THE INFLUENCE OF THE DISPERSION OF PARTICLES IN THE VICINITY OF A CRACK

VIOREL GOANTA

Technical University ”Gh. Asachi” Iasi

Abstract. In the matrix of a material which contains micro cracks particles with properties different than the ones of the main material can be dispersed. In this project the way in which the stresses in the vicinity of a micro crack vary, reported to the presence nearby of some inclusion particles with different properties. The purpose of this analysis is to find a method to stop the propagation of a crack in the stressed material reported to the direction of the crack.

Keywords: micro crack, inclusion particles, characteristics, finite elements

1. **INTRODUCTION**

The entering through dispersion of some particles with properties different than the ones of the main material may lead to an increase of the resistance to cracking of materials. The capacity to oppose cracking is measured based on the parameters developed by Fracture Mechanic. This is why finite elements analysis (ALGOR program) is made to model some central cracks stabbed in a mono axial stressed plate, with sizes greater than the crack’s. Because of the symmetry, it will be enough to analyze ¼ of the plate, because contour conditions are applied (the crack is modeled in the central area through the lack of the conditions), Figure 1. The mono axial stress which was applied on the plate is 100 MPa.

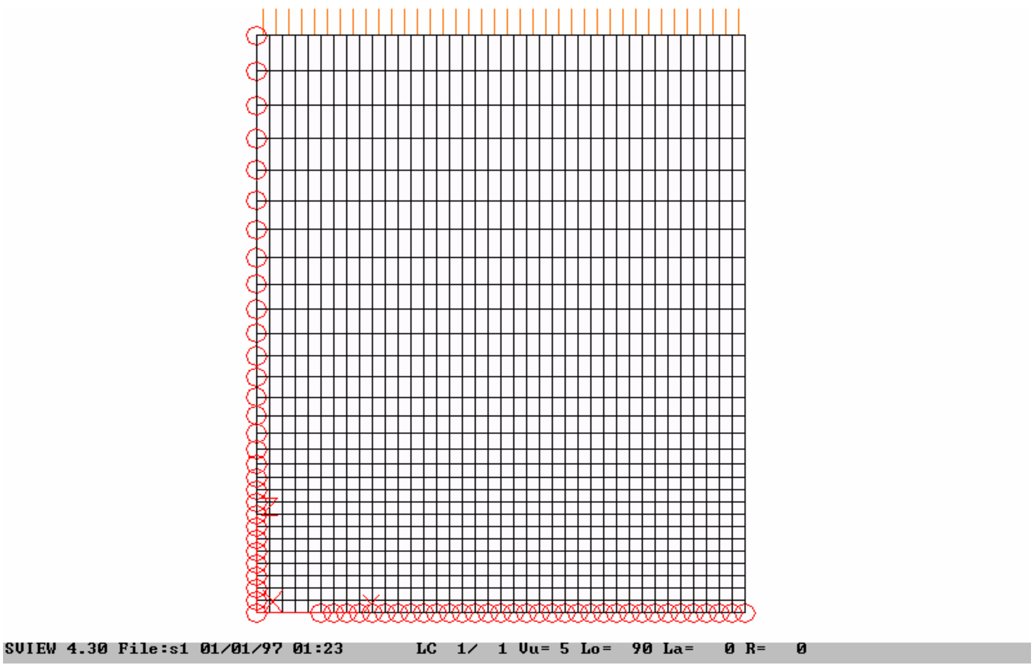


Fig.1. FEA Model of the plate

The map of the stresses on the stressing direction and the distances of the nodes from the vicinity of the crack, for the inclusion plate, are represented in *Figure 2*. We can see that the highest stress is at the top if the crack, is a traction one and has the value 315.24 MPa.

