MUSIC IN NUMBERS

51 Scientific publications including
- **14** Master Thesis
- **3** Doctoral Thesis
- **20** Press Releases

More than **50** events including
Public training, Workshops,
Conferences presentations,
Exhibitions, Public lecturers

1 Project website
with several issues of Project Newsletter

12 new jobs created

12 Exploitable results leading to patents,
copyright & utility model protection

Starting date: 1st September 2012
Duration: 48 months
Total Person Months: 936
Total costs: 9.302.070,00 €
EC funding: 6.135.000,00 €
Call identifier: FP7-2012-NMP-FoF-ICT
Objective: FoF-ICT-2011.7.1 – Target outcome c)
Collaborative Project
Grant agreement no: 314145

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rds moulding technology
MOTUL TECH Baraldi HPDC Division of the MOTUL Group
saen
ASSOMET Associazione Nazionale Industrie Metalli non Ferrosi

Smart Factories: Energy-aware, agile manufacturing and customization

MUSIC

MUlti-layers control&cognitive **S**ystem
to drive metal and plastic production line
for **I**njected **C**omponents

For High Pressure Die Casting and Plastic Injection Moulding

Contract no. 314145 - Collaborative IP project - FoF-ICT-2011.7.1

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Final Edition

REAL-TIME HPDC QUALITY PREDICTION AND OPTIMIZATION SUPPORTED BY TRAINED COGNITIVE MODEL

N. Gramegna, P. Donaggio, A. Bassi, G. Scarpa, Enginsoft SpA
E. Battaglia, E. Fiorese , University of Padova – DTG, Vicenza, Italy

Manufacturing current trends show an improvement in demand for light products considering the material substitution for complex structural parts, the design and technology innovation as well as the evolution in smart production.

Due to the high number of process variables involved and to the non-synchronisation of all process parameters in a unique and integrated process control unit, HPDC is one of the most "defect-generating" and "energy-consumption" processes in EU industry showing less flexibility to any changes in products and in process evolution.

In both, sustainability issue imposes that machines/systems are able to efficiently and ecologically support the production with higher quality, faster delivery times, and shorter times between successive generations of products. Starting from an intelligent monitor system of HPDC process, an advanced trained meta-model is the key factor to improve the manufacturing efficiency predicting the real-time quality and cost of the product.

The offered training methods and virtual or real Cognitive models correlate the input and sensors data with the quality indexes, energy consumption cost function.

The Machine Operator or Production Manager can react shot by shot, supported by Control & Cognitive system integrated in the foundry site, to improve the quality and the production rate of each production line.

APPLICATION OF COST MODEL APPROACH IN HPDC CONTEXTS

L. Macchion, G. Kral, F. Bonollo, University of Padova, DTG
N. Gramegna, EnginSoft SpA

The application of cost model approach in High Pressure Die Casting (HPDC) context has been investigated by defining parametric analysis to identify the main sources of costs and the related impacts on production processes.

Results highlight the possibility for companies to better control industrial costs of their products by examining in detail the different costs composing the HPDC process and verifying at the same time the adherence to budget.

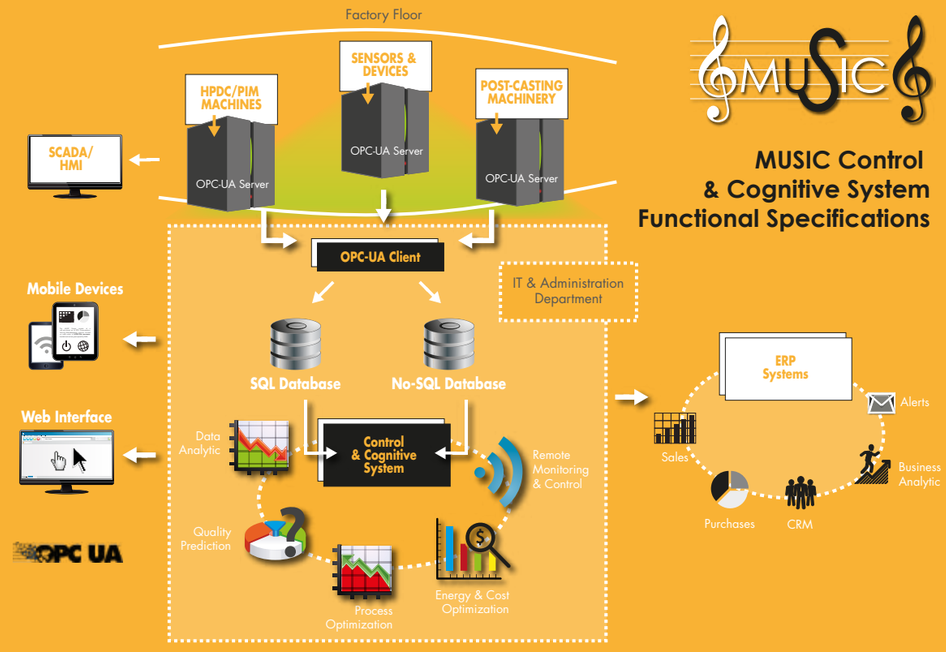
Furthermore, particular attention was dedicated to attest that the industrial cost of production significantly decreases when companies invest in quality controls during the casting trial activities.

