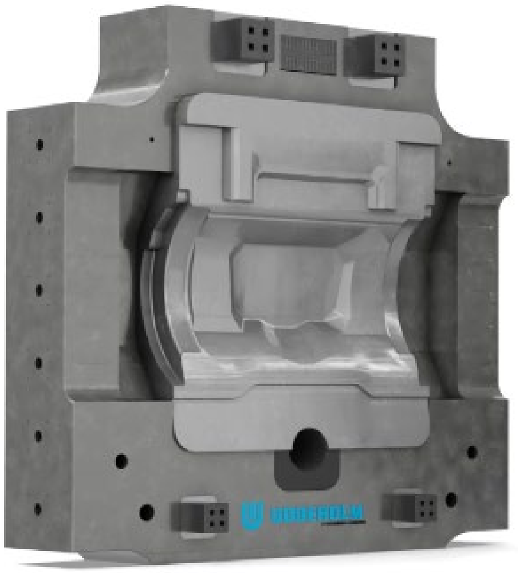
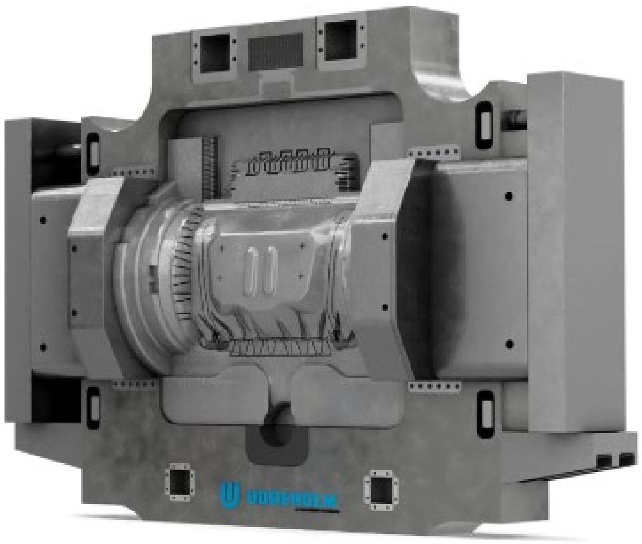
VIDAR SUPERIOR

An optimal choice for gigacasting





Sebastian Sivertsen

Abstract

Gigacasting, the process of producing large structural aluminum parts through high-pressure die casting, has seen global adoption across Asia, Europe, and North America. The increased size of castings demands significant improvements in die steel to ensure cost-effective production and extended die life. Among the critical failure mechanisms in aluminum high-pressure die casting (HPDC) are heat checking, soldering, erosion, and cracking, with heat checking being the most prevalent issue. To address these challenges, this study compares the performance of two steel grades, AISI H13 ESR and Vidar Superior, in terms of heat checking resistance and impact toughness.

Vidar Superior, a modified AISI H11 grade with low silicon content, demonstrates superior performance in both areas. Heat checking tests reveal that Vidar Superior develops fewer and shallower cracks under cyclic thermal stress compared to AISI H13 ESR. Additionally, impact toughness tests show that Vidar Superior has an average impact toughness of 35 Joules, significantly higher than the 16 Joules exhibited by AISI H13 ESR. These results suggest that Vidar Superior is better suited for Gigacasting applications, offering enhanced resistance to heat checking and crack propagation, ultimately leading to lower maintenance costs and longer die life.

Introduction

The spread of Gigacasting is global! Presses have been installed across Asia, Europe, and North America to produce large structural aluminium parts through high-pressure die casting. With a locking force of 6,000 tons and above, the demands on die steel are high to enable cost-effective production. This is achieved by producing several parts before maintenance is required due to failure mechanisms.

