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A STUDY OF SIMULATION MADE ON POWDER COMPACTION USING FRICTION FORCE AS ACTIVE FORCE

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Abstract: *The purpose of this study is to simulate powder compaction process with active friction forces for stainless steel powder 316L, and what is the impact of friction forces to increase densification in compaction process.*

The process is intended to be used in the compaction of hard deformable materials, which required very high compaction pressures. These pressures involve significant wear of the tools produce the compaction and thereby increasing production costs of finished parts from metal powders.

Keywords: *Simulation, stainless steel powder, active friction force*

1. INTRODUCTION

The compaction technique proposed in this paper is the application of the principle of pressing powders activation friction in extrusion.

Present paper deals with a technique for compaction of PM parts [5, 6] by use the friction force between pressing die and PM green compact as an active force in order to reduce the gradient density on the component length. By moving the container of the die to the punch direction according of a particularly speed, the friction force acts in the same sense as the pressing load with the results of improving pressing condition. The paper presents the experimental and simulation results of compaction with active friction forces and classical compaction [3], density distribution for 316 L stainless steel.

Technological processes that use pressure to achieve plastic deformation state are common element of friction forces. These forces can be active or resistive character depending on the context of their occurrence as: desirable or undesirable phenomenon in engineering.

The process of compaction, it involves a complex: factors, material and process variables [1, 2, 7].

2. EXPERIMENTAL PROCEDURE

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%. Activation of friction was achieved by moving the mold container in the direction of action of the lower punch.

Material. Stainless steel powder 316L produced by gas atomization, with a particle size < 120 µm was used in thus paper.

Process. Cold compaction with activated friction force.

Tools and devices. Compression test installation (Heckert) with maximum force of 200 KN

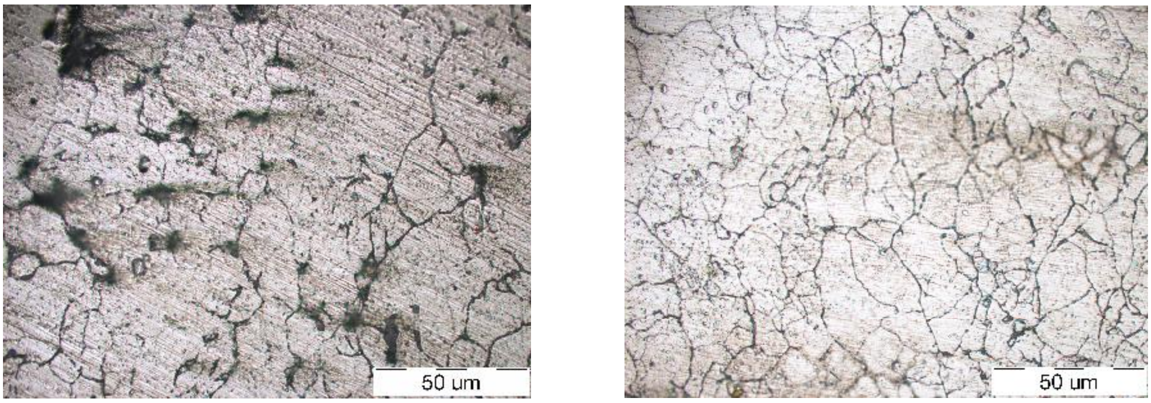
Green cylindrical compacts have been carried out on a tensile-compression test installation driven by a hydraulic cylinder located at the bottom.

Sintering. Vacuum furnace room is equipped with an electric heater and temperature control, so they were maintained in vacuum (10^{-4} bar) at a temperature of 1200 °C for 60 minutes.

The proposed process consists in moving the die during the pressing, die movement in the same direction with a given speed. As a result, the frictional forces acting in the same direction as the punch achieving a better distribution of powder flow during compaction process.

