Journal of Loss Prevention in the Process Industries 26 (2013) 338–343

Contents lists available at SciVerse ScienceDirect

Journal of Loss Prevention in the Process Industries

journal homepage: www.elsevier.com/locate/jlp

# Production of fire extinguishing mixture by solid propellant propulsion

Alexander I. Karpov*, Andrei Y. Leschev, Alexei M. Lipanov, Georgy A. Leschev

*Institute of Applied Mechanics, Russian Academy of Science, Ural Branch, T.Baramzinoi 34, Izhevsk 426067, Russia*

ARTICLE INFO

*Article history:*
Received 8 January 2011
Received in revised form
19 July 2011
Accepted 14 October 2011

*Keywords:*
Fire suppression
Water mist
Solid propellant
Gas generator

ABSTRACT

The behavior of fire suppression by water mist spray has been studied by using the experimental setup which employs the double-based solid propellant gas generator for water mist production. The burning products of solid fuel form a supersonic flow injected through the nozzle into the diffuser chamber having input for the water component ejected from the storage. High values of temperature and pressure at stagnation point impart the substantial kinetic energy to the flow, which provides the atomization of water droplets into mist spray. Since the water evaporation occurs already in the diffuser chamber due to the high temperature of input gas flow, the droplet size is gradually decreases to the lower limit value that could ever exist. The presence of vapor phase enlarges the volume of fire extinguishing jet allowing it to operate as a flooding agent (along with the effect of heat consumption due to water evaporation) at the very beginning of fire suppression process, much before the water droplets evaporation by the flame itself. Proposed technique of the water mist production has showed noticeable fire suppression capability through the series of testing application to the gasoline and wood model fire sources.
© 2011 Elsevier Ltd. All rights reserved.

## 1. Introduction

Since the phase-out of halons has been approved, the fire fighting community is in a permanent search (e.g. Kim (2002)) for the worthy replacement of this efficient extinguishing agent acting by the perfect kinetic scheme of combustion reaction inhibition. Unlike the using of halon's chemical extinguishing capability, possible substituting technologies considered here are based on the physical effects. There are, as distinguished for the water mist by Mawhinney, Dlugogorski, and Kim (1994) for instance, following primary mechanisms: gaseous and surface cooling due to evaporation, oxygen displacement by vapor phase in the flame zone and blocking radiant heat transfer to the unburnt fuel's surface. In fact, the effects of the same nature accompany the using of other types of extinguishing substances, which could be divided into the following categories by Kim (2002): inert gases, solid aerosol systems and water mist. Each of them has their own merits and disadvantages and there is no such a recognized superior fire suppressant as halon. Surely, above mentioned classification is rather optional and does not isolate items from each other. Thus, solid aerosol particles are to be delivered by some inert gas, water mist may be treated as a liquid aerosol mixture or other mutual combinations could take place depending on the specific technique.

In order to provide energy source for the production of sufficient amount of extinguishing mixture and its delivery to the fire site, considered "physical-type" facilities require substantial weight and space allowances, which are much greater than "chemical" (halon-based) ones need. This becomes the crucial factor of actual arrangement, which could be settled down by two ways described below.

First, the compressed gas systems are the most widely spread facility, which serves as a storage of inert gas (Underwriters Laboratories (1999)) applied directly to fire as an extinguishing agent as well as a power source to push the water (or any other suppressing component, e.g. foam) through the nozzle to produce extinguishing mixture (Adiga et al. (2005), NFPA (2000), Mesli, Quilgars, Chauveau, and Gokalp (1999), Yao and Chow (2000)). Thus, high-pressure compressor equipment (installed inward or remotely used) is necessary to inflate working body into facility.

Another approach to a problem is the use of solid propellant gas generator, which generally has a potential increase of efficiency by converting the chemical energy of the fuel. Again, variable combinations of techniques are available (Kim (2002)). By customary application of gas generators (Berezovsky and Joukov (1999), Gruzdev, Osipkov, Orionov, Rostorguev, and Sheitelman (2004), Wierenga and Holland (1999)), extinguishing agent is produced directly by the propellant's burning products only, which are the pure exhaust gases or solid aerosol mixture, depending on the propellant composition. Hybrid scheme (Bennett (2000), Grzyll (2000), Grzyll and Meyer (2005), Fallis, Reed, Lu, Wierenga, and

* Corresponding author. Tel.: +7 912 451 6399 (mobile), +7 3412 203476 (office), +7 3412 724252 (home).
*E-mail addresses:* karpov204@gmail.com, karpov@udman.ru (A.I. Karpov).

