Dedicated to Diecasting Industry

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ALUCAST® PARTNER IN PROGRESS FOR ALUMINIUM AND DIE CASTING INDUSTRY

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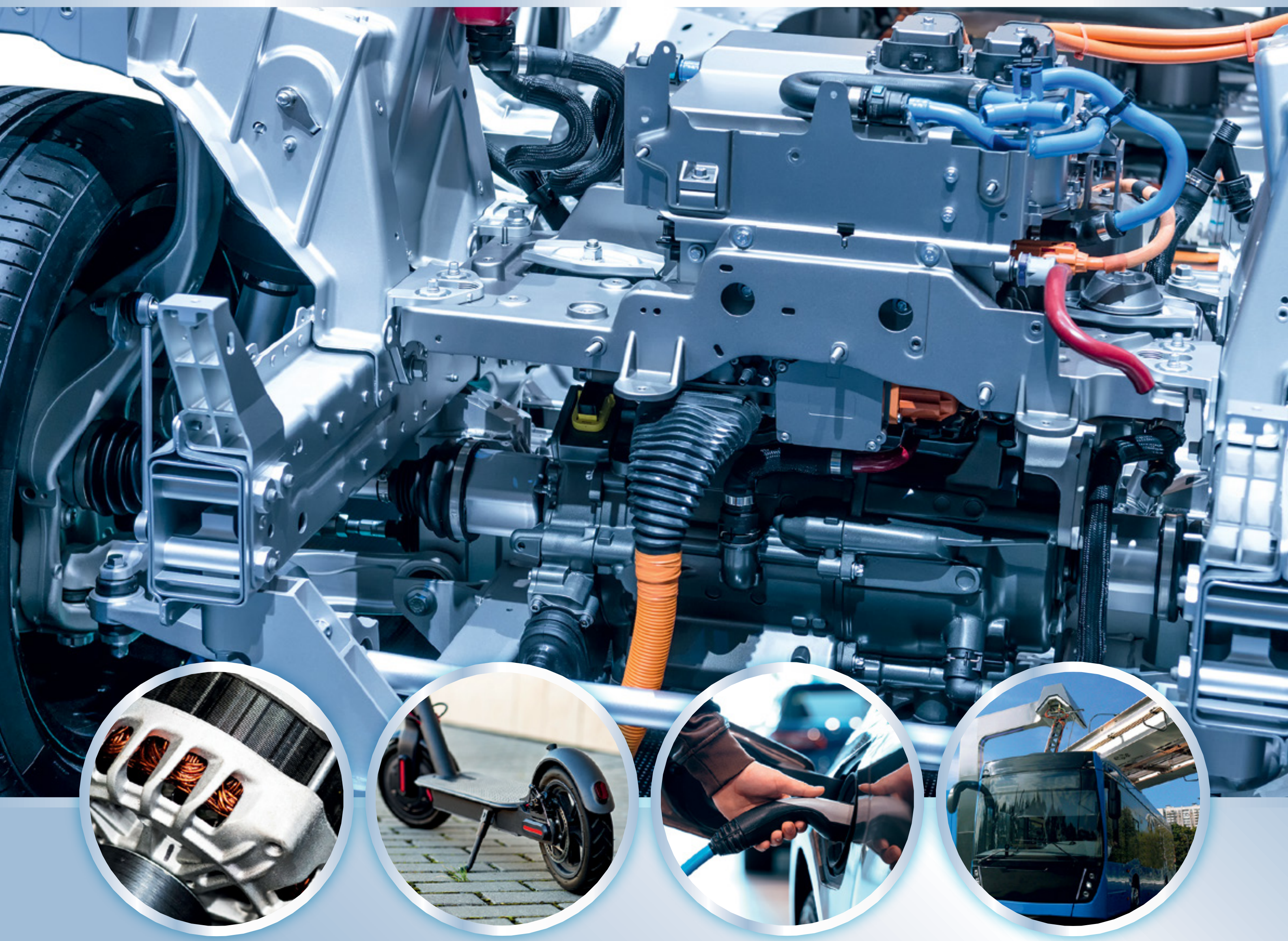
Role of Die-Casting in E-Vehicles



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Total	**68**	**142**	**60**	**270**

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ALUCAST®
PARTNER IN PROGRESS FOR ALUMINIUM AND DIE CASTING INDUSTRY

EDITORIAL

Dear Readers,

As per a recent study report by World Bank, the global economy, which has severely contracted, is expected to shrink by 5.2 per cent this year due to the massive shock of the Corona Virus pandemic and the shutdown measures to contain the spread. The COVID 19 induced recession is the first since 1870 to be triggered solely by a pandemic. Overall the per capita incomes are expected to decline by 3.6 per cent, which will tip millions of people across the world into extreme poverty this year. The poorest section of society will suffer more. Malnutrition and lack of medical care for the poor children will increase. The shock is hitting hardest in countries where the pandemic has been the most severe and where there is heavy reliance on global trade, tourism, commodity exports and external financing. Moreover, interruptions in schooling and primary healthcare access are likely to have lasting impacts on human capital development. The speed and depth with which this pandemic has struck, suggests the possibility of a sluggish recovery that may require policymakers to consider many more interventions. For many emerging markets and developing countries, however, effective financial support and mitigation measures are particularly hard to achieve because a substantial share of employment is in informal sectors. Further according to the report, economic activity among advanced economies is anticipated to shrink by 7 % in 2020 as their domestic demand and supply, trade and finance have been severely disrupted.

As I started writing this editorial, for the first time since March this year, the COVID 19 situation which was continuously worsening, has started showing minor trends of improvement. The "R0" factor or the most important disease transmitting factor has dropped below 1, which is good sign and is the only indication of slowing down the rate of spread. This does not mean that our country is safe or out of woods. We are far from attaining "Herd Immunity". It will take couple years or may be more to totally eradicate this menace. Science has yet to come up with proper medicine and vaccination against this deadly virus. Till such time, wearing a mask whenever you step out of your home, frequent hand washing and social distancing should be the obligatory norm. We need to take extra care to protect senior citizens and people ailing from other medical problems.

In the current uncertain economic environment, providing money directly into consumers' hands is likely to be inadequate as the middle class is more apt to save it for a rainy day rather than spend it. The poor and lower middle-class sections of our population are likely to spend the money on essential goods. Moreover the government is already distributing food grains free of cost to this vulnerable section of our populace. We therefore need to devise creative solutions to promote spending on non-essential goods and services, such as tax incentives for expenditure on cars, flats, white goods, travel etc. The government must continue to increase expenditure on infrastructure projects to provide stable and more employment opportunities. It is only then that our economic trajectory will resume its upward trend.

The vast majority of blue-collar industrial workers, we encounter in recent times, are longing to break free from the confines of their homes and start to collaborate with their colleagues in the same physical environment. We must find a way to safely allow this and mitigate risks through solutions like mandatory masks, working on alternating days and social distancing within the workplace. Wearing a mask is the single most effective preventive measure until a vaccine is made widely available. Working from home is a poor substitute in a fast-paced world where collaboration, personal interaction and team work are the key. Since COVID 19 is here to stay and we must learn to live with it, and not completely ignore the psychological needs and emotions of our workers. Any crisis brings opportunities for growth and change. This is an opportunity for the government to cut wasteful expenditure and costs, increase spending on much-needed infrastructure like roads, ports and airports, insure poor farmers against vagaries of weather and provide food/shelters for the 800 million poor. In doing so we must never forget the growing middle-class who help generate demand and keep our factories running. This will increase the fiscal deficit, but it can be reversed in the coming years. Government and industry leaders have their work cut out for them.

N. Ganesan
Editor

The New Normal
Post Covid Scenario and Implications – Some Pointers

- Srinivas Sastri, Chief Human Resource Officer, Sakthi Group

Shopping has always been close to my heart. In my schooling years, I always looked forward to visiting the local 'Kirana' store ('Maligai' shop as popularly known in the South of India). The thrill of standing in a queue waiting for your turn and then watching a product being weighed, packed and billed was fascinating. Over the decades the big format retail stores and the malls have taken over and provided the customer with a touch and feel experience prior to making the buying decision. Pre-packaged goods and electronic billing that was based on a single computer based key replaced time consuming methods. The new millennium ushered in e-commerce and online shopping that allowed one to shop from home.

Life came a full circle when the local 'kirana' store became our saviour during the Corona pandemic and emerged as a winner. The supply chain across states came to a grinding halt. It seemed that life had come a full circle. However what is interesting to note is that the Kirana store owner politely declined cash and encouraged the customer to transfer money through the likes of Google Pay. Could any of us ever imagined a 'kirana' store leading transformation in consumer behaviour a few years ago? Today Amazon and Reliance are developing business plans that seek to integrate the local store into their distribution and supply chain strategy.

The pandemic has and is expected to result in permanent and fare reaching changes for business and society alike. The factors that are likely to drive permanent changes to the manner in which society and business will conduct themselves, are being referred to as 'The New Normal'.

WORK FROM HOME was unthinkable less than a year ago. Though it has been very challenging for many organizations to adapt to this model, it is being reviewed as a viable option in the future. Organizations are drawing up plans to downsize the office space especially in locations with high rentals for commercial office space and gain huge savings. The office is likely to emerge as a location for strategic meetings rather than a 6 day 9am to 6pm sit down physical space. Lower commuting time and costs, higher productivity through better work life balance are possible advantages for the employee while lower infrastructure and fixed costs resulting in availability of increased capital are advantages for the organization.

INNOVATION will no longer be a 'nice' thing to do. It is going to be vital for survival. During the pandemic, we have seen several entrepreneurial ideas succeed. A simple example was the easy to use self-mop for cleaning homes in the absence of a house-help maid. Dishwashers using lesser water gained sales. Services that ensured the last mile delivery suiting the convenience of the customer have gained popularity. In Manufacturing, increasing pressure on the pace of design innovation requires companies to leverage supplier innovation as well, especially when it contributes to end customer value

TECHNOLOGY will continue to lead disruptive change. In the Manufacturing sector, migrant labour issues, social distancing norms, challenges of distribution, higher inventory holding costs etc. will influence the faster adoption of technology driven solutions especially for low end repeatable tasks. Auto sector has been among those that has led this transformation through robotics. This trend is likely to continue and make an impact in other spheres as well. In the services sector for example, credit appraisal considered a specialist skill for a long time has been replaced by technology enabled decisions in a fraction of time taken by the human. One of the leading financial services company actually clocked a record time of under 20 minutes to process a loan decision for a customer. Compare this with the times where one waited for weeks even to know the status of a loan application.

DISTRIBUTED BUSINESSES & AGGREGATED SERVICES
Moving operations to low-cost regions is an example of the many opportunities that an organization will explore to reduce total costs and to improve its ability to serve rapidly growing markets.

We will see increase in the outsourcing of strategic manufacturing design, and supply management activities to contract manufacturers and service providers. Aggregator Business Models will continue to grow. Amazon, Uber, Air BnB are all prime examples of organizations in this space.

SHIFT IN TALENT LANDSCAPE – ***What got us here will not get us there…***
The stenographer died! Microsoft Word with its auto correct feature dealt a cruel blow to this specialist role a few decades ago. Over the last decade, several such

technology driven tools and systems are replacing not just simple jobs but even roles that rely on complex decision making.

The ATM replaced the friendly neighbourhood cashier. During the pandemic, cloud computing applications have replaced the salesman. Insurance related decisions are examples that have influenced a major shift in customer engagement models. For example, we relied on a personal advisor for insurance and investment advice. That has been replaced today with internet based portals that inform, educate and allow speedy and quick decisions by the customer.

What it means is that some of the human skills we relied on are already becoming redundant as technology is providing faster, accurate and a more consistent experience for the user and the customer. Organizations will need to design roles and structures around outcomes that will increase agility and flexibility in decision support, rather than just the effort. They must encourage employees to develop critical skills that potentially open up multiple opportunities for their career development, rather than just skills training for the existing job. They must offer greater career development support to employees in critical roles who lack critical skills.

