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Research on Application of Forest Fire GS Mark III (Patent Pending) for Peat Fires Extinguishment Methods: A Field Experiment

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Abstract

Anthropogenic interventions and global warming are normally the cause of Malaysian peat fires. Fire suppression methods and techniques have garnered the attention of innovators. In the current study, a series of field experiments were undertaken to quantify the effectiveness of an invention of fire-fighting equipment called Forest Fire GS Mark III (patent pending). A number of hoses and water pumps, as well as accessories, are also integrated into the GS Mark III configuration. The installation of equipment only considers single hoses line with several lengths from an open water source. This involved three field tests using a single pump, an end-to-end pump, and series pumps. Both the end-to-end pump and the serial water pump were found to have significant performance with longer spray length and consistent water pressure. Further, according to the present invention, the area covered during extinguishment is about 18,000m^2 or 4.45 acres or 1.8 hectares within 50 minutes by mains off the end-to-end pump or serial pump installation. Conversely, the pressure and length decreased when the number of hoses increased. This study makes a good contribution to the firefighter community by providing the initial design of fire extinguishment methods under better conditions.

1. Introduction

Forests are extremely valuable because of their ability to trap rainwater, produce oxygen, store carbon, and provide habitat for a wide variety of animals. Haze is commonly caused by major forest fires, which can spread significant distances and blanket extensive areas. People's respiratory systems, health, livelihoods, and lifestyles can all be negatively impacted by air pollution, and in extreme circumstances, the pollution can even force schools and airports to close. Firefighter put their lives on the line in order to extingto fires.

The use of fire retardants, fire barriers, rewetting peatland, water bombing, and cloud seeding are s the strategies that are now being utilized to stop forest fires. However, these approaches can be risky, expensive, time-consuming, depending on the weather, and ineffectual geographically remote and inaccessible areas. A significant amount of study has been carried to cut carbon emissions, respiratory health problems, and economic loss brought on by forest fires and the smoke hat they produce.

In the earlier studies, fire suppression models (Duff and Tolhurst, 2015), stochastic fire simulation model (Riley et al., 2018) and the species, momentum, and energy conservation equations (Huang et al., 2015) have been used to model the decision-making process for a significant portion of fire costs and for a large portion of impacts to describe drying, thermal, and oxidative degradation during the smouldering combustion in previous studies. However, these models have significant drawbacks when it comes to simulating the spread of a fire.

The other solution was also proposed by the previous researchers to overcome the suppression method. Suppression chemicals which proposed by Plucinski, (2019) is not a promising alternative since the scale and purpose that they are considered. Kalabokidis, (2000) also reported that the chemical usage showed major impacts, on the environment, which may be through the adverse effects on water quality, and subsequently to aquatic ecosystems.

On wildfire suppression equipment, only a small amount of research and development work has been done. In 2018, Bartenev et al. developed a combined machine for putting out forest fires and using soil to create fire-break makers. This machine works by removing the upper fire-hazardous cover, which is made up of plant residues. Drapalyuk et al., 2019 proposed fire-fighting soil-thrower machine which provide better preventive and fireproof work in conditions of heavy soils, saturated with roots of the tree. Kasymov et al., (2017) have been presented backpack motorized fire extinguisher too minimizes the damage caused to the environment but limited for extinguishing low and medium intensity forest fires. However, the aforementioned machine do not extinguish for large fire especially involving ground or peat fire where the thickness of the burned layer is should taken into account. In addition, when a layer of organic soil ignites, it burns steadily without flaming and eventually spreads through the soil (Rein et al., 2008). Smouldering in peat soil can go days undetected Zaccone et al., 2014). During a peat fire, the temperature at ground level can reach 400 degrees Celsius, while temperatures 5, 10, 20, 30, and 40 centimetres below ground level can reach 200 degrees Celsius, 90 degrees Celsius, 50 degrees Celsius, and 45 degrees Celsius, respectively (Rinaldi et al 2019). Since peat soil has high water content, it is hard for firefighters to walk on it. Efforts to extinguish fires on peatlands is strenuous, wildly if the fire has penetrated the deep layer of peat, only heavy rain can effectively extinguish it (Rosita, 2018). In this regards, this paper intends to propose new suppression equipment for forest fire particularly peat fire which merge three suppression techniques ; direct attack and fire break, and total flooding.

2. Methodology

2.1. Forest Fire GS Mark III,

The Forest Fire GS Mark III (patent pending) comprise a sprinkler; connect to the 1¼ ” upper pipe; and it is attached to stop valves to allow and close the water flow to the sprinkler. The upper pipe are mounted to the Cross tees – four - steam divider. On the bottom of the cross tees divider, a ½” stop valve will be mounted to allow and close the underground water flow. An underground pipe ½” in size will be attached and a ½” round cap is fix at the end of the underground pipe as pipe cover. (The detailed of the aforementioned equipments is patent pending).

