Modeling of Spherical Tetrahedron Shaped Body Impact: Part 2 Impact against a tip of Fixed Spherical Tetrahedron.

Ivan Altaparmakov[1]

Abstract. **Simulations of spherical tetrahedron shaped body for ball mill are made. The impact of spherical tetrahedron shaped body against a tip of fixed spherical tetrahedron was modeled via explicit Finite Element Method. Distributions of Strain and Stress and Force to time diagrams are obtained for three cases of impact. 1. Impact of spherical tetrahedron spherical surface against a tip of fixed spherical tetrahedron. 2. Impact of spherical tetrahedron tip against a tip of fixed spherical tetrahedron. 3. Impact of spherical tetrahedron edge against a tip of fixed spherical tetrahedron. Conclusions about the workability of the spherical tetrahedron shaped body are made.**

Index Terms: **spherical tetrahedron, impact, ball mill, FEM.**
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I. Introduction

The study of collision between two bodies is primarily the impact of two spheres attached at one point through a connecting line element [Вернер; Stronge]. In this case there are considered two options - one body is stationary and the other is placed on it from a certain height, the two bodies move against each other. The most recent researches in this area are conducted using FEM modeling of the processes [Chuan-Yu Wu, Li and Thornton; Wu C.Y., Li and C.Thornton; Jaquelin, Laine, Bennani and Massenzio].

Application of impact of spherical body against other spherical body with small velocity is in ball mils, where part of the ball load rises to a certain height and then fall freely on other stationary balls. Collision between moving and stationary balls, in the case of spherical tetrahedron shaped balls there are several possible combinations of hitting surfaces.

The purpose of this work is to be modeled by FEM the stress-strain state of deformation on impact of various elements of the surface of the spherical tetrahedron shaped ball on the tip of other (fixed) spherical tetrahedron and to determine the size of the force at the time of impact.

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II. Formulation of the problem.

In the present work was studied stress-strain state and force upon impact of a spherical tetrahedron shaped ball on the tip of other (fixed) spherical tetrahedron, while the contact between ball and he tip of other spherical tetrahedron is with various elements of the surface of the ball - a spherical surface, edge and peak. (Figure 1.a, 1.b, 1.c).

The study was conducted as impact process is modeled by Finite Element Method (FEM). The licensed software ANSYS was used. The ball has the following characteristics: radius of spherical surface 86 mm, radius of rounding is 5mm. It is assumed that the ball is perfectly linear elastic with modulus of elasticity of steel 45 (0.45% Carbon) - 2.1E +005 MPa, i.e. not taken into account plastic deformations and strain stiffening. It is assumed that the ball falls from a height of two meters and at the moment of contact has a speed of 6.28 m / s. During the impact the other spherical tetrahedron is fixed and is made of the same material as the ball.

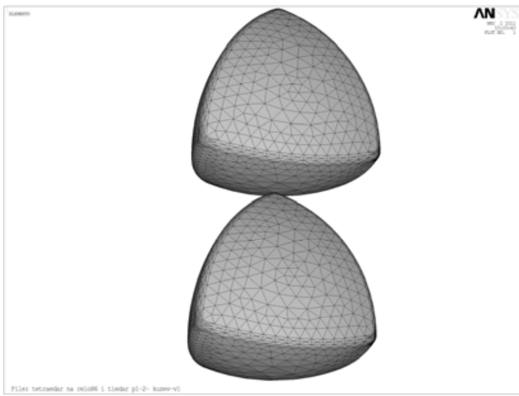

Fig.1a. Scheme of the bodies and the finite elements mesh for the case of a collision of spherical surface of a ball on top of another ball.

Figure 1.a shows the scheme of the bodies and the finite elements mesh for the case of a collision of spherical surface of a ball on tip of another ball. Here the bottom ball is fixed rigidly on the lower spherical surface.

Figure 1.b shows the scheme of the bodies and the finite elements mesh for the case of the impact of a ball tip on tip of another ball.

Figure 1.c shows a scheme of the bodies and finite elements mesh for the case of impact of the edge of the ball on tip of another ball.

