10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

EFFECT OF DIFFERENT LOAD DISTRIBUTION ON THE STRAIN CONDITION IN THE TABLET PRESS DIE

Maja Čavić, Milan Kostić, Miodrag Zlokolica, Zoran Milojević
Faculty of Technical Sciences, University of Novi Sad
Trg D. Obradovića, 21000 Novi Sad
Serbia
scomaja@uns.ns.ac.yu, mkost@uns.ns.ac.yu, mzlokolica@uns.ns.ac.yu, zormil@uns.ns.ac.yu

Milutin Tomović
Vertigo d.d.o.
Sinđelićeva 52-54, 32000 Čačak
Serbia
vertigo1@eunet.yu

ABSTRACT
This paper presents theoretical analysis of induced stress and strain state in the die of the tableting press. Die cavity has ellipsoidal surface with transversal rib. Outer surface of the die tool is elliptical. Several cases of load distribution, which result from different tablet shape as well as the influence of the change of different design parameters on the variations of the stress were investigated. Since analyzed die presents part of extreme complexity finite element method (FEM) was used. Optimal shape, dimensions and design parameters of the die are proposed.
Keywords: tablet press, die, stress analysis, FEM

1. INTRODUCTION
Tableting presses are used for uniaxial pressing of powdered materials into shaped tablets or compacts. They are used in a wide range of industrial processes such as compaction of pharmaceuticals and healthcare products, cosmetics, detergents, food production, electronic components and precision metal parts.

Tableting presses are designed in two configurations: single station presses and multi-station tableting press. Single station presses consist of a single tool set (die and punch set) in a die table. Multi-station tableting presses, also known as rotary presses, use a punch and die system with multiple stations or punches. Pharmaceutical and healthcare tablet facilities often use high-speed automatic rotary presses. These machines have a series of stations or tool sets arranged in a circle in a rotary carrier part. As the carrier part rotates, a control device controls filling, pressing and ejection. In most cases tablets have to be pressed and sintered to dimensional tolerance levels that do not require additional machining

Tablets in healthcare and pharmaceutical industries are mainly of circular shape, but due to market demands new shapes are being introduced: from elliptical to highly complex irregular profiles. Die for circular shaped tablets can de considered as typical thick wall pressure vessel and calculation of its stress and strain condition is well known. For more complex irregular shapes such analytical and empirical relations do not exist, so optimal shape, dimensions and design parameters of the die were proposed mainly by the designers experience and were additionally ensured by high safety factor. On the other hand, this leads to increased material thickness, while safety is not necessarily increased to a

desired level. Now days, due to computer advances designers can use Finite Element Method as fast and practical tool to analyze stress and strain of very complex mechanical parts and systems.
This paper presents part of research on a project of developing special high-speed automatic rotary press for use in pharmaceutical industry that is being realized on Faculty of Technical Sciences, Novi Sad in cooperation with company Vertigo, Čačak. A theoretical analysis of induced stress and strain state in the press die tool is performed, using FEM approach. Several cases of load distribution, which result from different tablet shape as well as the influence of the change of different design parameters on the variations of the stress, were investigated.

2. PROBLEM DESCRIPTION

Tablet is presented in Figure 1. Upper and lower part of tablet surface is a complex 3D shape obtained as surface lofted between two spline curves (spline1 and spline 2) generally consisting of two elliptic arcs. Guiding curve is ellipse (major axe=a-0,2, minor axe=b-0,2) lying in the plane π offseted from tablet plane of symmetry by aprox. 1,5 mm. It has triangularly shaped slot with variable depth. Middle part is elliptical surface aprox. 3 mm high with major and minor axes denoted as a and b, respectively.

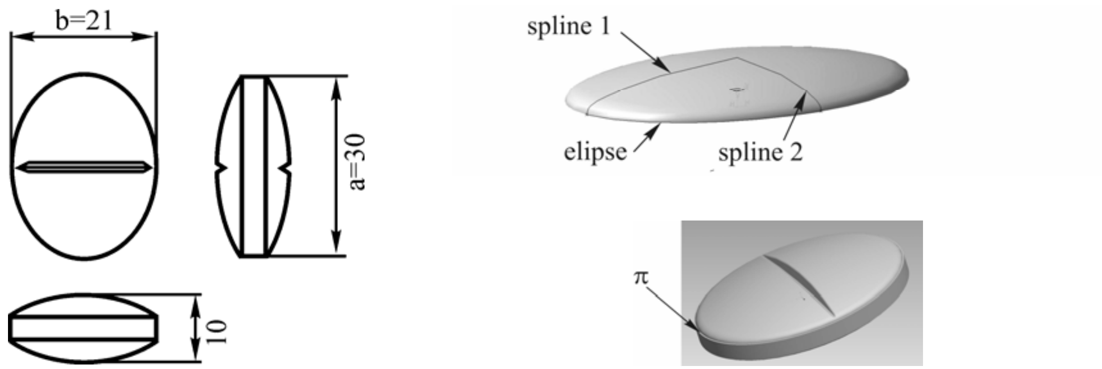

Figure 1. Technical drawing and 3D model of the tablet

Die tool consists of two parts – upper and lower die. Generally they are different, but for symmetrical tablet (like one considered here) working surfaces of both dies are identical. Shape of the die handle varies according to complete press design. In the case of tablet press that is object of this research lower die is estimated to be critical part so it is going to be investigated. Lower die is presented in Figure 2. Die cavity i.e. working surface is obtained as mirrored picture of the tablet surface. Outer surface of die head is elliptical.

