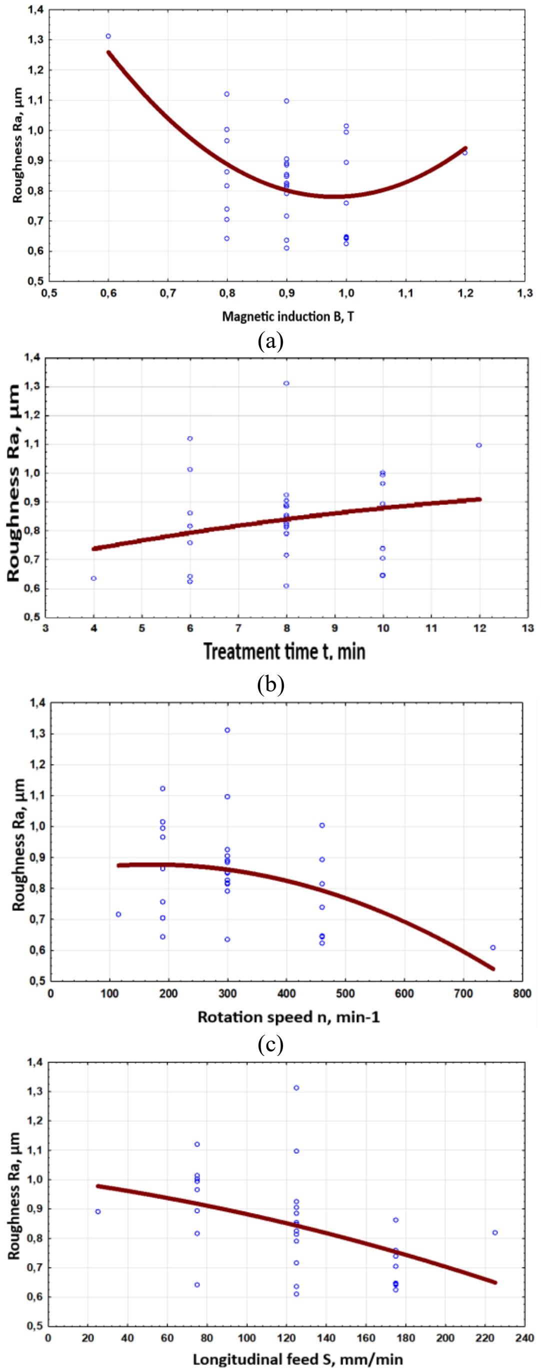


**Figure 7.** Graphs of the dependence of the roughness of the treated surface on the processing parameters: a) magnetic induction B; b) processing time t; c) rotation speed of the device n; d) longitudinal feed S

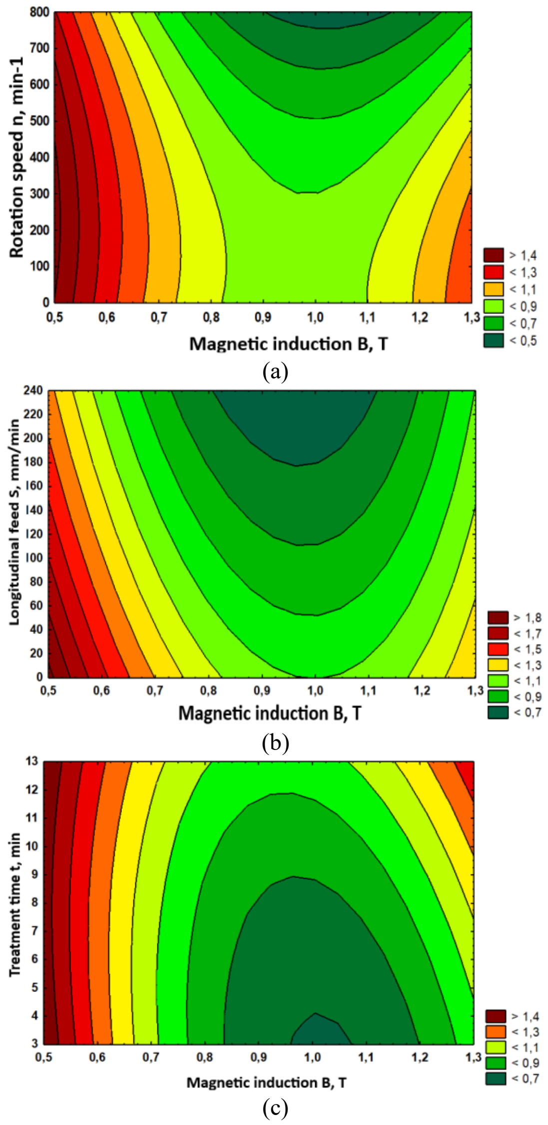


**Figure 8.** The surface roughness response surface Ra depends on: (a) magnetic induction B and rotational speed n; (b) magnetic induction B and longitudinal feed S; (c) magnetic induction B and processing time

also insufficiently researched. In addition, the processing of surfaces of arbitrary complex shapes while maintaining a constant working gap and the processing of the entire surface using software on numerically controlled machines have been studied even less. It should also be noted that there are practically no algorithms for the development and validation of devices for magnetic abrasive processing.