HPDC FOUNDRY COMPETITIVENESS BASED ON SMART CONTROL AND COGNITIVE SYSTEM IN AL-ALLOY PRODUCTS

N. Gramegna, Enginsoft SpA
F. Bonollo, University of Padova, DTG

High Pressure Die Casting (HPDC) technology is facing new challenges in terms of quality requirements from the end-users, production rate achievable, process monitoring and control, in a complex worldwide scenario. A relevant contribution to HPDC competitiveness has been offered by the EU-FP7-funded MUSIC Project. It is probably the biggest research project ever carried out in the field of HPDC, with 16 partners and an effort of about 1000 person-months. MUSIC developed a totally new Control and Cognitive system, giving an integrated and multi-disciplinary answer to the most relevant issues for HPDC industry: "zero-defect" production, real time process control, understanding the role of process variables, process optimization and real time cost evaluation.

Due to the high number of process variables involved and to the non-synchronization of all process parameters in a unique and integrated process control unit, HPDC is one of the most "defect-generating" and "energy consumption" processes. Sustainability imposes that machines/systems are able to efficiently and ecologically support production with higher quality, faster delivery times, and shorter times between successive generations of products. The new "smart Prod ACTIVE" tool is a flexible and totally integrated system able to predict the real-time quality and the cost. Its extension of application to further multi-stages and multi-disciplinary production lines (e.g. sheet metal forming, forging, rolling, thermoforming, machining, welding, trimming, or the innovative additive manufacturing) is planned to exploit the same methodology in different industrial contexts.



2

AN INTEGRATED AND INTELLIGENT SENSOR NETWORK AS TOOL FOR MONITORING HPDC PROCESS PARAMETERS

U.Gauermann, A. Mazzamuto, Electronics GmbH
N. Gramegna, P. Donaggio, EnginSoft SpA

In agreement with Industry 4.0 and Smart Factory vision, the Intelligent Sensor Network (ISN) is the hardware base to control the multi devices HPDC production line from the melting furnace, throughout the injection machine and die, to the final post-casting operations. Traditionally, each single device, delivered by different vendor, is using a specific PLC and user panel to setup and control some parameters of one phase of HPDC process.

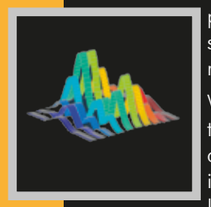
The machine operator and Production Manager have to manage all devices in a separate way and time. Typically, the press is controlling the injection, the die thermal behavior can be visualized by TTV thermo-camera during the injection and solidification heat pulsing and thermal-regulation unit impact. The setup and control of process stability, in all phases of the process, can be centralized today in a common database with unique smart user interface.

Data homogenization, centralization and synchronization are the key aspects of the monitoring system to collect information in a structured, modular and flexible database. This Intelligent Manufacturing Approach (IMA) works at machine-mould project level to optimize the production line starting from the management of manufacturing information based on OPC_UA communication protocol. The real-time data acquisition by LAN network and the remote visualization in a Computer monitor, Tablet or Smartphone, with available internet access are the innovative smart tools for the new era of machine operator and production manager. Information from ISM can be managed by specific self-adaptive device. In this way, ISN is a tool suitable for fully exploiting the potential of HPDC process, which can be transformed from a production-rate-dominated manufacturing field into a cost/efficiency-driven and integration-oriented process.

