The State-of-Art Simulation of High Vacuum and High Performance HPDC with ESI ProCAST

ESI's Virtual Manufacturing Solution for Castings

Investing in casting technology and optimizing to the right process conditions has never been as important as it is today. Foundry businesses are suffering due to the high costs of production and the challenges of choosing the perfect fit from a variety of processes such as Sand Casting, High Pressure Die Casting (HPDC), Gravity Casting and Low Pressure Die Casting (LPDC), as well as ensuring sound choice of methodology and process conditions. One process of particular interest is the HPDC process: an advanced technology which can give added leverage to the foundry to improve quality, save costs, and reduce scrap rate. A special feature of HPDC based on an evolution of the traditional process is maintaining a High Vacuum during the metal injection. Software editor ESI Group has proven to foundries the strategic value of its virtual manufacturing solution in simulating the performance of the High Vacuum HPDC processes: ESI ProCAST empowers foundries to get the methodologies and process conditions right, to deliver high quality castings while minimizing cost and time.

The automotive industry (including OEMs and their supply base) is recognized as the leading market for Die Casting. They demand high-performance castings from foundry suppliers and expect the best quality in terms of structural integrity, sound mechanical properties and good welding and heat treatment performance. These requirements are typically obtained via gravity and LPDC processes more often than with HPDC, because of its inherent limitations.

More specifically, HPDC requires Heat Treatment T6 and special Al alloy grades to increase mechanical properties. In the case of T6, gas porosity inside the component can form blisters during solubility heat treatment (at 520-530°C for 8-12 hours for example) decreasing the component performances. Special alloy grades have high viscosity due to low Si, which can cause filling issues and hence decreasing mechanical component properties. High Vacuum technology allows for the casting of structural parts and cast components with T6 and special alloy grades.

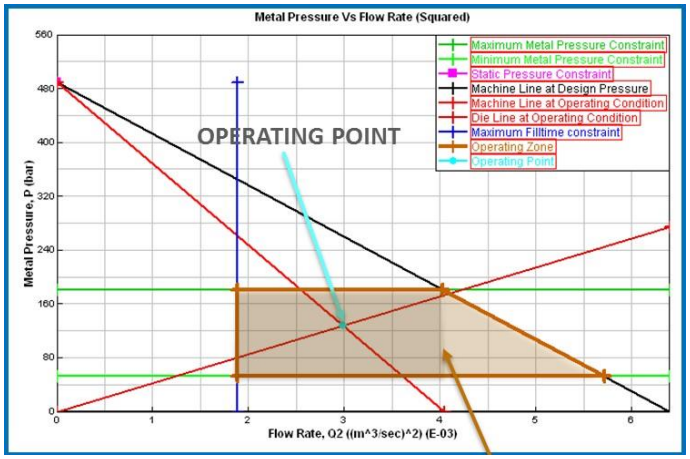

Image: *Pressure(P)-Flow Rate(Q)² Graph, as seen in ESI ProCAST*

This relatively new technology has improved in the recent years to offer two levels of vacuum: standard vacuum and high vacuum. Today's innovations in HPDC mainly happen in relation to High Vacuum technology developed by FONDAREX.

A second trend in the automotive industry is the development of high-performance Die Casting machines (DCM). The integration between the machine and vacuum can deliver top quality castings. This means that a gas evacuation curve, in phase with the injection curve and the flow rate, can control both the aluminum and air during casting. The key to success in implementing High Vacuum using DCM is to move from the traditional approach running casting trials based on experience to the full numerical simulation of the Vacuum HPDC process. Simulation is used to define the design of the die with the best gating system and evacuation lay-out. All these conditions are finally achieved with the right choice of process parameters, verified with the casting simulation solution, while considering real DCM hydraulic injection force.

