World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:17, No:02, 2023

42CrMo4 Steel Flow Behavior Characterization for High Temperature Closed Dies Hot Forging in Automotive Components Applications

Authors : O. Bilbao, I. Loizaga, F. A. Girot, A. Torregaray

Abstract : The current energetical situation and the high competitiveness in industrial sectors as the automotive one have become the development of new manufacturing processes with less energy and raw material consumption a real necessity. As consequence, new forming processes related with high temperature hot forging in closed dies have emerged in the last years as new solutions to expand the possibilities of hot forging and iron casting in the automotive industry. These technologies are mid-way between hot forging and semi-solid metal processes, working at temperatures higher than the hot forging but below the solidus temperature or the semi solid range, where no liquid phase is expected. This represents an advantage comparing with semi-solid forming processes as thixoforging, by the reason that no so high temperatures need to be reached in the case of high melting point alloys as steels, reducing the manufacturing costs and the difficulties associated to semi-solid processing of them. Comparing with hot forging, this kind of technologies allow the production of parts with as forged properties and more complex and near-net shapes (thinner sidewalls), enhancing the possibility of designing lightweight components. From the process viewpoint, the forging forces are significantly decreased, and a significant reduction of the raw material, energy consumption, and the forging steps have been demonstrated. Despite the mentioned advantages, from the material behavior point of view, the expansion of these technologies has shown the necessity of developing new material flow behavior models in the process working temperature range to make the simulation or the prediction of these new forming processes feasible. Moreover, the knowledge of the material flow behavior at the working temperature range also allows the design of the new closed dies concept required. In this work, the flow behavior characterization in the mentioned temperature range of the widely used in automotive commercial components 42CrMo4 steel has been studied. For that, hot compression tests have been carried out in a thermomechanical tester in a temperature range that covers the material behavior from the hot forging until the NDT (Nil Ductility Temperature) temperature (1250 ºC, 1275 ºC, 1300 ºC, 1325 ºC, 1350ºC, and 1375 ºC). As for the strain rates, three different orders of magnitudes have been considered (0,1 s-1, 1s-1, and 10s-1). Then, results obtained from the hot compression tests have been treated in order to adapt or re-write the Spittel model, widely used in automotive commercial softwares as FORGE® that restrict the current existing models up to 1250ºC. Finally, the obtained new flow behavior model has been validated by the process simulation in a commercial automotive component and the comparison of the results of the simulation with the already made experimental tests in a laboratory cellule of the new technology. So as a conclusion of the study, a new flow behavior model for the 42CrMo4 steel in the new working temperature range and the new process simulation in its application in automotive commercial components has been achieved and will be shown.

Keywords : 42CrMo4 high temperature flow behavior, high temperature hot forging in closed dies, simulation of automotive commercial components, spittel flow behavior model
Conference Title : ICAMAME 2023 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering
Conference Location : Barcelona, Spain
Conference Dates : February 16-17, 2023