Dressing Characteristics in Nitriding Treated Bearing Steel Under Ceramic Wheel Grinding Conditions

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Abstract

In the grinding operation dressing sequence give proper profile and surface dimensions. Dressing eliminates loaded part in the wheel surface and makes wheel edge sharpening. Also specific surface profile in the dressing unit conveys to the material, and this is the main function with the dressing process. In this study precise and high-speed bearing steel grinding process are established as well as dressing conditions. In the dressing unit improving study slot type dresser unit showed less grinding power than non-slot type. Surface roughness is higher in the slot type dresser equipped conditions.

Keywords: *Carbo-nitriding, Ceramic wheel grinding, Dressing unit, Surface roughness, Roundness*

1. Introduction

Grinding operation has the advantage of precise and sustainable form-shaping during the machining process. Now it has been adapted to wide areas of the industrial machining field. The primary goal of grinding is the generation of the designated surface roughness and user-oriented surface shape1. Also, its value and effectiveness depend on the high-speed grinding ability with various materials with precise tolerance areas. With these special characteristics, grinding is widely used for hard materials and surface-hardened material processing. In the basic internal grinding process, the wheel is fed perpendicularly into the part usually accompanied by a short stroke oscillation along the axis of the wheel. But some internal grinding which machining rolling element raceway profile does not have oscillation strokes like normal internal grinding. In this case, the raceway profile set-up by the formed roll dresser unit and this dressing process activates profile formation as well as re-dress for the re-sharpening of the grinding wheel.

Modern grinding technology maintains its flexibility and includes not only plunge grinding but also complicated profile grinding. Also multi-phase and multi-axis machines are generally used for increasing process productivity. Meanwhile, the dressing process in grinding wheels is critical to obtaining optimal performance. The available dressing methods are numerous and mainly depend on the grinding area topography. Dressing is not a single operation. It consists of several steps like truing, conditioning and dressing. Truing is cleaning out any metal embedded or loaded in the wheel surface. A more detailed function is obtaining a new set of sharp cutting edges on the grains at the cutting surfaces. Conditioning is removing bonds from around the abrasive grits, and dressing is truing the wheel and conditioning the surface sufficiently for the wheel to cut at the required performance level. In this study, the discussion will consider dressing conventional abrasive wheels with formed diamond roll dressers. The dressing process entails plunging the roll into the wheel at a fixed in-feed rate, measured in mm/min, at a fixed remove ratio for a fixed dwell time. The initial profile is endowed in the formed roll dresser surface with sintered diamond grit. This will give its features to the wheel surface through the dressing process. Initial dressing including rough-dressing which formed wheel surface more than 1mm which build initial profile. After this rough-dressing the wheel surface is fitted to the user-oriented profile and continually gives these features to the grinding part itself.

In this study checked and analyzed the internal grinding ability between the conventional dresser unit and improved dresser unit with slots in the diamond surface. This study checked the dressing unit improvement by analyze the grinding ability of double raceway grinding with 3SG ceramic wheel. Dressing sequence synchronized with single grinding operation by every single grinding is done, dressing process executed before starting next grinding operation.

2. Material Specification and Heat Treatment Method

Table 1. Chemical Composition of STB2 Bearing Steel (wt.%)

Elements	C	Si	Mn	P	S	Cr	Ni	Al	Ti	O
Contents	1.02	0.25	0.31	0.02	0.015	1.53	0.2	0.026	0.001	7ppm

