International Journal of Research in Engineering, Science and Management
Volume-1, Issue-11, November-2018
www.ijresm.com | ISSN (Online): 2581-5792

A Review on Investigation of Tool Wear Measurements

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***Abstract*: This paper is an overview of previous research papers which implies that the CBN (Cubic Boron Nitride) is used as a coating for tools and their wear condition is studied. In this paper, we use CBN material as a tool for improving tool life and wear condition. This experimentation is done by a pin on disc apparatus. Cubic boron nitride has a Rockwell hardness value between 80-95 HRC. The pin on disc apparatus have a machining disc which is a case hardening steel have the value above 65 HRC (Rockwell hardness). To determine the wear rate of cubic boron nitride tool by varying speed of disc and feed rate.**

***Keywords*: Rockwell hardness, Pin on Disc, Wear**

1. Introduction

Cutting tool wear is a key issue in all metal cutting processes, primarily because of its detrimental effect on the surface integrity of the machined component. In the machining of hardened steels, microstructural alterations to the machined surface are embodied in the 'white layer'. A partially transformed Nano-crystalline layer of material up to several micron in thickness. The primary influence on the depth of the white layer is the width of the wear land which forms on the tool flank face, its width usually denoted 'VBC'. It follows, therefore, that minimizing the depth of surface white layer requires either a more frequent replacement of the cutting tool or a reduction in the rate of cutting tool wear. The latter, which is the more favorable approach, is clearly facilitated by a thorough understanding of the mechanisms of tool wear. We demonstrate the potential of cutting tools in machining hardened steels of >65 HRC, however, it was not until the development of other cutting tools, cubic boron nitride (CBN) and in particular CBN composite tools that 'hard machining' became a process of significant industrial importance. The tool wear in hard machining, is concerned with the wear mechanisms of CBN tools. The wear mechanisms of CBN cutting tools is discussed. Commercially available CBN tool materials may be broadly classified as either high content CBN or low content CBN. The latter, which appear to have been initially developed because of difficulties involved in sintering pure CBN, usually contain a ceramic binder such as TiC or TiN. Generally, in finish hard turning of structural steels, ball bearing steels and case hardened steels, the low content CBN grades are found to offer superior wear resistance in comparison to the high content CBN grades. This phenomenon has received several different explanations, including the degree of work material adhesion to the tool surfaces and the lower dislocation density in the CBN grains constituting the CBN composites; the latter resulting in a lesser degree of wear. Regarding the chemical stability of CBN. On the wear surfaces of CBN composite tools and in the atmosphere surrounding the tool tip during Cutting.

2. Wear and wear mechanism

Wear is progressive loss of materials from contacting surfaces relative in motion. Among the fatigue and corrosion wear has been known as one of the three major factors limiting the life and performance of an engineering components and systems. Damages of wear are twofold. The dimension of the component is reduced due to material loss from the contacting surfaces. Its leads to the increased clearance between the moving parts, and consequently results in high vibration, high noise, reduced efficiency and system malfunction. While rotating load is involved, the reduced component dimension could promote fatigue fracture, leading to a catastrophic failure. The material is separated from worn surface, known as wear debris, is similarly harmful. It also may cause contamination, for example, when a machine for food or beverage processing has a wear problem. It may act as an abrasive when trapped inside the contacting surface, causing further increased rate of wear. It also may block a valve, a critical pipeline, an oil filter or accumulated in an electrical contacting point, preventing the normal function of a system. The cost of wear is in large, and thus great efforts have been made ever since the early ages of industry, with aims to eliminate wear. Different methods can be used to categorize a wear process. For examples, wear can be divided as lubricated wear and unlubricated wear. Severe wear and mild wear.

