Nasadenie jazierkového systému pri požiaroch v extrémnych terénnych podmienkach
Deployment of Pond System to Firefighting in Extreme Terrain Conditions

Ing. Milan Dermek

Ing. Bohuslava Kozičová

University of Žilina, Faculty of Security Engineering
Ul. 1. mája 32, 01026 Žilina, Slovakia
Milan.Dermek@fbi.uniza.sk, kozicova@gmail.com

Abstrakt

Článok sa zaoberá možnosťami hasenia lesných požiarov v extrémnych terénnych podmienkach. Zaoberá sa problematikou používania systému jazierka pre vodnú dopravu na miesto požiaru pri hasení požiarov za akých podmienok je výhodné nasadiť tento druh vodnej dopravy, ako postupovať, keď je to potrebné a jeho nasadenie. Preprava vody v otvorenom teréne je riadená základnými hydraulickými pravidelnosťami, ktoré určujú spôsoby nasadenia pondelňajšieho systému.

Klíčová slova

Lesný požiar, taktika požiaru, systém rybníkov, požiarne zariadenia, nedostupný terén.

Abstract

The article deals with the possibilities of overcoming forest fires in extreme terrain conditions. It is devoted an issue of using pond system for the water transport to the seat of fire during firefighting under what conditions it is advantageous to deploy this mode of water transport, how to proceed when it is required and its deployment. Transport of water in exposed terrain is governed by the basic hydraulic regularities that determine the ways of deployment pond system.

Keywords

Forest fire, firefighting tactics, pond system, firefighting equipment, inaccessible terrain.

Introduction

One of the most devastating type of a wildfire in our country is exactly a forest fire in mountains. Many of them from this kind of localities are for the most used fire appliance hardly available nor unavailable at all. The supply of seat of fire with water for extinguishing requires to create a firefighting tactics applied on mountainous terrains cover by wood vegetation. In this case one of the options is deployment of the pond system. Pond system is a method of long-distance ground transport of water to the seat of fire. This system is possible to use in extreme and inaccessible terrain conditions. Pond system is a system of transport link from hose lines and a low-capacity artificial tank. To make the transport of water into terrain with elevation possible, pumps have to be connected into the system which ensure the transport of water from the source to the seat of fire.

Pond system

A pond is a smaller tank with capacity of thousands liters. It is possible to pack and put the tank into a bag what makes the transport to the required place easier. At the deployment of the pond system it is important to create a so called nest for the pond. That is how the tank is secured against displacement, sliding or outpouring. The pump adds needed pressure for the water to overcome the height and length loss. Each kind of pump must reach such a power that the pumped water has the sufficient pressure to overcome the terrain differences, sufficient feed pressure before next pump and necessary pressure for extinguishing. Height loss is caused by elevation of the terrain. From the last pond one or more, if necessary, offensive hose lines are being stretched. The number of lines is determined by the number of seat of fire. Offensive hose line can be created from hoses type C or from hoses type D, according to the required pressure. Offensive line is finished with a branch with which the fire is extinguished. The branch can be full flow rate, water curtained or combined [1, 2].

Fig. 1. The connecting of a pond with pump and hoses (photo: author)

Deployment of the pond system

Option of the deployment and advantages of the pond system:

- transport of water into extreme inaccessible terrain for fire appliance,
- transport of water in terrain with high elevation,
- securing big enough flow necessary for extinguishing,
- at optimal setup of the parameters required pressure is secured for extinguishing also a larger seat of fire,
- in case of larger seat of fire it is possible to move the ponds upwards if needed,
- transport of water by pond system is economically more convenient as air transport,
- the pond system is possible to deploy in bad weather [2, 3].

Deployment of the pond system

At making the pond system it is important to plan and execute each of the activities in a way that the time requirements should be as short as possible. Connecting a system of ponds into action consists of this single steps [4, 5, 6]:

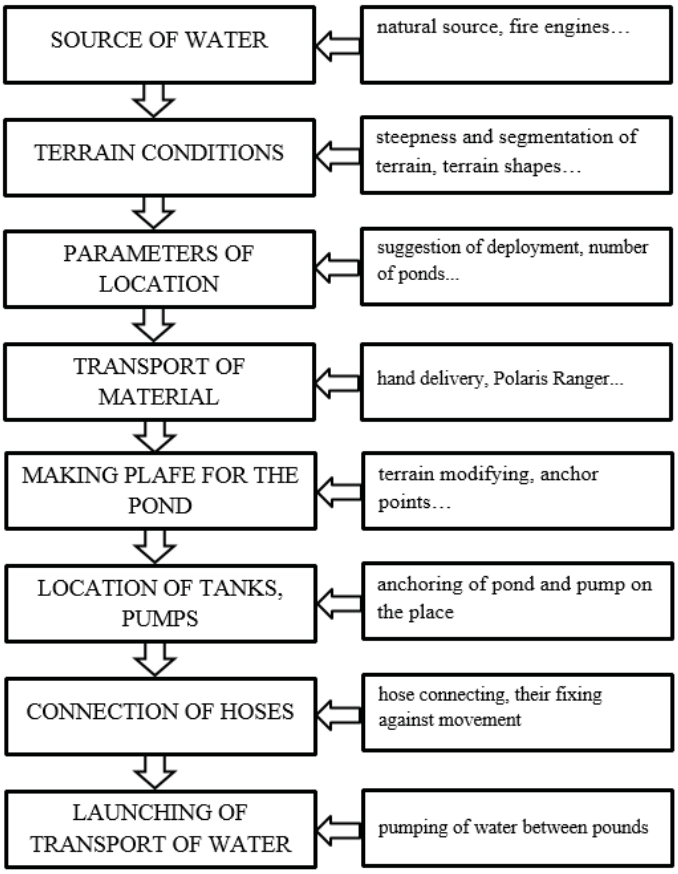

Fig. 2. Process of the deployment

Hydraulic calculation of the basic parameters for transport of water by the pond system

At placing each of the components of the pond system it is important to respect the physical laws of transportation of water. Optimal location of pumps and ponds means to calculate each parameters of the system in a way to reach effective flows of water [6].

Transport of water with pond system is controlled by basic hydrodynamic laws. Forest terrain is characteristic mainly by its segmentation and elevation. When water goes through a hose, some energetic loss is made. This losses are caused by height difference, friction and overcoming places in which the parameters of the flow are changing. For example reduction or enlargement of the hose diameter, overcoming potential obstacles so on.

To define the head loss by friction it is possible to use Darcy - Weissbach equation (1):

$$h_t = \lambda \cdot \frac{L}{d} \cdot \frac{v^2}{2g} \qquad (1)$$

h_f - head loss by friction [m], λ - friction factor (dimensionless unit), L - length of hose line or its part [m], d - diameter of hose [m], v - velocity of water flow [m.s^{-1}].

For using Darcy-Weissbach equation it is necessary to find out the friction λ and velocity of the transported water v. The length of the hose line L is the distance between the place of extinguishing and source of water in meters. It is counted with a specific length of used hoses. The diameter of a hose is set by the characteristics of the used fire equipment [3, 7].

Velocity of the flow of water is defined as (2):

$$v = \frac{Q}{S} = \frac{4 \cdot Q}{\pi \cdot d^2} = 1,27 \cdot \frac{Q}{d^2} \qquad (2)$$

v - average velocity of the flow of water [m.s^{-1}], Q - volume rate [m^3.s^{-1}], S - cross sectional area [m^2], d - inside diameter of a hose line [m].

Friction factor λ is possible to define with Reynolds number. The value of the Reynolds number characterizes the type of the flow. The flow of water in hose line can be laminar, turbulent or transitional (3).

$$Re_p = \frac{v \cdot d}{\nu} \qquad (3)$$

Re_p - Reynolds number for flow in pipe (dimensionless unit), ν - kinematic viscosity [m^2.s^{-1}], d - inside diameter of a hose line [m], v - average velocity of the flow [m.s^{-1}].

Flow of water in a hose line consists of more layers. At laminar pipe the layers of water slide on themselves, flow is steady. During turbulent flow each of the layers are mixed together and making whirls. Transitional flow represents the stage when one type of flow turns into another. Laminar flow turns into changes into turbulent especially at increasing the velocity of the flow and diameter of the hose. Exactly for the reason of necessary velocity is the flow of water in a hose line turbulent. Limit value of the Reynolds number is 2320. The flow of water with value of Re higher than 2320 is turbulent [6, 8].

Friction factor λ for turbulent flow is defined from the equation of Nikolajev - Lobanov (4):

$$\lambda = \frac{0,22}{Re^{0,211}} \qquad (4)$$

λ - friction factor, Re - Reynolds number for flow in pipe.

Another losses at long-distance transport of water are pressure losses caused by terrain elevation. They are determined according to formula (5):

$$h_g = h_{gk} - h_{gz} \qquad (5)$$

h_g - geodetic loss height caused by elevation of the terrain [m], h_{gk} - geodetic height of ending point [m], h_{gz} - geodetic height of initial point [m].

Overall loss height H presents the sum of loss height caused by elevation and head loss because of friction (6):

$$H = h_t + h_g \qquad (6)$$

H - overall loss height [m], h_g - geodetic loss height because of elevation [m], h_t - head loss from friction [m].

In the next step it is important to determine the specific energy loss for overall loss height (7):

$$Y_z = g \cdot H \qquad (7)$$

Y_z - specific energy, which is necessary to expend on overcoming the overall loss height [J.kg^{-1}], g - gravitational acceleration [m.s^{-2}], H - overall loss height [m].

From the value of loss specific energy we determine the number of needed pumps (8):

$$x = \frac{Y_z}{Y_{\check{c}}} \qquad (8)$$

x - number of pumps, which are necessary for overcoming overall losses [ks], Y_z - specific energy, which is important to expend for overcoming the overall loss height [J.kg^{-1}], $Y_{\check{c}}$ - specific energy of the pump [J.kg^{-1}]). [3, 7]

Location of the ponds in terrain

The graph is developed for three stages of elevation, and it is 15°, 25° and 35°. On the y axis the value of elevation is marked, which will be overcame at specific length of a hose line and for all the three elevation. The values of the length of the hose line are marked in 20-meters intervals, what response to the length of a single hose. This helping tool is created specifically for the pump Honda WH20X with operating pressure 0,81 MPa. At making the helping tool the values of volume flow 500 $l.min^{-1}$ and diameter of hoses 52 mm (hose type C) were used.