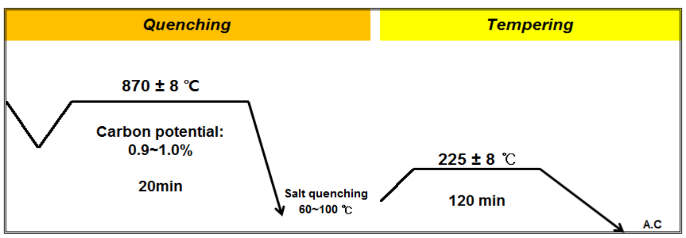

Figure 1. Normal Quenching-tempering Heat Treatment Cycle

Material is high chromium bearing steel, so called STB2. Figure 1 is heat treated cycle of the carbo-nitriding. This depends on the theory that nitrogen is second to carbon, which lowers the martensitic transformation temperature and gives tempering resistance to steel. This results in more retained austenite, more residual compressive stress, and higher temper resistance near the surface area. To diffuse nitrogen and carbon in the steel surface during the hardening stage while the carbon potential is 0.9~1.5%, a base gas composed of 8 vol% NH3 of base gas was added. Cooling is quenching in oil with 60~100℃. After heat treatment hardness remained at HRC 62. Nitrogen diffusion depth maintained a minimum 0.5mm and the core microstructure was fine acicular. With this heat treatment, material properties changed, such as increased wear resistance and corrosion resistance by a nitride network formed in the steel surface. Also carbo-nitriding allows a much lower quenching temperature compared with normal quenching and tempering heat treatment. It showed much less distortion after heat treatment. Nitrogen is generally sourced by decomposition of ammonia in the following reaction sequence during the gas nitriding procedure, using the heat as the method of the decomposition and the steel as the catalyst.

$$2NH_3 \leftrightarrow N_2 + 3H_2 \quad (1)$$

3. Machine and Dresser Unit Specification

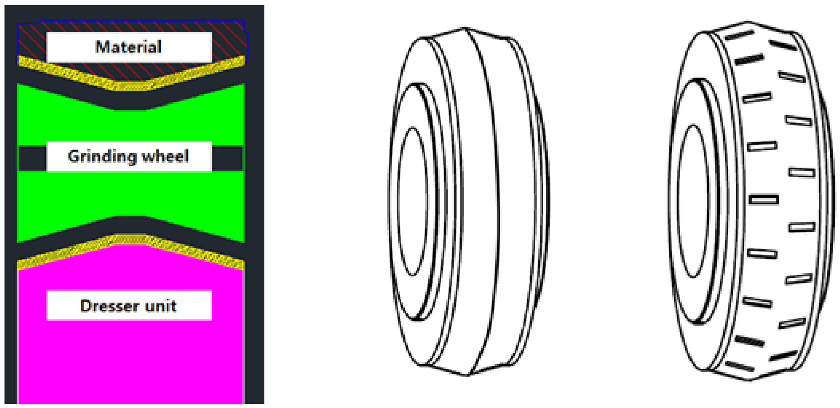

Figure 2. Dressing Unit Sequence, Non-slot and Slot Type Dresser

Table 2. Experimental Condition for Grinding Operation

Grinding machine	KIG-150 (Schaeffler Korea) Spindle motor capacity: 350V-18kW
Wheel	Ceramic: 3SG100L8V (63*14*16*56)
Work piece	STB2, Inner diameter: 72mm Width: 26mm Hardness: HRC62
Grinding conditions	Wheel speed : 30,45,60m/s Work piece speed : 1,042rpm Depth of cut: 100㎛ ,200㎛ Spark-out time: 0.5sec
Dressing Parameter	Dressing unit speed: 1,600rpm Dressing depth: 40㎛ Dressing interval:1 Pre rough dressing: 5mm
Grinding Fluids	CASTROL-HYSOL RD-KR(BP)

Condition	Wheel speed (m/s)	Cutting depth (㎛)	Heat treatment condition
#1	30	100	Non-slot
#2			Slot
#3		200	Non-slot
#4			Slot
#5	45	100	Non-slot
#6			Slot
#7		200	Non-slot
#8			Slot
#9	60	100	Non-slot
#10			Slot
#11		200	Non-slot
#12			Slot

The grinding wheel is 3SG grain and its dimension is double raceway type. The work piece size is much bigger and in only the carbo-nitriding heat treatment condition is considered in this part of the study. Dressing parameters were added to the experimental set-up to check this property. Dressing depth is fixed at 40 ㎛ and the interval is 1. This means when every grinding operation is done, it executed 1 cycle dressing. Before initiating grinding, the wheel needs to be pre-rough dressing with 5mm, which makes a unique profile in the wheel surface conveying from the formed roll dresser. Also this make the wheel surface pre-sharpening for enable optimal grinding when initial part. Table 3 is grinding condition set-up. For check the dressing unit ability and effect to the grinding operation, set-up the other condition is the same but only changed dresser unit condition with non-slot type and slot type. All grinding condition is controlled by FANUC system. During the grinding, power and load checked. After grinding operation is done check the surface roughness and roundness in each ground parts.

