Stress Relaxation Testing on a Mooney Viscometer

The stress relaxation of rubber can be tested using a Mooney Viscometer instrument. The rate of relaxation can be used to deduce important properties of rubber, including elastic and viscous behaviour, and rubber structure characteristics.

Test Description

A Mooney Viscometer consists of a rotor (cylindrical metal disc) embedded in a rubber sample inside a sealed cavity. The rotor rotates at a constant speed of two revolutions per minute. The resistant torque experienced by the rotor is then measured and recorded. The die configuration, test temperature and procedures are unique to a Mooney Viscometer instrument.

During a stress relaxation test, the rotor is abruptly stopped. As the sample relaxes, the subsequent decrease in resistant torque is measured as a function of time.

The corresponding international standards for Stress Relaxation Testing are ISO No. 289 and ASTM D 1646.

Test Specification

It is normal for stress relaxation to follow a Mooney viscosity test. Therefore a typical test procedure may be recorded as:

ML 1 + 4(100°C) + 120 s SR

M	Mooney
L	Large rotor
1	Preheat time in minutes
4	Test duration in minutes
100°C	Test temperature
120 s	Stress relaxation duration in seconds
SR	Stress relaxation

Test Results

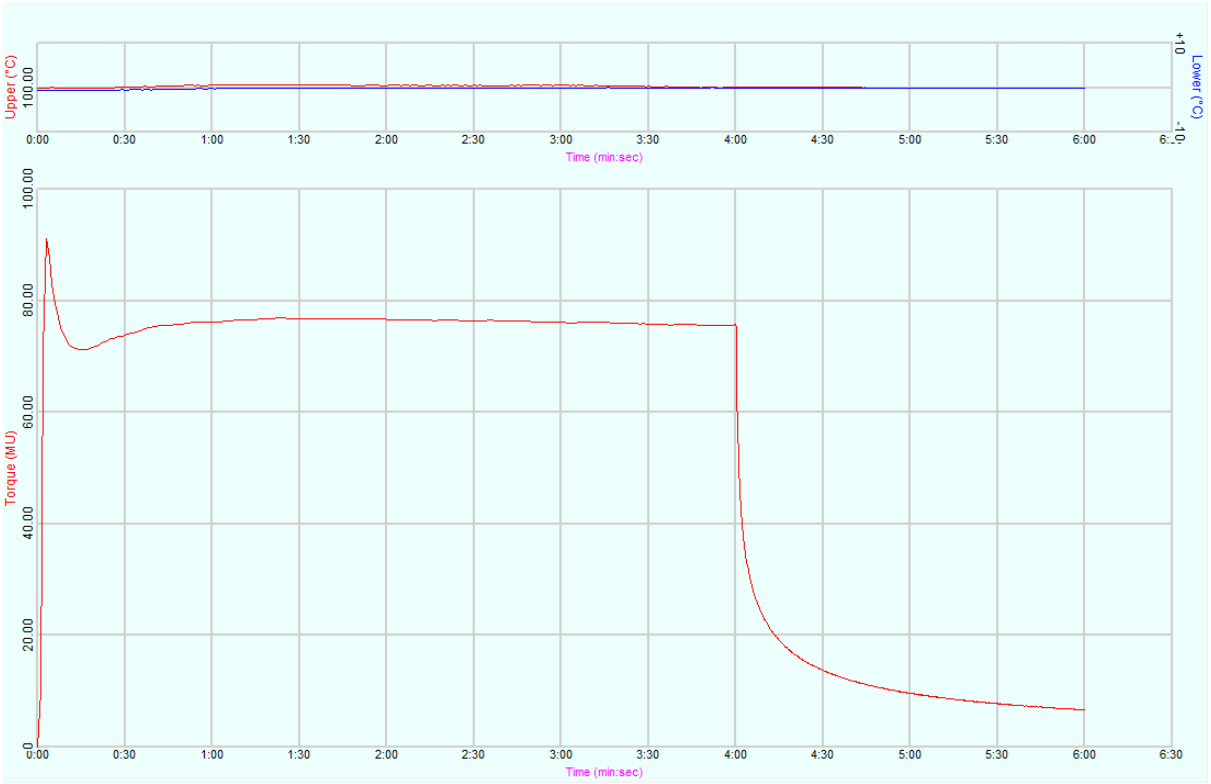

Figure 1 ML 1 + 4(100°C) + 120 s SR

Decay Time

Assuming a 100% torque value (in Mooney units [MU]) after the rotor stops:

StR (%) The torque after a user-defined decay of x% [MU]

StR (time) The torque after a user-defined decay of x minutes/seconds [MU]

StR Time@Decay (%) The time at which the torque has decreased by a set amount (%) [s or min]

Power Law Decay Model

By transforming the data after the rotor stops into a log-log representation, the exponential decay of the torque becomes an approximate linear relationship between log(Torque) and log(time). Using the equation for a straight line, the following coefficients are calculated, alongside the area under the line:

Slope (a) The rate of stress relaxation [MU s^{-1}]

Intercept (k) A constant equal to the torque 1s after the rotor is stopped [MU]

Correlation (r) The correlation coefficient for the regression analysis used in the power law model

SR Area (A) The area under the curve calculated using the power law method from 1s to the end of the test [MU s]

SR Area (A@%s) The area under the curve calculated using the power law method from 1s to a defined time [MU s]

Interpretation

In general, a relatively slow rate of relaxation points to a higher elastic component in the overall response of the rubber; whereas a faster rate of relaxation indicates a greater viscous component.

Stress relaxation behaviour is also closely linked to the structural characteristics of rubber, such as molecular weight distribution, molecular chains and gel components. Therefore, stress relaxation testing on a Mooney viscometer can be an effective way to evaluate the mixing profile and processability of rubber.