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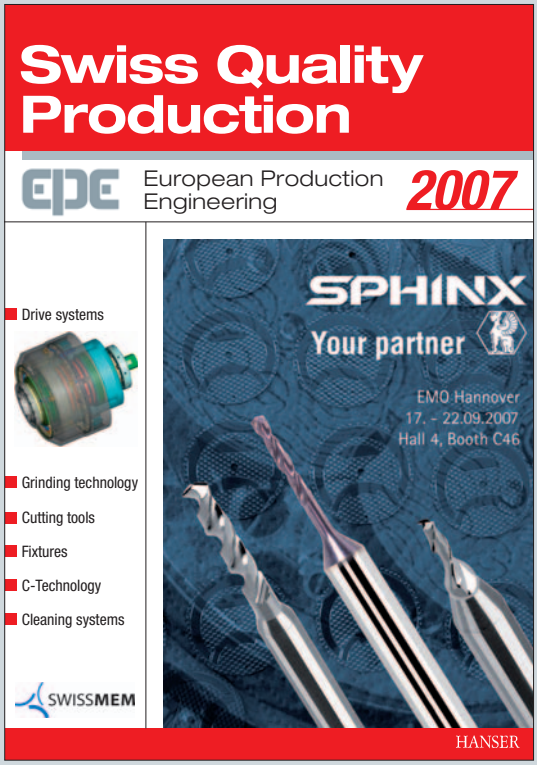
Tibor Cselle et al.

3 (+1) cathodes - 30 coatings - 300 batches



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The today's cutting is formed by ambitious materials that are often modified or new combined. Especially SMEs have to react quickly to changed machining tasks and have to adjust their cutting tools to the new challenges. That will be possible by applied, flexible produced coatings.

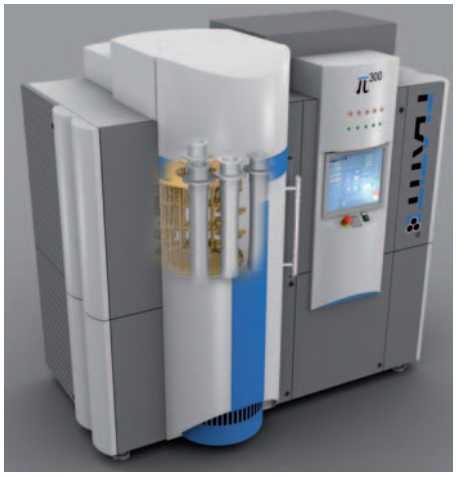

Fig. 1. The new ›π313‹-coater with 3 (+1) rotating cathodes

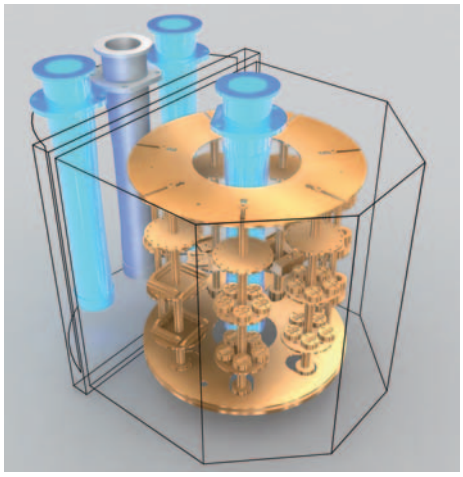

Fig. 2. Programmable change the cathode configuration even during the deposition process

Some years ago, rationalization premiums were paid to employees who replaced several materials by a universal one, saving transport and storage costs. Nowadays, this is no longer possible, due to the global competition [3]. To achieve the highest performance, one has to use optimized and correspondingly different materials according to the specific loads of each component. One observes the same trend in the coating industry. Only the large job coating centers try to push through their several standard coatings to fully utilize their large coating machines. Therefore they focus on large customers.

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Coatings have to be fast and individual producible

The SMEs not only need a variety of optimum raw materials, but as well:

- coatings which can be tailored for a particular application
- coatings which can be produced quickly and economically even for small series [5, 6].

With exactly this aim, the ›π300‹ family of machines was extended by the new ›π313‹ (Fig. 1). The π313 uses three LARC-cathodes (Lateral Rotating Cathodes) in the door and one CERC-cathode (Central Rotating Cathode) in the center of the coating chamber.

At any time, up to three cathodes may operate: either two LARC-cathodes (1, 3) and the CERC-cathode (4) in ›π312‹-configuration, or three LARC-cathodes (1, 2, 3) in ›π303‹-configuration. One ARC-power supply switches as programmed between cathode 2 and 4 therefore between both π-configurations, as many times as necessary within one coating batch (Fig. 2). In the conventional coating machines, the coating composition is determined, or at least decisively affected by the composition of the target alloy. If one wants to deposit a different coating in the next batch, for example to coat different components, one has to change targets beforehand. In some brand-new coaters even the MACs (Magnetic Confinement Control, cathode controller) are to be changed. This means, to be changed manually, mechanically.

