DETERMINATION OF THE POINT OF MATERIAL COLLAPSE

ADHESION TESTS OF TIRE CORDS

Textures for the industry, threads and cords are used to reinforce rubber compounds and products such as tyres, belts and conveyor belts. The failure limits of the cord rubber bond under static and the dynamic loading can be analysed with the Dynamic Mechanical Thermal Analysis.

Normally, cord materials are vulcanized in the elastomeric compounds during the production process. The dynamic mechanical properties of the final products, (i.e. combination of rubbery parts and textures) are of considerable interest. These properties depend on the temperature, the application of load and the bonding agent, the used tackifier. The tackifier grants an optimal adhesion between the rubber compound and the textures in the final product after the cure. Tension, pressure and shear stress for affect on this bonding layer in practice (stress of a conveyor belt on a return pulley, rotational movements of the belts, cornering processes and stress of a tyre at the starting and braking torque).

The nature of the tackifier has an important impact on the adhesion properties. This impact behaviour on the adhesion properties caused by the tackifier can be analysed with a Dynamic Mechanical Thermal Analysis (DMTA). A DMTA system, type Eplexor 500 N high end from Gabo Qualimeter Testanlagen, Ahlden/Aller, was utilized for the tests below. These systems are equipped with two independent drives for both the static and the dynamic sample loading. The static drive allows deformations up to 50 mm. Because of this feature, the machines are very appropriate for such adhesion tests. Normally, these examinations are performed in the tension mode.

In a „custom-made“ experiment for DMTA analyses the adhesion properties of texture cords in a texture cord rubber
The adhesion properties of two texture cord rubber systems with different tackifiers under static dynamical loading were determined. The data presented here are based upon an identical rubber cord system. Just the applied adhesion agents (tackifier) differ. A continuously increasing load sequence was chosen for both the static tension load and the dynamical oscillation mode. The ratio of static and dynamical load was maintained as constant (Factor 10). The static pre-load was increased at each load level (nine levels per decade). Typically the following load sequences were adjusted: 0.5 % static and 0.05 % dynamic, 1 % static and 0.1 % dynamic, 2 % static and 0.2 % dynamic etc. The test frequency was 10 Hz. 20 data points were set at each load level in order to detect an expected decrease of the applied force when achieving the physical limitation of the adhesion forces of the rubber cord system.

The test results show that the adhesion properties for two even texture cord rubber compounds differ distinctively depending on the used adhesion agent. The combination 1 (blue curve) shows better adhesion properties compared to combination 2 (red curve). At deformations of 6 % of static strain and 0.6 % of dynamic strain combination 2 does not show anymore a linear behaviour. The force required for the above mentioned deformation decreases, indicating a lack of adhesion properties. Finally, the adhesion of the texture cord in the elastomer fails.

The above discussed testing procedure allows determining the point of material collapse of the texture cord rubber compound. With this information one may generate a dynamical fatigue test that does not exceed the critical strain which leads to the failure of the adhesion for instance. For that reason a fatigue test was designed operating with total strain of 80 % to 90 % of the critical deformation level only. Both samples are the same texture cord rubber systems as above.

The combination of static and dynamic strain was about 15 % below the total strain applied during the initial tests to identify the failure limits of the texture cord rubber systems. A testing frequency of 50 Hz was applied at room temperature.

Again combination 2 (red) shows distinctively reduced adhesion properties. The adhesion fails also in the dynamic fatigue tests already after 115 000 cycles. The mechanical fatigue is clearly fast-aging compared to the first combination (blue). Even after 300 000 cycles there is no decrease of the dynamic E-Modulus due to fatigue in the last-mentioned combination. Mechanically, one can observe indeed that the texture cord of combination 2 begins to unhinge out of the rubber compound already after about 2 300 seconds. This behaviour manifests accordingly to the strong decrease of the E-Modulus.

In order to predict failure limits on textile cord rubber systems DMTA looks like as a method giving reliable test results. Moreover the choice of convenient materials can be verified easily with DMTA.

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