THE BEST OF TWO WORLDS: MATCHING TOOL STEELS WITH PVD COATINGS

voestalpine High Performance Metals
www.voestalpine.com/highperformancemetals/no/no/

voestalpine
ONE STEP AHEAD.

WELCOME TO voestalpine

We are voestalpine High Performance Metals (HPM), a group of specialized manufacturers and service providers in high-quality special steels and advanced materials. Together, we offer a solid portfolio, reliable support, and a clear focus on quality, innovation, and sustainability.

Unlike many competitors, we provide production, sales, and service from a single source—an integrated approach valued by customers worldwide.

Sales Offices ● Mills ● Distribution- & Service Centers ●

The voestalpine High Performance Metals products are manufactured in one of our eight production sites in Europe, North and South America. In addition, the Division has a global sales and service network with around 130 locations on all continents, which results in exceptional customer proximity.

Learn more about voestalpine:

- voestalpine eifeler Coating – Dusseldorf, Germany
- Uddeholm – Hagfors, Sweden

Serving with care. Coating with excellence.

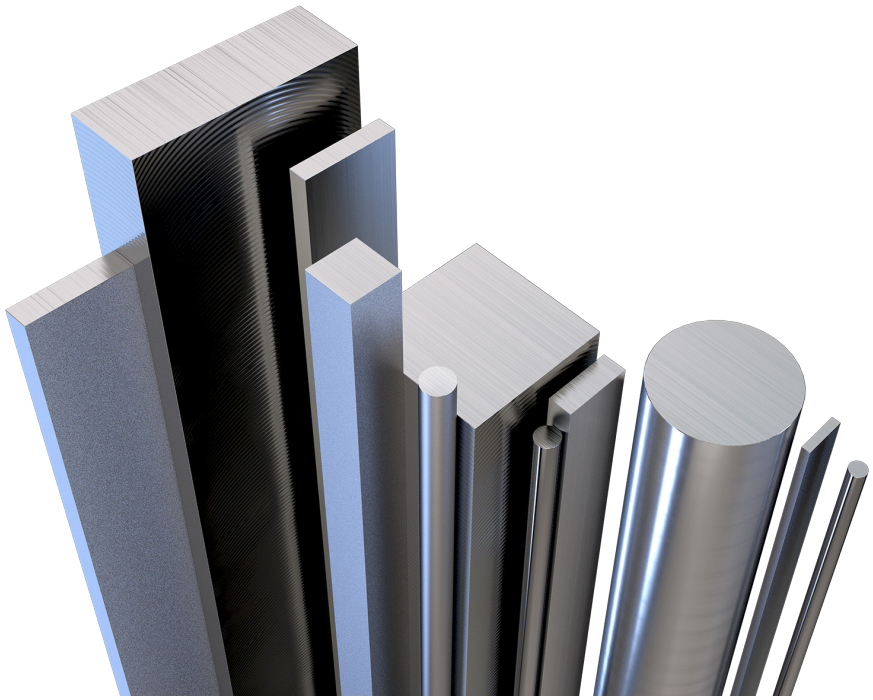
At eifeler, we deliver premium DLC and PVD coatings with a human touch—fusing precision engineering with responsive, reliable service. Every layer reflects our commitment to performance, precision, partnership, and long-term trust. The perfect blend of technical mastery and empathy that sets eifeler apart.

Manufacturing solutions for generations to come. Shaping the world®

Uddeholm is a global leader in tool steel, known for its Total Tooling Economy, strong brand, and technical expertise. We deliver resource-efficient solutions that boost customer competitiveness and sustainability. The main focus at Uddeholm is to supply tool and die solutions that make our customers more competitive in a sustainable way.

TAKE THE NEXT STEP IN TOOLING COMBINE TOOL STEEL WITH PVD COATINGS

The main reason for coating a tool is to combat wear and reduce costs. By extending tool life, coatings improve performance, minimize maintenance downtime, and drive cost efficiency. Boost your productivity with our advanced PVD and DLC solutions.



Because wear has many faces—abrasion, adhesion, diffusion, oxidation—and every one of them shortens tool life and drives up costs. PVD coatings help combat these mechanisms, extending durability, improving component quality, and reducing maintenance downtime. The result: greater productivity and lower total cost of ownership.

There's no universal solution in tooling. That's why selecting the right combination of tool steel and coating is essential. This brochure highlights proven pairings of PVD coatings and tool steels that deliver reliable performance across demanding applications.

More detailed information about tool steels and coatings can be found in other technical brochures delivered by voestalpine. For optimization of complex tooling solutions, we recommend you reach out to your local tooling and/or coating contact.

WHEN IT COMES TO TOOLING, FOUR FACTORS INFLUENCING TOOL LIFE

Tool life is a result of the complex interaction between several critical factors that govern wear, performance, and durability in manufacturing environments. Among these, four stand out as particularly influential: Tool Design, Contact Zone (including surface coating), Workpiece Design, and Work Process.

TOOL DESIGN

» Selection of base material
» Hardness
» Toughness
» Microstructure
» Tempering resistance
» Geometry
» Dimensional tolerances
» Manufacturing

CONTACT ZONE

» Surface topography
» Coating
» Lubricant

WORKPIECE DESIGN

» Tribology areas
» Strength
» Structure

WORK PROCESS

» Machine parameters
» Temperature
» Maintenance intervals

KNOWLEDGE IS POWER
UNDERSTANDING PVD COATING

Tool coatings are more than just a surface treatment – they are a critical performance factor. In demanding applications, coatings serve as the first line of defense against wear, friction, heat, and chemical attack.

Surface coating of tool steel is a common practice, with physical vapour deposition (PVD) being the most widely used technique. The coating is typically a thin ceramic layer (< 4 µm), characterized by very high hardness and low friction.

The efficacy of a PVD-coated tool is strongly dependent on the physical and mechanical properties of the steel. High hardness and compressive strengths are necessary to avoid the "glass-on-snow" effect, where the brittle layer cracks easily over a soft substrate. A high tempering temperature is recommended to ensure dimensional stability after the coating process.

It is also possible to combine PVD with a plasma nitriding treatment (Duplex) to increase the load-bearing capacity of the coating. The coating should also be defect-free and with a smooth surface to effectively reduce

sticking and friction. Tool materials with higher cleanliness and improved polishability can guarantee the homogeneity of the coating and a better surface finish on the components.

In this section, we introduce the three most common coatings and their properties.

PVD COATING

PVD is a vacuum-based coating process that deposits thin, hard ceramic layers onto tool surfaces. These coatings offer high hardness, low friction and thermal and chemical stability etc.

DUPLEX PVD COATING

Combines plasma nitriding with PVD to enhance compressive strength and performance.

CVD COATING

Chemical Vapour Deposition (CVD) occurs at ~1000°C and is ideal for carbide tools. It provides uniform thickness even in bores but requires post-hardening for tool steel.

PVD COATINGS AND THEIR PROPERTIES

» High layer hardness
» High wear resistance
» Low co-efficient
» Thermal stability
» Chemical stability

EXAMPLE OF PVD COATINGS

eifeler coatings	Colour	Typical applications
Duplex-VARIANTIC®	Old rose	High-strength sheets <700 MPa
Duplex-VARIANTIC®-1000	Dark redish gold	High-strength sheets <1,000 MPa
Duplex-VARIANTIC®-1400 plus	Blue-grey	High-strength sheets <1,400 MPa
Duplex-TIGRAL®	Dark grey	High-Pressure Die Casting
SUBLIME®	Grey	Gear Cutting applications
CARBON-X®	Dark grey	DLC for non-ferrous cutting applications, plastic injection and components
Duplex-CROSAL®-plus	Slate grey	Fineblanking
ARDURO®	Caramel Bronze	>55 HRC Ideal for machining hardened steel

KNOW YOUR ENEMIES
FAILURE MECHANISMS

Understanding how and why tools fail is the first step toward preventing it. In demanding applications, tools are exposed to extreme forces, temperatures, and friction—all of which contribute to wear, cracking, deformation, or even catastrophic failure. These failure mechanisms are not random; they follow patterns that can be predicted and countered.

