

## HSS Metal Powder Compaction Simulation with Assisted Friction

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### ABSTRACT

*The main objective of this study consists in improving density gradient in the powder compaction process, in defining a coherent approaching platform for the present-day trends in powder metallurgy research and development, and in developing a compaction process that could be used as a starting point for advanced powder processing technologies. Our approach will mainly focus upon issues concerning the conversion of the friction force in PM compaction processes.*

*Numerical simulation and metallic powder compaction process model are defined and exemplified by means of the MarcAutoforge software.*

**KEYWORDS :** simulation, active friction force, homogeneity.

### INTRODUCTION

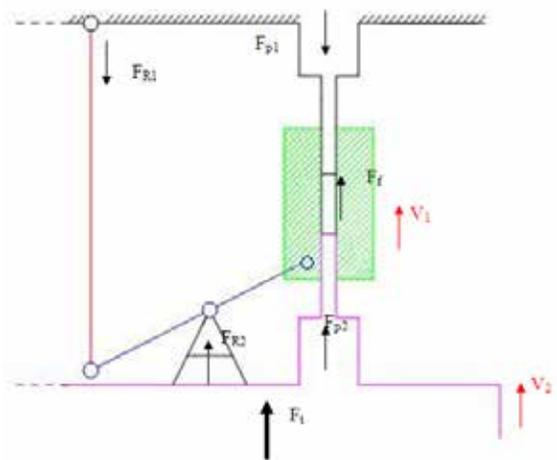
The metal forming industry is beginning starting to recognize the benefits which finite element analysis of metal-deformation processes could bring in reducing the lead time and in development costs associated with the manufacture of new components [5].

The simulation of the compaction process allowed to reproduce the density distribution [2,8,13] into the compact powder. Heterogeneity of the density distribution is a result of the stress transmission [1,6,7] that depends on the internal friction, as well as boundary conditions, contact powder/tools and lubrication. During the compaction process, the friction between powder and die leads to the heterogeneity of the density distribution. This heterogeneity has effects on mechanical resistance of compacts [3]. The density variation [7,14] in green bodies is subject to damaging during manipulations or low resistance, durability and exploitation of parts. Moreover, this heterogeneity is continuing to develop during the decompression and the ejection phases and leads to a dispersion of mechanical characteristics. Heterogeneity of the density distribution is principally owed to the friction imposed between tools and powder [3].

Aim of this study is to get a map of the improved gradient density in compact section, which highlight the active effect of friction between powder and die.

The compaction technique proposed in this research is the application of the principle of pressing powders activation friction in extrusion. This paper presents an improvement of PM parts compaction technique [9-12] using the friction force between pressing die and metal powders as an active force in order to reduce the density gradient on the green body length. Through the move of the die to the punch direction according to a particularly speed [Figure 1], the friction force acts in the same way as the pressing load and as a result, we have an improved pressing condition.

This activation of friction [4,11], in PM compaction processes, creates a peripheral flow of material to the central and peripheral axial-flow directions (Fig. 1b)). Material from these two locations can move simultaneously in the die and the result is the reduction of strains and the uniformity of strains, the increased strains, the increased working speed, and the increased degree of deformation. Thus, due the flow uniformity and standardization of their right under certain conditions, this procedure creates additional opportunities for reducing or eliminating the deformations.



**Figure 1. The compacting device [10]**

This paper presents the experimental and simulation results of compaction with active friction forces [4], density distribution for High-speed steel, DA 6.

### EXPERIMENTAL PROCEDURE

The process of cold compaction with active friction was used for powder densification. Before compaction, the powder was mixed with zinc stearate in a ratio of 0.5%. The activation of friction was achieved by the moving of mold container in the action of the lower punch direction.

High-speed steel, DA 6, with a particle size  $<160 \mu\text{m}$  was used in this paper.

Cold compaction using activated friction force method was used for densification of metal powders on compression test installation (Heckert) to 800 MPa pressure. Green cylindrical compacts with constant weight (5.5 g) have been carried out on a tensile-compression test installation driven by a hydraulic cylinder located at the bottom.

The proposed process consists in moving the die throughout the pressing, die movement in the same direction with a given speed  $V_f = 1.5 \cdot V_2$ . As a result, the frictional forces are acting in the same direction as the punch, and it is achieving a better distribution of powder flow throughout compaction process.

### FINITE ELEMENT SIMULATION

The commercial software MarcAutoforge was used to simulate the compaction process of HSS powder. The powder was modeled as a deformable continuum, while the punches and die were modeled as

analytical rigid bodies without any deformation. The wall friction effect was considered by adopting a Coulombic boundary condition on the interfaces powder/wall die and powder/punch [3].

Compaction pressure introduced into the simulation (pressure of lower punch) process was similar to the experimental data, 800 MPa.

Due to the axial symmetry, half of green body was meshed with square elements with edge of 0.5 mm. The simulation was performed in 100 items.

High speed steel powder density distribution is given by numerical simulation.