PREPARING FOR A NEW MILLENNIAL WORKFORCE

The new millennial generation youth is perhaps better ready than most of us for adapting to the future needs of the world. They have grown up in a time where social relationships, learning styles, and motivation to perform have undergone significant transformation. This generation is willing to explore newer and better ways of doing things. They rely on acquiring knowledge through real time and hands-on experience. They are comfortable in engaging with one another through virtual and digital media. They prefer to 'work with' rather than 'work for' and seek a balanced work and social life. They are not bound by rules and policies. It is therefore critical for the present day leaders to prepare a platform that will enable the next generation to learn and perform. Organizations will need to build on providing experiential learning, implement flatter organizations with minimal hierarchy and opportunities for applying multiple skills and decision making. Organizations must develop competencies essential for the future.

In summary the COVID-19 pandemic has dealt a rude shock to economies all around the world. Amidst this uncertainty, the key to revival is how people are equipped to come out of their homes, how people are equipped restart their lives and how businesses will prepare themselves to rise up to the new world challenges. Innovation, building future ready competencies and above all adapting to disruptive changes will be the new normal.

Author:

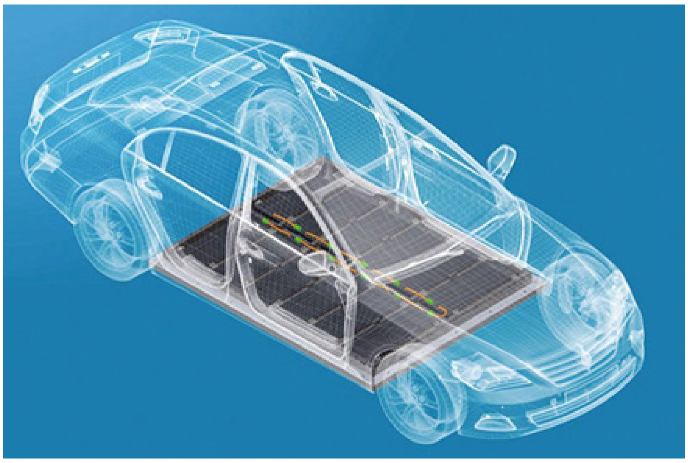
Srinivas Sastri
Chief Human Resource Officer
Sakthi Group

The use of vacuum in the pressure die casting process for producing battery housings for electric driven vehicles

- J. Emmenegger, Technical Engineer, FONDAREX SA

Introduction

Battery packs for electric vehicles (also called housings, frames or battery enclosures) have a pretty straightforward purpose: holding and protecting battery modules. They come in various shapes and sizes, and can easily be adapted for the different particularities of battery modules. Extrusion and Die-casting are commonly used in the production of aluminium alloy housing. The housing can be produced in two (base and top cover) or more pieces. The flatness and accuracy are affected to a certain extent, especially if the installation interface has sealing requirements. The more complex housings are the higher the demand to be vacuum pressure die cast. There are more possibilities with different shapes to produce. Die casting machines from 1600 t up to 4400 t are used to produce such housings. Due to size restrictions, large housings are tailor-welded to compensate if the size if too large.



Study of Kirchhoff Automotive

Application

The application of die-casting aluminium alloy in battery housing can be done with the low-pressure casting process or in the vacuum high pressure die casting. Depending to different requirements of the cars technology, it can integrate the cooling function in the body, omitting the individual cooling plate. This direction may be one of the trends in the future.

The battery housing is a so called lightweight body structure. This is one of the directions of efforts. Especially for battery packs of pure electric vehicles, the pursuit of high mileage on the premise of the current lithium ion battery level of development will inevitably require that the overall weight of the battery case will be reduced as much as possible while ensuring the high structural strength.

The weight of the battery pack can be reduced about 10 to 28% by using adapted aluminium casting alloy instead of using steel. At the end it will reduce the overall weight of the battery pack to some extent as well the final car weight.

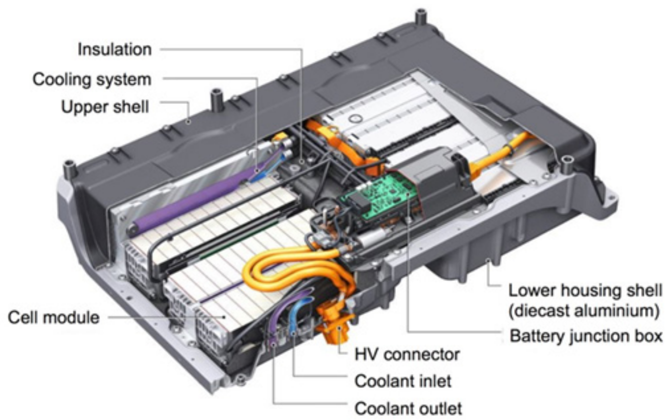


Illustration: Battery pack Renault

To get the right application on each part built into or a round a battery housing, the manufacturer must take in consideration:

- Mechanical shock and integrity
- Battery robustness for vibration
- Thermal shock and cycling
- Fire resistance
- External short-circuit protection
- Over temperature protection
- Overcharge and over discharge protection
- Different Norms as: UL 2580 Batteries for Use In Electric Vehicles, UL 2271 Batteries for Use In Light Electric Vehicle (LEV) Applications, ISO 26262 Road vehicles, UN ECE R100 and UN ECE R136 for European market access

To finally be able to high pressure die cast such parts an alloy with high casting ability, optimized for high thermal or electrical conductivity must be used. A casting treatment which gives highest conductivity compared with other AlSi-die casting alloys. Also the elongation can be important and it should be flangeable and corrosion resistance to weather. As an example the Castasil 21 is one of those alloys.

Since in pressure die casting the alloy is getting mixed with air in different steps of the process, the producer must do everything to avoid oxidation and air and gas inclusions into the micro structure of the component.

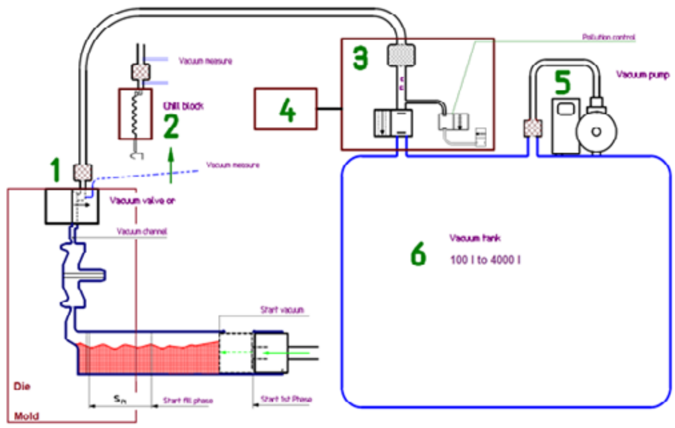
This is the reason why vacuum is used during the injection cycle (slow and filling phase).

Vacuum die casting or vacuum assist die casting can be described as a high quality casting method. Vacuum die casted alloys show a better micro structure, higher mechanical properties, better surface finish and higher overall product quality and stability. Further all after process works (machining, thermal treatments, and surface coatings) will show better results.

To make the vacuum technology use up to its best benefits following points in the high pressure die casting productions have to be adapted as well:

The overall application of the die, the precision of the die, the thermo-control of the die and the alloy, the overall metal handling, the process control and parameter settings, the die and plunger lubrication, the plunger and shot sleeve precision as well the vacuum connections and parameters are about the most important ones.

Function of the vacuum system in pressure die casting:



The basic vacuum pressure die casting system

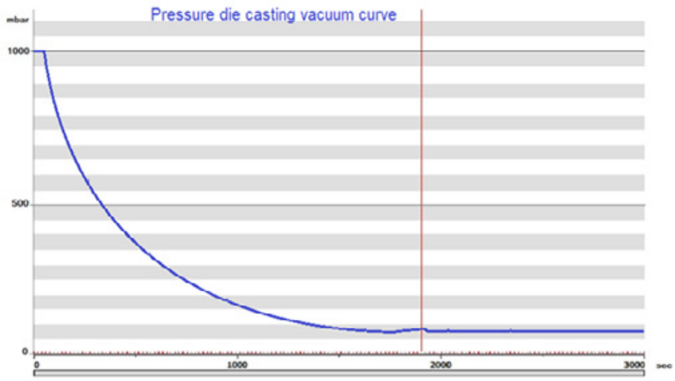
1. Vacuum valve in the die
2. Chillbloc in the die (either one needed)
3. Vacuum pneumatics
4. Vacuum automation
5. Vacuum pumps
6. Vacuum tank

When the plunger overtakes the pore hole, the vacuum is started. The air in the die (1) will flow into the vacuum tank (6). The vacuum level should drop within 0,3 to 0,8 sec below 150 mbar inside the cavity.

The part (battery housing) is connected by a vacuum channel to the vacuum valve (1) or the chill vent (2) If the engineering is well done, less overflow material is casted and therefore a more economical casting process is established.

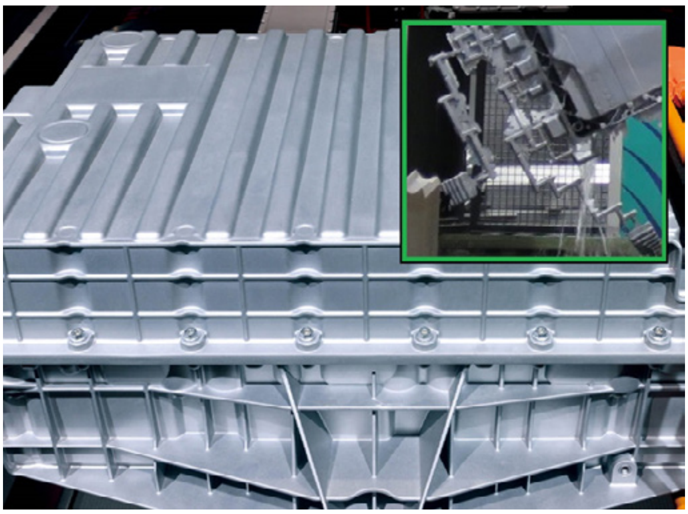
The vacuum built up is controlled in the vacuum unit by measuring the vacuum pressure during the whole injection:

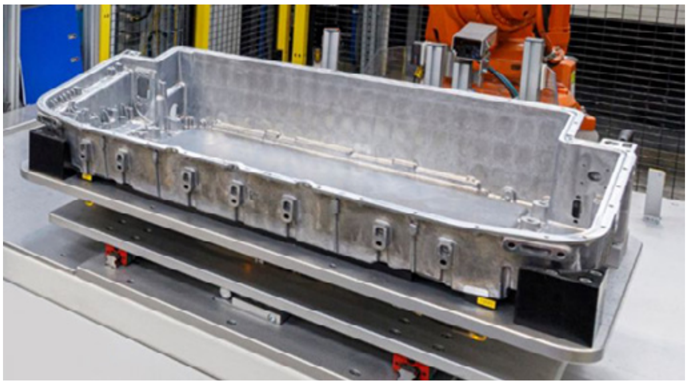
The vacuum curve looks like this:



The level is controlled if in tolerance during the injection of the liquid alloy. This will be an overall factor to make sure only good housings will go into after machining and the manufacturing process.

