SAVE THE WEIGHT WITH NEW 2MM LPDC PARTS WITH SIMULATION AND VACUUM

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Keywords: LPDC, Casting Simulation Software, Aluminum

Abstract
Project name is "2 Millimiters" and it is a MIUR project: "Accordo di Programma in materia di ricerca nei settori dell'Agroalimentare, Aerospazio, Edilizia Sostenibile, Automotive e Energia, Fonti rinnovabili e implementazione dei Distretti Tecnologici già riconosciuti". Protocol number R1.2011.0020660 of 22/11/11 – Lombardia region.

Project Partner are Altea, Diesse, FMB, Leonardo, Modelleria e Animisteria Franciacorta, Brescia University. FMB is the head of this project.

Official Project supplier: AQM, CSMT and ECOTRE Valente srl
Technological Project Sponsor: Ferrari Spa, OMR

ECOTRE is an Official Project supplier and it will present an overview of this project and it will focus on its Technology of casting simulation and vacuum.

OEM and automotive market is driving foundry suppliers to high performance castings: high structural integrity, high mechanical properties, welding and heat treatment. These requirements are typically obtained with gravity and low pressure die-casting. There are new important improvements in these processes. In fact, market need to reduce weight thanks to minor thickness. These processes have some limitations on minimum thickness allowable due to cavity misrun. In this case Vacuum technology has the role to eliminate gas and air counter pressure to completely fill cavities. This work will show some industrial application with vacuum in Low Pressure Die Casting.

Aim of the project is to produce automotive structural components for space frame with thickness reduced from 4 to 2mm by the use of innovative low pressure and gravity die casting plants and dies with vacuum, real time monitoring and closed loop logic management. Research and development of an optimal aluminum alloy suitable both for gravity die casting and LPDC has been carried on. ProCAST casting simulation software has defined alloy composition, component design, gating and evacuation system, die heating, process parameters and best fitting equipment.

Introduction

Major points of project “2 Millimiters” are:

-WEIGHT REDUCTION THROUGH THICKNESS REDUCTION TILL 2MM

Reduced thickness generates a bigger counter pressure in cavity both for more critical cross section and for higher difficulty to remove gas; this generate an increase of filling time and promotes misrun. Vacuum removes gas counter pressure (Figure 1).

Figure 1: Example of LPDC, Low Pressure Die Casting, component without vacuum
Courtesy of FMB

-INCREASE OF MECHANICAL PROPERTIES: Yield strength, Tensile strength and Elongation.

-REDUCTION OF INCLUSIONS, OXIDES, MICRO-SHRINKAGE that can affect fatigue life tests and that can’t be detected through standard X-ray analysis

-CONTROL OF MICRO-SHRINKAGE POROSITY DIMENSIONS in order to maintain them below limit fatigue crack propagation

-EVALUATION OF SHAPE, DIMENSION AND LOCALIZATION OF POROSITY THANKS TO ProCAST casting simulation software (Figure 2)

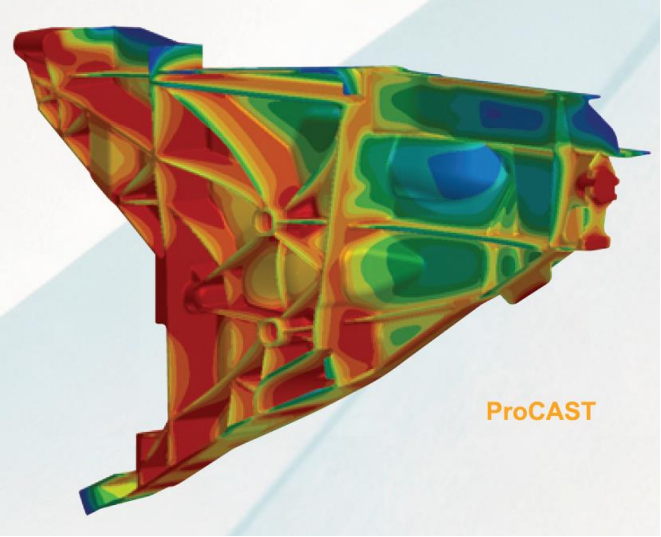

Figure 2: Example of Gravity Die Casting component with ProCAST casting simulation.
Courtesy of OMR

- Transfer of casting simulation results into FEM structural analysis software of final customer for component design and performance calculation.

