ISSN 2347 - 3983

Volume 8. No. 4, April 2020

International Journal of Emerging Trends in Engineering Research

Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter40842020.pdf

https://doi.org/10.30534/ijeter/2020/40842020

Laser alloying technology when changing the processing speed

[1] **Smirnova Zh.V,** Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russian Federation
z.v.smirnova@mininuniver.ru
[2]**Cherney O.T** Minin Nizhny Novgorod State Pedagogical University (Minin University), Nizhny Novgorod,
Russian Federation, fiolet1975@mail.ru

ABSTRACT

The article deals with the mechanism of laser alloying of P6M5 steel and the character of its change. The results of studies of laser doping and a change in the results with varying parameters of laser radiation are proposed. Tungsten boride (W2B5) was used as a legrant. The authors spent an analytical assessment of the mixing mechanism in laser doping. It is noted that the research of this sphere do not have a systemic nature. Many authors who explore this problem, think that it is one of the main and most controversial in laser doping. Therefore, the results are got by different scientists cannot be systematized due to significant differences in the schemes and conditions of research. It is investigated the processes occurring during the formation of the structure of surface layers during laser doping. It is obtained optimum laser processing conditions. It is proved experimentally that the processing speed during laser alloying effects on the nature of the distribution of the legrant in the alloy bath and regulates the mixing mechanism, including both diffusion and convection.

Key words: Laser alloying, convective mixing, molecular diffusion, alloying materials, process.

1. INTRODUCTION

It is known that alloying elements penetrate into the inner layers from the metal surface during laser doping. In this case, it is necessary to mix the alloying substance with the base metal.

Many researchers consider that the question of the mechanism of mixing during laser doping is one of the most controversial questions [1].

Grigoryants A.G., Safonov A.N. point to two possible mechanisms of mixing in their research: convective mixing and molecular diffusion.

According to A.A. Vedenov and G.T. Gladush's opinions, there are three models of the mechanism of mixing of a substance with a material, that is stirring. In some studies, the researchers assign the main role to convective mixing [4]. They think that convective flows in a bath with liquid can be described as a one-dimensional model of thermo capillary convectioned, which allows to estimate the characteristic velocity of the moving and its level of mixing (number of convective cycles - melt turns during the lifetime of the bath) and the level of distortion of the surface profile of the doped zone.

Further development of the mechanism of convective mixing is reflected in M.P. Matrosov and V.S. Mayorova's research results. Analytical forms are given for a two-dimensional problem, and also results are got on determining the shape for a liquid bath and the distribution of fluid velocities in their research works [2].

Besides, in their papers you can learn what the shape of the bath surface of the melt (concave or convex) depends on, the direction of convective flows on the surface (to the edges or to the center of the liquid bath), the ratio of the depth to the cross-sectional width of the alloy track and so on.

However, not all researchers think that the mechanism of convective mixing is prevailing. In the research works of Yu.A. Bykovsky , V.N. Nevolin , V.Yu. Fominsky the alloying mechanism is considered as diffusion. There is a conclusion about the possibility of development of diffusion processes occurring in the melt in the research work [3]. Also there is a detailed comparison of experimental data about the dynamics of changes in the distribution profile of atoms after laser irradiation. The energy of laser radiation is absorbed in the skin layer of the irradiated substance and transferred almost instantly (10-11 s) to the lattice. [5].The material which absorbs radiation in about 1 ns is heated to the melting temperature and according to the mechanism of thermal conductivity the deeper layers of the matrix material are heated. It is possible the simultaneous existence of a melt of the material of the legrant and matrix with the corresponding thickness of the alloying material (legrant) and a certain (threshold) energy density of laser radiation. They mix mutually in the liquid phase during the lifetime of the melt. A certain distribution of atoms is formed in the surface layer of the matrix as a result of diffusion [7].The cooling of the material is accompanied by the movement of the solidification front with characteristic speed of 10 m / sot of the liquid-solid interface to the surface. This movement "freezes" the concentration distribution of doping atoms in the surface layer of the metal matrix [6].

