doi:10.1017/S1431927621011703
Microsc. Microanal. 27 (Suppl 1), 2021

Analysis of the wear mechanisms of the boriding drill tip

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The manufacturing industry requires drill bits that can withstand the severe working conditions (wear and high temperatures) encountered during a drilling operation on 7075-T6 aluminum alloy; and at the same time meet the quality requirements (burr height and width and diameter error) requested by their customers. Based on the BP4.55M-1985 standard, it has been established that the types of normal (gradual) wear of a twist drill can be classified according to the zone they affect: wear on the rake face and flank wear; for measurement purposes, the following types of wear are present in the latter zone: i) maximum wear width, VBmax, ii) corner wear width, VBc, iii) chisel edge wear width, VBcl, and iv) margin wear, VBmg [1].

A commercial twist drill with the following geometric characteristics was used in this study: 7/32 in diameter, 130° tip angle, 35° helix angle, two flutes, and straight shank. The drill bit substrate was AISI M2 steel with the following chemical composition: 0.85% C, 3.96% Cr, 5.76% W, 5.09% Mo, 2.06% V, 0.45% Co, 0.42% Ni, 0.37% Si, 0.29% Mn, 0.019% S, 0.013% P and 80.73% Fe. The drill bit was subjected to thermochemical boriding treatment to modify its surface and obtain high protection against wear and corrosion [2] [3]. The boriding conditions were: temperature of 900°C, 6 hours of exposure, conventional furnace without controlled atmosphere and reused rehydrated paste [4] [5].

In a three-axis Vertical Machining Center (VMC) with Computerized Numerical Control (CNC), GUSS&ROCH, model VMC-640; a wear test was performed, which consisted of manufacturing non-through holes with the borided drill bit, on a 7075-T6 aluminum alloy plate, which had the following dimensions: 4.0 x 8.0 x 0.5 in. The following machining regime was used: cutting speed: 73.23 m/min, feed rate: 0.089 mm/rev and depth of cut: 12.5 mm. A semi-synthetic soluble cutting fluid was used for lubrication and dissipation of heat generated at the borided drill bit/work material interface. The flooding method was used to apply the cutting fluid.

After the manufacture of 1050 non-through holes and 35.75 minutes of work [6], it was observed that the chips generated were fan-shaped. In addition, the angle of the borided drill tip showed the following variation: from 130° 03' to 132° 01'.

A JEOL model JSM-IT100 Scanning Electron Microscope (SEM) was used to analyze the wear mechanisms at the tip of the borided drill bit after the drilling operation. The EDS (Energy Dispersing Spectroscopy) technique was applied to quantitatively determine the presence of alloying elements of the working piece (Al 7075-T6), on the surface of the borided drill bit.

Figure 1 shows the corner of one of the cutting edges of the borided drill bit after the wear test. This area is the farthest from the center of the drill bit, and rotates at the rated cutting speed. Figure 1a highlights the built-up edge formation (BUE); the corner wear width (VBc) has an average value of 33.92 μm.

This adhesion of workpiece material (Al 7075-T6) virtually eliminates contact between the borided drill bit and the workpiece [1]; such material becomes unstable with each chip-forming cycle, with a high probability of becoming dislodged and embedded in the drill bit body, as can be seen in the area bounded by the red line, which contributes to abrasive wear. Figure 1b shows the EDS spectrum performed on the surface of the cutting edge corner of the borided drill bit; and Figure 1c shows the results of the EDS analysis, highlighting the presence of aluminum and zinc, magnesium and copper, alloying chemical elements of the working material (Al 7075-T6).

Figure 2 shows the chisel edge of the borided drill bit after the wear test. In this area of the drill bit, the cutting speed is practically zero, the chisel edge pushes the material, not cuts it; therefore, it is said that drilling combines the cutting operation with the extrusion operation [7]. Figure 2a shows that there is material transfer in the chisel edge area. Figure 2b shows the EDS spectrum obtained when analyzing that area of the borided drill bit and Figure 2c shows the results of the EDS analysis, where the presence of aluminum and the alloying chemical elements such as magnesium, chromium and zinc stand out; which confirms that there is adhesion of the working material (Al 7075-T6) in the chisel edge of the borided drill bit.