The three most important cathode configurations

The π-machines predominantly use pure, unalloyed metal targets (Ti, Al, Cr, AlSi). The structure and perceptual composition of the coatings is steered by the software. A cathode change takes circa 30 minutes only, and is rarely necessary due to the task-oriented cathode configuration. (Fig. 3). The user can choose cathode configurations what ever he likes but there are three important ones:

- The ›default-configuration‹ makes effective and flexible deposition of Ti-Al based coatings possible (as TiN, TiCN, TiAlCN, TiAlN, AlTiN, nACo; each of these coatings with a DLC topcoat when required).
- The ›Ti-Cr-configuration‹ is primarily used for coating forming dies, for oxidization protection coatings and for tools designed to cut aluminum alloys (as TiN, TiCN, CrN, and CrTiN; each of these coatings with a DLC topcoat when required).
- The ›universal-configuration‹ offers the highest flexibility. In this configuration, more than 30 different coatings may be deposited without cathode change (table). These are practically all PVD coating compositions used in industry nowadays.

Figures: Platit

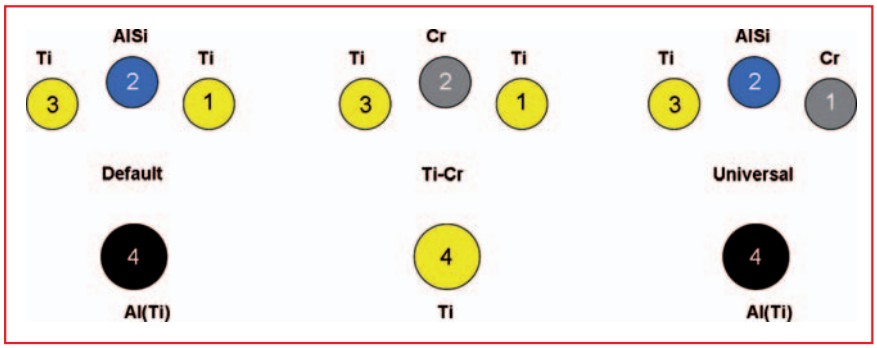

Fig. 3. Three most important cathode configurations of the π313

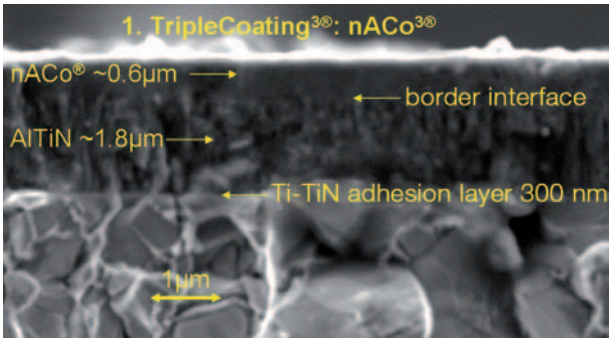

Fig. 4. nACo³, an example of a ›Triple‹-coating

With the aid of the freely programmable stochiometry, we developed new ›Triple-Coatings‹ (Fig. 4).

This triple coatings are fundamental designed as follows:

- The triple coating starts with an adhesive coating (for example TiN or CrN).
- The middle part, or kernel, consists of TiAlN-AlTiN, the most common composition for general applications. It can be configured to contain more or less Al to suit the application, by its build-up being a multilayer, nanolayer, or gradient.
- The topcoat is a superhard Nanocomposite coating (for example nACo: AlTiN/SiN), with very fine structure and high heat resistance [1, 2, 4, 6, 7].
- The advantage of the triple coatings is obvious; one combines the advantages of various coating materials and aims at a constant highest performance with minimal variation (Fig. 5).

The effective target area of a rotating cylindrical target is π-times broader compared to the area of a planar target of the same breadth. The material usage of the rotating target is substantially better, owing to the fact that the arc path consists of two movements (magnetic field guidance plus cathode rotation.

300 batches without target or cathode exchange

Since the introduction of the π-technology in 2003, more than 70 π-machines have been sold and put into operation, at 41 companies in 23 countries on 3 continents. The statistics show that, on average, more than 200 batches can be produced with one target. The ›world record‹ has been set up by the German company, HAM. They achieved 467 full batches of micro-drills with one single rotating Ti-target.

The universal-configuration (Fig. 3, right) has been developed for the most flexible coating operation, so that the most various coatings could be produced without changing cathodes, while not all cathodes are used for some coating types. In this way, up to 300 batches can be produced without cathode change with the 3 (+1) cathodes. The target cost per coated tool amounts to less than 10 cent, calculated for coating of 8 mm in diameter carbide end mills:

- 505 cutting tools in one batch;
- 151,200 cutting tools in 300 batches; with 5 hours/batch and 4 batches/day in 75 days;
- 14,263 Euro for exchanging of 4 targets (LARC: Ti, AlSi, Cr; CERC: Al(Ti));
- 0.093 Euro target costs/cutting tool.

The π-technology permits not only a flexible variation from one coating to the other, but as well, the freely programmable stochiometry (or composition) within one coating across the thickness is possible.

