Prolonging Operational Lifetime and Reducing Cutting-Edge Chipping in Die Cutters

ダイカッターにおける長寿命化とチッピングリスク低減

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キーワード；CC アンビルロール、ロータリーダイカッター、超硬合金

Abstract

We are aiming to make the die cutter stable for a long time. Wear conditions change with different combinations of materials for die cutters and anvil rolls. We required an anvil roll with prolonged operational lifetime and reduced cutting-edge chipping risk. In a previous study, we evaluated a carbide coated (CC) anvil roll through comparative testing with other materials. In the present study, we conducted long-run tests under high load conditions. We report the wear on the anvil roll and cutting edge of the die cutter, in relation to Young's modulus and hardness. Our results show that neither chipping nor a rapid increase in the cutting edge land width were observed for the CC anvil roll. In addition, the CC anvil roll prolongs operational lifetime and reduces the risk of cutting-edge chipping under high-load conditions.

私たちはダイカッターを長期間安定稼働させることを目標としている。摩耗条件はダイカッターとアンビルロールの材料組み合わせによって異なり、長寿命化と刃先損傷リスク低減効果をもつアンビルロールが必要とされている。前報告では、他材種との比較試験により Carbide Coated(CC) アンビルを評価した。本研究では、高負荷条件下での長期ランニング試験を行った。本報告ではダイカッター刃先の摩耗とアンビルロール表面の摩耗について、ヤング率と硬度の関係性を報告している。その結果、CC アンビルロールと接触している刃先には、刃先ランド幅の急激な増加が見られなかった。また CC アンビルロールは長寿命化を実現し、高負荷条件下においても刃先損傷リスクを低減することがわかった。

1. Introduction

The NT Die Cutter (Nippon Tungsten, Fukuoka, Japan) was commercialized in 1986 as a cemented carbide rotary cutter for processing paper and non-woven cloth, which are difficult to cut using a mold. NT Die Cutter consists of a rotary cutter with three-dimensional cutter blades on the cylindrical outer surface and an anvil roll with a smooth cylindrical outer surface. NT Die Cutter cuts raw material sheet to the required product shape by passing it between these two rolls. Nippon Tungsten manufactures rotary cutters and anvil rolls using cemented carbides and other ferrous materials. The combination of a cemented carbide rotary cutter with a cemented carbide anvil roll can achieve a long operational lifetime owing to the excellent wear resistance of cemented carbide. Although wear resistance is high, excessive force applied to the cutting edge due to exterior environment factors such as temperature and vibration increases the risk of cutting-edge chipping. With a cemented carbide rotary cutter and a steel anvil roll, the risk of cutting-edge chipping is low but the operational lifetime is shorter than that when both rolls are cemented carbide. We aimed to evaluate the CC anvil roll under harsh conditions.

2. Experimental

We evaluated wear on the die cutter at the cutting edge and abrasion flaw depths on the surface of anvil roll. Generally, the blade height of the die cutter is lowered due to progress abrasion at the cutting edge. In the present study we measured the decrease in blade height using a dial gauge. Abrasion flaws are typically generated on the anvil roll surface due to the contact with the cutting edge. The depth of abrasion flaws was measured using a surface roughness measuring device.

We conducted two experiments (A and B) to analyze blade wear and abrasion flaws. We used a cemented carbide rotary cutter with anvil rolls shown Fig. 1. In a previous experiment (Experiment A), we used a unique anvil roll with a separated structure in which bands of different materials were combined into one roll. The materials used were hardened steel (SKD11; JIS), CC similar to that used in the anvil roll (CC anvil roll; Nippon Tungsten), and cemented carbide (grade G30 and G50; Nippon Tungsten). The roll load was increased by 245 kgf (2402N) per 50,000 rotations from 490 kgf (4805N) at the beginning of the test to 1490 kgf (14611N) at the end of the test. In Experiment B, we used our CC anvil roll in which the whole surface is coated by carbide (coated range ϕ 100 mm × 155 mm). Experimental conditions are shown in Table 1. The physical properties of each material are shown in Table 2.

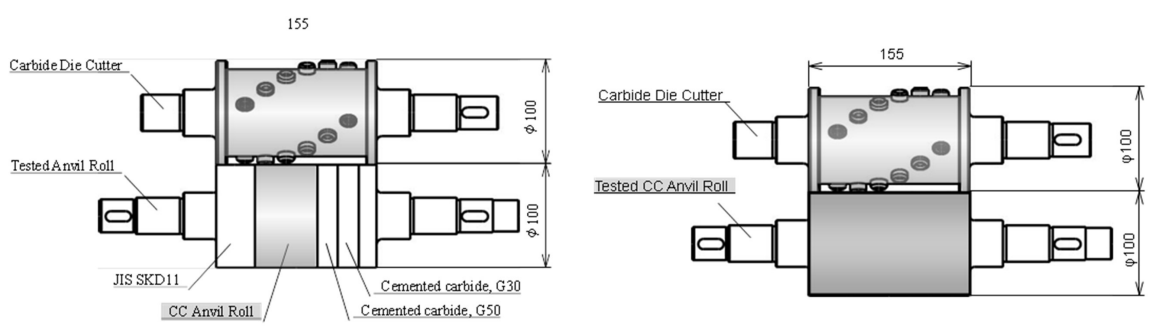

Fig. 1 Schematic of die cutter and anvil roll. (left) Experiment A, (right) Experiment B)