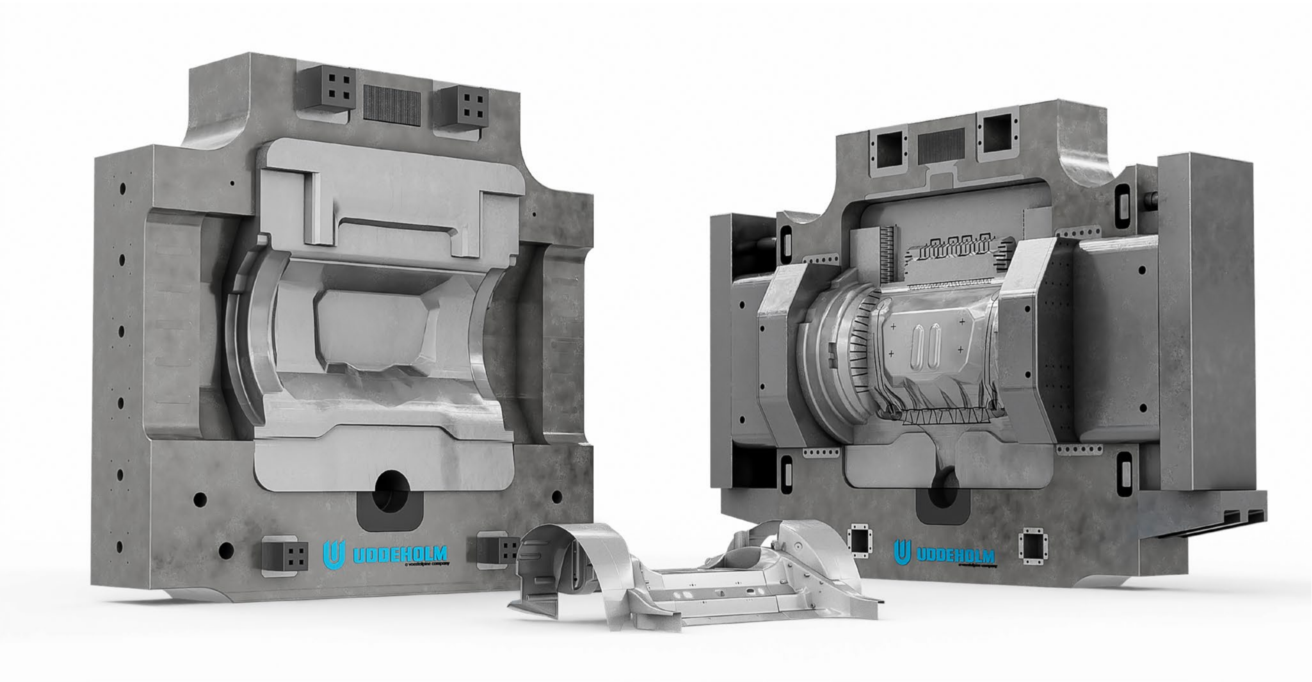
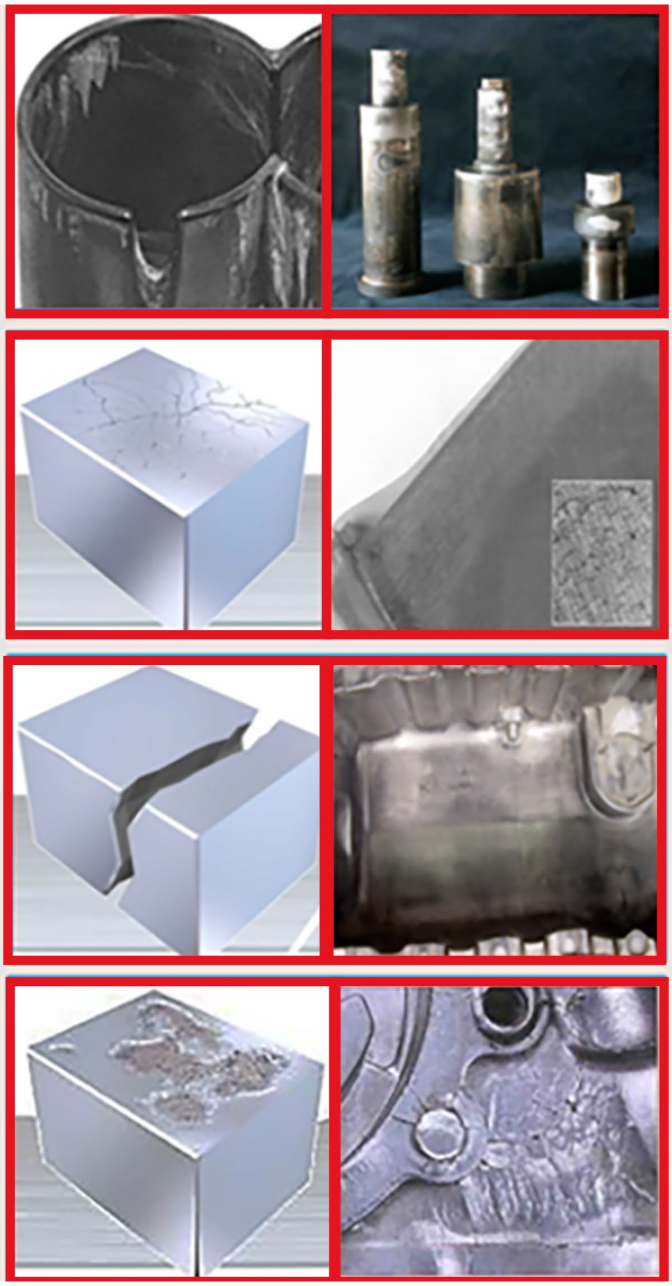