So, now, there is no both common approach to the solution of problem of the mechanism of laser doping, and there is no a research of the ratio between the possible mechanisms of laser doping.

2. RESULT AND DISCUSSION

Further, we consider the laser alloying of steel P6M5 and trace the change of the results when the processing speed changes. We use tungsten boride (W2B5) as a legrant. We spent research at a constant power density (q = 0.25 • 10 W / cm2) and the thickness of the legrant (h≈0.2-0.25 mm), which consists of powder W2B5 and a binding agent taken in a ratio of 1: 4. [8], [9].

Before testing, the microstructure of steel P6M5 is characteristic for steels of the ledeburite class, pre-processed: hardening+ tempering. The basic structure is martensite, the crystals of which are small and hardly distinguishable because of weak etchability. Along with martensite, there are carbides of eutectic origin [12].

The alloying bath is formed as a result of laser doping with tungsten boride (Fig. 1), the size of which are determined by the laser processing parameters. The depth of the bath decreases with increasing processing speed V, since a higher processing speed implies a shorter exposure time for the material (Table 1).

Table 1: Processing speed implies a shorter exposure time for the material

Laser processing speed V. mm /	**4**	6	8
Depth of alloy bath, mm	**1,63**	**1,50**	**1,3**

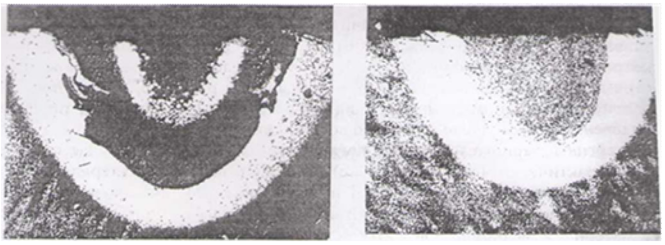

Figure 1: The macrostructure of steel P6M5 after laser alloying W_2B_5:

a - the appearance of the bath at V = 0.4 cm / s;
b - the appearance of the bath at V = 1.2 cm / s (x50)

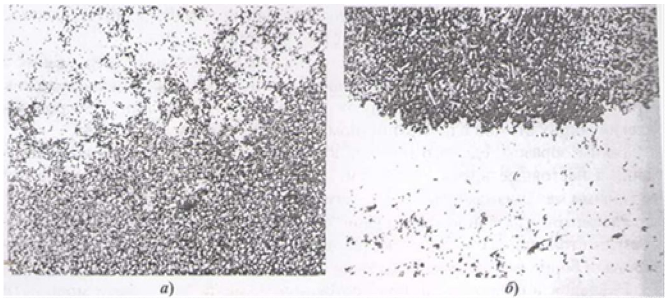

Figure 2: The microstructure of steel P6M5 after laser alloying W_2B_5:

a - upper transition zone in the alloy bath;
b - lower transition zone (alloying-hardening) (x 400)

Since laser alloying was conducted in the melting the surface layer mode, under the effect of laser radiation, steel in the bath volume turned into a liquid, mixed with an alloying coating and hardened quickly due to the mass of the base metal, which was as a heat sink.

The structure learned from laser doping by tungsten boride is presented in Fig. 2. The formed grains had various sizes and shapes: from small polyhedral to larger stretched ones. Such inhomogeneity of the structure can be caused by both peritectic and eutectic transformations, which did not manage to occur completely in such a short time, and by the influence of the mixing mechanism or mechanisms. The alloying bath consists of a number of concentrically located zones at a low processing speed (V = 0.4 m / s), with different level of etchability [10], [11].

