SOME QUESTIONS OF FIRE SUPPRESSION BY WATER MIST

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ABSTRACT

Investigations of different mechanisms for generation water mist and determination its efficiency for fire suppression were carry out. Water mist in the fire reduces temperature indoors, removes smoke and suppresses flame. The main mechanisms extinguishing by water mist are cooling of flammability materials (liquids) and forming the cloud of vapor for localization of heat source. If the drops haven't sufficient kinetic energy they can't surmount the convention heat flow and conductive-radiation barriers of the flame and can't reach the flame. As result the water mist can't suppress the flame. It is obvious that principal and constructional nozzle is very important for successful extinguishing. New principles of generation micro drops, as a result of the cross-feed non-stability hydrodynamic water stream were investigated and designed.

INTRODUCTION

Parameters, which determined the process of fire suppression, are the size of drops and speed of their movement in immediate proximity from the center of burning. For successful suppression of burning it is necessary that the size of drops was minimal. The small size of drops promotes the speed evaporation of water directly in flame, therefore there is an intensive cooling and formation extinguishing concentration of water pair, that promotes process of fire suppression. At the same time for the small drops it is more difficult to overcome the convectional thermal flows and thermal conduction-radiation barrier which generated by front of the flame.

The size reduction of the water particles complicates the maintenance of high speeds of drops and promotes the faster evaporation of drops outside of the flame which reduces efficiency fire suppression by water mist. For definition of critical conditions of an opportunity drop to penetrate the center of burning it is offered to use parameter F_E, which based on a parity kinetic energy of drops and thermal energy of a flame. Positive result of suppression flame can be achieved only under condition of:

$$\mathbf{F_E > K / Q_S;}$$

K - parameter of kinetic energy of drops;
Q_S - parameter of thermal energy of a flame.

The various principles of reception and transportation of water mist to the fire center were investigated, including:

1. Dispersion of water and formation of a flow of drops by high pressure (up to 150 bar) with using the small size injector;

2. Dispersion of water and formation of flow of drops for the account higher speed stream of gas propellant;

3. Formation combined flow of small and large size water drops, where for transportation of water mist to the zone of burning were used the flow of drops of larger size;
4. Generation of water mist with using the special nozzle of low pressure (below 12 bars).

INVESTIGATIONS

Investigations of the forming processes of water mist by special nozzle of low pressure and suppression flame are more interesting for us. At first time the mechanism of generation water mist stream is very simple, but more detail studying shows us the aggregate of difficult hydrodynamics processes which destructed water stream and generate micro drops without loss of the kinetic energy and formed high speed stream of drops, which can suppress fire. The researching into such processes were made by University of Maryland [1].

Offered method for formation stream of water mist based on the principal concussion of water film stream and perpendicular drop stream. Water film stream formed as result of force compact water jet from nozzle with perpendicular surface. Drop stream is parallel to compact water jet and generated by wave instability of surface of water jet from nozzle (Fig.1).

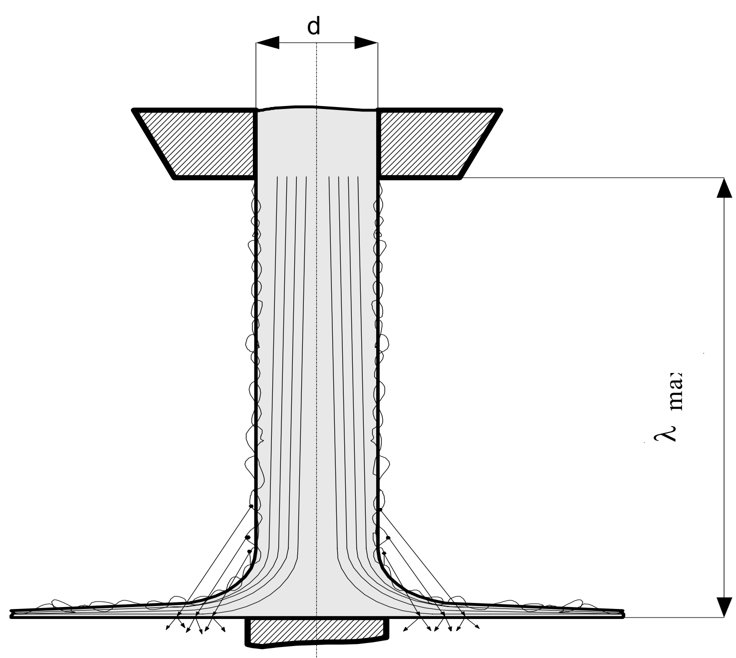


Fig. 1

Fluid flow of cylindrical stream accompanies the creation of the surface cross waves, which generate hydrodynamics instability of surface. We can see this effect on water film disk in the real tests. Dependence size water film disk of pressure is presented on Fig.2.

Full distract of film and form water mist stream is realized before 10 m/s, that satisfy water pressure 1.0 bar.

