ABSTRACT

Fabrication of IN718 sheet components often require larger deformation loads at room temperature. In order to reduce deformation loads and simultaneously improve formability, IN718 sheets were solutionized at $970°C$ and $1070°C$, and these solution treated sheets were referred as HT970 and HT1070 respectively. It was found that the HT1070 material showed approximately 30 % improvement in ductility and 27 % reduction in load with respect to HT970 material indicating improvement in the formability. Stretch forming process map in terms of fracture forming limit diagram (FFLD) was evaluated, and the failure limit of HT1070 material was observed to be higher as well. Also, the deep drawing process maps were evaluated at different blank holding force using hemispherical and flat bottom punch geometries, and the results were presented in terms of three distinct regions viz. wrinkling, safe and fracture. Further, six different ductile fracture models incorporating Hill48 anisotropy plasticity theory were calibrated for both the solutionized sheets. However, due to higher variations in predicted results, the experimentally evaluated FFLDs were considered, and these were mapped into strain path independent major stress vs. minor stress locus ($\sigma - \text{FFLD}$) and effective plastic strain vs. stress triaxiality locus ($\eta \text{EPS-FFLD}$). The mapped failure limits were successfully utilized as damage criteria in finite element (FE) analysis to predict the forming performance. Further, surface roughness analysis was performed to comprehend the quality of the deformed components. A very high and undesirable surface roughness was observed in HT1070 deep drawn cups due to higher initial grain size. Also, it was established that the presence of higher amount of cube and goss components in the initial texture and large difference in Taylor factor of individual grains led to higher surface roughness. Further, uniaxial tensile tests of HT970 sheets were carried out at elevated temperatures within 773 K-1023 K under the strain rate domain of 0.001-1 s^{-1}. Based on the tensile test results, eight different constitutive models were developed to describe the flow stress behavior of IN718 sheet material incorporating the effect of temperature and strain rate. The thermo-mechanical FE model of limiting dome height tests at elevated temperature was developed by incorporating three different constitutive models viz. Johnson-Cook (JC), Cowper-Symonds (CS), and mechanical threshold stress (MTS). The predicted punch load, thinning development and surface strain distributions were validated with experimental data successfully.

Keywords: Inconel-718, Solution treatment, Microstructure, Micro-texture, Forming process maps, Fracture models, FEM, Elevated temperature forming, Constitutive models