V. I. Savuliak, Dr. Sc. (Eng), Prof.; A. A. Lichmam

IMPROVEMENT OF SURFACED COATINGS STRUCTURES WITH SHOCK—VIBRATING MACHINING

The paper analyzes the possibilities of improving the structure of coatings, applied by surfacing, combining shock—vibrating machining and thermal impact. Minimization of energy costs and technological efficiency is suggested to be provided by the use of heat, generated in the process of coating deposition from welding arc. Analysis of the known research performed and results of the studies, carried out by the authors of the given paper allows to consider the research to be viable both in scientific and applied aspects to ensure the quality of machine parts and structures.

Key words*: coating, deposition, structure, shock—vibrating ultrasonic machining, Charpy principle, wear-resistance.*

Introduction. Cost effectiveness, availability and versatility - these are the main criteria that characterize small-scale and single-unit production. However, the cost of the finished products of these enterprises is several times more expensive as compared to mass production. The cost of universal technological equipment several times exceeds the cost of highly specialized equipment. Number of technological operations, lack of conveyor or production lines also has a significant impact on pricing. However, market demand varies from year to year and adaptation of mass production to new environment is becoming more difficult, versatility of small-scale enterprises allows them to carry out the conversion faster. Therefore, the development of new universal methods of production or uniting of the existing ones and creation on their base hybrid methods of parts processing nowadays is very relevant problem.

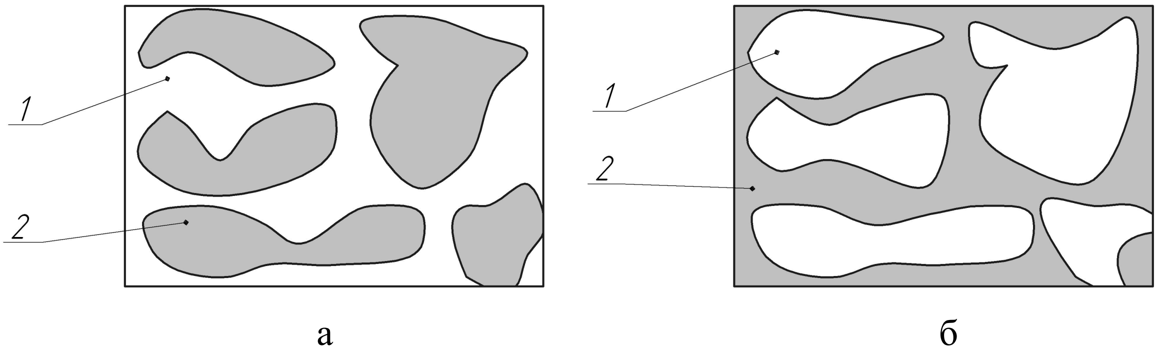
Aim of the research - analysis of the possibility to improve the structure of the surfaced coatings deposited by combining shock-vibrating machining with thermal impact.

Results of the research and their discussion. Main components of parts durability are materials, they are made of and methods of their machining . The usage of expensive alloy steel grades, having necessary specifications, can partially solve the problem, but the cost of these materials brings into question the expediency of their use. As the necessary properties of these alloys are not used in full volume of the detail, but only in the surface layers –it is not unreasonable to replace greater part of high- strength alloyed material by less expensive material - carbon steels with their further surface strengthening. Such methods of surface strengthening as carbonization and nitriding are very lengthy processes and have significant structural limitations. Using of traditional methods of surface plastic deformation (such as metal treatment under pressure and shock-vibrating machining) does not always produce expected results and they are usually not sufficient to get the required strength of the surface layer. Thermal methods of strengthening (hardening, annealing, aging, etc.) are promising but have constructive limitations. Such methods of strengthening are not used for low carbon steels.

The use of carbon steels with subsequent application of the composite materials on the working surfaces of the workpieces enables to reduce significantly the cost of materials and get the necessary wear resistance and strength, further pressure shaping will provide inverted structure of the obtained coating.

However, it should be noted that the wear resistance and structural strength of materials, in which the composite principle of strengthening by hard spots (carbides, borides, silicides, etc.) is realized, greatly depends on the structural condition [1,2]. Composite materials, where the structural principle Charpy is implemented , have better resistance to friction wear and fatigue strength.

Fig.1 shows the diagram of the composite material microstructure, consisting of two components: soft, but shockproof phase 1, and solid, wear proof, but more brittle phase (or structural component) 2.



