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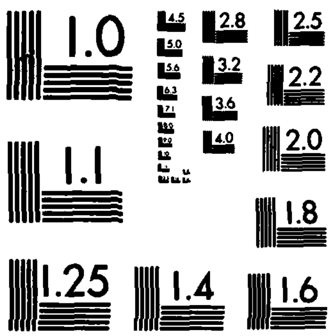
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FINAL REPORT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report lists and summarizes technical activities, reports, and publications completed during the period of the contract.

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Role of Chemical Bonding in Adhesion: Final Report

1. Introduction

This project was concerned with the principal factors that govern the strength of elastomers when filled with rigid particles. The factors studied were: (i) the level of adhesion between the elastomer and the rigid surface; (ii) the size and number of the rigid inclusions; and, (iii) the strength of the elastomer itself. The main findings are outlined below and in 38 technical reports and publications, listed on pages 3-6. Additional keywords: Elastomeric composites; rubber

2. Adhesion between elastomers and rigid surfaces.

The elastomers employed were polydimethylsiloxane, polybutadiene, ethylene-propylene copolymer (EPDM) and polyurethanes based on polybutadiene glycol. Substrate materials have included glass, aluminum, Mylar and various elastomers. Several specific modes of bonding have been detected in particular cases. In all cases, however, a direct correlation has been found between the mechanical strength of adhesion and the inferred degree of chemical interlinking between the two substances.

3. Effect of size, shape, and density of inclusions.

Small adhering sperical inclusions are not easily debonded. This experimental fact is supported by theoretical analysis also. However, failures were observed in the elastomeric binder near the bonded surface, and between two inclusions, when the local triaxial tension exceeded a critical level. A vacuole then appeared abruptly, and grew into a large propagating crack if the stresses were unbalanced in an appropriate way. This cavitation process is less serious with stiffer binders and with smaller inclusions, but it has not yet been thoroughly explored for highly-filled systems.

4. Strength of elastomeric materials.

Under severe conditions, notably at high temperatures and under sustained loads, and especially in the swollen state, the strength of crosslinked elastomers reaches a minimum level. This threshold value has been successfully measured for a wide variety of materials and shown to be in good agreement with a simple molecular theory. The threshold strength of any new elastomeric material, crosslinked to any degree, can therefore now be predicted with some confidence. Behavior under other conditions has also been studied. At high rates of strain, inertia effects become important and the maximum rate of crack growth has been shown to be of the same order as the speed of sound in the elastomer. (This is found to be extremely high for highly-stretched elastomers, which become effectively much stiffer.) At low temperatures, when the elastomer becomes glass-hard, the strength becomes comparable to that of rigid plastics. And when the elastomer is capable of crystallization the strength becomes much greater than before, probably due to the plastic work expended in disrupting crystallites. Further work is needed to put this last aspect of "reinforcement" on a sound theoretical basis.

5. Conclusions

Major advances have been made in our understanding of failure processes in elastomeric materials themselves, in elastomeric composites containing spherical or fibrous rigid inclusions, and at the interface between an elastomeric material and a rigid material. In the course of this work new test methods for measuring the strength of adhesion have also been developed.

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