Contact models for discrete element simulation of the initial powder compaction in a hot pressing process

Jerzy Rojek[1], Kamila Jurczak[1], Szymon Nosewicz[1], Dmytro Lumelskyj[1] and Marcin Chmielewski[2]

[1] *Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland*
[2] *Institute of Electronic Materials Technology, Warsaw, Poland*

Summary: This paper presents discrete element studies of a powder compaction process using two different contact models. Performance of the elastic Hertz–Mindlin–Deresiewicz model has been compared with that of the plastic Storåkers model. The results of laboratory tests of the die compaction of the NiAl powder have been used to validate numerical results.

Introduction

The discrete element method (DEM) has been successfully employed to modelling powder metallurgy processes involving sintering, cf. [1–3]. The sintering in a hot pressing process is performed under uniaxial pressure applied before heating the powder in a die. The present paper is focused on modelling the initial compaction in this process.

Contact models

A number of contact models for powder compaction have been developed within the framework of the discrete element method [4]. A model assuming rigid plastic behaviour according to the Hollomon stress-strain curve has been developed by Storåkers et al. [5, 6]. The hot pressing is performed with a relatively low pressure (up to 50 MPa) therefore we have checked if the elastic model is suitable to represent properly densification mechanisms at these conditions. Compression of two equal particles with radii $R = 10\ \mu\text{m}$ (Figure 1(a)) typical for the real powder particles has been analysed. Figure 1(b) shows comparison of contact force curves as functions of particle indentation for the elastic Hertz model and the plastic Storåkers model with different values of the hardening exponent m.

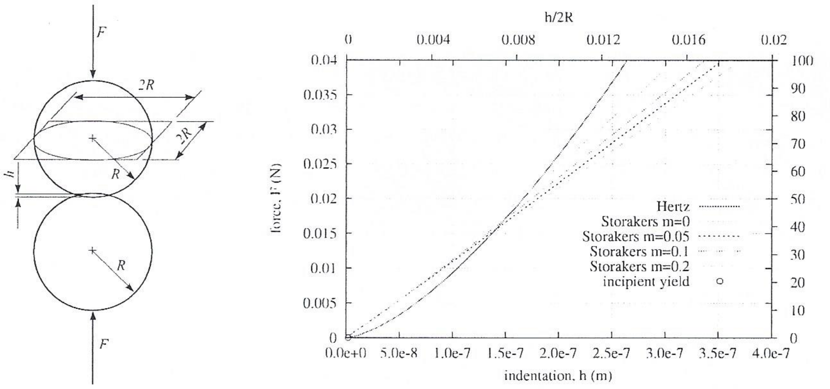
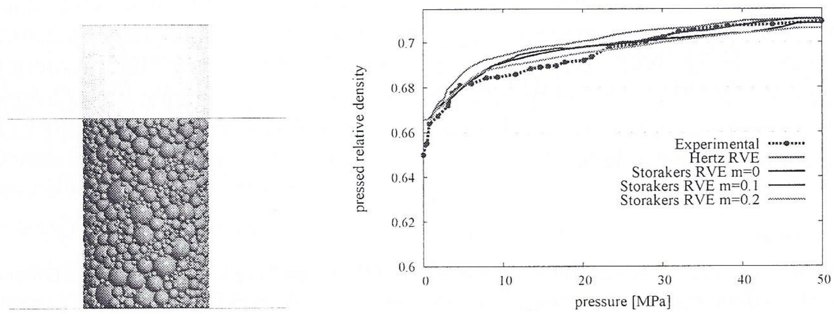


Figure 1: Compression of two equal particles: (a) problem definition, (b) contact force vs. indentation curves.

Simulation of powder compaction in a cylindrical die

The die compaction process of the intermetallic NiAl powder has been investigated experimentally and studied numerically. Simulations have been performed keeping the real size and size distribution of the powder particles and using a reduced cylindrical specimen and shown in Figure 2(a). The curves showing the relative density as functions of the applied pressure are given in Figure 2(b). The numerical results have been obtained for the Hertz and Storåkers models with zero friction conditions. The numerical results are compared with the experimental data showing quite a good agreement. Differences between the numerical results obtained with different models are relatively small. This is because the differences between the force–indentation curves predicted by the compared models in the range of contact pressure in our studies are relatively small, cf. Figure 1(b).



(a) (b)

Figure 2: Simulation of powder compaction in a cylindrical die: (a) DEM model, (b) relative density as a function of pressure – comparison of the numerical results for zero friction with the experimental data.

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