By identifying the dominant failure mode – whether it's abrasive wear, adhesive wear, thermal fatigue, or chipping – you can make informed decisions about tool steel selection, surface preparation, and coating strategy. Knowing your enemies means you can fight them with the right combination of material properties and surface technologies, ultimately extending tool life and improving process reliability.

WEAR

Wear is one of the most common causes of tool failure in industrial applictions. It occurs when material is gradually removed from the surface due to mechanical, thermal, or chemical interactions.

CHALLENGES

» High surface pressures
» High contact temperatures
» Abrasive and high-strength materials
» Cutting zones difficult to access for lubricants

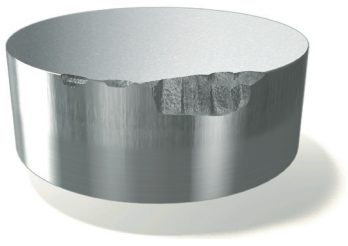
EFFECTS

» Shorter manufacturing cycles and service life per tool
» Increased use of lubricants
» High tool costs in the event of failure and maintenance
» Unreliable planning of production figures

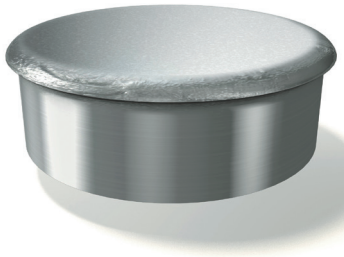
FAILURE TYPE

Solved by the substrate (e.g. the steel)

Chipping
Choose a steel with enough chipping resistance

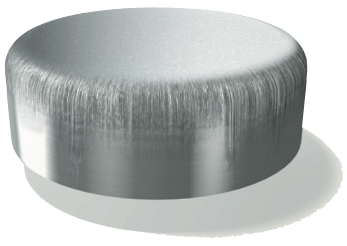


Plastic deformation
Choose a steel with higher compressive strength (hardness)

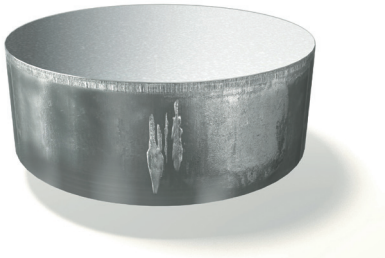


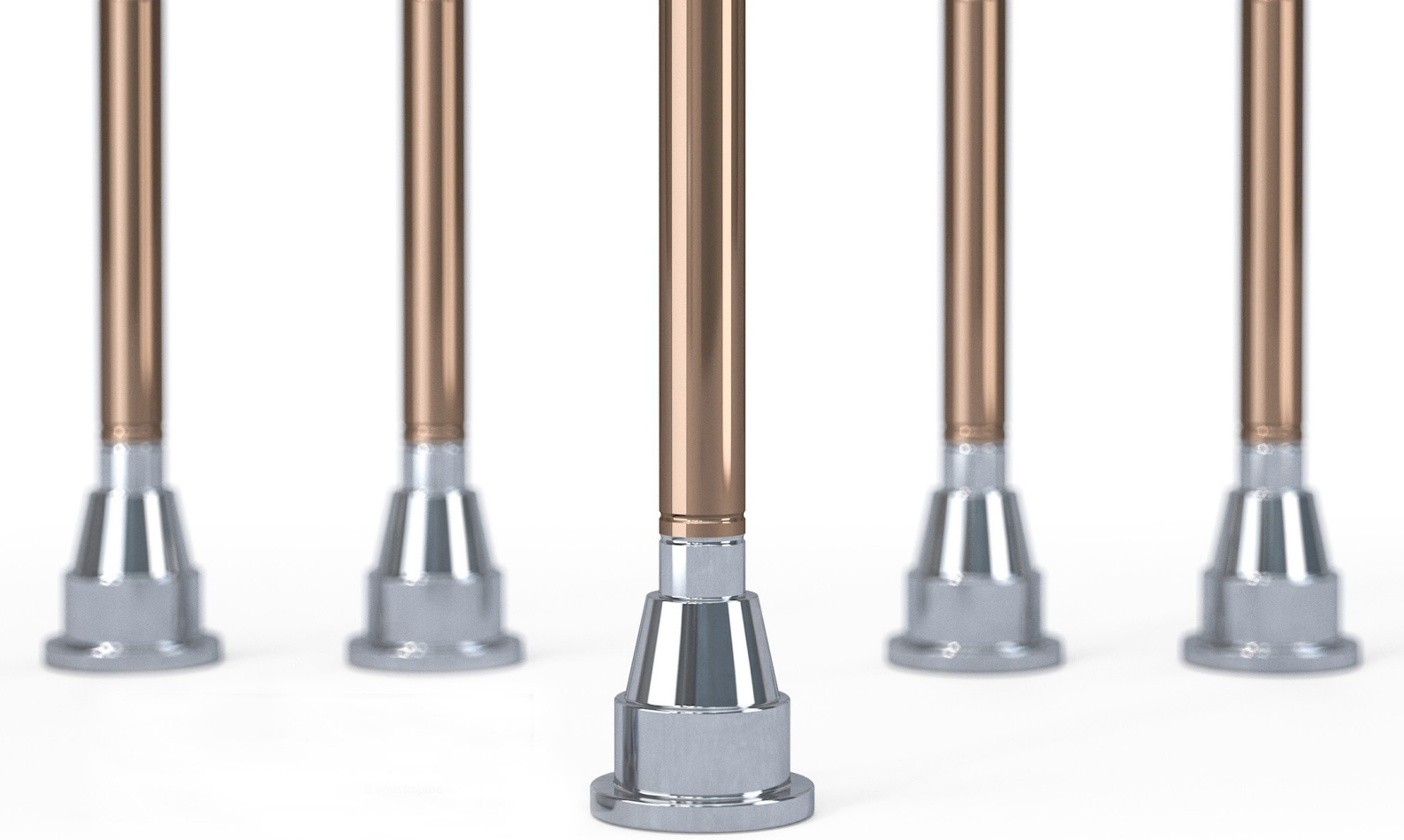
Solved by the coating

Abrasive wear
Choose a coating with high hardness and wear resistance



Adhesive wear/galling
Choose a coating with fine surface and low friction properties





FOUR CRUCIAL FACTORS TO CONSIDER

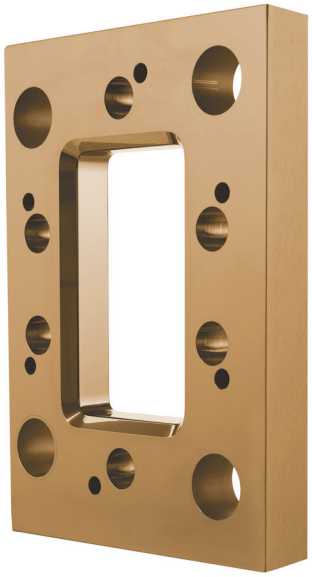
When choosing the combination of tool steel and PVD coating there are four crucial factors to consider:

FAILURE TYPE
Find the dominating wear mechanism

HEAT TREATMENT
Make sure that the heat treatment and coating process fit together

TOOL STEEL AND COATING SELECTION
Choose steel and/or coating for the dominating wear mechanism

SURFACE QUALITY
Surface finish in active surfaces and other areas exposed to high loads



A coating alone cannot compensate for an unsuitable substrate. High surface pressures and abrasive wear demand a steel with sufficient hardness, toughness, and dimensional stability — especially during heat treatment and coating processes. Selecting the right combination ensures that the coating adheres properly, resists cracking, and performs as intended under load.

FAILURE TYPE

Wear is one of the most common causes of tool failure in industrial applications. It occurs when material is gradually removed from the surface due to mechanical, thermal, or chemical interactions. In cold work tooling, wear mechanisms such as abrasive wear, adhesive wear, and surface fatigue are particularly prevalent.

