Final Report

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Fire in the hole! A new ground torch system with on-demand chemical injection

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Introduction

Wildfire researchers with FPInnovations purchased a ground torch system in 2004 and have since used it to light many experimental burns. This torch has also been used by Alberta Environment and Sustainable Resource Development (ESRD) and Parks Canada to ignite several prescribed burns over the years. Current torch systems—whether aerial or ground—often add a thickening agent (e.g., Flash 21) to fuel (e.g., gasoline) in a separate drum to create a gel. There are several problems with this design: operators are exposed to hazardous chemicals; the system fails frequently because of clogged lines; there is often unused gel that must be disposed of; and cleaning tanks and lines of gel is difficult and time consuming.

In January 2012, researchers with FPInnovations asked Gary Dakin and Mark Ackerman to design and build a new ground torch system that would improve on some of the shortcomings of the current design; namely, we wanted a torch that would mix the fuel and thickening agent in-line, on demand. They based their initial design on some exploratory work FPInnovations researchers conducted in 2007, and a University of Alberta Mechanical Engineering Student Design Project that FPInnovations sponsored—also in 2007.

System Design

The new ground torch system (the Dackermin Torch) consists of a small engine, a high-pressure gear pump, a 120L fuel tank, two chemical tanks (Flash21 A and B), a pair of Venturi-type chemical injectors, a static mixing element, a 10m hose, and an ignition wand (Figure 1 and 2). Fuel is drawn from the on-board fuel tank and the chemicals are injected into the fuel at controlled rates. The mixture is then drawn through the static mixing element, pressurized and sent through the hose to the wand.

A Honda GX160 engine drives a Viking gear pump, Model SG-0514. Power is transmitted from the engine to the pump through an electric clutch and belt system that is controlled by the wand operator. Because the operating speed of the pump is lower than the engine, the design team used a jackshaft to connect them through the electric clutch. The engine has an electric start and is independent of the tow vehicle for electrical power. The gear pump can move 20L/minute at its rated operating speed and works with low or high viscosity fluids. It has an operating pressure up to 500 psi continuous or 900 psi intermittent.

The fuel flow rate is controlled by a trigger on the wand and the rotation speed of the gear pump. Injection of the two chemicals is automatic in response to the fuel's flow rate; as the flow rate changes, the pressure changes across the flow control orifices, which produces a change in the chemical injection rate.

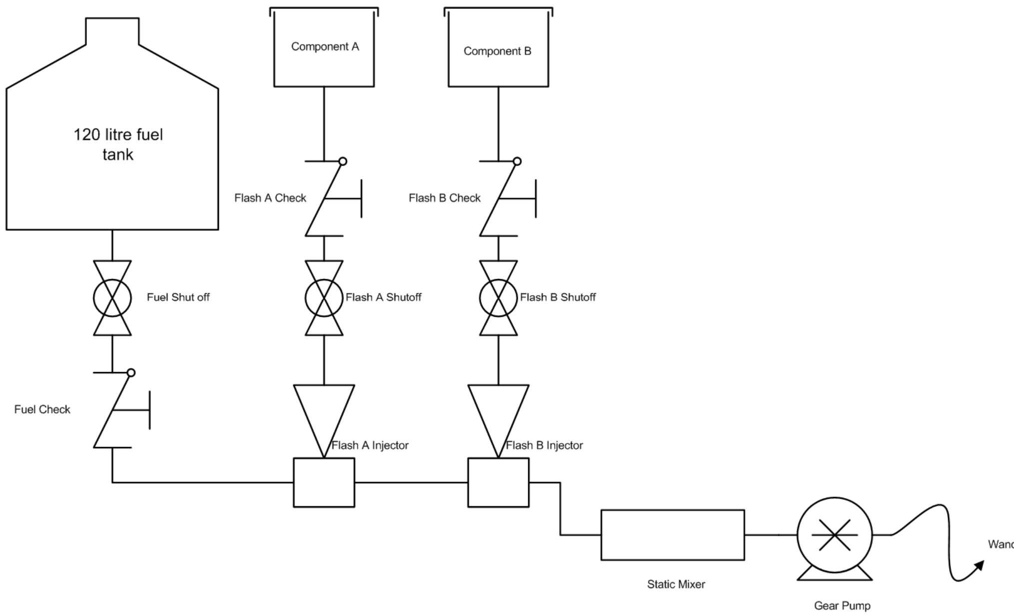

Figure 1. Schematic for the Dackermin Torch.

The system is controlled by both a master switch on the pump unit, and controls on the wand. The master switch must be in the 'ON' position before the wand controls will work. The wand controls include a flow rate trigger, a pump button and an ignition switch. The pump button sends power to the electric clutch that couples the motor and pump; if the wand operator fails to push this button, the pump will not turn and there will be no pressure at the wand. If the pump is turning and creating pressure while the flow rate trigger on the wand is closed, the fluid is re-routed internally through a pressure relief valve. Before starting the system, the fuel and chemical tanks must be filled and the manual flow valves must be open. Once started, the system takes about 30 seconds to produce and eject gel from the wand nozzle.

