The Increasing of the Wear Life of the Cutting and Stamping Tools by Using the Progressive Vacuum Ion-Plasma Coatings

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Abstract – The object of this work is nanotechnology of the wear resistant coatings condensation for stamping and cutting tools. The structure and mechanical properties of the coatings have been investigated. The main fields of application of the tools and the AVTOVAZ experience in tool strengthening have been shown in this paper.

1. Introduction

At AVTOVAZ tool industry the modern vacuum coating centre has been developed. That includes the most advanced PVD equipment, such us RSC "BALZERS" (Lichtenstein), "STANKIN", "VIT-14" (Russia) and coating technologies [1].

During the process of creation the centre the vacuum ion – plasma coatings TiN-, TiCN-, TiAlN-, CrN-based have been worked out for different fields of application: drilling, turning, gear cutting, milling, threading, forming.

These coatings are nanostructured, multilayer and gradient (for TiCN), have high level of adhesion due to the gas (Ar) ion bombardment and hydrogen deoxidation.

The properties, structure of the coatings (RCS "BALZERS") and the field of application are shown at the Table I.

Also the high-performance filtered PVD nanocoatings for cutting and stamping tools have been designed with using "VIT-14" (Russia) installation (Table II).

Table I. BALZERS coatings for cutting and stamping tools

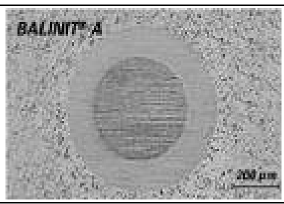
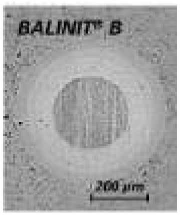
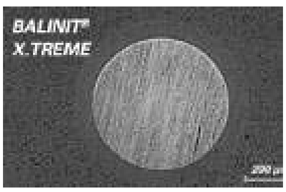
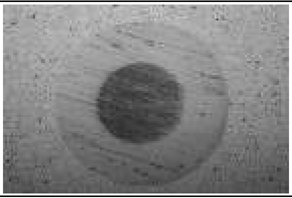
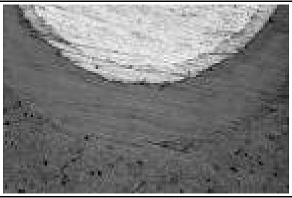
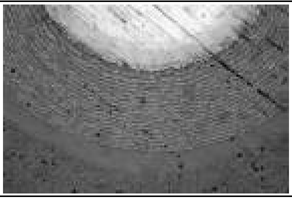
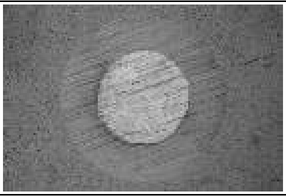
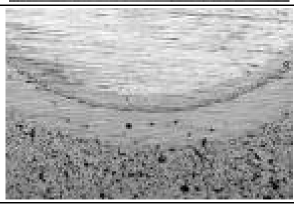
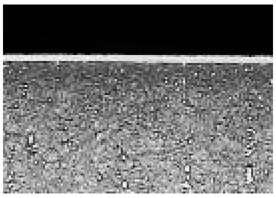
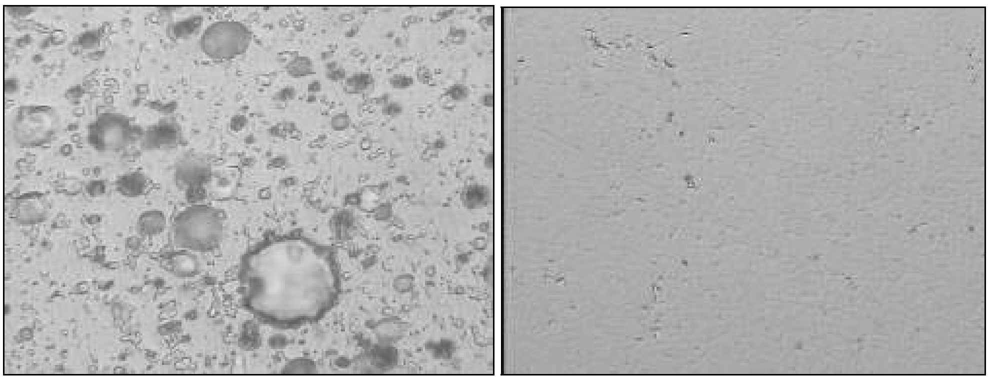
Product name, coating material	Coating structure	Properties	Basic advantages	Primary applications
BALINIT® A TiN (monolayer)		t, °C 600 2200–2300 HK0.05 Coating thickness: 1–4 um Friction coefficient against steel (dry) – 0.4 Coating color – gold	Standard coating with a broad application range. Substrate material – HSS, HSS-PM, CC	Steel machining, plastic moulding, stamping
BALINIT® B TiCN (multilayer, gradient)		t, °C 400 3000 HK0.05 Coating thickness: 1–3 um Friction coefficient against steel (dry) – 0.4 Coating color – blue-grey	High hardness, good toughness, high abrasion resistance. Substrate material – HSS, HSS-PM, CC	For tools under high mechanical load, milling, forming, stamping
BALINIT® FUTURA NANO TiN +TiAlN (multilayer, nanostructured)		t, °C 900 3300 HK0.05 Coating thickness: 1–4 um Friction coefficient against steel (dry) – 0.3…0.35 Coating color – violet-grey	Optimum ratio of hardness / internal stress. Higher thermal and chemical stability and sliding properties. Higher wear resistance. Substrate material – HSS, HSS-PM, CC	For HHS and carbide tools working under high thermal and abrasive load (drilling, turning, gear cutting, dry machining)
BALINIT® X.TREME TiAlN (monolayer)		t, °C 800 3500 HK0.05 Coating thickness: 1–4 um Friction coefficient against steel (dry) – 0.4 Coating color – violet-grey	High hardness. Substrate material – CC	For tools under high mechanical load, especially for hard machining + HSC

