WHITE PAPER

UDDEHOLM TYRAX THE PERFECT CHOICE FOR INJECTION MOULDING BIOCOMPOSITES

Sustainability is nowadays something that almost everyone is aware of and speaks about all over the globe, from big companies to the private person. Within the plastic moulding industry, Biocomposites offers a sustainable way forward for many manufacturers.

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Biocomposites is biobased fibers such as cellulose or flax and serves as a green alternative filler material, a replacement for the commonly used glass fiber or calcium carbonate. However, Biocomposites also set demands on the tool steel in our applications, the mix between wear and corrosion being the trickiest riddle to solve.

Uddeholm Tyrax ESR is a premium stainless tool steel developed for the most demanding injection moulding applications. Uddeholm Tyrax ESR is known for its corrosion resistance, high polishability, good ductility in combination with a working hardness of 56-58 HRC. This makes Uddeholm Tyrax ESR in combination with AM Tyrax and all the benefits that comes with the AM technique, makes Uddeholm Tyrax the most suitable material on the market for working with Biocomposites in plastic injection moulding.

Biocomposites

Sustainability is nowadays something that almost everyone is aware of and speaks about all over the globe, from big companies to the private person. Within the plastic moulding industry, Biocomposites offers a sustainable way forward for many manufacturers. Biocomposites is biobased fibers such as cellulose or flax and serves as a green alternative filler material, a replacement for the commonly used glass fiber or calcium carbonate. Combine this filler material with polymers and it will result in less environmental impact than a traditional plastic. Globally, the trend of Biocomposites is growing rapidly. Especially in Asia and Europe, mainly driven by consumer requirement sustainability goals from governments and countries.

In the automotive industry, Biocomposites are used when forming interior parts and smaller components. This is an effective way to reduce the total weight of the vehicle, which means less fuel consumption. It is also a great way to reduce the global footprint. Within the packaging and consumer industry, Biocomposites acts as a replacement for fossil plastics. This creates a more circular material flow.

However, as with most things, everything is not positive about Biocomposites. There are several challenges when procesing

this material in the injection moulding applications. First, natural fibres in Biocomposites are sensitive to high temperatures, often leading to fibre degradation during moulding, which can weaken the final product. These fibres also absorb moisture, which can cause defects like bubbles or poor surface finishes if not adequately dried. Additionally, achieving a uniform fibre distribution within the polymer matrix is complex, affecting materials strength. Lastly, variability in natural fibre quality can lead to inconsistencies in production, impacting the reliability and scalability of Biocomposites.

It is not only the product itself that has challenges, Biocomposites also puts high demands on the tool steel when processed in the injection moulding machine. As the number of shots increases, the wooden fiber fillers cause heavy wear on steel grades like 1.2083. Injection molders then tends to opt for non-stainless materials with achievable hardness levels of 56-58 HRC, to tackle the wear issues – only to end up with corrosion issues from the water vapor that the wood fibers leaves when processed.

Uddeholm has been involved with various companies throughout the development of Biocomposites and come up with a great solution to the demands that they put on the die steel and the solution is called Uddeholm Tyrax ESR, complimented with Uddeholm Tyrax for additive manufacturing.

Biocomposites

Get to know your enemies

If one were to analyze the failure mechanisms of the die steel in plastic injection molding, it is quickly understood that the defects found on the tool steel is heavily dependent on what type of plastic is processed.

As an example, if working with PVC plastics, the injection molder can expect corrosion attacks on the tool die. This occurs because when the PVC plastic is processed and/or exposed to temperatures (typically above 180°C) acid and gasses will be formed. The gas is hydrogen chloride gas, which is highly corrosive and a tool steel with great corrosion resistance is needed to process this type of plastic.

On the other hand, if one is working with a plastic with high amount of glass fiber in it, for instance glass filled Nylon. Usually written as PA6 or PA66, producers tend to use high amount of glas fiber fillers when working with these products. If processing this kind of plastic, the injection molder can expect heavy wear on the tool die. If also the goal is a high number of shots a lot if demands on wear resistance is needed from the tool steel.

Below is a list of the most common failures mechanisms of the tool steel within plastic injection moulding.

Corrosion is the most common failure mechanism within plastic injection moulding. There can be various reasons behind why corrosion occurs on the tool steel, but here are some:

- Aggressive resin.
- Stress corrosion cracking.
- Poor water quality.
- Galvanic phenomena

Wear is a common failure mechanism within plastic injection moulding, and it appears in both abrasive and adhesive version. Recommendations on how to handle wear issues:

- Carbides has a strong contribution to wear resistance, not only hardness levels.
- Keep at least 2 HRC difference between sliding parts.

