World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:13, No:03, 2019

Microstructure Evolution and Modelling of Shear Forming

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Abstract : In the last decades manufacturing needs have been changing, leading to the study of manufacturing methods that were underdeveloped, such as incremental forming processes like shear forming. These processes use rotating tools in constant local contact with the workpiece, which is often also rotating, to generate shape. This means much lower loads to forge large parts and no need for expensive special tooling. Potential has already been established by demonstrating manufacture of high-value products, e.g., turbine and satellite parts, with high dimensional accuracy from difficult to manufacture materials. Thus, huge opportunities exist for these processes to replace the current method of manufacture for a range of high value components, e.g., eliminating lengthy machining, reducing material waste and process times; or the manufacture of a complicated shape without the development of expensive tooling. However, little is known about the exact deformation conditions during processing and why certain materials are better than others for shear forming, leading to a lot of trial and error before production. Three alloys were used for this study: Ti-54M, Jethete M154, and IN718. General Microscopy and Electron Backscatter Diffraction (EBSD) were used to measure strains and orientation maps during shear forming. A Design of Experiments (DOE) analysis was also made in order to understand the impact of process parameters in the properties of the final workpieces. Such information was the key to develop a reliable Finite Element Method (FEM) model that closely resembles the deformation paths of this process. Finally, the potential of these three materials to be shear spun was studied using the FEM model and their Forming Limit Diagram (FLD) which led to the development of a rough methodology for testing the shear spinnability of various metals.

Keywords : shear forming, damage, principal strains, forming limit diagram
Conference Title : ICMFTMM 2019 : International Conference on Metal Forming Technology and Materials Modelling
Conference Location : Tokyo, Japan
Conference Dates : March 25-26, 2019

Open Science Index, Materials and Metallurgical Engineering Vol:13, No:03, 2019 publications.waset.org/abstracts/101233.pdf