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SUPREME Project: Sustainable and flexible powder metallurgy processes optimization by a holistic reduction of raw material resources and energy consumption

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Abstract

SUPREME aims at optimising powder metallurgy 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, SUPREME enables the reduction of the raw material resources (minerals, metal powder, gas and water) losses while improving energy efficiency and thus carbon dioxide emissions, into sustainable processes and towards a circular economy.

Introduction

To achieve this goal, an ambitious cross sectorial integration and optimisation has been designed between several powder metallurgy processes; gas and water atomisation as well as mechanical alloying for metal powder production, laser based additive manufacturing and near-net shape technologies for end-parts fabrication. A consortium of 17 partners has been gathered on this purpose under the coordination of the Commissariat à L’Energie Atomique et aux Energies Alternatives (CEA, France). CEA-LITEN is a major European research institute and a driving force behind the development of sustainable energies and Powder Metallurgy technologies.

Project partners

SUPREME [1] is a H2020-SPIRE funded project, which EU contribution represents almost €8m for 17 partners from 8 countries. 60% of the budget has been dedicated to industrial partners whose 30% for SMEs, which makes it an industrially-driven project. The innovations resulted from the close cooperation between research and technology organizations and companies aim a transfer to the market to have significant impact on wealth and jobs creation.

The Consortium sees a mix of organisations covering the full value chain from mineral to end parts applications: Atomising Systems Ltd (United Kingdom), CEA (France), Centro Ricerche Fiat (Italy), Deltas Srl (Italy), European Powder Metallurgy Association (Belgium), GKN Sinter metals (Germany), Innovation Plasturgie Composites (France), IRIS (Spain), MBA Incorporado SL (Spain), MBNnanomaterialia (Italy), Outotec (Finland), Prismadd (France), Prodintec (Spain), Renishaw (United Kingdom), RHP Technology GmbH (Austria), Tecnalia Research and Innovation (Spain) and TWI Ltd (United Kingdom).

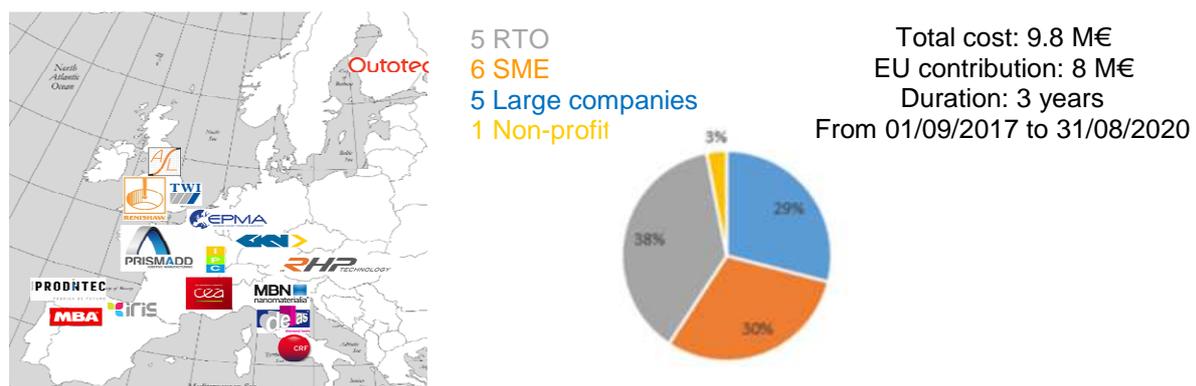


Figure 1: SUPREME consortium and budget

Its overall objective is to optimize the sustainability of powder metallurgy processes and hence to contribute to the goals of the Public-Private Partnership (PPP) in terms of resource and energy efficiency improvement. More specifically, the great value added of this consortium is not only its ability to cover the full value chain from raw materials to a broad set of end parts applications (from aeronautics to medical), but also to address several key process industries: minerals, ferrous and non-ferrous metals. SUPREME is also contributing to achieve the objectives of the European Innovation

Partnership (EIP) Raw materials, and more generally to foster the transition to a circular economy in Europe.

