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LASER HARDENING PROCESS ON Ck 45 DEPENDING ON THE LASER PARAMETERS - a small review

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Abstract. *This study displays the effect of laser surface hardening parameters on the Ck 45 steel. The method is mostly based on experimental tests, with micro-hardness data being used to obtain the hardness profile Ck 45.The beauty of the surface laser hardening technique is that, it hardens a specific area without changing the surface qualities of the surrounding area. Due to its versatility and capacity to manufacture parts with complex geometry, laser heat treatment is regarded one of the best-performing manufacturing technologies currently in use.*

Keywords: Laser hardening, hardening of steel Ck 45, parameters.

Introduction

Laser hardening is one of the economical techniques used to improve surface properties of target materials. This process is easy to use for improving surface properties of a complex shape component with minimum time requirement. The important beauty of this process is that only selective surface area properties can be improved without changing the remaining bulk material surface properties.[1-3].

Surface properties and wear resistance can be improved by laser hardening process. There are wide variety of industrial applications of laser hardening process for the mechanical components such as steering gear assemblies, diesel engine cylinder liner, turbine blades and stub axles to achieve maximum microhardness and to increase the wear resistance.Because of the self-quench and easily regulated laser power, laser surface treatment is a very versatile method that has been widely employed in the car and other industrial sectors.[4-5].

One important application is the laser hardening, which involves only a thermal effect on the surface where a new structure with high hardness is obtained on the top surface. In most of these applications, laser does not treat the complete surface of the components but rather small local tracks. With a designed and delicate movement control system, laser hardening is suitable for some components with complex geometry, i.e. edges, corners and holes.[6].

Many parameters that might affect the procedure should be examined in order to execute proper laser hardening for the parts and get the desired outcomes. Many studies have been conducted to determine the impact of the independent parameters of the laser hardening process, such as laser power, processing speed, laser spot size, and the work material's thermal characteristics.[7-8].

Methodology and Experimentations

Material.

The process of laser surface hardening performed on metal components reveals different types of responses like hardness, depth of hardness, grain structures. The material with few chemical compositions including Carbon, Chromium, Manganese, and Molybdenum in process shows different responses.[9].

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Table 1. Chemical composition and mechanical properties of C45 steel

Designation	Chemical composition, %								
	C	Si	Mn	P	S	Cu	Cr	Mo	Ni
C45	0,42-0,50	0,17-0,37	0,5-0,8	≤ 0,04	≤ 0,04	≤ 0,30	≤ 0,30	≤ 0,10	≤0,30
	Mechanical properties								
	R_e, MPa			R_m, MPa		A_5, %		HB	
	340			620		16		207	

The steel C45 has a carbon percentage of 0.5 percent, making it a medium carbon steel.Steel C45 has a high carbon content, as stated in table 1 [10], indicating that it is appropriate for laser hardening.

Lasers.

Carbon dioxide (CO_2) lasers have been used in heat treating for over 30 years, as an alternative for induction or other traditional heat treating techniques. However, limitations in CO_2 laser reliability and cost of ownership have made their use as a heat treating source less than ideal. Over the past few years, a new approach for heat treating based on the high-power, direct diode laser has emerged. Direct diode lasers utilize a very different technology than CO_2 lasers to produce light and in this way overcome the most significant disadvantages of CO_2 lasers. While direct diode lasers are by no means a panacea for all applications they do offer some compelling advantages in certain distinct applications. This article reviews the basics of laser heat treating, its optimum uses, and compares CO_2 with diode laser technology. [11].

For the majority of laser hardening applications, the HPDDL output beam illuminates an area that is smaller than the total area to be processed. Thus, either the work piece or the beam is moved in order to achieve total coverage. A typical implementation of this approach, in this case for a large construction vehicle spindle, is shown in the photograph.[10].

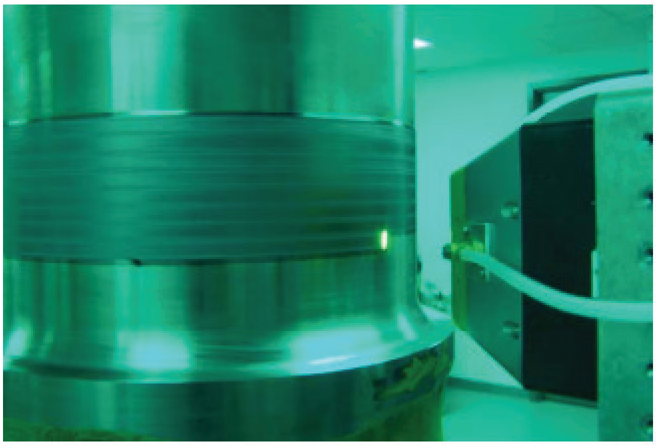

Figure 1 . The laser beam is moved across the part in order to heat treat large areas. [10]

HPDDLs offer a substantial cost advantage over CO_2 lasers. One reason for this is that their electrical efficiency (conversion of input electrical energy to useful light output) is about 3 — 4 times higher than that of the CO_2 laser. This translates directly into lower operating cost. Additionally, the HPDDL has "instant on" capability so there is no standby power consumption. Even larger savings results from reduced maintenance costs which are orders of magnitude less for the HPDDL as compared to a CO_2 laser.[10].

Results and Discussions

A typical laser hardening process is shown in Figure 2 whereby a defocused laser beam is utilized to scan over a surface to obtain the hardening effect. The hardened zone can be clearly distinguished from the base microstructure after etching with 2% nital solution.