Cracking of tool steel die may not happen as frequent within plastic injection moulding, as in blanking or HPDC. When it does happen, it is usually connected to:

- Sharp radii.
- Big tools made from material with lower ductility values.
- Linked to corrosion in cooling channels.

Uddeholm Tyrax ESR

Uddeholm Tyrax ESR is a premium stainless tool steel developed for the most demanding injection moulding applications.

Uddeholm Tyrax ESR is known for its corrosion resistance, high polishability, good ductility in combination with a working hardness of 56-58 HRC.

Uddeholm Tyrax ESR is ideal for moulds requiring a flawless, mirror-like finish, such as those used in the production of optical components and high-quality consumer goods. Its refined properties, achieved through the Electro-Slag Remelting (ESR) process, provides enhanced cleanliness, toughness, and ductility. On top of that, Uddeholm Tyrax ESR also offers great dimensional stability both in heat treatment and in service. The creative innovation in Uddeholm Tyrax ESR's chemical composition gives great hardenability, which means that compared to most materials on the market it brings the same properties and microstructure throughout the cross-section in bigger blocks.

Uddeholm Tyrax ESR stands out as a reliable choice for high-performance moulds, delivering both outstanding aesthetics and longevity in challenging environments.

Introducing AM Tyrax
Combining Uddeholm Tyrax ESR with AM Tyrax offers a smart and innovative solution that leverages traditional high-performance steel with advanced 3D-printed components, creating tooling that maximizes efficiency and performance. By integrating AM Tyrax (3D-printed parts onto blocks made of Tyrax ESR). With a so-called hybrid tool, manufacturers can achieve complex geometries and custom features that are difficult or impossible to create through conventional machining.

Uddeholm AM Tyrax							
C	Si	Mn	Cr	Mo	V	N	O
0.40	0.2	0.5	12.0	2.3	0.5	+	Max 0.02
Uddeholm Tyrax ESR							
C	Si	Mn	Cr	Mo	V	N	O
0.40	0.2	0.5	12.0	2.3	0.5	+	-

Chemical composition of Uddeholm Tyrax.

** Uddeholm Tyrax ESR & Uddeholm AM Tyrax are Cobolt free alloys.*

** Uddeholm Tyrax ESR & Uddeholm AM Tyrax contributes to the green steel campaign.*

Benefits of AM in plastic injection moulding
Using AM in plastic injection moulding offers manufacturers a faster, more flexible, and cost-effective approach to mould production. AM allows the creation of intricate, conformal cooling channels within the mould that would be impossible or costly to produce with traditional machining. Conformal cooling channels follow the mould's shape more closely, enhancing heat dissipation and reducing cooling times, which in turn leads to faster cycle times and improved part quality. There have been cases where the AM technique outperforms the cooling rate of the traditionally used Beryliumcopper. An element that is starting to get banned in many countries due to the health issues when working with the material.

AM, moulds, or mould inserts can be produced directly from CAD files, bypassing traditional tooling and machining steps. This significantly shortens lead times, allowing for quicker iterations and prototyping. For companies looking to test design changes or bring products to market rapidly, this is a major advantage.

There are also sustainability benefits by reducing waste and allowing for localized, on-demand production. AM supports more sustainable manufacturing practices. The ability to produce mould inserts with minimal material waste is a greener alternative compared to traditional subtractive machining. Uddeholm are proud to present the worlds first net zero tool, made from AM Tyrax. A co-operation between: voestalpine HPM Germany, AMC Düsseldorf, inSPire, Uddeholm and Eschmann.

Worlds first net zero tool, made from AM Tyrax.

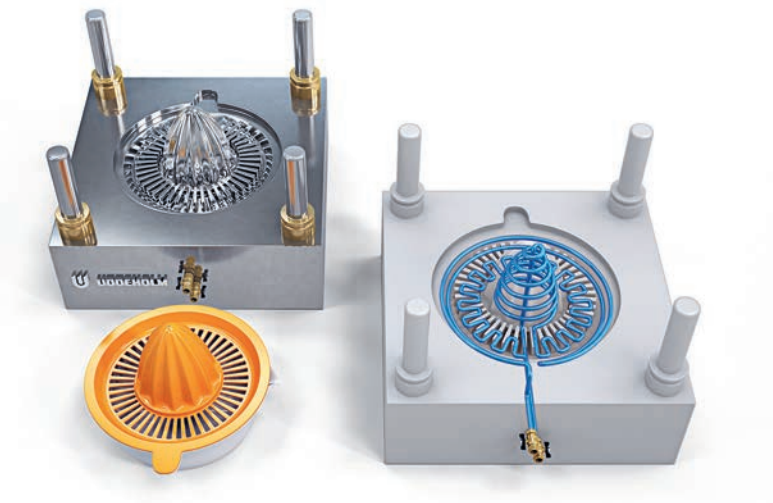


Illustration of cooling channels in a tool.