Below two pictures of housings produced for the European OMS:





Conclusion:

Producing battery housings in pressure die casting is a challenge. The die caster must be prepared to use latest technologies, perfect metal handling precise dies and a good process control. There are still a lot of researches done in the field of producing battery cells, the future will show of how many different types will be found in the electrical vehicles industry.

https://cleantechnica.com/2020/01/02/the-volkswagen-id-3s-battery/

https://aluminiuminsider.com/aluminium-extrusions-are-winning-the-race-for-battery-enclosure-in-evs/

Author:

J. Emmenegger

Technical Engineer

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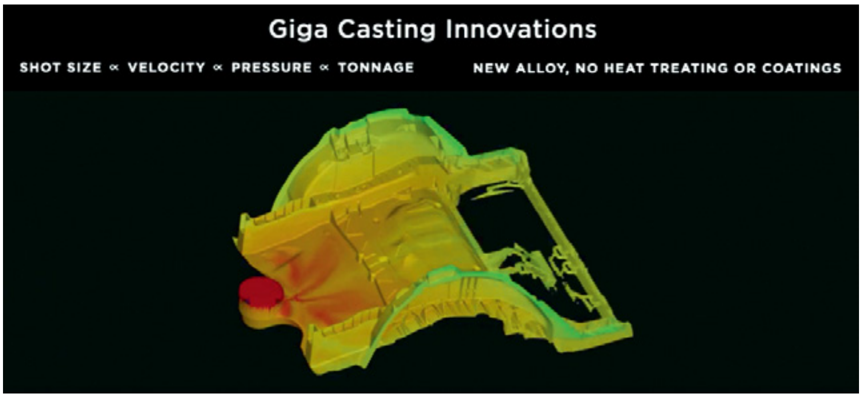
Tesla outlines new casting and battery architecture, future of EV designs

- Joey Klender

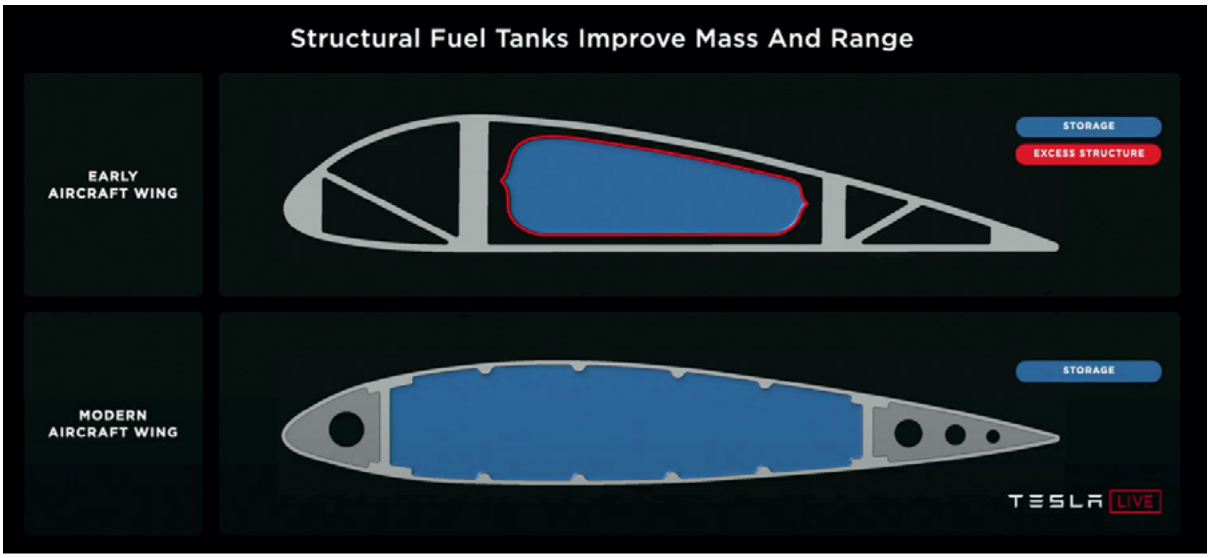
Tesla's Battery Day detailed a variety of topics that are related to the future of cell manufacturing efficiency. However, the presentation also showed how the automaker is improving the design of its vehicles by utilizing a new battery architecture. Tesla plans to adopt the same strategy within its vehicles to improve mass, range, and the structural integrity of its vehicles.

Teslarati reported earlier this year that Tesla would be using a single-piece casting design on the Model Y. The improved casting eliminates 79 parts per car, which not only increases manufacturing efficiency but also increases safety for drivers. The cost of each vehicle's rear underbody design also decreases by 40% thanks to the casting, which is performed by a massive machine known as the Giga Press.

The single-piece rear casting is made from Tesla's own high-pressure aluminum alloy that has a high strength thanks to no heat treatment or coatings that would take away from the structural integrity of the design. Heat treating a casting of this size after manufacturing causes deformation, CEO Elon Musk said during the event.

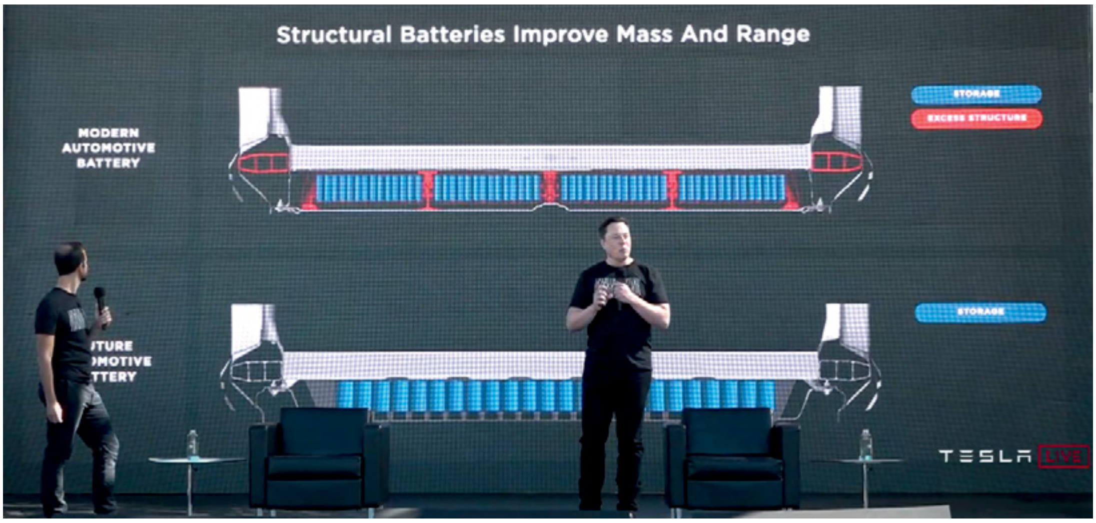


However, the manufacturing team at Tesla also drew inspiration from aircraft wings to improve the structural integrity of its vehicles. While the casting improves manufacturing efficiency and strength, the positioning of structural batteries eliminates excess structure from the battery packs, increasing density.



“The non-cell portion of the battery has negative mass,” Musk said. “We saved more mass in the rest of the vehicle than in the non-cell portion of the battery. So how do you really minimize the mass of the battery? Make it negative.”

The minimization of negative mass allowed the automaker to increase the density of the battery pack. Individual cells could be positioned more efficiently because excessive structures within the pack itself were eradicated. The new Tesla battery design is completely free of any negative mass, which improves pack density along with structural integrity.



“The pack itself is structural,” Musk stated.

Additionally, the filler within the Model 3 and Model Y packs, which currently uses a flame retardant, now uses a structural adhesive and flame retardant. This adhesive effectively attaches the cells to the top and bottom sheets of the pack. “This allows you to do sheer transfer between the upper and lower sheet,” which increases stiffness and prevents major deformation in the event of a crash.

Improvements in the casting design of Tesla’s future cars and the newly designed battery architecture, which uses new materials and strategies to increase stiffness, will increase the already safe vehicles that the company manufactures. Tesla already holds three separate five-star crash safety ratings with the Model S, Model 3, and Model X. The Model Y has not yet been tested, but the vehicle does use the one-piece rear casting design already at the Fremont production facility.

Tesla’s Battery Day did not disappoint. While the blueprint to cell manufacturing efficiency was laid out, the company also showed how battery layout and architecture could increase Tesla’s vehicle safety. The new design revolutionizes EVs as a whole and will eventually lead to more safety than previously displayed.

Source: https://www.teslarati.com/tesla-casting-battery-architecture-ev-designs/

(with special thanks to the author for permitting us to print the article)

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Issue	Theme
December 2020	**ALUCAST 2020 Special**

WEBINAR DETAILS : SEPTEMBER 2020

Following are the details of Webinar conducted by ALUCAST in the month of September :

ALUCAST in coordination with Vijayesh Instruments

Topic: CQI 27

Speaker: Vishwas Kale, Managing Director, Vijayesh Instruments Pvt. Ltd., Pune

Program Date: Wednesday 9th September 2020 Time: 3:00 pm

Participants attended: 10

ALUCAST

Topic: Heat treatment of Aluminium Alloy Castings

Speaker: N. Ganeshan, Trustee, ALUCAST

Program Date: Tuesday 15th September 2020

Time: 3:00 pm

Participants attended: 100

ALUCAST in coordination with Vijayesh Instruments

Topic: CQI 9

Speaker: Vishwas Kale, Managing Director, Vijayesh Instruments Pvt. Ltd., Pune

Program Date: Friday, 18th September 2020

Time: 3:00 pm

Participants attended: 10

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Send details to Rushikesh Bhange – rushikesh.bhange@alucast.co.in

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Mr. Amit Pal
Committee Member
ALUCAST (Delhi Centre)

Reduction of Oxide Inclusions in Aluminum Cylinder Heads through Autonomous Designs of Experiments

- Lubos Pavlak and Jörg C. Sturm, MAGMA GmbH, Aachen, Germany

Abstract

Oxide inclusions, which are created during the pouring process of aluminum alloys, are the main cause of leaks in castings. This contribution shows how the integration of autonomous design of experiments (DOEs) into the casting process simulation tool MAGMASOFT® *provides the basis for the evaluation and subsequent optimization of process parameters in the melt transport and pouring process, which are responsible for the creation and distribution of oxide inclusions. At the same time, quality criteria describing the creation of oxides during the casting process of cylinder heads was evaluated quantitatively. The utilization of autonomous DOEs creates variations of the gating system and process parameters autonomously. It will be shown that autonomous DOEs are leading to optimized gating designs and process parameters resulting in a significant reduction of oxides in castings. The experiments supported by simulation were accompanied and validated by high-speed video technology and the PREFIL-measurement technology.*

Keywords: aluminum casting, cylinder head, oxide inclusions, Design of Experiments, virtual experimentation, autonomous optimization, gating system

Introduction

Oxide inclusions, which are created during the pouring process of aluminum alloys, are deemed the main cause of leaks in thin-walled aluminum castings like cylinder aluminum melts, is not dissolved or re-melted due to its high melting temperature and remains in its solid state inside the casting. Any pouring process leads to turbulence at the melt surface. This leads to a break-up of the oxide skin, which then is entrained into the melt. Oxide skins lead to a material separation within the microstructure, which, depending on their size, can cause a reduction in local mechanical properties, or, especially in thin casting walls, they can cause leaks.

The damaging effects of oxides on the quality of castings can in the real world only be evaluated through experiments, i. e. leak tests on castings, after castings have been produced. The location of oxides, their distribution and the leaks they cause, are difficult to predict and are almost impossible to quantify. Literature1,2 describes potential causes and mechanisms that create oxides during the melting and pouring processes of aluminum alloys. However, the qualitative and quantitative evaluation of each root cause for the creation of oxides in each step of the production process of cylinder heads has so far not been comprehensively evaluated.

An efficient evaluation of the many different impact factors of the mold filling process on the quality of a cylinder head is only feasible through the utilization of casting process simulation. The simulation of flow phenomena and the mold filling process is an accepted standard procedure in the industry. Different simulation methods have been proposed in the last few years to describe the creation and transport of oxides during the mold filling process3-7, however, many of these models are only available as 2-dimensional models. Due to their complexity and the computing demands, they are not applicable to the specific conditions of aluminum alloys and are almost useless in foundries due to their extremely long calculation times.

The current version of the simulation software MAGMASOFT® offers an easy to use, meaningful, and quantifying option to evaluate the potential of oxide creation during the mold filling process of complex castings. The complete integration of autonomous DOEs by enabling autonomous optimization technology leads to the development of optimized gating systems and process parameters in a very short time frame, which can even be utilized early in the design process of a casting.

Experimental Melt Quality Evaluation

The melt quality was experimentally evaluated for different process steps. The PREFIL system used for this evaluation is based on the filtration of a liquid aluminum sample, which is passed through a ceramic filter under controlled conditions. The qualitative evaluation is performed on samples, which are extracted near the filter. The number, thickness, and length of oxide particles were evaluated using metallographic methods (Figure 1).

