U.D.C. 621.7.043

DEVELOPING THE TECHNOLOGY OF ARTISTIC PROCESSING OF MATERIALS

E.G. Berdichevsky, Candidate of Technical sciences, Full Professor
Novgorod Yaroslav Mudry State University, Russia

Considered innovative technologies of artistic processing of metals. Recommended by laser engraving, superplastic forming, the use of nanomaterials.

Keywords: innovative technologies, laser treatment, super-plasticity, nanotechnology, nanomaterials.

Conference participant

http://dx.doi.org/10.18007/gisap:tsca.v0i9.1432

Artistic material processing technologies in some cases differ significantly from those used in general engineering. The differences are caused by different requirements for the technological processes for conventional and artistic treatment. When we are talking about artistic processing of materials, to the forefront comes the need to provide a set of aesthetic qualities of the project manufactured. When manufacturing traditional products, the crucial role played by such indicators as accuracy of the process, quality and product formation. The aesthetic qualities of art products are classified into four groups: information expressiveness, compositional integrity, decorative quality, perfection of execution. Within each group there are several specific indicators identified by the expert. Thus, the group "information expressiveness" includes such indicators as the originality of personal artistic intent, expressiveness of the style, compliance with the fashion story, compliance with the form, ergonomic requirements. The "compositional integrity" group includes such indicators as tectonics of shape, harmony, flexibility, as well as ordered graphics and visual elements. The "decorative quality" group includes such parameters as colour, tone, texture, and pattern. The "perfection of execution" group includes accuracy of the entire product, the clarity of execution paths, the purity of the execution of relief, resistance to external damage and adverse effects.

Analysis of the experience of many companies has shown that this aesthetic quality of products can be successfully achieved using the following advanced technologies: laser engraving, forming under super plastic conditions, polished nanodiamonds, the use of nanomaterials in the process of manufacturing.

Modern laser engraving system can form not only relief or pattern on the processed surfaces, but also create color schemes due to formation of surface oxide films as a result of high-temperature reactions. Change of the laser irradiation regime can affect the quality of treatment by cooling on the formed image and the performance of the process of course. Russian companies produce highly precise laser equipment able to improve the artistic decoration of metal surfaces greatly. The equipment has fairly extensive changes in the specific area of the irradiation power, where the melting of the surface layer occurs (which provides a diverse colour palette). The equipment is fitted with solid-state systems, pumping energy of the fibre laser oscillator, which is located in the scanning head. This allows obtaining even in-depth high quality images on metals with high thermal conductivity.

In future the technology of laser engraving on the pre-coated steel should be recognized. It is shown that the velocity of the laser beam at 40 mm/sec with the modulation frequency ranging from 2 to 6 kHz and a current of at least 32A provides complete removal of the nickel coating thickness up to 8 microns. Further deposition of the oxide coating leads to achieving a rich black background image. The acceptable height of asperities of the laser-treated surface is 20 microns. It is achieved at the speed of the beam over 10 mm/sec. Clarity of line drawing reproduced is provided at the laser beam diameter not more than 0.03-0.05 mm.

When you clone the usual standard parts, the bulk of the work piece is usually processed in conditions of super-plasticity. When artistic processing of materials takes place, super plasticity should be used in stamping. The essence of the technology lies in the gradual heating of the thin-walled parts with fine-grained structure to the manifestation of the super-plasticity effect (for example, brass up to 500-700 digress Celsius), and subsequent deformation in the form of a matrix by the pressure of compressed gas (0.5-2 MPa). Super-plasticity deformation can create complex highly artistic topography with the relatively simple processing equipment. The technological process provides for the isolation of the product design, especially hard-relief elements requiring the pressure and deformation most of the time. The duration of the process of superplastic forming of a complex artistic terrain can take up to 60 minutes; formation takes place at a pressure of up to 1.25 MPa. If these modes are increased, this may lead to disappearance of the super-plasticity effect due to structural transformations in the deformed metals.

This technology can form highly artistic terrain relief elements with thinning to 0.2 mm, as well as elements with angular sizes ranging from 10 to 120 digress. Traditional stamping is often unable to provide similar image quality moulding.

When forming the artistic profile of the high-alloy steels in conditions when the effect of super-plasticity is difficult to achieve or impossible, we can recommend such advanced technology as hydro-pulse stamping.

Polishing is one of the leading technologies in the processes of artistic processing of materials, as it provides not only the desired surface roughness, but also the aesthetic characteristics, such as glare, reflectivity, opacity, susceptibility to decorative coatings. Polishing can open or conceal the texture of the material, depending on the designer's plan.

