Design and Evaluation of a Wildfire Sprinkler

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Technical report no. 53

Wildfire Operational Research Group

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301012308: Design and evaluation of a new wildfire sprinkler

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Abstract

The goal of the project was to develop a new wildland fire sprinkler capable of stream-height adjustment. A Fire Cobra prototype and a modified rainbird sprinkler were built and tested. Over the course of the project, a new industrial sprinkler called the FireBozz was identified in the market place.

Acknowledgements

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1. INTRODUCTION

Sprinkler systems are commonly used in wildland firefighting to wet fuels, protect structures, and reinforce fireguards ahead of an on-coming fire. The type of sprinklers most commonly used in wildfire scenarios are those that can be purchased at a local hardware store. Typically, sprinklers are mounted at ground level, or can be elevated using various attachments and improvised methods. Although off-the-shelf sprinklers meet many deployment objectives, the need to mount sprinklers to attain the desired stream height and coverage can take considerable time and effort.

The new wildfire sprinkler project was proposed by Alberta Agriculture and Forestry and endorsed by FPInnovations Wildfire Advisory Committee in 2010. The original goal of the project was to develop a new wildland fire sprinkler capable of stream-height adjustment. The project's objectives included creating a prototype design, construct, test, and prototype evaluation.

Several challenges were encountered over the course of this project, which caused delays, altered the project's direction, and affected the project's outcomes. This report presents the project's methods and results, and discusses what was learned.

2. METHODS

Product investigation

The first step was to confirm which sprinkler models and applications were currently being used in wildfire suppression. An internet search and agency discussions indicated the most common sprinklers used in wildfire applications were over-the-counter lawn-care sprinklers. Our research also indicated that many firefighting agencies had developed their own sprinkler kits (Figure 1), and in some instances had developed sprinkler trailers in order to organize equipment and facilitate quick deployment (Figure 2). Many of these sprinkler systems were typically used for protecting structures and to reinforce wildfire or prescribed-fire control lines. In most cases these sprinklers lacked vertical height adjustment and relied on additional work and or improvisation to adjust stream height (Figure 3).

Figure 1. Typical sprinkler kit.

Figure 2. Sprinkler trailer.

Figure 3. Improvised sprinkler mounting.

Project planning

An FPInnovations project plan[1] was developed in March 2011 to identify project objectives, methods, safety concerns, timelines, and deliverables. Additional project planning was also completed by some mechanical engineering students, as part of the prototype design phase. As the project progressed, original plans were adjusted to meet the challenges encountered.

[1] http://wildfire.fpinnovations.ca/10/WildfireSprinklerDesignProjectPlan.pdf

Prototype design

Design work was initiated through a MEC E 460 project proposal from the University of Alberta's Mechanical Engineering Department[2]. In September 2011, a student design team called Alberta Genuine Design was assigned to the project, and in March 2012 the design team submitted three design concepts based on both the project criteria established within the FPInnovations project plan, and criteria layed out in the MEC E project proposal. Included within this criteria, was the specific need to design a sprinkler capable of height adjustment. From the three proposed designs, the Fire Cobra (Figure 4) was identified for continued development, and in April 2012 the design team submitted its final report for the Fire Cobra design, complete with calculations and detailed drawings.[3]

Figure 4. Prototype design of the Fire Cobra sprinkler.

Prototype construction

Originally, prototype construction was planned as part of the students' overall MEC E 460 project. Due to time constraints the team was able to complete only the design phase. Prototype construction focus then shifted to partnering with the manufacturing industry, and several attempts were made to generate interest among sprinkler manufacturers. However, due to low interest, a decision was made to construct the prototype using a local machine shop in 2015.

[2] http://wildfire.fpinnovations.ca/10/MEC%20E%20460_Application_2012_Sprinkler_System.pdf
[3] http://wildfire.fpinnovations.ca/10/Mec%20E%20460%20-%20Phase%203.pdf

Prototype testing

Prototype testing was originally planned as an exercise that would be integrated with on-going FPInnovations project work at the Canadian Boreal Community FireSmart Project site in Fort Providence, Northwest Territories. Additional testing options also included hazard-reduction and prescribed-burn operations in Alberta. Testing criteria included: stream height and horizontal cast measurements, and prototype comparison with a typical sprinkler from an agency sprinkler kit.

