**Properties of TaWN and TaN/TaWN Coating Film Deposited on WC-Co-Based Cemented Carbide using Magnetron Sputter Ion Plating**

**Tadahiro WADA**


**INTRODUCTION**

Many difficult-to-cut materials are widely used. For dimensions of these components, it is required to be machined by the metal removal process (Tadahiro Wada et al., 2017).Titanium based films have been widely used as coating films (e.g., K. Sakagami et al., 1998, H. Nakagawa et al., 2002). R. Westergard, M. Bromark, M. Larsson, P. Hedenqvist, S. Hogmark. (1997). Mechanical and tribological characterization of DC magnetron sputtered tantalum nitride thin films, Surface and Coatings Technology, 97(1), 779-784. https://doi.org/10.1016/S0257-8972(97)00338-1

It is considered that the TaWN coating film in which W (tungsten) is added to the TaN coating film is effective for improving the adhesion with WC, which is the main component of the substrate. However, no study has reported on the cutting film performance and cutting performance of TaWN coating film with W added to TaN coating film.

The performance of the coating film and improving the cutting performance can be extended by the use of a multi-layer coating system (Maria Nordin et al., 1999, M. Nordin et al., 2000, M. Kathrein et al., 2005, reported the remarkable influence of additional elements on the properties of Ti-Al-xN based coatings. And, alloying with elements such as Ta, and B resulted in a significantly increased lifetime in various cutting applications. Yun Chena et al., 2016, reported that AlCrSiCN is harder than AlCrN.

(1) Droplets on the surface of both the TaWN and TaN/TaWN coating films were negligible.

**CONCLUSIONS**

In this study, the thickness, hardness and scratch strength of TaWN and TaN/TaWN coated tools were measured. The substrate used was a cemented carbide ISO K10. The work piece used was a hardened steel AISI D2. This work piece was turned with the TaWN and TaN/TaWN coated tools. The tool wear of the TaWN and TaN/TaWN coated tools was investigated. Furthermore, the TaN coated tool was also used.

(2) The hardness of the TaWN and TaN/TaWN coating films were 2340 HV0.25N and 2630 HV0.25N, respectively.

(3) The critical load of both the TaWN and TaN/TaWN coated tools was over 130 N.

(4) The friction coefficient of the TaWN/TaWN coated tool was 0.44 and 0.53, respectively.

(5) The wear rate of the TaWN/TaWN coated tool was slower than that of the TaN or TaWN coated tool.

**REFERENCES**


INTRODUCTION

Ti1-xAlxN and Cr1-xAlxN alloys are among the most widely used physical and chemical vapor deposited hard coating materials due to their outstanding functional properties [1]. In order to improve the micro-properties of the CrAlN-coating film, there is a method of forming a multilayered coating film [2, 3]. In another method, the properties of the CrAlN-coating film can be easily improved by adding silicon (Si) [4-9] to the target. Adding tungsten (W) to the film other than silicon is also effective for improving the properties of the CrAlN-coating film [10-14]. That is, in order to improve both the scratch strength and the micro-hardness of the (AlCr)N coating film, cathode material of an (AlCr,W)-target was used in adding tungsten to the cathode material of the (AlCr)-target [10]. In cutting hardened sintered steel, tool wear was experimentally investigated [10, 11]. Moreover, in cutting Sintered Steel [12] and hardened steel [13], tool wear was experimentally investigated. As a result, it was found that adding the tungsten composition to the (AlCr)-target has a considerable effect on the wear resistance of the cutting tool. However, the wear progress of the (AlCr,W)-based coated cemented carbide in cutting alloy steel have not been clarified.

In this study, to clarify of the effectiveness of the (Al,Cr,W) -coating film for cutting alloy steel, the tool wear was experimentally investigated.

CONCLUSIONS

In this study, to clarify of the effectiveness of the (Al,Cr,W) -coating film for cutting alloy steel, the tool wear was experimentally investigated.

The following results were obtained:

1. The wear progress of cemented carbide tool deposited using the (Al,Cr,W)-target was slower than that of the coated cemented carbide tool deposited using the (Al,Cr)-target.

2. The wear progress of the (Al64, Cr28,W8)N-coated tool was slower than that of the (Al60, Cr25,W15)-coated tool.

3. In the case of the coated cemented carbide tool deposited using the (Al64,Cr28,W8)-target, although the adhesiveness of the (Al64,Cr28,W8)(C,N)-coated tool became higher, the wear progress of the (Al64,Cr28,W8)(C,N)-coated tool became faster than that of the (Al64,Cr28,W8)(N)-coated tool.