Table 1 Experimental conditions

	Conditions	
Item	**Experiment A**	**Experiment B**
Rotational speed	600rpm	
Total number of rotations	250,000	5,000,000
Load on the Roll	490-1469kgf	1469kgf
Driving method for Anvil roll	Receiving a driving force of the motor through a pulley	
Driving method for Die Cutter	Receiving a driving force by the fiction force between die cutter and anvil roll	

Table 2 Physical properties of each material

Materials	Young's modulus(GPa)	Vickers hardness
Carbide Die cutter FND30	530	1633
JIS SKD11	210	685
CC30	338	1200
G30	550	1199

Abbreviations: SKD11: hardened steel, CC30: carbide coating, G30: cemented carbide.

3. Results and Discussion

3.1 Experiment A

3-1-1. Die cutter wear

Die cutter wear (μm) indicates the decrease in die cutter overhang.

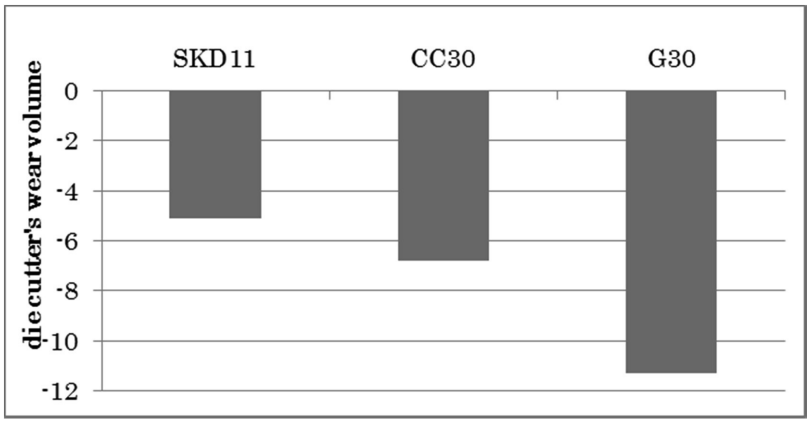

Fig.2 Comparison of die cutter wear among different anvil roll materials

Wear of the cutter was decreased by 44% against the CC30 anvil roll and by 58% against the SKD11 anvil roll, compared with against the G30 anvil roll.

3-1-2. Anvil roll wear

Anvil roll wear (μm) indicates the abrasion flaw depths in the anvil roll surface.

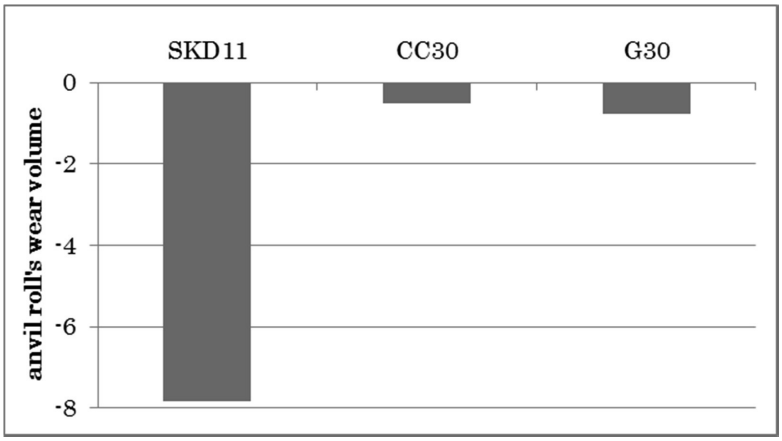

Fig.3 Comparison of anvil roll wear among different anvil roll materials

Abrasion flaw depths on the G30 anvil roll and CC30 anvil roll were between 1% and 5% those compared with those on the SKD11 anvil roll.

3-1-3. Total wear

Total wear (μm) is the sum of die cutter wear and anvil roll wear.

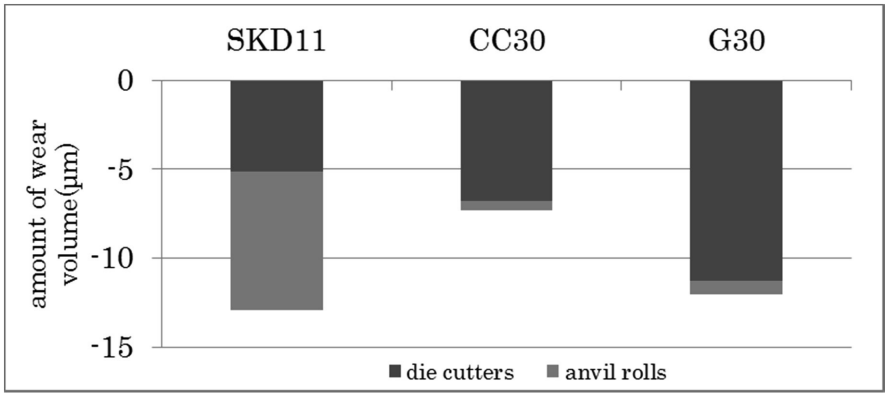

Fig.4 Comparison of total wear among different anvil roll materials

The total wear for SKD11 and for G30 were nearly the same, despite the wear ratio (die cutter/anvil roll) being different. In contrast, the wear for CC30 was approximately 50% that for SKD11 or for G30. Consequently, CC30 is expected to provide prolonged operational lifetime.