The Forest Fire GS Mark III as claimed in previous pragraph characterized in that a male coupling and female coupling which working as a connector to the hose, will connected on the left and right side of the cross tees four steam divider. Water supply will flow over to the upper pipe for water spraying and lower pipe for total flooding.

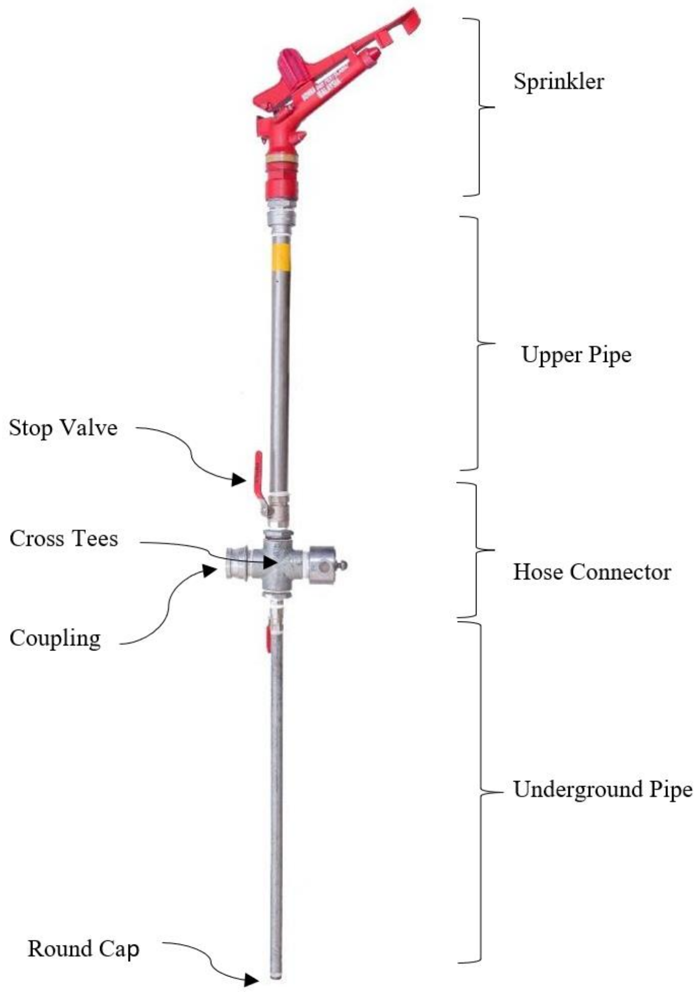

Figure 1: Forest Fire G.S Mark III

The Forest Fire G.S Mark III testing were conducted in an open area. Table 1 shows the apparatus needed in this study.

Apparatus	**Utilization**
Forest Fire GS Mark III	Water outlet
Water pump	Pump water to hose
Collecting Breeching	two water feed hoses supplying one outlet
2 ½ inches hose	Deliver water to outlets
Flowmeter	measuring nonlinear or linear flow rate
Wajex Hose c/w nozzle	Water outlet

Table 1: List of apparatus and its utilization

2.2. Experimental Set Up

The Forest Fire GS Mark III comprises a sprinkler, an upper pipe, a hose connector, and an underground pipe. The total length is 90 inches and weighs 9 kilogrammes. The diameter of the upper pipe is 1 1/4 inches, whereas the diameter of the underground pipe is 1/2 inches. The size of the discharged outlet at the sprinkler and the underground pipe is different. The discharge outlet of a sprinkler, which is regulated by a nozzle tip, is adequate for 10mm particles. In addition, the subsurface pipe initially consisted of four 4.6mm outlets. The stop valves are fitted on both the above- and below-ground pipes. During a fire suppression operation, these functions are employed to shut off a water supply for maintenance i an emergency.

In order to run the Forest Fire G.S Mark III, a water pump is equipped and positioned near water sources such as rivers, temporary ponds, and lakes. For water supply, hard suction hoses are laid from the water source to the water pump. The delivery hoses are fitted every 30 or 60 metres using Forest Fire G.S Mark III from the water pump. With these two installation alternatives, firefighters can make choices based on the severity of the fire. In the event of a peat fire, the installation of G.S. Mark III equipment at a distance of 30 metres is necessary to raise the groundwater level more quickly, which is equivalent to the technique of total flooding. Moreover, the distance of water spray radius covered between adjacent G.S Mark III. In cases other than peat fires, it is recommended to install G.S Mark III equipment every 60 metres because water spray can reach to a 30-meter radius around the fire.

Currently, the spray type of the Forest Fire GS Mark III sprinkler can be selected using either a static or rotating technique. With the rotating option, the sprinkler's water spray can be changed to 180 degrees or 360 degrees, depending on the fire suppression strategy and local fire scenario. In reality, the installation of Forest Fire GS Mark III along the hoses created a fire break zone to prevent the impacted fire area from spreading to the adjacent region.

