Single Point Incremental Forming to increase material knowledge and production flexibility

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Single Point Incremental Forming

to increase material knowledge and production flexibility

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Nowadays, manufactured pieces can be divided into two groups: mass production and production of low volume number of parts. Within the second group (prototyping or small batch production), an emerging solution relies on Incremental Sheet Forming or ISF.

ISF refers to processes where the plastic deformation occurs by repeated contact with a relatively small tool. More specifically, many publications over the past decade investigate Single Point Incremental Forming (SPIF) where the final shape is determined only by the tool movement. This manufacturing process is characterized by the forming of sheets by means of a CNC controlled generic tool stylus, with the sheets clamped by means of a non-workpiece-specific clamping system and in absence of a partial or a full die. The advantage is no tooling requirements and often enhanced formability, however it poses a challenge in term of process control and accuracy assurance. Note that the most commonly used materials in incremental forming are aluminum and steel alloys however other alloys are also used especially for medical industry applications, such as cobalt and chromium alloys, stainless steel and titanium alloys. Some scientists have applied incremental forming on PVC plates and other on sandwich panels composed of propylene with mild steel and aluminum metallic foams with aluminum sheet metal. Micro incremental forming of thin foils has also been developed.

Starting from the scattering of the results of Finite Element (FE) simulations, when one tries to predict the tool force (see SPIF benchmark of 2014 Numisheet conference), we will see how SPIF and even micro SPIF (process applied on thin metallic sheet with a few grains within the thickness) allow investigating the material behavior. This lecture will focus on the identification of constitutive laws, on the SPIF forming mechanisms and formability as well as the failure mechanism. Different hypotheses have been proposed to explain SPIF formability, they will be listed however the lecture will be more focused on the use of SPIF to identify material parameters of well-chosen constitutive law. Results of FE simulations with damage models will be investigated to better understand the relation between the particular stress and strain states in the material during SPIF and the material degradation leading to localization or fracture.

Last but not least, as industrial world does not wait that academic scientists provide a deep and total understanding on how it works, to use interesting processes, the lecture will review some applications. Examples in fields as different as automotive guard, engine heat shield, gas turbine, electronic sensor, shower basin, medical component (patient-fitted organic shapes) and architecture demonstrate that the integration of SPIF within the industry is more and more a reality.

Note that this plenary lecture is the result of the research performed by the author in the University of Liège (Belgium) and in Aveiro (Portugal) with the team of R. de Souza during PhD theses of C. Henrard, J. Sena and C. Guzman and different research projects. It is also a synthesis of the knowledge gathered during her interactions with many research teams such as the ones of J.R. Duflo from KU Leuven in Belgium, J. Cao from Northwestern University in USA, M. Bambach in BTU Cottbus-Senftenberg in Germany, J. Jeswiet from Queen’s University, Kingston, Canada who are currently working together on a state-of-the-art paper. The micro SPIF knowledge relies on contacts with S. Thibaud from the University of Franche Comté.