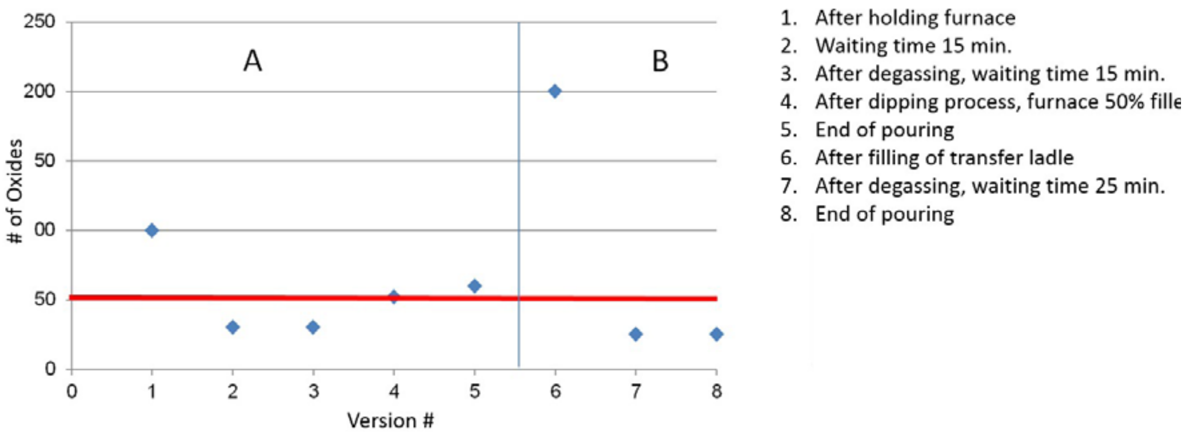


Figure 1. Measured number of oxides in the melt (PREFIL-method) for different process steps in two cylinder head production lines A and B: The red line marks the limit of 50 oxide skins per kg of melt.

Samples #1 through #5 have been taken from a cylinder head production line (A) with its melt being composed of 84% virgin alloy and 16% re-melt. Samples #6 through #8 are from a second production line (B) composed of 45% virgin material and 55% re-melt.

The number of oxide skins found in samples #1 and #6 significantly exceeds the established limit of 50 oxide skins per kg of melt and is, therefore, not acceptable. Melt transfer processes between the furnaces cause these extremely high values, especially when the transport ladle is emptied. The amount of oxide skins inside the furnace (sample #5) is still a little above the critical limit at the end of the pouring process. The oxide skin content of the melt can be reduced after the transfer processes though the establishment of sufficient holding times before or after the degassing treatment. A significant reduction in oxide skins is shown with the implementation of such (samples #2, #3, and #7). The results confirm that it is desirable to utilize a turbulence reducing transfer method, especially when emptying a ladle.

Experimental Evaluation of Flow Phenomena

High-speed video technology, providing up to 1,000 images per second, was used for the qualitative evaluation of flow phenomena during the different process steps (Figure 2).

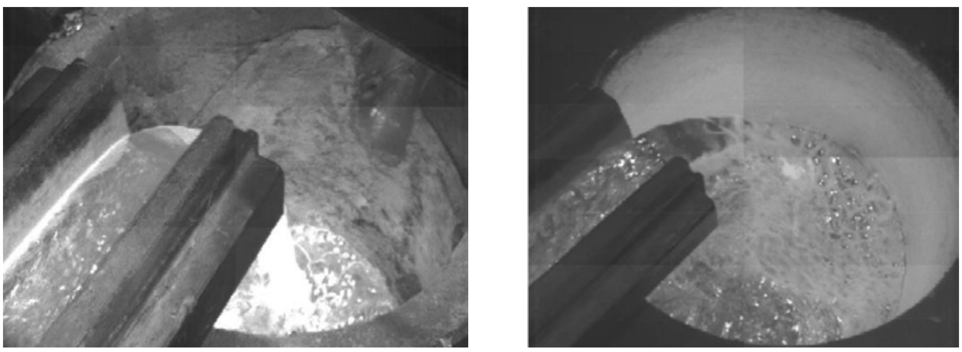


Figure 2. Evaluation of transfer processes with high-speed videos: Filling of transfer ladle (top), filling of holding furnace (center), filling of pouring ladle (bottom)

Transporting the melt from the melting furnace to the holding furnace happens via an extended pouring spout when both are in close proximity, or a transfer ladle when a bigger distance needs to be covered. After the melt treatments, the melt will be transferred into the mold via a pouring ladle. With each transfer, turbulences are created on the melt surface. This is a main cause for the creation of new oxides within the melt.

The videos show the mixing of the oxide foam swimming on the melt surface with the falling melt stream clearly visible. The observations from the transfer processes match the results of the PREFIL-measurements. All samples derived from the spout or the transfer ladle after filling of the holding furnace show values in excess of the critical limit (see also Figure 1). After the melt treatment inside the pouring furnace (degassing and holding), the number of oxide skins found in the melt is reduced.

The filling of a cylinder head creates a complex flow process. Turbulences caused by the free-falling melt in the gating system and when exiting from the gating system into the mold cavity cannot be completely eliminated, but can be reduced. The melt then flows through the different cores. Controlling the flow and reducing turbulence in the complex cavities of a cylinder head with wall-thicknesses of 4 mm requires a lot of experience and a fundamental understanding of flow phenomena.

During the design of runners and the location of gates between the runner and the casting, it is essential to consider melt velocities and to establish laminar flow conditions to avoid undesired flow phenomena when filling the cores. A non-optimal flow direction during the mold filling might lead to a local premature solidification on a core's surface. This leads to an oxide skin, which will be entrapped during the subsequent filling process and will remain in the casting (Figure 3). The intricate inside contour of the mold and the thin walls of the cylinder head increase the risk of oxide inclusion defects and resulting leaks, as trial runs with gravity cast cylinder heads confirmed (Figure 4).

Figure 3. Change in flow direction during the mold filling process of a cylinder head: The cover core was modified to allow high-speed videos of the melt flowing from the runner through the gates to be taken.

(a) Cut through leaking cylinder head (b) Fracture analysis through leaker (c) Microstructure analysis

Figure 4. Root-cause analysis on a leaking cylinder head: Leak tests under water indicate two leakers through rising bubbles (a). The fracture analysis shows an oxide skin spanning the entire thin wall (b). The microstructure analysis confirms the cause for the leaker (c).

Quantitative Analysis of Oxide Creation and Optimization Opportunities through the Utilization of Casting Process Simulation

Casting process simulation provides the quantitative impact evaluation of process parameters on the creation of air entrapment and oxides for the entire casting process – from melting all the way through to pouring the casting.

Several quality criteria are used to evaluate the total amount of entrapped air and resulting creation of oxides:

1. The amount of entrained air during the mold filling process

2. The accumulated free melt surface over the entire filling process

3. The amount of time the melt is exposed to air throughout the filling process (criteria 2 and 3 are indicators for the tendency to create oxides)

4. A criteria function depicting the locations where air is entrained during the mold filling process

5. Virtual particles in the melt (tracers), which are also reviewed to evaluate the flow during the mold filling process. These particles can also experience buoyancy and float or sink depending on their assigned mass.

Figure 5 shows examples of such quality criteria: the simulated entrainment of oxides through tracers, the calculated amount of entrapped air during the filling of the pouring ladle, and the velocity distribution inside the melt during the filling of the cylinder head. It is essential for all calculated quality criteria that they provide quantitative results. With that, the impact of changes in the gating system or process parameters (design parameters) can be evaluated and autonomously optimized through objectives defined in the casting process optimization program.

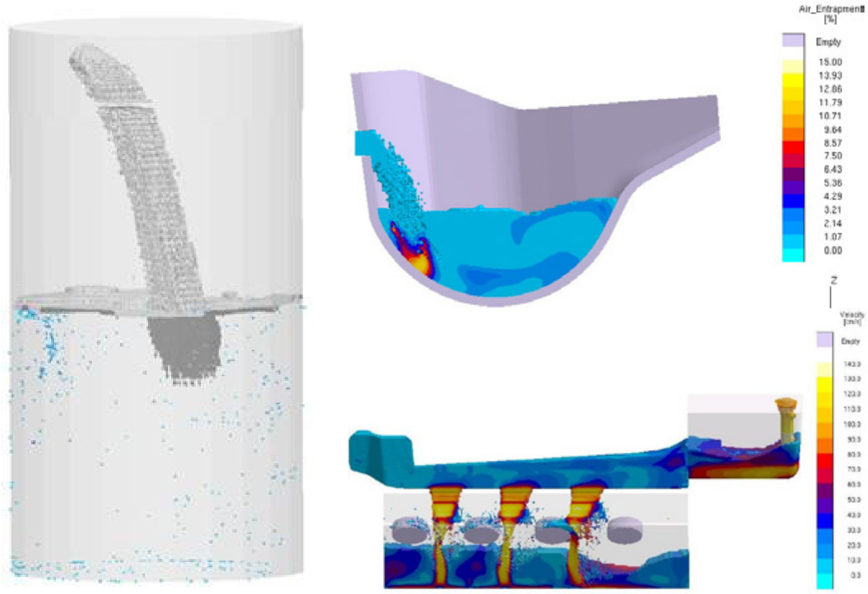
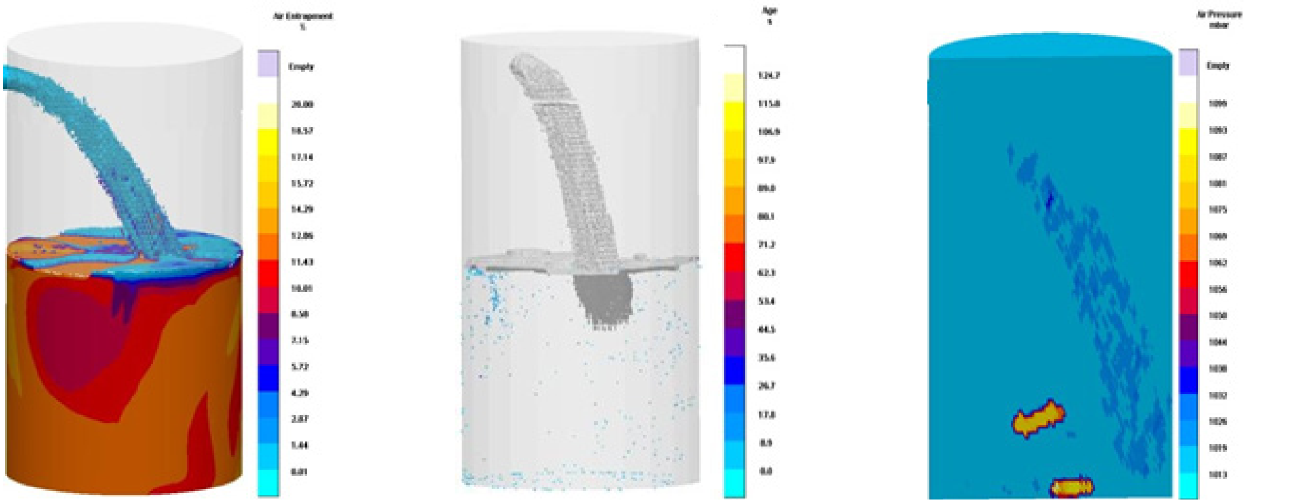


Figure 5. Examples of quality criteria of a casting process simulation tool, used for the evaluation of oxide creation tendency, oxide entrainment (left), entrapped air (upper right) and flow velocities (lower right).

The first casting process simulation evaluated the transfer process from a melting furnace to a holding furnace. The dimensions of the holding furnace are 60 cm (1,969 ft.) for the diameter and 150 cm (4,921 ft.) for its height. The total fill time is 60 s.



a) Air inclusions b) Free melt surface and oxide particles c) Location of air entrainment

Figure 6. Transfer of melt from melting to holding furnace. Criteria were calculated after 30 s filling time. Simulated air inclusion distribution during filling (a), display of free melt surface including the entrainment of oxide particles (b), amount of entrapped air shown in center cut through holding furnace (c).

The simulation results show how air is entrained in the melt, when the aluminum stream dives into the melt inside the holding furnace (Figure 6a). This process, as well as the movement of the entrained air inside the melt that is affected by its buoyancy and convectional forces, are causes for the entrainment of oxides into the melt (Figure 6 (c)).

The amount of oxide inclusions inside the melt at the end of the holding furnace filling derived from the simulation results, confirms that a large pouring height leads to the entrainment of oxides, which are created on the melt surface through the metal stream. Therefore, it is essential to establish transfer processes that minimize the entrainment of air and the creation of oxides. It is also advisable to place the casting's pouring location as close as possible to the holding furnace, so the use of transfer ladles can be eliminated.

Simulation and Optimization of the Pouring Ladle Filling Process

The video analysis of the filling process of a pouring ladle detected high surface turbulences. Thereby, the pouring ladle is dipped horizontally 2 cm below the melt surface and filled via a thin rectangular opening. The goal of the autonomous DOE is to establish process conditions that lead to a smooth filling of the ladle. At the beginning of the dipping process, the ladle is tilted backward at a specific angle, prohibiting the melt from falling freely out of the opening and allows it to flow smoothly over the contour of the ladle. Later in the process, the pouring ladle is tilted back to the original horizontal position.