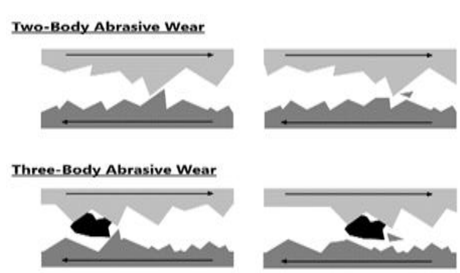

Fig. 1. Abrasive wear

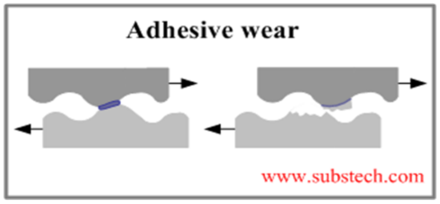

Fig. 2. Adhesive wear

3. Experimental setup and procedure

A pin-on-disk wear test system and photographs of two differently designed apparatus. One of the system type consists of a driven spindle and chuck for holding the revolving disk, a lever-arm device to hold the pin, and attachments to allow the pin to be forced against the revolving disk test material with a controlled load. Another system type loads a pin revolving about the disk center against a stationary disk. In case, any the wear track on the disk is a circle, involving multiple wear passes on the same track. The system also may have a friction force measuring system. For example: The coefficient of friction to be determined by a load cell. Test Parameters are Load, Speed, Distance and Temperature.

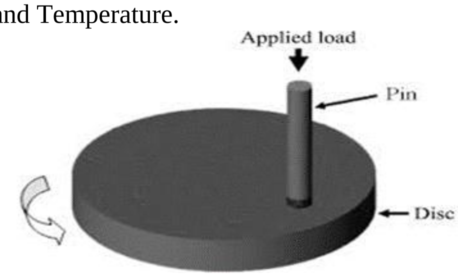

Fig. 3. Schematic diagram of pin on disc machine

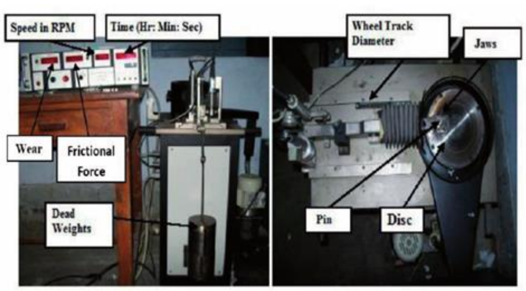

Fig. 4. Pin-On-Disc

- First, immediately prior to testing, and prior to measuring or weighing, clean and dry the specimens. To remove all dirt and foreign matter from the specimens. Use non-chlorinated, non-film-forming cleaning agents and solvents. Materials which are in dry conditions with open grains to remove all traces of the cleaning fluids that may be entrapped in the material. Steel (ferromagnetic) test material having residual magnetism should be demagnetized. Report the methods used for cleaning.
- To measure appropriate specimen dimensions to the nearest 2.5 µm or weigh the specimens to the nearest 0.0001 g.
- The disk is inserted securely in the holding device so that the disk is fixed perpendicular (61°) to the axis of the resolution.
- The pin specimen is inserted securely in its holder and, if necessary, adjust so that the specimen is perpendicular (61°) to the disk surface when in contact, in order to maintain the necessary contact conditions.
- Addition of proper mass to the system lever or bale to develop the selected force pressing the pin against the disk.
- The motor is started and adjust the speed to the desired value while holding the pin specimen out of contact with the disk. Stop the motor.
- The revolution counter (or equivalent) is set to the desired number of revolutions. The test with the material in contact under load. The desired number of revolutions is achieved when test is stopped. Tests should not be interrupted or restarted.
- The specimens are removed and clean off any loose wear debris. The features existence on or near the wear scar such as protrusions, displaced metal, discoloration, micro cracking, or spotting.
- The specimen dimensions is measured and is nearest 2.5 µm or reweigh the specimens to the nearest 0.0001 g, as appropriate. The test is repeated with additional specimens to obtain sufficient data for statistically significant results.
- The measurement of wear should be reported as the volume loss in cubic millimeter for the pin and disk, separately.
- The calculation for volume losses when the pin has initially a spherical end shape of radius R and the disk is initially flat, under the conditions that only one of the two members wears significantly, there is no significant disk wear. It is an (approx.) geometric relation that is correct to 1 % for (wear scar diameter/sphere radius) < 0.3, and is correct to 5 % for (wear scar diameter/sphere radius) < 0.7. There is no significant pin wear. It is an (approx.) geometric relation that is correct to 1 % for (wear track width/sphere radius) < 0.3, and is correct to 5 % for (wear track width/sphere radius) < 0.8.
- Wear volumes calculation for pin shapes of other geometries use the appropriate geometric relations, recognizing that assumptions regarding wear of each member may be required to justify the assumed final geometry.
- Measurements of wear scar should be done at least at two representative locations on the pin surfaces and disk surfaces, and the final results averaged.
- Whenever the pin and the disk wear significantly, it will be necessary to measure the wear depth profile on both members. A suitable method uses stylus profiling