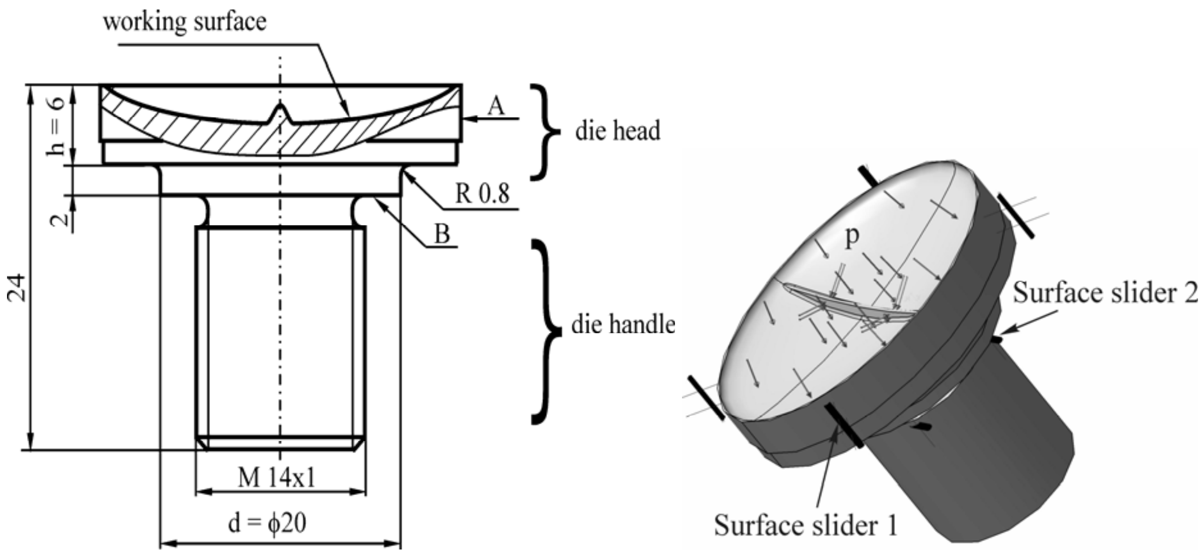

Figure 2. Technical drawing and 3D model of the lower die with load distribution and constraints

In the process of compressing comprimate behaves like a fluid, so evenly distributed pressure acts upon die tool parts that defines tablet surface. - die working surfaces and part compression chamber.

Needed compression force is estimated to be F = 7,5 t which yields to specific pressure p = 55 N/mm^2. During compression, elliptical part of the die head (surface A in Fig. 2.) remains in the compression chamber of the same shape with maximal allowance less then 0,03 mm. Surface B of the die is supported in such way that complete force is being distributed directly to the other parts of the die tool assembly. Both constraints are modeled as "surface sliders" – points on surfaces A and B can't move in the perpendicular directions.

3. SIMULATION AND RESULTS

Simulation was performed in program CATIA using module for Generative Structural Analysis. Elements used for meshing are parabolic tetrahedrons. Results for one particular case are presented in Figure 3., results for other cases are generally similar.

