Micro Deep Hole Peck Drilling of CrNi alloy

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Abstract

In this article the peck drilling process of a CrNi alloy by micro drills is presented. The process is realized on a high precision 3-axis machine tool with an air bearing spindle with a maximum rotation speed of 160.000 rpm. For the drilling tests uncoated tungsten carbide drills and drills with a TiAlN-coating are used. At first the process parameters are defined by analyzing the results of drilling tests by varying infeed and rotation speed with constant feed speed. By using the defined process parameters further tests are realized with the focus on the tool wear of the micro drills and the analysis of the chips depending on tool wear. The analysis of the chips includes the different shape categories and the chip size of the chips generated during the drilling process.

1. Introduction

For the generation of cylindrical deep holes a few methods like µEDM, ultrasonic machining, laser beam machining and micro drilling are applicable. Because of a short processing time to produce holes with good straightness, roundness, and surface roughness micro drilling is widely used [1,2]. By machining deep holes serious problems such as adequately cooling lubricant supply and a quick chip removal result due to low rigidity. These problems have to be solved to avoid the unstable drilling process and tool breakage [3]. Therefore, peck drilling is recommended for both chip removal and tool cooling when the drilling depth is three times the drill diameter [4]. Peck drilling is a drilling method in which a hole is drilled at an intermittent feed.
In this article a micro deep hole peck drilling process is showed. Furthermore the tool wear and the chips generated in the process will be improved.

2. Peck Drilling Process

The micro drills are used in a self-developed 3-axis micro-milling machine. The CNC-controlled axes are arranged as vertical milling machine. The horizontal X- and Y-axes are realized with air bearing linear stages. The vertical Z-axis is equipped with cross-roller bearings. All components are based on a granite base with vibration damping. This layout provides a resolution of 20 nm and a repeating positioning accuracy of 1 µm. A vertically mounted air bearing spindle provides 160,000 rpm. To generate deep micro holes in 18CrNi8 two types of drills are applied, tungsten carbide drills without coating and drills with TiAlN-coating (**Figure 1**).

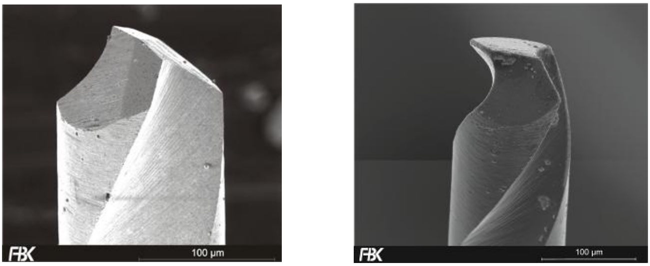


Figure 1: A uncoated (a) and TiAlN-coated (b) micro drill

The drills have a diameter of 127 µm and a length of 1.3 mm. In the first tests the parameters for a stable process are searched by varying the rotation speed and the one-step-feed-length (OSFL) (**Table 1**).

Rotation speed	[krpm]	60	60	60	50	50	50	50	30	30	30
OSFL	[µm]	50	20	10	50	20	10	5	50	20	10
Useful (coated)	(-/+)	-	-	-	-	+	+	+	-	-	-
Useful (uncoated)	(-/+)	-	-	-	-	-	+	+	-	-	-

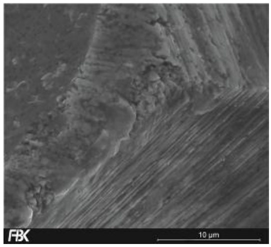
Table 1: Tested process parameters (feed speed 20 mm/min)

The useful process parameters (**Table 1**) are a rotation speed of 50.000 rpm and an OSFL from 5 to 10 µm. The OSFL of 20 µm is only useful for the coated drills. The uncoated drills were broken. Due to this, the following micro deep hole peck drilling tests will be done by rotation speed of 50.000 rpm and an OSFL of 10 µm.

3. Results

In this article the tool wear and the chip shape depending on tool wear is analyzed. Therefore, the tools and the chips are checked after a defined number of machined holes. The drills are checked every fourth hole until the tools break. The first check is after the first hole, the second after the 4th and the third after the 8th hole and so on.