The autonomous DOE is supposed to find the best initial tilting angle and the optimal point in time and speed of rotating it back to the horizontal position. The start angle and the total filling time were defined as process variables (start angle can vary between 0° and 50° in 10° steps, the total filling time can vary between 5.1s and 6.9s in steps of 0.9 s (figure 7).

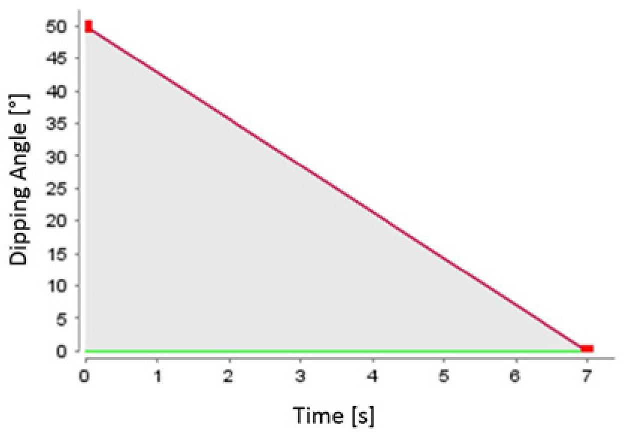


Figure 8. Quality criteria "free surface" as function of the start angle of the pouring ladle

This leads to six (6) different start angles and three (3) available filling times resulting in 18 process versions. The automatic evaluation of all 18 calculated versions is based on the previously defined goals. The optimization program used the free melt surface as quality criteria to evaluate the smoothness of the filling process. The goal, therefore, is to minimize the accumulated free surface during the filling process of the pouring ladle.

The correlation between process versions and desired goals can be evaluated in different ways by the software. One meaningful approach is the utilization of scatter charts for all results. These display correlations between changes in process parameters and their impact on different quality criteria for all calculated versions. In addition, it is possible to display the significance of each process variable on each quality criteria.

In Figures 8 and 9, each point in the diagraph represents one calculated version. The results show that the start angle of the pouring ladle has a large impact on the quality criteria "free surface". The larger the tilt angle at the beginning of the filling process, the lower is the value of this criterion, meaning the less turbulent is the filling.

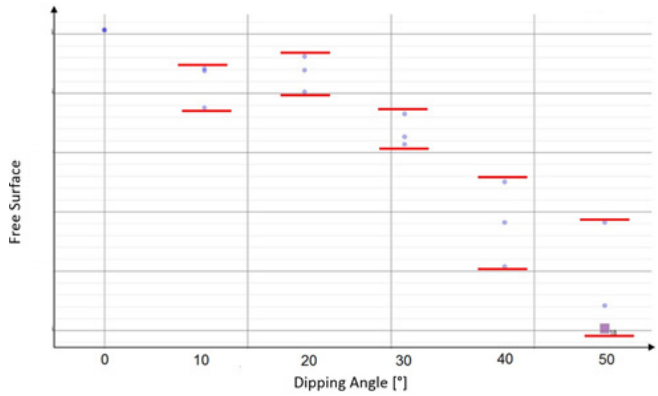


Figure 8. Quality criteria "free surface" as function of the start angle of the pouring ladle

However, the results also reflect that the total filling time has a negligible impact on the accumulated free melt surface (Figure 9). The best combination is a start tilt angle of 50 degrees and a filling time of 6.9 s (purple squares in Figure 8 and 9 lower right).

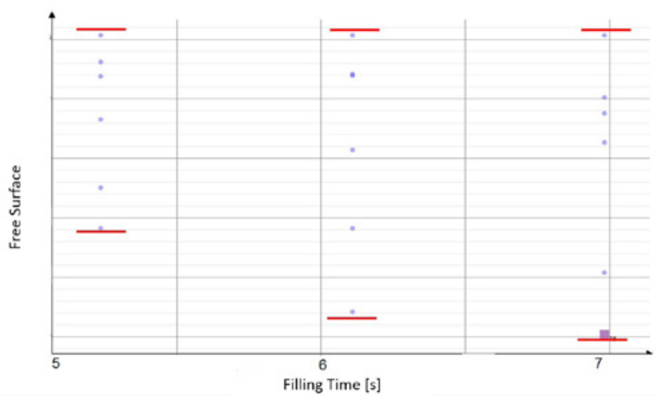


Figure 9. Quality criteria "free surface" as function of the filling time of the pouring ladle

Figure 10 shows the development of the “free surface“ over the entire filling process for the initial and the optimized versions. The best version reaches the maximum value for the free melt surface after about 1 s. At that point in time, the melt has filled the entire diameter of the pouring ladle. After that, the free surface remains approximately the same, which is an indicator for a smooth filling. In the initial version, the maximum value for the free surface was reached after 1.5 s, but was three times bigger than the one established in the optimized version.

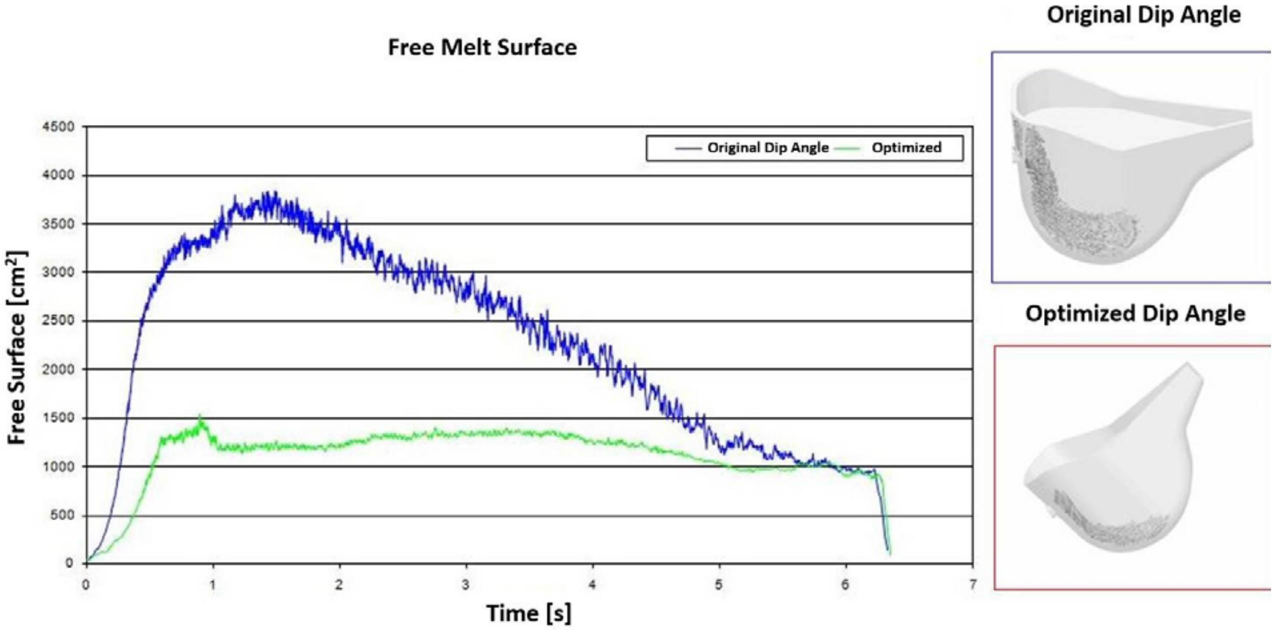
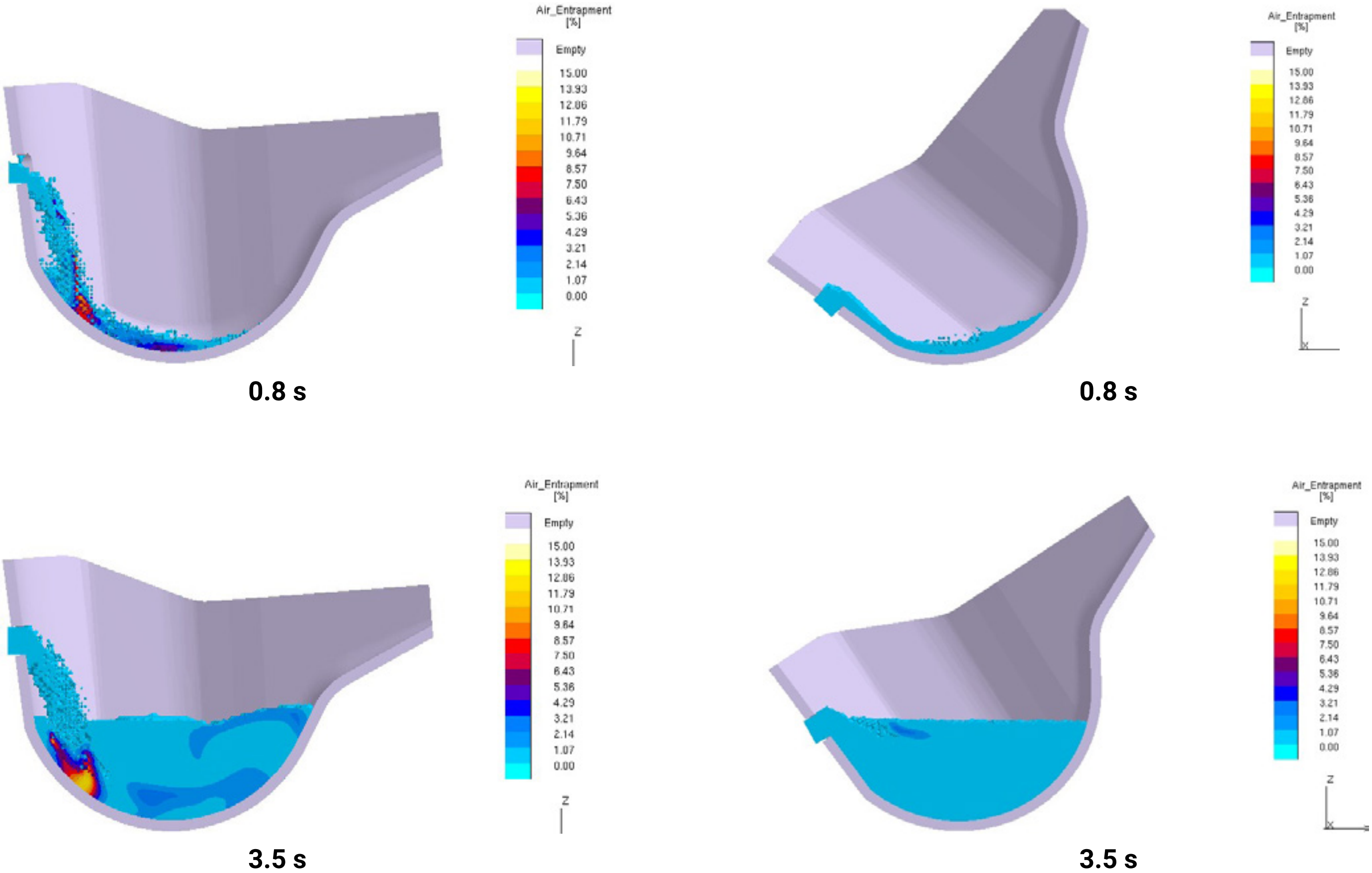


Figure 10. Calculated development of “free melt surface” over the entire filling process

The significantly higher values for the free surface are caused by turbulence inside the melt. The melt reaches velocities above 70 cm/s (2,297 ft/s) at the bottom of the pouring ladle after exiting the opening. The melt stream continuously entrains air and oxides (Figure 11). The optimized version shows no such air entrainment.