Relative density variation can be observed during compaction (Figure 2). This gradient of density distribution throughout the compacts height is between 37.82% -37.85% (Figure 2,a) particle rearrangement phase, start of compaction and 74.18% - 75.41% (Figure 2,d) in end-stage of compaction.

A similar results are obtained in this study, confirmed by an increase in the relative density, in agreement with the experimental results using the active friction force in compaction [9,11].

At the start of powder compaction the particles of powder does not suffering deformation. Filling vacancies by rearranging the particles and rolling and slip–stick are only moves made by these particles. Increased density, 37.84% can be observed on the axis, at a distance of about ¼ of punches (increment 2 - Figure 2, a).

It can be seen a positive influence of active friction force produced by movement of the die in same way with the lower punch. Thus, we also can note an increase of density in the peripheral and axial positions during the compaction are obtained, for compaction with an active friction force.

Increasing the axial density, in the compact from 38.05% ÷ 38.2% (increment 5 - Figure 2, b) up to 74.79% - 75.17% increment 100 - Figure

2, d) is due to the influence of punch action and the uniform density distribution throughout the height of compact is due to the active friction effect.

Predicted density of green bodys obtained by activating the friction forces in compaction increases by 3-4% comparatively to the compacts obtained by classical compaction. A good agreement between finite element simulation and experimental results was conducted by comparison between predicted density distribution and experimental density presented in [9,10].

Active friction forces between powder and die favorably influenced the densification of the powder. As a result, very dense areas are developed on the contact punch - die corners of the compact and a dense in core. Density increases from the upper to the lower punch. Activation of friction forces by moving die produces an improvement in density in the central – axially area and in peripheral area.

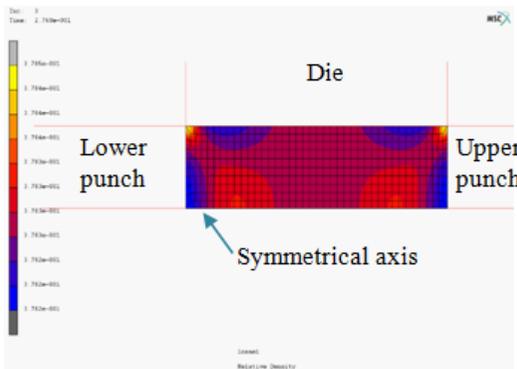
**CONCLUSIONS**

In this paper the simulation was performed using the commercial MarcAutoforge software. The compaction using friction as active force of a HSS powder was performed and simulated. A good representation of the HSS powder behavior into compaction has occurred.

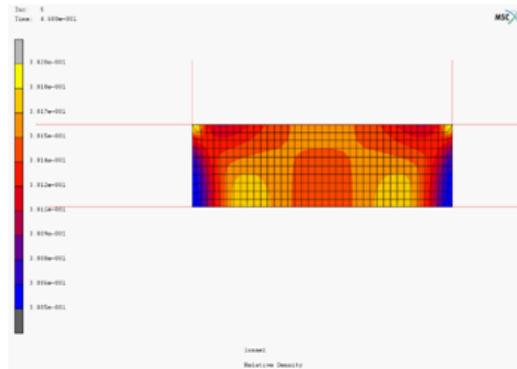
The simulation of the compaction powder process allowed to be reproduced the gradient of density. This method of compaction leads to an increase of homogeneity of the density on height of green body.

The active effect of friction leads to favorable influences expressed by an increase of 3-4% density.

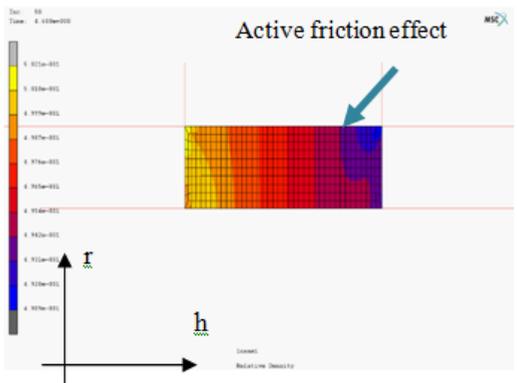
The advantages of this approach is the opened access for understanding, analyzing and predicting the density gradient caused by stress produced through the die walls moving at the same time with lower punch, but with a higher speed. One can conclude, from this work, that some of the parameters were well simulated and the simulation results are similar to the experimental results.



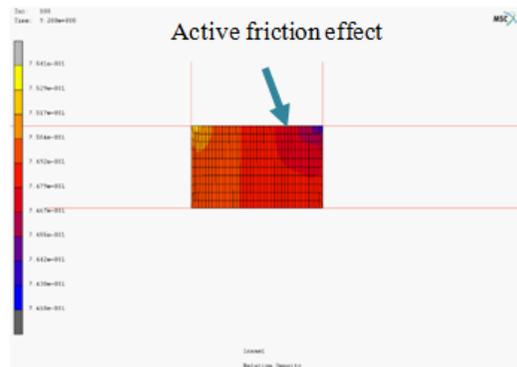
a)



b)



c)



d)

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