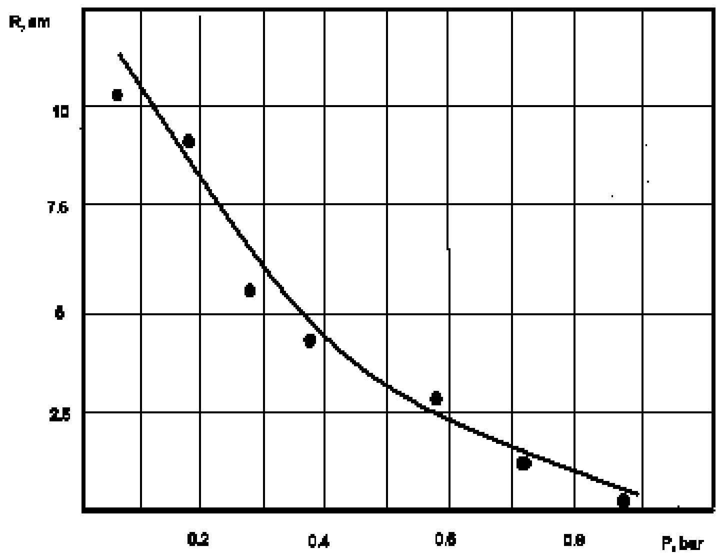


Fig.2

Maximum parameter value of the instability cylindrical water stream is realized for length of wave that determinate Releу equation

$$\lambda_{max} = 4.51d,$$

λ_{max} - length of wave conform to maximum parameter value of the instability cylindrical water stream;
d - diameter of the cylindrical water stream conform to nozzle orifice.

This process generate exponential increase amplitude cross instability of the interface cylindrical water stream and air. As the results of these process the coordinate of the water drops on the surface of cylindrical water stream will get maximum distance of axis of vertical water jet and cross the circle of the water film beyond the bounds of deflector surface. The impaction of these instability streams destroy the water disk without loss of kinetic energy and generate higher velocity flow of the water mist. The result of atomization water by impact of streams is the generated water coverage surface under the nozzle (in the centre protected area) and on the periphery one.

We can see zone of shading for water under the nozzle and formation of stability water disk with big drops, if the size of surface deflector will be more then cross section of cylindrical water jet. Water mist doesn't form if size of surface deflector will be less then cross section of cylindrical water jet. In these both situations the form of higher efficiency fire suppression water mist doesn't take place.

CONCLUSIONS

The construction of water mist nozzle of low pressure "Aqwamaster" (pressure work 5÷10 bar) realized the principle impaction of instability wave form water floors and generated of the high velocity water mist stream. Results of the fire tests of this nozzle (K_{ISO}=13.3, K_{NFPA}=0.9) showed the possibility to extinguish model flame class 55B with transformer oil for height placement 3-4 m. Functional dependence extinguishing time of transformer oil from intension of atomization water shown on Fig.4. Positive results for extinguishing wood (fire class A) was get for height placement nozzle 3-8 m. Functional dependence extinguishing time of wood from intension of atomization water shown on Fig.5.

The form of the water mist stream, which generates by nozzle "Aqwamaster", covers the surface below 9 м^2 (Fig. 6). Intension of atomization water produced this nozzle guarantee suppression different types of fire. Functional dependences for intension of atomization water from pressure and height placement of the nozzle are present on the Fig.7.

Nozzle "Aqwamaster" was tested on the real scales simulator of vertical cable pipes of a TV-tower "Ostankino" in Moscow, of cable channels for power plant and have received approval for their fire-prevention protection.

