

The adhesion of unbonded vulcanized rubber to various substrates has been studied extensively over the last two decades, there being a number of interests such as modelling interfacial failure of bonded components, and predicting the surface « stickiness » of vulcanized rubber articles. The general energetics approach has been applied to various cases of adhesion (and to friction).

Recent investigations on an extracted, chemically saturated vulcanizate (no bloom and reasonably inert), show that the dwell effect exists and continues over a very long period (years). More surprisingly, memory effects have been demonstrated for the contact of nitrile and EP rubbers against glass. Some of the increased adhesion that occurs as a result of contact dwell is retained when the rubber test-strip is detached from the glass and re-adhered, even to a different area of the glass. Hence, the memory appears mainly to be associated with the rubber. It is conjectured that rearrangement of molecules in the surface layer into more favourable configurations with respect to the glass may be involved.

The threshold energy for peeling of unbonded vulcanizates is influenced by the dwell effect, as may be expected, but if peel rates are low the dwell time variation cannot be studied readily. A theoretical estimate for this energy can be made in a similar way

to cohesive failure, though there are certain differences such as chain configuration near an interface and lower interfacial bond strength. The observations are consistent with the existence of a threshold energy determined by the interfacial bond strength and the long-chain molecular structure of the elastomer. This implies an energy for detachment greater than would be expected simply from surface energies. The energy increases with peel rate, as expected on the basis of viscoelastic behaviour. Broadly, the work of adhesion at higher rates is governed by an interfacial energy scaled up by a bulk dissipative factor, as foreseen long ago.

Good adhesion is more likely to result if the real of contact between joined surfaces can be maximized. For raw rubber flow can achieve this ; for vulcanized rubber the degree of intimate contact will depend on rubber softness and surface smoothness. At the interface, interactions may be physical or chemical in nature. Attractive forces for unbonded contacts are likely to be the Van der Waal's type, together with specific polar-polar and perhaps electrostatic contributions. Hot rubber bonding in which chemical reactions occur leads to covalent bonds. It is difficult to rank the various contributions in practice. Further, contaminants (liquids, bloom, dust) at an interface can greatly reduce adhesion and give rise to irksome variability in product performance.

L'industrie française de la transformation du caoutchouc dans son contexte national et international*

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Principaux traits de la situation économique française :

- La croissance économique française et ses principales composantes,
- La situation de l'industrie française et plus particulièrement de l'industrie automobile,
- l'évolution récente de l'investissement industriel et des résultats des entreprises, situation du commerce extérieur.

Présentation de l'industrie française de la transformation du

caoutchouc replacée dans son contexte économique général :

- structure de la profession,
- consommation des matières premières,
- évolution de la production,
- évolution du chiffre d'affaires et du commerce extérieur.

Cette 3^e partie a été consacrée à la présentation de quelques réflexions sur certains aspects des perspectives à moyen et long terme de l'industrie française de la transformation du caoutchouc, en se situant par rapport au contexte international en général et à l'accélération de l'intégration européenne en particulier.