Preliminary Measurement with a Cone Calorimeter

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INTRODUCTION

The cone calorimeter is now an international acceptable method [1,2] for assessing the rate of heat release (RHR) of materials exposed to controllable radiant heat flux of values from 0 to 100 kWm^{-2}. This is a bench-scale apparatus based on the "oxygen consumption" method where precise measurements of oxygen concentration and the flow rate in a horizontal duct are required, explaining why it is so expensive. Even so, the equipment is considered as an essential item for advanced fire research, development and education [3-7]. This is because the RHR is considered to be one of the most important parameters in describing the fire responses of materials, products and assemblies, particularly for organic materials.

A Cone Calorimeter was installed recently at the Department of Building Services Engineering, The Hong Kong Polytechnic University (PolyU). In addition to RHR, time-to-ignition, optical smoke density, mass loss rate, concentration of carbon monoxide, carbon dioxide and soot can be measured. Further, a humidity cabinet enclosing the cone is to be installed for controlling the air temperature, humidity and oxygen content.

Support for purchasing this cone calorimeter was from the mission of improving teaching and learning quality at the PolyU. This cone is mainly used for education purpose as a teaching equipment for 125 students per year; with 20 students studying for the degree MSc in Building Services Engineering, 40 students studying for full-time BEng (Hons) in Building Services Engineering, 40 students studying for part-time BEng (Hons) in Building Services Engineering, and 25 students studying for part-time degree in Building Services Engineering with Fire Engineering Specialism. In addition, the cone will be used by over 20 PhD research students working projects in Fire Sciences and Engineering.

Preliminary tests on three samples of common materials were performed to inspect the performance of the PolyU cone and reported in this paper. Tests in different materials using the cone calorimeter were performed by advanced laboratories such as the Swedish National Testing and Research Institute (SP) [3-7]. Comparsions with their results can check the measured RHR and other key parameters.

The three products tested in this paper are ordinary plywood (density of 564 kgm^{-3} and thickness of 11mm) ; polyvinyl chloride PVC (density 1195 kgm^{-3} and thickness 6 of mm), and FR cycolac (density of 1411 kgm^{-3} and thickness of 7 mm). The first two products were sent to the PolyU from SP [3] and the third sample is commonly used in Hong Kong.

RESULTS

Two tests (labelled as tests 1 and 2) on each of the three samples were performed in the PolyU cone according to ISO 5660 [2]. The specimens were held horizontal at a heat flux level of 50 kWm^{-2}. RHR curves are shown from Figures 1 to 3, together with the SP curves for the first two samples.

The data are further summarized into key parameters as total heat release Q_{total} (in kWm^{-2}), peak rates of heat release Q_{max} (in kWm^{-2}) and average rates of heat release Q_{60}, Q_{180} and Q_{300} (in kWm^{-2}) for three time periods, 60 and 180 and 300 s after ignition. Results from these tests are shown from Tables 1 to 3. There, results from SP are also shown for similar materials to the specimens sent to PolyU.

Table 1 : Results for Plywood

	PolyU Test		*SP Test*	
Test no.	**1**	**2**	**1**	**2**
Q_{max}/kWm^{-2}	213	207	304	276
Q_{total}/kWm^{-2}	18.6	14.8	80.2	76.5
Q_{60}/kWm^{-2}	164	196	196	201
Q_{180}/kWm^{-2}	113	100	173	173
Q_{300}/kWm^{-2}	160	152	170	170

Table 2 : Results for PVC

	PolyU Test		*SP Test*	
Test no.	**1**	**2**	**1**	**2**
Q_{max}/kWm^{-2}	259	257	137	139
Q_{total}/kWm^{-2}	1.6	3.1	15.7	16.5
Q_{60}/kWm^{-2}	241	252	94	98
Q_{180}/kWm^{-2}	106	135	63	66
Q_{300}/kWm^{-2}	96	104	46	51

Table 3 : Results for FR Cycolac

	PolyU Test		*SP Test*	
Test no.	**1**	**2**	**1**	**2**
Q_{max}/kWm^{-2}	301	227	-	-
Q_{total}/kWm^{-2}	1.92	1.42	-	-
Q_{60}/kWm^{-2}	178	214	-	-
Q_{180}/kWm^{-2}	220	201	-	-
Q_{300}/kWm^{-2}	301	222	-	-

DISCUSSION

Two peaks were observed in the RHR curves for plywood as shown in Fig. 1. At the early stage of burning, only the surface of the specimen was ignited. Swelling of materials occured later and the plywood began to delaminate. The whole specimen burnt and the second peak appeared. The SP curves also had two peaks but with higher values. Values for their three average RHR are similar to those from the PolyU tests.

