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USE ALGORITHM FOR CONSTRUCTION 3D VISIBILITY GRAPHS TO DESCRIBE PLASTIC AND ELASTIC DEFORMATION OF ROBOT LASER HARDENED SPECIMENS

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Abstract: *Visibility graphs have many applications. One of all applications is analyze trend line of market graph. Here we use 2D visibility graph for analyze it. Construction for 2D visibility graph is known. But in this paper, we will present algorithm for construction 3D visibility graphs. 3D Visibility computations are central in any computer graphics application. Drawing graphs as nodes connected by links in 3D space is visually compelling but computationally difficult. Construction of 3D visibility graph have big time complexity, thus require high professional computer or supercomputer. Article describe new method, algorithm for analyze 3D visibility graphs. We develop algorithm, which draws 3D visibility graphs, for analyze microstructure pictures of robot laser hardened specimens. Microstructure of robot laser hardened specimens is very complex, but we can present it with 3D visibility graphs. Algorithm for construction 3D visibility graph is very usefull in many cases, including illumination and rendering, motion planning, pattern recognition, computer graphics, computational geometry and sensor networks, military and automotive industry. This new algorithm we use to patterns recognition. In materials science, deformation is a change in the shape or size of an object due to an applied force (the deformation energy in this case is transferred through work) or a change in temperature (the deformation energy in this case is transferred through heat). With 3D visibility graphs we described elastic and plastic deformation of robot laser hardened specimens. For analysis of results, we use an intelligent system method, namely, a neural network, linear regression and support vector machine. We compare all methods.*

Keywords: *Elastic and plastic deformation, visibility graph, robot, laser, hardening,*

1. INTRODUCTION

In materials science, deformation is a change in the shape or size of an object due to an applied force (the deformation energy in this case is transferred through work) or a change in temperature (the deformation energy in this case is transferred through heat). The first case can be a result of tensile (pulling) forces, compressive (pushing) forces, shear, bending or torsion (twisting). In the second case, the most significant factor, which is determined by the temperature, is the mobility of the structural defects such as grain boundaries, point vacancies, line and screw dislocations, stacking faults and twins in both crystalline and non-crystalline solids. The movement or displacement of such mobile defects is thermally activated, and thus limited by the rate of atomic diffusion. Deformation is often described as strain.

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 1,5 mm with the hardness of the martensitic microstructure providing improved properties such as wear resistance and increased strength. We will find parameters of robot laser hardened cell, because we will reduce deformations. We observe a microstructure of robot laser hardened patterns. We find plastic and elastic deformations.

Depending on the type of material, size and geometry of the object, and the forces applied, various types of deformation may result. The image to the right shows the engineering stress vs. strain diagram for a typical ductile material such as steel. Different deformation modes may occur under different conditions, as can be depicted using a deformation mechanism map. 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 1,5 mm with the hardness of the martensitic microstructure providing improved properties such as wear resistance and increased strength. We will find parameters of robot laser hardened cell, because we will reduce deformations. We observe a micristructure of robot laser hardened patterns. We find plastic and elastic deformations.

2. MATERIALS AND METHOD

Our study was limited to tool steel of DIN standard 1.7225 (Fig. 1). The chemical composition of the material contained 0.38% to 0.45% C, 0.4% maximum Si, 0.6% to 0.9% Mn, 0.025% maximum P, 0.035% maximum S and 0.15% to 0.3% Mo.

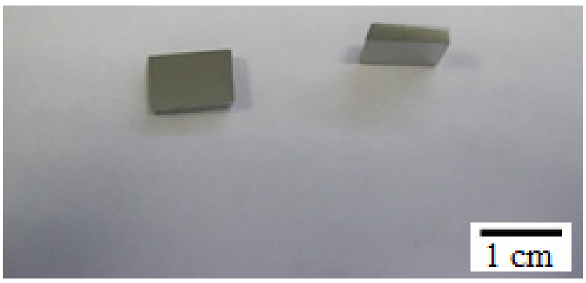


Figure 1. Transverse and longitudinal cross-section of hardened specimen

The specimen test section had a cylindrical form of dimension 25 × 10 mm (diameter × height). Specimens with porosity of about 19% to 50%, were prepared by laser technique, followed by hardening at T ∈ [1000, 1400] °C and v ∈ [2, 5] mm/s. We changed two parameters of the robot laser cell: speed v ∈ [2, 5] mm/s with steps of 1 mm/s and temperature T ∈ [1000, 1400] °C in steps of 100 °C (Fig. 2).

We develop new algorithm for construction visibility graph in 3D space. This algorithm we use to analyze mechanical properties of robot laser hardened specimens.

