ABSTRACT
Following the theory developed by Ting, analytical expression of contact radius for an advancing contact is derived. For receding phase, contact radius is numerically obtained. Contact pressures for increasing and decreasing contacts are derived as a sum of two terms: the first is a Hertz-type pressure and the second term gives infinite pressure at the edge of the contact. Theoretical results are compared with the experimental data.

INTRODUCTION
The solution to the problem of a smooth axisymmetric rigid indenter pressed into a viscoelastic half-space in the absence of adhesion was given by Ting, [1], for an arbitrary increasing or decreasing contact radius. The usual dynamic load considered by classical authors, Lee and Radok, [2], and Johnson, [3], is Heaviside function. Following Ting’s theory, the cyclic linear loading was considered, for a linear standard solid by Johnson, [4], or for Kelvin-Voigt and Maxwell models by Unertl, [5]. In technical applications, one of the most frequent loads is the cyclic force resulting from a pulse cosine applied over a step function. This force is considered inheren to investigate the dynamic contact between an incompressible Kelvin-Voigt half-space and an axi-symmetric rigid paraboloid.

THEORETICAL INVESTIGATION
The Kelvin-Voigt model consists of a spring in parallel with a dashpot. The retardation time of the model is $\tau_v = \eta / G$. The relaxation and the creep functions are:

$$
\Psi_v(t) = 2G[1 + \tau_v \delta(t)]; \quad \Phi_v(t) = [1 - \exp(-t / \tau_v)]/2G.
$$

(1)

Following the theory developed by Ting, for a cyclic loading described by the relation:

$$
P(t) = P_0 [1 - \cos(2\pi v t)]H(t) + P_0^t H(t),
$$

(2)
the contact radius is derived analytically for increasing contact and has the form:

$$
a(t) = \begin{cases} 
\frac{3RP_0}{16G} \left[ \cos(2\pi v t) + 2\pi v \tau_v \sin(2\pi v t) + (2\pi v \tau_v)^2 \exp(-t / \tau_v) \right] + 16G \left( \frac{1}{1 + (2\pi v \tau_v)^2} \right) \end{cases}
$$

(3)

For receding phase, it is found numerically.

As seen in Figure 1, at the end of the cycle, the contact radius tends to a value corresponding to the static force. There is a delay between maximum force and maximum contact radius. The influence of load frequency upon contact radius and pressure is evidenced. For increasing frequency, the delay between load and contact radius increases and the maximum contact radius decreases, as shown in Figure 2.
For increasing contact, the contact pressure is analytically derived using the contact radius:

\[ p(r,t) = \frac{4}{\pi R^2} \int_0^t 2G\left[\frac{1}{\tau} + \frac{\delta(t-\tau)}{\tau}\right] \left[\frac{1}{\delta(t)} - \frac{1}{\delta(t-\tau)}\right]^{1/2} \, d\tau , \quad (4) \]

while for receding contact numerical computation is necessary.

For both phases, increasing and decreasing contact, the pressures are derived as a sum of two terms: the first determines a Hertz-type pressure, Figure 3, and the second gives infinite pressure at the edge of the contact, as predicted by Lee and Radok. The central contact pressure is analyzed and, for increasing phase, has the shape from Figure 4. The central contact pressure increases with increasing frequency, Figure 5.

**EXPERIMENTAL RESEARCH**

Experimental investigations were carried out on a contact between a polymeric sphere and a glass plate, measuring contact radius and normal approach. The experimental setup contains: loading device, low frequency function generator, memory oscilloscope, optic microscope, video camera, displacement transducer, computer, monitor, data acquisition board, image and film programs.

A good agreement is found with theoretical results obtained for the Kelvin-Voigt model, as seen in Figure 6, whereas for other materials,[6], the Zener solid predicts better experimentally measurements.

**CONCLUSIONS**

For a cyclic loading, contact radius stems from applying the theory developed by Ting. The delay between radius and force increases with frequency and with increasing retardation time of the model, while the maximum contact radius decreases.

The contact pressure is the sum of two terms; the first represents the Hertz-type component and the second term gives infinite values on the contour. At low frequencies, the pressure in the center of the contact follows the force.

**REFERENCES**