Analysis of the effect of compaction mode on anisotropy of thermal conductivity of compact

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Abstract

Heat transport through porous materials is a fundamental problem in many engineering applications including several powder metallurgy processes. In this work, we analyze the effect of compaction mode on the thermal conductivity of compacts in closed die compaction and hydrostatic compaction by a two-dimensional (2D) Discrete Finite Element Method (DFEM). The simulations show that the effective thermal conductivity increases with the relative density as expected. However, an anisotropy of conductivity develops in the specimen in uniaxial compaction, with the effective conductivity of the compact in the compaction direction is higher than the transverse one and it may be as high as 20%.

1. Introduction

Thermal properties of low relative density materials are important in many problems involving powders, such as sintering [1], Selective Laser Sintering (SLS) [2], microwave sintering [3] and powder beds under low pressure [4].

Many researchers have attempted to measure or model the effective thermal conductivity of particulate materials. In [5-8], the effect of porosity and size on the effective thermal conductivity was investigated. Hadley [9] and Tehranian etc. [4,10] investigated the effect of applied external loads on powder bed conductivity. Bounds method has been applied to derive the effective thermal conductivity of mixture of two phases composite [11]. Mean field or Effective Medium Theory (EMT) was also used to calculate conductivity [12]. The complexity of derived and proposed of expressions depends on how much information of pore structures are taken into account. A recent summary of these expressions is available in [13]. Argento and Bouvard [14] studied the conductivity evolution of monosize spheres via densification. Conductivity evolution between two particles was first calculated by finite element method and was used to derive an expression relating effective conductivity and relative density. This study considered only densification under isostatic stress condition.

Most of the thermal conduction work is limited to the compact under either isostatic stress or to thermal properties in axial direction under uniaxial compaction. The result may not be applicable to large and complex shape compacts which experience non-isostatic stress. In this work, we are studying the thermal properties of powders under the application of pressure. In addition to the usual examination of their dependence on relative density, we are interested in the potential of anisotropy as a result of the application of non-isostatic stress.