Casting Process selection

First analysis has been done on a structural part with a benchmark between different casting processes: HPDC, Sand casting, Gravity die casting with and without vacuum and LPDC with vacuum.
Evaluation parameters of this benchmark are 4: investment, product cost, casting weight and yield stress.

-HPDC has been selected as reference point for this benchmark: thickness of 2 mm is easy to obtain from this process and this target satisfies customer request of weight saving. Regarding investment and achievable mechanical performance anyway this isn't the best solution.
-SAND CASTING is the most interesting process regarding investment but generates an excessive cost of product, even if mechanical properties as well as weight provides good results.
According this information permanent mold process is the most appealing solution to obtain a good balance between all requests.
This evaluation analysis on process selection due to previous 4 parameters is LPDC.
Based on this result, the component has been developed with a thickness of 2 mm (instead of previous version of 3 mm) in LPDC plus Vacuum equipment (figure 4).
Weight component is reduced from 1.913 kg to 1.582, with a weight reduction of 18%.

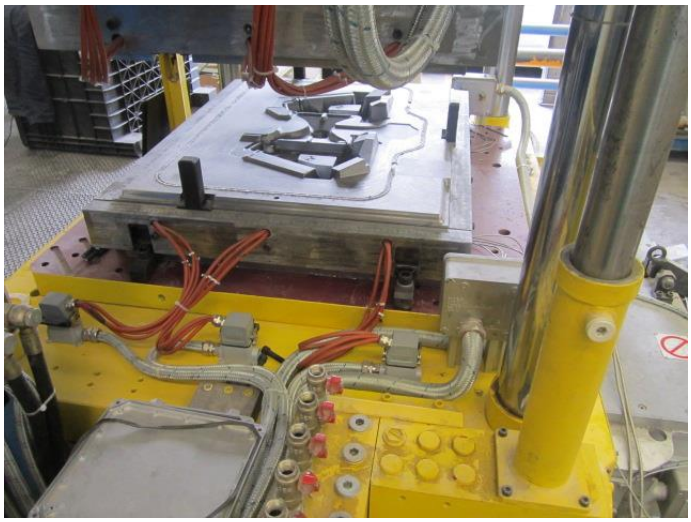

Figure 4: 2mm mould done by Modelleria e Animisteria Franciacorta on LPDC machine done by Diesse
Courtesy of FMB

Alloy selection
Second step op component development has been done on new alloys: TL118 or C1A1 Alcoa and B356.2 with the target to increase yield stress.
Several test on chemical composition optimization has been done and on cast specimen tensile test and flexural test has been performed.
At the end of 2014 FMB, Brescia University and AQM have realized 1350 test, generating a database with correlation between alloy, microstructure, heat treatment cycle, production parameters and mechanical properties.

B356.2 is the alloy selected for the project and its mechanical properties are according to Customer performance specification.
Microstructure of alloy as well as its weldability have been investigated because it was necessary to know behavior of component after welding with car spaceframe.

Component Production

This paper describes production of component in LPDC with vacuum.
Steel Mould has done by Modelleria e Animisteria Franciacorta and has two mirrored cavities and an area has been realized to obtain sample for mechanical tests.
Mould and process parameters has been projected and tested using ProCAST casting simulation software.
Simulation works have investigated start-up a steady state of production, in order to focus on achievable quality in case of fully industrialized equipment, as shown in picture 5.