3. RESULTS AND DISCUSSION

Experimental results:
A comparison was made between classical compaction and compaction with friction using the active force at pressures of 600 and 700 MPa.
Densities were obtained after sintering Figure 3 between 82% and 89%, in line with the literature [4] (to 1240 °C value obtained is 90% of theoretical density), taking into account the conditions of sintering.
We obtained a uniform density distribution for samples of 10.5 grams for compaction with friction using the active force and lower values 1% ÷3% for samples compacted classic.
Microstructures (Figure 1) made on the evidence presented polygonal grains with rounded edges.



a) b)

Figure 1. 316L stainless steel microstructures at pressures of 700 MPa:
a) classic compaction b) compaction with active friction force

Austenitic phase is represented by light gray. We see a large number of pores, dark, some of them interconnected, where classical compaction, compaction unlike friction using the active force, where they are rare, small and rounded.
Simulation:
With program MarcAutoforge we simulated the two methods of compaction of 316L stainless steel powder. We passed to simulating processes after entering all input data (material, lubricant, die size, punch, equipment, strength, size of the final green compact and step grid).
Die size:

$$d_{\text{int}} = 11.2\,[mm];$$

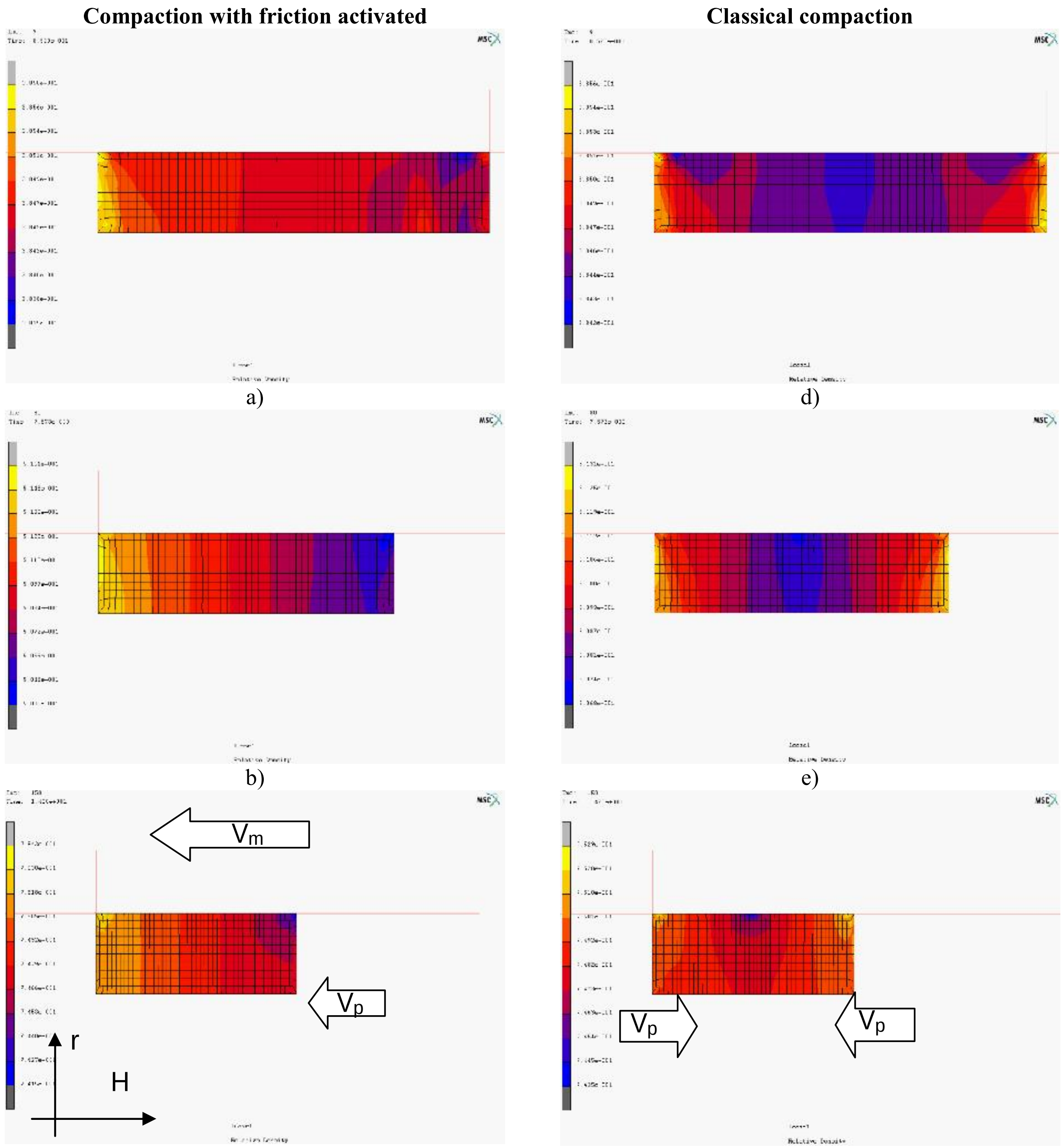
$$d_{ext} = 70\,[mm];$$

$$l = 65\quad[mm\ ]$$

Punch size:

$$d = 11.19\,[mm\ ]$$

The analysis model is an axially symmetric model, finite element modeling of the structure was carried from of field closed half boundary plan. Achieving this has involved the generation of a boundary contour, the lines that define the model of analysis. Cartesian coordinate system was used to obtain mesh grid model. Border area of the geometric model of the plan is a rectangle.
Considering all input data, the laws of material flow and function for porous materials and the laws of friction was switched to running the simulation for the two compaction processes.
Evolution type of compaction densification approach can be seen in Figure 2.



a) d)
b) e)
c) f)

Figure 2 Simulation of compaction 316L stainless steel samples

We see the positive displacement matrix for compaction using friction as active force (Figure 2 a, b, c) compared with conventional compaction (Figure 2 d, e, f). Thus, there is an increase of density in the peripheral and axial zone of the green compact during densification in compaction process using the active friction forces.

Density distribution for process of compaction (Figure 2) is represented by bands of blue, red, yellow, depending on the degree of densification.