Context of the project

The automotive sector is the major market for sinter/press structural Powder Metallurgy parts. Globally, the automotive sector acquires highest market share of 73% of all Powder Metallurgy structural components¹. Most of the components nearly around 75% are utilized for transmissions and engines. The industrial motors/controls and hydraulics has a market share of 9%. SUPREME addresses both Additive Manufacturing (AM) and Near-Net Shape (NNS) Powder Metallurgy processes (Figure 2a), covering a wide particle size distribution (Figure 2b). Powders used are either produced by gas atomization or water atomization. While the former are rather spherical, the others have very different morphologies (Figure 3).

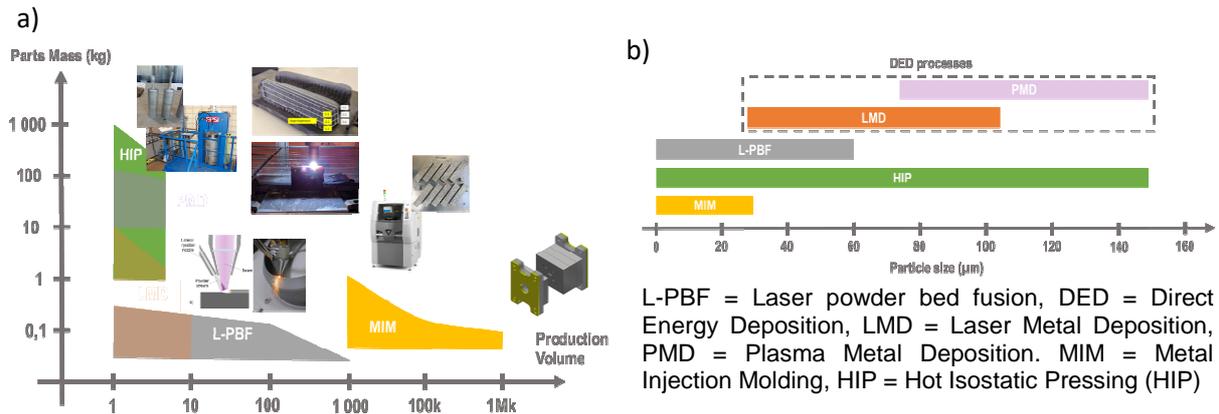


Figure 2: a) Parts Mass versus Production volume for the five PM processes addresses in SUPREME; b) Typical particle size ranges of these processes

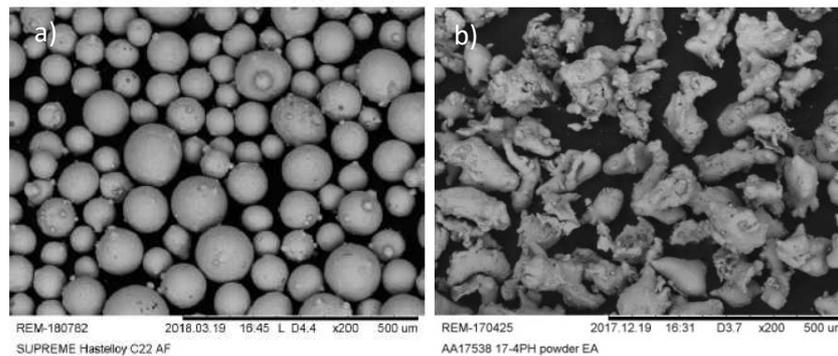


Figure 3: Examples of: a) Gas-atomized and b) Water-atomized powders

Project concept

The overall objective of SUPREME is to optimize ferrous and non-ferrous metal PM processes, currently individually available at TRL7 and beyond, by cross-sectorial improvements in material and energy efficiency throughout the value chain, from raw materials (fluids, solids or gases, including minerals and water) to finished products in a range of different end-applications (automotive, cutting tools, aeronautics, medical and tooling). The goal is then to demonstrate a new integrated and optimized approach of a set of PM production routes in real industrial settings, from TRL5 to TRL7, i.e. ready for adoption on the PM market. This will enable a significant reduction in the total cost