Improved wear resistance with Uddeholm Tyrax
Uddeholm Tyrax offers several advantages over the standard material 1.2083 which is the most used material on the market when it comes to plastic injection moulding. To prove that Uddeholm Tyrax is outperforming 1.2083 type material, testing results will be presented below. Improved wear resistance has been tested via the Pin-on-Disc. It is important to notice that this method measures amount of material removed, so a low value is wanted. This test proves that Uddeholm Tyrax brings superior wear resistance compared to 1.2083 material and will therefore lead to increased tool life.

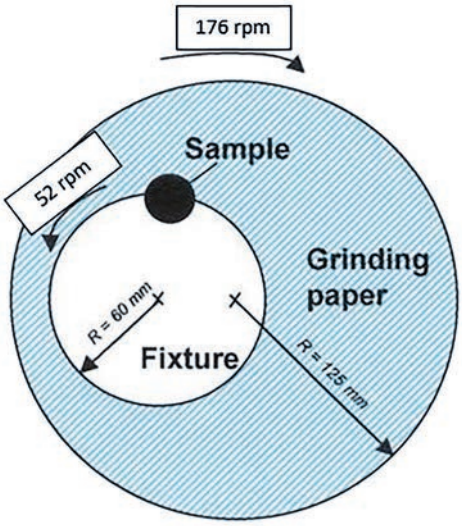
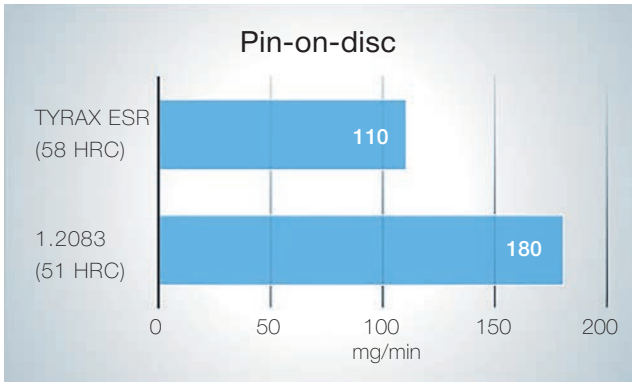
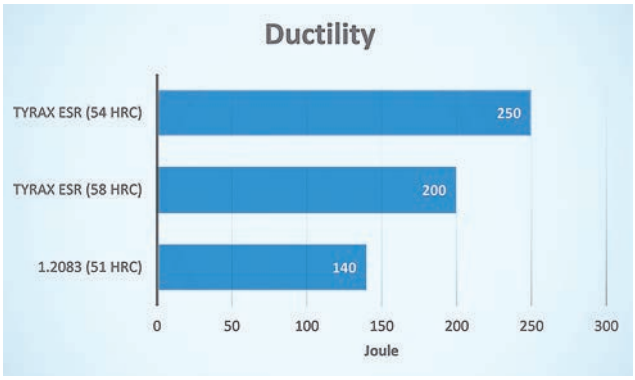


Illustration of the testing method Pin-on-disc.

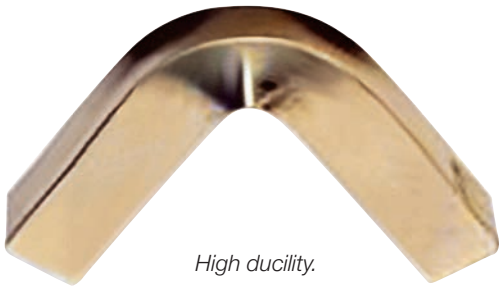


Result from Pin-On-Disc trials between Uddeholm Tyrax ESR and 1.2083.

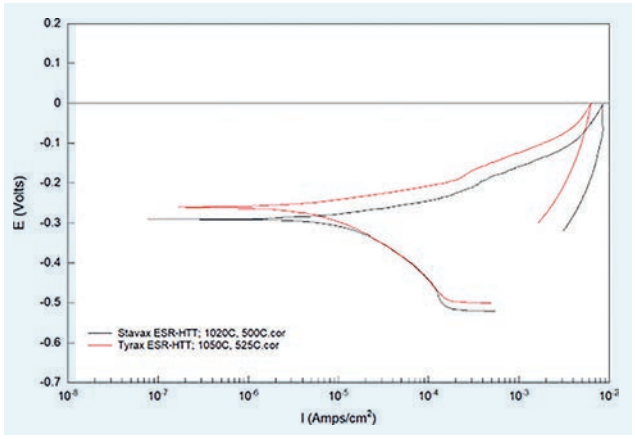
Superior ductility and corrosion resistance with Uddeholm Tyrax
Tyrax's advanced alloy composition enhances ductility and corrosion resistance compared to the 1.2083 types of materials. The secret lies in the optimization of the microstructure that Uddeholm Tyrax provides. The matrix reaches a higher hardness level and it possess a different type of carbides that are more effective against abrasion. The addition of nitrogen in the alloy system also contributes to greater corrosion resistance, which can be seen by the potential being higher in the polarisation curve below, compared to Uddeholms 1.2083 type material Stavax ESR.



