TYRAX ESR

The Perfect Choice For Injection Moulding Biocomposites

Magnus Glans - Application Manager, Uddeholm

Abstract

Sustainability is now something that almost everyone is aware of and discusses around the globe, from large companies to private individuals. In the plastic molding industry, biocomposites offer a sustainable path forward for many manufacturers. Biocomposites are bio-based fibres, such as cellulose or flax, and serve as a green alternative filler material, replacing the commonly used glass fibre or calcium carbonate. However, biocomposites also impose demands on the tool steel in our applications, with the combination of wear and corrosion presenting as the trickiest riddle to solve.

Tyrax ESR is a premium stainless tool steel developed for the most demanding injection molding applications. It is known for its corrosion resistance, high polishability, and good ductility, combined with a working hardness of 56-58 HRC. It is highly recommended for use with biocomposites in plastic injection molding.

Biocomposites

Sustainability has become a widely recognized and discussed concept globally, encompassing stakeholders ranging from large corporations to individual consumers. In the context of the plastic molding industry, biocomposites provide a viable sustainable alternative for numerous manufacturers. Biocomposites are composed of bio-based fibers, such as cellulose or flax, and serve as an environmentally friendly alternative to traditional filler materials, such as glass fiber or calcium carbonate. When combined with polymers, this filler material results in a lower environmental impact than traditional plastics. The trend of biocomposites is growing rapidly worldwide, particularly in Asia and Europe, mainly driven by consumer demands and sustainability goals established by governments and countries.

Fig. 1 Biocomposites.

In the automotive industry, biocomposites are used to form interior parts and smaller components. This is an effective way to reduce the total weight of the vehicle, leading to lower fuel consumption. It also serves as an excellent method for reducing the global footprint. In the packaging and consumer goods industry, biocomposites serve as a replacement for fossil-based plastics, creating a more circular material flow.

However, as with most things, not everything about biocomposites is positive; there are several challenges associated with processing this material in injection molding applications. First, the natural fibers in biocomposites are sensitive to high temperatures, which can often lead to fiber degradation during molding, weakening the final product. These fibers also absorb moisture, which can result in defects such as bubbles or poor surface finishes if not adequately dried. Additionally, achieving a uniform fiber distribution within the polymer matrix is complex, which affects the material's strength. Lastly, variability in the quality of natural fibers can lead to inconsistencies in production, impacting the reliability and scalability of biocomposites.

It is not only the product itself that presents challenges; biocomposites also place high demands on the tool steel when processed in the injection molding machine. As the number of shots increases, the wooden fiber fillers cause significant wear on steel grades such as 1.2083. Consequently, injection molders tend to opt for non-stainless materials with achievable hardness levels of 56-58 HRC to address the wear issues. However, this often leads to corrosion problems caused by the water vapor released by the wood fibers during processing. Uddeholm and ASSAB have been involved with various companies throughout the development of biocomposites and have devised an excellent solution to meet the demands placed on die steel.

Get to know your enemies!

If one were to analyze the failure mechanisms of die steel in plastic injection molding, it would quickly become clear that the defects found in the tool steel are heavily dependent on the type of plastic being processed.

For example, when working with PVC plastics, the injection molder can anticipate corrosion attacks on the tool die. This happens because when PVC plastic is processed and/or exposed to temperatures typically above 180°C, acids and gases are produced. One of these gases is hydrogen chloride, which is highly corrosive, making it necessary to use tool steel with excellent corrosion resistance to process this type of plastic.

On the other hand, when working with a plastic that contains a high amount of glass fiber, such as glass-filled nylon—commonly referred to as PA6 or PA66—these products typically have a glass fiber content ranging from 10% to 50%. When processing this type of plastic, the injection molder can anticipate significant wear on the tool die. Furthermore, if the objective is to achieve a high number of shots, the tool steel must meet substantial requirements for wear resistance.

Below is a list of the most common failure mechanisms of tool steel used in plastic injection molding.

Corrosion is the most common failure mechanism in plastic injection molding. There can be various reasons why corrosion occurs on tool steel, and here are a few:

- 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 & adhesive version. Here are recommendations on how to handle wear issues:

- Carbides contribute significantly to wear resistance, not just through hardness levels.
- Keep at least 2 HRC difference between sliding parts.