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Wear Mechanism of Multi-layer AlCrWN/AlCrWSiN Coatings on Cemented Carbide Tool Prepared by Arc Ion Plating in Dry Cutting of Sintered Steel

Tadahiro WADA and Hiroyuki HANYU∗

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INTRODUCTION

A machine part having a complicated shape can be accurately mass-produced by powder metallurgy, while a sintered material can be produced because it has a large degree of freedom in terms of material design. For dimensional accuracy, it is often necessary for sintered steel machine parts to be machined by a mass production metal removal process. The tool life in cutting sintered steel is shorter than that in cutting molten steel such as carbon steel. Moreover, as sintered machine parts are often cut at high cutting speed for mass-production, the tool materials must have effective wear resistance. An aluminium-chromium-based coating film has been developed. Comparing the performance of AlCrN coated tool inserts with that of TiN coated ones, the former can achieve approximately 35% more depth of cut and can attain higher cutting speed due to better thermal resistance of the coated inserts [1]. However, the results of our study indicate that the critical scratch load, which was the value measured by the scratch test, of the AlCrN coating film was 77 N and the micro-hardness was 2760 HV0.25N. Therefore, in order to improve both the scratch strength and the micro-hardness of the AlCrN coating film, cathode material of an Al-Cr-W target was used in adding tungsten (W) to the cathode material of the Al-Cr target. As a result, the scratch strength and the micro-hardness of the AlCrWN coating film increased to 81 N and 3110 HV0.25N, respectively [2]. To improve the properties of the coating film, the cathode material of an Al-Cr-W-Si target was used [3-5]. For example, Yu-ping Feng et al. reported that the hardness of AlCrSiWN coating film is higher than that of AlCrN at temperatures below 700 degrees Celsius [3]. Many multi-layer coating materials to improve tool life have been developed [6-10]. The wear progress of the multi-layered AlCrWCN/AlCrWSiCN-coating materials to improve tool life have been developed [6-10]. The wear progress of Type III, which was the multi-layer coated tool, was the slowest in cutting sintered steel. Moreover, as sintered machine parts are often cut at high cutting speed for mass-production, the tool materials must have effective wear resistance. An aluminium-chromium-based coating film has been developed. Comparing the performance of AlCrN coated tool inserts with that of TiN coated ones, the former can achieve approximately 35% more depth of cut and can attain higher cutting speed due to better thermal resistance of the coated inserts [1]. However, the results of our study indicate that the critical scratch load, which was the value measured by the scratch test, of the AlCrN coating film was 77 N and the micro-hardness was 2760 HV0.25N. Therefore, in order to improve both the scratch strength and the micro-hardness of the AlCrN coating film, cathode material of an Al-Cr-W target was used in adding tungsten (W) to the cathode material of the Al-Cr target. As a result, the scratch strength and the micro-hardness of the AlCrWN coating film increased to 81 N and 3110 HV0.25N, respectively [2]. To improve the properties of the coating film, the cathode material of an Al-Cr-W-Si target was used [3-5]. For example, Yu-ping Feng et al. reported that the hardness of AlCrSiWN coating film is higher than that of AlCrN at temperatures below 700 degrees Celsius [3]. Many multi-layer coating materials to improve tool life have been developed [6-10]. The wear progress of the multi-layered AlCrWCN/AlCrWSiCN-coating materials to improve tool life have been developed [6-10]. The wear progress of Type III, which was the multi-layer coated tool, was the slowest in cutting sintered steel.

CONCLUSION

In this study, to clarify the effectiveness of the multi-layer AlCrWN/AlCrWSiN-coated cemented carbide tool, the wear progress was investigated in cutting sintered steel using three types of coated tools. Tool I had a mono-layer (Al60,Cr25,W15)N-coating film, Tool II had a mono-layer (Al53,Cr23,W14,Si10)N-coating film and Tool III had a multi-layer (Al60,Cr25,W15)N/ (Al53,Cr23,W14,Si10)N-coating film.

The following results were obtained:

(1) The main tool failure of the three types of coated tools was flank wear within the maximum value of the flank wear width of 0.2 mm.
(2) The wear progress of Type III, which was the multi-layer coating system, was the slowest in cutting sintered steel.

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* OSG Corporation
Tool Wear of Poly Crystalline Diamond in Cutting WC-Co Cemented Carbide with High-Pressure Coolant Supplied

Tadahiro WADA

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INTRODUCTION

WC-Co hard metals or cemented carbides are used in applications where wear resistance is important [1]. For example, they are widely used for a variety of machining, cutting, drilling, and other applications [2] due to their very high hardness and excellent resistance to shock and wear [3]. Sintered WC-Co components have to be machined in order to meet the demands of good surface quality and precision [4]. To achieve hard metal parts finishing, replacement of electro-discharge machining (EDM) and diamond wheel grinding is required. In fact, both are time consuming techniques, the former being very expensive due to the electrode cost, while the latter suffers from reduced lifespan of the tools, and the wheels requiring frequent dressing and sharpening [5]. Polycrystalline diamond (PCD) cutting of WC-Co cemented carbide is described in the catalog of several cutting tool makers [6]. Katsuko Harano et al. [7] reported that in turning WC-7 mass% Co cemented carbide (grain size: 2 μm) with the PCD tool, whose average grain size was 5 μm, under the condition of a cutting speed of 0.33 m/s, a depth of cut of 0.05 mm and a feed rate of 0.1 mm/rev, the flank wear width is about 0.22 mm after cutting to 280 m. Therefore, when cutting cemented carbide at a high cutting speed, due to elevation of cutting temperature, the tool life is remarkably shortened. For this reason, the recommended cutting speed is 0.17-0.33 m/s in cutting cemented carbide with a PCD tool [6].

