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Theoretical and experimental study on rifling mark generating phenomena in BTA deep hole drilling process (generating mechanism and countermeasure)

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Introduction

Boring and Trepanning Association (BTA) deep hole drilling is a method of producing large-diameter deep holes. In this process, chatter vibration sometimes occurs, and a spiral pattern called a "rifling mark" is formed on the surface of the bore. Figure 1 shows a bore hole with the rifling mark and five-sided polygonal deformation. The rifling mark formed on the bore reduces the accuracy and precision of the hole's roundness and cylindricity, and consequently, the quality of the work material is reduced.

There are many researches for deep hole drilling. The vibration of the tool and the boring bar [1]-[4], the relationship between the tool vibration and the shape of the rifling mark [5][6], the relationship between the hole straightness and the support misalignments [7] and the chatter detection by nonlinear time series modeling [8] have been studied. However, the generating mechanism of the rifling mark has not yet been clarified.

A vibration damper which is set externally to the boring bar and suppresses vibration of the boring bar is in practical use. Also, the vibration suppression methods using an impact damper [9] and a magneto-rheological fluid damper [10] are proposed. However, the perfect suppression of rifling mark is difficult, because the vibration damper cannot be attached to the tip of the boring bar and the natural frequencies and vibration modes of the boring bar change with increasing the hole depth.

The authors considered the phenomenon to be the result of an unstable vibration caused by time delay and studied the generating mechanism numerically using a simple analytical model [11]. Furthermore, the countermeasure against the rifling mark generating phenomenon by the optimal placement of the guide pads and the use of an additional guide pad has been discussed [12]. It has been confirmed that the additional placement of a guide pad is an effective countermeasure.

In this report, the actual BTA drilling machine in which a rifling mark is generated is considered. The supporting condition of the boring bar is modeled accurately based on the actual machine, and the rifling mark generating phenomenon is analyzed numerically. To clarify the rifling mark generation mechanism, the authors also performed experiments with an actual BTA machine. In the experiments, the vibration of the boring bar during the deep hole drilling process was measured. Measurements of the roundness of the bore hole along the entire length of the work material were also recorded. Additionally, the effect of the additional guide pad is analyzed numerically and confirmed experimentally.