¹ Data from CETIM 2016

breakdown as well as in the environmental footprint towards a more sustainable Industry, and therefore to reinforce PM Industry competitiveness in Europe to maintain and develop jobs. The SUPREME project is covering the all value chain from raw material extraction to end-user demonstrators. For each step, a demonstrator will be set, in order to demonstrate the savings (energy, fluids and raw materials) achieved during the project (Figure 4). Demonstrator 1 targets the minerals extraction efficiency improvements, Demonstrator 2 the powders manufacturing efficiency, Demonstrator 3 the manufacturing process efficiency, and Demonstrator 4 the savings (energy & resources) given for each application covered by the project industrial partners.

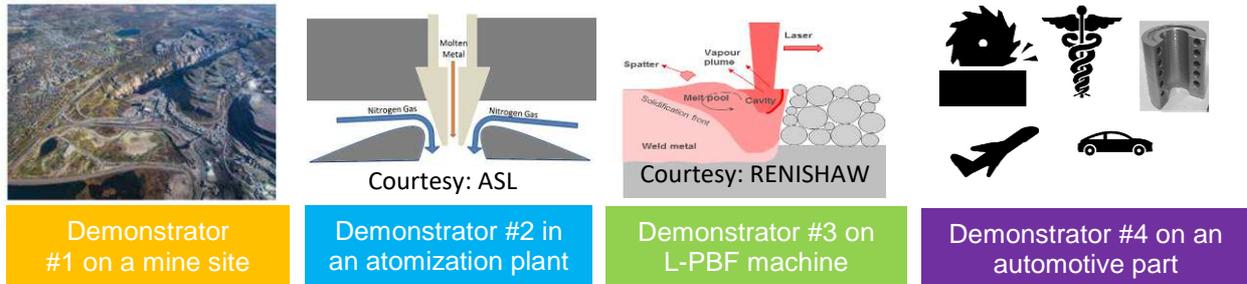


Figure 4: A demonstrator planned at each step of the value chain

Project methodology

SUPREME project aims to achieve a holistic processes optimization for more sustainability in Powder Metallurgy that will be quantified by a set of Key Performances Indicators (KPI), monitored by a quality and process control, and validated by an eco-innovation methodology. Depending on the type of PM process considered, the parameters available for process control and monitoring as well as the current practices in the sector to be compared to, the KPIs will be defined as follows:

- Two main KPI to quantify material and energy efficiency improvements: Raw material resources efficiency AND Energy efficiency,
- Two KPIs derived from the above main KPIs to track impacts on productivity and CO₂ emissions: Production rate AND Carbon dioxide emissions.

Several production routes have been defined to demonstrate process optimization in terms of raw material resources reduction, energy efficiency, yield improvement, carbon dioxide decrease based on a set of advanced ferrous and non-ferrous metals. On the upstream of the value chain, SUPREME should enable to achieve more efficient mineral concentration based on on-line process control and grinding energy use: a process demonstration is planned in real operation settings. Then, SUPREME will address powder manufacturing, by covering atomisation and mechanical alloying processes.

