MODELLING OF POWDER BASED COMPLEX SHAPE MANUFACTURING

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SUMMARY: The internal version of finite element method aimed at the simulation of powder compaction is suggested. The powder material behaviour is described by the modified relationships of plasticity theory for porous bodies. The creation of initial geometric model as well as the generation of finite elements mesh, formulation of material properties, formulation of boundary condition and visualization of final results are carried out on the base of package GID. Various diagrams of die-compaction were considered. Both external friction and pressing diagram effect on final properties of part are analyzed. Obtained results are compared with experimental data of density field which are closed each other.

KEYWORDS: *powder compaction, metal forming, finite element analysis, numerical simulation*

INTRODUCTION

The computer simulation is used here to improve existing metods of manufacturing the PM - parts. The study of distribution of the density fields - is in the focuss of interest. The effect of the pressing diagrams on finite properties of parts is studied. All considerrations bellow are connected with part illustrated by Fig. 1.

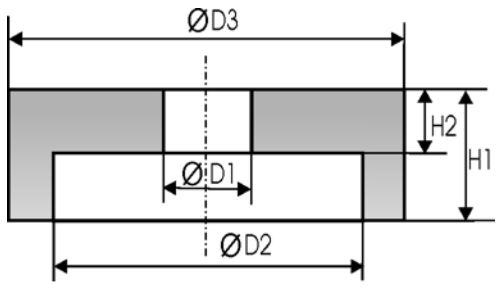

Fig. 1 : The configuration of part

The experimental information concerning the final distribution of a density and all geometrical parameters of part are taken from work [1]. The first of all the simplest diagram is considered: two lower punches are immobile. Then the diagram for which rates of punches are proportional to current heights will be analyzed. Finally, the pressing diagram suggested in [1, 2] will be considered. In the last case the process of pressing consists of three stages.

1.Methods of simulation

The simulation is carried out by use of the finite element method. The modified relationships of plasticity theory for porous body are used. It has been considered rigid - plastic behaviour of material.

The similar ideas were used in [3,4]. The boundary value problem reformulated in a finite element form has been solved using the step by step computation. For each step of loading (or straining) the system of non-linear algebraic equation has been solved by use of Newton – Rafson procedure. Iterations were finished if the convergence criterion was satisfied. On the base of obtained rate field the density field as well as the stress components has been defined. Than the same procedure has been carried out for the next step of loading. The rate of convergence was controlled by the choice of initial estimate. For this purpose the extrapolation on the base of previous rate field (obtained for previous moments) has been used. Besides we have used solution obtained on the base of linearization as a first estimate.

All punches**,** core – pine and sleeve are supposed to be rigid. At the surface of these elements the external friction is taking place.

To prevent the complications due to the strong deviation of the mesh of elements (because of deflection) special procedure has been used. The given mesh of finite elements is mapped at the final configuration of part. Then it was mapped onto initial configuration.

The creation of initial geometric model, generation of finite elements mesh, formulation of material properties, formulation of boundary condition and visualization of final results are carried out on the base of package GiD: pre- and post- processing system for F.E.M. calculations (International Center For Numerical Methods In Engineering CIMNE).

Academic and professional (one month password) versions of system have been used.

The system GID was customized and configured by means of creation of files: conditions file (.cnd), materials file (.mat),problem and intervals data file (.prb), template file (.bas), command execution file (.bat).

The examples of pre-processing and post-processing are presented at the Fig. 2, Fig. 3.