Testing of the Fire Cobra prototype sprinkler was to occur in two stages:

1. Functionality testing, including attaching the prototype to a water source and observing the performance of the Fire Cobra under a range of pressures.
2. Performance testing, pending initial results of the functionality testing, and included:
    a. Establishing a functional pressure range.
    b. Measuring stream cast (height and distance) at pre-determined angles (30, 50, and 70 degrees).
    c. Measuring the stream-cast footprint at pre-determined angles (diameter).
    d. Comparing the prototype to a rainbird sprinkler (repeat of above measurements using a typical sprinkler and kit).

Equipment requirements for these tests included:

- One Fire Cobra prototype.
- One water-pressure gauge.
- One Mark-3 pump / kit.
- Two lengths of 1.5-inch fire hose (approximately 30 m total).
- 60 m of 5/8-inch garden hose.
- One 5/8-inch adapter.

The possibility of constructing additional prototype sprinklers to enable full kit comparisons was discussed, but the decision was deferred to such time as the prototype proved functional.

3. RESULTS

Product investigation

Initial investigations reaffirmed the potential for a new, innovative sprinkler, i.e., typical sprinklers found in sprinkler kits did not have height-adjustment capability. Over the course of the project a new industrial sprinkler called the FireBozz was identified in the market place (Figure 5). The legs of the FireBozz can be adjusted to change the stream angle height.

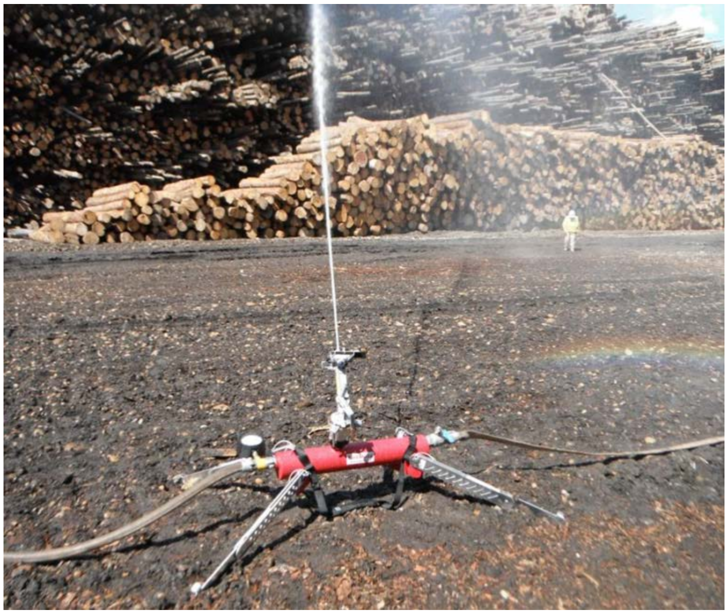

Figure 5. FireBozz sprinkler.

Prototype construction

Construction of the Fire Cobra prototype was completed in 2015 (Figure 6). Spray height is adjusted by moving the upper black rubber hose down the curved metal hose holder, thus changing the spray angle. To keep manufacturing costs low through the prototype testing phase, heavy-gauge steel was used as opposed to the proposed design materials such as aluminium.

Figure 6. Fire Cobra prototype complete with height adjustment.

During construction of the prototype the machine shop identified that the heavy-gauge rotation spring (Figure 7) could impede sprinkler functionality. Based on this feedback, several lighter gauge springs were purchased for testing.