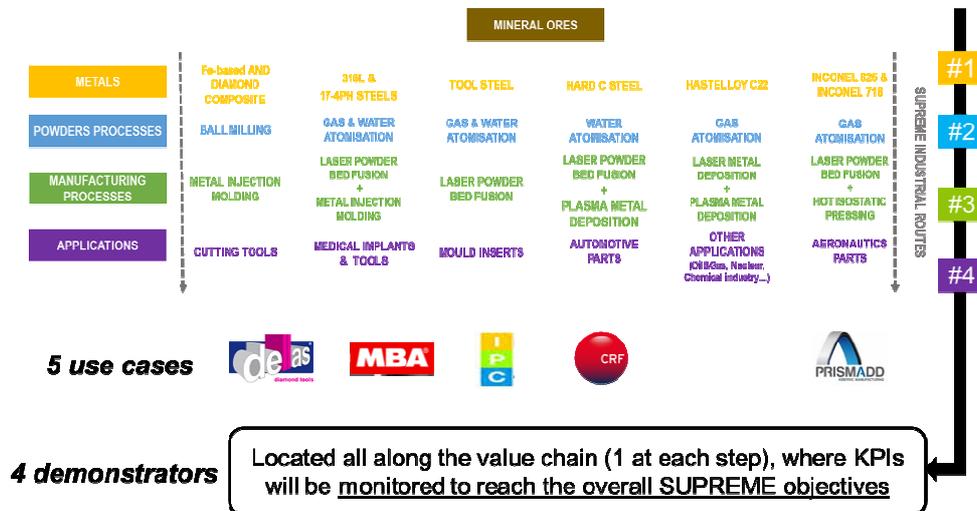


Figure 5: Description of SUPREME production routes, use cases and positioning of demonstrators

Quality & Process monitoring system:

Key Performances Indicators (KPI) will be monitored by a quality and process control, that will be developed and implemented at each step of the supply chain, i.e. for each demonstrator. The process control system will be composed of a set of sensors and a process control platform which will integrate the inputs from all process relevant information and produce recommendations or even closed loop control for improving the yield and critical process parameters (Figure 6).

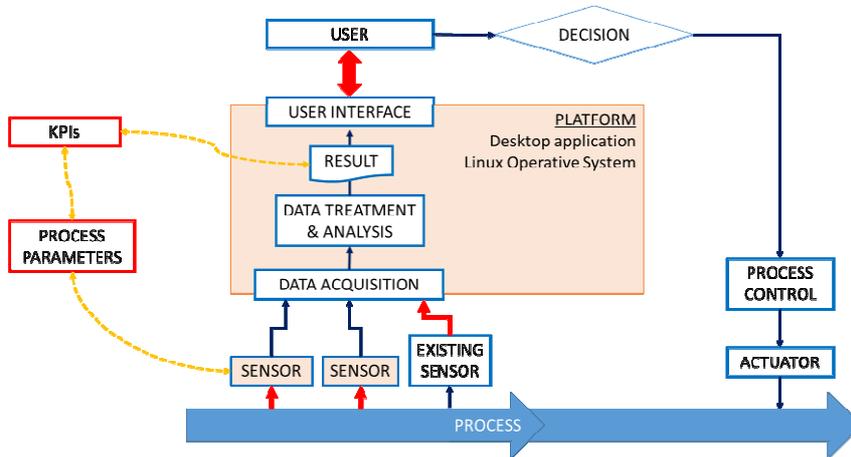


Figure 6: Schematics of the principle of process parameters and KPI measurements

Project objectives

Overall objectives for each KPI:

The objectives were quantified for each KPI at each step of the value chain. The sum of the percentage gain for each KPI allowed to fix values of improvement or reduction compared to the current practices (Figure 7).