One sharp peak was found in the early stage of the RHR curves for PVC as in Fig. 2. Black smoke came out during the test and the specimen expanded to large volume of black residue at the end of the test. The SP curves had a lower value of the peak value Q_{max}. A possible reason is the specimen tested was not a whole PVC block, but a PVC wallcarpet on gypsum paper plaster board.

Cycolac had steady values in the RHR curves throughout the burning process as shown in Fig. 3. Black smoke came out during the test. No comparison with others was made for the sample.

CONCLUSION

Three common materials were tested using a cone calorimeter at The Hong Kong Polytechnic University. Reasonably good agreement among the PolyU results and the results of SP was found for plywood and PVC samples. Further comparsions with other materials will be made. The cone will also be used extensively for assessing the fire responses of materials used in the new airport of Hong Kong as a research project funded by the Research Grants Council.

ACKNOWLEDGEMENT

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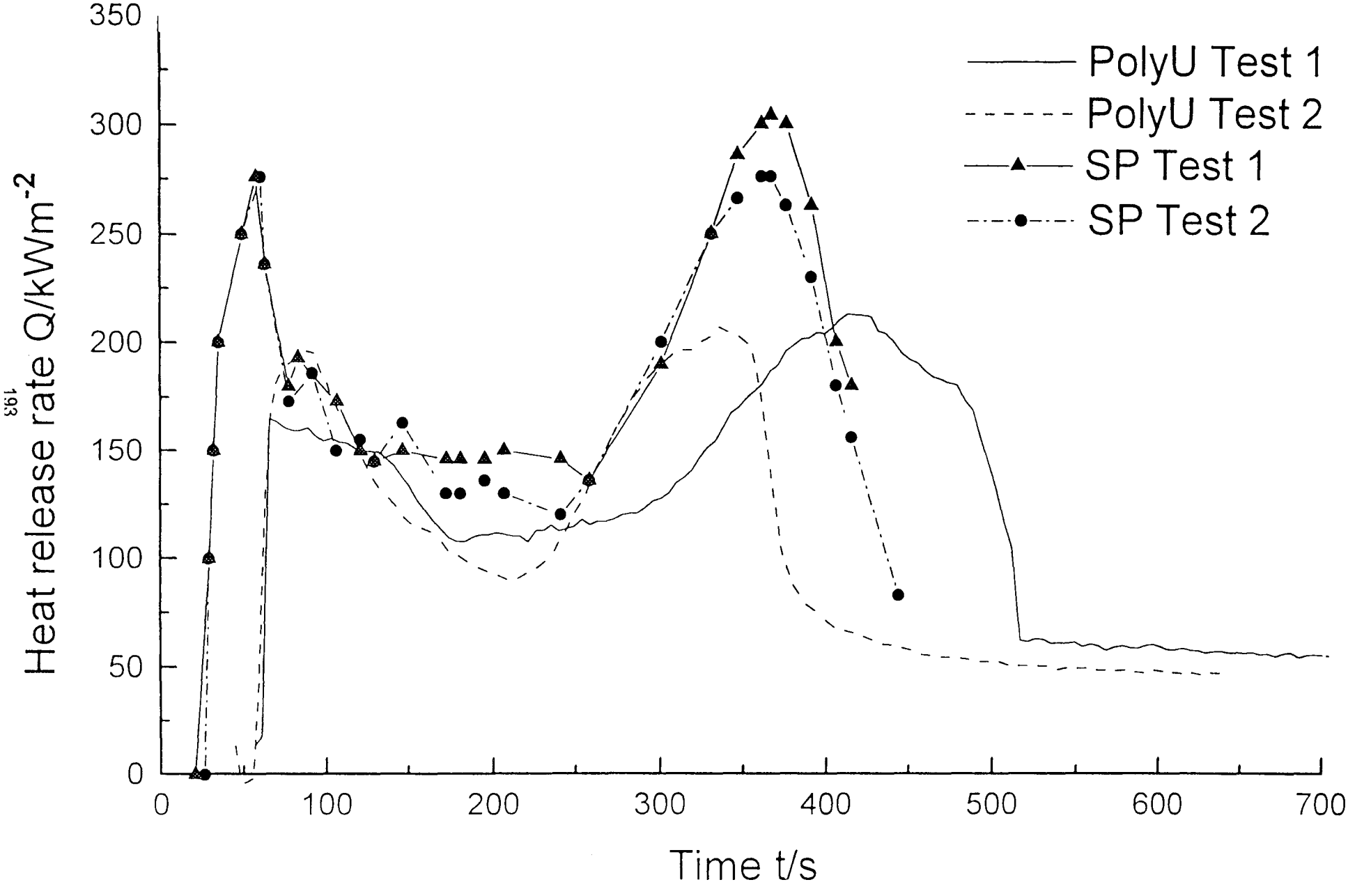
PolyU Test 1
PolyU Test 2
SP Test 1
SP Test 2
Heat release rate Q/kWm-2
Time t/s
0
50
100
150
200
250
300
350
0
100
200
300
400
500
600
700

