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THE OPTIMAL TOOL STEEL SOLUTIONS FOR AHSS

A COMPREHENSIVE FOCUS ON VANADIS 4 EXTRA SUPERCLEAN, VANADIS 8 SUPERCLEAN, AND VANCRON SUPERCLEAN

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ABSTRACT

The increasing use of Advanced High-Strength Steels (AHSS) in modern manufacturing, particularly within the automotive industry, places significant demands on tooling materials. High forming forces, accelerated wear mechanisms, and risks of chipping and galling necessitate advanced solutions. This article explores the performance of Vanadis 4 Extra SuperClean, Vanadis 8 SuperClean, Vancron SuperClean, and Caldie—four high-performance tool steels tailored for cold work applications involving AHSS.

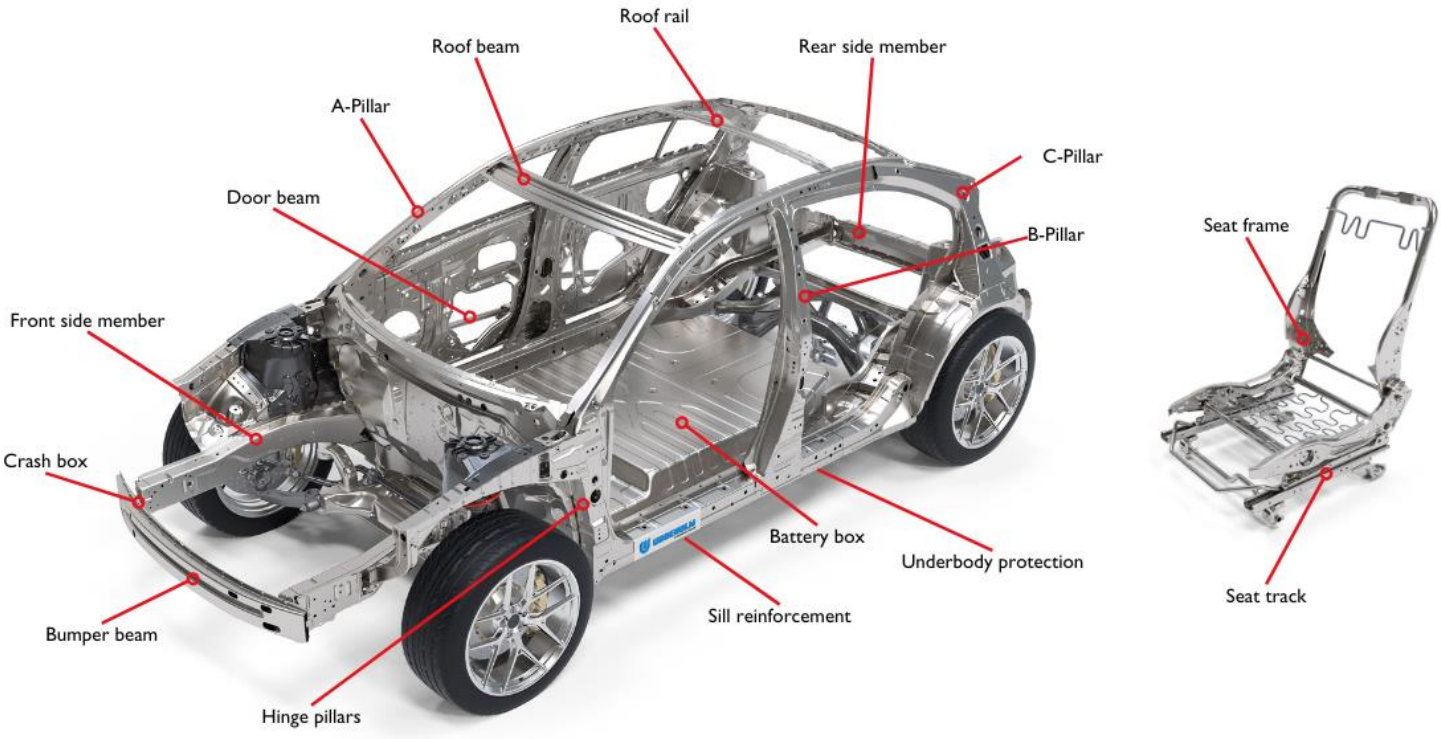
By leveraging powder metallurgy (PM) and advanced alloying techniques, such as electro-slag remelting (ESR), these steels offer superior resistance to abrasive wear, adhesive wear (galling), and fatigue cracking while maintaining adequate ductility and dimensional stability. Vanadis 4 Extra SuperClean balances toughness and wear resistance, Vanadis 8 SuperClean excels in extreme wear conditions, Vancron SuperClean integrates galling resistance, and Caldie provides exceptional chipping resistance for medium-to-severe AHSS applications. All with the ability to extend the tool life even further by adding a coating on top.

