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Easy installation, reliable sealing – pressure and temperature resistant b&m-KL Plugs

Freeze-fit plug vs. b&m-KL Plug

The art of sealing in large die-casting dies

There are good reasons to rethink the performance of cooling channels, especially if the aim is to improve casting part quality, cost efficiency, and ecological footprint. This is the case at Schaufler Tooling. The company uses an intelligent sealing system from baier & michels to overcome even complex challenges, whether in dies for mega and giga castings or for dies prepared for micro spray.

By Andreas Wollny

Leaks are some of the most annoying occurrences in the daily processes involving die casting and die making. They are the main drivers of unplanned downtime during the production process and can have different causes. Leaks on the outside of a die, for example on the connecting thread, are relatively easy to fix. Cracks between the die and a cooling

channel occur less frequently but are often reducing the overall equipment effectiveness (OEE) significantly. And then there is the variant that prompted Siegfried Heinrich, Managing Director of die manufacturer Schaufler Tooling in Laichingen, Germany (fig. 1), and his team to search for the optimum solution: leaks on sealing plugs.

“For several years, we used freeze-fit plugs”, reports Siegfried Heinrich. Heinrich explains that, while the key feature of these proven sealing elements is their effectiveness, “they are quite a burden in terms of material and energy consumption as well as working hours and safety”. Schaufler was therefore open to new solutions that would meet the high sealing requirements while

Table 1: Effort comparison freeze-fit plugs and b&m-KL Plugs. Reference: cavity part with 15 plugs.

	Freeze-fit plug process step	Time [min]	b&m-KL Plug process step	Time [min]
Preparing the die insert	hard milling	75	drill to target diameter	10
	ream	5		
	re-machine to larger diameter, if necessary	15		
Preparing installation	measure the holes	30	check the holes	10
	turn the plugs	60		
	heating of cavity part (approx. 6 h)	15		
Installation	insert the plugs	30	install the KL Plugs	15
	leak test	10	leak test	10
	grind flat	30		
Reworking in the case of a leak	re-machine the hole	90	set 2nd plug	3
	measure the plug	3	or replace the plug	5
	turn the plug	5		
	heating of cavity part (approx. 6 h)	15		
	insert the plug	10		
	leak test	5		
	grind flat	3		
Total		401		48-50

substantially reducing the effort required for installation and removal.

Large dies = more closing and sealing elements

A look at a simple cavity insert with 15 openings illustrates just how important this challenge is. The four phases – preparing the insert, preparing installation, installation, and rework in case of a leak – take around 400 minutes on average when a freeze-fit plug is used at Schaufler (table 1). “Die-casting dies, for example for a shock tower or a transmission housing, can contain up to 150 plugs – that means 150 potential leaks”, says Thomas Schwegler, Head of Design Engineering. “And in the project that we have been implementing recently, things are on a much larger scale than that”.

One could also say: gigantic. This becomes evident when stepping into the new Schaufler production building in Laichingen. Dies with a total weight of up to 200 tons have been manufactured in this 1000 m² workshop since last summer – for die-casting machines with clamping forces between 6000 and 12 000 tons. This makes the company part of a very small group of pioneers worldwide who are able to supply the automotive industry with so-called mega and giga dies.

“Side members, for example, are considered very heavy and complex parts in conventional die casting of structural parts”, explains Schwegler. “As a comparison: For mega and giga castings, two side members and up to

three crossmembers, for example, can be produced in one die and therefore in a single casting”. The increasing requirements for the geometry of the parts also have an impact on the number of cooling circuits. According to Thomas Schwegler, the Schaufler engineers need three to four times as many circuits as before. The number of required drilled holes and sealing elements also increases accordingly.

Other challenges

“And there is another innovation: micro spray”, adds Managing Director Siegfried Heinrich. “This principle has proven to be an opportunity and a burden at the same time”. In this process,

minimal quantities of release agent emulsions or water-free release agents are sprayed onto the surface of the die. The background: With water-based spray, large and rapid temperature changes cause thermal fatigue cracking on the surface relatively early on. These enter the die insert and progress all the way to the cooling channels, allowing cooling water to get inside the die.