The results of experimental studies of magnetically abrasive treatment of a flat surface made of A93003 (AlMn) aluminum show that the use of permanent magnets in devices for MAT allows for high stability of the magnetic field, which, in turn, ensures uniform distribution of the brush of magnetically abrasive particles over the treated flat surface. This leads to a significant improvement in the processing quality, a reduction in roughness and an increase in the wear resistance of the material. When processing aluminum surfaces, roughness decreases to values close to mirror ones, which is especially important for parts operating under friction conditions. In addition, the use of permanent magnets reduces the energy consumption of the process, since there is no need for a constant supply of electric current to create a magnetic field.

For the considered ranges of MAT parameters of a flat surface, patterns of the influence of parameters on surface roughness are obtained, which are presented in Equations 1-7 (Table 2).

**TABLE 2.** Mathematical dependencies

| | |
|---|---|
| $Ra = 3{,}3986 - 6{,}5096 \cdot B + 3{,}3225 \cdot B^2$ | (1) |
| $Ra = 0{,}601 + 0{,}0385 \cdot t - 0{,}0011 \cdot t^2$ | (2) |
| $Ra = 0{,}08476 + 0{,}0003 \cdot n$ | (3) |
| $Ra = 1{,}0026 - 0{,}0009 \cdot S$ | (4) |
| $Ra = 3{,}7048 - 5{,}9731 \cdot B + 0{,}0006 \cdot n + 3{,}1121 \cdot B^2 - 0{,}0005 \cdot B \cdot n$ | (5) |
| $Ra = 4{,}339 - 6{,}6955 \cdot B - 0{,}003 \cdot S + 3{,}3546 \cdot B^2 + 0{,}001 \cdot B \cdot S$ | (6) |
| $Ra = 4{,}3395 - 7{,}0348 \cdot B - 0{,}0567 \cdot t + 3{,}3782 \cdot B^2 + 0{,}0531 \cdot B \cdot t + 0{,}0019 \cdot t^2$ | (7) |

## 5. CONCLUSION

Magnetic-abrasive treatment using permanent magnet devices is an effective method of finishing flat surfaces, ensuring high quality and precision of processing. The advantages of this method include both the stability of the magnetic field and the uniform distribution of abrasive particles in the working gap, as well as a significant reduction in energy consumption. In the future, we should expect the development of MAT technologies, which will expand the scope of the technology and increase the efficiency of processing various materials, including those that are difficult to process.

The main problems in the processing of compounds from dissimilar materials by the MAO method include:

- Differences in the coefficients of thermal expansion of materials.
- Unequal magnetic permeability of the components.
- The risk of selective processing (one material is processed more intensively than the other).
- Problems with the adhesion of abrasive particles to different materials.

Our method solves these problems through:

- Optimization of the magnetic abrasive composition.
- Magnetic field control.

This study outlines several critical directions for future research: 1) comprehensive comparative analyses between MAT and alternative finishing techniques (laser polishing, chemical-mechanical polishing); 2) extension to complex geometries (gear teeth, spherical surfaces) and internal channels requiring specialized validation algorithms; 3) development of industrial-scale equipment; 4) long-term performance evaluation under operational conditions (wear, thermal cycling, corrosion); and 5) hybrid process development (MAT-ultrasonic/EDM combinations) for superalloys and ceramics. These investigations will build upon the current methodology focused exclusively on external surface treatment.