Density resulting from the compaction simulation with friction using the active force (Figure 2 c) vary between 7.673 [g/cm^3] in the upper right represented by dark blue (the lower punch) and 7.843 [g/cm^3] represented in yellow in the upper punch and the density resulting from classical compaction are between 7.701 [g/cm^3] in the central peripheral (represented by blue) and 7.821 [g/cm^3] represented in areas with little yellow top and bottom punches. One can see that we achieved a better distribution of the density on approximately two thirds of the surface, on compaction with active friction using to about half if classic compaction.

Maximum deformation zones are identified by yellow, where the maximum local density reached 7.843 [g/cm^3] for stainless steel compacts 316L obtained by compaction with friction activated (Figure 2 c) and 7.821 [g/cm^3] for compacts 316L obtained by classical compaction (Figure 2 f).

We can see a greater maximum deformation area for compaction with active friction forces than conventional compaction where a few small areas have reached maximum values.

4. RESULTS AND DISCUSSION

Cylindrical green compacts were made of 10.5 grams with classical compaction and friction activated compaction at a pressure of 600 [MPa] and 700 [MPa]. The inner diameter of the die is 11.12 [mm].

Density gradient was determined experimental. Height density distribution reported in parts was determined by Archimedes method.

Half the compact green density distribution obtained after the simulation process is shown in Figure 2, which shows how the friction helps to better densification and uniform density in the periphery (Figure 2 c)

We obtained a uniform density distribution for samples of 10.5 grams with activated compaction achieved by friction, but with lower values 1% ÷3% for samples compacted classic. As a consequence, the fill height of the die is no longer conditioned to 3x height of compact. These results are applicable for parts with large lengths.

5. CONCLUSIONS

Densification behaviour of stainless-steel powder 316L during compaction was investigated.

It was comparatively studied in this paper, two methods of densification of powders, classic - bilaterally and with friction activated. The main difference between the two processes is given by the influence of frictional forces between particles, powders and tools.

Experimental and simulation results have demonstrated a more uniform distribution of density across the height of the compact obtained by activation friction force.

Experimental data validation made by simulation.

Uniform density distribution of the height of green compact.

Remove the neutral zone, low density, where the existing classical compaction-bilateral

Activation of friction between the die and the powder has the effect of reducing the pressing force applied to die and lower tool wear.

Minimum implementation costs in the industry, which concern only the movement of mobile device for driving the die.

The process of compaction with friction force that is active hard pressed materials suitable for very long.

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