on each abrasion trace in four perpendicular sections according to the standard

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Investigation of adhesion behaviour of DLC coated cold forming tool steel

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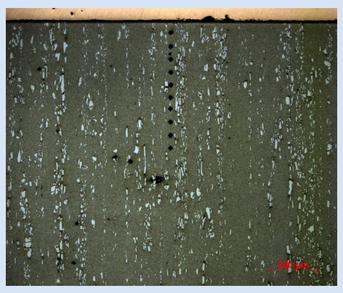
INTRODUCTION

Mono- and multilayer coatings can be suitable alternatives to traditional bulk materials due to their favorable mechanical properties. Thanks to the ever-evolving coating technology and process, there are a wide variety of coating types today, such as soft, hard, or super-hard coatings that can be made with single or multilayer coatings. Adhesion and damage to coatings is especially important for coated tools, where damage to the coating can reduce tool life and result in deterioration of the surface quality of the product.

The adhesion test of the different underlayered (TiBN, CrN and TiAlN) DLC coated Böhler K100 (X210Cr12) forming tool steel is designed with the Mercedes test (Rockwell C Adhesion Test), which is frequently used to classify the layers, and is complemented by instrumented scratch test.

1. Thickness and microhardness

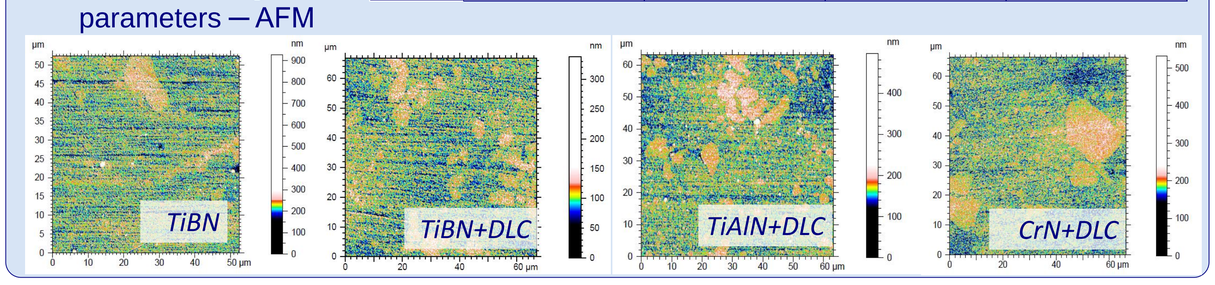
	TiBN	TiBN+ DLC	TiAlN+ DLC	CrN+ DLC
Thickness of TiBN / TiAlN / CrN layer [µm]	2,207	2,04	1,72	1,341
Thickness of the WC layer [µm]	-	0,72	0,562	0,474
Thickness of DLC layer [µm]	-	1,461	1,472	1,5
Σ Thickness [µm]	2,207	4,22	3,75	3,315
HV0.1	401,4	474,4	475,2	552



2. Surface roughness

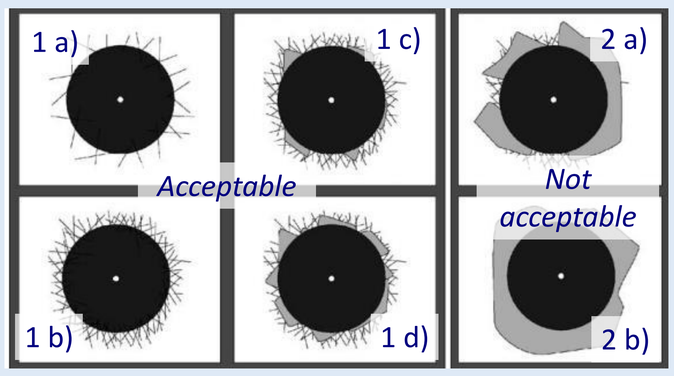
- Effects of underlayer on the 2D roughness parameters – AFM

SR, nm	TiBN	TiBN+DLC	TiAlN+DLC	CrN+DLC
Rz	156	93,4	110	107
Ra	19,3	13,9	14,2	14,3

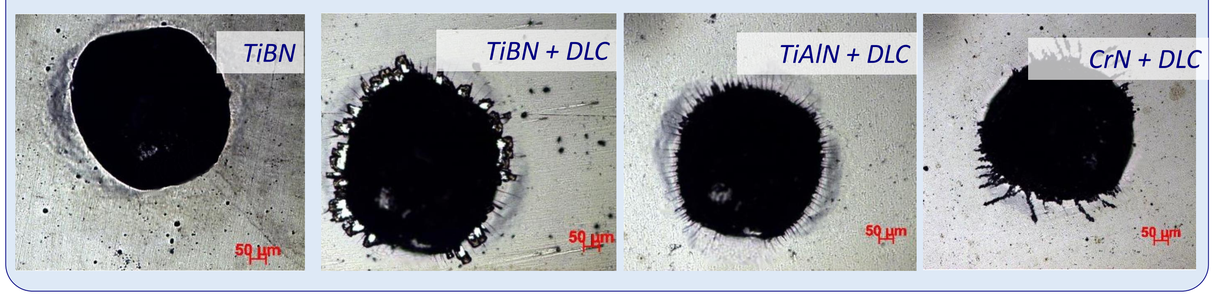


3. Rockwell-C adhesion test

- Examination of adhesion properties of coatings;