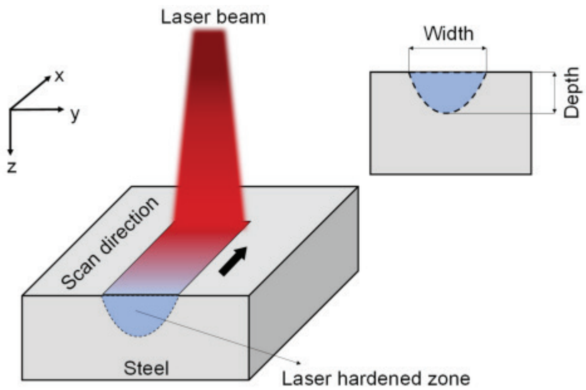

Figure 2. A single laser-hardened track showing associated depth and width.

Heat input can be varied by changing the power and speed. If the power is high and the scanning speed is slow.The efficiency is low at low heat input which is expected as a lower heat input is insufficient to increase the temperature at the surface. With the increase in heat input, the temperature at the surface can reach the austenitization temperature required for hardening. Further increase in heat input expands the austenitized region in the steel substrate which transforms into martensite on rapid cooling.Increase in hardened depth and width with an increase in heat input. This results in a rapid increase in hardening efficiency. However, it is to be noted that the austenitized region does not keep on linearly increasing. The increment slows down at higher heat input. This is because the depth of penetration is limited by the thermal conductivity of the material. Therefore, the hardening efficiency slightly reduces after approximately 20 J/mm2 . The further increase in heat input might result in surface melting.[11].

The absorption of the laser beam by a steel surface increases with the decrease in laser wavelength. Higher absorption should result in a larger amount of energy available for surface heating. Nevertheless, infrared lasers are still widely employed for surface hardening due to their low cost and easy availability.A slightly lower efficiency was calculated for the fiber laser used in our experiment compared to others. This is probably due to the low power used in our case. With the low power available, the hardened volume is small and much of the energy is lost in heating the substrate.[12]

The effect of laser power on the depth of hardness

As the power of the laser beam increases between 210 and 330 watts, the value of the signal to noise ratio and hardness depth of laser hardened sample increase too which is shown in Fig. 3. It is observed increments in the hardness depth are 308.51, 325.14 and 340.25 µm respectively of laser hardened samples of Ck45 steel with variations in the laser beam power of 210, 270 and 330 watt at constant 1.0 mm/s laser scan speed and the maximum achieved hardness depth is 340.25 µm.[13]

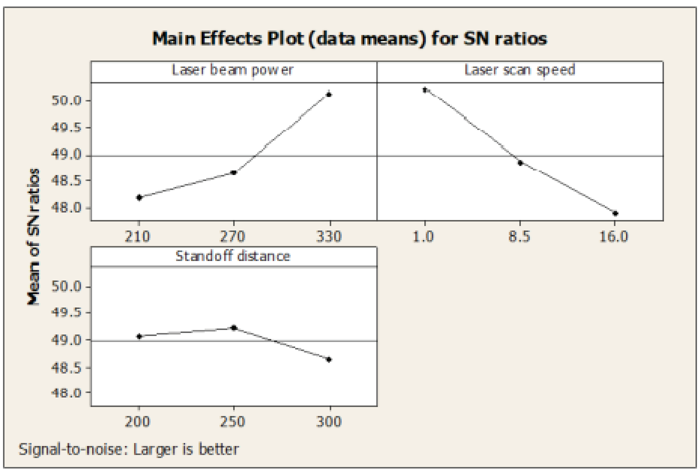

Figure 3. Main effects plot for S/N ratios [13]

The effect of laser scanning speed on the depth of hardness

The effects of the process parameters as a laser scanning speed on the laser treated samples hardness depth value shows that a curve trend graph is inversely proportional as shown in Fig. 3. As the variations in the laser scanning speeds are 1.0, 8.5 and 16.0 mm/s at 330 watt constant laser beam power is observed. Table 2 shows the effects of laser scanning speed which decreases the hardness depth to 340.25, 322.32 and 300.34 μm respectively and decreases the signal to noise ratio values. [13]

Sr. No.	Laser Power (w)	Laser scanning speed (mm/s)	Standoff distance (mm)	Width (μm) Ck45	Hardness depth of HAZ(μm)	S/N Ratio
1.	210	1	200	1114.81	308.51	49.7854
2.	210	8.5	250	1088.34	249.10	47.9275
3.	210	16	300	1037.75	220.13	46.8536
4.	270	1	250	1094.68	325.14	50.2414
5.	270	8.5	300	1022.67	264.18	48.4380
6.	270	16	200	1063.68	231.32	47.2843
7.	330	1	300	1090.14	340.25	50.6360
8.	330	8.5	200	1093.22	322.32	50.1657
9.	330	16	250	1027.93	300.34	49.5523

Table 2. Experimental Ck45 steel laser hardness depth

Conclusions

Laserhardening is widely used in many industries and laserhardening of steel C45 is common occurrence. The experiments show that it is possible to harden the steel C45 with CO_2 laser however results was not continual good but showed that used laser with choosen parameters is suitable to achieve the requirements what are stated in the drawing.

From all the three variables, laser scanning speed is the foremost impacting noteworthy calculates of laser hardness depth of Ck45 steel, taken after by the laser beam power and standoff distance separate individually.

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