2.3. Experimental Configuration

2.3.1. Single Pump Approach

Knowledge of the Forest Fire G.S Mark III in the performance of the water pumping sprinkler systems is important to maximize its effectiveness in extinguishing the peat fire. Forest Fire G.S Mark III is the latest design from its model. The design concept is similar to the sprinklers

There are two designs conducted for a single pump approach. The **first** type of test utilized six Forest Fire GS Mark III while for the **second** design, three Forest Fire G.S Mark III and three Wajex hoses were employed. The field test conducted was to evaluate every design performance base on the pump's pressure. Flowmeters were placed in each test designs.

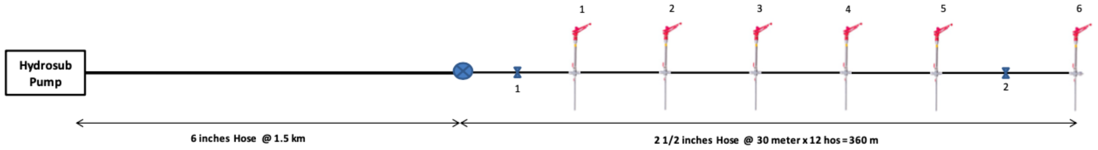

Figure 2: First design

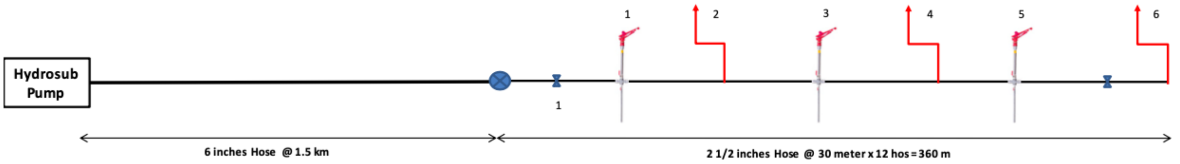

Figure 3: Second design

2.3.2. End-to-End Approach

The test were carried out in a real peat fire test in Tanjung Sepat, Kuala Langat Selangor on 6th March 2021 during the drought season.

The hoses were connected to two portable water pumps between end to end from a different water source. So, the water is put under pressure along the hoses. This test involved laying approximatle of 300m hoses or 10 rolls of delivery hoses. Every 30m, Forest Fire GS Mark III and Forest Fire GS Mark II were installed alternately.

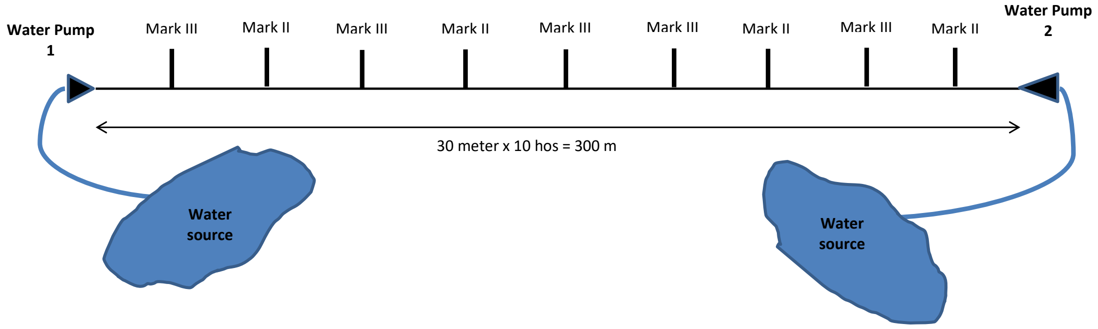

Figure 4: End-to-end pump

2.3.3. Serial Pump Approach

The first rule that should be applied in serial pump approach is the pressure at the second pump should be lower than the first pump. In the same way, the GS Mark III installed before a second pump should not have a pressure drop. Pressure is considered dropped as a spray length at that point is lower than spray length at the next point.

To execute the serial pump approach, a water pump, 16 hoses (480 meters) and 8 units of Forest Fire GS Mark III were set up. Two hoses from the water pump were connected to the hose line using a collecting breaching.