3.1 Tool Wear



The tungsten carbide drills without coating has a very high tool wear. After drilling one hole the cutting edge is broken out and the chisel edge is worn and chamfered (Figure 1b,c). Furthermore some material adherence on the tool tip and a built up edge arises. With these tools, it was not possible to drill more than three holes. Therefore, these tools were not examined further.

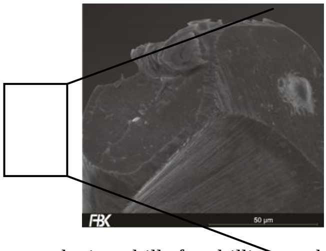


Figure 2: Used uncoated micro drill after drilling one hole and worn cutting edge

With the TiAlN-coated micro drills (Figure 1) it is possible to generate much more deep holes by peck drilling process. After four holes the coating was broken out at different areas and some parts of the cutting edge broken out. Between the fourth and sixteenth hole the tool wear is very small and is optically not recognizable. The wear at the cutting edge was increasing rapidly after 16 drilled holes. The TiAlN-coating and the tungsten carbide are broken out. The formation of a built up edge at the cross cutter can often detect. How to see in Figure 3, the wear on cutting edge after 24 drilled holes is approximately like the wear of uncoated micro drills without coating after one hole (Figure 2).

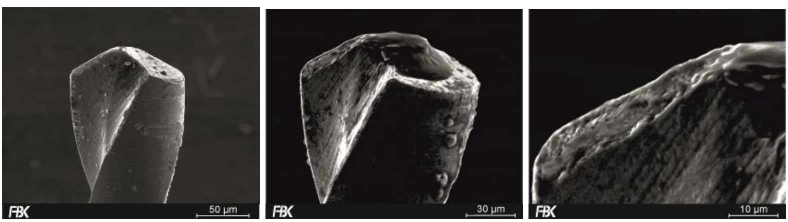


Figure 3: Used TiAlN-coated micro drill. From left to right: 4 holes and 24 holes and worn cutting edge

3.2 Chip space

To characterize the chips in demand of the tool wear, the chips and the cooling lubricant were absorbed with a filter fleece for each four holes. The chips were separated from the fleece and investigated in SEM. The analysis of the chips showed that three different chip types occur. In Figure 4 are shown, a spiral chip, a segmented chip and a microchip type with very high segmentation. After 16 holes the spiral chip don´t occur and the number of segmented and especially the high segmented chips increase. With the higher tool wear the segmentation of the chips is increased. In Figure 5 the high segmented chips are shown.

Figure 4: Chip types resulting of deep hole peck drilling process (after 4 holes)

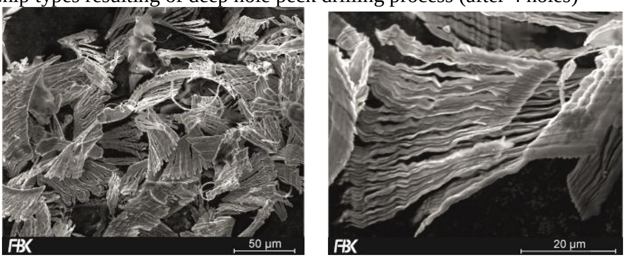


Figure 5: Chip types after 24 holes, high number of segmented end high segmented chip (left) and high segmented chip (right)

4. Conclusion and Outlook

In this article a deep hole peck drilling process with conventional micro drills in CrNi alloy is presented. Therefore the useable process parameters are defined. For drilling CrNi alloys uncoated micro drills are not suitable. With TiAlN-coated micro drills it is possible to generate more than 24 holes (1.200 µm deep). The tool wear increases rapidly after 16 holes. The micro drills are used up to 24 holes without tool damage.

In following works, the tool life should be analyzed by using the micro drills until tool damage and the chip formation of the high segmented chips should be analyzed. Furthermore the process parameters should be optimized for tool life improvement.

References:

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