These challenges are intensified by high surface pressures, elevated contact temperatures, and difficult-to-lubricate cutting zones. If not properly addressed, wear can lead to shorter tool life, unpredictable performance, and increased maintenance costs.

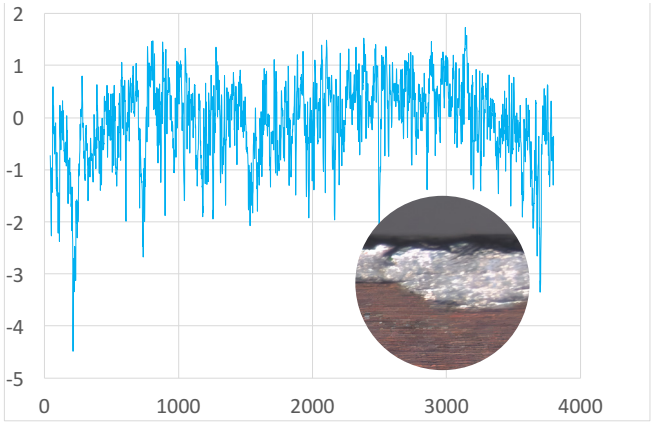
By understanding the wear environment and tailoring both steel and coating accordingly, manufacturers can significantly improve tool durability and process reliability.

HEAT TREATMENT

The most important part of the heat treatment is to temper the steel at a temperature higher than both the coating process (typically 450°C) and the retained austenite area.

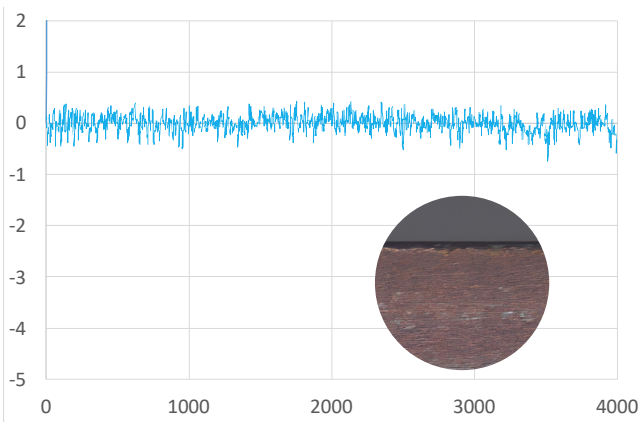
To ensure optimal performance and coating durability, always follow the recommended heat treatment guidelines for the specific steel grade. These recommendations are tailored to preserve the material's properties and support the coating's function.

FAILURE INITIATED BY BAD SURFACE CONDITION



Surface profile with deep grinding marks, Ra = 0,5 µm, Rz = 4,0 µm

PROBLEM SOLVED BY BETTER SURFACE CONDITION



Same surface profile after polishing with #600 grit, Ra = 0,1 µm, Rz = 1,0 µm

TOOL STEEL AND COATING SELECTION

The synergy between tool steel and coating is a decisive factor in achieving optimal tool performance and longevity. Tool steel provides the foundational properties—such as toughness, hardness, and thermal stability—while the coating enhances surface characteristics like wear resistance, friction control, and heat management. Selecting the right combination is not a one-size-fits-all decision; it must be tailored to the specific demands of the application, including the workpiece material, process conditions, and expected tool life.

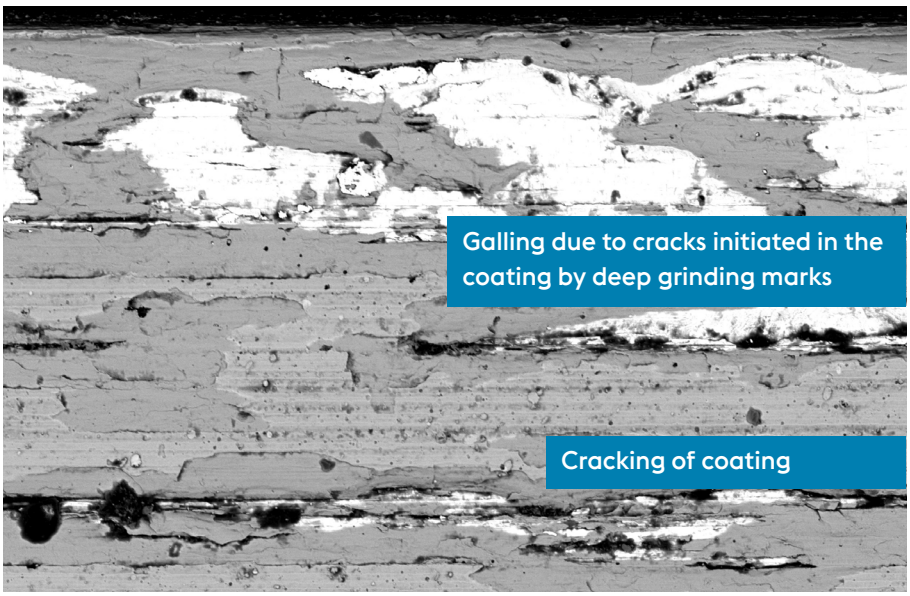
SURFACE QUALITY

Before coating the tool, the surface quality must be adjusted to the needs of the application, especially in the active areas of the tool.

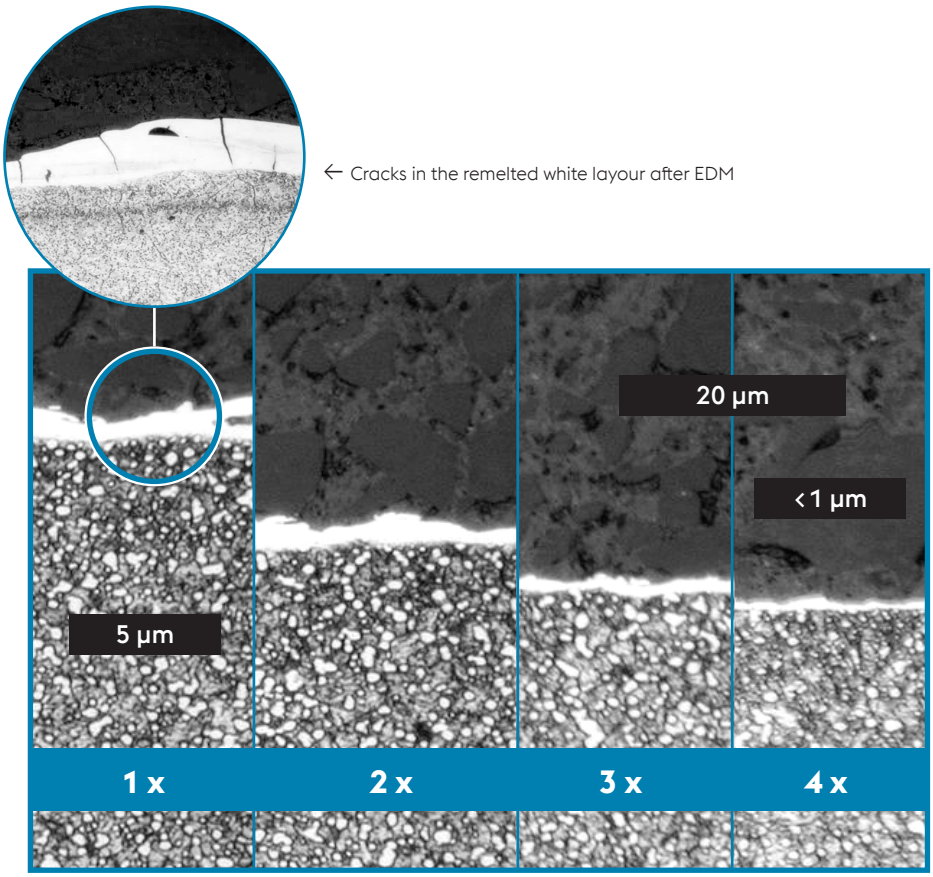
The active areas of the tool should be smooth and free from corrosion and white layers to obtain the best performance result. After grinding, a typical surface finish of Ra~0.5 µm is obtained, which is not smooth enough for a high-performance tool in cold work application. A rough surface (by e.g. grinding marks) may lead to inhomogeneous coating layers and cracks in the PVD coating. Thus, polishing to Ra <0.2 µm in active areas is recommended before a PVD coating is applied. For critical applications, even finer Ra <0.05 µm.