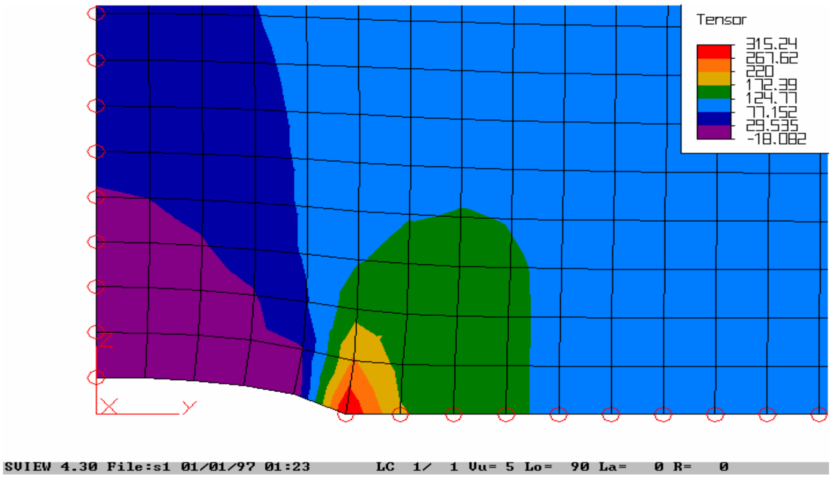


Fig. 2. Map of the stresses in vicinity of the crack

Based on the lack of contour conditions in the central area, the nodes in this region move and model this kind of crack.

2. MODELING USING INCLUSION PARTICLES FROM SOFT MATERIAL

Considering the geometric and stressing symmetry described, a semi-circular particle will be entered in the vicinity of the crack *(Figure 3).* To simulate the presence of an inclusion particle made of a material with properties different than the ones of the main material, an inclusion particle with the following material properties was introduced:

- for the main material:
- for the inclusion particle:

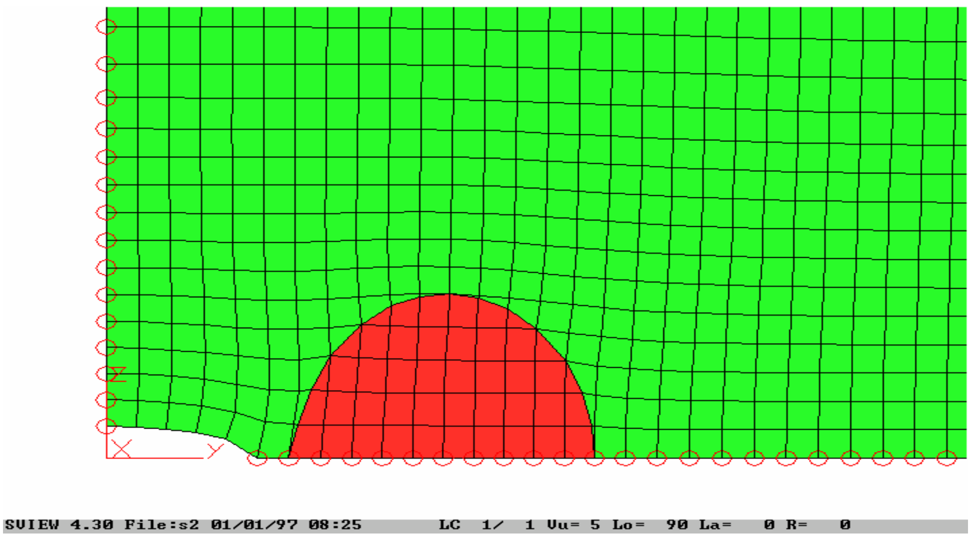
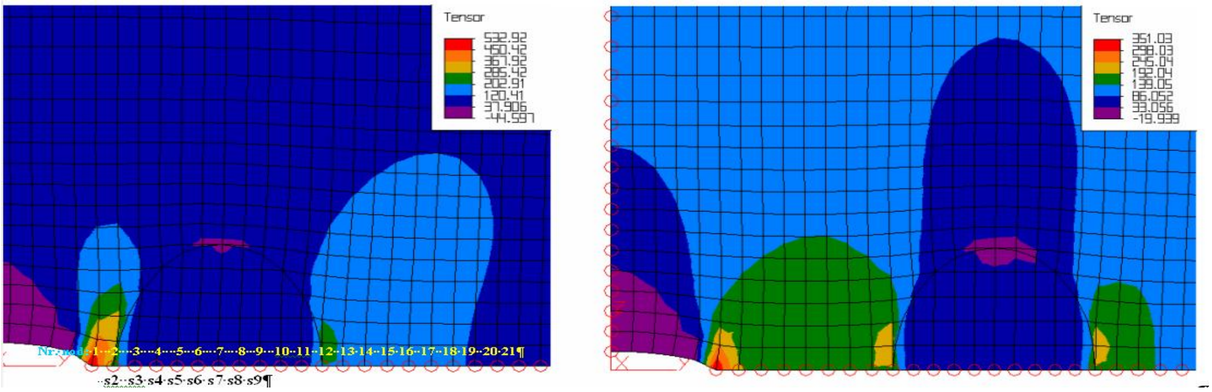