Figure. 1 Visualization of Gigacasting dies and part

In aluminium high pressure die casting, there are four main failure mechanisms: heat checking or thermal fatigue, soldering, erosion, and cracking. If we asked most HPDC companies what their main die failure is that prevents them from achieving maximum die life, the majority would say heat checking, followed by soldering or erosion. However, sometimes cracking can occur, which can halt production very quickly. The most common failure mechanisms are explained in Figure 2.



Soldering is when the Al sticks to the die. Core pins or other areas that get very hot, suffer this problem.

Heat checking combination of thermal cyclic stress, tensile stress and plastic stress

Cracking Thermal and/or mechanical overloading of the die

Erosion Hot mechanical wear, mainly due ot the velocity of the melt

Figure. 2 shows the most common failure mechanism in HPDC

When it comes to Gigacasting, the larger casting size results in more heat entering the die, and the larger die sizes lead to higher costs. To tackle these challenges and achieve longer die life, thereby lowering costs, two main areas play a significant role in the selection of die steel. The first is the material's ability to delay heat checking and extend the die's life before a crack network starts to form on the surface. The second is reducing the risk of cracks penetrating the die, which can cause significant damage and make weld repairs more difficult. To resist crack propagation, the die material needs to have high impact toughness.

In addressing the main problem of heat checking, the chemistries of 1.2344 (AISI H13) and 1.2343 (AISI H11) fall short or have compromises in this area. AISI H11 and H13 are considered the base standard for die steel in high-pressure die casting. However, for Gigacasting, there is a need for better properties to delay heat checking and improve impact toughness, which is often a cost-effective solution for the entire production series.

Experimental methodology for Evaluating Heat Checking and Impact Toughness in Die steel

Heat checking and Impact toughness tests were conducted on two different materials. Samples were taken from an AISI H13 ESR block and a block made of Vidar Superior (Table 1). Vidar Superior belongs to a new generation of modified AISI H11 ESR steel grades with low silicon content to achieve very high impact toughness.

Table 1. Shows chemical composition of the two steel grades

TOOL STEEL	C	Si	Mn	Cr	Mo	V
AISI H13 ESR	0.40	1.0	0.4	5.2	1.4	0.9
Vidar Superior	0.36	0.3	0.3	5.0	1.3	0.5

Heat checking samples, which were cylindrical with a through hole, were taken from the two steel grades (Figure 3). Charpy-V impact toughness samples were taken in the short transverse direction. Heat treatment was performed according to NADCA specifications to achieve a hardness of 44-46 HRC.

Diameter: 50 mm, 1.97”
Internal Diameter: 35 mm, 1.38”
Length: 100 mm, 3.94”

Figure. 3 Shows thermal fatigue sample geometry

The heat checking test was performed on a test rig where the sample is fixed between two holders connected to a water tank. Water flows at a constant rate through the sample hole, acting as a cooling channel. A copper coil is placed around the center of the specimen's outer diameter, with a length of 60 mm. The coil is connected to an High Frequency generator, resulting in induction heating of 35 kW. Behind the copper coil, and around the outer diameter of the sample, a nozzle is placed and connected to a compressor. The nozzle applies forced air to the outer surface of the sample to increase the cooling rate. The tests were conducted with a temperature variation between 700°C and 20°C for 800 cycles. Evaluation was performed by measuring all cracks from the surface into the material, with the results shown as average crack depth.

