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Technical Report

Investigation on the effect of lubrication and forming parameters to the green compact generated from iron powder through warm forming route

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ABSTRACT

In order to generate green compacts of iron ASC 100.29 powder at above ambient temperature and below its recrystallization temperature, a warm compaction rig is designed and fabricated which can be operated at various temperature and load. The aim of this paper is to present the outcomes of an investigation on the effect of lubrication and forming parameters, i.e., load and temperature to the green compacts generated through warm compaction route. The feedstock was prepared by mechanically mixing the main powder constituent, i.e., iron ASC 100.29 powder with different weight percent of zinc stearate at different mixing time. Compaction load was varied from 105 kN to 125 kN using simultaneous compaction mechanism. The microstructures of the green compacts were analyzed by Scanning Electron Microscopy (SEM), and the mechanical properties are measured through density measurement, hardness test and electrical conductivity test. The study found that increase in compaction load as well as forming temperature give improved microstructure and mechanical properties. It is also found that effects of lubrication to the mechanical properties of green compacts are strongly dependant on the lubricant content as well as mixing time of iron powder with the lubricant.

1. Introduction

Nowadays, the number of engineering components and automotive parts manufactured from shaped and sintered metal powders has been increasing. In the last three decades, a wide range of structural components especially for the use as automotive parts has been developed for production using this method [1]. Most of them are manufactured by a process called die compaction method through warm forming route or conventional cold forming route. The production of solid components from powders by compaction and sintering is known as powder metallurgy, which has been existence since the early 1900s as a new generation of manufacturing process [2].

Powder compaction process is the production of any powder material by compacting in a container to a desired shape. The compacted powder mass is called a green compact, which only has sufficient strength to be handled for further treatment [3]. Powder compaction is an attractive forming process since it offers an approach to net-shape or near-net-shape manufacturing. The main objective in powder forming process is to obtain green compacts with relatively high density and uniform density distribution in the component [4]. Metal powder may be compacted either at room temperature, which is termed as conventional cold compaction, or at elevated temperature which is warm compaction, which was introduced in the market in 1994 [5].

Compaction process involves the transfer of pressure to each particle contained in the powder. Generally, the compaction mechanism relates directly to the density and the pressure [6]. When a powder is being compacted in a rigid cylindrical die, the axial pressure exerted upon the powder by the compaction punch is only partly transformed to radial pressure upon the die wall. This radial pressure can be quite substantial but it does not reach the level of the axial pressure because the powder is not a liquid and does not have any hydraulic properties [7]. Aggregates of metallic particles are considered as frictional, nearly non-cohesive and granular [8]. When the load acts upon the powder in the die cavity, the powder deforms plastically. Each of the particles fills the gap among them. This results in reduction of pores. This means, density increases inside the compacted powder. During compaction, powder exhibits strain or work hardening, the volume decreases and hardness increases [9].

Previous study on the effect of temperature to the deformation of powder has been conducted by Wechsler [10]. The study found that, the strength of the product is less dependent on forming temperature and pressure, but is strongly influenced by density, particle size and shape. However, an experimental work on microscopic aspect has been conducted by Gagne [11] in classifying the behavior of metal powder under compaction at 23 °C and 150 °C using Scanning Electron Microscope (SEM). This work showed that there

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