Fig. 3. Inclusion particle

In *Figure 4* there can be observed, that a significant increase of the stress at the top of the crack happens (532 MPa reported to 315 MPa), considering an inclusion particle with the properties presented exits.



a) in vicinity of the crack b) moved reported to the top of the crack

Fig. 4. Soft inclusion particle

The same particle models in different positions along the y axis, in the positions noted with s2, s3 – s9. In drawing 4b the stresses map is represented, when the inclusion particle is placed with the front part in the ultimate position s9. The stress at the top of a crack remains greater than when there was no such particle in the main material (351 MPa reported to 315 MPs), but smaller than when the particle is in the vicinity oh the top of the crack.

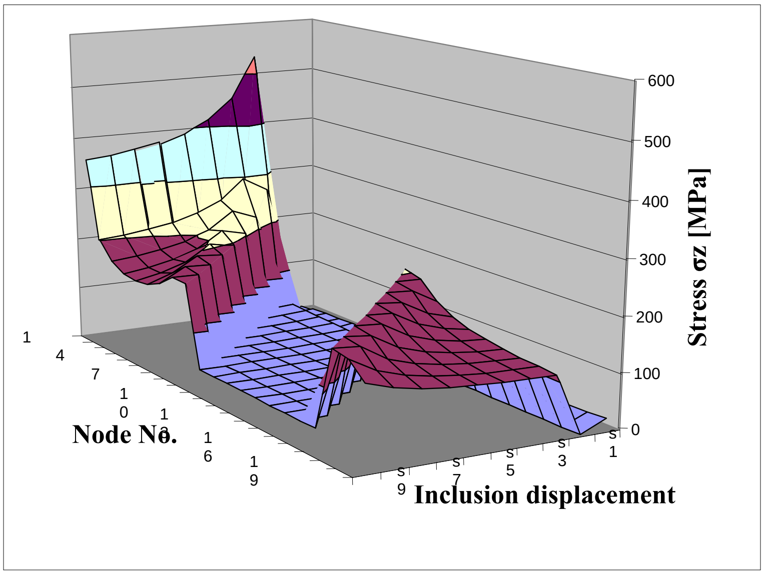


Fig. 5. The variation of the σ_z, stress in nodes 1÷21,
at the displacement of the soft inclusion in positions s2÷s9 - 3D view

In *Figure 5* the variation of the σ stresses is graphically represented, at the top of the crack, when the soft inclusion in position s2-s9 moves. In drawing 6 the variations of the stresses in nodes 1-21 is represented, for 3 cases: without inclusion, with inclusion in position s1 and with inclusion in position s9. From drawings 5 and 6 we can see that:

- reported to the "no inclusion" case, the stress at the top of the crack hardly increases when an inclusion particle softer than the main material is introduced and in the conditions when this particle is in the vicinity of the crack;
- even if this inclusion particle moves reported to the top of the crack, the stress still remains greater in the nodes from the top of the crack than in the case of absence of inclusion;

- in the nodes corresponding to the presence of inclusion particle, the stress has smaller values than in the case of absence;
- the stress gets greater and greater in the nodes corresponding to the areas of material after the inclusion particle reported to the top of the crack