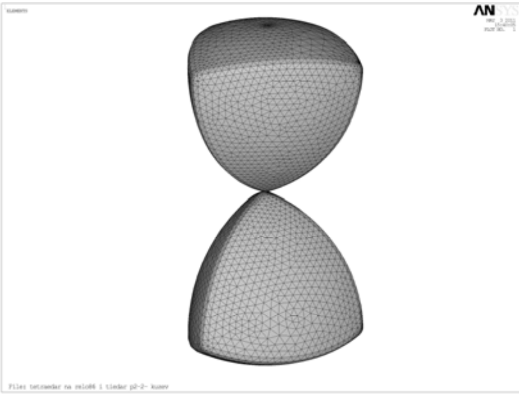

Fig.1b Scheme of the bodies and the finite elements mesh for the case of impact of a ball tip on tip of another ball.

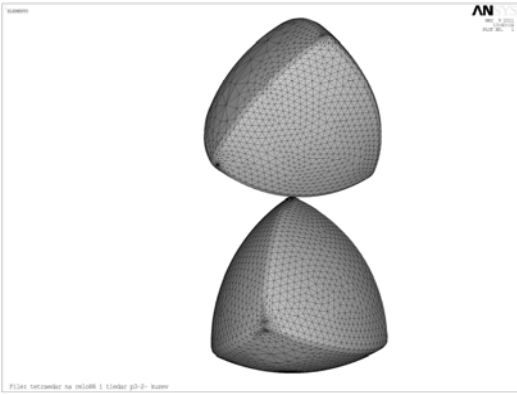

Fig.1c Outline of the bodies and the finite elements mesh for the case of impact of the edge of the ball on tip of another ball.

III. RESULTS

Figure 2.a.1 and 2.a.2 shows a diagram of stress in the contact point between the balls and a diagram of forces depending on the time of impact of the spherical surface of a ball on top of another ball. As shown in Figure 2.a.1 loads is a very complex character over time which may be associated with the distribution of mechanical waves in the ball. Stresses reach about 3600 MPa - stress in previous cases reached over 1000 to 2000 MPa. Forces reached 120 000 KN.

Figure 2.b.1 and 2.b.2 shows a diagram of stress in the contact point between the balls and a diagram of forces depending on the time of impact of the tip of a ball on tip of another ball. Nature of the diagram is similar to the diagrams of the first case. Stress reaches 1400 MPa and the duration of impact was 0.5 ms. Forces reached 100 000 KN. Time of impact is greater than the previous case and the zone with a large stress is wider. This is due to the fact that objects with relatively large mass collide by surfaces with a relatively small radius of curvature.

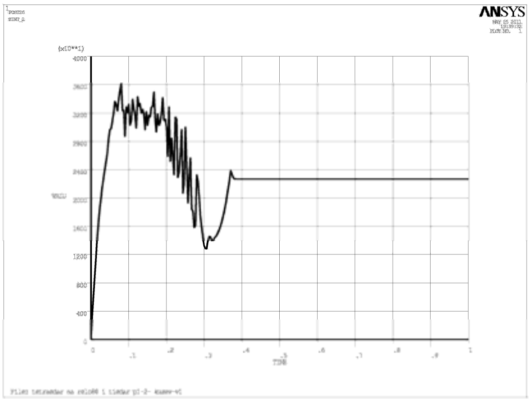

Fig.2a.1 Diagram of stress in the contact point between the balls depending on the time of impact of the spherical surface of a ball on tip of another ball.

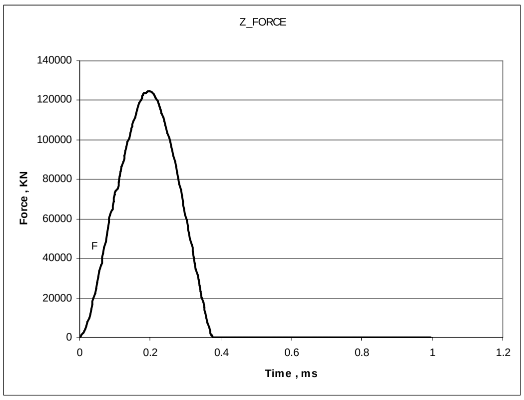

Fig.2a.2 Diagram of forces between the balls depending on the time of impact of the spherical surface of a ball on tip of another ball.

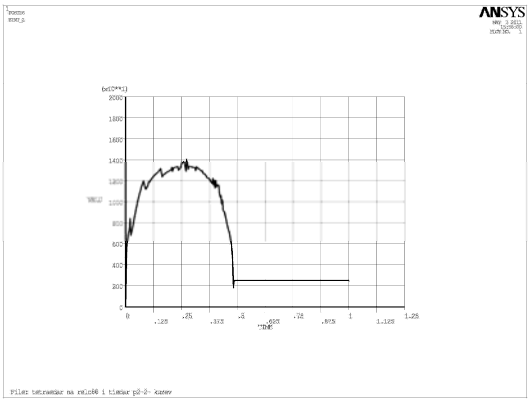

Fig.2b.1 diagram of stress at the contact point between the balls in dependency of the time of impact of the tip of a ball on tip of another ball.