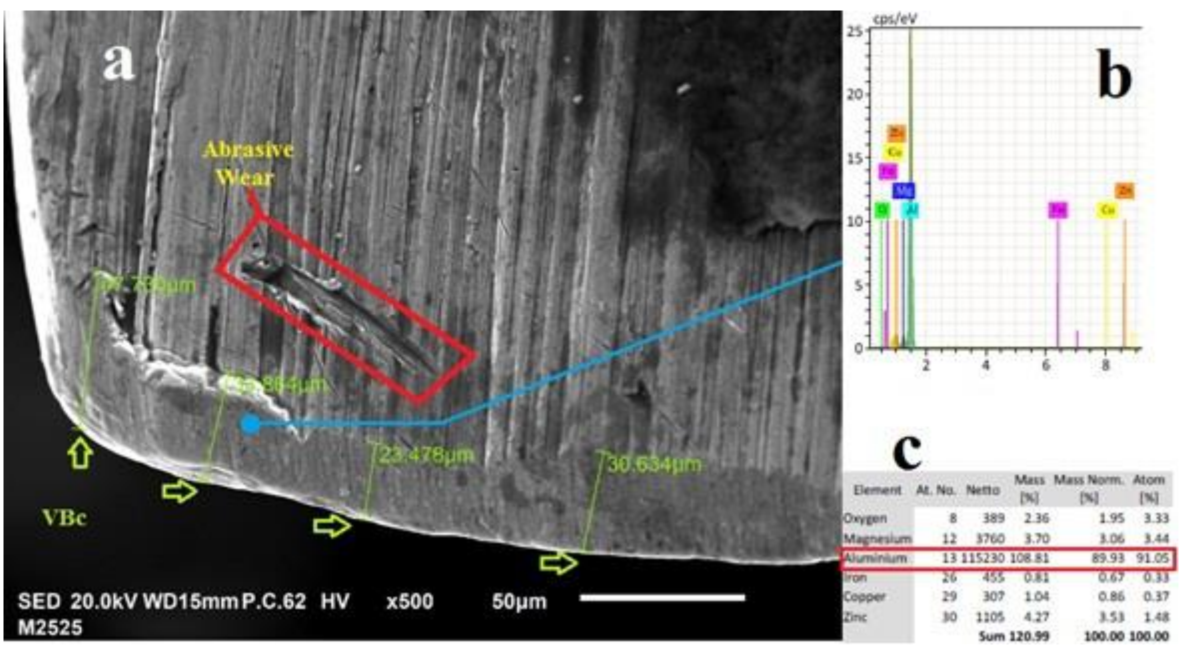
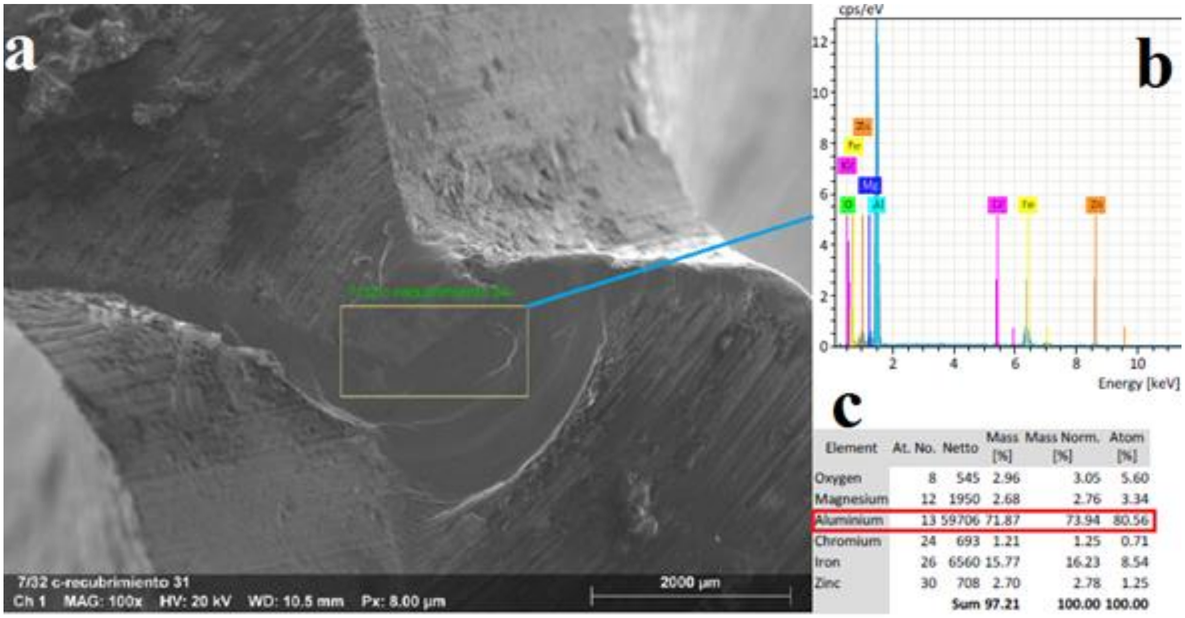


Figure 1. Figure 1 Corner of one of the cutting edges of the borided drill bit after manufacturing 1050 non-through holes, a) Built-Up Edge formation (BUE), presence of abrasive wear and corner wear width (VBc), b) EDS spectrum, and c) quantification of the alloying chemical elements of the working material (Al 7075-T6).

https://doi.org/10.1017/S1431927621011703 Published online by Cambridge University Press



Element	At. No.	Netto	Mass [%]	Mass Norm. [%]	Atom [%]
Oxygen	8	545	2.96	3.05	5.60
Magnesium	12	1950	2.68	2.76	3.34
Aluminium	13	59706	71.87	73.94	80.56
Chromium	24	693	1.21	1.25	0.71
Iron	26	6560	15.77	16.23	8.54
Zinc	30	708	2.70	2.78	1.25
		Sum	97.21	100.00	100.00

Figure 2. Figure 2 Chisel edge of the borided drill bit after manufacturing 1050 non-through holes, a) bonded material in that area, b) EDS spectrum, and c) quantification of the alloying chemical elements of the working material (Al 7075-T6)

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