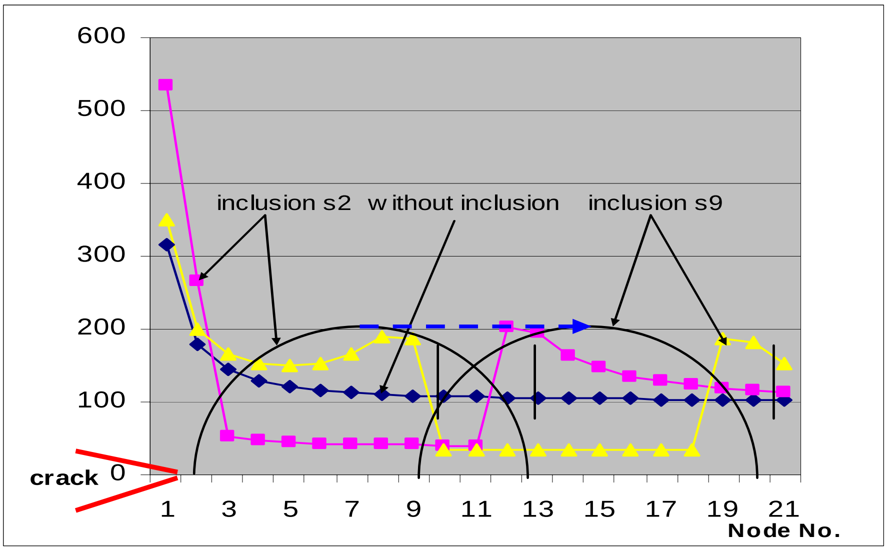
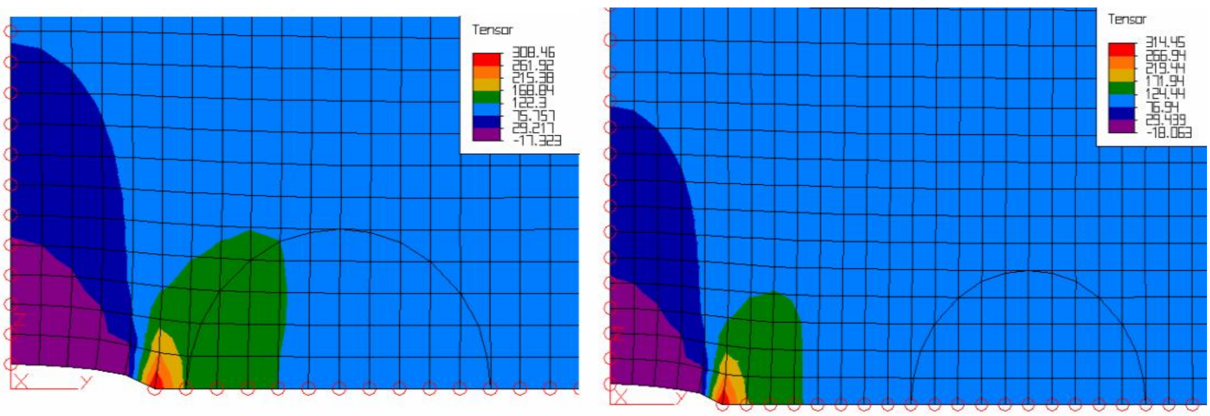


Fig. 6. The variation of the stress σ_z at displacement of the soft inclusion particle - inclusion in positions s2 and s9

3. MODELING USING HARD INCLUSION PARTICLE

Finite elements modeling is being made using inclusion particles with the properties below, in the vicinity of the crack, which makes the inclusion particle to be made of a harder material than the base one. To simulate the presence of such an inclusion particle, a particle with the following properties has been introduced in the vicinity of the crack: for the base material, for the inclusion particle. From the *Figure 7* we can see, that the stress at the top of the crack is smaller in the presence of the inclusion particle (308.5 MPs reported to 315.2 MPs), when the particle is close to the top of the crack. When the particle moves away *(Figure 8),* the difference becomes smaller, the stress at the top of the crack is 314.4 MPa. In drawing 8 the graphic variation of the 0 stresses is represented, at the top of the crack, when hard inclusion moves to positions s2-s9.