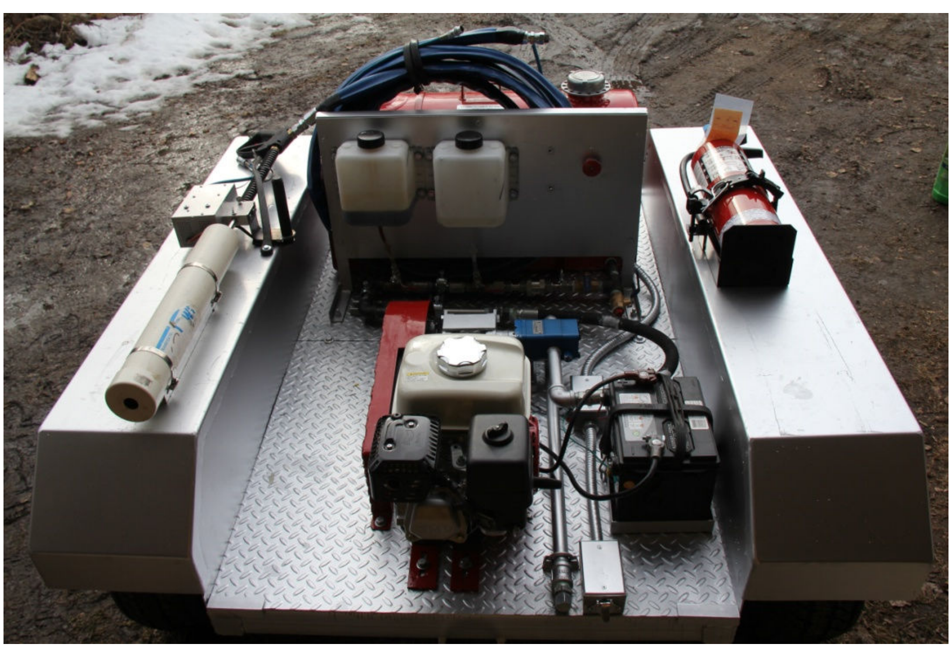

Figure 2. The Dackermin Torch.

The system is easily cleaned by closing the two chemical tank valves and running the system until pure gas is ejected from the wand. The master switch is then turned off and the fuel valve is closed; the system now contains pure gasoline and is ready for transport. If the torch needs to be stored for an extended period, the fuel must be blown out of the lines using compressed air.

Because Flash 21 B is very acidic, many system parts (where possible) are either stainless steel or polyethylene. The chemical injectors were machined from PTFE (polytetrafluoroethylene) and the hose is lined for use with petroleum products.

The system is mounted on a robust custom trailer (Figure 3) and can be towed by any vehicle with a hitch. When the fuel tank and chemical tanks are full, the complete unit weighs approximately 500lbs. Users should consider this weight, along with the terrain and travel distance, when selecting a tow vehicle.

Figure 3. The Dackermin Torch and custom trailer.

System Testing

The design team first tested the Dackermin Torch in early May 2012 and the in-line, on-demand chemical injection system worked well. Below 5°C the Flash21B component thickened, less was injected into the fuel, and the gel consistency was compromised. The design team is considering two options to address this problem:

- install a variable flow control orifice
- heat the chemical tanks

The system sprayed gel approximately 20m (60ft) with a 4.8mm nozzle on the wand. A larger nozzle will reduce the pressure within the system and will decrease exit velocity and shorten the throw range.

Connor Creek Prescribed Burn

Later in May 2012, the design team had the opportunity to test the Dackermin Torch over two days at the ESRD Connor Creek prescribed burn in the Woodlands Area (Figure 4). On the first day, the system was mixing sporadically. The design team found small white crystal-like particles in the lines which they believed formed from mixing older Flash21 chemicals with newer ones (the tanks had been topped off with older chemicals). The system was flushed and the tanks filled with new Flash21 chemicals. The problem did not re-occur.

Figure 4. The Dackermin Torch in use at the Connor Creek prescribed burn.

On the second day, the design team discovered that the ignition circuitry in the wand was damaged en route to the ignition line; the result of a faulty holder. After some modifications to the holder mechanism, the wand is now held firmly in place during transport. Despite no ignition capabilities that day, the design team continued testing and observed no issues with gel consistency or spray distance.

Canadian Boreal Community FireSmart Project Site

In June 2012, two of our researchers required ignition for their experimental burns at the Canadian Boreal Community FireSmart project site in Fort Providence, NT (Figure 5). The first ignition line, on June 23, was 200m and took the ignition team 7 minutes to complete. The second ignition line, on June 24, was 100m and took the ignition team 3 minutes to complete. Ignitions were efficient and successful; the ignition team encountered no problems during either operation.

Figure 5. The Dackermin Torch in use on an experimental burn at the CBCFS project site.

Discussion

The Dackermin Torch was designed and built for our group's on-going research needs. Over the course of this project, we discussed with the design team a number of ideas to further develop both the system and its operating procedures:

System Design

- Because we anticipate using the torch in colder temperatures, a modification will be necessary to address the problem of Flash21B thickening below 5^{o}C.
- Although the system is currently mounted on a custom trailer, it is designed to be removable. A custom sled could be designed as an alternative for operations in snowy conditions, or the unit could be transported in a vehicle bed.

System Operation

- A manual will be developed that outlines the operation, maintenance and safety procedures.
- To safely operate the torch, a minimum team size of 3 and no more than 5 is required: a driver, a wand operator, a hose handler, a system supervisor, and a safety lookout. The number of personnel required depends on field application, mode of transport, season and experience of team members.
- The torch is noisy and it is difficult for the ignition team to talk to each other. The ignition team should wear hearing protection and standard hand signals should be developed for communication.
- It is best to clean the system immediately at the conclusion of the assignment so the fuel used to flush the system can be burned off as part of the operation.

As we continue to use the Dackermin Torch for experimental and prescribed burns, we will monitor its robustness over time.

For more details about the Dackermin Torch, please contact Ray Ault:

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