Cracking of tool steel dies may occur less frequently in plastic injection molding than in blanking or high-pressure die casting. When it does happen, it is usually associated with:

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

Tyrax ESR

Tyrax ESR is a premium stainless tool steel developed for the most demanding injection molding applications. It is known for its corrosion resistance, high polishability, and good ductility, combined with a working hardness of 56-58 HRC. Tyrax ESR is ideal for molds that require 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, provide enhanced cleanliness, toughness, and ductility. Additionally, Tyrax ESR offers excellent dimensional stability both during heat treatment and in service. The innovative composition of Tyrax ESR's chemicals contributes to its great hardenability, which means that, compared to most materials on the market, it maintains the same properties and microstructure throughout the cross-section, even in larger blocks.

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

Improved wear resistance with Tyrax ESR

Tyrax ESR 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 Tyrax ESR is outperforming 1.2083 type material, testing results will be presented below. Improved wear resistance has been tested via the Pin-on-Disc. <u>It is important to notice that this method measured amount of material removed, so a low value is wanted.</u> This test proves that Tyrax ESR brings superior wear resistance compared to 1.2083 material and will therefore lead to increased tool life.

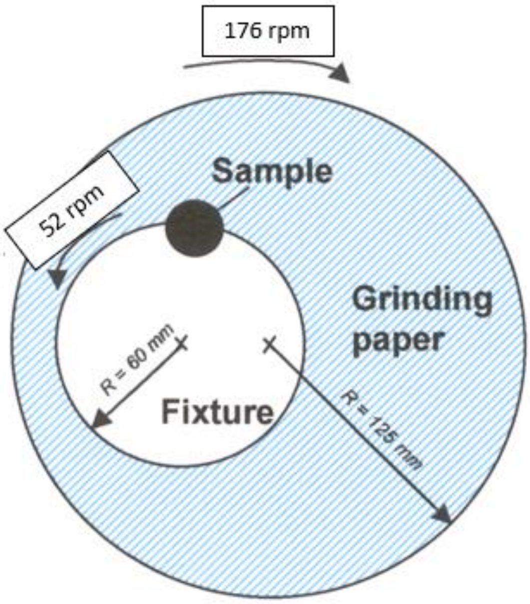


Fig. 2 Illustration of the testing method Pin-on-disc.

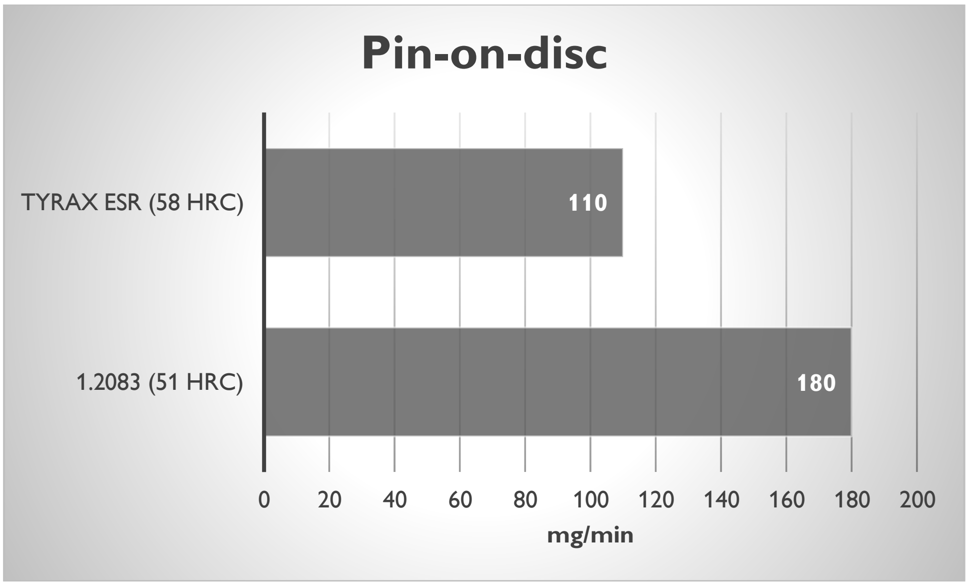
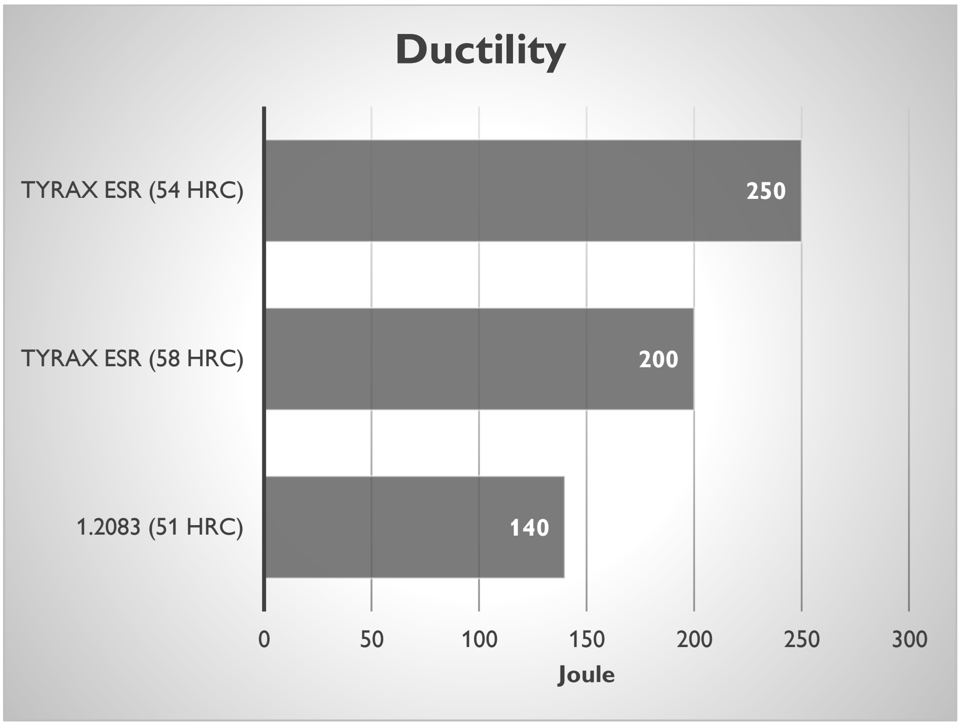