These results indicate that the surface hardness of the anvil roll dominates the wear of anvil roll, as the wear of the CC30 and G30 anvil rolls is similar but much larger than that of the SKD11 anvil roll. In contrast, the surface hardness of the die cutter for the CC30 and G30 anvil rolls is the same, but we

observed a big difference in the anvil roll wear. We also observed a slight difference in wear between the CC30 and G30 anvil rolls despite them having different surface hardnesses. We predicted that the Young's modulus of the CC30 anvil roll is smaller than that of G30 anvil roll. According to the test result, the CC anvil roll has both high hardness and lower Young's modulus, as shown by the small amount of wear.

3-2-1. Comparison of wear for experiments A and B

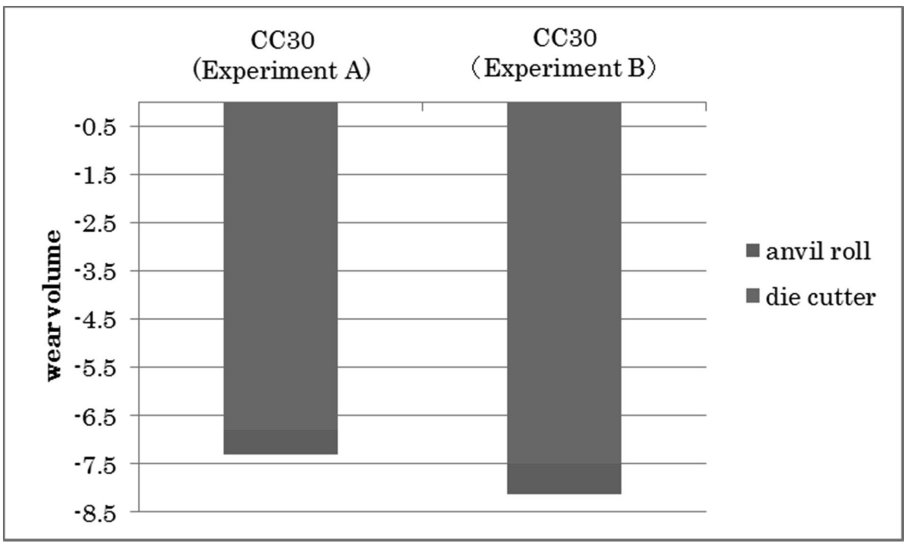

Fig.5 Comparison of wear for experiments A and B

The test results of Experiment B confirm the prolonged operational lifetime of the CC anvil roll. The results show that wear increased by only 10% compared with Experiment A, whereas the number of rotations was 2000% that of Experiment A.

3-2-2. Observation of cutting edge

Neither chipping nor a rapid increase in the cutting edge land width were observed after Experiment B. The Fig 6 shows a photograph of the top of the cutting edge.

The CC anvil roll is a solid option to reduce a risk of the chipping. Even under the higher load of Experiment B, the anvil roll and die cutter ran for a long time. We estimate that the Young's modulus of the CC anvil roll is low allowing it to absorb excessive stress at the moment of contact between the die cutter and the anvil roll.

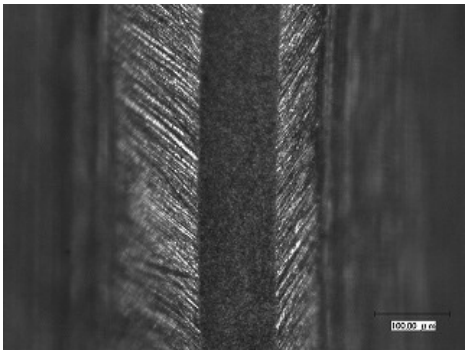

Fig.6 Photo of cutting edge

4. Conclusions

4.1 From Experiment A

・Wear of the die cutter decreases with decreasing Young's modulus.

・Wear of the anvil roll decreases with increasing surface hardness.

・The CC anvil roll had the lowest total wear for both die cutter and anvil roll.

・Lower Young's modulus and harder surface is desirable for a durable anvil roll.

4.2 From Experiment B

・Wear increased by 10% for a 2000% increase in loading rotation.

・Neither chipping nor rapid increase in the cutting edge land width were observed.

・The CC anvil roll prolongs operational lifetime and reduces the risk of cutting-edge chipping under high-load conditions.