Through detailed analysis, including mechanical properties, failure mechanisms, and real-world case examples, this article highlights how selecting the appropriate tool steel enhances tool life, reduces downtime, and optimises productivity in demanding AHSS forming and blanking operations.

ADVANCED HIGH-STRENGTH STEELS

Sustainability, efficiency, and safety are at the heart of today's global manufacturing priorities, particularly in the automotive industry. Advanced High-Strength Steels (AHSS) play a critical role in achieving these goals, offering unmatched weight reduction while maintaining high strength and crash performance. AHSS enables vehicle manufacturers to produce lighter, safer, and more fuel-efficient vehicles, which in turn reduces emissions and the overall environmental footprint.

The use of AHSS is expanding rapidly, driven by strict emission regulations and the need for cost-efficient lightweight designs. It has become a cornerstone material in producing automotive structural components such as B-pillars, crash beams, and battery enclosures for electric vehicles (EVs) and hybrid models. Globally, this trend is accelerating, where sustainability goals and government directives are reshaping the automotive landscape.



However, AHSS is not without its challenges. Its high strength and advanced microstructure make it more demanding to process, particularly in cold work applications such as forming, blanking, and punching. These challenges manifest in several critical ways:

Abrasive Wear: The high hardness of AHSS causes increased tool wear, where the tough steel being formed acts like sandpaper, rapidly scratching and grinding down the tool surface. This leads to tools wearing out quickly, becoming dull, and losing effectiveness during forming operations.

Adhesive Wear (Galling): When forming coated or stainless AHSS, severe friction between the tool and the material can cause material to stick to the tool surface. This creates rough, torn areas and damages both the tool and the workpiece.

Chipping and Cracking: The intense mechanical loads required to process AHSS can lead to chipping—where small pieces break off from the tool's edges—and cracking, where small cracks form and spread under repeated stress. This often occurs during blanking or stamping operations, reducing tool lifespan and precision.

Plastic Deformation: Under high contact pressures during AHSS forming and blanking operations, standard tool steels can bend or dent permanently. This compromises the tool geometry and precision, leading to poor-quality parts and increased maintenance needs.

The strength of AHSS dictates whether a tool will hold its shape or succumb to plastic deformation, but it's the unique microstructures within AHSS that define how the material interacts with the tool during production. Each phase—whether ferrite, martensite, bainite, or austenite—brings its own challenges, influencing tool performance through wear, sticking, or deformation.

TYPICAL AHSS SHEETS AND ITS STRUCTURE		
AHSS Type	**Structure**	**Typical Strength (MPa)**
Dual Phase (DP)	Ferrite + Martensite	500–1000
Complex Phase (CP)	Ferrite + Bainite + Martensite	780–1000
Martensitic (MS)	Martensite	1100–1400
Ferritic-Bainitic (FB)	Ferrite + Bainite	600–800
TRIP	Ferrite + Bainite + Austenite	500–700
TWIP	Austenite + Twinning	900–1200

Table 1. AHSS sheet type and its microstructure

Ferrite: causes sticking which causes Galling, which leads to Adhesive Wear

Martensite: leads to Abrasive wear and edge chipping.

Bainite: contributes to a mix of Abrasive and Adhesive wear**.** Also, somewhat sticky

Austenite, especially in TRIP and TWIP steels, causes Plastic deformation and localised stress damage derived from high work hardening rate.

Understanding these relationships helps manufacturers select the appropriate solution. And this often-require different combination of hardness, wear resistance, ductility, and dimensional stability.

Below is an example where Vanadis 4 Extra after blanking of a typical AHSS sheet in a thickness of 1.5 mm.