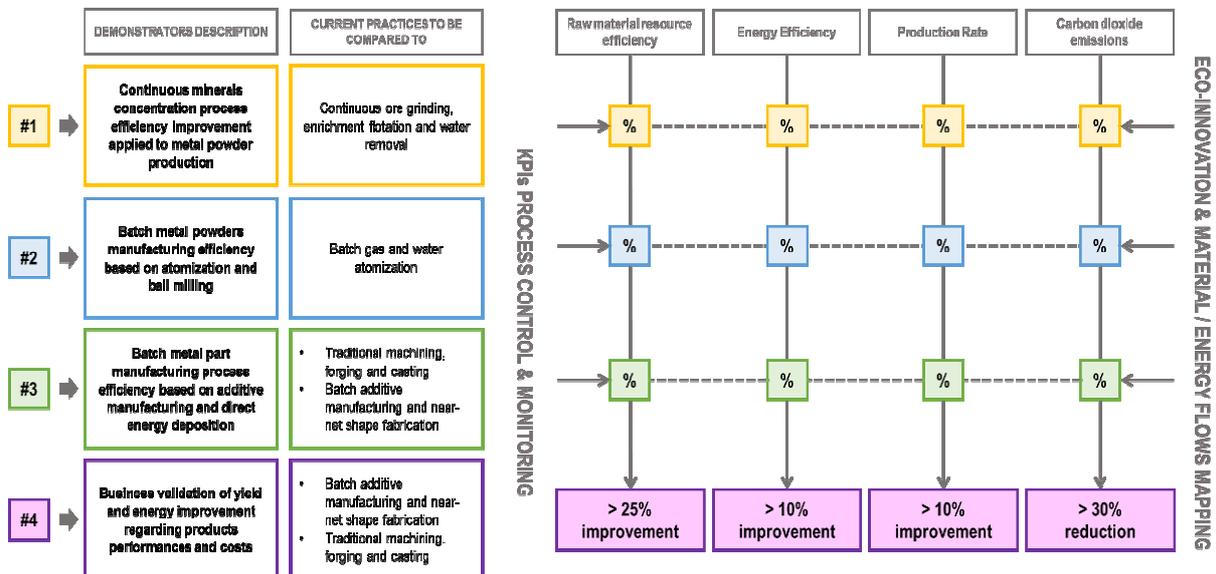


Figure 7: Matrix of the KPI gain percentage versus the four demonstrators

Baseline of current processes:

A mapping of material and energy flows throughout the value chain and across all covered PM metallurgy processes was performed. An example is given on Figure 8. At the end of the project, a cross-cutting eco-innovation methodology will track the progress and be able to map the process flows (material and energy) to demonstrate dioxide carbon emissions reductions.

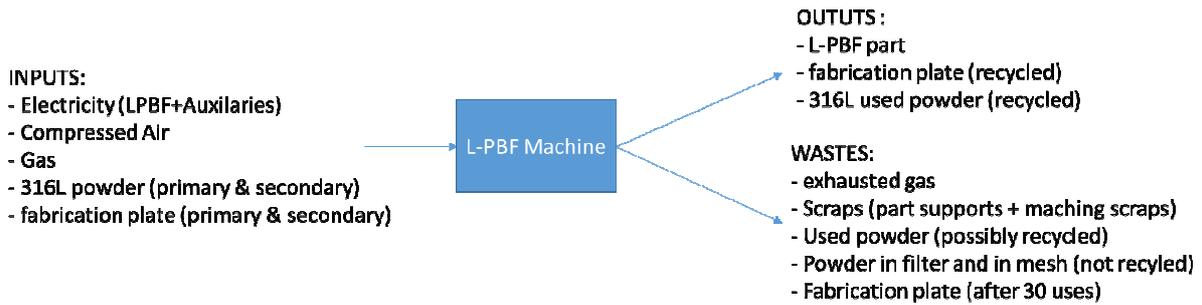


Figure 8: Global view of the inputs, outputs and wastes for the production of 316L parts on a L-PBF machine

First results

Four demonstrators have been selected. Demonstrator #1 located on a mine site will monitor three steps of the process: Fe-ore grinding, Fe-ore flotation and water management (Figure 9a). Demonstrator #2 in an atomization plant will gather data from power meters (Power consumption, see Figure 9b), run records (Length of run, mass of powder), PLC (Nitrogen consumption) and powder analysis (Powder size). Power Consumption per kg of different cuts, power used to produce N₂ gas and comparison between water-atomised and gas-atomised will be also monitored.