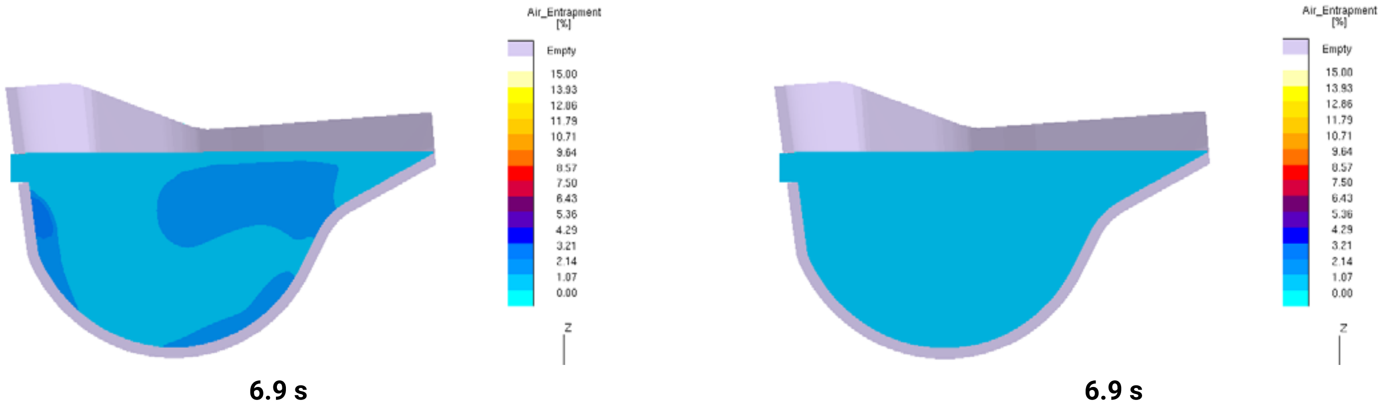


Figure 11. Air entrapment during filling process of pouring ladle comparing the initial process (left) and optimized version (right) (cut through center of pouring ladle)

The criteria "air contact" refers to the time, each melt particle is in contact with air, and is an important indicator of the amount of oxides created. In the initial version, almost the entire melt volume is exposed to air for a longer period of time (Figure 12) compared to the optimized version, where a stable melt surface is established much faster.

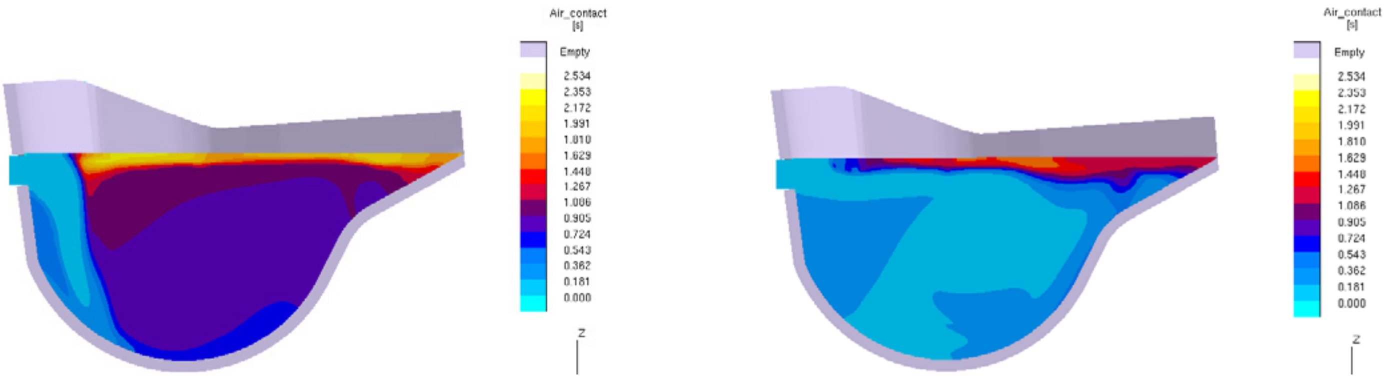


Figure 12. Comparison of air exposure between stationary filling (left) and optimized, tilted filling (right) (cut through center of pouring ladle)

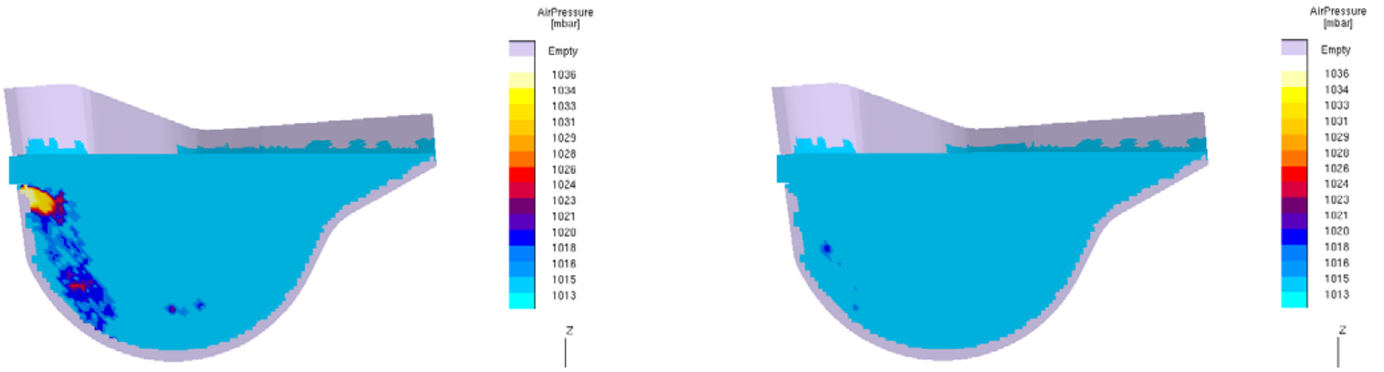


Figure 13. Comparison of location where air is entrapped during stationary filling (left) and optimized tilted filling (right) (cut through center of pouring ladle): The initial version entrained air mostly during the initial free fall of the melt out of its opening into the pouring ladle.

The simulation results show that the entrapped air bubbles are moving towards the surface of the melt due to their buoyancy and melt turbulence. They are leaving a trail of oxides along the way. As the melt enters the gating system and the mold cavity straight from the pouring ladle, all oxides existing at that time will enter the casting with detrimental impact on its quality.

Gating system optimization for cylinder heads

Leaks caused by oxide inclusions were the main source of defects for the evaluated cylinder head. The analysis of the mold filling process through high- speed videos and the simulation of the mold filling process of the original geometry demonstrated the potential for its optimization. Melt quality and how the mold is filled, both, have a direct impact on the amount and distribution of oxide inclusions in the casting. The original gating system created the following main contributors to the creation of oxides:

- Immense melt turbulence in the pouring basin
- High melt velocity in the main runner
- Less than optimal flow direction of the melt when entering the mold cavity through the gates

An autonomous DOE was used to evaluate and quantify the impact of several geometric modifications of the gating system and process parameters on the creation of oxides, as well as the entrainment of already existing oxides into the casting and their distribution.

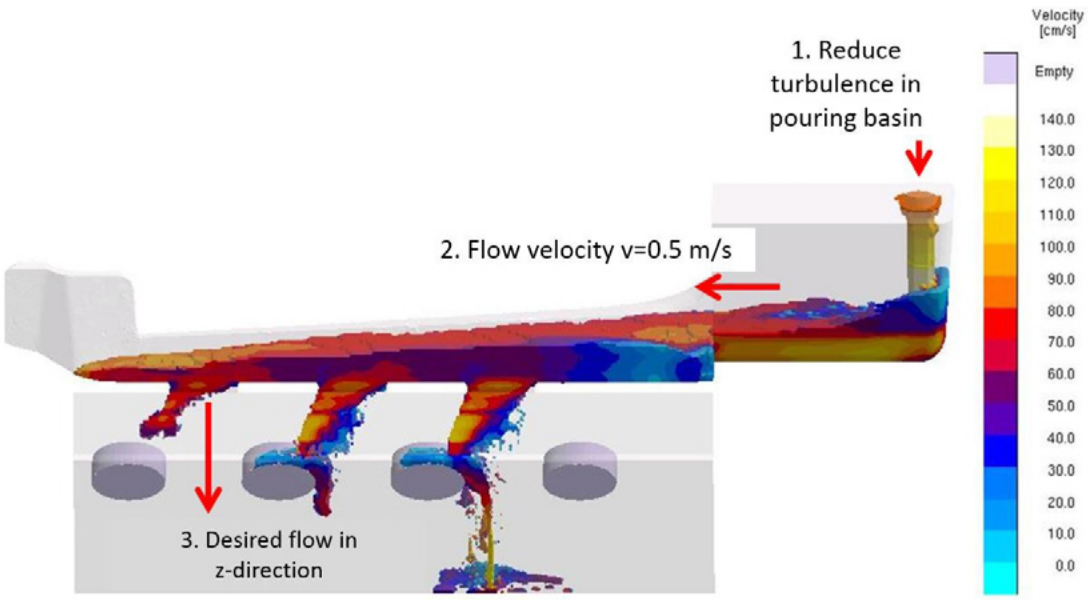


Figure 14. Schematic display of optimization goals of the autonomous DOE

The first goal for the autonomous DOE was it to find an optimized layout of the gating system that will minimize the turbulence (and oxide creation) in the pouring basin. The pouring height and orientation of the melt stream was varied (hitting the rear pouring basin wall versus the pouring basin's bottom) to reduce the originally observed back wave of the melt collapsing on itself when hitting the pouring basin walls (Figure 14 (1.)).

The second goal was to reduce the velocity of the melt when leaving the pouring basin and entering the runner. Besides using runners which were directly connected to the pouring basin, a deviation basin was evaluated. Several alternatives for the transition between the pouring basin into the runner (rising or stepped versus flat) were expected to support the desired velocity reduction (Figure 14 (2.)).

The third goal was to realize a constant vertical flow from the gates towards the water jacket cavity inside the cylinder head. This was supposed to reduce or even eliminate premature solidification of the melt on the channel cores. Elongated gates and additional flow aids below them were the variables of this optimization aspect (Figure 14 (3.)).

The optimization runs in MAGMASOFT® used a parameterized geometry of the original gating system. The complex cylinder head geometry was substituted for efficiency reasons by a simplified geometry. The wall thicknesses and angle of the wall below the gates, as well as the position of the channel cores, exactly matched the configuration of the real cylinder head.

Adding up geometric variations as central or back-wall filling of the pouring basin, flat or rising transition from pouring basin to runner, short or long gates, and present or non-present filling aids lead to 16 to be calculated versions (Figure 15).

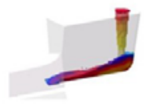
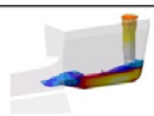
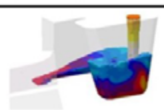
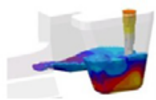
Pouring basin with flat/stepped transition		Version	Gate Height	Flow Aid
1		A	6 mm	none
2		B	16 mm	none
3		C	6 mm	6 mm thick
4		D	16 mm	6 mm thick

Figure 15. Trial plan and nomenclature for the 16 evaluated variations

The following functions for the evaluation of all simulation results were defined:

1. Minimize the maximum melt velocity in control point C1 in the transition between the pouring basin and the runner
2. Minimize the melt volume through gates A1, A2, and A3 with undesired flow direction (deviation from z-direction) (figure 16)
3. Reduce the accumulated “free surface“ of the melt during the mold filling process

The autonomous DOE was performed in MAGMASOFT®, including the generation of the geometry variations, their enmeshment, the calculation and evaluation of quality criteria and functions assessing all simulations.

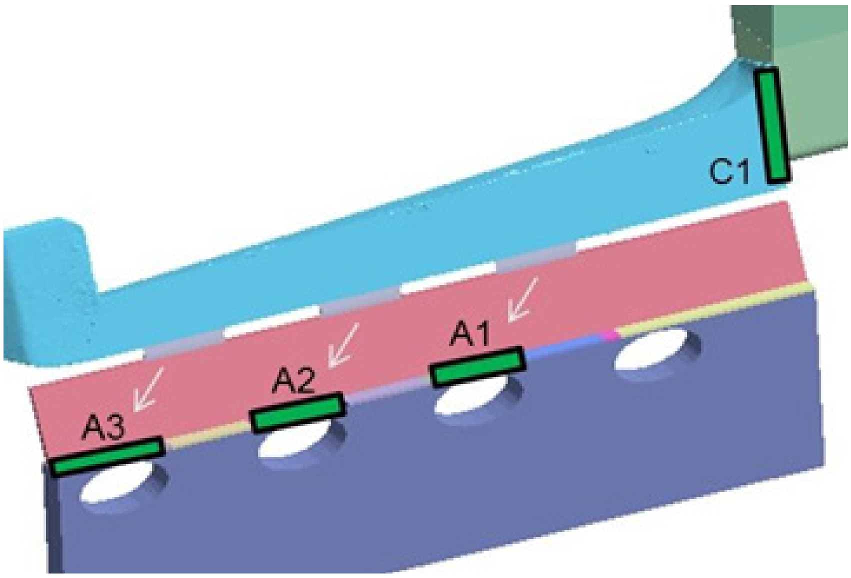


Figure 16. Definition of evaluation areas A1, A2, A3 for the evaluation of the deviation of the melt flow from the desired z-direction and the location of control point C1 for the melt velocity evaluation

Optimization Evaluation

Velocity Reduction in the Runner

The melt front velocity of aluminum alloys is not to exceed 50 cm/s, to avoid instabilities and surface turbulence at the melt front1 which lead to an increase of the free surface area of the melt, which results in oxides inclusions. The velocity reduction can also support the creation of the desired vertical melt flow direction exiting the gates.