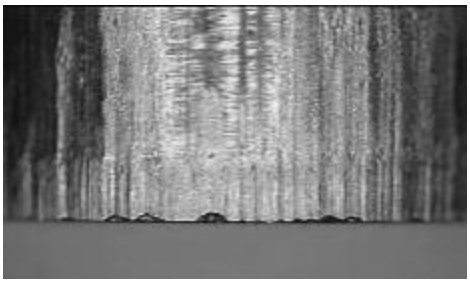


Figure 1. AISI D2, 50000 parts

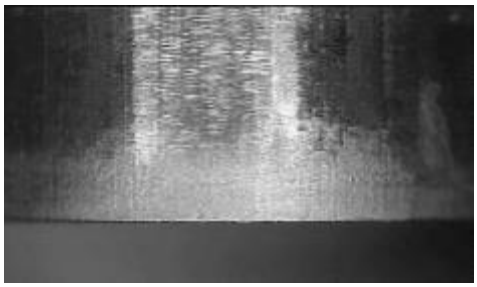


Figure 2. Vanadis 4 Extra SuperClean, 50 000 parts

Traditional steels struggle to meet the increasing demands of AHSS, and often leading to costly tool failures, downtime, and increased maintenance efforts.

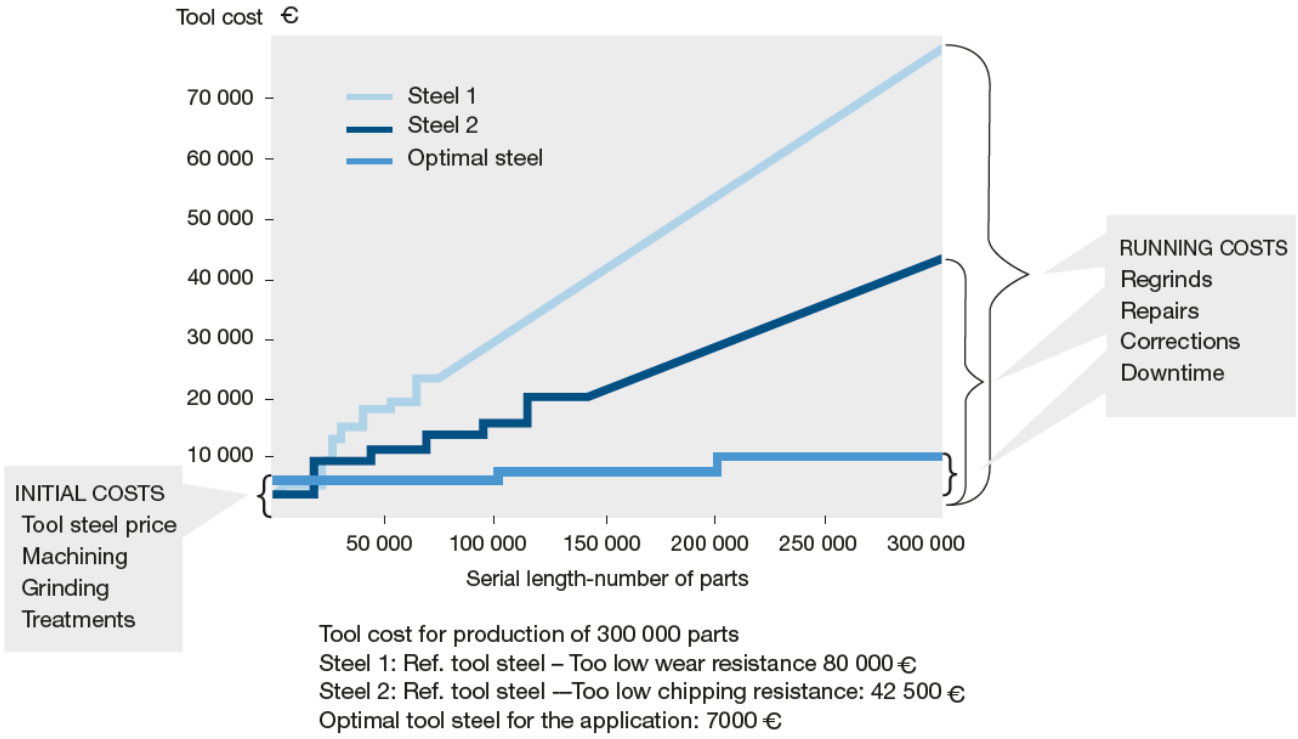


Figure 3: Total tool cost considerations. Steps in lines indicates cost for refurbishment.