a) in vicinity of the crack b) moved reported to the top of the crack

Fig. 4. Hard inclusion particle

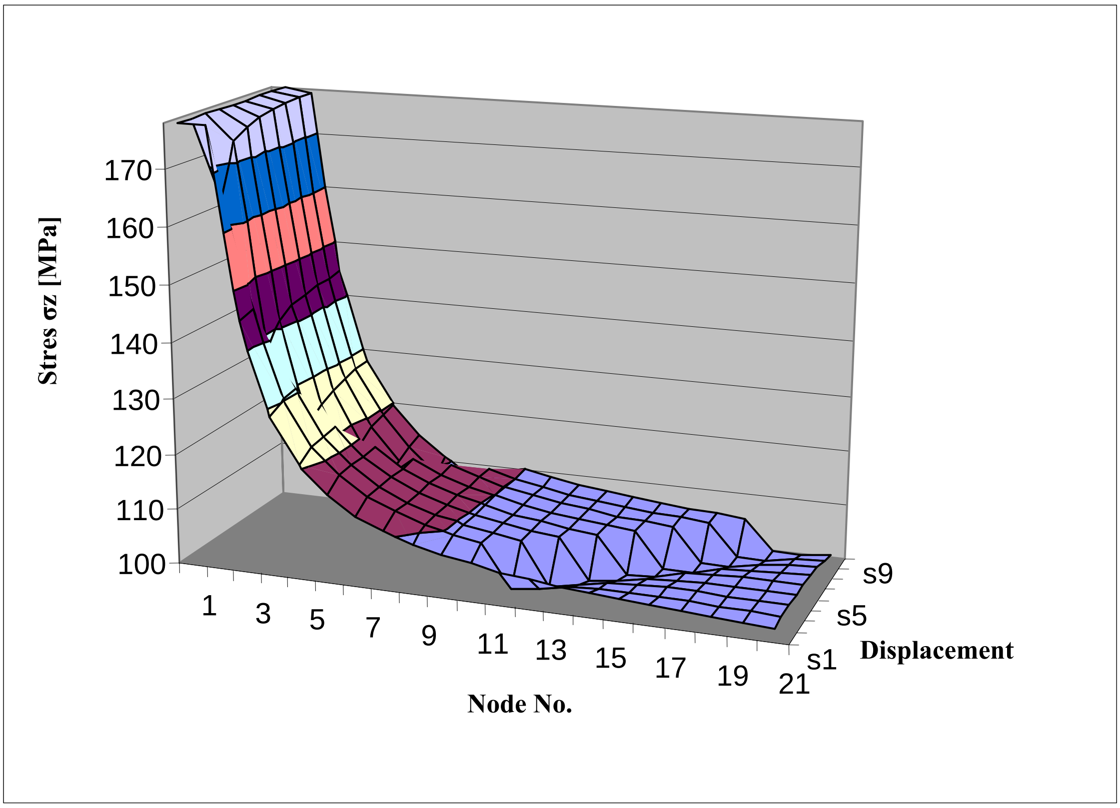


Fig. 8. The variation of the σ_z, stress in nodes 1÷21,
at the displacement of the hard inclusion in positions s2÷s9 - 3D view

In Figure 9 the variations of the stresses in nodes 1-21 is represented, for 3 cases: without inclusion, with inclusion in position s2 and with inclusion in position s9.