3

INTELLIGENT MANAGEMENT OF THE LUBRICATION PHASE IN HIGH PRESSURE DIE CASTING

C. Raone, Motultech Baraldi
N. Gramegna, EnginSoft SpA
F. Zuliani, University of Padova, DTG



In the process of high pressure die casting of light alloys, the lubrication of the mold by spraying dilute aqueous emulsions is the less controllable phase of the cycle. Many parameters in the application (type and number of nozzles, pressures and distances, time of spray, lubrication cycle) as well as those related to the chemical aspects, play a role on the mechanisms of wetting of the surface, heat exchange and deposition of the film.

Within the FP7 MUSIC Project, it has been designed and assembled an equipment for bench testing, with the aim of studying the influence of various parameters on cooling effect, in the application of a spray lubricant on a die at different surface temperatures. An H11 steel plate is cyclically heated at preset temperatures, then automatically translated and sprayed. Infrared thermal images of its surface are recorded before and after spraying, and elaborated in terms of ΔT on different areas. From the early tests it turned out that an increase in the concentration of the die lubricant led to an increased cooling of the plate, whereas the influence of the distance between nozzles and steel plate was far less important, in the given conditions.

4

CORRELATION BETWEEN PROCESS PARAMETERS AND QUALITY CHARACTERISTICS IN ALUMINUM HIGH PRESSURE DIE CASTING

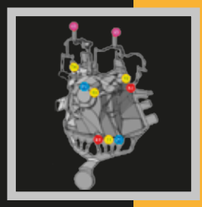
Martina Winkler, Lothar Kallien, Thomas Feyertag, Aalen University of Applied Sciences

Aluminum high pressure die casting is one of the most productive manufacturing processes. The complexity of the parts rises and the quality requirements are increasing. The challenge in high pressure die casting is to reach the high quality standards in spite of the huge number of quality influencing process parameters. The interaction of all quality influencing parameters leads to extremely high scrap ratesup to 10 -25%. The European research project MUSIC (MUlti-layers control and cognitive System to drive metal and plastic production line for Injected Components) has the aim to decrease the scrap rates in high pressure die casting by developing an intelligent cognitive system taking all quality controlling parameters into account. In the frame of the project a special casting geometry has been developed, that allows the production of parts with several defects such as shrinkage porosity, cold shuts and distortion. The die is instrumented with many new and innovative sensors to monitor new process parameters, such as the sound of the shot, which have not been applied to date. The sensor data, the process parameters of the machine and the peripheral devices are stored together with the quality index of the castings in one common database. To find correlations the process parameters were varied with different DOEs. The database with the data of the cast trials is the basic information for the prediction of the cast part quality.

5

INNOVATIVE CONTROL AND REAL-TIME QUALITY PREDICTION FOR THE CASTING PRODUCTION OF ALUMINUM ALLOY STRUCTURAL COMPONENTS

B. Kujat, AUDI AG
N. Gramegna, EnginSoft SpA
M. Benvenuti, University of Padova, DTG

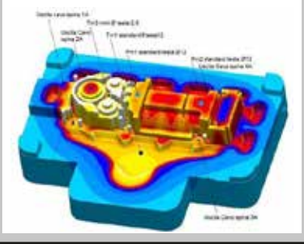


Thin-wall structural parts produced by high pressure die casting (HPDC) are designed and applied in the automotive production sector. The Audi strategy is the application of lightweight alloy components produced by HPDC in the structure of future car bodies. One of the key components of this strategy is the shock tower. The research of smart control strategies in order to improve the quality and production efficiency of these parts is a main objective of the technical center for HPDC of AUDI AG.

An optimized cognitive method is therefore introduced and integrated in a single centralized control system.

The shock tower use case is the selected demonstrator for testing and validating the cognitive control system. Based on an intelligent sensor network, communication with all devices, process data management and a quality prediction in terms of filling and solidification defects, a vast improvement of the casting production process is expected.