Furthermore, depending on the application, a post-treatment of the coated tool may be recommended and should be discussed with the respective sales contact at voestalpine eifeler Coating GmbH.

CRACKING



Coated tool surface with insufficient surface quality after some production.



Heat-affected surfaces from WEDM need to be removed and 3–4 passes are needed to deduce the heat-affected zone that have small cracks and high stress level.

MATCHMAKING DONE RIGHT CHOOSING THE PERFECT COMBINATION

ultrafine coating series: a unique eifeler technology.

This section explores how thoughtful pairing of substrate and coating can significantly improve durability, reduce downtime, and support consistent production quality.

OBJECTIVE

Within PVD coating the goal is to achieve maximum protection of the tool against adhesive and abrasive wear. To achieve this, and to significantly increase tool life, a suitable coating should be applied to the heavily used working area of the tool, tailored to the specific application.

OPTIMIZING THE SURFACE DESIGN

Before applying a coating, it's essential to ensure that the tool's surface and base material are properly prepared. These factors directly affect coating performance and durability.

Is the substrate hardness sufficient?

» The base steel must be hard enough to support the coating and resist deformation.

Is the surface topography appropriate?

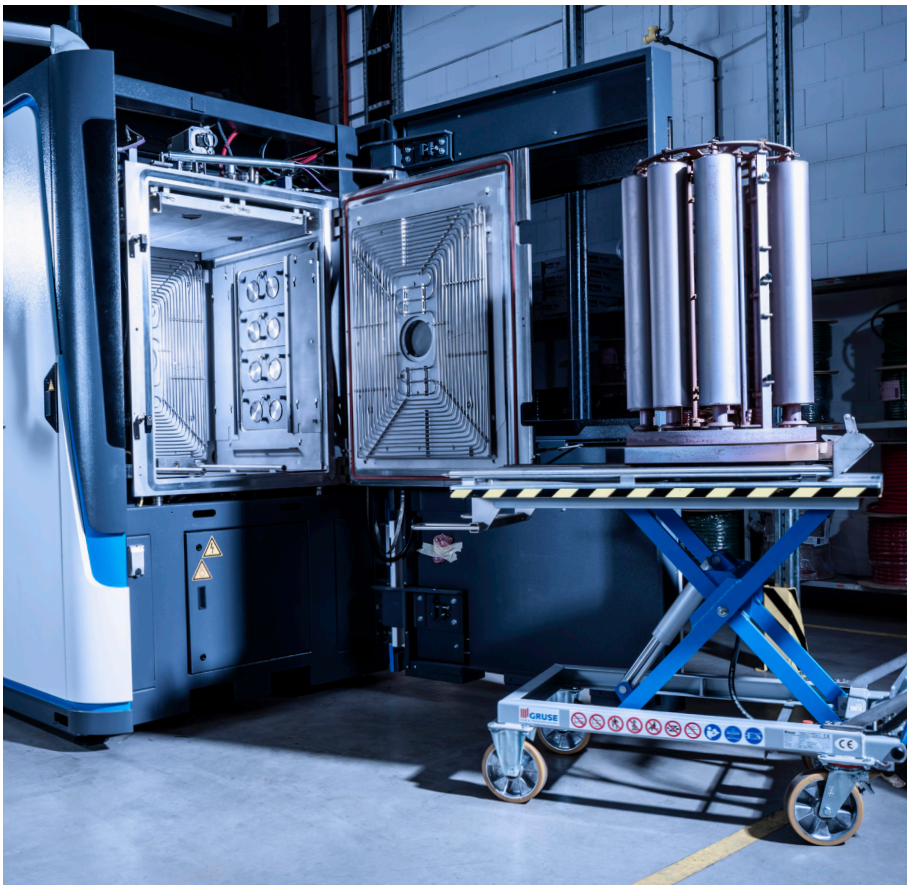
» The surface should be smooth and well-prepared.
» A good polish generally provides the best results.

REQUIREMENTS OF THE COATING

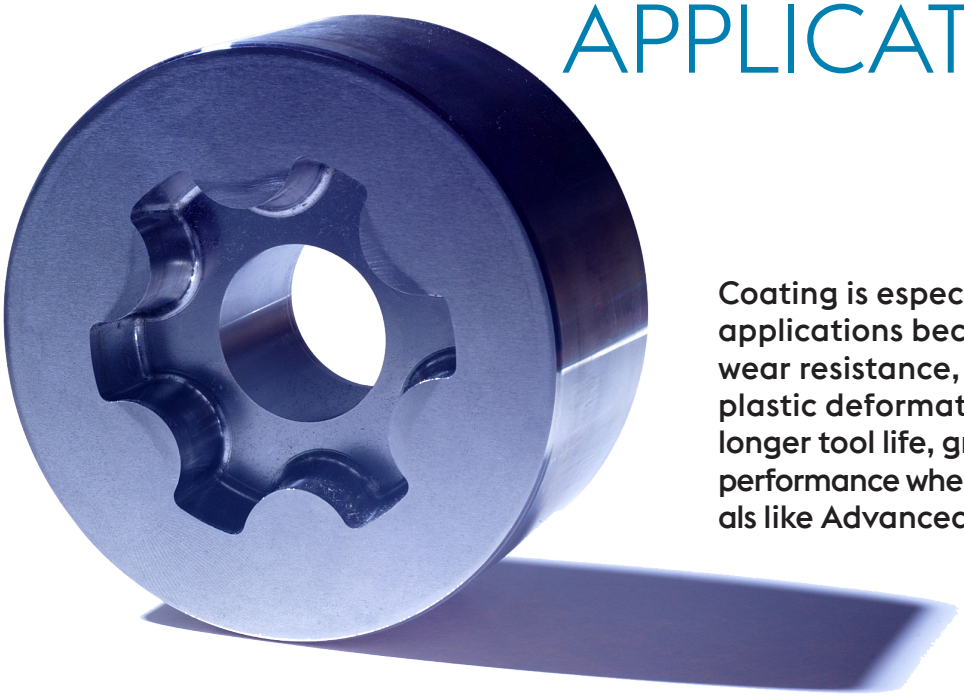
To perform effectively under demanding conditions, the coating must meet several technical criteria related to the application environment. The coating must be suitable for the application in terms of:

» Thermal resistance
» Hardness
» Coefficient of friction

The coating must be able to withstand the surface pressure and shear forces that occur during tool operation without flaking. Equally important is that the coating's layer thickness in the working area is precisely tailored to the application — thick enough to provide effective protection, yet not so thick that it risks cracking or delamination.



STEEL AND COATING COMBINATION WITHIN COLD WORK APPLICATIONS



Coating is especially beneficial in Cold Work applications because it significantly enhances wear resistance, reduces friction, and prevents plastic deformation. These improvements lead to longer tool life, greater process stability, and better performance when working with demanding materials like Advanced High-Strength Steels (AHSS).

DESIRABLE PROPERTIES NEEDED IN COLD WORK

- High wear resistance
- High hardness
- High compressive strength
- Good toughness / chipping resistance
- Dimensional stability
- Surface finish compatibility

COLD WORK FAILURES THAT CAN BE SOLVED BY THE STEEL

Gross Cracking
Use tougher steel grades with better ductility.

Chipping
Select steel with a good balance of hardness and toughness; upgrade to higher quality or more suitable grades.

Plastic Deformation
Choose steel with high compressive strength and hardness to resist overload and deformation.

Fatigue Failure
Use steel with high fatigue strength and dimensional stability.