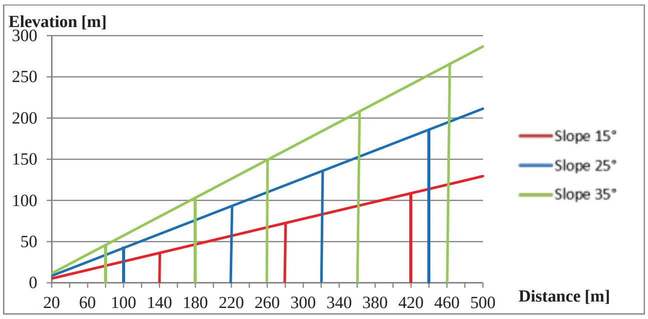

Fig. 3 Graph of determining the number of ponds and their location according to elevation and distance

Critical points in transport of water with the pond system:

- time consuming process of determining or calculating the parameters of locating the ponds,
- requirement of previous experience for the choice of the suitable way and the single places on the base of specific characteristics of terrain surface,
- time consuming process of building the pond system,
- placing the pond in dangerous area of the fire ground, where can be located sharp rocks or overhangs, incoherent terrain and so on,
- threat for the firefighters in response with fire, falling rocks, trunks and so on,
- danger for the components of the Pond system (falling rocks or branches can damage the pumps, hoses and other),
- if performing the activities is not automatic for the intervening firefighters, organization faults and wasteful time loss come up [9].

Deployment of the pond system

In case of using the pond system it is necessary to come out from two following assumptions. Firstly, it is important to respect the properties of specific terrain and situation on the seat of fire. Suggestion and placement the components must come out from individual research of the terrain, which is appropriate to combine with using modern informatics systems. Secondly, it is needed to know the theoretical laws and hydraulic principles, with which the transport of water in hose line is controlled. The pond system is a solution suitable only for specific situation and conditions. If there is a fire in unavailable mountain environment and the situation is in addition complicated because of weather (alternatively another unfavorable factor) it is optimal to use the pond system for securing the seat of fire with water. Its main advantage is, that in extreme terrain conditions it is possible to secure necessary flows of water for extinguishing. On the other side the disadvantages are the time requirements for specification the parameters and making the pond system at the scene of incident. Transport of water using the pond system is managed by hydraulic laws, with which it is possible to calculate the needed placement of pumps. For simplification the activity and fast estimation of deployment the pond system and calculating at intervention a diagram was made using this calculations. With this diagram is helping for fast defining the necessary number of ponds and their location.

References

[1] BLAŠKO, D. 2008.: Technické zabezpečenie na zdolávanie lesných požiarov. In *SPRAVODAJCA - Protipožiarna ochrana a záchranná služba*. ISSN 1335-9975. 2008, č. 1, s. 20 - 25.

[2] ŠUBA, J.; CHROMEK, I. 2007.: Jazierkový systém dopravy vody na hasenie požiarov v náročných horských terénoch. In *SPRAVODAJCA - Protipožiarna ochrana a záchranná služba*. ISSN 1335-9975. 2007, č. 4, s. 20 - 22.

[3] KOZIČOVÁ, B. 2015.: *Doprava vody na hasenie lesného požiaru v extrémnych terénnych podmienkach*. [Master thesis]. University of Žilina. Faculty of Security Engineering, Zilina: FŠI ŽU, 2015. 80 p.

[4] DANKO, J. 2010.: Doprava vody do výšok v horskom teréne. In: *Spravodajca - Protipožiarna ochrana a záchranná služba*. ISSN 1335-9975. 2010, roč. 41, č. 2, s. 12-15.

[5] HLAVÁČ, P. 2008.: Zvýšenie efektívnosti využitia vody pri zabránení šírenia lesného požiaru. In: *Delta*. ISSN 1337-0863. 2008, roč. 2, č. 4, s. 15-20.

[6] KVARČÁK, M. 1998.: *Požární taktika v příkladech*. Ostrava: SPBI, 1998. 232 s. ISBN 80-86111-08-3.

[7] DRUSA, M. a kol. 2003.: *Hydraulika a hydrológia*. Žilina: EDIS vydavateľstvo ŽU, 2003. 260 s. ISBN 80-8070-037-0.

[8] SVETLÍK, J. 2003. Doprava vody na požiarisko. In Sborník přednášek z medzinárodní konference *Požární ochrana 2003*. Ostrava: VŠB - Technická univerzita, 2003. ISBN 80-86634-17-5, s. 426 - 430.

[9] HUDEC, O. 2015.: *Modul pozemného hasenia STRED*. Informácie o jazierkovom systéme.