High Pressure Die Casting (HPDC) of light alloys and **Plastic Injection Moulding** (PIM) are two of the most representative large-scale production-line in manufacturing field, which are strategic for the EU-industry largely dominated by SMEs. Due to the high number of process variables involved and to the non-synchronisation of the process control units, HPDC and PIM are most "defect-generating" and "energy-consumption" processes in EU industry showing less flexibility to any changes in products and in process evolution. In both, sustainability issue imposes that machines/systems are able to efficiently and ecologically support the production with higher quality, faster delivery times, and shorter times between successive generations of products. Therefore, the MUSIC is strongly aimed at leading EU-HPDC/PIM factories to cost-based competitive advantage through the necessary transition to a demand-driven industry with lower waste generation, efficiency, robustness and minimum energy consumption. The development and integration of a completely new ICT platform, based on innovative Control and Cognitive system linked to real time monitoring, allows an active control of quality, avoiding the presence of defects or over-cost by directly acting on the process-machine variables optimisation or equipment boundary conditions. The Intelligent Manufacturing Approach (IMA) will work at machine-mould project level to optimise/adapt the production to the specific product and can be extended at factory level to select/plan the appropriated and available production line. The sensors calibration and quality measurements will be the pre-requisite of Intelligent Sensor Network (ISN) to monitor the real-time production and specific focus will be also devoted to Standardisation issues. The challenge of MUSIC is to transform a production-rate-dominated manufacturing field into a quality/efficiency-driven and integration-oriented one to exploit the enormous (and still underestimated) potential of HPDC/PIM through collaborative research and technological development, along the value chain with research groups, design, engineering and manufacturing companies and through advances in manufacturing, ICT and model process technologies.



PROJECT MAIN EXPLOITABLE RESULTS:

- ♪ New Total Thermal Vision
- ♪ Advanced Temperature control Unit
- ♪ Device monitoring the production of pressure casting and other apparatus
- ♪ New Control and Cognitive System
- ♪ Cost & Energy models
- ♪ Self-adaptive Chill vent

2012 — 2013 — 2014 — 2015 — 2016

SEPTEMBER — SEPTEMBER

From Music to Symphony in Smart Factory

PROGRESS BEYOND THE STATE OF THE ART

Introducing intelligent manufacturing systems in HPDC, made available by autonomous and self-adaptive devices, will totally change the actual organisation and potential of this process. According to the experience of MUSIC Partners, which are well-established players in the HPDC and PIM manufacturing scenario, **six main challenges** have to be faced for the progress in this field which can be identified in terms of :

1. leading HPDC and PIM processes to "zero-defect environment"
2. introducing real-time tools for process control
3. monitoring and correlating all the main process variables
4. making the process set up and cost optimisation a knowledge-based issue
5. involving to multi-disciplinary R&D activities
6. impacting on EU HPDC and PIM Companies, by dissemination and standardization activities

EXPECTED END RESULTS AND INTENTIONS FOR USE AND IMPACTS:

The Intelligent System coming from MUSIC will lead to an optimised and intelligent design and manufacturing of HPDC/PIM components for different industrial sectors. The consequences of this are manifold: weight reduction of products, better use of natural resources, new applications (in automotive and in other fields) of materials. The positive impacts will affect all categories in a transversal way:

SMEs:

- ♪ increased efficiency of HPDC/PIM manufacturing will give the bases for increased production, sales and use of these components
- ♪ competence/know-how developed in the project will be further utilised in EU manufacturing industry, contributing to improving the quality of their products, to win the competition with low cost/low quality products coming from some Asian Countries;
- ♪ increase in the process yield and in the quality content of castings (these are their specific MUSIC outcomes) will lead to new applications;
- ♪ for **SMEs** engineering companies, the availability of the Intelligent System will give them more reliability since the design stage, thanks to an improved material and process knowledge.

Industries:

- ♪ for end-users industrial companies, the possibility of employing new-concept components will improve the technological margin of their products (improved reliability and safety, cost optimisation).

Universities and Research Centres:

- ♪ for universities and research centres, leading the diffusion of a new knowledge based approach in manufacturing & engineering, developing specific educational programmes, is a demanding challenge.

The **benefits for consumers** are clear: "zero-defect manufacturing" for HPDC/PIM products means increased safety (for any kind of product considered) and decreased costs (no scraps, better efficiency in processes, less energy consumption).