You can see in fig. 1a, that the used legrant (W_2B_5) is located unevenly in the alloying bath, forming zones of different concentrations. Besides there are visible fractions of the legrant in the center of alloying bath, which have moved for short distances. This situation is characteristic of the diffusion mixing mechanism. Eddy flows of the legrant are fixed in the peripheral place of the bath on both sides. They were formed as a result of the convection mechanism.

3. CONCLUSION

So, we could see the effect of two mixing mechanisms at the same time at a low processing speed. The mixing mechanism can be complex and consist of several processes but it is impossible to say what mechanism is priority in this case. The size of the alloying bath decrease with increasing speed of laser alloying to V = 1.0 ÷ 1.2 cm / s and the structure becomes more homogeneous (Fig. 1, b). The greater uniformity of the structure is explained by more intense mixing, but in such a short time it is unlikely for the diffusion mechanism, although it is real for the convective one.

In conclusion, we would like to say that the processing speed during laser alloying influence on the distribution of the legrant in the alloy bath and regulates the mixing mechanism, including both diffusion and convection..

REFERENCES

1. Bykovsky Yu.A., Nevolin V.N., Fominsky V.Yu. Ion and laser implantation of metallic materials. - M .: Energoatomizdat, 1991.-235 p.
2. Vedenov A.A., Gladush G.T. Physical processes during laser processing of materials. - M .: Energomashizdat, 1985 .-- 208 p.
3. Grigoryants A.G., Safonov A.N. Surface laser treatment methods. Ser. Laser equipment and technology. - M .: Higher. school., 1987.V.3.-190 s.
4. Technological lasers: a Handbook. In 2 t. / Ed. G.A. Abilcia-tova. -M.: Engineering, 1991.V. 1 -431 p.
5. Mayorov V.S. The use of surface-active substances to change the nature of convection during laser doping // All-Union Conference on the Interaction of Optical Radiation with Matter. Leningrad, March 14-18. 1988 / L .: Metallurgizdat. - 452 p.
6. Mayorov V.S., Matrosov M.P. The effect of surface-active substances on the hydrodynamics of laser doping of metals // Quantum Electronics. T. 16. No. 4. 1986. S. 806-810.
7. A. P. Menushenkov, V. N. Nevolin, V. N. Petrovsky. Physical fundamentals of laser technology. M.: NRNU MEPhI, 2010, 210 pp.
8. Laser technology for processing materials: modern problems of basic research and applied development / Ed. V. Ya. Panchenko. - M.: Fizmatlit, 2009 - 664 p.
9. Smirnova, Z.V., Rudenko, A.A., Vaganova, O.I., Cherney, O.T.,, Mokerov, D.S., Semakhin, E.A. The research of carbon construction steel at laser alloying //International Journal of Innovative Technology and Exploring Engineering 2019. 8(9), c. 2371-2375 https://doi.org/10.35940/ijitee.I8945.078919
10. Smirnova, Z.V., Vaganova, O.I., Cherney, O.T., Romanovskaya, E.V., Andryashina, N.S., Toshin, D.S. The organization of emergency and dispatching servicing of an apartment house// International Journal of Innovative Technology and Exploring Engineering 8(9), 2019. c. 1477-1480 https://doi.org/10.35940/ijitee.I8194.078919
11. Smirnova, Z.V., Mukhina, M.V., Katkova, O.V., Gruzdeva, M.L., Chernei, O.T. Network Interaction as a Factor of Professional Qualities' Development of Service Workers//Lecture Notes in Networks and Systems, 87, pp. 698-704. International Journal of Innovative Technology. https://doi.org/10.1007/978-3-030-29586-8_81
12. A.A. Sokolovsky1,2, A.I. Zemtsov3 , D.I. Kovalev4 , E.M. Shishkov3,4, A.A. Kazantsev Hybrid Fiber Optic Temperature Sensor Powered by Optical Radiation //International Journal of Emerging Trends in Engineering Research Volume 7, No. 12 December 2019 https://doi.org/10.30534/ijeter/2019/217122019