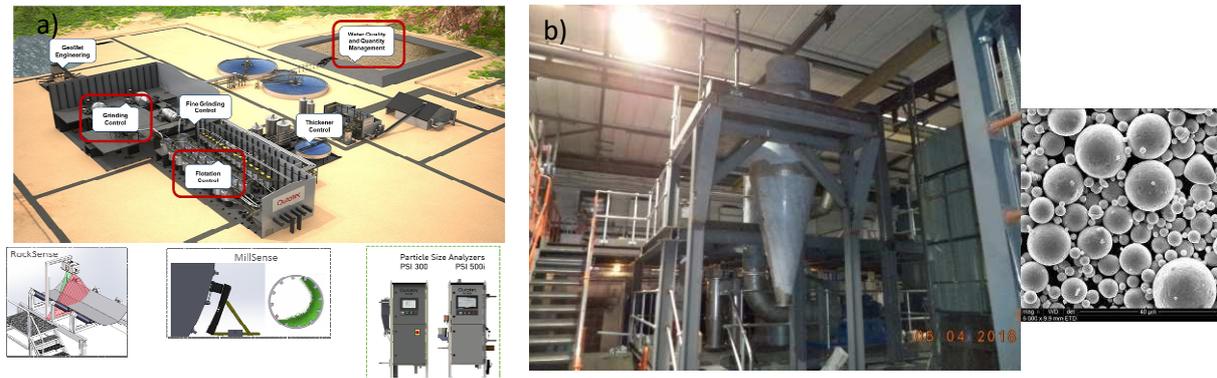


Figure 9: Demonstrators on a) Mine site; b) Gas Atomisation plant and corresponding powder

Demonstrator #3 on a 1kW-laser L-PBF machine will allow to measure the increase in L-PBF productivity, thanks to upgraded optics, new scan strategy, automatic powder removal system, new waste management and AM production system model (Figure 10a). Data from powders re-use study will also be taken into account.

Demonstrator #4 on a Hard-Carbon steel automotive part will consist of comparing KPI obtained from L-PBF process to the KPI of traditional processes and determine the gain percentage (Figure 10b).

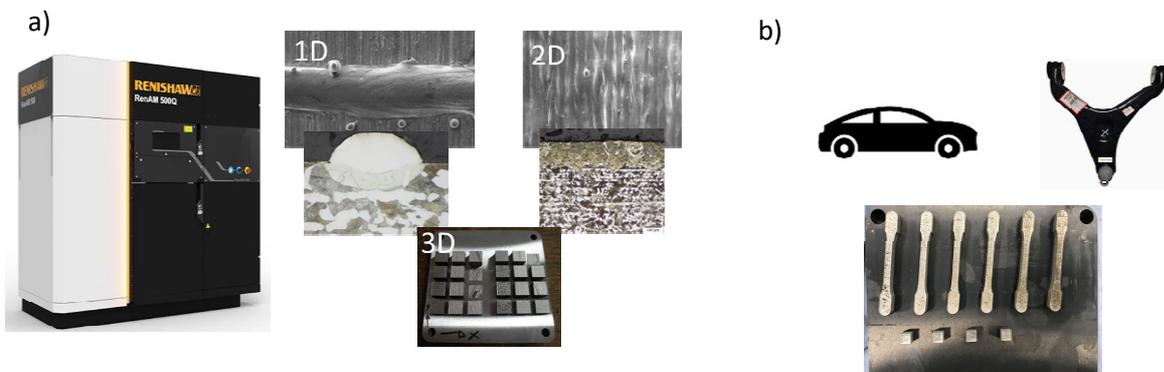


Figure 10: Demonstrators on a) L-PBF machine and b) Automotive part

Conclusion

The project should contribute to a more sustainable environment while helping to strengthen European process Industry competitiveness, in particular powder metallurgy, in today's global competition and tomorrow's future challenges for the planet.

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[1] <https://www.supreme-project.com>