Robot laser hardening and describe mechanical properties of nanomaterials with mathematical method

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Abstract

This paper describes some of our experience in laser surface remelting, consolidating, and hardening of steels. The process of laser hardening with remelting of the surface layer allows us to very accurately determine the depth of modified layers. In this procedure, we know the exact energy input into the material. Heating above the melting temperature and then rapidly cooling causes microstructural changes in materials, which affect the increase in hardness. Mathematics and Computer Science are very useful in many other Science. We use mathematical method, fractal geometry in engineering, exactly in laser technics. Moreover, with fractal geometry we analize complexity and nanostructure of robot laser hardened specimens. We analize specimens hardened with different parameters of robot laser cell. So we changed two parameters speed v ∈ [2, 5] mm/s and temperature T ∈ [1000, 1400] °C. In this work, we have used a scanning electronic microscope (SEM) to search and analyse the fractal structure of the robot laser hardened specimens. The present study is intended to use new method, fractal geometry to describe completely mechanical properties of robot laser hardened specimens. Finally, concept of fractal geometry is applied to characterize the nanostructure and derive the useful relationship between fractal dimension and nanostructural features.

Key words: Engineering, technology, fractal structure, material, laser, hardening,

Introduction

Laser hardening is a metal surface treatment process complementary to conventional ame and induction hardening processes. A high-power laser beam is used to heat a metal surface rapidly and selectively to produce hardened case depths of up to 1,5mm with the hardness of the martensitic micro-structure providing improved properties such as wear resistance and increased strength. Fractal patterns are observed in computational mechanics of elastic-plastic transitions. The Fractal dimension is a property of the fractal, which is maintained through all the extensions and is therefore well dened. In addition, it shows how complex the fractal is. The Fractal dimension is generally not calculated by the above-mentioned procedure, as this is possible only on pure mathematical constructs, which do not exist in nature. Fractals is a new branch of mathematics and art. Perhaps this is the reason why most people recognize fractals only as pretty pictures useful as backgrounds on the computer screen or original postcard patterns. Most physical systems of nature and many human artifacts are not regular geometric shapes of the standard geometry derived from Euclid. Fractal geometry offers almost unlimited ways of describing, measuring and predicting these natural phenomena. Fractal structures we can find in robot laser hardened patterns to if we observed it with electron microscope. Robotic laser surface hardening heat treatment is complementary to the conventional flame or inductive hardening. The energy source for laser hardening, the laser beam which heats up very quickly and the metal surface area of ponds up to 1.5 mm and a hardness of 65 HRC.

Materials preparation and experimental method

We made patterns of a standard label on the materials according to DIN standard 1.7225. We hardened tool steel with the laser at different temperature T ∈ [1000, 1400] ° C with steps 100 ° C and different speed v ∈ [2, 5] mm/s. In all these attempts we have made picture of microstructure. We made recordings of hardened surface area. Also, we wanted to know or find the fractal structure of the optimal parameters of hardening. Each pattern was etching and polish, before we looked it with a microscope. First, we made recordings using an optical microscope and then with an electron microscope. Images were made by field emission scanning electron microscope JSM-7600F JEOL company. Figure 1 shows the longitudinal and transverse cross-section of hardened materials 1.7225.

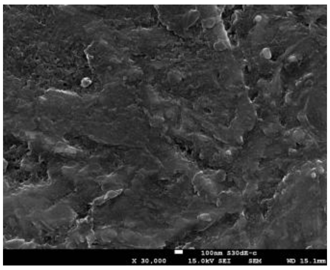

Fig. 1: Microstructure of robot laser hardened specimen with 1000° C and 2 mm/s

We use mathematical method, fractal geometry to describe complexity of hardened specimens. In Fig. 2 are presented calculation of fractal dimension. Firstly, we convert SEM micrograph to binary picture. To calculate fractal dimension we use box couting algorithem. Log-log plot present the fractal dimension.

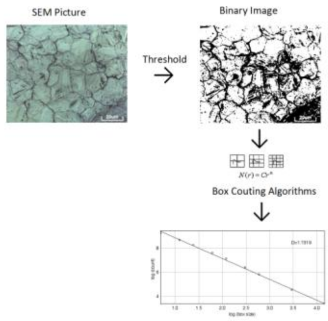

Fig. 2: Calculation of fractal dimension with box couting method

Conclusion

The paper present using fractal geometry to describe mechanical properties of robot laser hardened specimens. We use relative new method, fractal geometry to describe complexity of laser hardened specimens. The main findings can be summarized as follows:

1. There exist a fractal structure in the robot laser hardening specimens.
2. We describe complexity of nanostructure with fractal geometry of robot laser hardened specimens.
3. We have identified the optimal fractal dimension of different parameters robot laser hardened tool steel.
4. We use box-couting method to calculated fractal dimension for robot laser hardening specimens with different parameters.
5. Fractal dimension varies between 1 and 2. By increasing the temperature of the robot laser cell becomes a fractal dimension larger and nano-grain size becomes smaller. Then we can use the fractal dimension as an important factor to define the nano-grain shape.

3. Acknowledgements

The present work was supported by the European Social Fund of the European Union.

4. References

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