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Thesis subject :

<u>Consideration of part-tools interaction in the numerical simulation of high pressure die casting process</u>

The manufacturing of high pressure dies casting parts (EDM housings, battery packs, structural parts…) requires the design, the manufacturing and maintenance of complex tools, the molds, specific to each part and which represent a significant part of the cost of the component.
Tool durability depends on many factors, including their design and how they will be lubricated and cooled by the cooling circuits during the process. On the other hand, the surface condition and the wear of the tools also have an influence on the quality of the part. There is a strong thermal, chemical, and mechanical interaction between the manufactured part and the tools in contact with this part throughout the process.
Concerning high pressure die casting, studies are underway to produce increasingly large and complex parts (Mega-casting). These developments make it possible to envisage significant cost reductions but make the development of the process and the control of the durability of the tools and the part more complex.
The multi-physical conditions (thermal, chemical and mechanical) involved in the process are extreme: aluminum in liquid phase (600°C), high pressure (1000 bars) and very high speed (180 km/h). During this thesis, an in-depth study, combining experimental and numerical analysis, will be carried out to identify the mechanical and thermal interactions that take place between the molds and the part, and understand the wear modes of the molds and their effects on these interactions.

Scientific challenge: Characterization and multi-scale and multi-physics modeling of the part/tool interface in high pressure casting.

After a period of immersion on an industrial site and a state-of-the-art review of industrial knowledge, the first step of the project will consist of the study of wear patterns and their impact on the mechanical properties according to the tool life (SEM images, EBSD mapping, X-ray diffraction (XRD) analysis, surface topography, compression tests, nanoindentation measurements).
The aim of the second main step will be to understand and quantify the impact of worn tooling zones on part quality and tool defectology, using an experimental and numerical design. For this purpose, a contact simulator will be set up, based on prototype benches developed at the LAMIH and the TriboLab test bench, capable of reproducing contact conditions combining high temperature and high speed, will be used. This will enable to qualify contact in the zones of interest targeted in step 1, in terms of friction, heat exchange and surface defects.
In parallel, each zone of interest will be simulated in great detail using FEM (Thercast© in particular), possibly coupled with DEM (Discrete Element Method) or SPH (Smooth Particle Hydrodynamic). These simulations will enable to determine the true thermomechanical contact conditions in the worn zone for a given nominal load derived from initial process models.

This study will enable to optimize the aluminum die-casting process, in particular through numerical simulation under degraded conditions. To contribute to this in the most generic way (applicable to several types of parts), a knowledge base will be generated (usable by an AI-type method), which will enable significant progress to be made towards mastering of wear and its impact on the success of the process.

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Candidate profile:

- Mechanical engineering degree with knowledge of materials processing and numerical simulation.
- Pragmatic scientific approach and good grasp of the economic context.
- Excellent oral and written communication skills in French (fluent) and English (B2).
- Desired skills: innovative spirit, ability to make proposals, collaborative spirit.
- The thesis work will be carried out in collaboration with STELLANTIS employees with extensive, often empirical, experience of forming processes. The candidate must therefore have the communication skills and open-mindedness to be able to dialogue and capitalize on this experience.

Start date: position to be filled in September 2024

CIFRE contract

Salary: around 36 750 euros gross/year

Host Laboratory : LAMIH, Université Polytechnique - Hauts de France, Valenciennes (59)
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