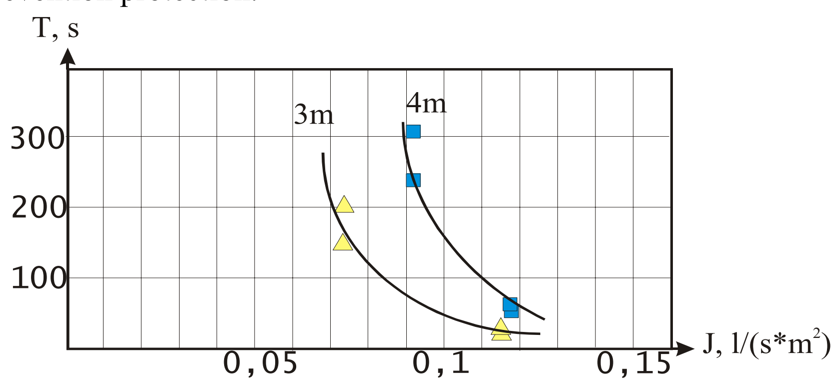
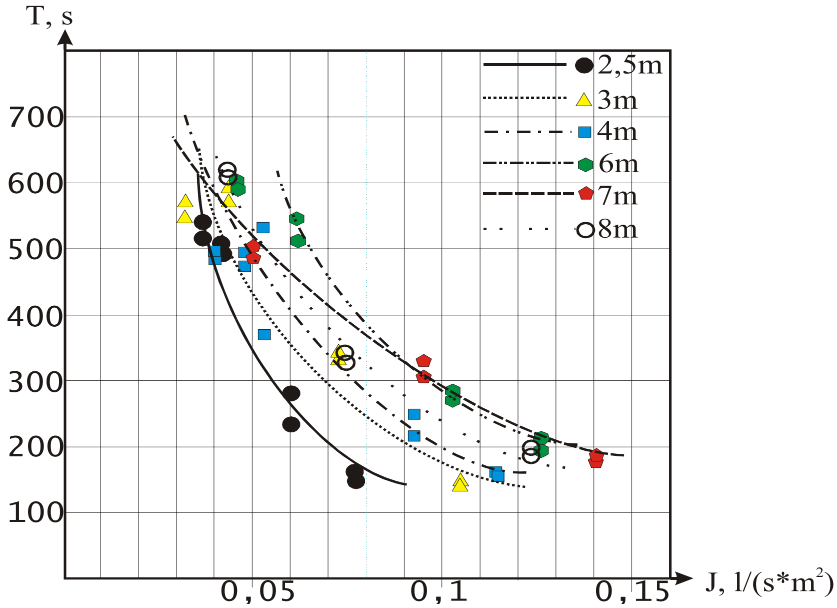
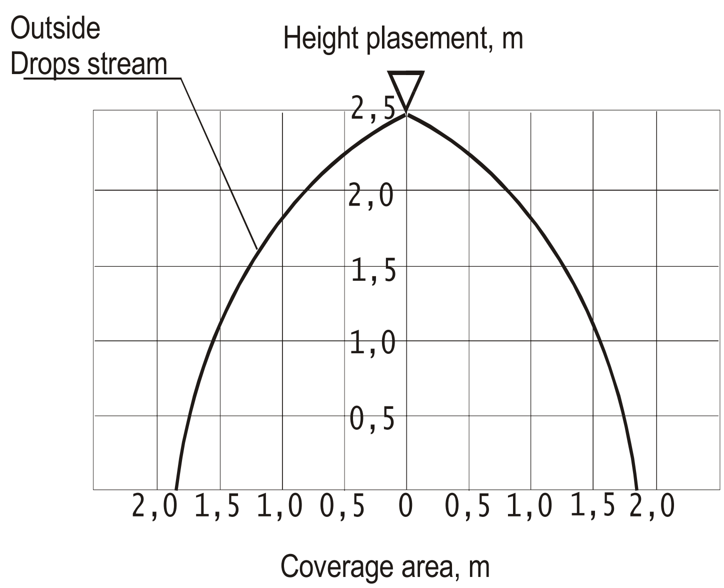


Fig.4.

Fig.5.



T, s
700
600
500
400
300
200
100
0,05
0,1
0,15
J, l/(s*m²)
2,5m
3m
4m
6m
7m
8m



Outside
Drops stream
Height plasement, m
2,5
2,0
1,5
1,0
0,5
2,0 1,5 1,0 0,5 0 0,5 1,0 1,5 2,0
Coverage area, m

Fig.6.

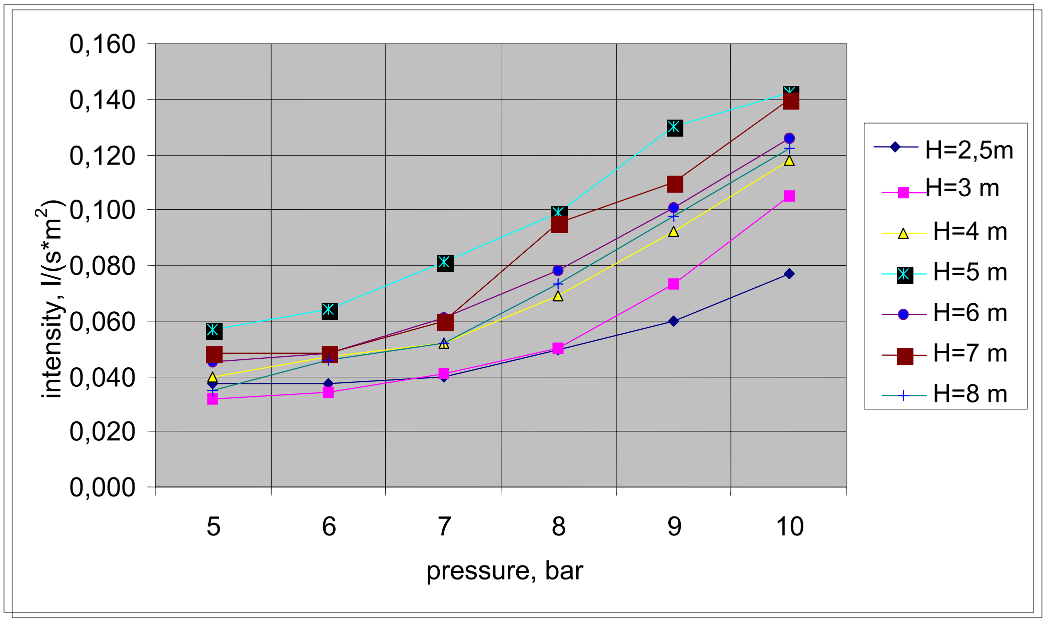


Fig.7.

REFERENCE

1. André W. Marshall "An Analytical Model for Predicting Initial Spray Properties From Liquid Suppression Devices", Workshop on Fire Suppression Technologies. Mobile, Al, February 24-27, 2003.