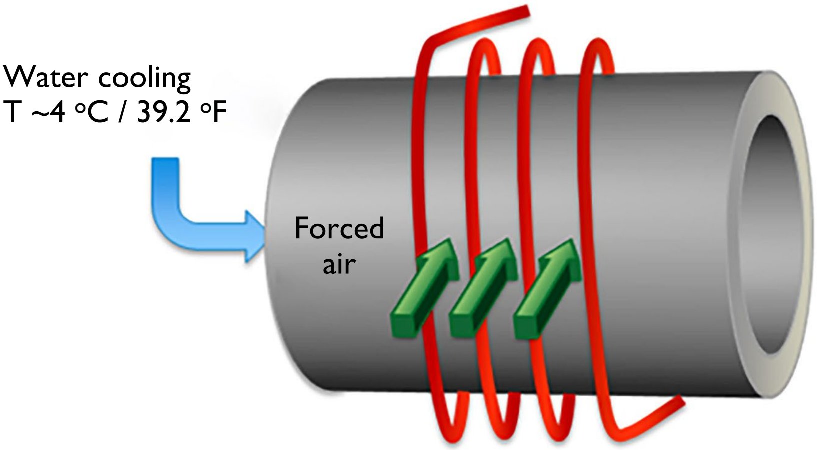


Figure. 4 Shows how the test setup is built around the sample

The impact toughness test was performed using a Charpy impact testing machine, which consists of a heavy pendulum mounted on a stand. Charpy V-notch specimen have a dimension of 10mm x 10mm x 55mm with a machined V-shaped notch into the specimen. The notch is 2mm deep with a 45-degree angle and a 0.25mm root radius. The energy absorbed during fracture indicates the material's ability to withstand sudden impacts, which is crucial in applications where the material may experience dynamic loading or shock.

The properties which give performance

The results of the thermal fatigue tests showed that AISI H13 ESR exhibited deeper cracks compared to Vidar Superior (Figure 5). This indicates that Vidar Superior develops fewer deep cracks when exposed to the cyclic thermal stress that occurs during the casting cycles of Gigacasting.