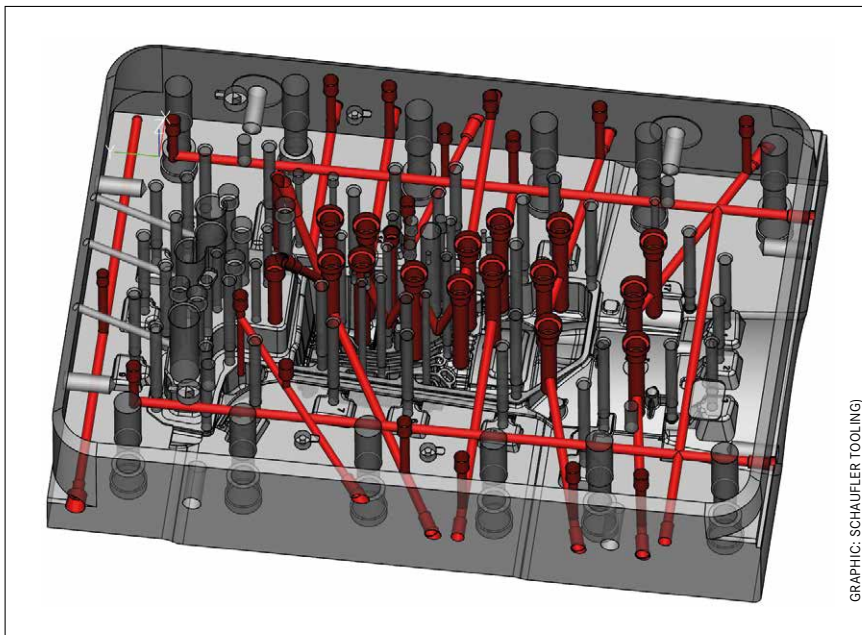
The same risk is also present inside the cavity parts. The driver for this is corrosion in the cooling channels. “This

Fig. 1: Siegfried Heinrich (left), Managing Director of Schaufler Tooling, with Constantin Egold, Technical Product Manager at b&m.



SEALING SYSTEM

Table 2: Test procedure.	
Parameter	Value
Temperature of the heat transfer oil	300 °C
Flow pressure	2.5 bar
Water volume for quenching	10 l
Water temperature	approx. 20 °C
Quenching cycle	2 min
Cycle duration	1 h
Cycles per day	2
Total duration	8 days
Tempering period	8 h
Tempering temperature	540 °C
Leak test	nitrogen
Sealing pressure	20 bar
Sealing period	60 min



GRAPHIC: SCHAUFER TOOLING

Fig. 2: 3D image of a conventional insert: The cooling channels are shown in red. For mega/ giga die-casting dies, their number multiplies.

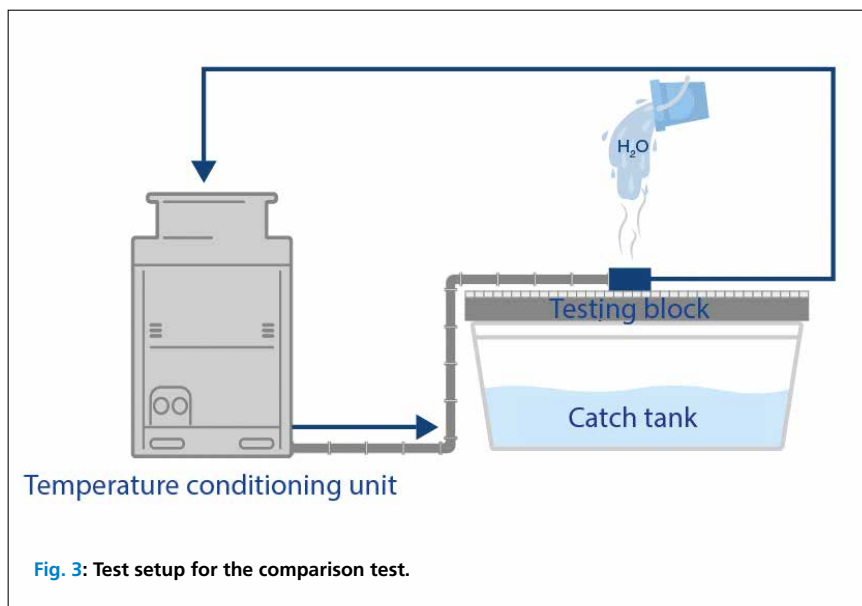


Fig. 3: Test setup for the comparison test.

is primarily caused by the free carbonic acid from softened water. We are currently trialing effective solutions for this issue”, says Heinrich. “Micro spray enables our customers to achieve significantly increased die life. At the same time, it helps to reduce cycle times and to minimize wastewater quantities”.

But even though micro spray opens new possibilities for reducing alternating thermal loads on the surface of the die, efficient heat removal should be ensured. And that can be achieved only by complex internal cooling with very strong performance. That means: even more changes of direction in the cooling channels and even more holes to be sealed.