Fig. 2 : PVC

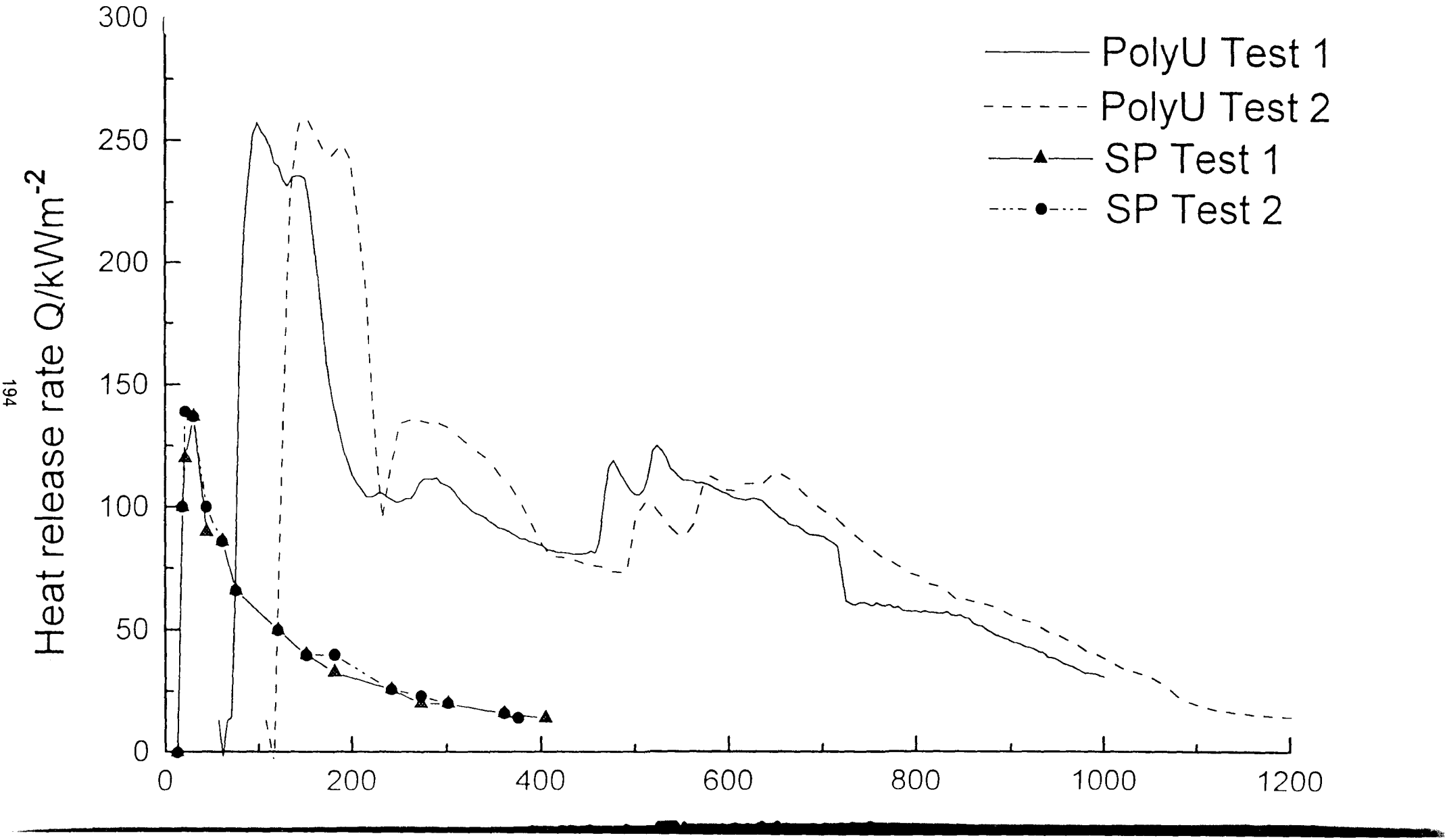
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
Heat release rate Q/kWm-2
PolyU Test 1
PolyU Test 2
SP Test 1
SP Test 2

Fig. 3 : FR Cycolac