1 - soft plastic phase; 2 - hard, wear proof phase
Fig. 1. Diagram of the composite material components

The case,where the Charpy principle is realized, is shown in Fig. 1, a. Crystals of solid, but wear-resistant phase 2 are surrounded by viscous matrix 1 and are not in contact with each other. This location is the best, and in this case the positive properties of the components are used to the full extent and negative - are leveled: solid phase 2 prevents from deformation and wear, soft shockproof phase 1 holds from chipping the particle of phase 2 and prevents from spreading of microcracks, formed in the structure of the solid phase 2.

The opposite case (Fig.1, b) shows the negative combination of properties of phases 1 and 2. Shares of the soft phase 1 are isolated from each other by a solid grid of fragile phase 2,that is an ideal conductor for spreading of microcracks. Under the impact of external stresses microcracks grow into continuous crack , leading workingpiece failure .

The structure, shown in Fig. 2, illustrates the case where the Charpy principle is not realized: in unalloyed eutectic white cast iron the structure of ledeburite usually consists of cylindrical rods of austenite that is transformed, when cooled, into pearlite or ferrite. Although the amount of such austenite reaches approximately 50% (and in hypoeutectic cast irons is even higher) its plastic properties can not be realized to full extent because these rods are isolated from each other by a solid matrix of ledeburite cementite.

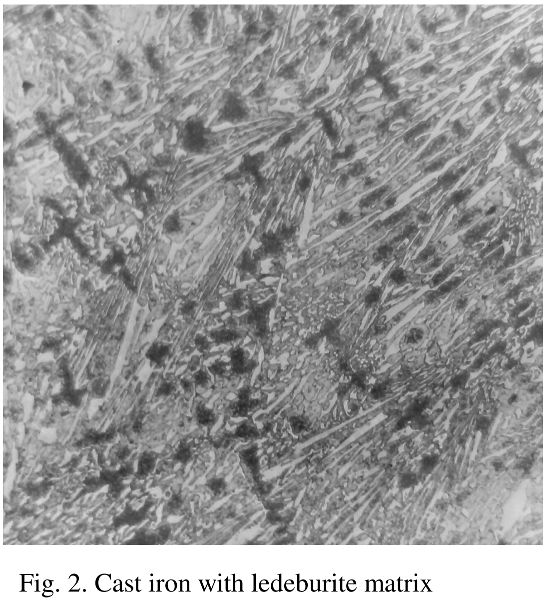


Fig. 2. Cast iron with ledeburite matrix

Such structure cannot be corrected only by heat treatment, but addition of alloying elements such as Ti, V, Cr, and others enables to obtain the globular structure of inclusions, surrounded by ferritic matrix (Fig. 3). Cracks that arise in brittle inclusions under the influence of internal stress, do not spread further and high ductility and weldability of the ferrite contributes to their self-healing.

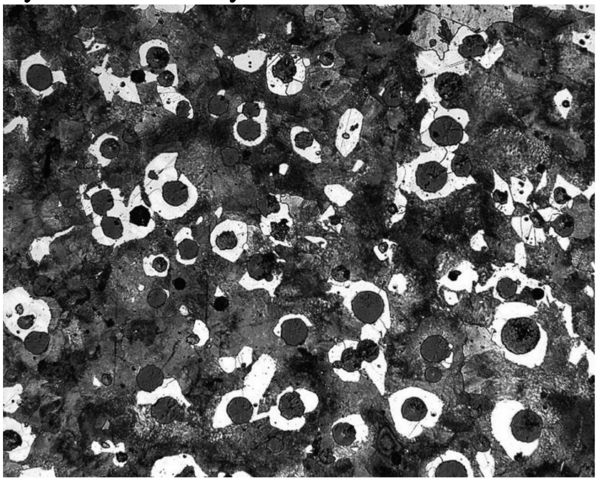


Fig. 3. The structure of the alloy by Charpy principle structure

But as the practice of previous studies shows[3], to obtain the necessary characteristics only alloying is not sufficient. The use of alloying along with plastic deformation gives significantly better results and provides qualitatively better characteristics of high- carbon alloy. By means of plastic deformation one and the same alloy can be inverted from the structure, that does not correspond to Charpy principle (Fig. 1, b), into the structure that completely corresponds to this principle Fig. 1, a.

Excellent results can be obtained using the combined methods of local heating of the surface layer, with simultaneous ultrasonic treatment of the heated layer (Fig. 4).