Diagram of stresses in the contact point between the balls and a diagram of forces depending on the time of impact of the edge of the ball on tip of another ball is shown in Figure 2.c.1 and 2.c.2. Chart has the features of other cases. Stresses reached up to 6400 MPa and the duration of impact was 0.4 ms. Forces reach 110000KN. Residual vibrations are negligible.

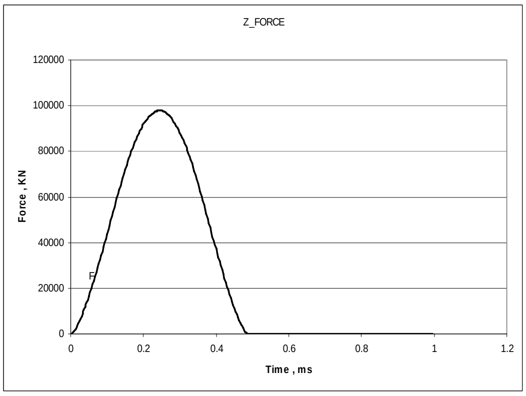

Fig.2b.2 Diagram of forces between the balls depending on the time of impact of the tip of a ball on tip of another ball.

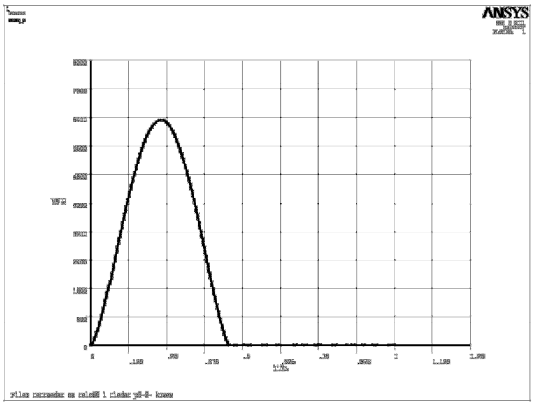

Fig.2c.1 diagram of stresses in the contact point between the balls depending on the time of impact of the edge of the ball on top of another ball.

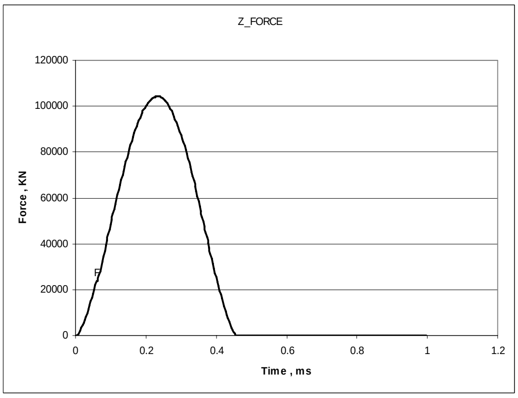

Fig.2c.2 diagram of forces between the balls depending on the time of impact of the edge of the ball on tip of another ball.

Figure 3.a shows the distribution of stress intensity in a section which passes through the edge and through the spherical surface of the ball at the moment of highest load. From Figure 3.a is seen that the load is concentrated in the contact area. Stresses reached values of about 36,400 MPa. This phenomenon could have a beneficial effect on the durability of the ball. This case deserves detailed study with a small network of finite elements.

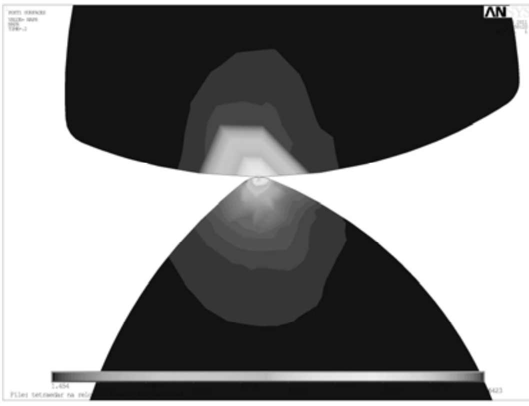

Fig.3a Distribution of stress intensity in a section which passes through the edge and through the spherical surface of the ball at the moment of highest load.

