# SUPREME

## The objectives of the project

SUPREME aims at optimizing powder metallurgy (PM) processes throughout the value chain. It focuses on a combination of fast growing industrial production routes and advanced ferrous and non-ferrous metals. By offering more integrated, flexible and sustainable processes for powders manufacturing and metallic parts fabrication, it enables the reduction of the raw material resources losses while improving energy efficiency and thus carbon dioxide emissions, into sustainable processes and towards a circular economy.

To achieve this goal, an ambitious cross sectorial integration and optimization has been designed between several PM processes; gas and water atomization as well as mechanical alloying for metal powder production, additive manufacturing and near-net shape technologies for end-parts fabrication. A consortium of 17 partners is gathered on this purpose under the coordination of CEA-LITEN. It sees a mix of organizations covering the full value chain from mineral to end parts applications: ASL (UK), CEA (France), CRF (Italy), Dellas Srl (Italy), EPMA (Belgium), Fundación Idonial (Spain), GKN Sinter Metals (Germany), IPC (France), IRIS (Spain), MBA (Spain), MBN (Italy), Outotec (Finland), Prismadd (France), Renishaw (UK), RHP (Austria), Tecnalia (Spain) and TWI (UK).

SUPREME is a H2020-SPIRE funded project with an EU contribution of almost €8m. The innovations resulted from the close cooperation between RTD organizations and companies aim a transfer to the market to have significant impact on wealth and jobs creation.

The overall objective is to optimize the sustainability of PM processes and hence to contribute to improvements in terms of resource and energy efficiency. More specifically, the great value added of this consortium is to address several key process industries: minerals, ferrous and non-ferrous metals. SUPREME is also contributing to achieve the objectives of the EIP Raw materials and to foster the transition to a circular economy in Europe.

# Work performed and main results achieved so far

Regarding mineral processing, an Iron ore mine in Sweden was selected for the 1st demonstrator. Stability of the grinding process results, throughput and electricity consumption were collected for evaluating the future improvements. On-line measurements of particles and slurries are installed for real-time information.

Regarding powder production, the expected gas- (GA) and water-atomized (WA) powders have been delivered to partners. Evaluation of yield and energy consumption per kilogram of atomized powder of current gas atomizer for 316L powder has been done for later comparison with a new gas atomizer (2nd demonstrator), commissioned in September 2018. A WA High Carbon Steel powder has been proved to be compatible with Laser Powder Bed Fusion (L-PBF) process. A cobalt-free powder composition has been selected for Metal Injection Molding (MIM) and produced by ball milling with good sphericity.

Regarding 3D metal printing, a single laser and 4-lasers L-PBF Renishaw machines are planned to be used to increase productivity (3rd demonstrator – parts 1 & 2). Regarding Plasma Metal Deposition (PMD) process, yield has been optimized for three alloys by adjusting parameters. Deposition rate was increased from 1.5 kg/h to 3 kg/h. For the L-PBF powders re-use study, after 12 cycles with same Inconel 625, the powder properties and parts mechanical properties remain unchanged. Optimized parameters in a L-PBF machine (3rd demonstrator - part 3) allow to produce higher than 99.5% dense (High Carbon steel) parts.

Regarding MIM process, WA 17-4PH and GA 316L feedstocks were prepared and fully characterized; for 17-4PH, the reduction of debinding time compared to commercial feedstock lead to yield process improvement; tensile properties are comparable to commercial solution. For the Co-free alloy, feedstock development, water debinding, and first injection trials have been done and lead to 98% dense parts. Regarding the Hot Isostatic Pressing (HIP) process, tensile and Charpy tests of Nitrogen-GA-powder HIPped samples show lower necking and impact strength than specified but Plasma-atomized-powder reached the specifications.

Nine use-cases have been selected: a gang saw blade tool for cutting stones (Co-free material by MIM); a bracket used as a motor support for aeronautics (Inconel 625 by L-PBF); 2 medical implants (316L by L-PBF and MIM) and 2 medical tools (17-4PH by L-PBF and MIM); 2 automotive engine mounts (by L-PBF and by PMD), the former corresponding to the 4th demonstrator; and mold inserts including a lattices structure for injection molds (L40 tool steel by L-PBF).

| #1 | #2 | #3 | #4 |
|---|---|---|---|
| Continuous minerals concentration process efficiency improvement applied to metal powder production | Batch metal powders manufacturing efficiency based on atomization | Batch metal part manufacturing process efficiency based on additive manufacturing | Business validation of yield and energy improvement regarding products performances and costs |
| Fe ore<br>OUTOTEC / LKAB | 316L GA<br>ASL | L-PBF (316L GA or Hard C Steel)<br>GKN (200W) & RENISHAW (500W & 4x500W) | Auto (Hard Carbon Steel Engine Mount)<br>CRF |