Such innovation has been applied on real industrial cases, such as the manufacturing of an automotive oil pump casted by Italian foundry F.A.R. The new virtual simulation approach has been instrumental in helping F.A.R. reduce production costs for the oil pump, prompting them to switch from 1-cavity to 2-cavity dies. The one cavity die was used on a 560t machine. Standard approach using the empirical injection nomogram on Flowrate and Injection Pressure showed the necessity to use a 1000t-1200t DCM to produce this oil pump on 2 cavities. However, F.A.R. had selected a specific DCM named PFO 750 Green Line, developed by Italian manufacturer COLOSIO to reduce energy cost and increase efficiency with an inverter. The challenge for F.A.R.'s technical & management teams was therefore to develop this new 2-cavity die on a 750t – and not 1000t, DCM. F.A.R. also elected to use High Vacuum on the 2-cavity die to solve gas porosity problems and reduce the injection force by sharply decreasing air counter-pressure during filling, in order to reach the final quality targets.

Today, the HPDC market is equipped with the right devices and technologies to produce high performance parts, but until recently there was a lack of casting simulation solutions to take real DCM performance into account. ECOTRE Valente SRL and ESI Group collaborated to develop the new ProCAST toolset for casting simulation: V-DCM (Virtual-Die Casting Machine) to see if DCM has enough hydraulic injection force to fill the die cavity while maintaining the second phase velocity to achieve the expected filling time.

The hydraulic injection force calculated by ProCAST includes geometrical and gas counter-pressure inside the chamber and cavity. This opposes the high resistance to the part filling. A fully integrated simulation including the virtual hydraulic power and vacuum machine has been completed. ESI's Software Solution ProCAST has the ability to create a customized simulation by including technical datasheets, such as for Hydraulic Injection Force, Hydraulic Cylinder Diameter as well as Hydraulic Inline pressure to save costs and time. The speed and pressure profiles also have been virtualized and enable the import of the best injection profiles, from the casting simulation solution straight into the DCM PLC system. ProCAST calculates real-time pressure and injection force needed by the DCM to maintain plunger velocity. The image below shows ESI ProCAST simulation results using this Real-Time Control. This calculated value is then compared against the power limit of the DCM.

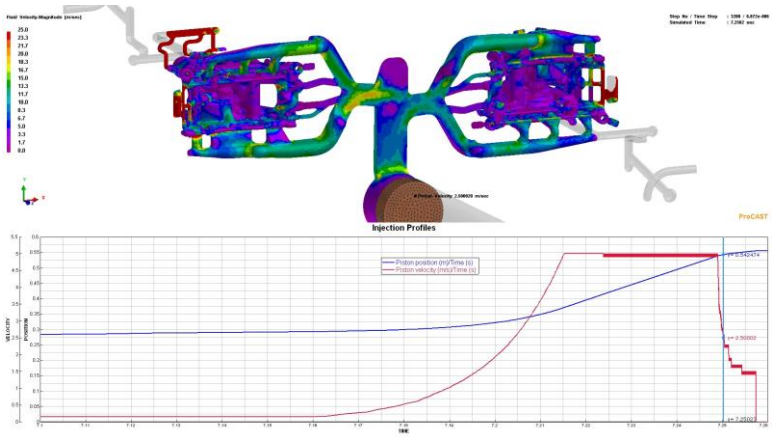

Image: *ESI ProCAST simulation results using the new Real Time Piston Control feature.*

All empirical evaluations of the discharge coefficient performed without simulation to choose the size of DCM, are far off and cannot deliver significant cost reduction and casting quality, as shown for the case of the F.A.R. foundry. Thanks to ProCAST however, it is possible to optimize the gating and evacuation system to use less hydraulic injection force. Usage of a vacuum system reduces even further the required hydraulic injection force. The casting simulation solution ESI ProCAST is the best way to determine the right DCM to produce a prospective cast part.

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About ESI Group

ESI Group is a leading innovator in Virtual Prototyping software and services. Specialist in material physics, ESI has developed a unique proficiency in helping industrial manufacturers replace physical prototypes by virtual prototypes, allowing them to virtually manufacture, assemble, test and pre-certify their future products. Coupled with the latest technologies, Virtual Prototyping is now anchored in the wider concept of the *Product Performance Lifecycle*, which addresses the operational performance of a product during its entire lifecycle, from launch to disposal. The creation of *Hybrid Virtual Twins*, leveraging simulation, physics and data analytics, enables manufacturers to deliver smarter and connected products, to predict product performance and to anticipate maintenance needs.
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