Fig. 3 Result from Pin-On-Disc trials between Tyrax ESR and 1.2083.

Superior ductility and corrosion resistance with Tyrax ESR

Tyrax ESR'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 Tyrax ESR 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 1.2083 type material.



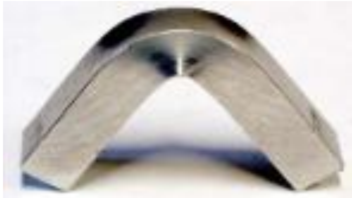


Fig. 4 Result from un-notched impact testing.

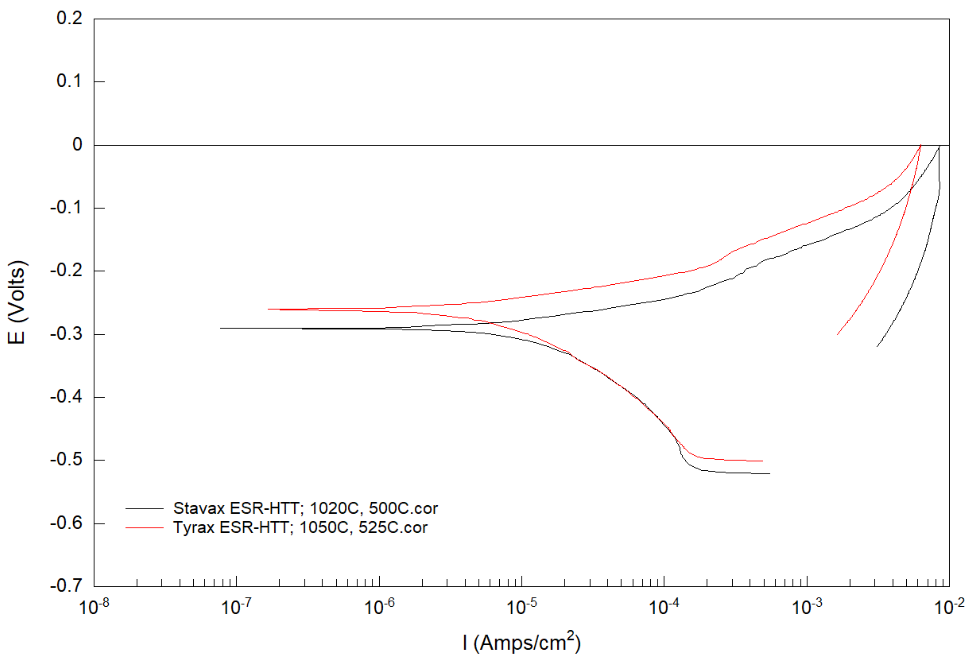


Fig. 5 Polarisation curve of Tyrax ESR vs 1.2083 Type material

Best polishability in class

Many tool steels are not optimized for the polishing process. Their carbide distribution and high number of impurities make it difficult to achieve a high gloss finish. Tyrax ESR makes it possible to reach an A-1 surface finish level in the SPI guide (the American standard for surface finish) with only three polishing steps, in contrast to 1.2083 type material, which requires five steps. This results in a time savings of approximately 40% during the manufacturing of the tool, thus reducing unnecessary costs. The surface mirrors your needs.