ASSAB SOLUTION TO AHSS

ASSAB, has responded to these challenges with high-performance solutions specifically engineered for AHSS. The five standout ASSAB tool steels precede now are Caldie, Unimax, Vanadis 4 Extra, Vanadis 8 SuperClean, and Vancron SuperClean. These grades highlight their unique properties, advantages, and ideal applications in AHSS forming and cutting operations.

Powder Metallurgy (PM) Tool Steels

The Powder Metallurgy (PM) process represents the pinnacle of tool steel manufacturing. Unlike conventional metallurgy, PM produces small, evenly distributed carbides that result in superior wear resistance, toughness, and a homogeneous steel structure. This makes PM steels the ideal solution for applications demanding extreme performance, such as blanking and forming AHSS.

Vanadis 4 Extra SuperClean

The composition of Vanadis 4 Extra, an optimised alloying of chromium, molybdenum, and vanadium that creates a microstructure with evenly distributed carbides. This carefully controlled PM process results in a material that provides:

High Abrasive and Adhesive Wear Resistance: The presence of finely dispersed carbides ensures strong resistance to wear mechanisms that dominate in blanking and forming operations with AHSS.

Exceptional Ductility and Chipping Resistance: Where brittle failure can be catastrophic, Vanadis 4 Extra demonstrates elevated ductility, significantly reducing the risk of chipping or cracking, particularly under high cyclic loading conditions.

Figure 1. Four-point bend test comparison with PM 23-type, 60-62 HRC

Dimensional Stability: Minimal distortion during heat treatment and minimal aging effect during operation ensures precision and consistency in tool performance, a critical factor for high-accuracy applications.

Manufacturability and Practicality

From a production perspective, Vanadis 4 Extra offers significant advantages in machinability and grindability, properties not always associated with high-alloy tool steels. This facilitates efficient tool production and finishing, enabling manufacturers to maintain tight tolerances without excessive processing costs.

Vanadis 4 Extra SuperClean is particularly well-suited for applications where AHSS imposes severe conditions on tooling materials, such as:

- Tools subject to cyclic loading where wear resistance must be balanced with ductility to prevent early failure.
- Tools that face high mechanical stresses during shaping and must resist both plastic deformation and fatigue cracking.
- The ability to maintain performance in these demanding environments makes Vanadis 4 Extra SuperClean an optimal "all arounder" where traditional tool steels often fail to deliver sufficient durability.

Vanadis 8 SuperClean

The composition of Vanadis 8 SuperClean, with its high vanadium content and optimised composition, results in a tool steel with a fine and uniform carbide distribution. This advanced microstructure provides superb performance in terms of wear resistance, making it particularly suited for demanding applications with long production runs and abrasive conditions.

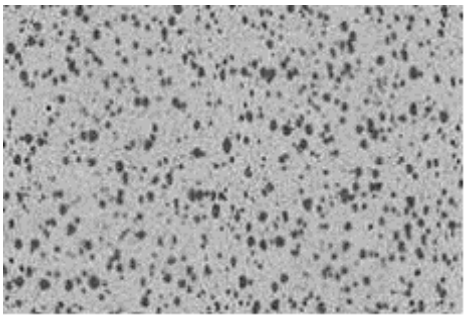


Figure 2. Vanadis 8 SuperClean, 15% MC carbides

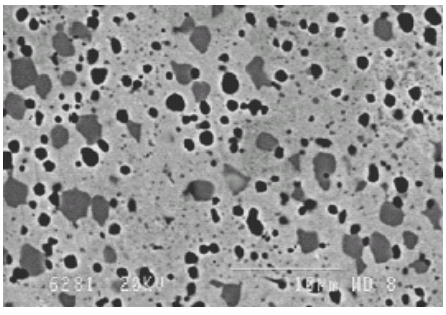


Figure 6. PM grade that contains 13% (9% MC+ 3% M7C) mixed size carbides

How the Carbide Structure Increases Tool Life

The high proportion of fine vanadium carbides in Vanadis 8 SuperClean provides maximum resistance to abrasive wear, which is critical when working with hard, abrasive materials like AHSS.