## 6. REFERENCES


1. Yungmeister D, Lavrenko S, Yacheikin A, Urazbakhtin RY. Improving the shield machine cutter head for tunneling under the conditions of the Metrostroy Saint Petersburg mines. ARPN Journal of Engineering and Applied Sciences. 2020;15(11):1282-8.
2. Orekhova TN, Sivalneva MN, Frolova MA, Strokova VV, Bondarenko DO. The effect of mechanical and thermal treatment on the characteristics of saponite-containing material. Записки Горного института. 2025(272 (eng)):91-9.
3. CHAWLA G, MITTAL VK, MITTAL S. Experimental investigation of process parameters of al-sic-b4c mmcs finished by a novel magnetic abrasive flow machining setup. Walailak Journal of Science and Technology (WJST). 2021;18(18):9885 (13 pages)- (13 pages). 10.48048/wjst.2021.9885
4. Maksarov V, Maksimov D, Sinyukov M. Quality control of complex contour surfaces in aluminium alloy items during magnetic abrasive finishing. Tsvetnye Metall. 2023;4:96-102. 10.17580/tsm.2023.04.13
5. Jadhav S, Sawant S. Dry sliding behaviour study of novel low-metallic friction materials by using DoE-Taguchi method. International Journal of Engineering. 2024;37(3):452-9. 10.5829/IJE.2024.37.03C.01
6. Safari M, Joudaki J, Rezaei M. Investigation of Laser Cutting of Thin Polymethyl Methacrylate Sheets by Response Surface Methodology. International Journal of Engineering Transactions C: Aspects. 2024;37(3):484-95. 10.5829/ije.2024.37.03c.05
7. Shibanov D, Ivanov S, Yemelyanov A, Pumpur E. Evaluation of working efficiency of open pit shovels in real operating conditions. MIAB Mining Inf Anal Bull. 2020(10):86-94. 10.25018/0236-1493-2020-10-0-86-94
8. Wu J, Zou Y, Sugiyama H. Study on ultra-precision magnetic abrasive finishing process using low frequency alternating magnetic field. Journal of Magnetism and Magnetic Materials. 2015;386:50-9. 10.1016/j.jmmm.2015.03.041
9. Zhukov I, Martyushev N, Zyukin D, Azimov A, Karlina A. Modification of hydraulic hammers used in repair of metallurgical units. Metallurgist. 2023;66(11):1644-52. 10.1007/s11015-023-01480-w
10. Nikolaev AK, Zaripova NA. Substantiation of analytical dependences for hydraulic calculation of high-viscosity oil transportation. Записки Горного института. 2021;252:885-95. 10.31897/PMI.2021.6.10
11. Yushkova EA, Lebedev VA. Enhancement of energy efficiency of the vacuum oil distillation unit using pinch analysis. Записки Горного института. 2023(261 (eng)):415-27.
12. Pryakhin E, Sharapova D. Repair ability of low-alloyed steel strength of K70 (X90) class. Key Engineering Materials. 2020;836:131-5. 10.4028/www.scientific.net/KEM.836.131
13. Zherlygina E, Kuranova M, Gusev V, Odintsov E. Identification of hazardous sites based on studying the development of man-made fractures within the rock mass. Russ Min Ind. 2025;1:162-9. 10.30686/1609-9192-2025-1-162-169
14. Singh P, Singh L, Singh S. Manufacturing and performance analysis of mechanically alloyed magnetic abrasives for magneto

abrasive flow finishing. Journal of manufacturing processes. 2020;50:161-9. https://doi.org/10.1016/j.jmapro.2019.12.033