It all comes down to sealing

“Mega and giga casting and trends like micro spray multiply the number of potential leakage points”, says Siegfried Heinrich (fig. 2). “At the same time, minimizing the risk of leaks has always been a deciding factor in our daily business, even on traditional dies”. But his company not only wanted to sell die-casting dies, but to also contribute to their customers’ ability to manufacture successfully with optimized overall equipment effectiveness (OEE). Schaufler has now implemented a new sealing solution that, according to Heinrich, “significantly improves the interplay of quality, cost efficiency, and ecological footprint”.

The solution, which is mostly replacing freeze-fit plugs and other common products, is called the b&m-KL Plug. The closing and sealing element is manufactured by baier & michels (b&m). The fastener technology specialists with headquarters in Ober-Ramstadt, Germany, are part of the Würth Group. Constantin Egold, Technical Product Manager at b&m, reports on the development: “Our aim was to create a completely new system that offers convincing performance in direct comparison with expander plugs, screw plugs, or press-fit balls”.

New design idea in a comparison test

A radical idea paved the way: The design engineers at b&m integrated the principle of a blind rivet into that of a closed blind rivet nut. The result is a single-piece, weight-optimized closing and sealing element. The right material pairing is crucial here: The component and the b&m-KL Plug must have the same linear expansion coefficients.

An analysis conducted by Schaufler was crucial for the implementation: an eight-day direct comparison between a freeze-fit plug and the b&m-KL Plug that simulated the thermal stresses during a normal casting process and tested the service life of the sealing elements. A rectangular block made of hot work tool steel (1.2343) with a hardness between 43 and 46 HRC was used as the test part. Holes with 14 mm and 18 mm diameter were drilled into the block, into which several combinations of freeze-fit plug and b&m-KL Plug were then inserted.

Schaufler subjected the test part to two load cycles per day (table 2). Step one: The unit was heated to 300 °C with a temperature conditioning unit and a heat transfer oil (fig. 3). When the temperature had been reached, an employee quenched the block with 10 l of water (approx. 20 °C) every two minutes over a one-hour period (fig. 4). After a simulated maintenance break of two hours, the block was rotated 180°, moving the sealing plugs that had been on the underside to the top, and the load cycle was restarted. The test setup was based on a previous analysis of different sealing options that were implemented by Schaufler Tooling in 2005. At that time, the freeze-fit plug had been the most practical option and had remained in use despite continued new approaches.

Positive conclusion

With a view to the current analysis, Thomas Schwegler, Head of Design Engineering at Schaufler, draws the following conclusion: "The b&m-KL Plugs offer great advantages already during drilling of the holes". This is because the hole can be out-of-round by up to 0.05 mm and the surface quality can have an Rz of up to 16 µm, both of which are easy to achieve with a pilot drill. The holes for the freeze-fit plugs, on the other hand, must not be out-of-round by more than 0.01 mm and the surface quality must not exceed an Rz of 4 µm. In addition, the personnel at Schaufler must make a customized hole for each freeze-fit plug.

"The b&m-KL Plugs", explains Schwegler, "are easy to install and adapt to the hole". Moreover, the freeze-fit plug must be cooled down to -196 °C with liquid nitrogen before installation and the workpiece has to be heated to +350 °C (fig. 5). The b&m-KL Plugs, on the other hand, can be installed quickly and easily with a rivet



Fig. 4: Miriam Groß, toolmaker in training at Schaufler Tooling, oversees the test for the comparison of the sealing plugs.

nut setting tool, without generating any waste. This makes it possible to install and remove the plugs directly at the place of use. To remove the b&m-KL Plugs, the adapter on the setting tool is changed and the plug can simply be pulled out. A slide hammer can also be used. The hole is not damaged during the process. "And the worker can then directly install a new b&m-KL Plug", adds Thomas Schwegler. "Freeze-fit plugs, however, have to be drilled or milled out, and the hole then has to be reworked and a new sealing plug has to be turned".

The conclusion from the Schaufler test: As a sealing element, b&m-KL Plug is fully equivalent to the previously used freeze-fit plug. But they are much easier to use, as a specific calculation illustrates: In the die insert mentioned above with 15 plugs, freeze-fit plugs consume 401 minutes of working time on average, whereas b&m-KL Plugs require a mere 48 to 50 minutes. "In certain applications, we still use freeze-fit plugs, though", says Thomas Schwegler. "Especially where the sealing element must be adapted to the geometry of the surface. This includes sealing faces where the aluminum comes into contact with the die". Schaufler also uses flanged plugs in some cases.

Recently, though, b&m-KL Plugs are used to seal 80 to 90 percent of all holes in the cooling systems at Schaufler. "That is because these plugs", explains Managing Director Siegfried Heinrich, "improve our process stability and that in turn is a crucial factor for our productivity."



Fig. 5: Before use, a freeze-fit plug must be cooled down to -196 °C with liquid nitrogen, while the corresponding die insert must be heated to 350 °C.

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