RESEARCH REVIEW JOURNALS
Volume-04
Issue-02
February-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[UGC Listed Journal]

Experimental Investigation on Polycarbonate Fire using various Parameters

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ARTICLE DETAILS

Article History
Published Online: 20February 2019

Keywords
Polymer, Furniture, manufacturing

ABSTRACT

Polymers are most commonly used in manufacturing applications and the home. Each of the electric appliances, furniture, glazed windows & pillow are comprised of polymer, that make the majority of the fire lots in the family room of a home as well as the machinery components in the working hall of the market. Polycarbonate is used as a fuel in the experiment in this paper. The polycarbonate is cut in to required shape and the polymer is burned until its degradation temperature is reached. After the degradation temperature is reached the water mist is operated to extinguish the fire. This water mist is produced by various different set of parameters. The extinguishment is recorded by a video camera and the time taken for each extinguishment is found out from the video. Thus the effect of each parameter like pressure, nozzle diameter and height between nozzles, fuel are found out. In this experimentation the effect of coverage area and flow rate is also taken in to consideration. Here the experimentation is done until the effect of pressure gets converges.

1. Introduction

Plastics (polymers) are a big and growing portion of the fire load in houses, industrial locations, and transport. Furthermore, the plastics which are most popular would be the cheapest and also are inclined to become probably the most flammable. Flammability, which typically describes the propensity of a chemical to ignite readily and also melt rapidly with a flame, is but one sign of fire hazard. The connection between measures of flammability: heating discharge capacity as well as flame resistance compared to the truckload cost of commercial polymers. The commodity polymers costing under approximately thirty seven rupees a kilogram include more than ninety five % of the polymers in use, along with these will go on to burn after short contact with a tiny flame. Engineering as well as specialty plastics costing more than seventy four rupees per kilogram are generally polymers with aromatic backbones & fluoropolymers, which self extinguish or maybe resist ignition due to higher thermal stability or minimal energy value.

The financial incentive to add flame retardants to commodity polymers to pass flammability requirements has focused polymer flammability exploration in the last several years on the systems plus efficacy of flame retardant additives instead of on polymer flammability as being an intrinsic material property. This particular pattern in investigation, mixed with the reality that flaming combustion of solids is a very coupled, multiphased process which fire test results count on the device, test circumstances, and also sample geometry, has restricted the comprehension of polymer flammability to a qualitative and descriptive nature.

2. The burning process

Gases as well as volatile fluids are small particles which are held together by weak (< one kJ/kg) secondary chemic bonds. These volatile elements spontaneously create combustible mixtures with air which ignite readily and also melt with a very high velocity. Polymers are extremely big macro molecules with similar intermolecular as well as intramolecular forces as lower molecular weight elements, but the boiling temperature of theirs is basically infinite due to the high molecular weight of theirs. So, both intramolecular and intermolecular synthetic bonds of polymers have to be broken to produce volatile energy species. This particular procedure demands a continuous and large source of winter power for ignition and sustained burning.

The key chemical processes are proven on the right hand side , including winter wreckage of the polymer in a slim covering level (the mesophase) as a result of the actual physical (energy transport) processes, blending of the volatile pyrolysis solutions with air flow by diffusion, then combustion of the fuel air combination in a combustion zone which creates sparkling power with a spectrum of wavelengths such as noticeable. The combustion zone is bounded by a fuel rich region on the interior along with a fuel lean region on the exterior. To increase the focus of oxygen in the planet is recognized to boost the flame heat flux, both because of a greater flame temperature, a rise in the amount of the combustion zone, or maybe a rise in the soot focus (luminosity) of the flame. Physical tasks and the chemical of flaming combustion specific to every one of the gasoline, meso, and then stable phases are shown in figure 1.

