Contemporary Engineering Sciences, Vol. 5, 2012, no. 11, 511 - 520

Improving the Surface Layer of D2 Heat Treated Alloy

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Abstract

This paper presents an experimental study to reveal the effects of improving the surface layer of D2 heat treated alloy by using forces and pressure, this pressing force affects both the surface roughness of the alloy and also on the hardness of the alloy. It is found that Diamond pressing process(DPP) has a considerable effect on the surface layer micro hardness of D2 heat treated alloy steel. The best improvement was achieved on feed rate (0.12 mm/rev) at pressing force (50 N) to give (891 HV).

Keywords: heat treatment, D2 alloy, hardness, surface roughness, pressing forces

1. Introduction

Of many different processes used for finishing some simply clean continents from surfaces. Other processes can remove or form the surface material to produce the desired results. The finishing processes can be broadly classified into mechanical, thermal, and electrochemical methods. The term ‘‘mechanical finishing ‘‘encompasses the technology of the edge and surface conditioning of metal and nonmetal products for both cosmetic and functional purposes generation of smooth and specular surface to improve appearance of components is an essential part of the manufacturing cycle of the most manufactured products, but functional finishing is still move important .most mechanism will run longer and more efficiently if component surfaces and edges are smooth. If an appropriate scratch pattern is generated, edges and surface may have much improved retention of lubricants, resulting in still smoother operation. Removal of stress raisers at sharp corners and generation of controlled radii on edges can substantiality improve thermal and mechanical fatigue strength of highly stressed components. Removal of tensile stress by improved surface integrity will reduce or eliminate their contribution to service failures. Moreover, Generation of high compressive stress, which can be achieved by several mechanical finishing processes, can significantly increase the resistance to fatigue stress and thus increase the service life of highly stressed parts .improved edge and surface condition in passages through which gases or fluids flow reduces ‘‘drag ‘‘and thus increases flow rates. Mechanical finishing is an essential part of the manufacturing cycle for most products. A high standard of mechanical finish will normally result in a better looking. Proper attention to the technology of mechanical finishing will result in improved productivity as well as an improved product.

Mechanical finishing process for processing steels may be classified as follows: Manual filing, scraping, and deburring, Polishing, buffing, and brushing, Abrasive and nonabrasive blasting, Mass finishing, Shot peening, Honing and lapping, Abrasive flow machining.

Many researches discuss this issue theoretically, Tugrul O. et al. 2007, Surface finishing and tool flank wear have been investigated in finish turning of AISI D2 steels (60 HRC) using ceramic wiper (multi-radii) design inserts. Multiple linear regression models and neural network models are developed for predicting surface roughness and tool flank wear. In neural network modeling, measured forces, power and specific forces are utilized in training algorithm. Experimental results indicate that surface roughness *R*a values as low as 0.18–0.20 _m are attainable with wiper tools. Tool flank wear reaches to a tool life criterion value of VBC = 0.15mm before or around 15 min of cutting time at high cutting speeds due to elevated temperatures. Neural network based predictions of surface roughness and tool flank wear are carried out and compared with a non-training experimental data. These results show that neural network models are suitable to predict tool wear and surface roughness patterns for a range of cutting conditions.

S. Prabhu et al. 2010 studied a single wall Carbon nano tube (SWCNT) is having high Mechanical and Electrical Properties specifically High Electrical Conductivity. By using these properties of the single-wall carbon nano tube mixed with dielectric fluids in EDM process to analysis the surface characteristics like surface roughness, micro cracks in AISI D2 tool steel a work piece material which is very much used in moulds and dies. Experimental results indicated that the surface texture after EDM is determined by the discharge energy during processing. An excellent machined nano finish can be obtained by setting the machine parameters at low pulse energy. The surface roughness and the depth of the micro-cracks were proportional to the power input. Furthermore, the SEM application yielded information about the depth of the micro-cracks is particularly important in the post treatment of AISI D2 tool steel machined by EDM.

2. Experimental work

2.1 Equipment and tools

The flowing list shows the equipment and tools, which have been used throughout this project:

1- Engine lathe machine, type: Triumph 2000 for turning preparation of the specimens.
2- Single – point carbide cutting tools.
3- Grinding wheel, as shown in fig 1.