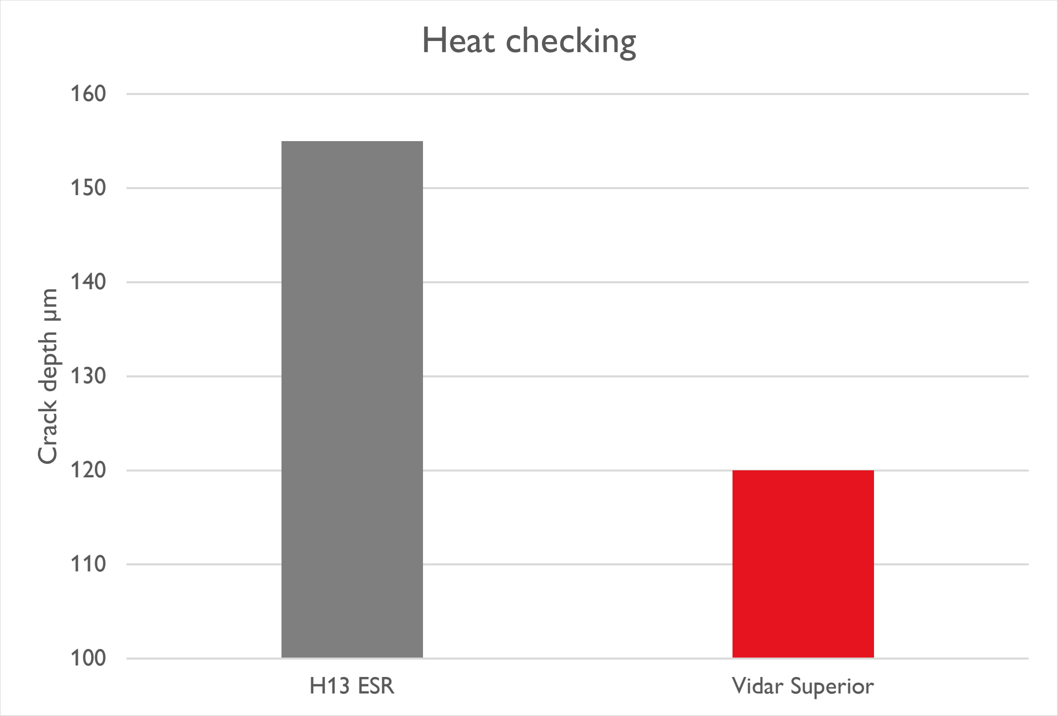


Figure. 5 Shows the average crack depth

When it comes to crack propagation, a higher impact toughness value means that a greater amount of energy is needed to break the material. The results show that Vidar Superior has a higher impact toughness, with an average value of 35 Joules, compared to AISI H13 ESR, which has an average value of 16 Joules.

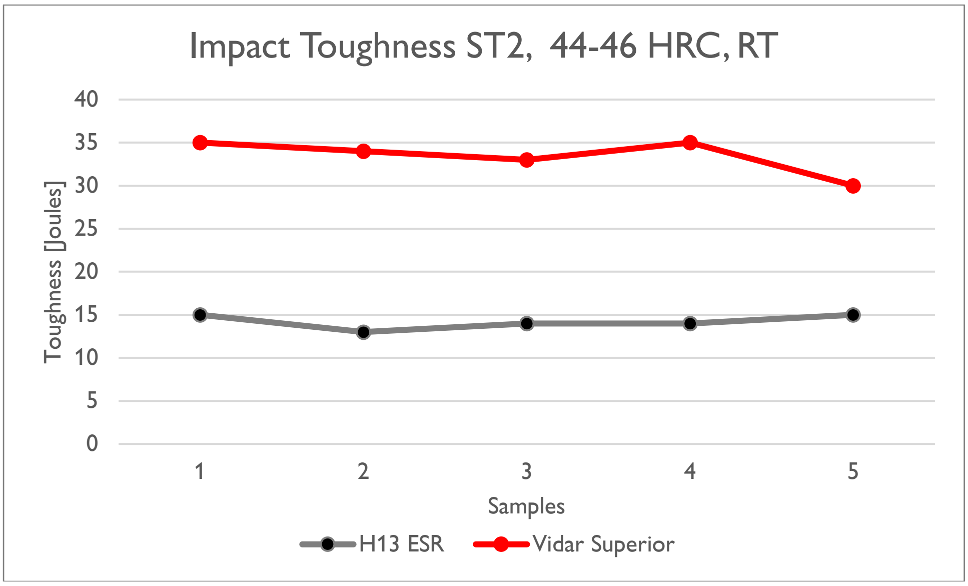


Figure. 6. Shows impact toughness results

Conclusions

The global expansion of Gigacasting has significantly increased the demand for advanced die steels capable of withstanding the rigorous conditions of high-pressure die casting. As presses are installed worldwide to produce large aluminum structural components, the challenges associated with die longevity and cost-effectiveness become more pronounced. Key failure mechanisms in aluminum high-pressure die casting include heat checking, soldering, erosion, and cracking.

Our study has demonstrated that traditional die steels, such as AISI H13 and AISI H11, while standard in high pressure die casting, exhibit limitations in their resistance to heat checking and impact toughness. Specifically, AISI H13 ESR showed deeper cracks and lower impact toughness compared to Vidar Superior. The latter, a modified AISI H11 steel with low silicon content, outperforms the former by offering better resistance to heat checking and higher impact toughness.

Vidar Superior's superior performance evidenced by fewer and shallower cracks and a higher impact toughness addresses the critical needs of Gigacasting. This steel's enhanced properties make it a more effective choice for applications requiring extended die life and reduced maintenance costs. Therefore, adopting Vidar Superior can lead to more cost-effective and reliable Gigacasting operations, ultimately contributing to the efficiency and sustainability of large scale aluminium component production.