The fine carbides act as a protective barrier, resisting the micro-cutting, which occurs when hard particles slide against the tool surface.

Tools made from Vanadis 8 SuperClean maintain their sharp cutting edges and dimensional accuracy for far longer. While large, coarse, and mixed carbides in High-Speed Steels can create stress concentrations and initiate chipping and cracks, the fine, evenly distributed carbides in Vanadis 8 SuperClean minimise this risk.

At the same time, its homogeneous and superclean structure enhances the steel's ductility, allowing it to absorb higher loads without chipping or cracking.
High hardness of the small carbides improves resistance to premature edge wear, ensuring longer tool life under heavy loads.

This combination makes Vanadis 8 SuperClean the ideal tool steel for long production runs where tools are subjected to extreme wear and high stresses, such as in blanking and punching operations for AHSS.

By leveraging the hardness and stability of vanadium carbides, Vanadis 8 SuperClean not only extends tool life but also improves overall manufacturing efficiency, reducing the need for tool maintenance and replacement.

Vancron SuperClean

Vancron SuperClean is a nitrogen-alloyed PM tool steel and it distinguishes itself among high-performance tool steels due to its unique nitrogen-alloyed composition combined with Powder Metallurgy (PM) technology. This advanced microstructure introduces a balance of wear resistance, galling resistance, making Vancron SuperClean particularly effective in forming and blanking applications where adhesive wear, such as galling, is a dominant challenge.

Figure 7. Stamping punch suffered severe galling

Nitrogen-Rich Carbonitrides – Built-In Galling Resistance

The nitrogen alloying process leads to the formation of nitrogen-rich carbonitrides, which provide a naturally low-friction surface within the steel matrix. Unlike external coatings, which can wear off or delaminate over time, this property is inherent to the material itself. The smooth, low-friction surface minimises metal-to-metal adhesion, reducing the risk of galling under high contact pressures

and sliding conditions, particularly when working with coated AHSS (e.g., galvanised or aluminised steels).

In addition to its galling resistance, finely distributed vanadium carbonitrides, deliver excellent abrasive wear resistance. This ensures tools retain their edge integrity and performance over long production runs, even in highly abrasive environments.

Vancron SuperClean is particularly well-suited for applications where reliable, long-term tool performance is essential:

- Forming tools for coated AHSS, such as galvanised (GI/GA) or aluminised sheets.
- Blanking and punching tools requiring low friction and high edge wear resistance.
- Complex stamping and forming operations with high sliding pressures and surface contact.

By eliminating the need for additional coatings, Vancron SuperClean simplifies tooling maintenance while delivering consistent performance. Self-lubricating properties provide a unique for applications where the work material sticks to the tool and takes away the risk of premature tool failures and replacements.

CONCLUSION

The increasing use of Advanced High-Strength Steels (AHSS) in modern manufacturing presents significant challenges, particularly for tooling materials exposed to abrasive wear, galling, and chipping. ASSAB's high-performance tool steels—Vanadis 4 Extra SuperClean, Vanadis 8 SuperClean, and Vancron SuperClean—are specifically developed to address these issues and extend tool life in demanding cold work applications.

Vanadis 4 Extra SuperClean provides an excellent balance of wear resistance and toughness, making it the versatile choice for applications requiring both durability and resistance to chipping.

Vanadis 8 SuperClean excels in environments dominated by abrasive wear, offering superior edge retention and tool life for long production runs.