Fig .1 Grinding Wheel

4- Diamond Pressing tool, figure 2.

Fig.2 Diamond pressing tool

5- Elliptical diamond tip as shown in figure 3.

Fig .3 Elliptical diamond tip

6- Shot peening machine. Fig.4

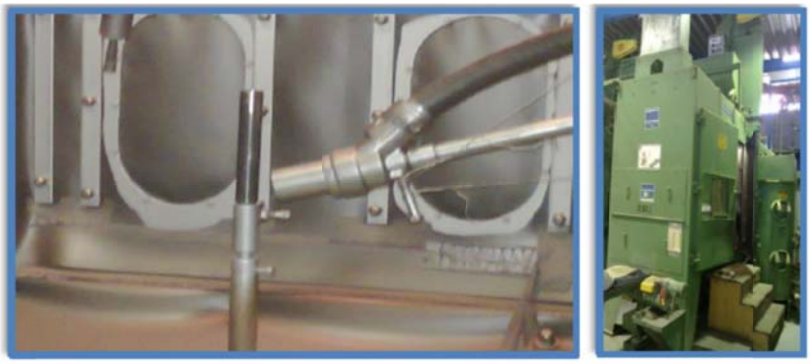

Fig .4 A : Inside view for shot peening machine and holding base B) : Shot peening machine.

7- Work piece fixture foe cylindrical specimens Fig.5

Fig.5 D2 work pieces.

8- Cut wire shot: 0.4 practical size and (770-830HV) 63-65HRC hardness. Fig.6.

Fig.6 Cut wire shot

9- Almena strip, Almena strip gage. Almena strip holder .

10- Emery paper ranging between 400 – 1200 (400, 600, 800, 1200).

11- Quenching and mineral oils for quenching heat treatment and for protection the specimens.

12- Etching solution Nita 6% nitric acid used for etching of the specimens, Etching time about (15 - 60) sec.

2.2 Heat treatment of D2 alloy steel

D2 is a high-carbon, high-chromium tool steel alloyed with molybdenum and vanadium characterized by:

- High wear resistance
- High compressive strength
- Good through-hardening properties
- High stability in hardening
- Good resistance to tempering-back

Table 2.2: chemical composition of D2 alloy steel, table 1.

Type (AISI)	C Wt %	Cr Wt %	MO Wt %	V Wt %
D2	1.55	12.0	.7	1.0

D2 alloy is recommended for tools requiring very high wear resistance, combined with moderate toughness (shock-resistance). D2, it is used when cutting thicker, harder materials; when forming with tools subjected to bending stresses and where high impact loads are involved. D2 alloy can be supplied in various finishes, including the hot-rolled, pre-machined and fine machined condition. It is also available in the form of hollow bar and rings.

3. Results and Discussion

3.1 Diamond pressing process: Surface roughness test:

The Diamond pressing process has a considerable effect on the surface quality Ra of the D2 heat treated alloy steel