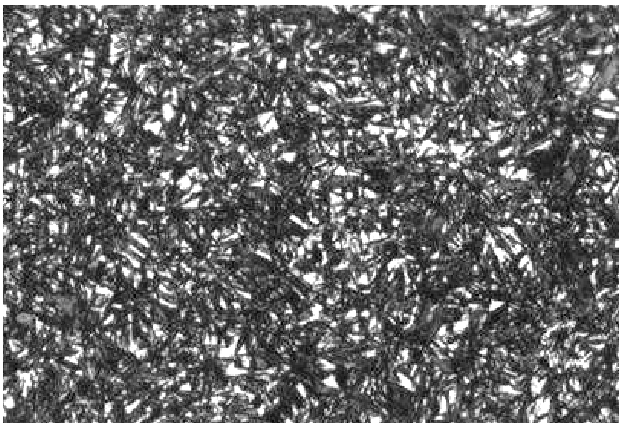


Fig. 4. Fine-grained steel structure

In the studies [4] significant improvement of the microstructure of steel12HMF surface layer due to chromium carbides grains refinement was theoretically proved and practically confirmed: at the initial state their size was ≈ 350 nm, and after a combined machining (laser irradiation + ultrasonic machining) ultrafine structure with the grain sizes of ≈ 80 nm, boundaries of which are blocked by a large number of secondary dispersed carbides with the size of ≈ 20 nm, was formed . Also, these studies showed that if the above-mentioned types of strengthening are used separately, the result of grains refinement is almost two times less.

Similar studies, regarding the weld were conducted by A. I. Paschenko [5]. The results of the research showed that machining of the weld by superficial deformation allows to improve strength and fatigue resistance.

From the above- mentioned research the conclusion can be made : one and the same chemical composition of the steel, depending on the methods of its processing may comply with Charpy principles or not.

However, the cost of ultrasonic and laser equipment substantially limits the possibilities of small enterprises. Therefore, based on the positive experience of combining heat and vibration methods of surface treatment [4], the problem of development of such methods in which shock-vibrating surface treatment is combined with traditional and available methods of coating, including spraying and welding becomes urgent. It should also be noted, that the coating of unalloyed carbon steel significantly reduces the cost of the work piece material and modern methods of spraying enable to obtain coating of necessary chemical composition and thickness. The analysis of vibroimpulsively processed hot weld metal showed:

1.Plastic deformation of hot metal removes stress, arising during thermal impact.

2 Formation of cold-work hardening surface is provided, weld metal porosity reduces.

3. More uniform formation of the applied layer thickness is provided .

4Separation of slag and crust is provided, thus the purity of further application of surfacing rolls under the radial surfacing of working surfaces of cylindrical parts is improved .

CONCLUSION:

1. Usage of carbon structural steels as the base of work piece and further application of wear-resistant material provides low cost of production and the combination of this method of strengthening with vibrating methods of surface hardening enables to obtain coating with inverted fine-grain structure.

2. Methods of combining ultrasonic treatment along with strengthening by means of laser irradiation are investigated thoroughly but forging methods with lower frequencies and greater energy of blow of weld deposit are not studied in full and need further research.

REFERENCES

1. Жуков А. А. Износостойкие отливки из комплексно-легированных белых чугунок / А. А. Жуков, Г. И. Сильман, М. С. Фрольцов. – М. : Машиностроение, 1984. – 104 с.

2. Savulyak V. I. The Structure of the cementite phase in the constructional alloys on the Fe-C base / V. I. Savulyak, A. A. Zhukov, T. F. Arkhipova // Journal “Modeling and Optimization in the Machines Bulding Field”. Romanian Academy. – 1999. – V. 5. – P. 5 – 8.

3. Савуляк В. І. Підвищення зносостійкості циліндро-поршневих пар гідромашин шляхом використання високовуглецевих сплавів заліза з інвертованою структурою / В. І. Савуляк // Проблеми техніки. – 2003. – № 1. – С. 146 – 153.

4. Джемелівський В. В. Комбіноване лазерно-ультразвукове поверхневе зміцнення деталей і можливості його використання при виробництві та ремонті обладнання / В. В. Джемелівський, Д. А. Лесик // Збірник наукових праць (галузеве машинобудування, будівництво). ПолтНТУ. – 2014. – № 3 (42). – С. 61 – 69.

5. А. с. 111494 СССР. МКИ 21 Н 30/10. Способ проковки сварных соединений / А. И. Пащенко. – №8319/576122 ; заявл. 17.12.55 ; опубл. 1955.

Savuliak Valeriy – Dr. Sc. (Eng.), Professor, Head of the Chair of Wear Resistance Increase.

Lichmam Artom – Master of Science in Engineering with the Chair of Wear Resistance Increase.
Vinnytsia National Technical University.