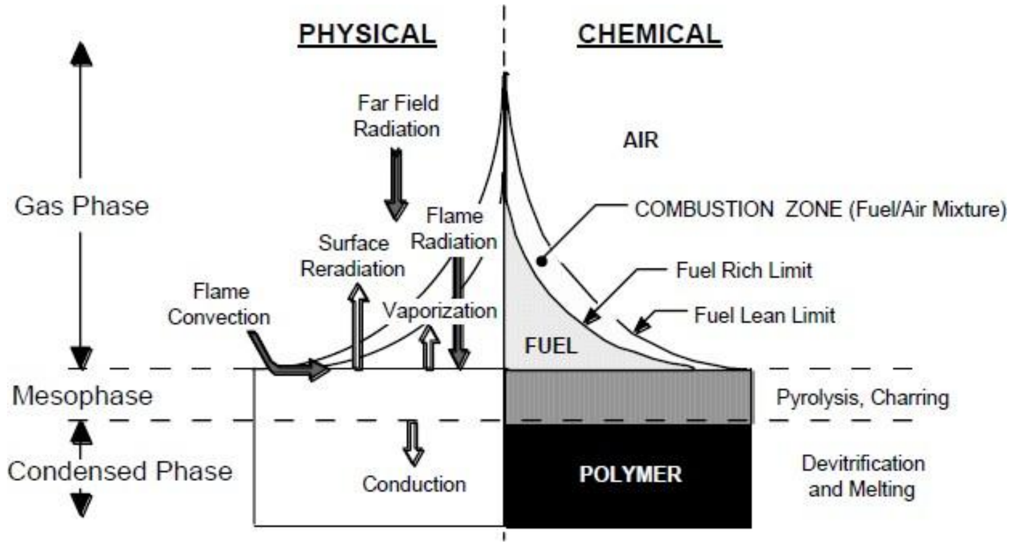

Figure 1 Degradation Phase in Polymer

3. Review of literature

B.Yao (2010), et al., released a paper "Experimental research of suppressing Poly(methyl methacrylate) fires utilizing water mists". This particular paper investigates the Full scale burning assessments on checking out the suppression of Poly(methyl methacrylate) (PMMA) fires using water mists are reported in this specific paper. The bath mists have been produced out of an individual substance nozzle running at lower pressures of up to 0.8 MPa. The flame suppression

procedures have been noticed as well as examined utilizing a Charge Coupled Device (CCD) camcorder. Experiments were performed underneath the exhaust hood of a fan duct process in an oxygen use calorimeter. Results suggested that PMMA fires are suppressed efficiently making use of this low pressure water mist program. The drinking water mist qualities as well as fire behavior, like heat discharge rate, are examined for modeling firesuppression.

A.Jenft (2014), et al., released a newspaper "Experimental as well as numerical research of pool fire suppression utilizing watermist" In this particular newspaper the experimentation in a real-scale space had been completed on water mist program to a pool flame. Gas oil firein Thirty five cm cylindrical pool is extinguished. Drinking water software is analyzed with a nominal flow rate the same as 25l/min supplied by a pair of 4 nozzles, injecting droplets with mean Sauter diameter equal to 112 μm. Observations of fire suppression in these circumstances exhibited 2 actions, that were examined as well as thorough with the aid of numerical simulations conducted withFDS.v5

F. Laoutid(2010),et al., released a paper "New prospects in flame retardant polymer materials: from basics to nano composites" this particular newspaper informs all about the polymer combustion as well as test employed to discover the fire behavior of polymer material. The addition of nanomaterial for various mesh size increase the fire retardant qualities of the polymer, discovered by utilizing the DSC curves. The power of the polymer by this particular inclusion of polymer is considered in this paper.

Zhigang Liu(2006), et al., released a paper "A research of lightweight water mist fire extinguishers useful for extinguishment of several flame types" This newspaper details equally experimental and theoretical studies on the program associated with a lightweight water mist extinguisher in suppressing several flame types. 2 prototype transportable water mist fire extinguishers have been created and the feasibility of theirs within extinguishing flammable fluid, cooking oil as well as wood crib fires, and also for use of fires linked to an energized goal was investigated. The interaction among the fire and water mist plume was analyzed by examining the instantaneous practice of fire extinction, and grill as well as gas temperature profiles. Both theoretical analysis as well as experimental results demonstrated that the extinguishing method and systems in addition to water mist attributes required change with the kinds of fires encountered.

X. Deckers(2013), et al., released a paper "Smoke control in case of fire in a big automobile park: Full scale experiments" The primary research in this particular paper is definitely the exploration of the effect of a smoke as well as heat management (SHC) system with forced manual horizontal ventilation on the smoke design in case of an automobile park fire, the preferred flame heat discharge rate (HRR) is required using well controlled fluid pool fires. Various variables are varied: the fire HRR; the smoke extraction flow rate; the flow patterns (through changes of inlet air opening); as well as the presence (or not) associated with a transversal beam. Not surprisingly, much less smoke back-layering is found for lower fire HRR as well as higher smoke extraction fee, the result of the second simply being much more vital.

4. Research methodology

Preparation of Sample

Polymer is cut in to required shape of 300mm X 300mm X 10mm. Totally 15 number of samples are prepared for the experimentation purpose.

Experimentation Chart

The experimentation is carried for the following combination of parameter. The pressure parameter is increased from three numbers to five numbers. The number of parameter combination is shown in the table 1.