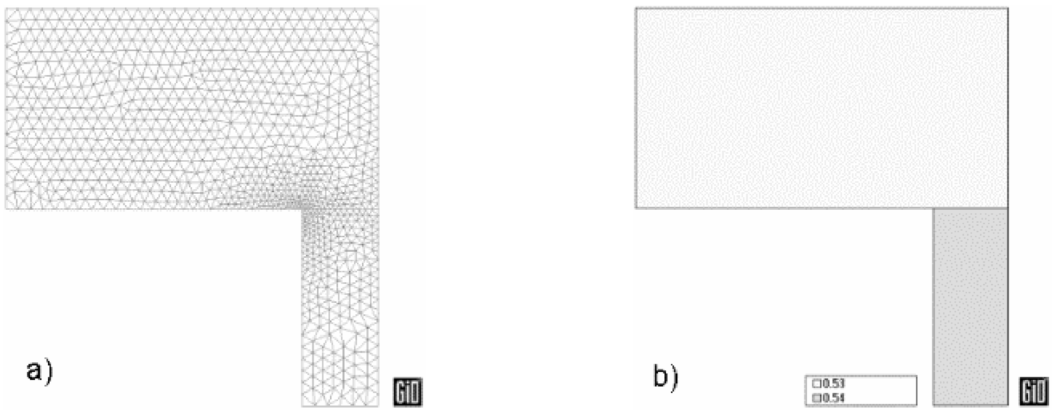

Fig. 2 : Pre-processing: a – mesh generation; b – conditions and materials properties (relative porosity)

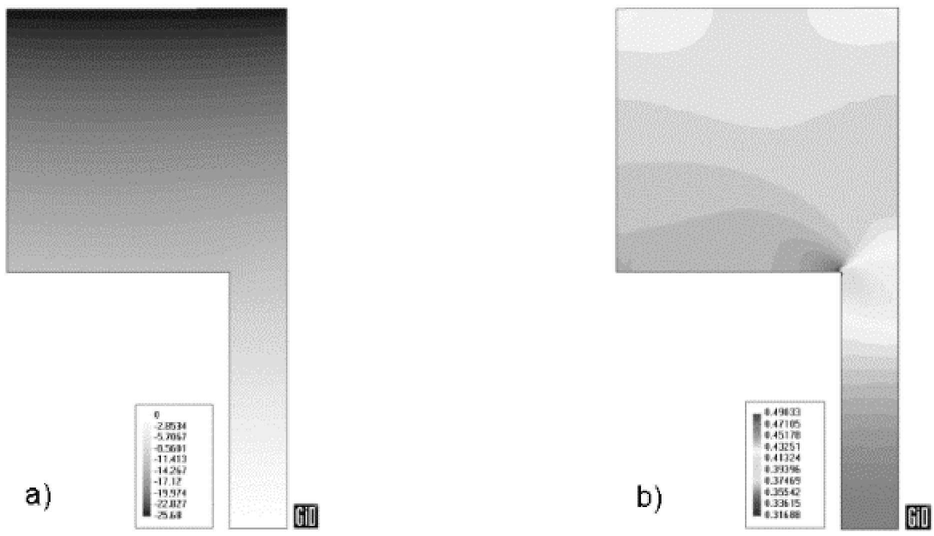

Fig. 3 : Post-processing: visualization of results (a - contours for equal axial component of velocity; b - contours for equal density)

2. **Obtained results**

One-side pressing. The given diagram is the simplest one, but can be practically used only when the ratio of height /diameter is very small. In our case the density variation is very significant. The shear strain rate achieves the largest value in the neighborhood of internal angle. It should be emphasized that the contours of equal shear strain rates remind to the paths of the overconsolidated cracks propagation are known from practice [2].

Diagram for which rates of punches are proportional to current heights. One should note that in condition of the absence of external friction the given diagram unlike to one – side pressing provides the uniform density distribution [5]. The presence of external friction results in irregular distribution of a density. Controlling a direction of external friction, it is possible to reduce the noted effect, however nonuniformity of a density remains.

Modified pressing diagram. Unlike to both previous diagrams in the case considered in paper [1] rates of punches is variable for period of compaction (Figure 4).