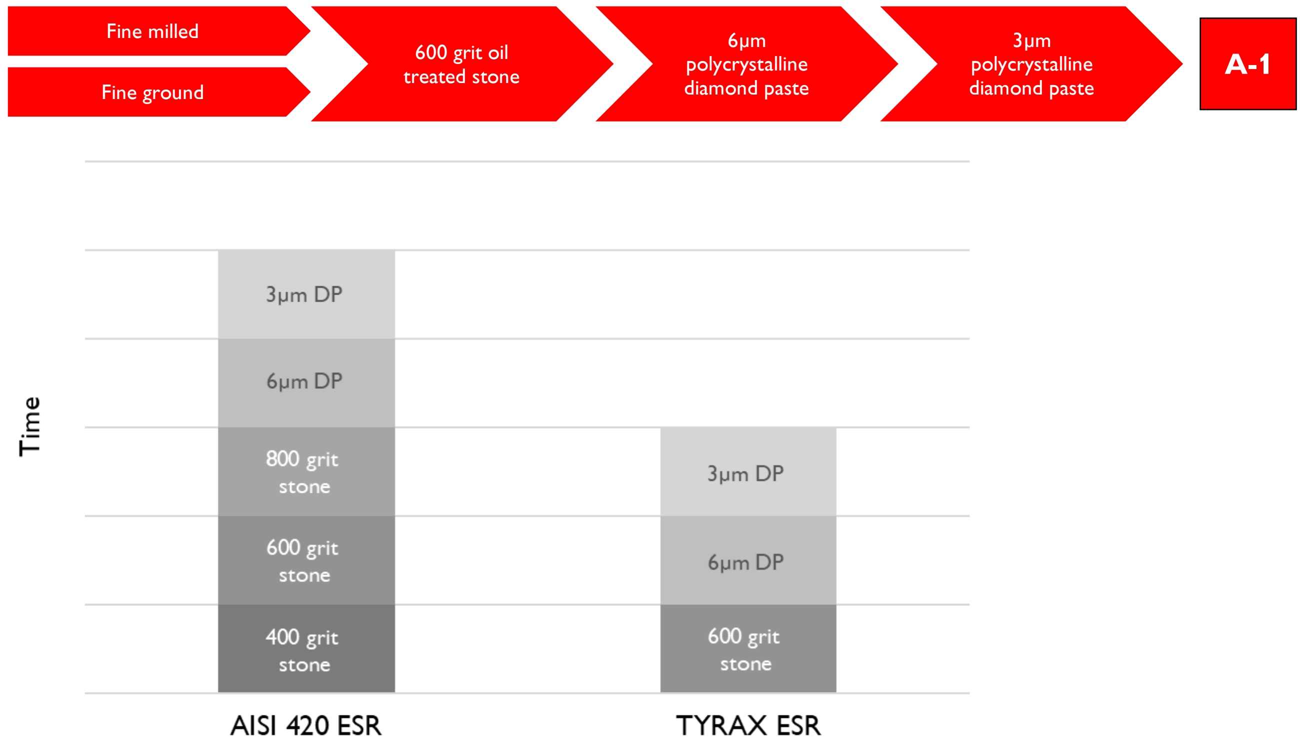


Fig. 6 Steps needed to reach A-1 Surface level.

Table 1. The SPI-guide.

S.P.I Mold Finish Guide	**Roughness Average, 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
B3	9.0 - 10.0	0.23 - 0.25
C1	10.0 - 12.0	0.25 - 0.30

Conclusions

Biocomposites offer a sustainable path forward for many manufacturers in the plastic molding industry. Biocomposites consist of bio-based fibers such as cellulose or flax and serve as an environmentally friendly alternative filler material, replacing the commonly used glass fiber or calcium carbonate.

Globally, the trend of biocomposites is growing rapidly, particularly in Asia and Europe, driven mainly by consumer demand and sustainability goals set by governments and countries.

Our studies show that Tyrax ESR outperforms the most commonly used material in the industry, 1.2083/420 type material, in all aspects of plastic injection molding production. Uddeholm and ASSAB understand the failure mechanisms that affect tool steel when processing biocomposites.

Uddeholm and ASSAB have anticipated the growth of biocomposites and has collaborated with various companies that have sought to process plastics containing biocomposites during their development. This has enabled Uddeholm and ASSAB to understand market needs.

Uddeholm and ASSAB are proud to present a sustainable and cost-effective solution for processing plastics containing biocomposites, offering a healthier alternative to beryllium copper alloys.