In order to identify an effective PCD tool for the high-speed cutting of WC-16 mass% Co cemented carbide, the influences of the diamond content and the diamond particle size on the tool wear were experimentally investigated. The WC-16 mass% Co cemented carbide was turned with high-pressure coolant supplied, the tool wear was experimentally investigated.

CONCLUSIONS

To identify an effective PCD tool for the high-speed cutting of WC-16 mass% Co cemented carbide, the influences of the diamond content and the diamond particle size on the tool wear were experimentally investigated. As the WC-16 mass% Co cemented carbide was turned with high-pressure coolant supplied, the tool wear was experimentally investigated.

The following results were obtained:

1. In turning WC-16 mass% Co cemented carbide with the PCD tool, the wear progress slowed down considerably by using the high-pressure coolant supplied method.
2. In the case of the cutting of high-pressure coolant supplied by the PCD tool, the tool wear of the PCD tool decreased significantly with the increase in the diamond particle size.
3. In the case of the cutting of the high-pressure coolant supplied by the PCD tool, which has a large diamond particle size, WC-16 mass% Co cemented carbide could be cut at the higher cutting speed of 1.167 m/s.

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REFERENCES

INTRODUCTION

Engineering processes can be used to modify the surface properties of metallic materials in different types of industries. Thermal spraying is a common process used for depositing the metallic matrix and deposited coatings due to easy process ability, reasonable material costs and good mechanical properties [1]. To increase the wear, erosion, and corrosion resistance of tribologically-stressed functional surfaces, the use of thermally-sprayed coatings is increasing [2]. Many studies on thermal spraying have been reported [3-8]. Ni-based materials alloyed with Cr or/and Al such as NiCr, NiAl or NiCrAl are frequently employed as coatings to protect components against high-temperature corrosion [8]. A thermally-sprayed coating such as NiCrBSi made by adding Cr, B, Si to Ni gives excellent strength and excellent resistance to adhesive and abrasive wear at elevated temperatures. In particular, applications are [3], for example, piston rings or rollers in steel making [3]. WC-Co coating is widely used for wear resistance applications. The WC-Co coating to WC-Co improves binding of the metallic matrix with the WC grains and provides a better wear-resistant coating [9]. Stellite-21, WC-Co-Cr and Cr3C2-NiCr coating powders were deposited on high tensile steel being used for tiller blades by the pulsed detonation spraying technique and the wear behavior of these coatings was evaluated by the pin-on-disc mechanism at an ambient temperature under dry conditions in accordance with the ASTM G-99 standard [10]. As a result, it was observed that the WC-Co-Cr coating on high tensile steel provided higher wear resistance in abrasion in comparison to Cr7C2-NiCr and Stellite-21 [10].


In this study, in order to obtain an effective tool material for intermittent cutting of two types of thermally-sprayed coatings, tool wear was investigated experimentally. The Ni-based self-fluxing alloy coating (Ni67, Cr16, B4, Si4, Cu3, Mo3, Fe2, 5C, 0.5) and the thermally-sprayed (WC-Cr-Ni) cermet coating (W70, Cr19, Ni5, Cr6) were used as the thermally-sprayed coatings. AISI 304 stainless steel was used as a substrate material of thermally-sprayed coatings. In the case of the intermittent cutting of Ni-based self-fluxing alloy coating, conventional cutting materials, namely CVD-coated cemented carbide and ceramics, were used as cutting materials. In the case of the intermittent cutting of the thermally-sprayed (WC-Cr-Ni) cermet coating, in addition to Si3N4 ceramics, three types of uncoated cBN and a coated cBN were also used as the tool material. The uncoated cBN and the coated cBN were deposited with different thermal spray techniques, Surface and Coatings Technology, 318, pp. 233-243, 2017.

CONCLUSIONS

In this study, to obtain an effective tool material for the intermittent cutting of two types of thermally-sprayed coatings, worn tool edge was investigated experimentally. The results are as follows:

A. In the case of intermittent cutting of Ni-based self-fluxing alloy coating AISI 304:

1. The cBN having the large grain size of cBN and high contents rate was effective for wear resistance.
2. The cBN having high hardness and the transverse-rupture strength was effective for wear resistance.
3. In the case of the cBN C, there was little difference in the VB/Max between 0.50 m/s and 1.00 m/s.

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