Université Bourgogne Europe, Dijon, France

MASTER THESIS M2 CDM (5 months, Feb. - June)

2025-2026

Title of the project: Elaboration of duplex composite stainless steels by powder metallurgy

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Location/ Laboratory / Department / Team : Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB) UMR-6303 (Dijon)

Summary:

The production of metallic components through powder metallurgy is a rapidly growing field. Improving service properties is a key challenge for many industrial sectors, including aerospace and nuclear industries. In this context, Hot Isostatic Pressing (HIP) and Spark Plasma Sintering (SPS) represent alternative manufacturing and shaping processes for metallic parts, compared to conventional methods such as casting, forging, and machining. The advantages of these processes include:

- material-related benefits: the resulting microstructures differ from those obtained by conventional processes. In particular, they are highly homogeneous with fine, equiaxed grains, which can lead to improved mechanical and service properties;

- the ability to develop new material grades;

- shaping capabilities: HIP technology makes it possible to produce near-net-shape components, even with complex geometries, potentially reducing - or even eliminating - post-processing machining costs.

In a previous study, duplex composite steels (named COMPLEX steels) were successfully developed by mixing austenitic stainless steel powder (type 316L: γ, 17% Cr, 12% Ni, 2% Mo) with ferritic stainless steel powder (type 410L: α, 13% Cr). The originality of this approach lies in the fact that, in parts sintered by SPS and HIP, the characteristic size of the phases corresponds to the size of the initial powder particles (up to several hundred microns), which is significantly larger than the grain size typically observed in duplex steels produced by conventional methods. Five powder mixtures containing ferritic powder mass fractions ranging from 10% to 90% were sintered and characterized. Microstructural results revealed the formation of martensite at the austenite/ferrite interfaces, and EDS analyses showed that the diffusion of iron, chromium, and nickel between 316L and 410L influences the width of the martensitic region.

The objective of this internship will be to develop COMPLEX steels using a mixture of 316L austenitic and 430L ferritic powders, both containing the same chromium content. The study will focus on elemental diffusion phenomena within a powder mixture with homogeneous chromium composition, and on the resulting impact on the final microstructure. Both pressure-assisted sintering techniques, SPS and HIP, will be used in a complementary manner. The powders and the sintered materials will be characterized from a chemical and microstructural standpoint using optical microscopy, scanning electron microscopy, and EBSD analysis, coupled with X-ray diffraction. In parallel, mechanical properties will be evaluated through hardness measurements, impact testing, and tensile testing.

Type of project (theory / experiment): experiment

Required skills: knowledge in physical chemistry of metallic materials and metallurgy

To apply, please send a CV and a cover letter to:

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