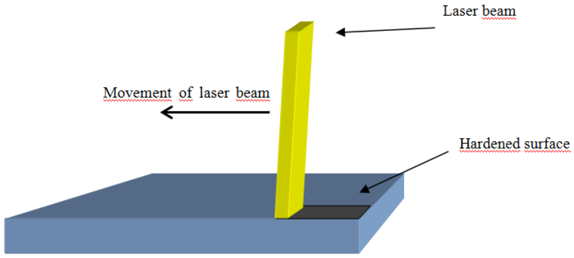
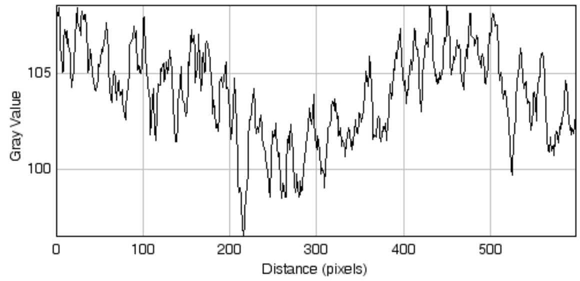
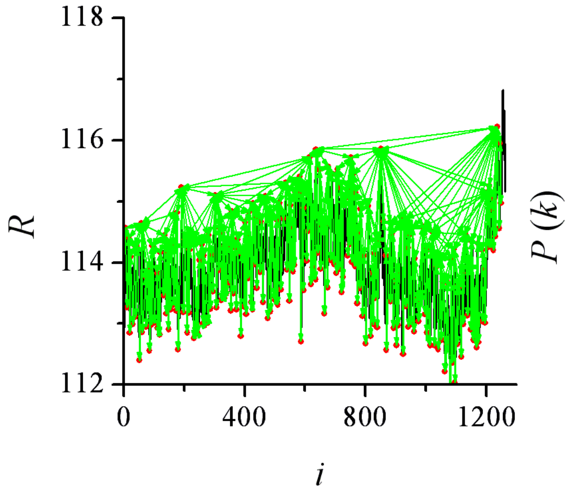


Figure 2. Robot laser hardening with different temperature and speed

Firstly, we analize profile graph of microstructure picture with visibility graph.



Graph 1. Profile graph of surface hardened specimen

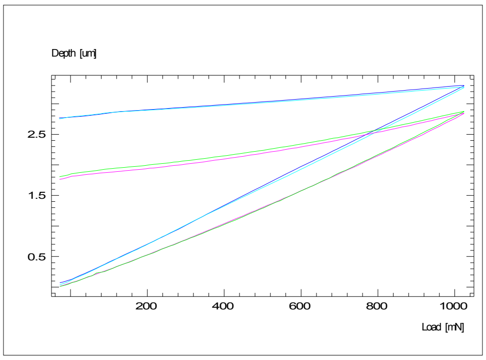


Graph 2: 2D Visibility graph for graph 1

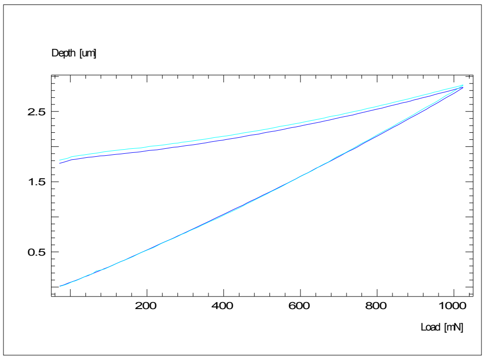
Reason for develop constructing the visibility graph in *3D* space is analyze mechanical properties of robot laser hardening. Robot laser hardened specimens have better microstructure mechanical properties after hardening. With 3D visibility graph we describe complexity of microstructure (Fig. 2 and Fig. 3) of hardened specimens. We will know which extremes on graph of microstructure are connected.

3. RESULT

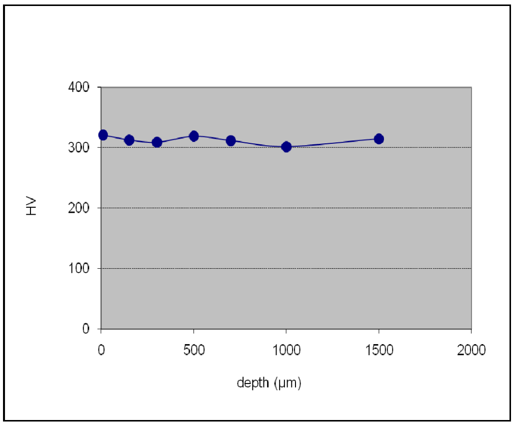
On Graph 3 is presented deformation before laser hardening. Graph 4 present deformation after laser hardening. On Graph 5 is presented relationship between hardness (HV) and depth before laser hardening. On Graph 6 is presented relationship between hardness (HV) and depth after laser hardening.



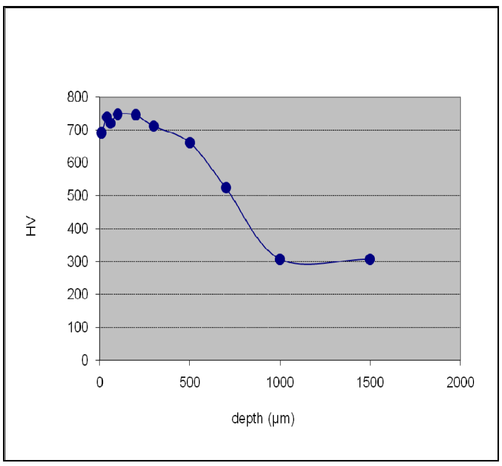
Graph 3. Deformation before laser hardening



Graph 4. Deformation after laser hardening



Graph 5. Hardness in depth before laser hardening



Graph 6. Hardness in depth after laser hardening

4. CONCLUSION

We made experiments hardened specimen. We present deformation on material before and after robot laser hardening. We present relationship between hardness and depth befor and after hardening. In the future we want to explore deformatiuon as a function of more parameters of a robot laser hardening. Robot laser cell parameters are strength, energy density, focusing distance, energy density in the focus, focus position, temperature and speed of hardening. We will interested to investigate deformation in the two-beam laser robot hardening (a laser beam is split into two parts).

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