Figure 3.b shows the distribution of the stress intensity in a section which passes through the edge and through the spherical surface of the ball at the moment of highest load. It is seen that stresses are concentrated at the contact point. The stress gradients are significant. Figure shows the separation of the two bodies at the same time the stresses is large. This may be due to the spread of waves in the balls.

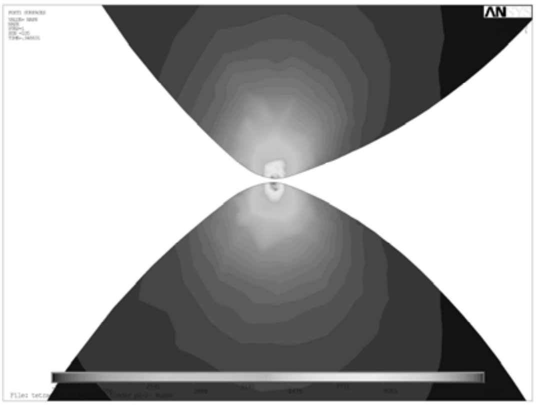

Fig.3b Distribution of stress intensity in a section which passes through the edge and through the spherical surface of the ball at the moment of highest load.

Figure 3.c.1 shows the distribution of stress intensity in a section which passes through the edge perpendicular to the edge and through the spherical surface of the ball at the moment of highest load. It is seen that stresses are heavily concentrated in the area of contact and at the drop ball stresses are larger - reaching 122,000 MPa. In the fixed ball stresses are about two times smaller. In both cases, the stress gradient is very large, and in the drop ball stresses are larger.

Figure 3.c.2 shows the distribution of the stress intensity in a section which passes through the edge parallel to the edge and through the spherical surface of the ball at the

moment of highest load. Again, stress is concentrated in the contact area and gradients in the incident and in the fixed ball are large.Larger gradient is in the incident ball. There is not much difference in picture of the stresses in a section parallel and perpendicular to the edge of the falling ball.

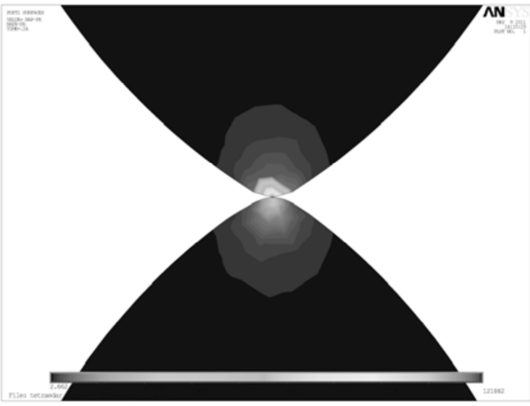

Fig.3c.1 Distribution of stress intensity in a section which passes through the edge perpendicular to the edge and through the spherical surface of the ball at the moment of highest load.

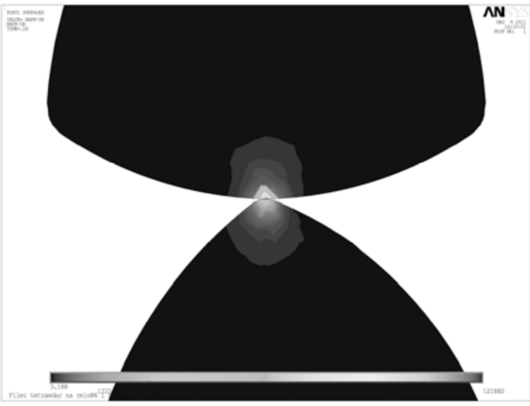

Fig.3c.2 Distribution of stress intensity in a section which passes through the edge parallel to the edge and through the spherical surface of the ball at the moment of highest load.

The distribution of the strain intensity in a section which passes through the edge and through the spherical surface of the ball at the moment with the higher load (Figure 4.a.) as well as in stresses shows that the load concentrated in the contact area, which confirms the conclusions made from the stress intensity distribution about the presence of mechanical waves in the ball.

The distribution of the strain intensity in a section which passes through the edge and through the spherical surface of the ball at the moment with the higher load (Figure 4.b) shows a similar nature to the distribution of stress because their bodies are assumed to be made of fully linear elastic material and plastic deformations are neglected.

Figure 4.c.1 and Figure 4.c.2 show respectively the distribution of the strain intensity in a section which passes through the edge perpendicular to the edge and through the spherical surface of ball and distribution and strain intensity in a section which passes through the edge parallel to the edge and through the spherical surface of the ball at the moment at higher load.