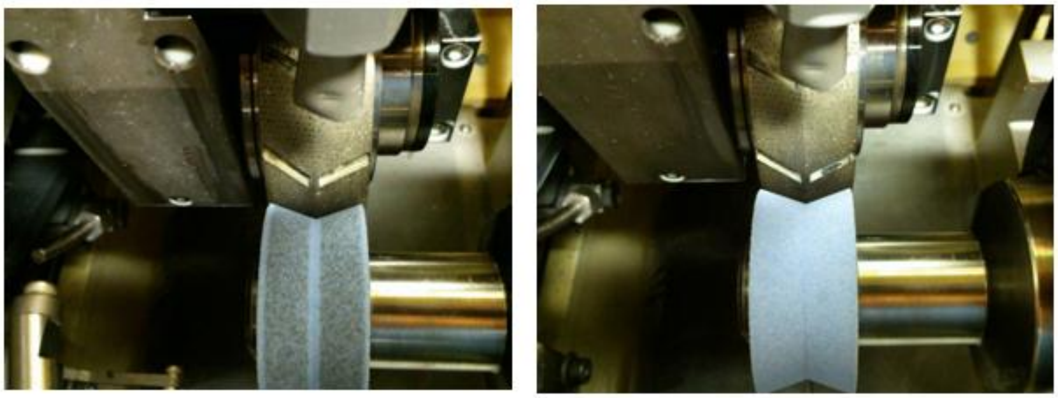

Figure 3. Before and After Dressing Operation in the Grinding Wheel Surface

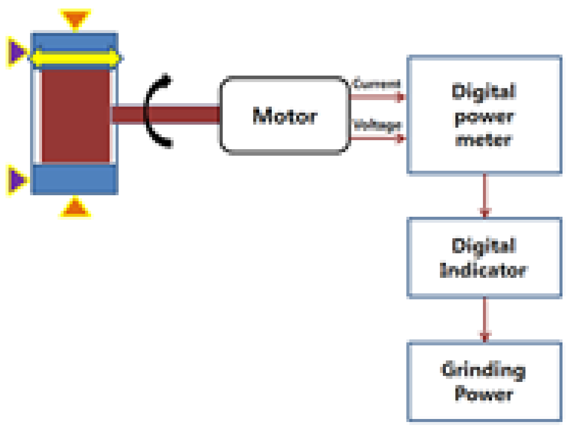

Figure 5. System Configuration of Grinding Machine & Power

Figure 5 is the experimental machine set-up for grinding power and grinding load check. Wheel spindle main power input is 350V-18kW. Grinding power output monitored in the Warner KT4060-10 converter, grinding load output is checked in the 16bit AD converter results through PRI-3400 indicator. Surface roughness check after grinding operation is by Taylor-Hobson Form taly-surf and roundness is checked by Mahr MMQ-400 measuring device. Work-piece rpm is 1,042rpm, wheel speed is variable to 30, 45, 60 m/s. Depth of cut is designated to 100, 200 ㎛ in each wheel speed conditions. Oscillation during the grinding operation is Set-up by 1.5mm over at each material edge end. Speed is 2500m/min which travel back and forth along the bore axis. Spark-out time is 0.5sec and grinding material guided shoe Support during the grinding operation.