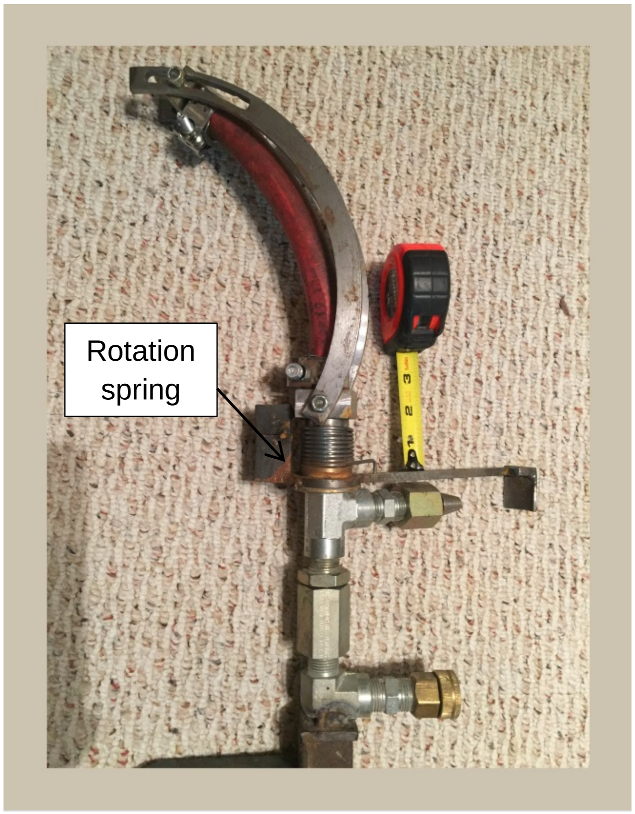

Figure 7. Location of the rotation spring on the Fire Cobra prototype.

Prototype testing and evaluation

Two functionality tests of the Fire Cobra prototype were completed. One took place near Hinton, Alberta in May 2016 and another took place near Fort Providence, Northwest Territories in June 2016. The Hinton test served as the initial test using a low-pressure municipal water source. This test was performed to establish a baseline for future testing at higher pressures. The Fort Providence test was conducted at higher water pressures using a local dugout and a Mark-3 pump and hose lay.

The equipment used in these tests included:

- One Fire Cobra prototype (Hinton and Fort Providence).
- 60 m of 5/8-inch garden hose (Hinton).
- One 5/8-inch adapter (Hinton).
- One water-pressure gauge (Hinton and Fort Providence).
- One Mark-3 pump / kit (Fort Providence).
- Two hose lengths (approximately 30 m) of 1.5-inch fire hose (Fort Providence).

Hinton test

The sprinkler prototype was attached to a residential outlet using a regular garden hose. The system registered a pressure of ~45 psi at the sprinkler head, which was insuffcient pressure to rotate the sprinkler. The water cast produced a light focused stream with very little spray, and the pressure was insufficient to create sufficient sideway force for sprinkler rotation. The stream carried ~8.5 m with the nozzle adjusted ~25 degrees upwards. The test was repeated using a light rotation spring with no difference in results. Our conclusion was that the prototype would not function properly under this pressure.

Fort Providence test

The sprinkler prototype was attached to 30 m of 1.5-inch hose using a 5/8-inch adapter and a length of 5/8-inch sprinkler hose. A Mark-3 pump generated ~85 to ~105 psi at the sprinkler head; however, no rotation was observed within this pressure range. The water stream from the sprinkler carried ~14 m. Our conclusion was that the prototype design was inferior and would require additional design modifications to become functional.

Test of a modified rainbird

Given the issues encountered with the Fire Cobra prototype, a simple trial was completed using improvised parts attached to a standard rainbird sprinkler (Figure 8). This was not part of the original project plan; however, an opportunity was realized and pursued. A modified rainbird kit was assembled using a ½-inch rubber hose, a nozzle, and an aluminum bracket. The hose was attached to the rainbird's rear sprinkler port and the spray height angle was adjusted using a nut-and-bolt assembly located at the top of the bracket. Given the original rainbird sprinkler had not been altered, with the exception of the added kit, water streamed through the rainbird nozzle and the kit nozzle.