The evaluation shows a clear dependency of the melt velocity at the control point on the evaluated design and process variables (Figure 17). Versions 4A through 4D are the best, as they are showing velocity values very close to the goal of being below 50 cm/s, which is a reduction of 50% compared to the starting configuration (A1 with 105.7 cm/s).

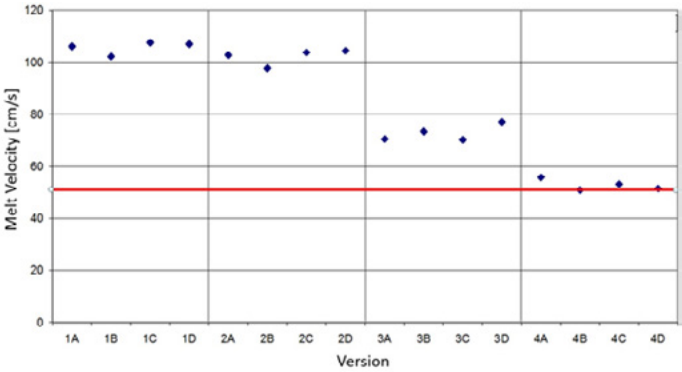


Figure 17. Average melt velocity at transition between pouring basin to runner (control point C1) for all evaluated designs: The red line depicts the desired critical value of 50 cm/s melt velocity.

Controlling the melt flow direction out of the gates

The second goal was to establish a vertical flow of the melt out of the gates into the casting without hitting any of the cores. The melt not flowing in the desired z-direction is shown for all versions in Figure 18. It is clearly shown that the melt flow direction in gate A1 deviates from the desired z-direction the most of all versions. This is caused by the pressures and kinetic energy values, which decrease from gate to gate. The evaluation also shows that for all "D-versions", meaning independent from the pouring basin geometry and its connection to the runner, show the least melt volume deviating from the desired flow direction. Version 4D is the best, as only 52 cm3 melt from all three gates is deviating from the desired flow direction. A closer evaluation of the simulation results of that version also shows that the melt is only barely touching the channel core sides (Figure 19).

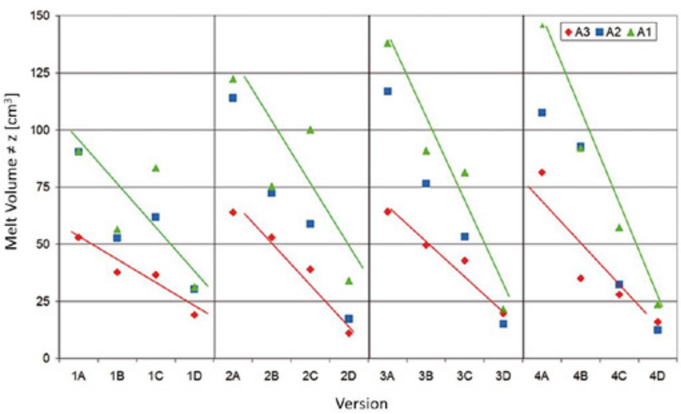
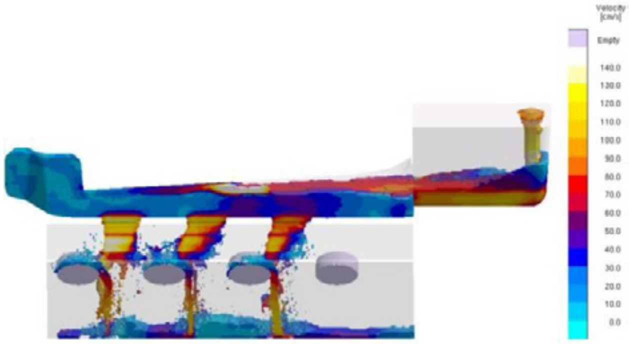
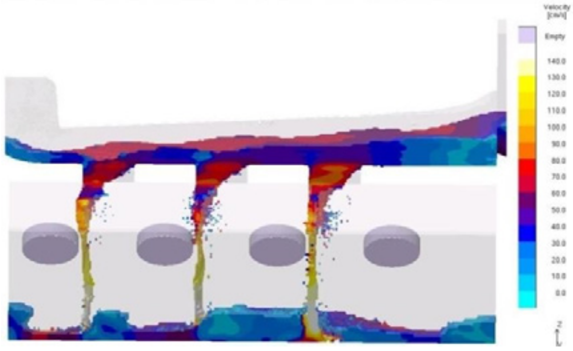


Figure 18. Melt volume [cm³] deviating from the vertical (desired) flow direction in gates A1 through A3 for all 16 versions



Version 1A; 2.67 s



Version 4D; 3.84 s

Figure 19. Comparison of melt velocities and direction for versions 1A and 4D at the same point in time

Reduction of Free Melt Surface

The criteria "free surface" in MAGMASOFT® measures the melt in contact with air during the mold filling process. This criterion can be used at specific times during the mold filling process (Figure 20) or show accumulated values over the entire filling process (Figure 21). The geometry changes in the gating system lead to differences in volume and weight between the versions. The melt volume in version 4D is 4.48 liters and is, in comparison to versions 1A with 2.82 liters, about 62% bigger. Despite that fact, the accumulated free surface shrinks by about 5% from 120,678 mm2 of version 1A to 114,944 mm2 in version 4D. The oxide creation risk is thereby significantly reduced (Figure 22).

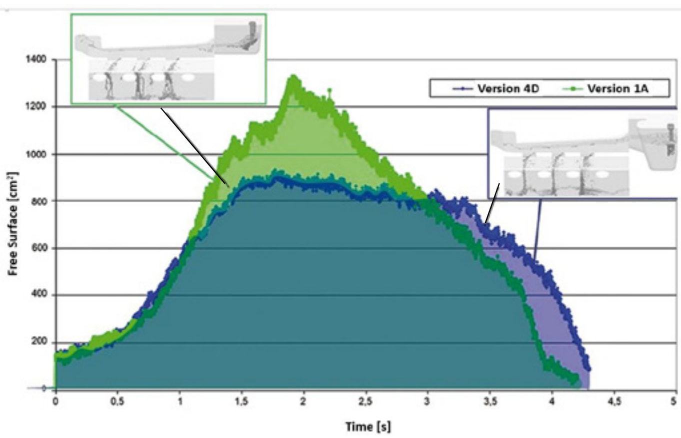


Figure 20. Free melt surface as function of time for versions 1A and 4D

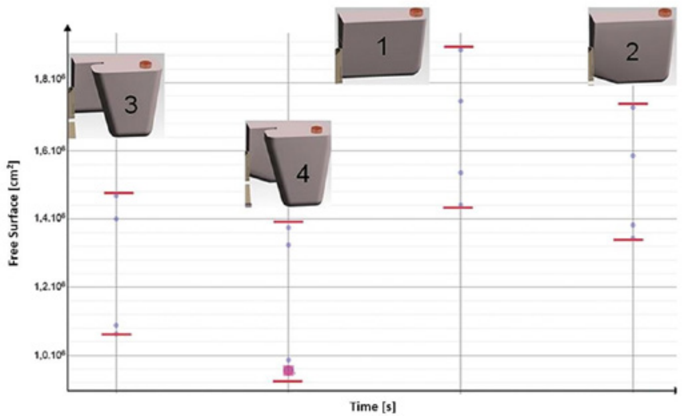


Figure 21. Over entire mold filling process accumulated "free melt surface" [cm2] for different pouring basin geometries and variations of its transition to the runner

Evaluation of relationships between process parameters and goals

The significance of the relationships between the different modified process parameters and the evaluated goal functions can be displayed by the software through "main effect diagram" (Figure 22) and easily evaluated.

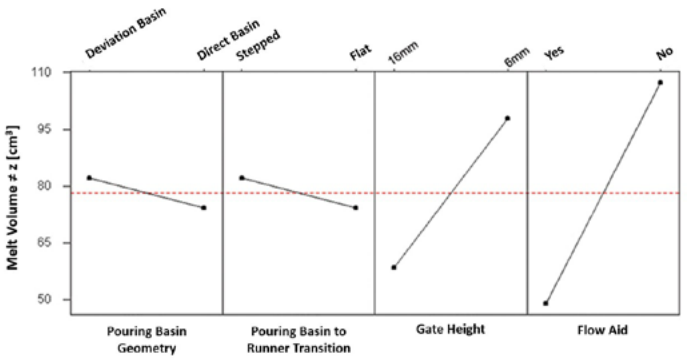


Figure 22. The main effect diagram of the impact of each variable on the goal function "melt volume with undesired flow direction" for gate A1

The y-axis displays the melt volume streaming through gate A1, which is not flowing in the desired flow direction. The lines show the impact of the four variables on the evaluated goal function. Shallow line angles in the windows for "pouring basin geometry" and "transition pouring basin to runner" indicate that these two parameters have only a small impact on this goal function. "Gate height" and the "presence of filling aids" have a much bigger impact.

The impact of filling aids on the flow direction in the desired z-direction is shown in a scatter chart in Figure 23. The cuts that are machined in have a significant impact on accomplishing the desired flow in z-direction.

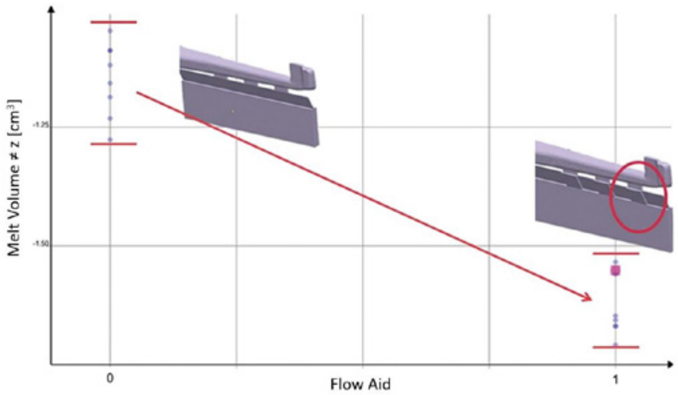


Figure 23. Impact of flow aids on the melt volume flowing in the desired z-direction (0 = no flow aids, 1 = flow aids present)

In parallel to the discussed three goals, virtual particles (tracers), representing oxide particles already present in the melt and not created during the mold filling process, were evaluated. These particles were assigned to the density of aluminum oxide and the typical size of oxide skins. The tracers move mostly due to flow dynamics inside the melt, but also experience buoyancy resulting from the density difference between melt and oxide skins. As the final melt quality is strongly dependent on the transfer processes experienced by the melt before entering the mold, it was evaluated, how significant the amount of entrained oxide particles is for each evaluated version.

The evaluation of the number of oxide particles inside the casting for the original version 1A and version 4D (best version for all other quality criteria) clearly shows the impact of the pouring basin geometry and its transition to the runner (Figure 24). Even if the total amount of oxide particles in version 4D is larger, due to its larger melt volume less oxides enter the runner and the casting, due to the optimized pouring basin design and the stepped transition between the deviation basin and the runner. The fraction of oxides inside the casting is cut in half coming from 11.7% down to 5.7%.