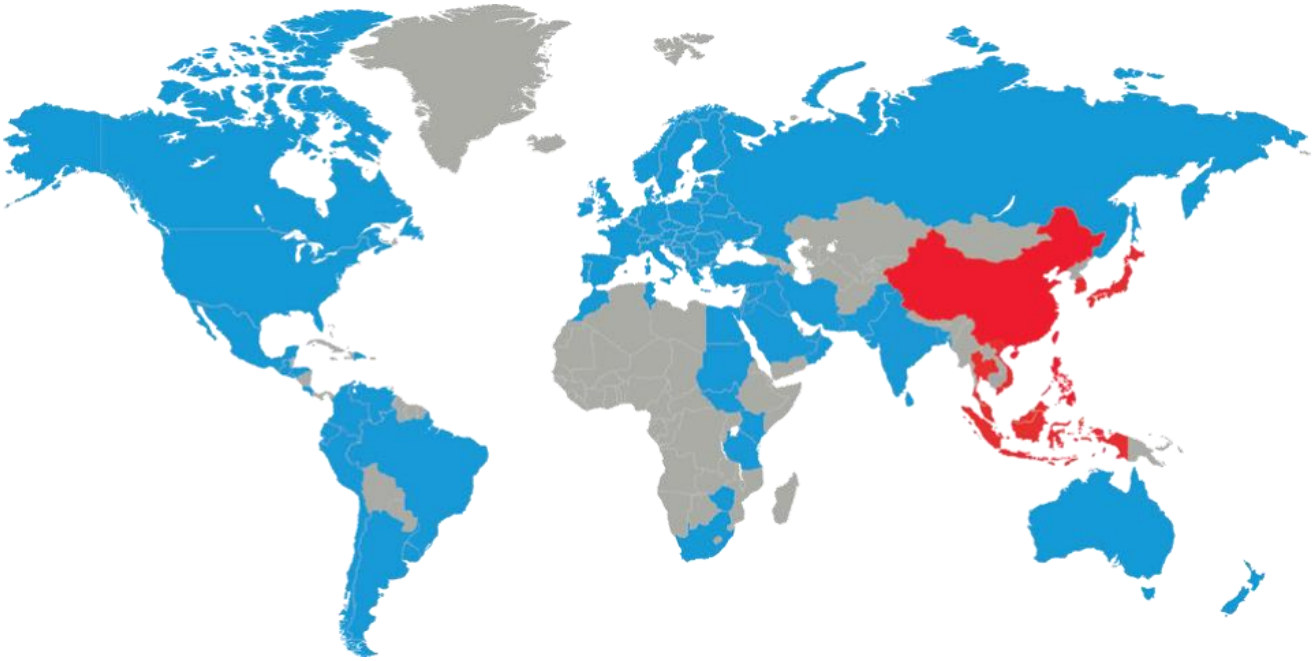
Vancron SuperClean, with its nitrogen-rich carbonitrides, offers inherent galling resistance and reduces the need for coatings, making it particularly effective for forming coated AHSS.
By selecting the appropriate tool steel for specific challenges—whether galling, abrasive wear, or chipping—manufacturers can enhance productivity, reduce downtime, and achieve consistent, high-quality results when working with AHSS materials.

When to Use Vanadis 4 Extra SuperClean, Vanadis 8 SuperClean, and Vancron SuperClean

Tool Steel	Primary Strength	Applications	Ideal for
Vanadis 4 Extra SuperClean	Balanced toughness and wear resistance	Blanking, forming, and stamping tools for AHSS	Applications requiring a balance of toughness and wear resistance to prevent early failure.
Vanadis 8 SuperClean	Exceptional abrasive wear resistance	High-volume blanking and punching of AHSS	Environments with extreme abrasive wear where maximum edge retention is critical.
Vancron SuperClean	Superior galling resistance, low friction	Forming tools for coated AHSS (e.g., galvanised)	Applications where adhesive wear (galling) dominates, and coatings are impractical.

Table 2. ASSAB solutions in different environments

By leveraging the unique properties of these advanced tool steels, manufacturers can optimise tooling performance and address the diverse challenges pose



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the most suitable treatment for each application. ASSAB not only supplies steel products of superior quality, but we also offer state-of-the-art machining, heat treatment, surface treatment services and additive manufacturing (3D printing) to enhance your tooling performance while meeting your requirements in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

In Asia Pacific, ASSAB anchors the distribution network for Uddeholm, a Swedish tool steel manufacturer with more than 350 years of experience in the tool steel industry. Both are integral parts of voestalpine AG, a prominent Austrian-based company listed on the Vienna Stock Exchange since 1995. Together, we establish ourselves as a key player in the steel and technology sector, with a diverse range of products and services.

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