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Large-scale fire test for interior materials of the Korean high speed train

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Abstract: A large-scale fire test was conducted in the room where the interior materials of a railroad vehicle for KTX (Korean eXpress Train)-II were used. As flame source in the room, a gas burner was used; the output of the gas burner was set to increase over time. The purpose of the test is to evaluate the fire resistance performance of the interior materials of a KTX-II when they ignite and flames spread and to obtain various types of data on flames developing into flashover and engulfing the interior materials of KTX-II These data will be used to verify and build a simulation model of fire development on the interior materials of a railroad vehicle.

Keywords: Large-scale fire test, interior materials, Korean high speed train

1 Introduction

Since the Daegu subway fire disaster, there have been public announcements of regulations in Korea regarding the fire resistance performance of the interior materials of railroad vehicles to ensure their fire safety[Korea Land, Transport and Maritime Affairs (2008, 2010)]. Such regulations concerning the fire resistance performance of the interior materials determine performance through lab-scale sample tests that allow judging the suitability of the materials for fire safety; Note, however, that it is not easy to realize the phenomenon of development of flames into a big fire in an actual situation to judge the level of fire safety of railroad vehicles. For these reasons, it is more reasonable to evaluate the level of fire safety through a large-scale fire test rather than a sample or lab-level test. Since measuring the heat release rate for an entire railroad vehicle is difficult, numerical analysis was performed [Chiam (2005)]. Large-scale fire tests on the interior materials have been conducted recently before and after the replacement of materials [White, Park and Webb (2008); Lee, Park, Jung, White, Webb and Hwang (2009)]. This test was run

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on interior materials meeting the new domestic quality standards in a simulation vehicle model containing the end of KTX-II to observe and measure the phenomenon of development of flames into a fire in the inside of the vehicle.

2 Set-up of the test

2.1 Fire test facility

The test on the interior materials of the KTX Sancheon railroad vehicle was conducted in a rectangular parallel-piped test room 3.6m long, 2.4m wide, and 2.4m high, which meets the standard of ISO 9705 [International Organisation for Standardization (1993)]. In the test, the smoke arising from the inside of the test room was collected through the ventilation hood and duct installed outside the room, and the temperature and smoke density of combustion gases, heat release rate, etc., were measured. The heat release rate can be calculated by measuring the changes of the concentrations of the oxygen, carbon monoxide and carbon dioxide, and mass flow rate of collected gas.

2.2 Interior material of KTX II

In this test, the representative interior materials installed in the inside of the KTX-II vehicle in the test room are flooring, curtains, chairs, and walls. For the end part fitted to the end of the vehicle, metal finished with paint was used as material. The flooring is synthetic rubber, and its main components are shown in Table 1. The curtains are 70% polyester and 30% polyvinylchloride.

Table 1: Composition of floor covering

Composition	**ratio**
Styrene-butadiene Rubber	30%
Aluminum Silicate	45%
Processing waxs(polyolefin, polyethylene glycol etc)	10%
Zink oxide	2%
Sulphur	1%
Frame retardants	10%
Pigments(Titanium dioxide, Iron oxide etc)	2%

The Nomex sandwich panel of the vehicle ceiling and walls consist of four layers of flame-resistant PVC (polyvinylchloride), Phenolic Resin (40%) + Glass Fabric (60%), Nomex honeycomb, and Phenolic Resin (40%) + Glass Fabric (60%). The

Nomex honeycomb core is of the Aramid Fiber PN1 type about the size of a 1/8-inch cell.

The seat cover of the chairs is made of Moquette (Wool+Polyester), and polyurethane foam was used as cushion for driving comfort. The hand supports and tables were made of polycarbonate plastic, and magnesium alloy was used for the structures. Fig. 2 shows the interior materials installed in the test room.

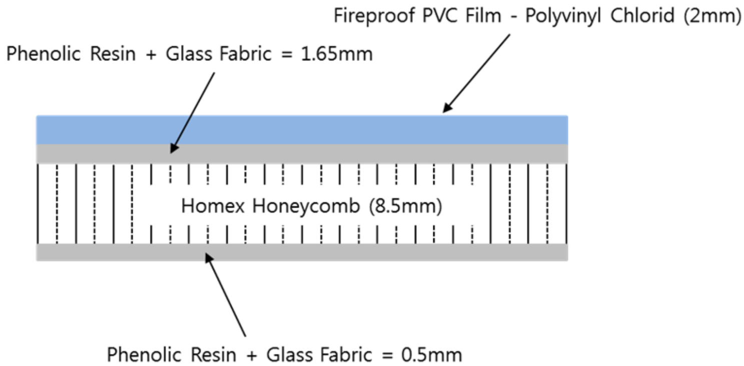

Figure 1: Structure of KTXII panel

Figure 2: Installation of materials

Figure 3: Sand burner installed between seats

2.3 Installation of equipment

For the fire source, the ISO9705 standard-compliant sand burner in Annex A was used and positioned between the front and rear seats as shown in Fig.3. The burner used as fire source is designed to burn as propane spreads and spurts through the sand in the 170mm quadrangular cross section on top. The output of the burner was based on the biggest scenario from among the standard fire sources prescribed in CEN/TS 45545-1[European Committee for Standardization (2009)] for the first 10 minutes and was set to be maintained at 75kW for the first 2 minutes, 150kW for the next 10 minutes 200kW for 12 minutes, and 250kW afterward. A total of 44 thermocouples were installed during the test – 13 on the roof, 9 on the end, 11 on the floor, and 11 each on the right and left walls. As for the plate thermometer, a total of 3 were installed: 1 in the middle of the floor, and 2 on the wall opposite the fire source.