*Figure 1 : Demontrators*

Regarding quality and process control, the production route and specific processes to be monitored have been selected. Demonstrators are: (i) iron ore grinding process, (ii) gas atomization process, (iii) 3D metal printing of topologically-optimized automotive part with 3 different L-PBF machines. Information for each process of the current and SUPREME production routes were collected, as well as baseline values for the Key Process indicators (KPIs). A monitoring system, aiming at retrieving data from the demonstrators and quantifying the improvements between old and SUPREME processes, is currently under construction.
The project was promoted through various means (logo, leaflets, poster, public website, EPMA newsletter, 4 SUPREME Newsletters, Conferences & Exhibitions); posters and papers presenting the project were given at Euro PM2018 and Euro PM2019.

## Expected results and potential impacts

Results beyond the state of the art are: (i) Hot pressed and sintered Co-free cutting tools parts showed density over 97.5%, good mechanical properties and diamond retention; (ii) Tensile and hardness properties of a steel alloy obtained by PMD are comparable to the ones of the corresponding wrought alloy; (iii) after twelve re-use of Inconel 625 in L-PBF, neither the powder properties, nor the mechanical properties are impacted; (iv) High Carbon Steel parts with density higher than 99.5% without cracks were obtained by L-PBF starting with a water-atomized powder and their tensile properties fulfilled the specifications. A first topologically optimized L-PBF High Carbon Steel engine mount was fabricated with a 33% weight reduction compared to its cast counterpart.

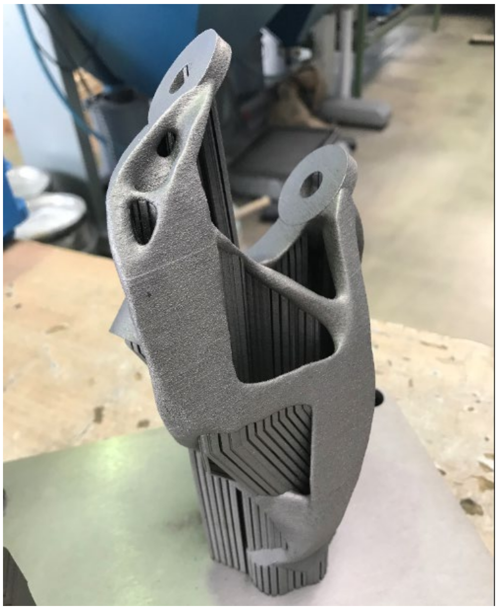

***Figure 2 :*** **1st topologically optimized part produced by L-PBF process**

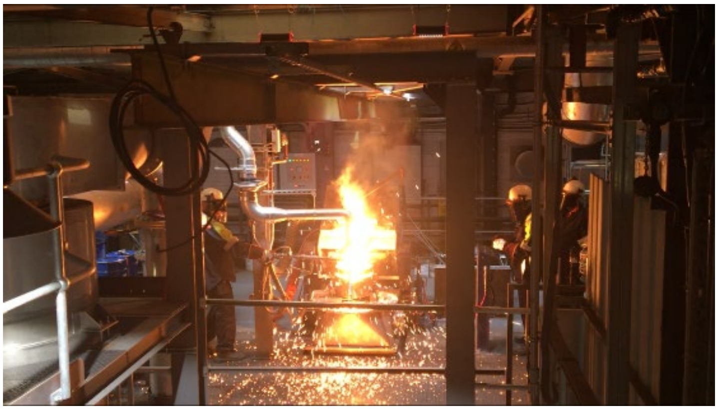

***Figure 3 : Improved gas atomisation***

Expected results until the end of the project are numerous; for, at least, the four demonstrators mentioned previously, the aims are to quantify material and energy efficiency improvements and to track impacts on productivity and $CO_2$ emissions.
Potential impacts are:

- (i) 25% reduction in yield losses when compared to the current practice
- (ii) 10% improvement in energy efficiency
- (iii) Adoption of the new technological improvements for enhanced resource efficiency in industrial processes
- (iv) regarding direct environmental impact, use of Fe based material instead of Cobalt will improve the working conditions and reduce the European industry dependence to critical metals
- (v) in the automotive and aerospace sectors, enabling lighter weight and higher strength structures will significantly contribute to the reduction of vehicle and aircraft weight and, by this, will contribute to the reduction in fuel and electricity consumption, hence less carbon dioxide emissions. A reduction in energy consumption during the powder manufacturing process will also have a direct impact on the intrinsic energy content of the finished part.

***Figure 4 : Participants of the T0+18 SUPREME Meeting in Brussels***

Find out more at www.supreme-project.com

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