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Finite element analysis of a two layer viscoelastic material in contact with a flat punch

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ABSTRACT – This paper presents a normal contact problem between a hard flat punch and a deformable rubber (viscoelastic) material. A Castaldo Gellata Fuschea (SRCGF) material was used for the rubber. Abaqus 6.13 was used to analyze the contact system. Result showed that there is a similarity between the model and the literature for characterizing the viscoeleastic properties.

1. INTRODUCTION

Coating of metal, ceramic or rubber has been used widely in the world today. In pewter metal souvenir industry, rubber coating is used at mold spin casting formation in vulcanizer. Rubber coating consist of two layers silicone rubber, patched and then inserted into Mold Frame Vulcanizer until 180^o for about an hour. To identify the characteristic of rubber during suppression process, contact analysis based on Finite element analysis (FEA) was performed in this study.

The objective of this paper is to identify and examine the mechanical characteristic of Castaldo Gellata Fuschea (SRCGF) viscoelastic material in a cover mold frame vulcanizer S45C that is often used as spin casting mold in metal souvenir industry. The variation in the number of rubber material suppressed and the indenter geometry in each material will be analyzed. The cover mold frame vulcanizer S45C is used as punch flat indenter for the two-layer material SRCGF that patched each other to get an optimal mold result after vulcanization.

2. METHOD

Finite element analysis that is performed in this study uses the commercial finite element analysis software Abaqus 6.13 [1]. Based on the stress function curve of the work of Shergold, et al. [2], silicone rubber 8800, constants of C_{01} and C_{20} of SEF Mooney-Rivlin are used as references to analyze maximum stress curve in the SRCGF material. The SEF Mooney-Rivlin for the SRCGF material is assumed as an incompressible material and was determined by uniaxial test until 15 MPa stress and 400% strain.

The FEA model in this study is developed based on the FEA model of Tian and Saka [3] and Cao, et al. [4]. Figure 1 shows the developed FEA contact model between a hard S45 flat punch indenter on a deformable viscoelastic material.

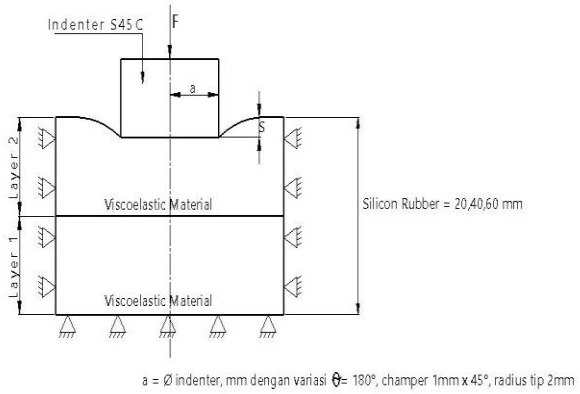

Figure 1 FEA contact model between a flat punch S45C indenter and a viscoelastic rubber material.

In Figure 1 the rigid indenter S45C, as the cover mold frame, will suppress the silicone rubber. The boundary condition of the contact system can be seen in detailed in this figure. The SRCGF material that was used as a rigid semicircle object has a diameter of 150 mm. This indenter diameter is made with three geometry flat punch indenter variations, 180^o, chamfer 1 mm x 45^o, and 2 mm radius tip. The deformable viscoelastic rubber thickness was varied with 20, 40 and 60 mm and is divided into two-layer SRCGF material. The load of 50 N and 400 N was applied in this model.

The S45C indenter used a flat punch form. This is based on the real condition in mold spin casting process for metal souvenir. The process of vulcanizing in a metal souvenir industry is depicted in Figure 2. Two-layer SRCGF material patched into one and is inserted into body mold vulcanizer. It is pressed by cover mold and then the vulcanizing process in a Vulcanizer Quadro Parallel machine. The results will be presented in a form of von Misses stress distribution and stress-strain relation.

Figure 2 Vulcanizing SRCGF material process steps in a metal souvenir industry.

3. RESULTS AND DISCUSSION

For verification, the developed model (SRCGF material) has been validated with the model of Shergold, et al. [1] and it showed a good agreement. Results of the von Misses stress distribution for the SRCGF indenter with different geometry is presented in Figure 3. In this figure the total thickness of the two-layer deformable viscoelastic material is 20 mm. The highest stress is observed for the SRCGF radius tip of 2 mm, i.e. 4.709 MPa at 400% strain.

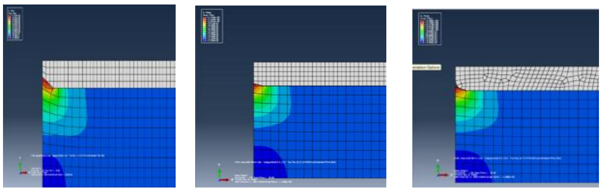

Figure 3. The von Misses stress distribution from the contact of different hard SRCGF flat punch indenter.

Figure 4 shows the stress-strain relation for several viscoleastic materials. For the SRCGF and the Sill880 the curves almost coincide. The maximum stress is about 11.7 MPa for 400% strain value.

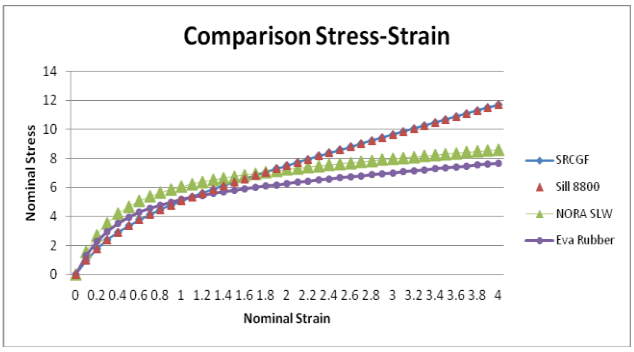

Figure 4. Stress – Strain SRCGF and Sill8800 curve

4. CONCLUSION

Finite element analysis of the contact between a rigid flat punch indenter and a deformable viscoelastic material has been performed. Results showed that the SEF curves for both rubber materials tested are similar with the developed model. The maximum von Misses stress of 4,709 MPa at 400% strain occurred for the SRCGF indenter with 2 mm tip radius. However, the change of the flat punch indenter S45C does not give significant effect to the indentation depth.

5. REFERENCES

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