and it is the only approach to determine the exact final shape of the wear surfaces and thereby to calculate the volume of material lost due to wear. For disk wear, the average wear track profile can be integrated to obtain the track cross-section area, and multiplied by the average track length to obtain disk wear volume. For pin wear, the wear scar profile can be measured in two orthogonal directions, the profile results averaged, and used in a figure-of-revolution calculated for pin wear volume.

- Loss of mass results may be used internally in laboratories to compare materials of equivalent densities, this test method reports wear as volume loss so that there is no confusion caused by variations in density. Report and use the best available density value for the materials tested when calculating volume loss from measured mass loss.
- The material is being tested exhibit considerable transfer between specimens without loss from the system, volume loss may not adequately reflect the actual amount or severity of wear. In this test method for reporting wear should not be used.
- The coefficient of friction (defined in Terminology G 40) should be reported when available. Discuss the conditions associated with the friction measurements, for example, initial, steady-state, etc.
- The test material specification is important. The report should be minimum and specify material type, form, processing treatments, surface finish, and specimen preparation procedures. If appropriate, indentation hardness should be reported.

4. Cubic boron nitride

After diamond, Cubic boron nitride (CBN) is the second hardest substance. Under high temperature and pressure, the structure of boron nitride is transformed from hexagonal to cubic. Moreover, CBN exhibits not only better wear resistance, but also higher thermal conductivity than diamond. It implies a wider range of applications for CBN compared to diamond. It is widely used as the hard phase within cutting tools for industrial abrasive machining processes, such as grinding and honing, and under harsh service conditions, i.e. elevated temperature or high speed. CBN composites basically consist of two phases: CBN grains and a binder. According to its chemical nature, binder materials can be classified as metallic, polymeric (resin) and ceramic. CBN composites are sintered by mixing CBN particles and binder material powders under high temperature and vacuum. However, due to the manufacturing processes, the CBN particles are not regularly distributed in the produced composite. In addition, shape, dimension and orientation of the particles are not standardized. During abrasive machining processes, the emerging CBN grains located on the cutting surfaces work as sharp edges and remove the material of work piece. Therefore, geometrical properties of CBN grains can strongly influence the quality of the machined work piece surfaces. Cubic boron nitride (CBN) are widely used as cutting tool materials high precision abrasive machining processes. They are consists of super hard CBN abrasives and a softer binder. CBN abrasives are one of the hardest materials.

5. Case hardening

It is the process of hardening the surface of a metal object while allowing the metal deeper underneath to remain soft, thus forming a thin layer of harder metal (called the "case") at the surface and it’s have low carbon iron and steel, which has poor to no hardenability of its own, the case-hardening process involves infusing additional carbon or nitrogen into the surface layer and it is usually done after the part has been formed into its final shape but can also be done to increase the hardening element content of bars is to be used in an similar process. The hardening is also used to describe this technique, when discussing modern armour. Because of softer metal is usually less brittle than hardened metal, through-hardening is not always a suitable choice for uses where the metal part is subject to sliding contact with hard or abrasive materials. In case-hardening can provide a part that will not fracture. Without cracking, the soft core that can absorb stresses and also provides adequate wear resistance on the surface.

