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Eligibility Adopting Error Functions to Reproduce the Combustion Behavior of the Covering Materials of Cables

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Extended Abstract

Electric cables, which are indispensable to construct electric facilities have combustible materials for its insulation and jacket. Since heavy amount of cables are installed in various places, enormous damage will occur, when they are burned in fire. To prevent these kind of incidents, various types of fire hazard assessments are implemented for electric cables. Although it is preferable to perform real scale experiment for fire hazard assessment for cables, it is not practical to assess all types and sizes of cables installed, by high cost large-scale testing. From this reason, numerous attempts have been made to predict combustion behaviour of electric cables in real scale experiments using bench scale testing. [1][2] In this work, novel attempt is made to decompose the temporal heat release curve of the material, which composes electric cable covering, provided by Cone Calorimeter test to the combinations of characteristic error functions, under assumption that combustion of the each material is proceeded independently and stepwise with the passage of time and the overall heat release curve of composite material is constructed by summation of heat release curve of each material. 100mm×100mm×1mm size of sheet samples fabricated from materials used for electric cables were burned and heat release curves of each material combusted were obtained using bench scale testing apparatus, Cone Calorimeter specified in ISO 5660-1 [3]. Two kinds of samples were adopted for the present test purpose, such as Poly vinyl chloride sheathing material (sample 1) and flame retardant EVA sheathing material (sample 2)

Obtained heat release curves were decomposed using commercially available software, then two types of error functions are applied to fit. One is Gaussian function, which is most commonly used distribution function for peak fitting of chromatography and another one is Exponentially Modified Gaussian (EMG) function, which is reported that more precise fitting result is derived than Gaussian function when applied for peak fitting of chromatography [4]. In the application of both error functions, several decomposed curves are obtained on both samples and it is found that composite curve of decomposed curves could have over 99% correlation with original heat release curve obtained by combustion in the Cone Calorimeter, if number of decomposed curves are not limited. As a result of combining and evaluating a number of analysis results while considering the physical meaning of the number of peaks (one peak represents a single phenomenon), it is better to apply the EMG distribution function to obtain more physically correct results. For Sample 1, combustion stages of plasticizer and polymer, following stage of glowing combustion of remained carbon are well described by decomposed curves and for sample 2 which not include combustible material other than base polymer, over 99 % correlation was achieved with original heat release curve by one distribution curve using EMG distribution function. It suggests that by introducing this method, it is possible to predict the combustion characteristics of the cable covering having a multi-layer structure.

References

[1] Emil Braun, John R. Shields and Richard H. Harris: "Flammability Characteristics of Electrical Cables Using the Cone Calorimeter" , NISTIR 88-4003, 1989, pp.13-20
[2] Johan Mangs, Simo Hostikka: "Experimental characterization of the MCMK cable for fire safety assessment" , VTT-R-06873-12, 2014, pp.17-20
[3] ISO 5660-1: "Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)", Third edition, 2015
[4] Mark Jeansonne and Joe P. Foley: "Review of the Exponentially Modified Gaussian (EMG) Function Since 1983", Journal of chromatographic science Vol. 29, Issue 6, 1991, pp258-266