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Forming Limit Analysis of Molybdenum Reinforced Carbon Steels

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Abstract. The occurrence of ductile fracture during the plastic deformation of powder metallurgy materials is adverse and damaging and the prediction of fracture is very important in the early stages as early modifications will prevent failure. This will tend to save a lot of money and forming limit studies in many metal forming processes is up most important. Forming limit analysis on the cold forged molybdenum reinforced carbon steels were carried out in this work. In this study two key strain hardening parameters are used to study the formability characteristics. This analysis is effectively used for design of powder metallurgy parts and most importantly the die design as repressing needs to be employed before pores appear as cracks on the free surface. The cold forging was carried out on Fe-0.8%C, Fe-0.8%C-1%Mo, Fe-0.8%C-1.5%Mo and Fe-0.8%C-2.0%Mo and the formability behavior of the same is presented.

Introduction

The forming limit of powder metallurgy materials is absolute necessary in designing of the forming operation and to produce defect free parts [1]. The formability of the powder metallurgy part is important in deciding if the compact will be shaped effectively or fracture occurs in the forming process. Poshal and Ganesan [2] predicted the values of deformation characteristics and formability factor using a proposed network model. They tested the model with experimental values and concluded that it is a promising technique and capable of predicting forming limit parameters together with production advice relating to many aspects of powder metallurgy including design, production and control. One of the important parameter, formability factor, β, developed by Abdel-Rahman and El-Sheikh [3] describes the effect of mean stress and the effective stress and the influence of density on the forming limit.

It is noted that both the strain hardening exponent and the strength coefficient are basic mechanical behavior performance parameters of metallic materials [4]. Strain hardening is vital in forming operations since it controls the amount of uniform plastic strain the material can sustain during deformation without failure [5,6]. Martin, Forn and Nogue [7] studied the strain hardening behavior and temperature effect in an attempt to optimize the parameters for deforming processes of powder metallurgy materials. Further, Narayanasamy et al. [8] explored on the instantaneous strain-hardening behavior of an aluminum-iron material. The effect of various iron content and preform geometry on strain hardening and densification were established. The present study evaluates the formability behavior by studying the strain hardening parameters, strain hardening exponent (n_i) and strenth coefficient (K_i) and plotting the forming limit diagram.

Experimental Details

The required amount of powders were taken and mixed in the planetary ball mill for 4 hours to prepare Fe-0.8%C, Fe-0.8%C-1%Mo, Fe-0.8%C-1.5%Mo and Fe-0.8%C-2.0%Mo powder composites. Then compacts of 18 mm height, 24 mm diameter and 0.86 relative density were prepared by compressing the powders using 1 MN hydraulic press. These compacts were sintered for 60 minutes in an electric muffle furnace and finally cooled in the same furnace. Open die cold forging was employed under dry friction condition and graphite lubricant condition. The geometrical