Parameters	
Standard	VDI 3198
Load	1500 N
Tool	120° diamond spheroconical



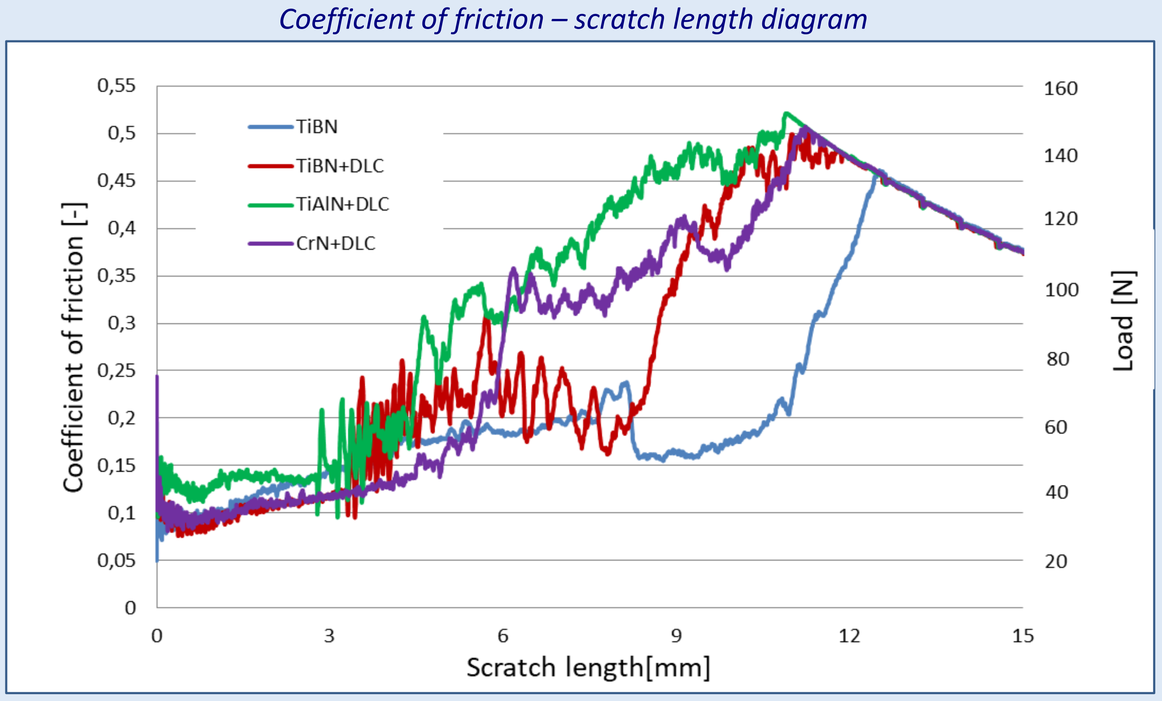
4. Instrumented scratch test of DLC coated tool steel

- Determination of critical force of coating peel-off

Parameters	
Measuring equipment	SP-15
Loading mode	Linearly increasing, normal load
Initial force	2 N
Scratch length	15 mm
Table movement speed	5 mm/s
Normal force	150 N

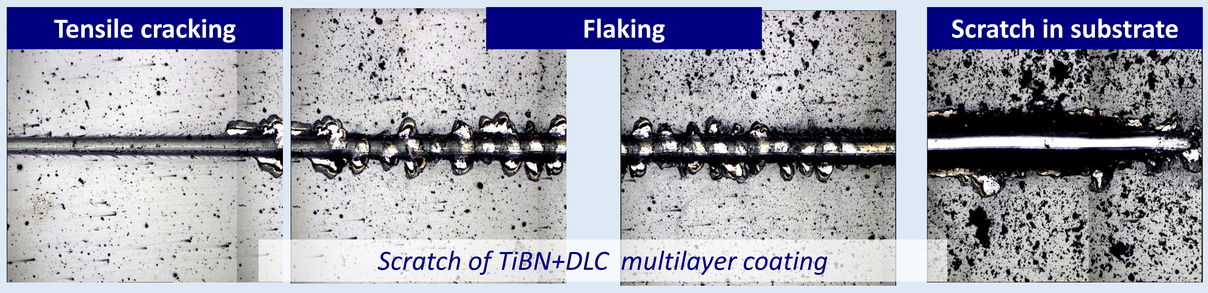

Instrumented scratch tester

Coefficient of friction – scratch length diagram



Results of scratch test

Coating type	Coefficient of friction, µ[–]	Critical force, F_{crit}[N]
TiBN	0.18	105 N
TiBN + DLC	0.17	100 N
TiAlN + DLC	0.1-0.12	42 N
CrN + DLC	0.15	80 N



Scratch of TiBN+DLC multilayer coating

Results

- ***The highest critical load*** *required for the release of the* ***TiBN coating can be reconciled with the adhesion properties*** *of the coating;*
- ***The same is true for the TIBN underlayered DLC coating. The coating peels of at a scratch length of 10 mm;***
- *During scratch testing of* ***TiAlN + DLC*** *coating,* ***the coating detached from TiBN much earlier compared to underlayered coatings****. Much* ***less critical load*** *is required to damage the coating.*
- *In the case of the* ***CrN + DLC coating****, it takes* ***more time for the coating to peel off.***

5. CONCLUSION

In our research, the adhesion properties of various underlay DLC coatings were investigated using Rockwell adhesion testing and instrumented scratch testing. The results of the studies can be summarized as follows:

1) he Rockwell-C adhesion test is suitable for the qualitative description of the adhesion properties of coatings, but does not provide quantitative results. Based on the tests performed, the coatings can be considered suitable for adhesion.
2) It can be determined on the basis of the scratch tests performed. that the scratch resistance of different single and multilayer coatings is typically different, the critical loading force characteristic of layer deposition in the TiBN coated sample is the largest, the critical loading force is lower for coatings with a DLC topcoat, presumably due to early layer damage.
3) The Rockwell C adhesion test, supplemented by an instrumented scratch test, may be suitable for DLC coated tool steels for a broader description of the adhesion properties of coatings.

References

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