Drill for machining ultra-deep micro holes

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1. Outline

The Epoch Micro-step Borer drill for machining of ultra-deep micro holes is a cutting tool that is capable of machining micro holes that have a high aspect ratio (L/D) of 100, which is not possible with conventional machining methods.
In recent years, the trend towards smaller size and molds and parts has increased the demand for the machining of very small holes, and various companies have been developing tools for that purpose. However, the length-to-diameter ratio of the holes that such tools can produce has been limited to about 20 times, and deeper holes can be made only by electric discharge machining. Electric discharge machining also has depth limitations and involves other problems such as electrode lifetime and machining time. To solve those problems, we developed a new concept of the “Chip stopper”, which used together with a highly rigid neck shapes that is capable of machining ultra-deep micro holes not previously possible with conventional methods.

2. Explanation of the Device

When machining holes of 1 mm or less in diameter, the rigidity of the tool and the removal of cuttings are problems that generally require that the process proceed in steps. The tool we have developed assumes such stepwise machining, and adopts a shape that was developed to satisfy the requirements of deep hole boring.

To increase tool rigidity, it is necessary to increase the cross-section area of the tool. However, if the core thickness (web thickness) is made too large, there will be insufficient pocket space for the cuttings. Furthermore, deep boring generally means that the flutes are also long, and that creates a problem for tool rigidity. If we assume a step-wise boring process, however, there is no need for the flute to be that long. and the straight shaft (Fig. 2). The original design of a drill assumes that the cuttings are carried up along the flute smoothly. That is to say, we here reverse conventional common sense and design in a barrier to prevent the upward movement of cuttings.

This machining mechanism is illustrated in Fig. 3. For the amount of machining in each step, the drill returns to near the opening of the hole and then moves back into the hole. The effect of the chip stopper is to keep the cuttings produced by the machining in only the cuttings removal flute so that they can be removed cleanly when the tool is moved to the opening of the hole. The same diagram shows that the chip stopper also improves the guidance of the tool during machining, resulting in a straight bore of high precision.

An actual example of a hole bored with the developed tool (Diameter:0.5 mm and Length:50 mm long) is shown in Fig. 4. This hole has a length to diameter ratio of 100 and demonstrates ultra-deep boring that is beyond consideration when using conventional methods. The figure also shows that the surface roughness inside the hole is good, so this tool achieves a high degree of boring precision that is difficult to realize even with electric discharge machining. Even for drills of ordinary size, deep holes are often bored in steps where the tip of the drill is returned to near the opening of the whole in cycles, but the development of this tool is premised on such cycling. The design concept of this tool reverses the conventional idea that deep bores cannot be made without long flute. This design retains only the minimum necessary length of flute at the tool tip and makes the straight neck behind the cutting edge slightly smaller in diameter as shown in Fig. 1. This design greatly increases total rigidity and strengthens it against bending.

Because the straight shaft part of the tool has no pocket for the cuttings, any cuttings that move into that part of the tool bind and cause tool breakage, and thus prevent further machining. To avert that problem, this design involves a cuttings stopper placed between the grooved part of the tool

3. Summary

The drill for machining ultra-deep holes described here is being sold under the product name of Epoch Micro-step Borer S (standard since June 2010). This tool is playing a part in the most advanced machining operations and is currently being used in the fabrication of the latest medical parts, various types of nozzles, and metal dies.

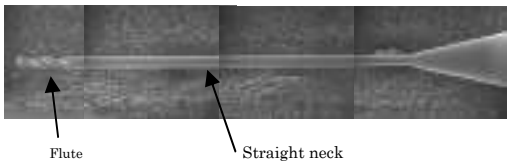

Fig.1. Drill shape

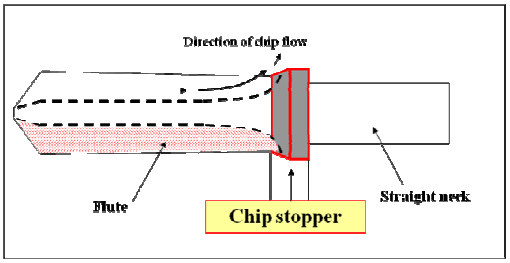

Figure 2. Chip stopper

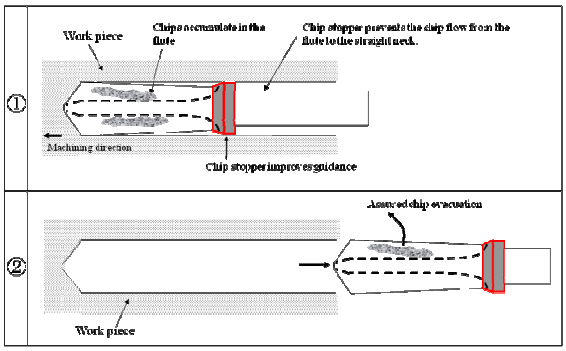

Fig.3. Boring mechanism of the developed drill

Fig.4. Boring example: Ultra-deep micro hole bored (L/D=100)

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