

## The Ultra-hard Honing Oilstones

Z. C. Zhou<sup>a</sup>, J. Du<sup>b</sup>, Y. K. Zhang<sup>c</sup>, Y. P. Zhang<sup>d</sup>, S. Y. Gu<sup>e</sup>

School of Mechanical and Electronic Engineering, Suzhou Vocational University, Suzhou, 215104, China

<sup>a</sup>zcc@jssvc.edu.cn, <sup>b</sup>duj@jssvc.edu.cn, <sup>c</sup>zyk@jssvc.edu.cn, <sup>d</sup>zyp@jssvc.edu.cn, <sup>e</sup>gsy@jssvc.edu.cn

**Keywords:** ultra-hard honing oilstones, CBN oilstone, diamond oilstone

**Abstract.** Physical, chemical and mechanical properties of some abrasives such as diamond, CBN are described in this paper. The preparation and application of ultra-hard oilstones such as diamond and CBN are also discussed. They are widely applied in honing and promote great development of honing technology. However, the standardizing binder compositions of diamond and CBN can not easily obtained. In addition, the precision requisition of grinded parts is different from part to part and the material kinds are diverse. Therefore, the oilstone performance is difficult to match the grinded parts. Those factors result in the complication of the oilstone preparation.

### Introduction

Honing is an important processing method to obtain precise and ultra-precise machine parts, especially the hole-parts, e.g. cylinder liner, fluid cylinder. The property of oilstones is a key factor. It influences the processing precision and quality of the parts, but also processing efficiency and oilstone consumption. The property parameters of oilstones are included in types of abrasive, hardness, particle sizes [1]. There are many kinds of grinding materials. Diamond and Cubic Boron Nitride (CBN) belong to super-hard abrasives. SiC and Al<sub>2</sub>O<sub>3</sub>, etc, have low hardness compared with CBN and diamond [2]. The hardness of oilstone is regarded as the jointing firmness of abrasive with binder, which is also called as holding force of binder with abrasive. The surface of oilstone can not be easily removed when the holding force is large [3]. The hardness of oilstone should be adapted to that of the finished material and flexural strength should be meted basic requirements. The particle sizes of abrasives are also related to the roughness of the finishing surface of parts. Therefore, many factors should be considered when the oilstone is chosen, which include the material, roughness, dimensional precision, shape of finished parts. In this paper, the abrasive characteristics of the honing oilstone are described. The study development of the preparation and choice of oilstone is also discussed.

### The common characteristics of the ultra-hard abrasives

The oilstone can be produced in common using the abrasives such as diamond, CBN, Al<sub>2</sub>O<sub>3</sub>, SiC and so on. They have not only different hardness, but also different physical and chemical properties. The diamond and CBN belong to the ultra-hard abrasives.

**The characteristics and properties of the diamond.** The diamond is the highest in hardness in all materials now, whose chemical composite is carbon containing little impurity. The natural diamond contains the impurities such as N, Al, Si, Ca, Mg, and so on. There are graphite, catalyst metal, pyrophyllite and N in the synthetic diamond [4].

The diamond is isometric system crystal with face-centered cubic lattice. The lattice constant (a) is 0.35670 nm. The Moh's hardness of diamond is 10 and micro-hardness is up to 10000~101000 MPa. The high hardness of diamond is related to large bond energy. The wear resistance of diamond is about 140 times as big as Al<sub>2</sub>O<sub>3</sub>. The natural diamond has an elastic modulus of 900 MPa and a bending strength of 210~490 MPa and a compressive strength of 2 GPa. For the synthetic diamond, elastic modulus is between 740 and 1050 GPa. The bending strength is 300MPa and a compressive strength 2 GPa. The diamond has large heat capacity and good thermal conductivity. The coefficient

of heat conductivity is  $0.35\text{cal}/(\text{cm s } ^\circ\text{C})$  and specific heat is  $0.12\text{ cal}/(\text{g } ^\circ\text{C})$ . The linear expansion coefficient is  $0.9\sim 1.18\times 10^{-6}/^\circ\text{C}$  ( $0\sim 100^\circ\text{C}$ ). The melting point is above  $3550^\circ\text{C}$ . The diamond will burn if it is heated to the temperatures of  $850^\circ\text{C}\sim 1000^\circ\text{C}$  in air. The diamond can be dissolved in the salt molten mass such as monarkite, potassium nitrate, etc though it can not be dissolved in sour and alkali.

**The characteristics and properties of CBN.** CBN is cubic crystal consisting of N and B. It has not been found in natural world [5]. Its hardness is next only to the diamond. However, the thermal stability and chemical inertness of CBN are substantially superior to those of the diamond. CBN is transformed from hexagonal boron nitride (hBN) under high temperature and pressure [6-7]. Boron nitride possesses two like-diamond structures formed by the  $\text{SP}^3$  hybridization in addition to the two structures of hBN and rBN. The former two structures are CBN with zinc blende structure and WBN with wurtzite-type.

CBN and diamond are similar in their structures and their lattice parameters are very close. The lattice of diamond is  $0.3567\text{ nm}$  and CBN  $0.3615\text{nm}$ . Their bondings are the same that are covalent bond formed by the hybridization along the tetrahedron. The diamond contains only the covalent bonds between C and C while the CBN consists of the covalent bond between B and N.