6. Result

The flank volume wear rates, of the CBN cutting tools in the three heats of BS 817M40 steel of 52 HRC. The wear rate parameter is calculated according to the relationship illustrated. As noted above, the tests with heat 3 were undertaken on a different lathe as those tests with heats 1 and 2. As such, caution must be exercised in making a quantitative comparison of the tool wear rates in machining heat 3 and heats 1 and 2. The validity of a semi-quantitative comparison, however, is confirmed by the results of wear tests undertaken with alumina tools in which heat 3 was machined on both lathes; near identical wear rates were observed, that there is an almost fourfold variation in the flank (volume) wear rates of the CBN cutting tools in machining the different heats of BS 817M40 steel. The relative tool crater wear rates, (1KT/1lc Fig. 2), in machining the different heats was similar to the relative flank volume wear rates; for example in machining heats 1 and 3, the crater wear rates were 6.7 and 1.6 mm/km, respectively, a difference of 418%. The difference in the flank volume wear rates in machining heats 1 and 3 is 376%.

7. Discussion

Previous studies on the wear of CBN cutting tools have generally focused on either predominantly mechanical or predominantly chemical wear mechanisms. Of the latter, diffusion of BN in the steel chip and the formation of low melting point reaction products have been suggested. Among the mechanical or thermo-mechanical wear mechanisms discussed in the literature are micro-fracture due to adhesion between the chip and the tool, etching wear, soft abrasion and self-attrition by spalled grains. While the operation of these mechanisms cannot be ruled out, the relative abundance of different elements on the wear surfaces of the tools used to machine heats 1 and 2, which are present in the work material in small (Mn , Si) or very small (Al, S, O) quantities, suggest that the dominant wear mechanism is chemical in nature. The large number of elements present on the tool wear surfaces, which as previously noted may also include B, C and N, make it virtually impossible to determine the phases present and in particular, the reactions through which they were produced. It is clear however, that many of the elements identified on the wear surfaces are work material inclusionary elements, i.e. Al, Mn, S, Ca and O. While Si is also frequently observed in inclusions in steels, it was not noted in the inclusions in the steels tested in this study. Lists the inclusionary element composition of the three heats of steel and the corresponding flank and crater wear rates. Those elements marked with footnote were present only in very low quantities, or not at all, on the wear surfaces of the tools used to machine the respective heats. Of the six elements listed, a reasonable correlation appears to exist between a high work material Al and S content and a relatively rapid tool wear rate. The variation in the Mn and Si content of the three heats is probably insignificant (as is the Cr, Ni and Mo content). Rather, the amount of Mn present in the work material inclusions is determined largely by the S content. However, the presence of Si on the wear surfaces suggests that elements in solution (in the work material) may also react with the tool and need not be present in the inclusion compounds. The role of Ca in the assumed chemical reaction is probably also relatively insignificant; heat 2 contains only 3 ppm Ca, compared to 6 ppm in heat 3, yet results in a tool wear rate three times that of heat 3.

8. Conclusion

In the present paper, we had detailed study on CBN, Pin-On-Disc wear testing machine and case hardening. Most of the tools are coated with cubic boron nitride. But this paper, we use cubic boron nitride as a tool which is used as an insert 80-95 HRC and nose radius is a range between 0.6-1.5 mm. Case hardening steel as a disc which is above 65 HRC (Rockwell hardness). Experimentation is done only in Pin-On-Disc apparatus. In this apparatus, we found out wear coefficient and friction coefficient by changing speed, and also analyze the surface. The wear test experiment is conducted in both wet and dry lubrications. Friction and wear test in high speed tests are consistently lower than the low speed tests.

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