Development of degradation model of viscoelastic polymers during thermo-oxidative aging by Oberst beam testing

Sun Yong Kim[1], and Doo Ho Lee[2]

[1]*School of Mechanical Engineering, Ulsan College, Ulsan, 44610, S. Korea*
sykim2@uc.ac.kr

[2]*Department of Mechanical Engineering, Dongeui University, Busan, 47340, S. Korea*
dooho@deu.ac.kr

ABSTRACT

Depending upon the environmental conditions such as oxygen, ozone, sunlight, thermal, UV and radiation, the characteristic of viscoelastic polymer would be degraded. It is well known that oxidative degradation is generally considered to be the most serious problem for rubbers at high temperature. The prediction of their performance requires the knowledge of their dynamic properties as a function of frequency and temperature. In order to identify the characteristic of viscoelastic polymer during thermo-oxidative ageing, Oberst beam testing would be adopted. The aim of this research project is to identify the degradation characteristics of viscoelastic polymer by ageing at different properties and time period.

1. INTRODUCTION

Viscoelastic polymers are extensively used to manufacture dynamic damping materials in machinery. Its vibration damping properties are extremely informative in many applications, ranging from appliances to aerospace systems. The prediction of their performance requires the knowledge of their dynamic properties as a function of frequency and temperature. However, the dynamic properties are degrading depending upon in a wide variety of environmental and service conditions such as thermal, UV and/or radiation. It is well known that oxidative degradation is generally considered to be the most serious problem for rubbers at high temperature. Considerable efforts have been devoted to study and characterize the prediction of polymer during the thermal, UV and radiation degradation of polymers (Mathew, C.C. (2013) & Asseref, P.M et al (2013)). However, the papers have been more focusing on life of polymers by accelerated thermal ageing rather than prediction the dynamic properties. In terms of engineer and designer, the prediction of dynamic properties of viscoelastic polymers are much more useful data to predict the characteristic of systems.

We are currently involved in an extensive research project to develop a thermo-oxidative degradation model of viscoelastic polymers, commonly used as damping materials using Oberst beam testing (David, 2001). In order to characterize the dynamic properties of viscoelastic polymer by ageing at different temperatures and time period, Oberst beam testing would be adopted. Kim & Lee (2009) have presented the complex modulus of viscoelastic polymer using optimization technique with Oberst beam test.

The aim of this research project is to identify the degradation characteristic of viscoelastic polymer by ageing at different temperature and time period.

2. EXPERIMENTAL

2.1. Materials

Rubber polymers like Natural Rubber, Acrylo-Nitrile Butadiene Rubber (NBR) and Ethylene Propylene Diene Rubber (EPDM) are often used to develop rubber components. Among them, NBR were fabricated for the testing and some required testing items are shown in Table 1. The dimensions are 420mm(Length) × 12mm(Width) × 2.0mm(Height) for Oberst beam testing.

Table 1. Testing results of NBR samples

Test Items	Test Results		
	Average	Minimum	Maximum
Specific gravity	2.22	2.21	2.23
Hardness (Shore A)	60	59	60
Tensile Strength [kg/cm^2]	138.8	129.9	144.1
Elongation [%]	575	525	600

2.2. Oberst beam

Figure 1. Obesrt beam configuration

Figure 1 shows the Oberst beam configuration. A viscoelastic polymer sheet is attached on one-side of base beam. Through a vibration testing, modal loss factors could be calculated by half power method from measured frequency response functions. The dimensions of base beam are 421mm (Length) × 12mm (Width) × 1.5mm (Height) for bare beam and the material is stainless steel. Elastic modulus and density are 210GPa and 7,860 kg/m³ respectively. Firstly it needs to know the characteristic of base beam in order to identify the range of frequency for calculating of modal loss factors from Oberst beam testing. The natural frequencies and mode shapes are presented in Figure 2. The frequency ranges are considered as from 100Hz to 4000Hz. In order to validate the simulation, an experimental testing of base beam will be conducted.

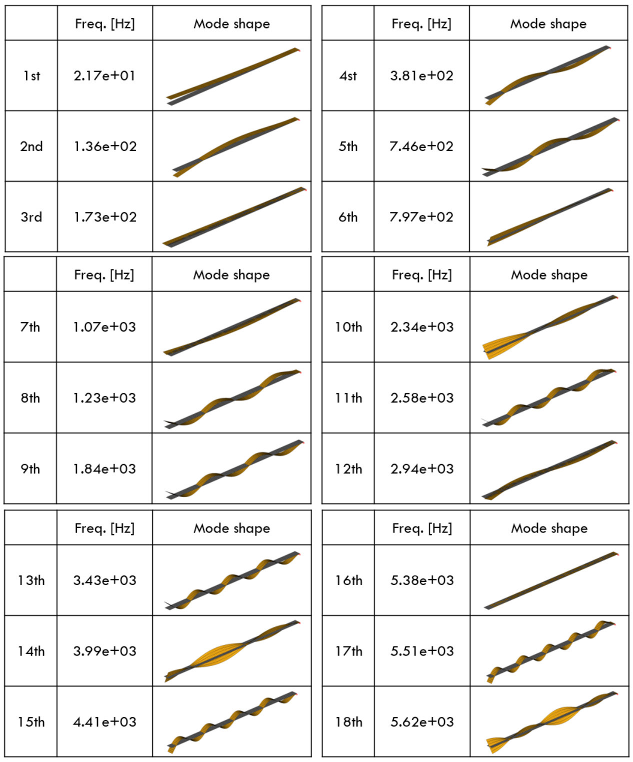

Figure 2. Natural frequencies and mode shapes of bare beam

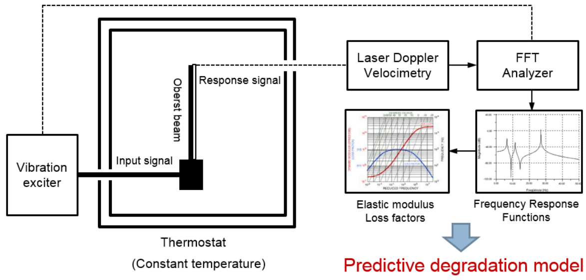

Figure 3. The scheme of Oberst beam testing

Table 2. The number of NBR samples for testing

	25°C			50°C			75°C			100°C			115°C		
	Beam	Tensile	Hardness	Beam	Tensile	Hardness	Beam	Tensile	Hardness	Beam	Tensile	Hardness	Beam	Tensile	Hardness
1-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
14-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
30-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
45-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
60-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
75-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
90-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
100-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
120-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
150-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
180-day	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Figure 3. The scheme of Oberst beam testing

Figure 3 shows the scheme of Oberst beam testing in order to measure the modal loss factor at a different temperature for thermos-oxidative ageing. Table 2 shows the number NBR samples for Oberst beam testing, tensile strength and hardness for different temperature and time period.

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