The high-tech industry expects each component to achieve highest performance. To fulfill this, each product must be manufactured, and coated as well, appropriately with respect to its particular application. In SMEs in particular, a multitude of ›dedicated‹ coatings is needed, produced flexibly, within shortest time and all this even for small quantities of tools. So as to meet these needs the new π313 coating machine:

- is equipped with 3 (+1) rotating cylindrical cathodes,
- can deposit 30 different coatings in its universal-configuration, through the

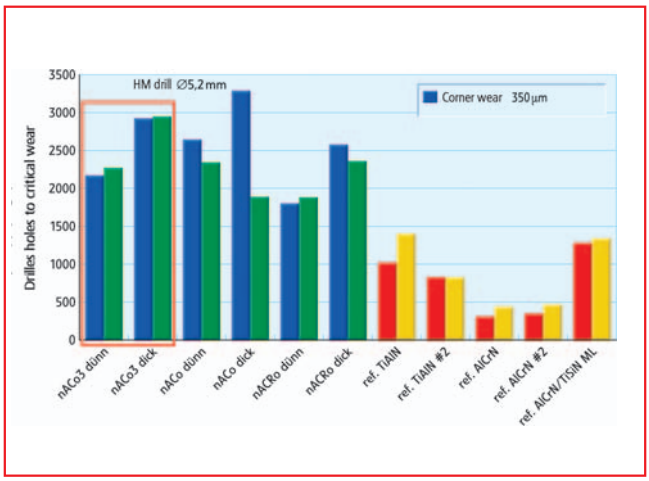

Fig. 5. Triple coatings offer a high capability with minimal variation

virtue of freely programmable stochiometry and

- can produce up to 300 batches without cathode exchange.

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Coating	Special features	Common application ranges
TiN	Monoblock structure	General, universal coating
SuperTiN	TiN – TiCN – TiN multilayer	Improved TiN
Ti2N	With high Ti content	Medicinal tools, implants
TiCN-grey	Conventional grey TiCN	Tapping
TiCN-MP	Multi-purpose, high-toughness TiCN	Tapping, stamping, milling
cVIc; TiCN + CBC	TiCN with a lubricating DLC topcoat	Forming, stamping, milling of Al alloys
TiAlCN	Reference: UNICUT Gradient structure; Ti/Al > 75/25 percent	High performance universal coating
GRADVIC; TiAlCN + CBC	TiAlCN with a lubricating DLC topcoat	Tapping, forming, stamping
UniversAl; TiAlN-ML	Reference: FIRE Multilayer structure; Ti/Al; 50/50 percent	Universal coating for steel and cast iron processing, particularly drilling
TiAlN-F	Reference: FUTURA Nanolayer structure; Ti/Al; 50/50 percent	Universal coating for steel and cast iron processing, higher toughness
TiAlN-G	Gradient structure; Ti/Al < 50/50 percent	Optimized universal coating
AlTiN-T	Reference: X-TREME Monolayer structure, Ti/Al; 40/60 percent	Universal coating with higher hot hardness for steel, cast iron machining
AlTiN-C	Reference: X-CEED Monolayer structure, Ti/Al; 33/67 percent	High performance coating for dry machining of steel and cast iron
AlTiN-ML	Multilayer structure; Ti/Al; 33/67 percent	High performance coating with enhanced toughness
AlTiN-G	Gradient structure; Ti/Al < 40/60 percent	Optimized high performance coating, the standard nowadays
µAlTiN	Reference: TINALOX Gradient structure	Optimized high performance coating with the highest surface quality
CrN	Monoblock structure	Standard coating for forming
CROMVIC; CrN + CBC	CrN with a lubricating DLC topcoat	Low lubrication forming
CrTiN	Nanolayer structure	Forming, corrosion protection and aluminum machining, wood cutting
CrTiN + CBC	CrTiN with a lubricating DLC topcoat	Like CrTiN at low lubrication
AlCrN-AlTiCrN	Reference: ALCRONA, ›All in one‹ coating instead of conventional AlCrN	Milling, hobbing
AlTiCrN + CBC	›All in one‹ coating with DLC topcoat	Low lubrication cutting, forming
nACo	Nanocomposite AlTiN/SiN	Hard and dry machining
FI-VIC; nACo + CBC	Nanocomposite AlTiN/SiN + DLC topcoat	Coating of machine components
nACo^3	TripleCoating^3 TiN + AlTiN + Nanocomposite AlTiN/SiN	Universal TripleCoating without chromium
nACRo	Nanocomposite AlCrN/SiN	Sawing, milling, hobbing, drilling
nACVIc nACRo + CBC	Nanocomposite AlCrN/SiN + DLC topcoat	Forming, aluminum machining, wood cutting
nACRo^3	TripleCoating^3 CrN + AlCrN + Nanocomposite AlCrN/SiN	Universal Triple Coating
nATCRo	›All in one‹ Nanocomposite AlTiCrN/SiN	Sawing, milling, hobbing, drilling
nATCRo^3	TripleCoating^3 Ti-CrN + AlTiN + Nanocomp. AlTiCrN/SiN	Universal Triple Coating with lower target costs and simpler stripping

30 different coatings without cathode change using the ›universal cathode configuration‹ of the π313