3 Results

(a) 3 min. (b) 5 min.

(c) 7 min. 30 sec. (d) 11 min.

Figure 4: Fire spread of KTXII interior materials

Fig. 4 shows the spread of fire in the inside of the test room at various times. For

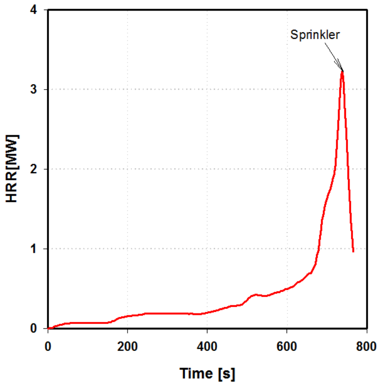

Figure 5: Heat release rate

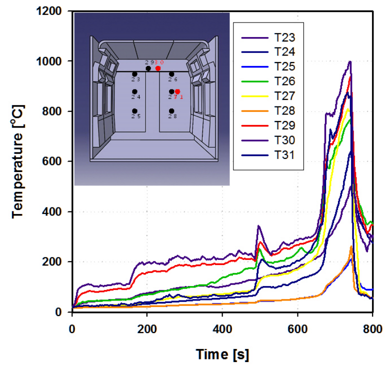

Figure 6: Temperature on the end wall

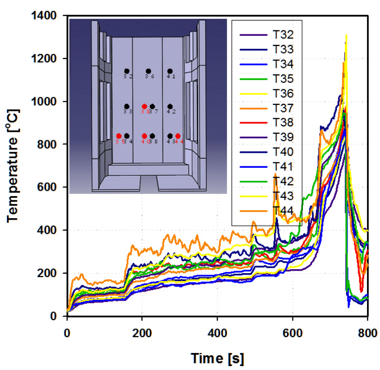

Figure 7: Temperature on the ceiling

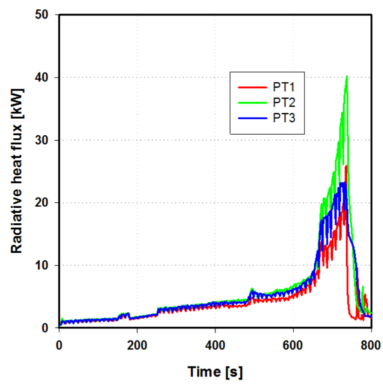

Figure 8: Radiative heat flux

3 minutes after the start of the test, only the sand burner flame could be seen to be burning without the interior materials igniting. Four minutes later, the smoke started to become stratified around the ceiling of the test room; seven minutes later, the developed smoke layer descended to a height of about 1.2m from the floor, with flames spreading after 7.5 minutes to all chairs first assembled. After ten minutes, they developed into a big fire that – after about 13 minutes – necessitated using the fire-extinguishing equipment in the test room to protect the facilities from the fire. The heat release rate measured in the experiment is shown in Fig. 5. The heat release rate initially showed slow development, only to exhibit a rapidly rising flashover phenomenon about 660 seconds later. Figs. 6 and 7 show the temperatures measured at the ceiling and the end wall. The temperature was observed to

increase with the increase in HRR. Fig. 8 shows the heat flux measured by the plate heat flux gauge in the inside of the test room. The PT3 heat flux gauge installed facing the ceiling first showed similar heat flux as the other heat flux gauges installed on the side; after the flashover, however, it exhibited heat flux far higher than that reaching the other wall.

4 Conclusions

A large-scale fire experiment was carried out in a test room fitted with the interior materials used for KTX (Korean eXpress Train)-II. After the flames spread to the top of the railroad vehicle, they were observed to have developed into flashover, engulfing the chairs and the floor due to the radiant heat from the flames on top; thus sweeping through the entire area of the inside of the vehicle to become a huge fire. In case of difficulties in conducting real-scale fire tests on railroad vehicle, this fire test – carried out on a mock-up room that simulated a part of a railroad vehicle – can reproduce the aspect of fire from its early stage to the stage of sweeping through the entire car. The heat release rate, surface and air temperatures, and heat flux values measured in this experiment will be used to verify and develop a forecasting model of a railroad vehicle's interior materials that ignite and cause a major fire.

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