4. Results and discussions

4.1 Grinding Power Results

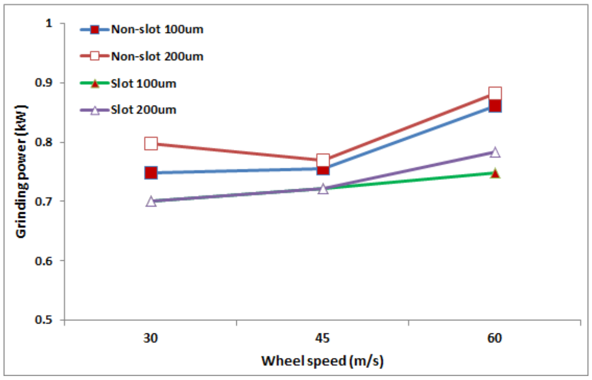

Figure 5. Grinding Power Results in Various Grinding Condition

Figure 5 is grinding power results under various grinding conditions with non-slot and slot type dressers. The grinding power trend was much higher for the non-slot type dresser, especially in high-speed area. This can be explained by when slot type roll dresser made a single dressing, wheel surface edge extrude much than non-slot type and this sharpening edge reduce the glazing and loading during the grinding process. So when slot type dresser equipped grinding power much smaller than non-slot type.

4.2 Surface Roughness and Roundness

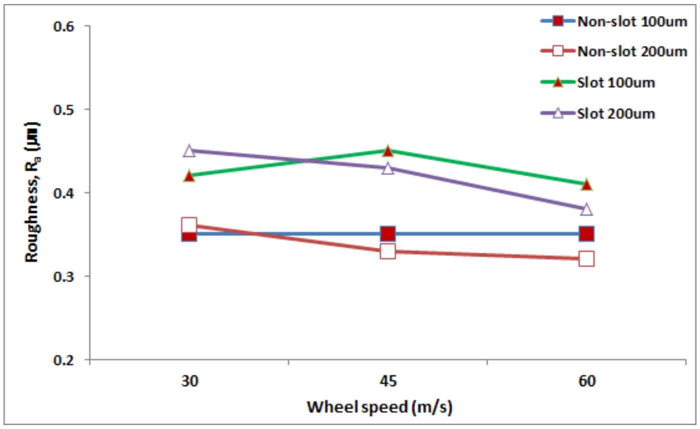

Figure 6. Surface Roughness Results in Various Grinding Condition

Figure 6 is surface roughness results in various grinding condition with slot type and non-slot type dresser equipped. Surface roughness trend show slightly increasing in the slot type dresser unit. Roughness also improved as wheel speed and cutting depth increased. But the non-slot type dresser unit showed similar trends during the grinding operations. This could explained slot type dresser re-generate the wheel's sharp edge more than non-slot type during the dressing sequence, and this sharp edge grinds the material surface with more peaks and valleys.

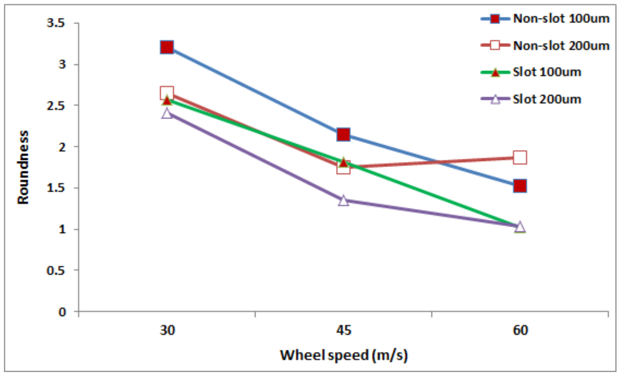

Figure 8. Roundness Results in Various Grinding Condition

Figure 8 is roundness results in various grinding condition with slot and non-slot type dresser equipped. In roundness features, when the wheel speed increased, then roundness became stable accordingly. Also when cutting depth increased roundness improved slightly in both dresser unit cases. This result demonstrates the merit of the high-speed grinding process. In the form shape tolerance area, high-speed grinding shows better behavior and slot type dresser also shows better behavior. This means it prevents conventional loading and glazing occurrences in the wheel surface much better than non-slot type dresser units.

5. Conclusions

1. In the grinding power, slot type dresser unit equipped condition showed less grinding power results than non-slot type dresser unit. This mainly explained by more sharp edge extruded in the slot type dresser. That means slot in the dresser surface facilitate grinding fluid discharge and ground part remainder during the grinding.

2. Surface roughness increased in the slot type. Slot in the dresser surface make wheel surface sharper and cutting edge extrude more than non-slot type.

3. Roundness improved in slot type dresser equipped conditions.

Acknowledgements

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