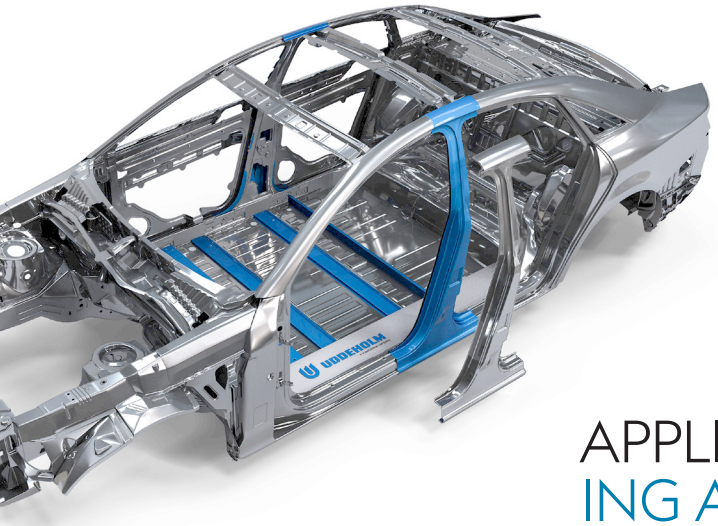
COLD WORK FAILURES THAT CAN BE SOLVED BY PVD COATING

Abrasive Wear
Coating adds a hard, low-friction surface that resists material removal.

Adhesive Wear / Galling
Coating reduce friction and prevent material transfer between tool and workpiece.

Surface Fatigue
Coating protects against micro-cracking and surface degradation under cyclic loads.

Friction-Induced Damage
Coating lower friction, improving process stability and reducing heat buildup.



APPLICATION EXAMPLE, FORMING AND TRIMMING OF AHSS

The use of Advanced High-Strength Steels has increased significantly in car body-in-white (BIW) structures. Hence, from a tooling perspective, the demand for better tool steels has also been growing rapidly.

Most of the traditional tool steels and high-speed steels can perhaps fulfil one good property, for example high wear resistance with low chipping resistance. This will cause a high risk of breakage due to the high cyclic load on the tool when working in higher strength steels. A much wider property profile is necessary to secure a high productivity and predictable tool life without unplanned stops. A better solution for AHSS application is often a high-performance tool steel in combination with a PVD coating.

EXAMPLE OF PVD COATINGS SUITABLE FOR COLD WORK

eifeler coating	Colour	Application
Duplex-VARIANTIC® -700	Old rose	High-strength sheets <700 MPa
Duplex-VARIANTIC® -1000	Dark redish gold	High-strength sheets <1,000 MPa
Duplex-VARIANTIC® -1400 plus	Blue-grey	High-strength sheets <1,400 MPa
Duplex-TIGRAL®	Dark grey	Electrogalvanized high-strength sheets <1,200N/mm^2
DUMATIC®	Reddish/Grey	Broadband coating for stainless steel
CARBON-X®	Black	Aluminium
Duplex-CROSAL®-plus	Slate grey	Fineblanking

COLD WORK STEEL GRADES SUITABLE FOR COATING WITHIN voestalpine

voestalpine SOLUTION

CHARACTERISTICS

Steel grade	Ductility	Wear resistance	Compressive strength
*) Uddeholm Sverker® 21	★	★★	★★
Uddeholm Sleipner®	★★★	★★	★★★
Uddeholm Vanadis® 4 Extra SuperClean	★★★★★	★★★	★★★
Uddeholm Vanadis® 8 SuperClean	★★★★	★★★★	★★★
Uddeholm Vanadis® 8 XL	★★	★★★★★	★★★
Uddeholm Vancron® SuperClean	★★★★	★★★★★	★★★
BUddeholm Vanadis® 23 SuperClean	★★★★	★★★★	★★★
Uddeholm Unimax®	★★★★★	★	★
Uddeholm Caldie®	★★★★★	★	★★

*) AISI D2, DIN 1.2379, JIS SKD11

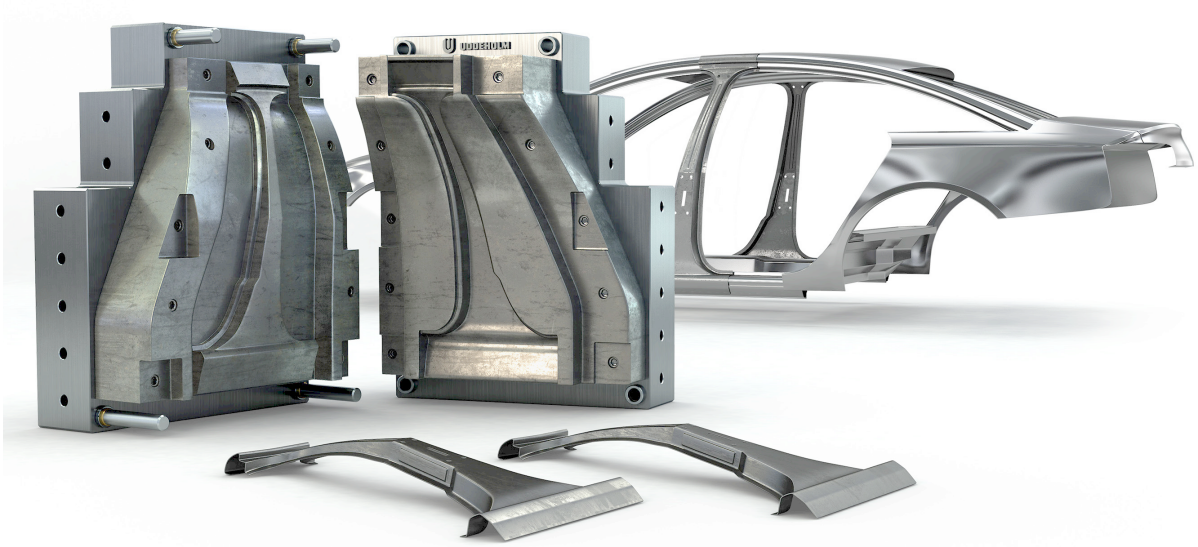
STEEL AND COATING COMBINATION WITHIN HOT WORK APPLICATIONS

When choosing a tool steel suitable for Hot Work applications the properties of that steel are important.

There are many different applications within Hot Work, such as HPDC (High Pressure Die Casting), Forging, Extrusion and Hot stamping. These different segments have very different demands on the tool steel. Therefore, the correct tool steel must be selected, as certain steels can solve these issues better than others.

DESIRABLE PROPERTIES NEEDED IN HOT WORK

- » Hot strength
- » Hot hardness
- » Temper resistance
- » Thermal conductivity
- » Toughness / Ductility
- » Creep strength
- » Resistance to thermal fatigue
- » Cleanliness & icrostructure
- » Consistency



HOT WORK FAILURES THAT CAN BE SOLVED BY THE STEEL

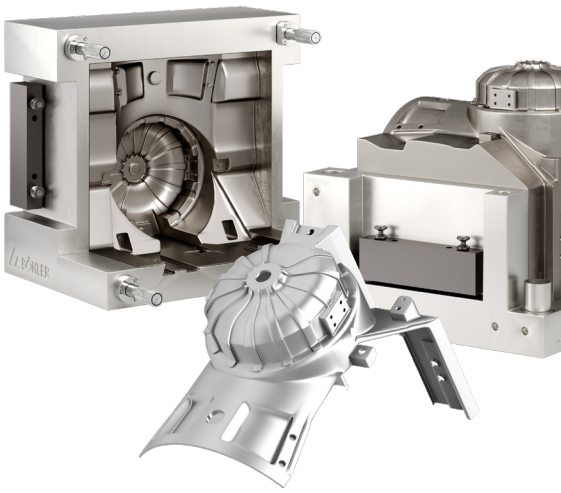
Gross Cracking
Use tougher steel grades or adjust hardness to resist cracking under thermal and mechanical stress

Heat Checking
Select steel with high thermal fatigue resistance and good toughness to reduce surface cracking

HOT WORK FAILURES THAT CAN BE SOLVED BY PVD COATING

Erosion
Coating adds a hard surface layer that resists material loss from molten metal flow

Soldering
Coating protects against chemical reactions and bonding between tool and molten metal



Abrasive / Adhesive Wear (Hot Stamping)
Coating reduces friction and wear from high-pressure contact with hot sheet materials

Not all application areas are suitable for coatings as each tool must be judged on its merits. However eifeler PVD coating on right tool steel selections can improve tooling performance in two main ways, first is the improvements against failure mechanism such as soldering and erosion/washouts. The second is that PVD reduce friction between die and the castings which aiding part ejection especially in challenging areas with low draft angles below 1°C.