It is known that the main mechanical properties are strength, micro-hardness and toughness for the CBN single crystal. The Moh's hardness of CBN is 9.8 and its micro-hardness is  $7000\sim 10000\text{ MPa}$ . The compressive strength of CBN is  $0.8\text{ GPa}$  and the linear expansion coefficient is  $2.1\sim 2.3\times 10^{-6}/^\circ\text{C}$ . Its melting point is above  $3300^\circ\text{C}$ . CBN has extremely excellent chemical stability for the acids. It is not corroded in all the acids such as hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid, hydrofluoric acid, aqua regia and so on. CBN doesn't apparently interact with Fe and C, which provides the extreme superiority for the grinding iron and steel.

### **The preparation and application of honing oilstone**

The development of diamond and CBN materials promotes the jumping of honing technology [8]. The diamond honing oilstone is manufactured using metallic binder. A binder with high binding strength and good wear resistance is used to prepare the diamond honing oilstone in order to improve the cutting action and machining efficiency [9]. Li Yan-ping et al [10] discussed the new development of honing oilstone. The diamond and CBN honing oilstone can be used to hone all kinds of materials, which are steel, hard alloy, cast iron, superheat resisting alloy, electrodeposition, overlay, ceramics and glass. The diamond honing oilstone is shaped using cold or hot compression technology. The metal mold is used when the cold compression is adopted. A large pressure of  $400\sim 500\text{MPa}$  is needed and mold lifetime is long. The graphite mold is used when the hot compression. The shaping pressure is small that is  $15\sim 20\text{ Mpa}$ . The strength loss is small and mold consuming is large when the sintering temperature is low and the shaping pressure is small. Shu Zhi et al developed a honing oilstone with new binder and summarized a perfect composition, technology and manufacturing method. The main compositions of the binder are Fe,  $\text{Q}_{663}$ , Cu, Ni, Sn, Ti, Cr, TiC, WC and ceritics [11]. Zou Wenjun et al [9] introduced the preparation of the honing oilstone to machine the plateau honing cross hatch of the engine cylinder liner. The 170/200 mesh diamond is used to prepare the honing oilstone and the honing testing is completed. The honing oilstone hardness is up to HRB100.2 and the bending strength is  $231.3\text{MPa}$  when the compositions consist of 50%Cu, 20%Fe, HP1 addition agent 10%, HP2 addition agent 15%, HP3 addition agent 5%. The optimal sintering technology is that the sintering is kept for 4 mins at  $760^\circ\text{C}$  and  $3\text{MPa}$ . Wang Yanhui et al [12] introduced the surface treating technology and application of the ultra-hard diamond and CBN honing stone. The new development of surface treating technology is also summarized in Ref. [12]. The plated-Ti diamond and CBN by the evaporating in vacuum is widely applied in all kinds of tools with metal and ceramic binders in order to avoid falling abrasive particles and to prevent the abrasive particles from the thermal etching of the binder. The diamond volume is decreased and the cost of the binders is also reduced when the plated-Ti diamond is used. The combine plated-Ti/Ni diamond can further improve the efficiency of the plated-Ti diamond.

The lifetime is prolonged and the sharpness is improved ten percent. The plated- $\text{Al}_2\text{O}_3$  ultra-hard abrasive particles are suit for the tools whose binder is resin or ceramic. The plated-Si diamond and CBN possess large binding force and good thermal-resistance. Especially, they have good compatible binding force with Fe-based and ceramic binders and play an important role in the Fe-based and ceramic binders Li Zhihong et al [13] manufactured the CBN tool material with the ceramic binder. The results showed that the suitable sintering temperature of vitrified bond CBN grinding tools should be lower than 800 °C. The strength of vitrified bond CBN grinding tools was obviously affected by the difference of thermal expansion coefficient between vitrified bond and CBN abrasives. C1 bond was more suitable for the manufacturing of vitrified bond CBN grinding tools. Within the sintering temperature range, relatively higher sintering temperature was beneficial to the strength of the bond bridge and the holding strength between bond and CBN particles.

Ichida et al [14-16] deals with the grinding characteristics of newly developed ultrafine-polycrystalline CBN (CBN-U). The results show that the grinding ratio is around 10 times higher than that with the conventional CBN (CBN-B) abrasives. Grinding forces in grinding with CBN-U abrasives are reduced by 20-30% compared with those in grinding with CBN-B abrasives. The CBN-U is suitable for the applications with a high dimensional accuracy in creep feed profile grinding for nickel-based super-alloys, because it gives less profile wear, and hence better form retention, than conventional CBN abrasive. The fracture strength of CBN-U grain is about 1.6 times higher than that of the representative conventional polycrystalline CBN grain (CBN-W5). The grinding ratio in grinding with the CBN-U grains is around 8 times higher than that in grinding with the CBN-W5 grains. Ichida et al [17-18] also investigated the formation mechanism of finished surface in ultrahigh-speed grinding with cubic boron nitride wheels. It have been confirmed that the roughness of the ground surface decreases with an increase in grinding speed, and this decrease is mainly due to the reduction of the swelling ratio with increasing grinding speed.

## Conclusions

Ultra-hard honing oilstones with diamond and CBN are widely applied in honing and promote great development of honing technology. However, the standardizing binder compositions of diamond and CBN can not easily obtained. In addition, the precision requisition of grinded parts is different from part to part and the material kinds are complicated. Therefore, the oilstone performance is difficult to match the grinded parts. Those factors result in the complication of the oilstone preparation.

## Acknowledgement

This work is sponsored by Qing Lan Project of Jiangsu in China.

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