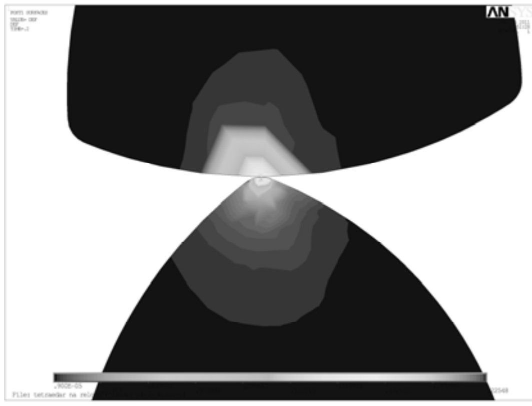

Fig.4a Distribution of strain intensity in a section which passes through the edge and through the spherical surface of the ball at the moment with the higher load.

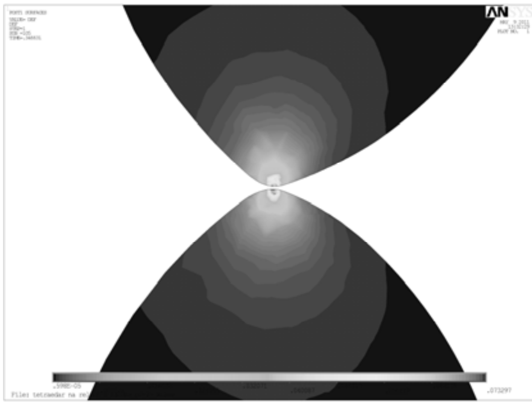

Fig.4b Distribution of strain intensity in a section which passes through the edge and through the spherical surface of the ball at the moment with the higher load.

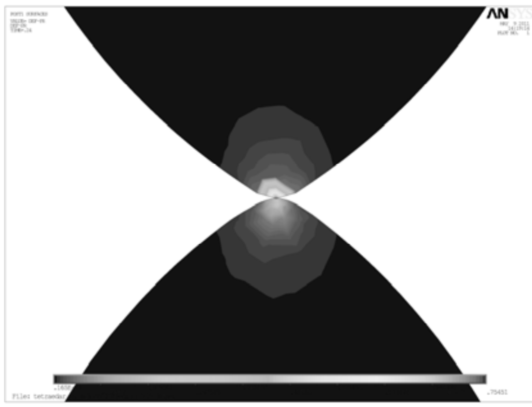

Fig.4c.1 Distribution of strain intensity in a section which passes through the edge perpendicular to the edge and through the spherical surface of the ball at the moment with the higher load.

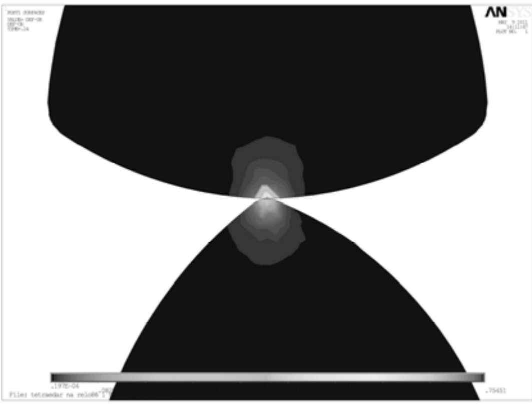

Fig.4c.2 Distribution of strain intensity in a section which passes through the edge parallel to the edge and through the spherical surface of the ball at the moment with the higher load.

It is seen that the nature of the distributions is similar to the nature of stress distribution that can be expected due to the adoption of the linear elastic nature of the processes.

IV. Discussion of results and conclusions

As a conclusion it can be concluded that the balls are considered good by destroying power. In the edges this capability is aimed at separation of the lower bodies. Durability of the bodies is also great especially in the spherical surface due to waves which are received during the impact to the spherical surface. Waves in this case are determined by the specific shape of their bodies. As in the previous part increased radius of the spherical surface lower the gradients of stresses and lowers the maximum stress, this way wear resistance is increased. Lower radius at the tips and edges increases stress gradients and maximal stress, this way the destruction capabilities of the spherical tetrahedron is increased. Significant stresses reached shows that stress stiffening at the surfaces, tips and edges will have significant impact to wear resistance of spherical tetrahedron.

Acknowledgments

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