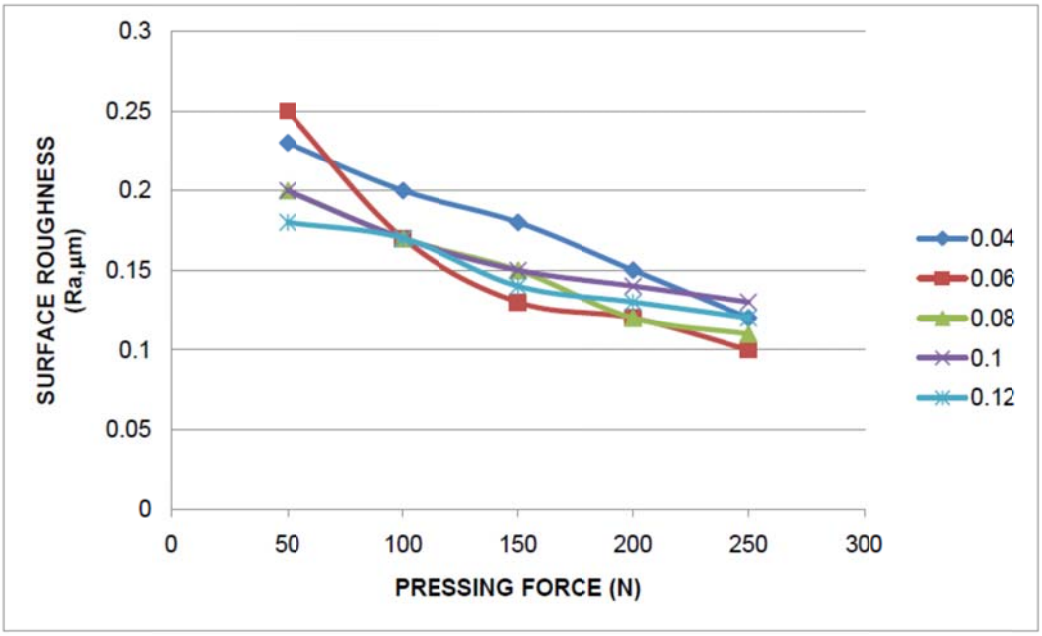

Fig. 7 :average surface roughness(µm) Vs pressing force(N).

The initial (before diamond pressing) surface quality Ra was as the following: Ra =1.5µm.the final surfaces quality of the processed surface were shown on table 2. pressing up to 50 N after which the surface quality (Ra) adversely effected by increasing the pressing force. However, D2 alloy steel could give a considerable improvement on surface quality by using pressing feed rate equal to 0.04mm/rev and pressing force equal to 250N. Summary of results of the effect of diamond pressing force on the surface quality (Ra)is reported in table 2.

Table (3.1): Result of the effect of diamond pressing force on the surface quality (Ra) and Microhardness .the initial Ra=1.5 μm an(497.8HV) for the specimens.

Specimen	Feed (mm/rev)	Zone no	Pressing force (N)	Surface roughness (Ra)	Micro hardness (HV)
1	0.04	1	250	0.1	685
2		2	200	0.13	697
3		3	150	0.16	705
4		4	100	0.18	751
5		5	50	0.26	735
6	0.06	1	250	0.1	699
7		2	200	0.12	718
8		3	150	0.13	722
9		4	100	0.17	736
10		5	50	0.25	759
11	0.08	1	250	0.11	697
12		2	200	0.12	715
13		3	150	0.15	725
14		4	100	0.17	753
15		5	50	0.20	759
16	0.1	1	250	0.13	635
17		2	200	0.15	649
18		3	150	0.2	691
19		4	100	0.14	756
20		5	50	0.17	783
21	0.12	1	250	0.13	678
22		2	200	0.14	742
23		3	150	0.17	787
24		4	100	0.18	790
25		5	50	0.12	891

- Micro hardness test for diamond pressing:

In this section of the current study, the effect of different amounts of pressing force on the state of alloy steel surfaces was studied , the result of this study is plotted in figure (3.2). this figure shows the effect of different amounts of pressing force (50 – 250 N) on the surfaces layer micro hardness (HV) of the D2 heat treated alloy steel. The initial micro hardness of the surface layer (before diamond pressing) was (497.8HV), while the final micro hardness of the processed surface (after diamond pressing) was changed as shown on table (3.1) at pressing force of (50 – 250 N).

