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Digitalisation and Artificial Intelligence in Forging

Creating a digital twin of a forging platform for operator training in a VR-environment

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Cyrille Baudouin is an associate professor. He works on forging workpieces inspection, in-situ data acquisition on forging devices, and monitoring of forging processes. He develops models to link process parameters and the quality of forging workpieces. Recently, he focused on the development of digital twins for the laboratory.

Abstract

In forging processes, numerical simulations are now indispensable tools for anticipating the outcome of a process without depending on physical experimentations. Unlike the experimentation, these simulations provide an advantage by allowing the estimation of variables that are difficult to measure in real-life situations, such as deformation fields and temperature distributions throughout the forged workpiece. They are highly effective in making accurate predictions and enable quick experimentation with different process parameters to explore various 'what-if' scenarios. Nevertheless, a significant limitation of these simulations is their time-consuming nature, preventing real-time predictions.

Recently, thanks to advances in computing capabilities and the development of surrogate models, the concept of digital twins has developed. The digital twin is considered to be a dynamic replication of the physical production system. As they are several definitions, we consider here that a digital twin includes five elementary building blocks: 1) a physical entity, 2) a digital entity, 3) a sensor data acquisition to update the digital environment, 4) advanced models to update the digital environment in

real-time, and predict future behaviour, 5) a data flow from advanced models to control the physical system.

The digital twin of the VULCAIN technologic platform (forging process) of the Design, Manufacturing, and Control Laboratory (LCFC, Arts et Metiers & Lorraine University - France) is currently being developed with the aim of training operators. Among the advantages of VR training on digital twin, we can mention the immersion in technological platforms at an industrial scale, a safety situation for trying trial and error scenarios, the visualization of invisible phenomena in a realistic context (working of the machine, or fields evolution for instance), or even attractiveness for young talents.

This presentation shows how the digital environment was built and the tools used for the dynamic motions of this digital twin. In particular, the implementation of surrogate models to adapt the geometry and the deformation field in the case of a copper upsetting, as faithfully as possible and with a quick calculation, is detailed. For the moment, the digital twin operates in asynchronous mode with respect to the physical entity but a training scenario makes it possible to understand the dissipation of kinetic energy into plastic deformation energy on a screw press. The operator can thus better judge how to conduct the process to avoid wasting energy dissipated in the press frame.