Is the substrate hardness sufficient?
» The base steel must be hard enough to support the coating and resist deformation.

Is the surface topography appropriate?
» The surface should be smooth and well prepared.
» A good polished generally provides the best results.

EXAMPLE OF PVD COATINGS SUITABLE FOR HOT WORK

eifeler coating	Coating type	Colour	Key properties	Thermal limit
CROSAL®–plus	AlCrN	Slate grey	» High oxidation resistance » Outstanding hot hardness	1100°C (2012°F)
Duplex–TIGRAL®	AlCrTiN	Grey	» High hot hardness » Excellent oxidation resistance » Excellent abrasion resistance	900°C (1650°F)
Duplex–VARIANTIC®	TiAlCN	Old rose	» Good chemical resistance » Low friction » Good oxidation resistance in semi-warm-forming	900°C (1650°F)

HOT WORK STEEL GRADES SUITABLE FOR COATING WITHIN voestalpine

voestalpine SOLUTION

CHARACTERISTICS

Steel grade	Impact toughness	Heat checking resistance	Wear/Erosion resistance
*) Uddeholm Orvar® Supreme	★★	★	★★
Uddeholm Unimax®	★★	★★★★	★★★★★
Uddeholm QRO® 90 Supreme	★	★★★★★	★★★
Uddeholm Dievar®	★★★★	★★★	★★

*) AISI H13, DIN 1.2344, JIS SKD 61

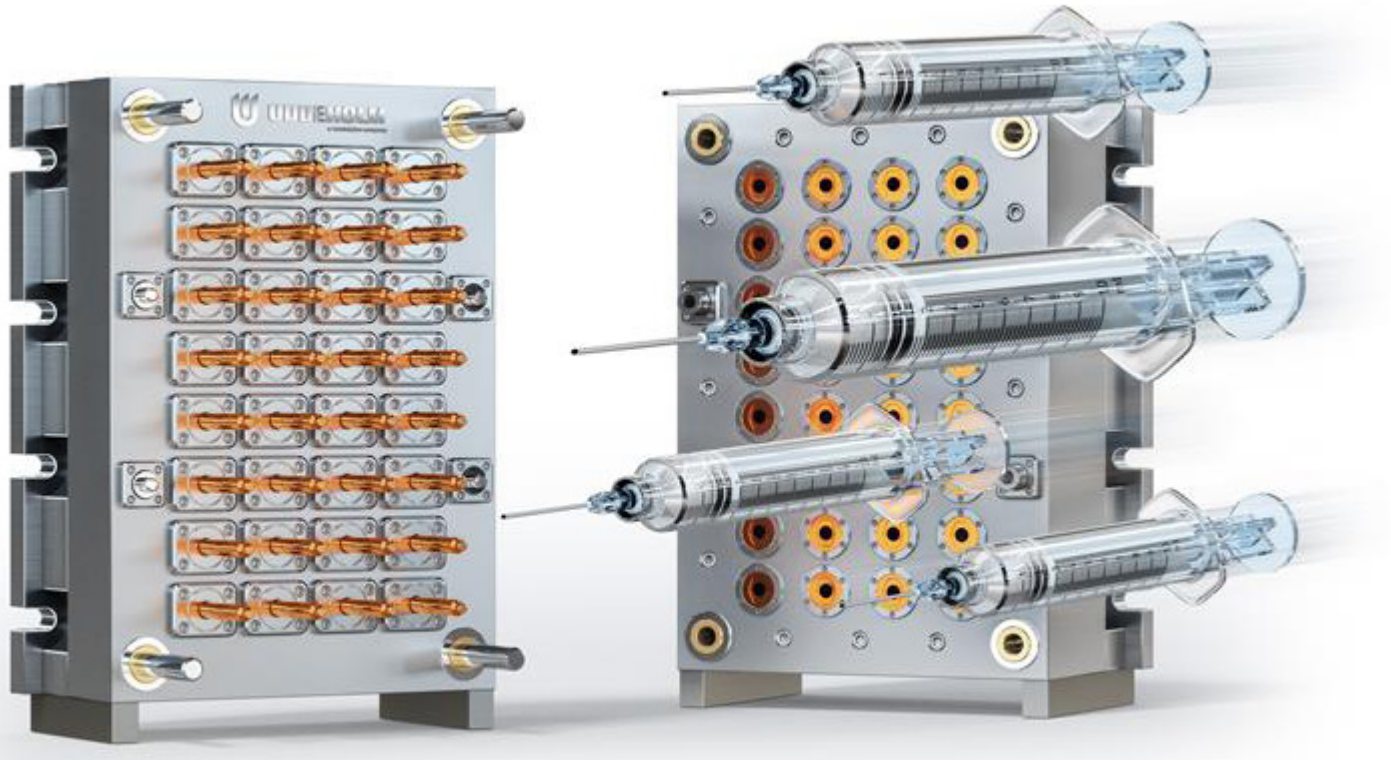
STEEL AND COATING COMBINATION WITHIN PLASTIC APPLICATIONS

It is important to choose the right steel grade for the moulding since plastic moulding is a demanding process, especially when it comes to PIM (Plastic Injection Moulding).

PVD coating of plastic moulds is a way to improve the mould life for moulds used for injection moulding, extrusion, vacuum forming and blow moulding. It is important to have a good support material with sufficient hardness, uniform microstructure and cleanliness for a successful PVD coating.

DESIRABLE PROPERTIES NEEDED IN PLASTIC APPLICATIONS

- Wear resistance
- Hardness
- Toughness / Crack resistance
- Corrosion resistance
- Surface finish / Polishability
- Thermal conductivity
- Dimensional stability
- Machinability



PLASTIC FAILURES THAT CAN BE SOLVED BY THE STEEL

Cracks / Gross Cracking
Upgrade to a steel grade with better toughness to withstand high static or dynamic loads

Plastic Deformation
Use steel with higher hardness to resist loads exceeding the material's yield strength

PLASTIC FAILURES THAT CAN BE SOLVED BY PVD COATING

Abrasive Wear
Coating protects against hard particles in plastic resin (e.g., glass fiber)

Release Problems (Sticking)
Coating reduces adhesion between plastic and mold surface

Adhesive Wear / Galling
Coating minimizes friction between sliding parts

Diesel Effect
Coating shields against corrosive off-gassing from materials like PVC or flame retardants

Cleaning Difficulties
Coating prevents deposits from sticking, making mold surfaces easier to clean

EXAMPLE OF PVD COATINGS SUITABLE FOR PLASTIC MOULDING

Coating	Wear resistance	Sticking resistance	Colour	Typical characteristics or example of application	Typical thermoplastics
TiN ultrafine	★★★★	★★★★★	Gold	» Good chemical resistance » Good temperature resistance in air (up to 500°C) » Resistant to abrasive wear of e.g. mineral filled organic materials » Improvement of the mold release	PS, SB, SAN, ABS, ASA, PA, PC, PBT, PET, PMMA, CA, CP, CAP
CARBON-X® (DLC)	★★★	★★★★	Dark grey	» Good chemical resistance » Smooth surface » Low temperature coating process (~200°C) » Very low coefficent of friction » Recommended for sliding elements	PE, PP, PA
CrN	★★★★★	★★★	Slate grey/ Silver grey	» High hardness and adhesion » Very good chemical resistance » High temperature resistance in air (up to 600°C) » Thicker layers possible	PA, PC, PBT, PET, PEEK, PPS, PSU, PES, PPE, PPO, TPU