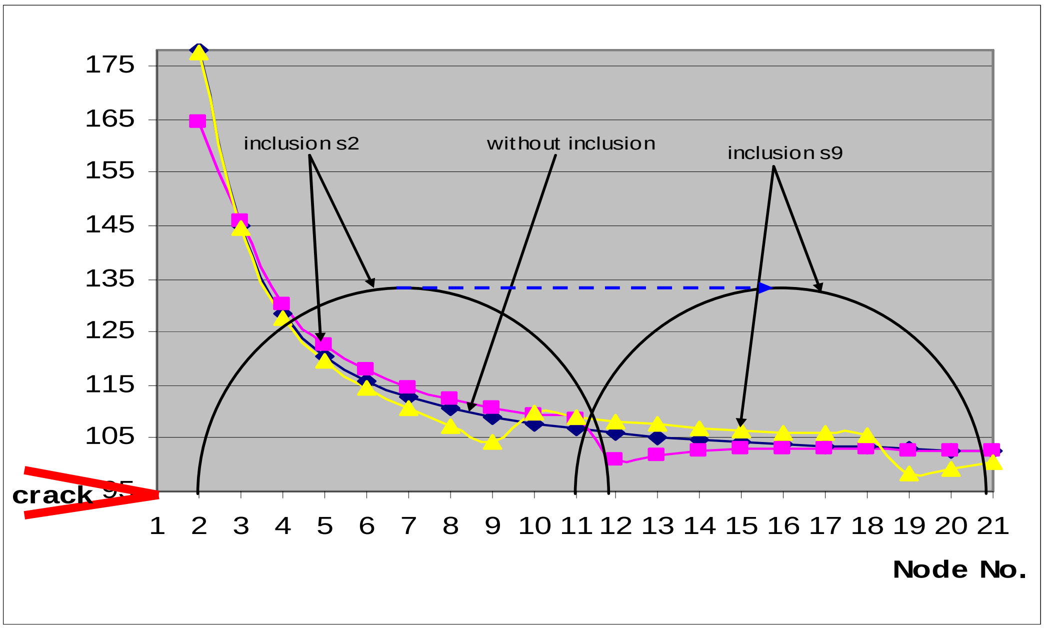


Fig. 9. The variation of the stress σ_z at displacement of the hard inclusion particle
- inclusion in positions s2 and s9

From *Figures 8 and 9* we can see the following:

- - reported to the "no inclusion" case, the stress at the top of the crack is smaller when an inclusion particle harder than the main material is introduced and in the conditions when this particle is in the vicinity of the crack;
- even if this inclusion particle moves reported to the top of the crack, the stress still remains smaller in the nodes from the top of the crack than in the case of absence of inclusion;
- in the nodes corresponding to the presence of inclusion particle, the stress has greater values than in the case of absence;
- the stress gets smaller again in the nodes corresponding to the zones of material after the inclusion particle reported to the top of the crack.

4. CONCLUSIONS

In this project a study was made, about the variation of the stresses in the materials with cracks which contain dispersed particles having properties different than the main material.

As an observation, the distribution of the stresses change in the vicinity of the crack through the dispersion of some particles with different properties reported to the main material.

After introducing some softer particles, the stress at the top of the crack significantly increases, but in turn the stress at the inclusion particle area decreases. In these conditions, an experimental study may be made, considering that, although there are proper conditions to propagate a macro-crack starting from the top of the existent crack, it is possible that this propagation may stop in the area of inclusion.

By introducing an inclusion particle harder than the main material, the stress at the top of the crack decreases. In these conditions, although the stress in the area of the particle increases reported to the case without particle, it may be possible that the crack won't propagate.

REFERENCES

1. Dubourg M.C., Villechaise B., "*Analysis of Multiple Fatigue Cracks - part I".* Theory Journal of Tribology, pg. 455-461, July 1992
2. Fantozzi G., *"Rupture de Materiaux",* INSA, Lyon, 1992
3. Gavignan T.H., Steele J., *"Applied Finite Element Modelling Practical Problem Solving for Engineers"*, Ed. Marcel Decker, New York, 1989
4. Gavignan T.H., Queeney R.A., *"Theoretical Fracture Resistance of Particle-Hardened Brittle Solids",* Fracture Mechanics. Theory and analysis, pg. I.84-I.95, 1993
5. Goanţă V., Palihovici V., "*Experimental Determination of Cracking Strength",* Buletinul Institutului Politehnic Iaşi, Tomul XLV(IL), fasc. 1-2, 1999, pg. 249-256
6. Jansen M., Zuidema J., Wanhill R.J.H., *"Fracture Mechanics",* 2002