Wear Mechanism of Multilayer AlCrWN/AlCrWSiN-coatings on Cemented Carbide Tools Prepared by Arc Ion Plating in Dry Cutting of Hardened Sintered Steel

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INTRODUCTION

Comparing the performances of the AlCrN coated tool and TiN coated tool, the AlCrN coated tool can increase the depth of cut by about 33% [1]. Furthermore due to the better heat resistance of the AlCrN coating film, the tool life of the end mill with the AlCrN coating is longer than that with the TiAlN coating [2-3]. However, our study results show that the critical scratch load of the AlCrN coating film, which is the value measured by the scratch test, is 77 N and the micro-hardness is 2760 HV0.25 N. Therefore, in order to improve both the critical scratch load and micro-hardness of the AlCrN coating film, a cathode material of the Al-Cr-W target with tungsten (W) added to the cathode material of the Al-Cr target was used [4]. The Al-Cr-W based coating film has both high hardness and excellent critical scratch load and can be used sufficiently as a coating film of WC-Co cemented carbide cutting tools [4]. Furthermore, the friction between the face of the cutting tool and the chip decreases when W is added [5-6].

The addition of Si to the TiN coating film converts the [111] -oriented columnar structure to a dense fine grain structure.

Thin films of Ti-Si-N have been deposited by physical vapor deposition to improve the wear resistance of TiN coatings [7]. Cutting experiments showed that the TiAlSiN coated end mill with a Si content of 4.78 atom% had the least flank wear and improved its milling distance by about 20% over the TiAlN coated end mill [8]. Furthermore, at a temperature of 700 ° C or lower, the hardness of the AlCrWSiN film is higher than the hardness of AlCrN [9]. The addition of Si leads to the refinement of crystal grains and greatly influences the phase composition and mechanical properties due to its formation. Amorphous Si3N4 [10-11]. Many multilayer coating films have been developed to improve tool life [12-16].

The rate of wear of the AlCrWN/AlCrWSiN-coated tool, which has the multilayer coating system, was slower than that of the single layer AlCrWSiN coated tool in the cutting of hardened steel at a feed rate of 0.2 mm/rev [17]. In addition, the tool wear of the AlCrWN/AlCrWSiN-coated tool, which has the multilayer coating system, was investigated in the cutting of hardened sintered steel. [18]. Furthermore, the properties of the multilayer AlCrWN/AlCrWSiN-coating film were also clarified [18]. However, the wear mechanism of the multilayer AlCrWN/AlCrWSiN-coated tool has not been clarified in the cutting of hardened sintered steel.

In this study, to clarify the wear mechanism of the multilayer AlCrWN/AlCrWSiN-coated tool in the cutting of hardened sintered steel, the rate of wear in the cutting of hardened sintered steel using three types of coated tools was investigated. The Type I tool had a single layer (Al60, Cr25, W15)N coating film, the Type II tool had a single layer (Al53, Cr23, W14, Si10)N coating film and the Type III tool had a multilayer (Al60, Cr25, W15)N/(Al53, Cr23, W14, Si10) N-coating film. SEM observation and EDS mapping analysis of the abraded surface of the coating film were performed.

Conclusion

In this study, SEM observation and EDS mapping analysis of the abraded surface of the coating film were performed in order to clarify the wear mechanism of the AlCrWN/AlCrWSiN-coating film in the cutting of hardened sintered steel. The Type I tool had a single layer (Al60, Cr25, W15)N coating film, the Type II tool had a single layer (Al53, Cr23, W14, Si10)N coating film and the Type III tool had a multilayer (Al60, Cr25, W15)N/(Al53, Cr23, W14, Si10) N-coating film.

The following results were obtained:

(1) The wear rate of the Type III tool was the slowest.
(2) The area of the worn surface on the rake face "S" and the contact length between the rake face and the chip "D" were measured. Comparing the three types of coated tools, both the "S" and the "D" of the Type I tool were the smallest, and those of the Type II tool were the largest.
(3) The main wear mechanism of the Type II and the Type III tool was abrasive wear. However, the main wear mechanism of the Type I tool was both abrasive wear and adhesion wear.
(4) The critical scratch load of the Type I tool, 81 N, was lower than that of the Type II or the Type III tool, over 130 N.

Therefore, comparing the Type I and Type III tools, due to the wear mechanism of the Type I tool being both abrasive wear and adhesion wear, the wear rate of the Type I tool, which has the lower critical scratch load, was slower.

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