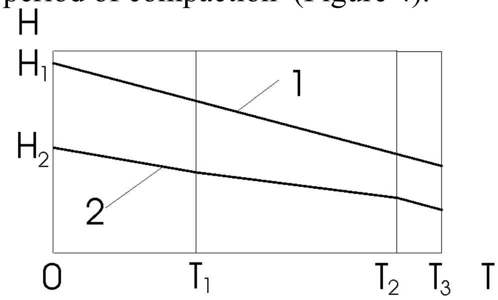

Fig. 2 : The pressing diagram, suggested in paper [1, 2]; 1 –upper punch, 2 –lower punch

Pressing diagram now consists of three parts. At the first stage the rate of the second punch - V_2 is less then V_1. At the second stage the second punch passes ahead the first one and at the third stage $V_2 = 0$. The initial properties is not uniformly distributed. The densities of the upper and lower parts are correspondetly 3.5 g/sm^3 and 3.4 g/sm^3.

This stipulates the same level of shear strain rates that in previous case and provides the most uniform density field.

The results of computer simulation and experimental data [1,2] are closed each other.

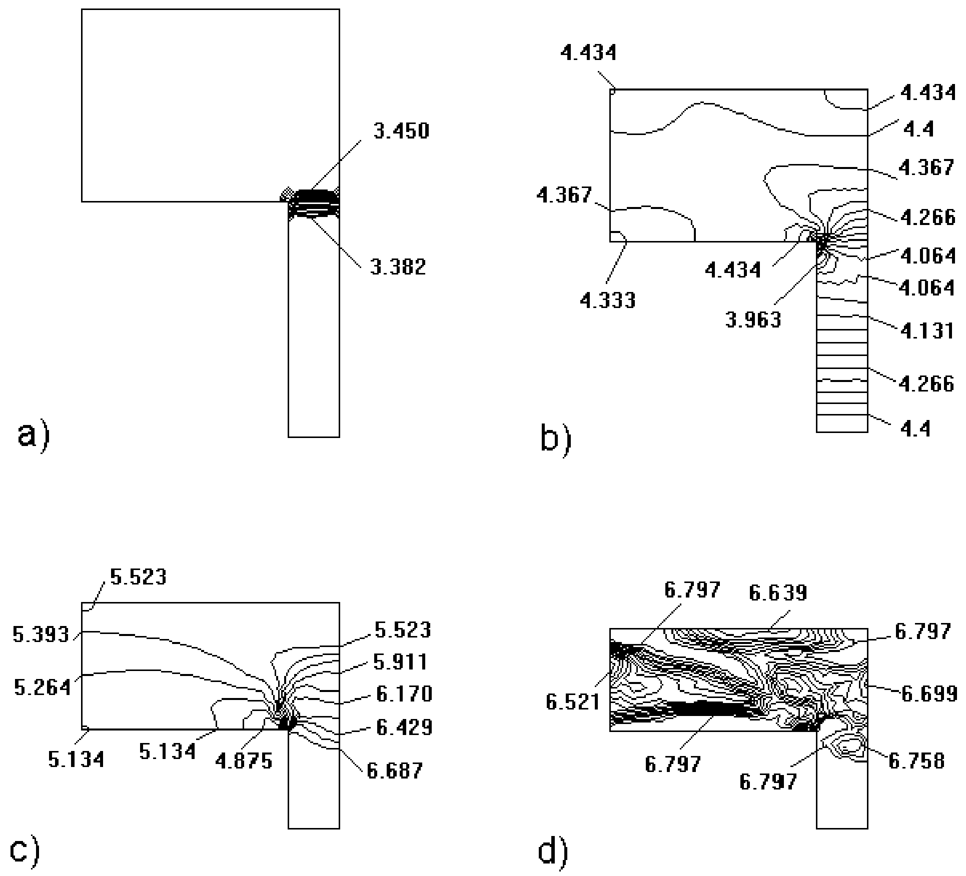

Fig. 5 : Contours for equal density (a –T=0.01s, b - T=0.44s, c – T=1.03s, d – T= 1.16 s)

3. Conclusions

GiD can be customized and configured by users. In our case it has allowed to modelling of powder based complex shape manufacturing

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