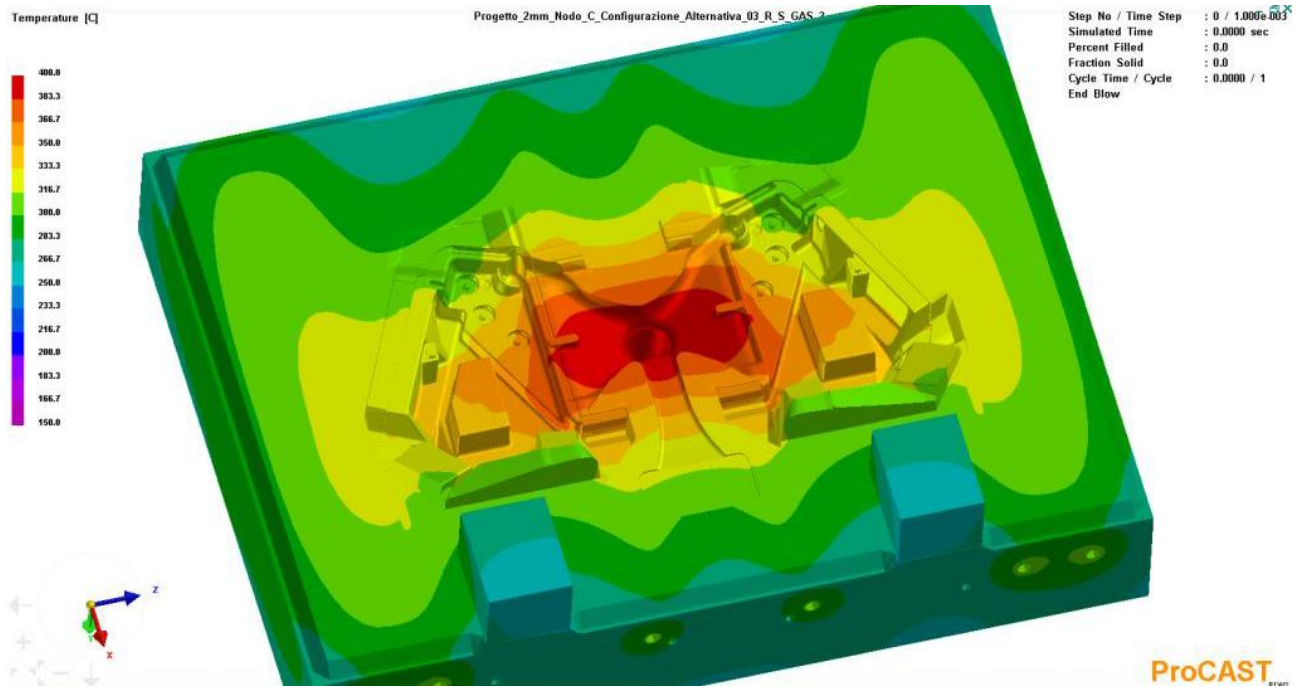

Figure 5: 2mm LPDC Die thermal map ProCAST simulation done by ECOTRE. Courtesy of FMB

First simulation has shown part misrun due to excessive cooling of Al alloy during filling. In fact the design of this component with 2mm thickness and a big exposed surface was the first topic to be solved. In this scenario Al alloy exchange a lot of heat with mould, increasing its viscosity and requesting more pressure from furnace.