Result from un-notched charpy-v testing.

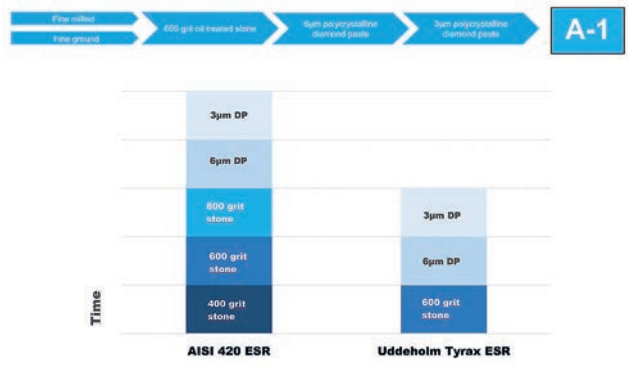


High ducility.



Polarisation curve of Tyrax ESR vs Stavax ESR

Best polishability in class
Many tool steels are not optimised for the polishing process. Their carbide distribution or high number of impurities make it difficult to achieve a high gloss. Uddeholm Tyrax ESR make it possible to reach A-1 surface finish level in the SPI guide (American standard for surface finish) with three polishing steps, compared to 1.2083 type material which requires 5 steps. Saving time (Approximately 40%) during manufacturing of the tool means cutting unnecessary costs. The surface mirrors your needs.



Steps needed to reach A-1 Surface level.

S.P.I. Mold Finish Guide	Roughness Avarage R.a. value	
	Microinches µ"	Micrometers µm
A-0	0.1 - 0.5	0.003 – 0.013
A-1	0.5 – 1.0	0.013 – 0.025
A-2	1.0 – 2.0	0.025 – 0.051
A-3 / B1	2.0 – 4.0	0.05 – 0.10
B2	4.0 – 6.0	0.10 – 0.15
B-3	9.0 – 10.0	0.23 - 0.25
C1	10.0 – 12.0	0.25 - 0.30

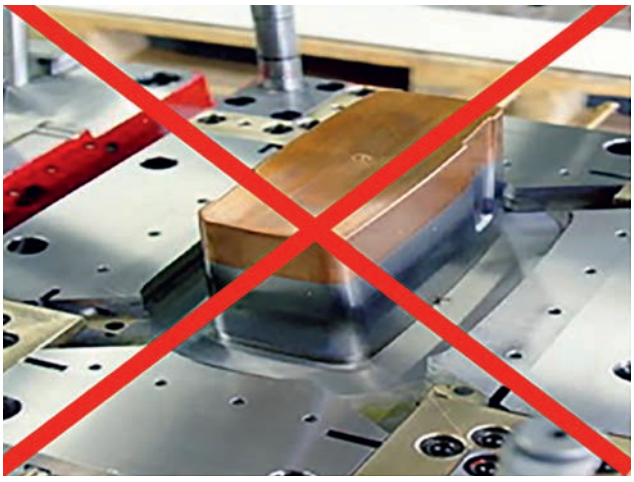
The SPI-guide

Conclusions

Biocomposites offers a sustainable way forward for many manufacturers within the plastic moulding industry. Biocomposites is biobased fibers such as cellulose or flax and serves as a green alternative filler material, a replacement for the commonly used glass fiber or calcium carbonate.

Globally, the trend of Biocomposites is growing rapidly. Especially in Asia and Europe, mainly driven by consumer requirement sustainability goals from governments and countries. Our studies shows that Uddeholm Tyrax outperforms the most used material in the industry, 1.2083/420 type material in all aspects when it comes to plastic injection moulding production. Uddeholm understands the failure mechanisms brought to the tool steel when processing Biocomposites.

Uddeholm has been foreseeing the growth of Biocomposites and been involved with various companies that have tried to processed plastics containing Biocomposites during its development, this way Uddeholm knew the markets needs and from this path Uddeholm Tyrax ESR & Uddeholm AM Tyrax was born.



Uddeholm is proud to present a sustainable and cost-effective solution to processing plastics containing Biocomposites and offer a healthy option to the Beryliumcopper alloys.