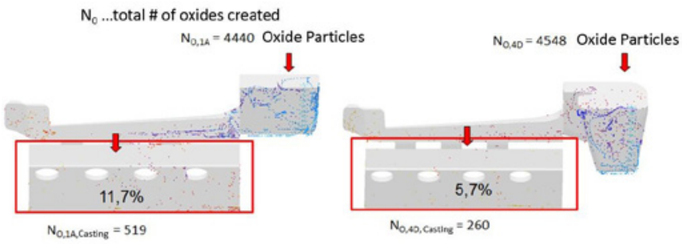


Figure 24. Total amount of oxide particles No, total amount of oxide particles in casting No,Casting, and percentage value of oxide particles, which are found inside the casting at the end of the mold filling process (for versions 1A and 4D)

Comparison of simulation results with real castings

Version 4D is the best solution for all evaluated quality criteria to reduce oxide inclusions. Therefore, this version was implemented in a real-world casting to compare it to the original version. Cylinder heads produced by both versions were examined using standard methods to find leakers. The statistical evaluation shows a clear reduction of oxide inclusion related leakers and confirms the validity of the chosen quality criteria (Figure 25).

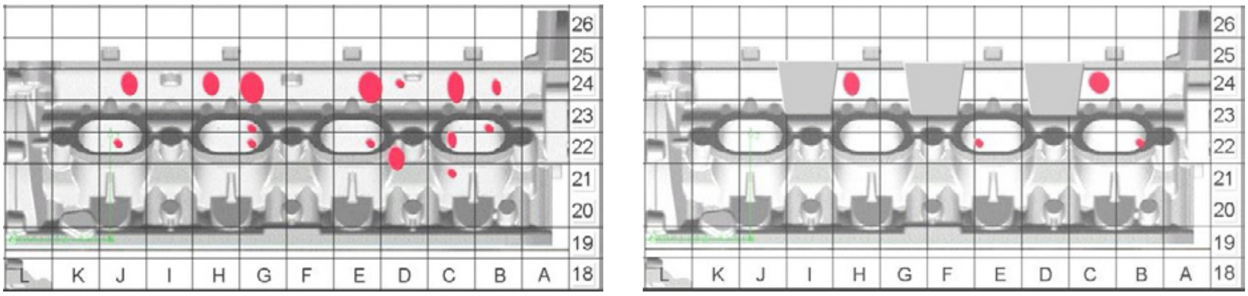


Figure 25. Evaluation of leakers due to oxide inclusions of cylinder heads of version 1A (left) and version 4D (right). The red dots depict the location and frequency of leakers.

Summary

Casting process simulation was used to analyze potential sources for oxide creation during the semi-permanent mold casting process of cylinder heads. The experimental evaluation of the impact of melt transfer processes on melt quality using the PREFIL measurement method, confirmed that the free fall of the melt during melt transfer processes and the related free melt surface turbulence bares a high risk for oxide creation. Using the filling of a pouring ladle as an example, it was shown how the integration of autonomous DOE's in MAGMASOFT® aids in varying process parameters to efficiently and quickly reduce the risk of oxide creation. It was demonstrated that through the utilization of the simulation tool MAGMASOFT® and its fully integrated autonomous DOE functionality, it is possible to efficiently evaluate ideas for the improvement of gating systems and process parameters early in the casting process development process for a new part. Beyond providing solutions for cylinder heads discussed in this paper, this new methodology provides comprehensive knowledge of quantifiable relationships between process parameters and quality criteria. This enables designers and foundry engineers to pursue several, even conflicting, goals at the same time.

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ALUCAST SNIPPETS

Shiv Nadar University & IIT Mumbai Have Developed More Efficient Lithium-Sulphur Batteries for EVs: Researchers at the Indian Institute of Technology (IIT) Bombay and Shiv Nadar University claim to have developed a technology for manufacturing of environment-friendly Lithium-Sulphur (Li-S) batteries which will be three times more energy-efficient. These batteries are said to be even 3 times more cost-effective than Lithium-ion batteries commonly used in most Electric Vehicles.

According to the research team involved in this achievement, the Li-S battery tech takes advantage of the principles of green chemistry, amalgamating usage of by-products from the petroleum industry (Sulphur), agro-waste elements and copolymers such as cardanol (a by-product of cashew nut processing) and eugenol (clove oil) as cathodic materials.

The team said that tech could revolutionise the existing multi-billion-dollar industries including electric vehicles, consumer electronics, drone and other products that depend on the usage of a Lithium-Ion battery.

“The research focusses on principles of green chemistry to find a solution that addresses the requirements of industries and the environment, simultaneously. The capability of three times more energy density, coupled with being a significantly safer technology, holds the promise of accelerating the adoption of clean, battery-led energy across multiple domains,” said Bimlesh Lochab, Associate Professor at Shiv Nadar University.

(Source: www.carandbike.com)

Upcoming EV Charging Stations In Delhi: Delhi government agencies are said to be working on setting up 200 new ev public charging stations and battery swapping touchpoints across the country’s capital soon. These EV charging stations will be set up across prominent locations across the city, as per the new Delhi EV Policy 2020.

Delhi To Mumbai In EV By BluSmart Mobility: Delhi to Mumbai in an electric vehicle may seem impossible, but BluSmart Mobility has flagged off India’s first all-electric travel between two states. The company attempts to travel approximately 1376 kilometres and reach Mumbai on September 9, 2020, which is known as the World EV Day. The company is using a Mahindra e-Verito for the journey.

EESL To Procure 250 Electric Cars For Government Use: EESL to procure 250 Tata Nexon EV and Hyundai Kona EV SUVs for government use in India. The companies were selected through an international competitive bidding process, which was aimed at increased participation. Both companies will supply 150 Nexon EV and 100 Kona electric premium SUVs, respectively.

All Petrol Pumps Could Get Charging Stations In India: The Indian Government plans to install charging stations across all fuel stations in the country. According to the recent reports, India has over 69,000 petrol pumps in the country owned by various oil corporations. The government has announced that it could ask all of them to install at lease on charging station.

Tata Motors Joins World EV Day Celebrations: Tata Motors joins World EV Day celebrations in the country. The company is said to be one among the founding partners for the World EV Day along with ABB and Green.TV. The celebrations will be inaugurated on September 9, 2020. It will be celebrated every year to encourage current and prospective drivers of electric vehicles.

Ultraviolette Automotive Receives Additional Funding: Ultraviolette Automotive receives additional Series B funding backed by TVS Motor Company. The Bangalore-based EV manufacturer has received an additional investment of Rs 30 crore form TVS. Ultraviolette Automotive launched the F77 performance electric motorcycle last year and is expected to start deliveries in 2021.

Hero Electric Partners To Launch Rapid Charging E-Bikes: Hero Electric & EV Motors India partners to launch rapid charging e-bikes. The partnership aims to provide a new service for last-mile delivery operations in the country. The service will be offered in a few cities as part of its pilot project, ahead of the nation-wide launch. Along with e-bikes it will also provide charging infrastructure.

Ather Electric Scooters To Launch In Kozhikode: Ather Energy to launch electric scooters in Kozhikode during its phase 1 sales expansion. The company has decided to add one more city. According to the company, the pre-orders, dealership requests, and also the volume of requests for test rides has resulted in including the new market in Phase 1 of their expansion.

(Source: www.60secondsnow.com)

ALUCAST SNIPPETS

Electric Vehicle in India

In 2011, the Indian Government endorsed the proposition to set up a National Mission for Electric Mobility (NCEM) to advance electric portability and assembling of electric vehicles in India.

In 2013; the National Electric Mobility Mission Plan 2020 was dispatched for the advancement of half and half and electric versatility in India, focused on continuously guaranteeing a vehicle populace of around 6–7 million electric/cross breed vehicles in India by 2020 alongside a specific degree of indigenisation of innovation.

In 2015, the Government of India presented the FAME India plot [Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India], with the target to help cross breed/electric vehicles' market improvement and assembling eco-framework. The plan has four centre territories innovation advancement, request creation, pilot extends and charging foundation.

The Indian Government prior paraded an aggressive thought of having electric vehicles to represent 100% of all new deals by 2030, later just to accompany a no need of a different strategy for EVs in India.

Charging foundation is one of the key concern zones for EVs. As of late, the legislature declared "charging of e-vehicles would be a help and not offer of power. Subsequently, each one of those setting up charging stations would not need a permit".

The automobile business specialists and related affiliations (SIAM) believe that the nation should target 40% of individual vehicles and 100% of public vehicle vehicles to turn electric by 2030. It has recommended 2047 as the objective for all-electric traveller vehicles.

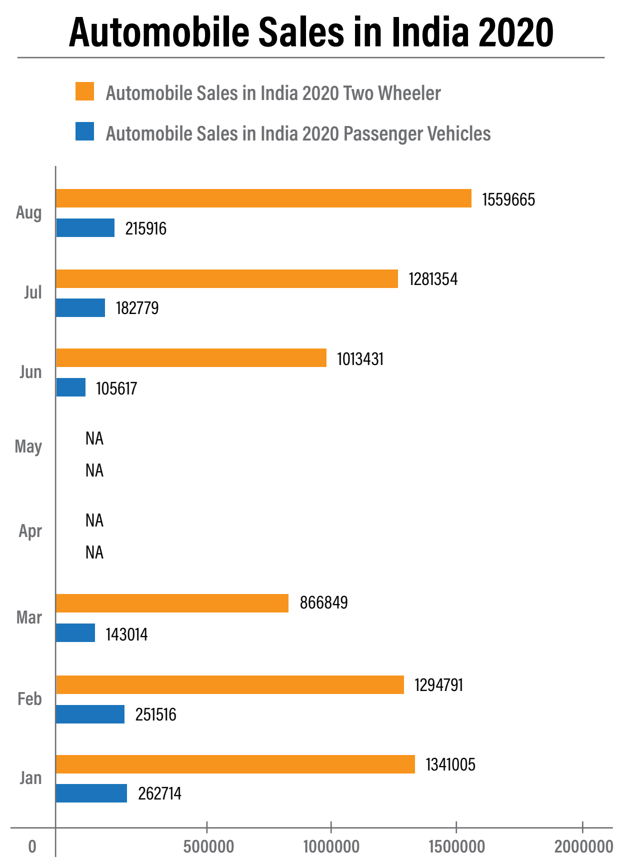
In India, the attention will be on getting the public vehicle armada onto the charge venture before zeroing in on private vehicles. Need will be provided in the request for electric transports, 3 wheelers, armada vehicles, 2 Wheelers and afterward private vehicles.

To drive this way of thinking vigorously, the focal government has begun some key activities:

In 2017, the Government of India through broad clerical conversations concocted a significant arrangement report regarding "Extraordinary Mobility for All". One of the key mainstays of this extraordinary versatility is the development of EVs and the EV foundation that is probably going to be required.

The Government of India is pursuing an EV strategy in which there are solid pointers from different strategy creators in India to maintain an attention on EVs and to take a gander at other low carbon alternatives, for example, Methanol and CNG. The administration intends to pursue making an interest for EVs by purchasing in mass, which could give enormous requests to automakers.

While there is a dream for 100% electric vehicles by 2030, most industry specialists demonstrate that around 40-45% EV transformation by 2030 is a practical desire. A significant push towards EVs will be driven by the public transportation prerequisites in India - armada vehicles, e-transports, 3 wheelers and 2 Wheelers. Individual vehicle choices for EVs will at present be a generally little component in the entire pie.



NA indicates numbers not available for the lockdown period

Source: SIAM

BÜHLER Page

myBühler Customer Portal

Easy access to machine details, parts, and orders

As the impact of the internet on everyday life increases constantly and 24/7 access to information becomes the new standard, Bühler provides its customers with up-to-date information anytime and from anywhere.

The myBühler Customer Portal offers customers easy access to all details of their machines and parts, including documents such as user manuals and 3D spare parts catalogs. myBühler provides its users with a 24/7 overview of their Bühler equipment and makes it easy to find the spare parts they are looking for.

Customers can generate quotations online and just order right away, as they need it. The tool provides insight into pricing and procedures upfront, e.g. showing information about various possible shipping methods, which allows the customer to choose the right shipment, based on his timeframe and cost range.

Additionally, myBühler will be the entry point for various Digital Services, such as E-Learnings and Downtime Analysis.

More Information about myBühler: https://www.buhlergroup.com/content/buhlergroup/global/en/services/Spare-and-Wear-Parts/Customer-portal-myBuhler.html?cid=Trade-Media_Story_DC-myBuhler-nextfoundry-EN-