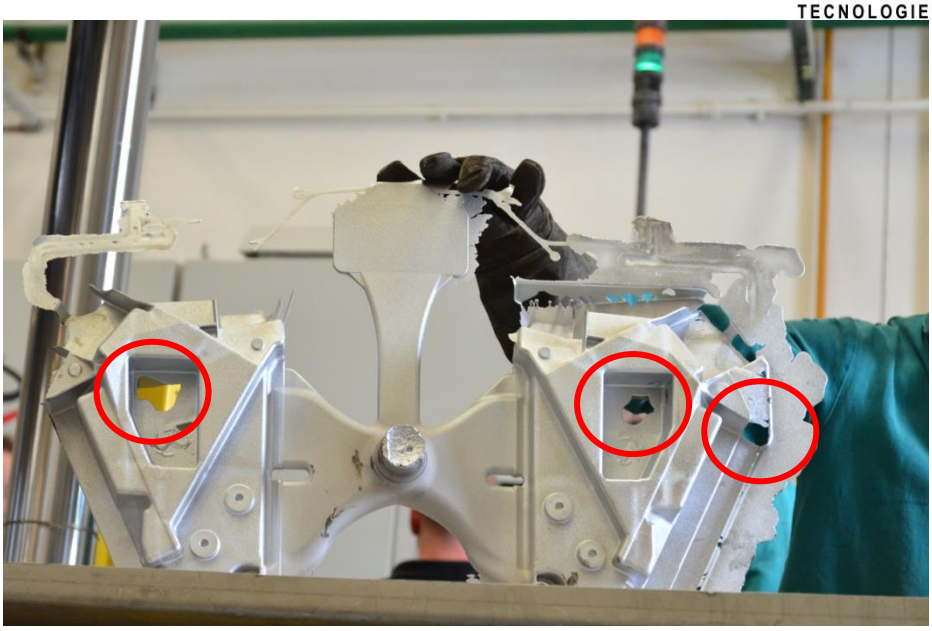

Figure 6: 2mm LPDC casting showing misrun. Courtesy of FMB

Moreover it has been simulated filling and solidification of casting with and without vacuum, in order to understand the kind of vacuum tank and valve or chill vent to be used.
According these results vacuum system has been selected: application of vacuum on casting has been developed using simulation. This operation has allowed to optimize filling of venting system, to avoid pollution equipment and optimizing the amount of gases removed and counter pressure reduction, as shown in picture 7.

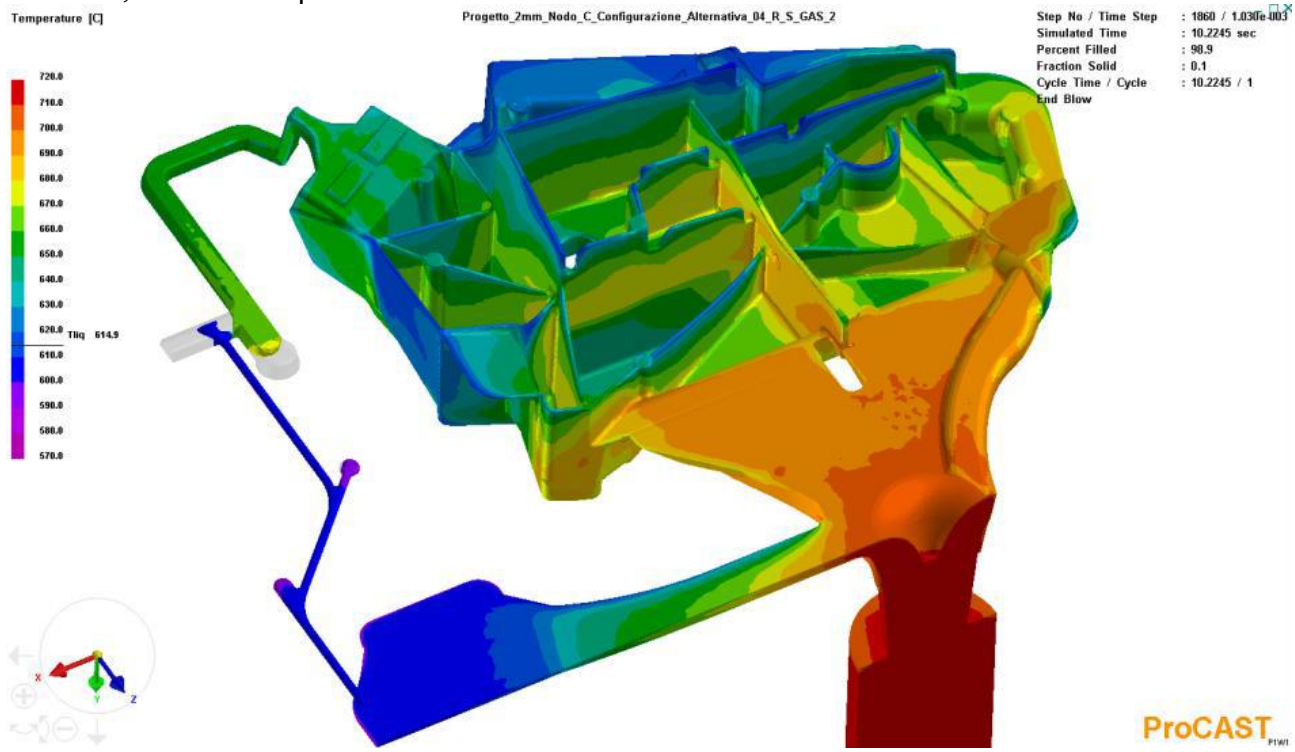

Figure 7: 2mm LPDC Filling simulation with vacuum. ProCAST Simulation takes into account gas inside cavity. Courtesy of FMB