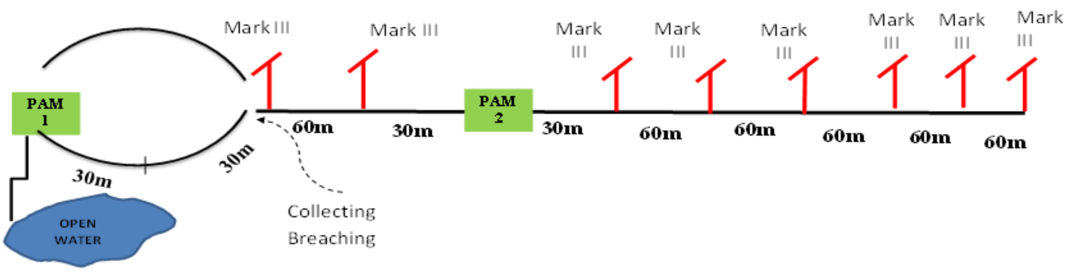

Figure 5: Serial pump arrangement

3. Results and Discussion

3.1. Single Pump Approach

During the test, the environment condition where the test is taken place is very important to get accurate data. This test was conducted place in the open environment, and the weather is not windy. The following table present data from the test conducted to test the performance of Forest Fire G.S Mark III. The result of test 1 and test 2 are as follow:

Table 2: Result for 1st Design

Hydrosub pump pressure (Bar)	Flowmeter 1		GS Mark III					Flowmeter 2		GS Mark III
			1	2	3	4	5			6
	Pressure (Bar)	Flowrate (L/Min)	Spray Length (Meter)					Pressure	Flowrate (L/Min)	Length
5	5.01	1070	24.19	17.17	10.9	6.28	5.09	0.43	80	4.23
7	6.1	1210	28.87	23.93	18.45	9.42	7.83	0.62	110	7.5
9	7.72	1370	29.41	19.93	19.26	11.96	11.11	0.84	130	8.69
11	8.35	***1440***	31.9	28.86	23.91	17.22	13.43	0.99	147	12.08

Table 3: Result for 2nd Design

Hydrosub pump pressure (Bar)	Flowmeter		GS Mark III + Wajex Hose					Flowmeter		Wajex Hose
			1	w	3	w	5			W
	Pressure (Bar)	Flowrate (L/Min)	Spray legth (Meter)					Pressure (Bar)	Flowrate (L/Min)	Length
5	3.86	850	22.3	13.88	8	6.58	5.5	0.15	12	2.6
7	5.55	1100	28.89	17.43	10.66	8.34	8.18	0.84	70	4.26
9	7.3	1300	30.75	23.19	16.45	14.13	14.95	1.02	117	10.99
11	9.03	1440	29.46	20.56	19.56	17.76	15.92	1.34	128	12.69

The data of design 1, and 2, show that increasing the hydrosub pump pressure increase the flow rate and the spray length. The pressure reduction from the first output station to the last output station. The length of spray also reduces from every output station to output stations.

3.2. End-to-End Approach

The installation of the equipment took about one hour. The area covered during extinguishment about 18, 000m2 or 4.45 acres or 1.8 hectares within 50 minutes.

3.3. Serial Pump Approach

The result of testing is elaborated as follows:

Table 4: Result for Serial pump

Field Test	Pump 1	Spray Length		Pump 2	Spray Length					
	Pressure (Bar)	GS Mark III	GS Mark III	Pressure (Bar)	GS Mark III	GS Mark III	GS Mark III	GS Mark III	GS Mark III	GS Mark III
		1	2		3	4	5	6	7	8
Test 4	7 bar	19.62	19.96	5 bar	21.92	21.24	19.26	17.65	17.54	17.20

The test performance showed the spray length remained nearly similar even though the hose line increased to 480 meters. Using a collecting breaching technique, the water flow rates remain maintained along the hose line. For a longer hose line, a powerful water pump should be used to get a longer spray length and keep the flow rate along the hose line. The performance also showed that any Forest Fire GS Mark III could be changed to be an attack hose (with nozzle) for direct attack purposes.

4. Conclusion

To extinguish traditional forest fires, the Forest Fire G.S Mark III is also designed to extinguish peatland fires where the source of the flame is buried deep underground. The most successful and capable means of extinguishing a peat forest fire, according to the experienced firefighters involved in peat forest fire operations, is watering or flooding the area until the underground water layer is raised. Using Forest Fire G.S Mark III equipment, the spray of water flowing out of the underground pipe can permeate the peat soil's pores, flooding the peat layer under the surface. In addition, spraying on the higher pipe and rotating sprinklers assist in saturating the upper and lower soil surface layers.

With the development of G.S Mark III technology, extinguishing operations can be conducted constantly for 24 hours (including at night). Firefighters need just monitor the portable water pump at the fire scene. The method and application of G.S Mark III equipment are highly effective at preventing the spread of fires, hence avoiding considerable forest destruction and losses for all parties. In addition, firefighters are protected from a variety of perils, including pit falls, wild and toxic animals, and even pre-war munitions. This method of extinguishment can also restrict the exposure of firefighters to harmful plants, water-borne infections, and mosquito-borne disorders.

Further, according to the present invention, the area covered during extinguishment about 18,000m^2 or 4.45 acres or 1.8 hectares within 50 minutes by mains off end to end pump or serial pump installation.

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