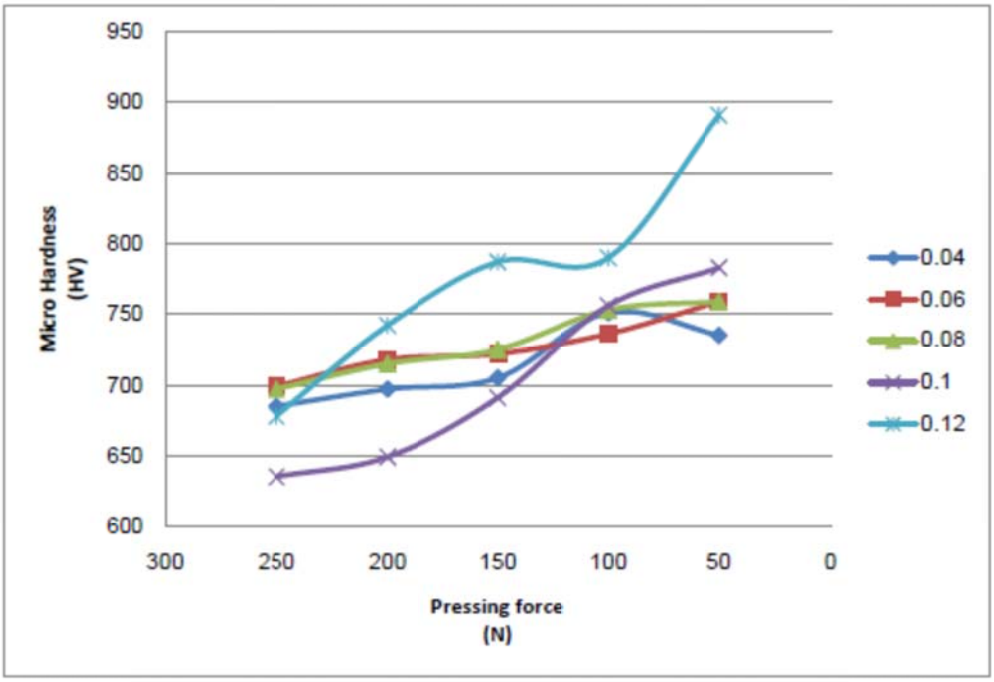

Fig. 8: Surface layer Micro-hardness (HV) Vs diamond pressing force .

From figure 8, it is obvious that the micro hardness of the surfaces layer of D2 alloy steel, directly is effected by increasing the pressing force up to (50N), after which the Microhardness of the surface layer is adversely affected. However, the best improvement of the surface layer Microhardness was for specimen which have (0.12mm/rev) feed rate at pressing force (50N) to give (891 HV).

For the Microstructure analysis of D2 heat treated alloy steel, figure 9 and 10 show micrograph of the D2 surface that have been processed by diamond pressing, from plates it was found that there is a difference between the structure of the deformed layer and the parent metal.

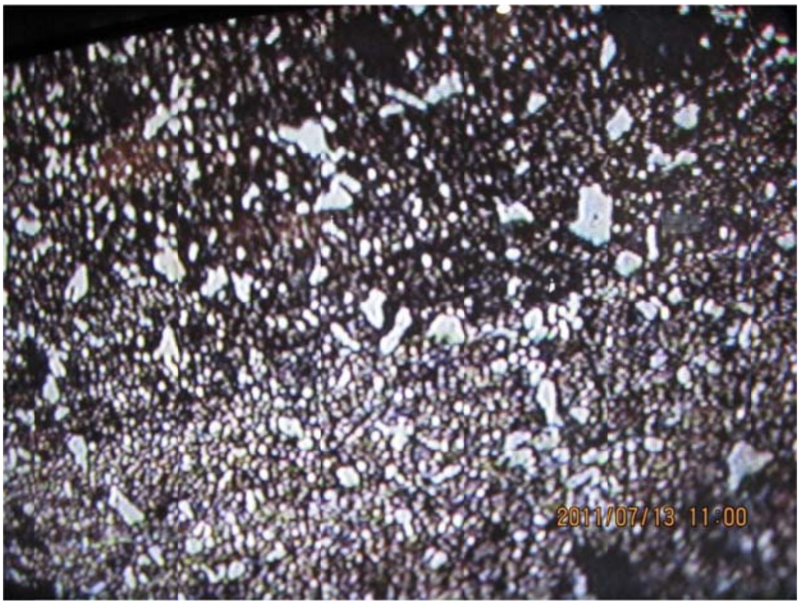

Fig.9 A micrograph of the surface deformation of the d2 heat treated alloy steel with magnification 200X (diamond pressing parameters for the specimen were: Pf=100 N Fp=0.12mm/rev).

Fig.10 A micrograph of the surface deformation of the d2 heat treated alloy steel with magnification 200X (diamond pressing parameters for the specimen were: Pf=50 N Fp=0.12mm/rev).

4. Conclusions

Diamond pressing process(DPP) has a considerable effect on the surface layer micro hardness of D2 heat treated alloy steel. The best improvement was achieved on feed rate (0.12 mm/rev) at pressing force (50 N) to give (891 HV). For certain (DPP) parameters, it is concluded that the (DPP) has positive effect on the surface quality (Ra). But the best improvement in surface quality was achieved on feed rate (0.06 mm/rev) to pressing force (250 N) to give Ra= 0.1μm.

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Received: September, 2012