15. Singh DK, Jain V, Raghuram V. Experimental investigations into forces acting during a magnetic abrasive finishing process. The International Journal of Advanced Manufacturing Technology. 2006;30(7):652-62. 10.1007/s00170-005-0118-6
16. Baron YM. Magnetic abrasive deburring technology for blanks. International Journal of Engineering Research in Africa. 2016;25:1-10.
17. Barman A, Das M. Simulation and experimental investigation of finishing forces in magnetic field assisted finishing process. Materials and Manufacturing Processes. 2018;33(11):1223-32. 10.1080/10426914.2018.1453157
18. Bolobov VI, Popov GG. Methodology for testing pipeline steels for resistance to grooving corrosion. Записки Горного института. 2021;252:854-60. 10.31897/PMI.2021.6.7
19. Ivanov SL, Ivanova PV, Kuvshinkin SY. Promising model range career excavators operating time assessment in real operating conditions. Записки Горного института. 2020;242:228-33. 10.31897/pmi.2020.2.228
20. Litvinenko VS, Petrov EI, Vasilevskaya DV, Yakovenko AV, Naumov IA, Ratnikov MA. Assessment of the role of the state in the management of mineral resources. Записки Горного института. 2023(259 (eng)):95-111. 10.31897/PMI.2022.100
21. Gabov V, Zadkov D, Babyr N, Xie F. Nonimpact rock pressure regulation with energy recovery into the hydraulic system of the longwall powered support. Eurasian Min. 2021;36:55-9. 10.17580/em.2021.02.12
22. Singh DK, Jain V, Raghuram V. Parametric study of magnetic abrasive finishing process. Journal of materials processing technology. 2004;149(1-3):22-9. 10.1007/978-3-030-43312-3_8
23. Salmanian A. PM, Rezaei M. . Investigating the influence of the effective parameters on the tooth geometry of the spherical involute bevel gears through solving Napier’s equations. International Journal of Engineering Transactions A: Basics. 2026;39(1):44-58. 10.5829/ije.2026.39.01a.05
24. Singh RK, Gangwar S, Singh D. Experimental investigation on temperature-affected magnetic abrasive finishing of aluminum 6060. Materials and Manufacturing Processes. 2019;34(11):1274-85. 10.1080/10426914.2019.1628263
25. Khairy AB. Aspects of surface and edge finish by magnetoabrasive particles. journal of materials processing technology. 2001;116(1):77-83. 10.1016/S0924-0136(01)00840-8
26. Kumar R, Komma VR. Development and experimental investigation of magnetic abrasive finishing of 17-4PH steel. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science. 2024;238(10):4463-76. 10.1080/10426914.2021.2016822
27. Pandey K, Pandey U, Pandey PM. Statistical modeling and surface texture study of polished silicon wafer Si (100) using chemically assisted double disk magnetic abrasive finishing. Silicon. 2019;11(3):1461-79. 10.1007/s12633-018-9961-6
28. Ko S, Baron YM, Park J. Micro deburring for precision parts using magnetic abrasive finishing method. Journal of Materials Processing Technology. 2007;187:19-25. 10.1016/j.jmatprotec.2006.11.183
29. Girma B, Joshi SS, Raghuram M, Balasubramaniam R. An experimental analysis of magnetic abrasives finishing of plane surfaces. Machining science and Technology. 2006;10(3):323-40. 10.1080/10910340600902140
30. Sharma VK. Modeling and analysis of a novel rotational magnetorheological abrasive flow finishing process. International Journal of Lightweight Materials and Manufacture. 2021;4(3):290-301. 10.1016/j.ijlmm.2021.02.001
31. Vasiliev A. S. GAA. Special strategy of treatment of difficultyprofile conical screw surfaces of single-screw compressors working bodies. Journal of Mining Institute. 2019;235: 60-4. 10.31897/PMI.2019.1.60
32. Chang G-W, Yan B-H, Hsu R-T. Study on cylindrical magnetic abrasive finishing using unbonded magnetic abrasives. International Journal of Machine Tools and Manufacture. 2002;42(5):575-83. 10.1016/S0890-6955(01)00153-5
33. Kwak J-S. Enhanced magnetic abrasive polishing of non-ferrous metals utilizing a permanent magnet. International Journal of Machine Tools and Manufacture. 2009;49(7-8):613-8. 10.1016/j.ijmachtools.2009.01.0
34. Mishra V, Burada DR, Karar V, Manna A, Jha S, Khan GS. Investigations on flexible pad polishing for nano-finishing of freeform optics mold. Journal of Micromanufacturing. 2020;3(2):99-112. 10.1177/2516598420939740
35. Alam Z, Iqbal F, Ganesan S, Jha S. Nanofinishing of 3D surfaces by automated five-axis CNC ball end magnetorheological finishing machine using customized controller. The International Journal of Advanced Manufacturing Technology. 2019;100(5):1031-42. 10.1007/s00170-017-1518-0
36. Chen Y, Zheng Y, editors. Design and Characteristics Analysis of Electromagnets Based on ANSYS Maxwell. 2024 3rd International Symposium on Semiconductor and Electronic Technology (ISSET); 2024: IEEE. 10.1109/ISSET62871.2024.10779827
37. Major Z, Bodnár L, Merczel DB, Szép J, Lublóy É. Analysis of the heating of steel structures during fire load. 2024. 10.28991/ESJ-2024-08-01-01

Persian Abstract

**چکیده**

بااین مقاله به چالش حیاتی دستیابی به پرداخت سطح با کیفیت بالا برای اتصالات مواد غیر مشابه می‌پردازد که برای کاربردهای هوافضا، انرژی و مهندسی دقیق ضروری است. روش‌های مرسوم اغلب به دلیل تفاوت در خواص مواد، نتایج ثابتی ارائه نمی‌دهند. ما یک فرآیند عملیات مغناطیسی-سایشی (MAT) بهینه شده با استفاده از آهنرباهای دائمی NdFe 0.6-1.2 T و ساینده‌های کامپوزیتی Fe/SiC توسعه دادیم. نتایج تجربی نشان می‌دهد که روش ما به یکنواختی سطح برتر Ra 0.6-1.0 µm با ۲-۳ برابر بهره‌وری بالاتر در مقایسه با سنگ‌زنی دستی دست می‌یابد. یافته‌های کلیدی شامل تعیین پارامترهای بهینه B = 1.0 T، n = 460 min-1 است. نوآوری این کار در بهینه‌سازی سیستماتیک MAT برای اتصالات مواد غیر مشابه و اولین نمایش مقیاس‌پذیری صنعتی برای قطعات تا ۰.۵ متر مربع نهفته است. این نتایج کاربردهای MAT را گسترش می‌دهد و جایگزینی مقرون به صرفه برای روش‌های پرداخت موجود ارائه می‌دهد.