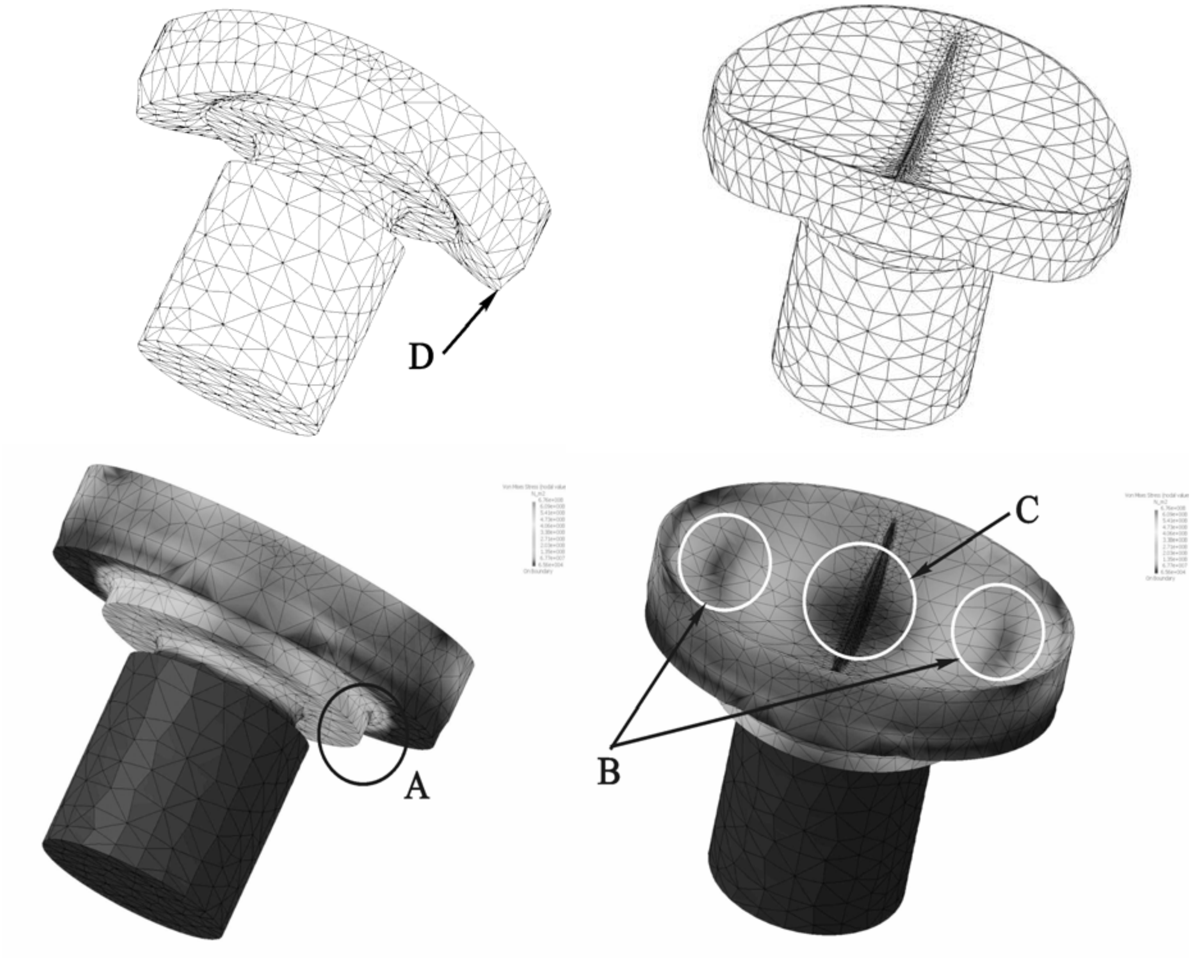

Figure 3. Deformed mesh and stress upon von Mises criterion, case 1b

It was generally expected and, through simulation, confirmed that highest stress values will occur on place denoted as A (Figure 3.) which means that possible lowering of stress concentration can be achieved through changing either height h or radius R (Figure 1.). Parameters h and R were varied and results are presented in Table 1. Increase of R lowers maximal stress but change of h has even more effect – 100% increase of h decreases maximal stress by 1.76 times.

Stress distribution in working surface of the die is rather uniform with small increase at places B (above place A) and C (near transversal rib).

Maximal deformation occurs at D, with vertical component predominant. Horizontal components have very small value and are directed towards the center of the die.

Table 1. Stress upon von Mises criterion and deformations for various values of h and R

Case	h [mm]	R [mm]	a/b	Max von Mises stress [N/mm^2]	Max deformation [mm]
1a	6	0.4	30/21	470	0.0083
1b	6	0.8	30/21	413	0.0088
1c	6	1.5	30/21	333	0.0076

Case	h [mm]	R [mm]	a/b	Max von Mises stress [N/mm^2]	Max deformation [mm]
2a	4	0.8	30/21	533	0.0160
2b	6	0.8	30/21	413	0.0083
2c	8	0.8	30/21	303	0.0064

Different tablet shape is also very important parameter and its influence on the stress and strain distribution is presented in Table 2. It indicates a tendency of stress and deformation increase for more elongated tablet shapes

Table 2. Stress upon von Mises criterion for various cases

Case	h [mm]	r [mm]	a/b	Max von Mises stress [N/mm^2]	Max deformation [mm]
3a	6	0.8	30/31	413	0.0083
3b	6	0.8	1.2	291	0.0053

4. CONCLUSION

For geometrically complex machine parts, determining stress and strain condition using the existing analytical methods is not reliable, even not possible. This paper has presented efficient way to calculate stresses and deformations at a press die using finite element method. Proposed approach also enables the designer to change quickly part model geometry in CAD module of the program and to evaluate the influence of the geometrical changes. Physical testing time, and respectively, costs are reduced and more reliable construction is obtained.

5. REFERENCES

[1] Timoshenko S., Young D.H.: Strength of Materials, McGraw-Hill Book Co, California, 1956.

[2] Shigley J.E., Mischke C.R.: Mechanical Engineering Design, McGraw-Hill Book Co, New York, 1989.

6. ACKNOWLEDGMENT

The presented results are part of the research project No. 8008 - “Development of new production technology for SWEET SPOON tablet” supported by Serbian Ministry of science and environmental protection.