STUDIES ON DYNAMIC TENSILE MODULUS AND STRUCTURAL CHANGES OF POLYMER-CONDUCTIVE FILLER COMPOSITES UNDER ELECTRIC FIELD INVESTIGATED AS LOW FREQUENCY EARTHQUARK COUNTERMEASURES

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ABSTRACT

Development of desirable positive temperature coefficient (PTC) materials and the theoretical analysis of PTC mechanism play important roles in promoting significant applications to floor heating. Certainly, it is obvious that light PTC materials as heating elements have advantage for saving of construction cost of building circulation rather than heavy hot water tube in addition to the safety and cleanliness. In addition to intensity of earthquake, the horrors of low-frequency earthquake (0.1 ~ 2 Hz) must be taken into consideration for collapse of construction. However, there has been no report for damage of PTC materials against low-frequency earthquake, since no method has been established for testing mechanical properties under applied electric field, different from usual techniques by usual external heating.

This presentation deals with frequency dependence of the dynamic tensile modulus of PTC materials under applied electric field. Fine home-made attachments were fixed on a commercial viscoelastic spectrometer to measure the dynamic tensile modulus with different frequencies at the desired temperatures. Efforts were done to determine static strain in order to place the sample in tension during axial sinusoidal oscillation. The measurements were carried out for ultra-high molecular weight polyethylene (UHMWPE)-nickel (Ni) coated carbon fiber (NiCF) composites which have been adopted as PTC materials. The drastic descent of the storage modulus was confirmed in lower frequency range (0.01~2 Hz) at surface temperature (T_s) elevated by Joule heat. That is, E' value by self-heating is much lower than that by external heating at the same temperature. This tendency became considerable beyond 65 ^{o}C. Judging from heat conductivity of the innocent wooden plate with ca. 30 mm thickness, the desired setting temperature of PTC plate as heater is thought to be 60 ~ 70 ^{o}C at outdoor air < 0 ^{o}C, in order to keep the surface temperature of decollated floor to be ca. 20 ^{o}C. Of course, the heat generation temperature of PTC plate must be controlled by outdoor air temperature carefully. The reference temperature was determined to be 65 ^{o}C to draw master curves for investigating detailed relaxation mechanisms by considering that Joule heat in PTC plate as heater transfer to decollated floor surface through innocent wooden plate. Incidentally, the composite was cut when T_s was beyond 93 ^{o}C. In contrast, the cutting did not occur in higher frequency range (100~10 Hz) at T_s = 105 ^{o}C. The present fundamental work warns that protection of PTC materials used as floor heating must taken into consideration in terms of low frequency earthquake in addition of seismic intensity. Simultaneous measurements for X-ray, electric current and T_s, the reason indicated that α -dispersion associated with relaxation of crystal grains by Joule heat occurred at lower temperature in comparison with usual external heating and this phenomenon is attributed to a number of transferring electrons between overlapped adjacent Ni surfaces by tunneling effect.