Table 1 Parameter combination

Sl No	Pressure (bar)	Height (m)	Diameter(mm)
1	6	2.5	0.6
2	6	3	0.8
3	6	3.5	1
4	7	2.5	0.8
5	7	3	1
6	7	3.5	0.6
7	8	2.5	1
8	8	3	0.6
9	8	3.5	0.8
10	9	2.5	0.6
11	9	3	0.8
12	9	3.5	1
13	10	2.5	0.8
14	10	3	1
15	10	3.5	0.6

5. Results & Discussion

Polycarbonate is kept in the sample holder and 300 ml of kerosene is poured in the sample holder. Then it is lit by match stick and fire is left to grow fully over the polymer (ie., approx time 18 min). Then the k type thermocouple is kept at the centre of the polymer fire and the temperature is noted. The pressurized nitrogen cylinder is opened and set to the required pressure of 6 bar and it is allowed pressurize the water reservoir for the exact 6 bar pressure by closing the ball valve. Then the height between the nozzle and the sample holder is adjusted for the height of 2.5m.Nozzle of diameter 0.6mmisattachedtothesystem.When the temperature in the thermo couple reaches 3860 C is reached, the ball valve is opened to produce the mist. The extinguishment is recorded in the video camera and later this video is analyzed to find the extinguishment time. The experimentation is repeated for every combination of parameters as shown in the table 1 and video is analyzed to find out the extinguishment time for each combination of parameters. Stage of extinguishment of PC fire is shown in the figure 2. and extinguishment time for PC is shown in the table 2.