PLASTIC STEEL GRADES SUITABLE FOR COATING WITHIN voestalpine

voestalpine SOLUTION

CHARACTERISTICS

Steel grade	Toughness	Polishability	Wear resistance	Corrosion resistance
*) Uddeholm Stavax® ESR	★★	★★★	★★	★★★
Uddeholm Mirrax® ESR	★★★★	★★★	★★★	★★★★
Uddeholm Tyrax® ESR	★★★★	★★★★★	★★★	★★★
**Uddeholm Unimax®	★★★★	★★★★	★★	N/A
**Uddeholm Dievar®	★★★★★	★★★	★★	N/A

*) ~AISI 420, ~DIN 1.2083, ~JIS SUS 420

**) Non corrosion resistant grades

STEEL AND COATING COMBINATION WITHIN COMPONENT BUSINESS

Successful component design hinges on a holistic approach: selecting the right steel, applying the appropriate coating, and ensuring compatibility through controlled heat treatment and surface preparation. This integrated strategy enables manufacturers to meet the evolving demands of industries such as food processing, automotive, and energy.

In the component business, the synergy between steel selection and surface coating can sometimes be critical to achieving optimal performance, durability, and efficiency. Components often operate under demanding conditions—high loads, abrasive contact, and thermal cycling—which necessitate tailored solutions that go beyond conventional tooling strategies.

One key function of coatings is friction reduction, where the goal is to minimize resistance between moving surfaces. This is particularly valuable in applications such as meat grinding kits or circular knives, where smoother operation translates to better energy efficiency and reduced wear.

In some cases, the coating itself serves a lubrication function, forming a thin film that separates contact surfaces and reduces direct metal-to-metal interaction. PVD coatings are increasingly used in these contexts. They offer high hardness, excellent adhesion, and low friction coefficients.

Choosing the right coating will not only enhance wear resistance, but also contribute to dimensional stability and reduced failure mechanisms such as chipping and erosion. But remember, the choice of steel grade is equally important.

For example, steels with high hot strength, toughness, and temper resistance—are essential qualities for components exposed to thermal and mechanical stress. Here, a steel grade optimized for coating compatibility is essential, ensuring that the substrate supports the coating's performance without premature degradation.

Within the Component Business, coatings can make a significant difference by increasing tool life. For example, the VARANTIC® coating is an excellent choice for meat mincing. Its combination of high hardness and low friction not only extends tool life but also reduces maintenance and boosts productivity significantly.

STEEL AND COATING COMBINATION WITHIN CUTTING TOOLS

Elevated temperatures, aggressive machining parameters and extremely hard workpiece materials – the requirements for the machining of hard materials continue to evolve creating both challenges and opportunities.

CHALLENGES

Manufacturers face relentless pressure to cut costs while upholding productivity and quality. In milling hardened steels, tool wear, unplanned downtime, and frequent end-mill replacements rack up expenses and disrupt operations.

When end mills tackle ultra-hard steels (up to 66 HRC) at high spindle speeds, deep axial depths, and aggressive feeds, cutting edges endure extreme thermal loads, abrasive wear, and mechanical stress. These conditionsdrive rapid flank wear and built-up edge formation, especially in dry high-speed milling.

Conventional multilayer PVD coatings lack the oxidation resistance and toughness needed to withstand severe thermal-mechanical cycling, resulting in premature tool changes. This performance gap spurred development of ARDURO®, an AlTiSiN coating engineered for hard-milling steels above 55 HRC.

SOLUTIONS

To conquer dry, high-speed hard milling, our team developed ARDURO® —a next-generation Arc-PVD coating engineered specifically for milling end mills and micro tools.

Its precision-engineered AlTiSiN multilayer design combines a high-performance thermal barrier with optimized residual stress, resisting delamination and shielding the substrate from extreme mechanical loads. Superior oxidation resistance up to 1,100 °C and controlled microstructure ensure durability under severe thermal-mechanical cycling.

An ultra-low surface roughness (Ra 0.02 ±0.01 µm) promotes flawless chip flow and suppresses built-up edge, even in complex flute geometries. Applied at 1–5 µm thickness via process-controlled deposition, ARDURO® delivers uniform coverage across intricate tool profiles.

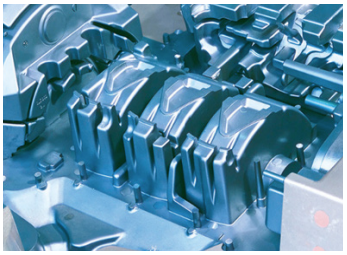
The signature caramel-bronze finish provides an instant visual quality control check of coating uniformity. In benchmark milling tests on hardened steels up above 55 HRC, ARDURO® extended tool life by 20–50%, slashing replacement costs and unplanned downtime for an efficient process. Choose ARDURO® when hard machining leaves no margin for error.

Milling cutters coated with ARDURO®

BEST PRACTICES BY CASE STUDIES

Throughout this last section, we'll explore real-life case studies where carefully selected combinations of tool steel and PVD coatings have delivered measurable improvements in tool life, performance, and reliability.

GOOD CHOICES WITHIN HIGH PRESSURE DIE CASTING



Application
Aluminium HPDC core pin

Problem
Soldering

Solution
Switch to a premium tool steel and coat it with a suitable PVD coating

Steel grade	1.2367 mod.	Uddeholm® QRO90 Supreme
Surface treatment	PVD Coating	eifeler Duplex-TIGRAL®
Outcome	**-**	**350% tool life increase**

BETTER MATERIAL, GENERATING BETTER OUTCOME

Steel grade	W. Nr 1.2344 / AISI H13	Uddeholm Dievar®
Surface treatment	None	Duplex-TIGRAL®
Outcome	**8,000 parts**	**~27,000 parts**

Application
Aluminium HPDC water jacket insert

Problem
Cracking and soldering

Solution
Switch to a premium tool steel, pre-treatment and coat it with a suitable PVD coating

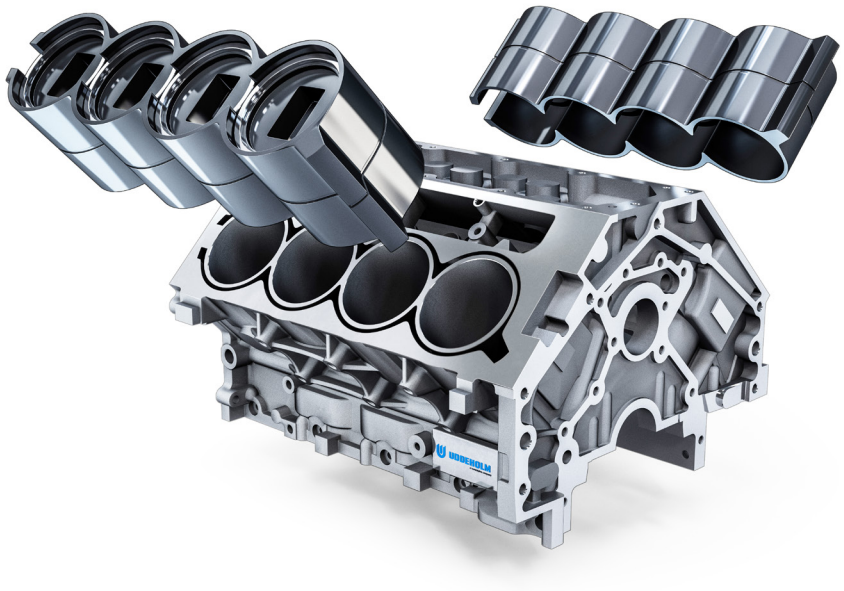
UPGRADE INCREASED TOOL LIFE WITH 400%

Steel grade	1.2367	Uddeholm Dievar®
Surface treatment	No coating	Duplex-TIGRAL®
Outcome	**6,000 parts**	**>30,000 parts**