0950-4230/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jlp.2011.10.007

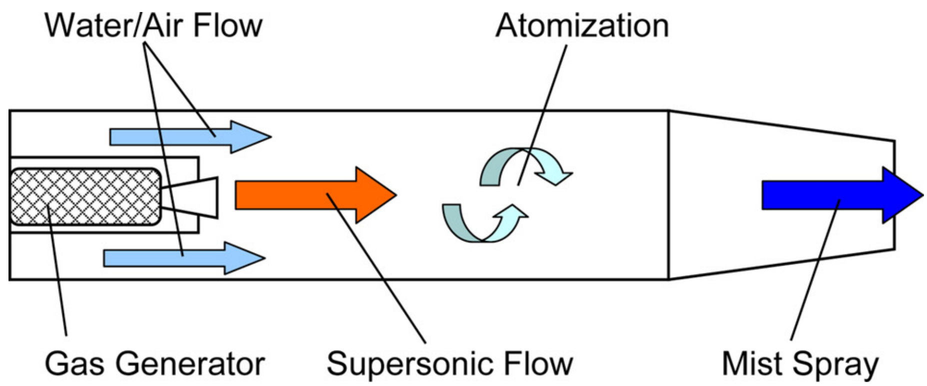


**Fig. 1.** The conceptual scheme of water mist production.

Holland (2000), Mitchell (1999), Lu and Wierenga (2000)) uses the high-pressure burning products as an energy source to release the suppressing component (primary or additional), which could be of gas or liquid consistence, from the storage. One more application by Poulsen (1991) of jet engine to fire suppression consists in just an accelerating delivery of extinguishing mixture prepared somehow separately.

This study presents the approach to application of solid propellant propulsion for production of water mist. Distinctive feature of such a technique (if comparing with commonly used hybrid gas generators) is that the gas generator is utilized here not only as a power source to drive self-maintained extinguishing agent, but acting as a straight origin, which directly generates the water mist spray.

## 2. Description of the method

The displacing mechanism used in the above mentioned hybrid gas generator system faces a basic shortcoming of energetic and operational efficiency. The gas generator and the storage of fire suppressing component (connected by the pipe for burning products) operate, in fact, separately. Beforehand, the process of solid fuel combustion has to proceed far enough to produce sufficient amount of burning products, enabling to inflate suppressant and displace it from the storage. Thus, the storage itself is a two-way (with burning products' input and suppressant's output) hydraulic system, which must be able to hold sufficiently high pressure to provide delivery of suppressing agent at the proper distance to the fire source. Considering such a process from the view-point of thermodynamic analysis, there is a mechanical energy conversion occurring three times in such a way: potential energy of high stagnation pressure in the generator's combustion chamber transforms to the kinetic energy of burning products ejected from the nozzle and supplied through the pipe to the storage, where high stagnation pressure (potential energy) achieved again, and, finally, fire suppressant jet is formed, which must have possibly higher kinetic performance. Here, the method is described, which allows to use the single energy transformation only, and, by this way, to achieve higher energetic efficiency resulting in improved weight and space performance of the fire suppressing facility. The primary concept of the considering approach proposed by Leschev, Lipanov, Makarenko, and Timofeev (1996) consists in using the kinetic energy of supersonic flow generated by the burning products of solid propellant gas generator of Leschev, Lipanov, Makarenko, and Timofeev (1995) to direct production of fire extinguishing mixture.

Conceptual arrangement is shown in Fig. 1. The burning of the solid propellant charge is initiated by the squib and, as stable regime of combustion under approximately uniform pressure level has been reached, exhaust gases are injected into the diffuser chamber through the nozzle. Water component is contained in the outer storage under atmospheric or slightly excessive pressure and is ejected into the diffuser chamber through the flow area on the outside of gas generator's case. It has been found on the base of testing runs, that access for outer air to the water flow is helpful for preliminary mixing and leveling the pressure in the water storage during the sucking out.

Nitrocellulose/nitroglycerine double-based propellant, optionally including ballistic modifiers, has been used to achieve higher energetic efficiency of the output of fuel's chemical potential. Such type of propellant is characterized by the stagnation pressure

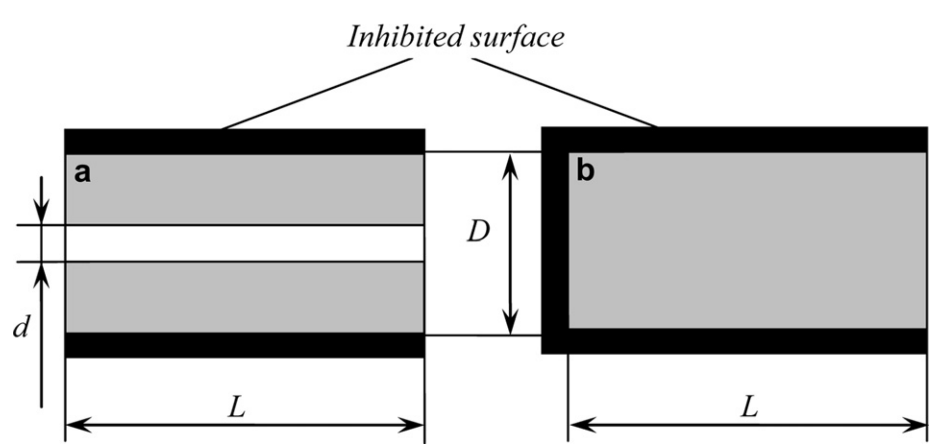


**Fig. 2.** The geometric configuration of the burning surface of solid propellant charge. *a)* – cylindrical channel, *b)* – butt-end.

Download English Version:

https://daneshyari.com/en/article/586902

Download Persian Version:

https://daneshyari.com/article/586902

Daneshyari.com