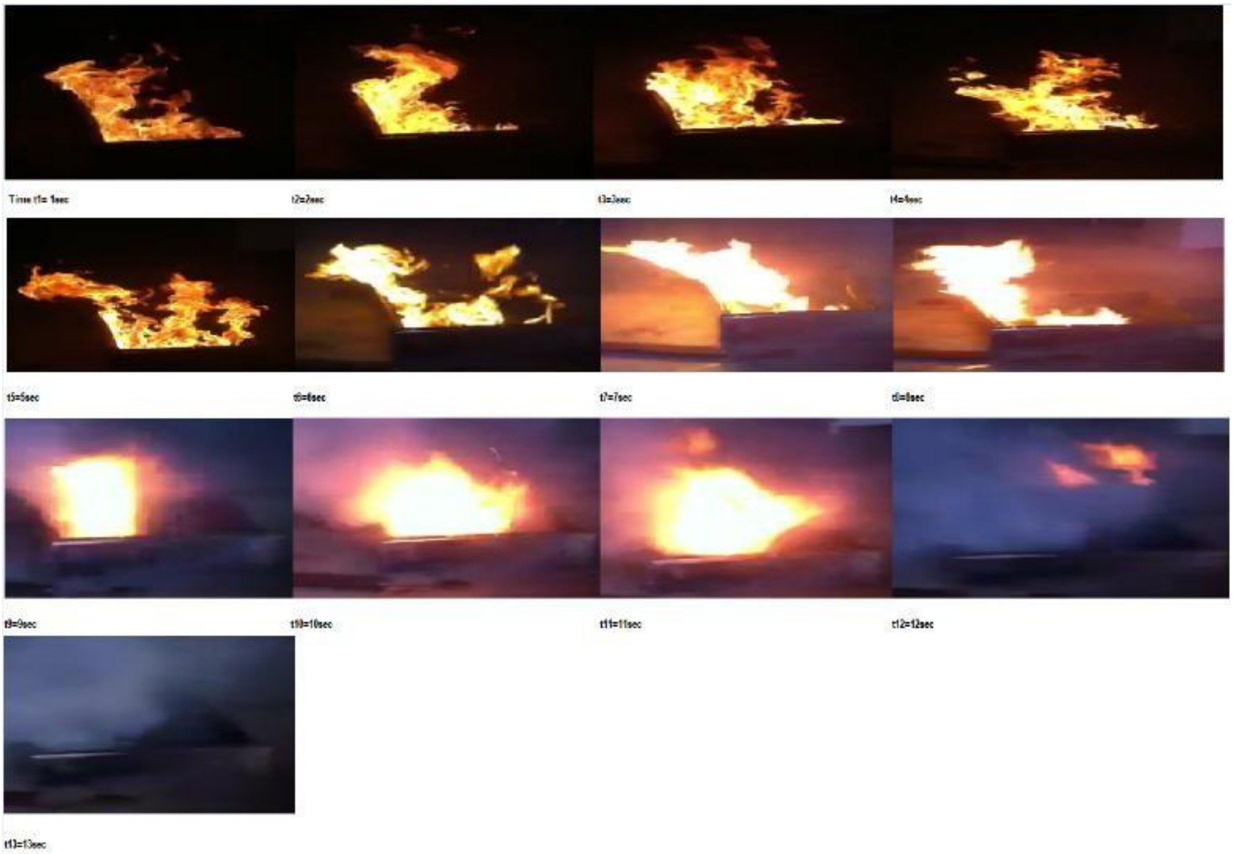

Figure 2: Stages of Extinguishment of Poly Carbonate Fire

Table 2: Extinguishment time

Sl No	Pressure (bar)	Height (m)	Diameter(mm)	Cone angle (o)	Coverage area(m2)	Extinguishment Time (sec)
1	6	2.5	0.6	13.2	0.262	24
2	6	3	0.8	14	0.426	19
3	6	3.5	1	14.6	0.631	22
4	7	2.5	0.8	16.1	0.392	22
5	7	3	1	18.7	0.766	18

6	7	3.5	0.6	17.1	0.869	23
7	8	2.5	1	21.2	0.687	17
8	8	3	0.6	19.6	0.825	16
9	8	3.5	0.8	20.7	1.282	18
10	9	2.5	0.6	24.2	1.04	9
11	9	3	0.8	27	1.62	12
12	9	3.5	1	28.9	2.5	11
13	10	2.5	0.8	32	1.61	13
14	10	3	1	34.7	2.7	15
15	10	3.5	0.6	30.1	2.78	17

Quantity of Heat

The quantity of heat produced ensure us how much quantity of water is required for extinguishment of polymer. By measuring weight of the polymer before and after burning the amount of fuel spent can be found. Initial temperature is 0^0C and final temperature is 386^0C which is the degradation temperature of Polycarbonate. Mass of polymer sample burnt is shown in the table 3.

Table 3: Mass of polymer sample burnt

Sl no	Mass of polymer	
	Before burning m1 (kg)	After burning m2 (kg)
1	1.35	0.98
2	1.35	0.99
3	1.35	0.98
4	1.36	0.98
5	1.35	0.98
6	1.36	0.98
7	1.35	1.00
8	1.34	1.00
9	1.34	1.00
10	1.35	1.05
11	1.34	1.02
12	1.35	1.02
13	1.35	1.01
14	1.35	1.01
15	1.34	1.00

Calculation for quantity of heat

Calculation for finding out the quantity of heat is shown below Quantity of heat Q = (m1-m2)Cp(ΔT)

- m1- Mass of polymer before burning(kg).
- m2- Mass of polymer after burning(kg).
- Cp- Specific heat capacity of Polycarbonate- (1250 J/kg^{0}C).
- ΔT- Final temperature – Initial temperature- (386^0C-0^0C = 386^0C).

For experiment number 1:

- Quantity of heat = (m1-m2) Cp (ΔT).
- = (1.35-0.98)1250(386-0).
- = 178.52kJ.

Similarly the calculation is done for all the experiments and the quantity of heat produced is shown in the table 4.

Table 4: Quantity of Heat produced

Sl no	Mass of polymer		Quantity of heat Q (kJ)
	Before burning m1 (kg)	After burning m2 (kg)	
1	1.35	0.98	178.52
2	1.35	0.99	173.70
3	1.35	0.98	178.52
4	1.36	0.98	183.35
5	1.35	0.98	178.52
6	1.36	0.98	183.35
7	1.35	1.00	168.87
8	1.34	1.00	164.05
9	1.34	1.00	164.05
10	1.35	1.05	144.75
11	1.34	1.02	154.40
12	1.35	1.02	159.23
13	1.35	1.01	164.05
14	1.35	1.01	164.05
15	1.34	1.00	164.05

6. Conclusion

From the table 4 it can be found that at parameter (Pressure 9bar, Height 2.5 and nozzle diameter 0.6mm) the extinguishment time is less, even though the flow rate produced at this parameter is less than that of the experimentation done at 10 bar pressure. This suggests that the increase in the flow of water will not alone decrease the extinguishment. It depends on also the coverage area and optimum coverage area should be adopted for early extinguishment. The coverage area is not only depending upon pressure alone, it varies with height and nozzle which can be identified from table 10.2. The optimum parameter for extinguishing the polypropylene of size 300mm X 300mm is found to be with pressure of 9bar, height 2.5m and nozzle diameter 0.6mm. This further confirmed by the table 4 due to the early extinguishment, the polymer left unburned has moremass.

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