Figure 8: 2mm LPDC vacuum system with Ecotre design channel system evacuation Integration Vacuum-Diesse machine done by Leonardo. Surface paint by Altea. Courtesy of FMB

Final loop of simulation has investigated mould deformation.
Deformation has been studied both during filling and solidification.
FEM deformed model has been exported to CAD in order to design a new counter deformed mould able to consider die and component deformation and provide a part according to drawing tolerances and avoid die burrs (figure 6).

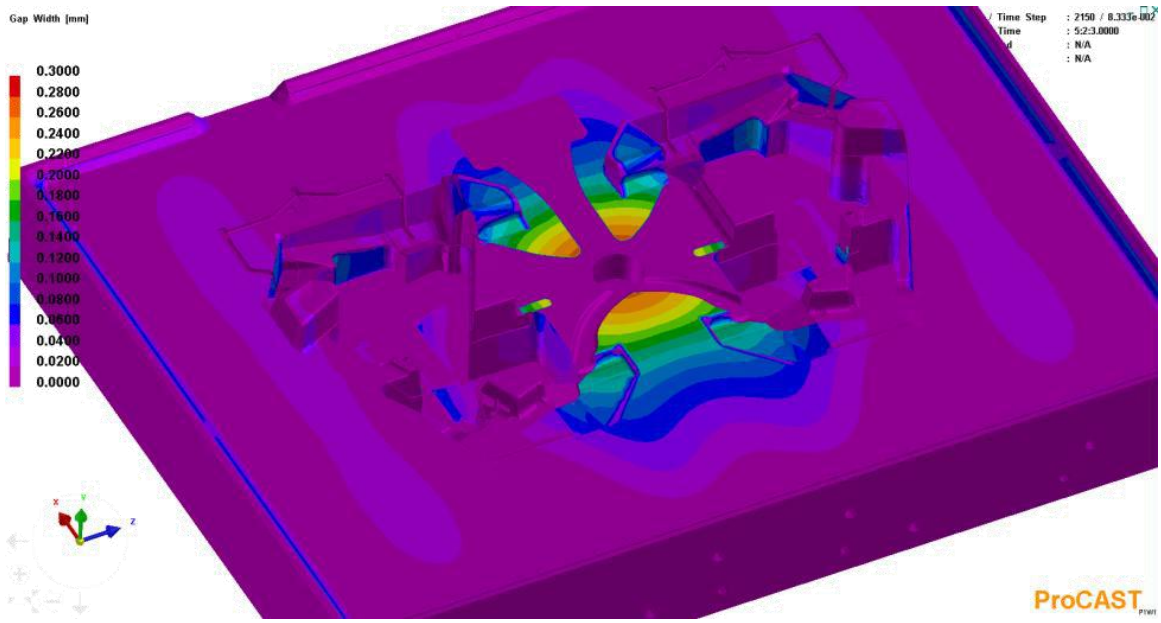

Figure 9: 2mm LPDC Die deformation ProCAST simulation done by ECOTRE. Courtesy of FMB

Conclusion

Casting obtained with vacuum application is sound and complete according to ProCAST simulation results (figure 10).

Figure 10: 2mm LPDC casting. Courtesy of FMB

Mechanical properties have been tested using a dedicated specimen obtained from raw casting, positioned halfway between mould cavities.
To obtain sound and complete specimen a dedicated vacuum channel has been designed.
Mechanical test results have reached goal of project

Acknowledgments

Authors want to thank all people of FMB and OMR, Officine Meccaniche Rezzatesi, for their trust and action on Italian automotive innovation
Thanks to all Project Partner: Altea, Diesse, FMB, Leonardo, Modelleria e Animisteria Franciacorta, Università degli Studi di Brescia
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Progetto 2 MILLIMETRI

n° protocollo R1.2011.0020660 del 22/11/11 – Regione Lombardia

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