Table II. High-performance filtered coatings for cutting and stamping tools

Coating material	Coating structure	Properties	Basic advantages	Primary applications
TiN (monolayer, nano crystalline, filtered)		*t*, °C 600 2500–2700 HK0.05 Coating thickness: 1–5 um Coating color – gold	Optimum ratio of wear resistance/ thermal stability	Standard coating with a broad application range. Steel machining, plastic moulding, stamping
TiAlN (two-layer nano crystalline, filtered)		*t*, °C 900 3000–3300 HK0.05 Coating thickness: 1–4 um Coating color – violet-gray	Higher thermal stability and sliding properties	For carbide tools working under high thermal and abrasive load (drilling, turning)
TiN +TiAlN (multilayer, nano crystalline, filtered)		*t*, °C 900 3000-3300 HK0.05 Coating thickness: 1–4 um Coating color – violet-gray	Optimum ratio of hardness / internal stress. Higher thermal stability and sliding properties	For HHS and carbide tools working under high thermal and abrasive load (drilling, turning, gear cutting, dry machining)
CrN (monolayer, nano crystalline, filtered)		*t*, °C 700 2200 HK0.05 Coating thickness: 2–6 um Coating color – silver-gray	High oxidation – and corrosion resistance	Hot/warm forming, die casting, Cu alloy machining
TiN + CrN (Two-layer, nano crystalline, filtered)		*t*, °C 700 2200 HK0.05 Coating thickness: 2–6 um Coating color – silver-gray	Optimum ratio of hardness/ internal stress. Higher thermal stability and sliding properties	For tools working under high thermal fatigue and abrasive load
Complex processing (ion – plasma nitriding + coating)		Diffusion layer: 1300 HV0.05 Thickness – 10–50 um	Low gradient in properties between coating and the base metal. Higher thermal stability and hardness of the base metal (increase on 30–50 °C). Optimum structure of nitrated layer (without nitride – and carbonitride phases)	Hot/warm forming. For HHS tools working under high thermal and abrasive load



a *b*

Fig. 1. Structure of commercial (*a*) and filtered (*b*) TiN coating (×1000)

The main adventures of FAD (filtered arc deposition) technique are:

– the absence of micro droplets in structure;

– significant grains refinement of the coating that leads to the formation of nano-crystalline (grains size around 50 nm) surface layer;

– high microhardness in comparison with commercial coatings;

– roughness after deposition does not increase (Fig. 1).

Preliminary ion-plasma nitriding before the coating deposition allows improving the heat endurance about 30–50 °C, decreases the gradient in physicomechanical properties between the coating and the base metal.

High adhesion of filtered PVD nanocoatings, low porosity and absence of micro droplets ensure the high productivity of cutting and stamping tools, working in difficult conditions of machining.

References

[1] A.I. Dodonov and V. Bashkov, *Patent WO 98/45871*.