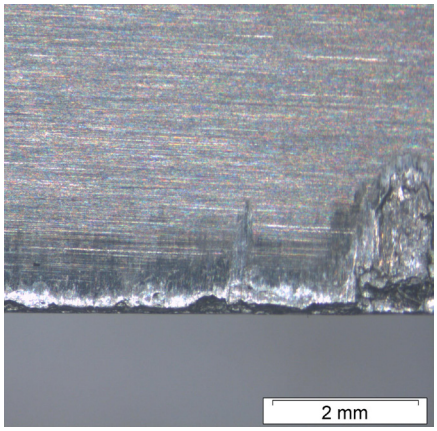
Application
Aluminium HPDC water jacket insert

Problem
Soldering and heat checking

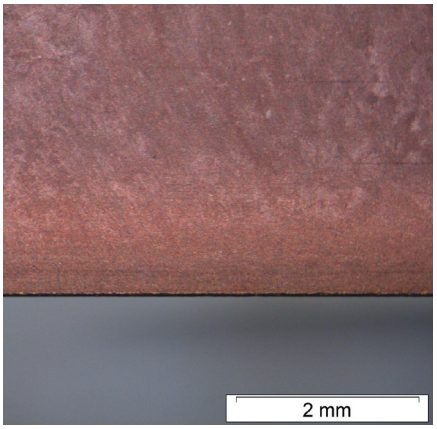
Solution
Switch to a premium tool steel, nitriding and post-oxidation



BLANKING OF ADVANCED HIGH STRENGTH STEELS



An uncoated suface of a traditional tool steel



A coated surface of a premium tool steel

Application
Blanking

Work material
AHSS CR1000Y1370T-CH, t=1.5 mm

Problem
Short tool life due to premature chipping

Solution
Switch to a premium tool steel, coated with a suitable PVD coating with improved surface finish

Steel grade	AISI D2 / W.INr.-1.2376	Uddeholm Caldie®
Surface treatment	None	Duplex-VARIANTIC®-1000
Outcome	**-**	**Stable production and longer tool life**

CHOOSING A BETTER TOOL STEEL WITHIN BLANKING – 350% TOOL LIFE INCREASE

Application
Blanking of a distributor switch

Work material
SPCC

Problem
Chipping

Solution
Upgrade to a premium tool steel

Steel grade	AISI M2	Uddeholm Caldie®
Surface treatment	Duplex-VARIANTIC®	Duplex-VARIANTIC®
Outcome	**100,000 parts**	**350,000 parts**

COATING GENERATING $80,000/YEAR SAVINGS

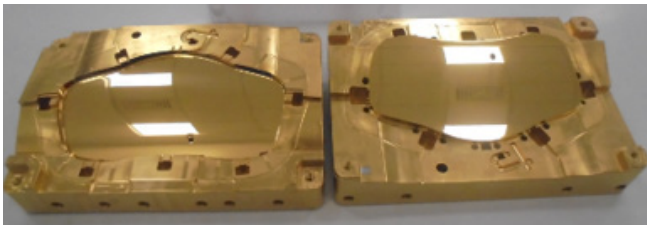
Application
Hollow core pin for cylinder head

Work material
Aluminium, low iron and low silicon

Problem
Soldering and erosion

Solution
Switch to a premium tool steel and coat it with a suitable PVD coating

Steel grade	Uddeholm QRO® 90 Supreme	Uddeholm QRO® 90 Supreme
Surface treatment	None	Duplex-TIGRAL®
Outcome	**4 days**	12–16 days



DON'T FORGET, SCRAP IS MONEY

Steel grade	Uddeholm Stavax® ESR
Type of lubrication	Silicon spray
Coating	TiN-ultrafine
Pre-treatment	Polishing and outgassing
Post treatment	Polish
Outcome	**Wastage scrap reduction from 70% to 2%**

Application
Car speedometer cover

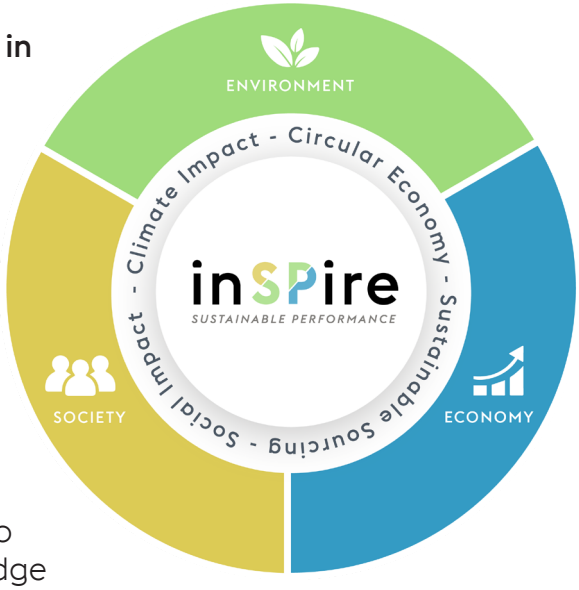
Work material
Plastic: Polycarbonate

Problem
Scratches and scoring while moulding

Solution
Applying a PVD coating

SUSTAINABILITY AT HPM

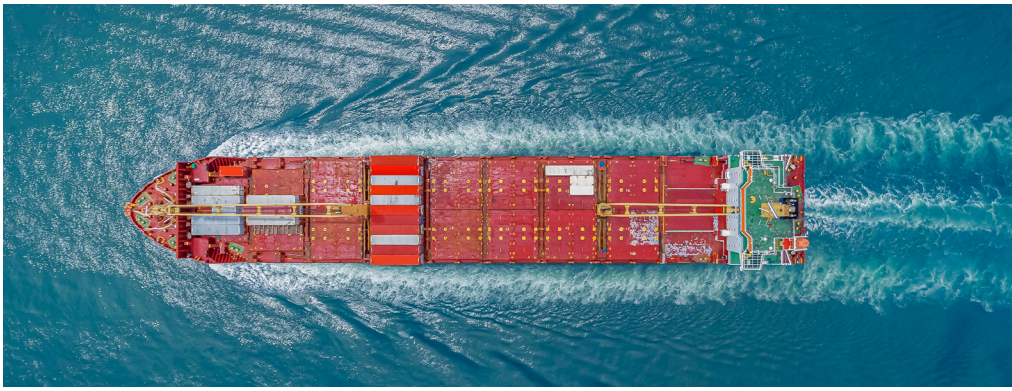
With inSPire, our sustainability framework, we have an ambitious vision integrating all pillars of sustainability in our daily operations to ensure long-lasting performance for current and future generations.



We are on a mission. As the world's leading supplier of high performance materials with a unique service network that ensures customers confidence, we establish sustainable performance beyond expectations for our planet and generations to come.

With our integration of products, services and technical advisory we create a profound impact on our business area. Leading by example, we enable our customers to engage in sustainable initiatives while also driving our suppliers and partners to be at the cutting edge of essential transformation processes for tomorrow. Together, we inspire the change in our industries by always thinking and walking one step ahead.

Our goals are clear, we seek to make considerable contributions in the areas of circular economy, climate impact and sustainable sourcing. This is why we have developed our very own sustainability framework outlining our four focus topics: circular economy, sustainable sourcing, social and climate impact - and respective sustainability actions while addressing all pillars of sustainability.



Reducing CO_2 emissions by 50% in our operations (Scope 1 & 2) by 2029

Contributing to the voestalpine group target of reducing CO_2 emissions by 25% in our supply chain (Scope 3) by 2029

Using over 90% of recycled scrap and secondary raw materials in our production processes by 2030

voestalpine High Performance Metals Norway
Kveldroveien 9
1407 Vinterbro, Norway
T. +43/22 91 80 00
M. info@uddeholm.no
www.voestalpine.com/highperformancemetals/no/no/

voestalpine
ONE STEP AHEAD.