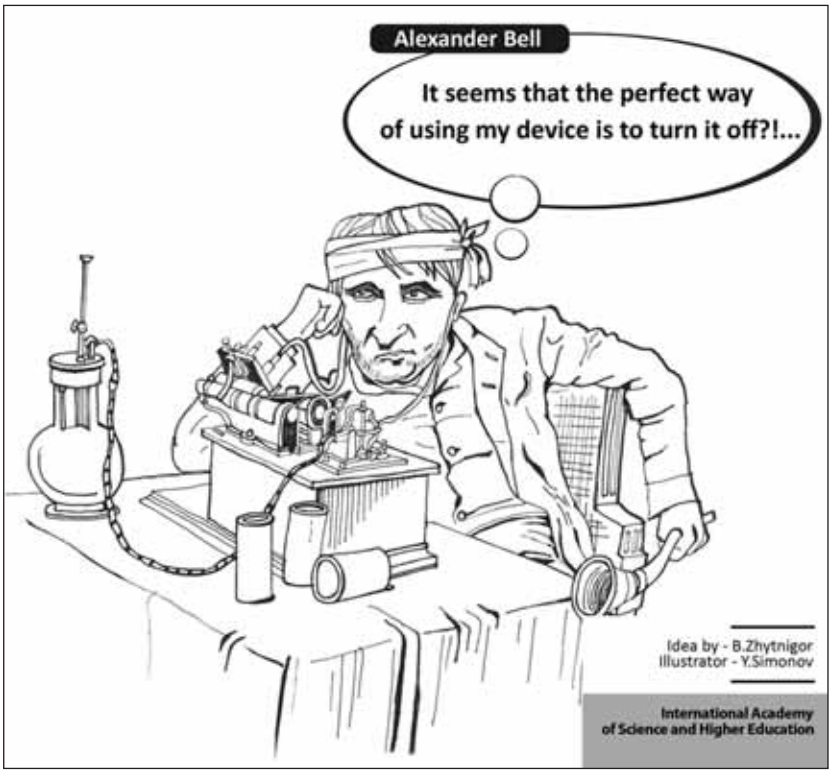
Traditional polishing technologies, used in general engineering, are ineffective in relation to the art products. Innovative solution is to use the polishing compositions of nanocarbon diamonds (among the leaders in nanomaterials). Nanodiamod charge is the primary product of detonation synthesis and is a homogeneous black powder. The absorption coefficient is 99% of the blackbody. The content of nanodiamonds in the charge is 30-60%, specific surface - 400÷500 m^2/g. Bulk density is 0.4÷0.6 g/sm^3. The average size of single crystals is 120÷140 nm. The particle charge is negative. Starting air temperature of oxidation - 350°C.

Nanodiamond particles are aggregated into complex structures, the magnitude of which depends on the methods of preparation and polishing compound of the composition of the dispersion medium. Nanodiamonds have a strong structuring effect on the polishing composition in an amount of 0.1÷0.3%. The complex structure of nanodiamonds promotes effective dissipation of local stress arising from the strains and stresses in the surface layer. For optimization of processing and polishing of material the alignment of the relief is observed in all cases. At the same time highly aesthetic mirror surface of different levels of glare and without micro-defects is formed.

The advantages of nanodiamond polishing are vital, as they cover relatively high cost of nanomaterials.

Preservation of art and decorative relief images on the metal surface is a responsible procedure. Traditionally, the hydrophobizing layer was applied in order to ensure the protection of the outer surface of the artistic product. This technology is unreliable due to the short time needed for the protective layer to crock. Peeling of the protective layer after cracking causes additional damage to the aesthetic qualities of the surface. The solution is to use ultrathin films of nanomaterials on the basis of water-soluble polymers as protective coating. The stabilizing effect of such coatings is based on the fact, that nanomaterial acts as a scavenger of free radicals, and thereby interrupts the processes of oxidation and degradation of the surface material of artistic products. Studies have shown that such a mechanism of action of the hyperfine nonocoating does not require preservation of its full integrity. Even in the presence of cracks and uncovered areas of the surface properties of nano-safety are maintained. The described technology is especially effective for protection of monuments, sculptures and antiques.

In summary, we would like to conclude that the considered innovative technology, based on laser engraving, super-plasticity effects and the use of nanomaterials, is very promising and can be recommended for widespread use in the artistic treatment of materials.



References:

1. Afonkin, M.A., Larionov E.D., Mountain S.V. Analysis of technological possibilities of laser and engraving complexes., Photoequipment. - 2010., No. 5., pp. 4-10.

2. Matyushina, A.E., Chezny, M.M. Investigation of the effect of laser irradiation on the cover for engraving on steel ornament., Design. Materials. Technology. – 2007., No. 2 (3)., pp. 74-77.

3. Tsepin, M.A, etc. Assessment of the condition of the equipment and tools at their heating and superplastic forming of products with artistic relief. Forging and stamping production. - 2005., No. 11., pp. 28-32.

4. Korovkin, O.N. Improvement of design and manufacturing techniques of a relief of art products sheet superplastic formovka. Author's abstract edging. Dissertations. - Kirov, 2007. – 23 p.

5. Zemtsov, M.I. Ocenka predel'noj stepeni formoobrazovanija pri jelektrogidroimpul'snoj formovke iz trubchatyh zagotovok tonkostennyh mnogogrannyh detalej [Assessment of the marginal degree of shaping at the electric hydro-impulsive forming of thin-walled multifaceted details using the tubular blanks]., Design. Materials. Technology. - 2010., No. 2., pp. 45-49.

6. Dolmatov, V.U. Modern industrial technology of receiving detonation nanodiamonds and main areas of their use. Works of the international scientific and practical conference «Nanotechnologies – to production 2006». – Fryazino., 2006., pp. 113-151.

7. Zuyev, V.V. Superthin fullerenovy coverings for protection of monuments of architecture. Works of the international scientific and practical conference «Nanotechnologies – to production - 2006». – Fryazino., 2006., pp. 249-251.

Information about author:

1. Evsey Berdichevsky - Candidate of Technical sciences, Full Professor, Novgorod Yaroslav Mudry State University; address: Russia, Novgorod-city; e-mail: bersev@mail.ru