A rainbird sprinkler and modified rainbird kit were then attached to the Mark-3 pump and hose setup, as described above for the Fort Providence test. The horizontal stream from the rainbird nozzle was ~12 m and the semi-vertical stream from the kit nozzle was ~8 m. An additional measurement was also taken with the vertical nozzle adjusted to the horizontal position, which produced a similar stream distance in both the original rainbird nozzle and the adjusted kit nozzle. During testing the improvised kit hose separated under higher pressures. The conclusions reached from this testing included:

1. It is possible to use an attachment kit to modify an existing kit sprinkler.
2. Engineering would be required to provide for a more streamlined kit design capable of sustaining the desired pressure ranges.

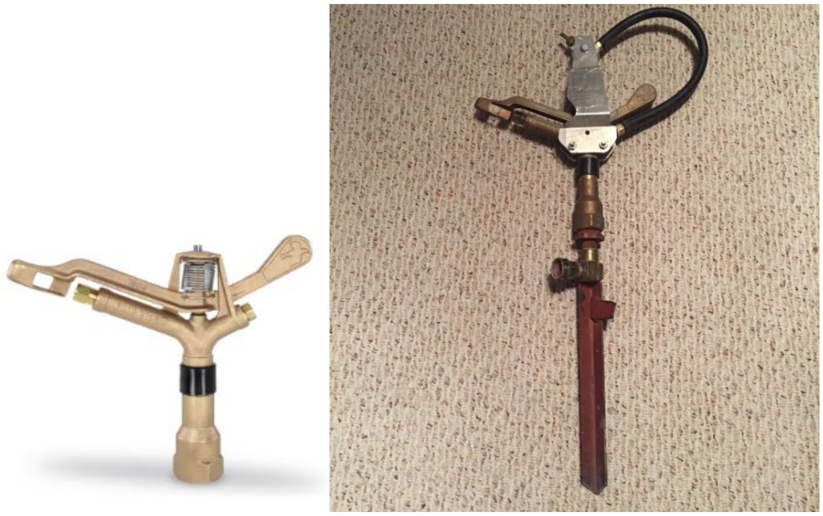

Figure 8. Modified rainbird kit.

4. DISCUSSION

The Fire Cobra sprinkler design achieved the project goal in terms of height adjustability; however, the engineered prototype clearly required additional design work and testing to achieve functionality, including:

1. An engineered solution to prototype rotation is needed. The parts related to rotation were not addressed in the original design, and although an attempt was made by the machine shop to address rotation during prototype construction, the parts added and their tolerances were loose and rotation did not function properly. Rotation arm balancing would also be required as part of the solution to the rotation issue.
2. A design for the rotation spring is required. Spring force was not defined in the design and the original spring used in the Fire Cobra was considered too stiff. Although multiple smaller springs were obtained by the machine shop, they also proved too stiff to facilitate proper rotation.
3. The materials used in construction of the prototype may have contributed to prototype's failure, i.e., in terms of weight.

In testing the Fire Cobra, a simpler concept using an attachable kit was also explored. This concept could provide a more versatile and cost-effective solution. However, this design requires additional thought and engineering, e.g., regarding the use of a sacrificial stream to power the rotation, which may reduce pressure, stream distance, and overall coverage.

Another concept, which was not explored during project testing, is to provide height adjustment through the placement of a swivel joint between the sprinkler stake and the rainbird. This would also require additional thought and engineering.

The FireBozz sprinkler (Figure 5) does provide for height adjustment and is now commercially available. However, the rainbird and FireBozz sprinklers are quite different in size, weight, and cost. Although there is some overlap in how and where they are applied, it is suspected that each may have their own application niche. This too has not been fully explored; however, additional information is being generated from an FPInnovations research project involving the FireBozz, which may be helpful once research is complete.

Based on the test results obtained in this project, and considering the need for additional investment in the Fire Cobra, the kit concepts generated during testing, and the existence of an industrial height-adjustable sprinkler, we are recommending bringing this project to conclusion. Should there be interest in pursuing this work, it is recommended that a new project be formulated based on renewed objectives and the findings presented here.

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