LOCATING THE AREAS OF ARISING OF NEW OUTBREAKS IN SPREADING FOREST FIRE THROUGH COMPUTER SIMULATION ALGORITHM

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Abstract

Using computer modeling for simulation of the distribution of high temperature gas flow in the presence of wind is a possibility to determine the areas in which it is expected another outbreak of fire. The presented algorithm for computer simulation is built on a relatively quick solution integral method with accuracy allowing prognosis the development of fire setting. The algorithm is easy to learn and can run on any laptop configuration. It is necessary to input data for power of the fire and wind velocity. It allows to determine the maximum speed of the gas burning flow and its temperature.

***Key words**: forest fire, integral method, computer model, high temperature gas flow, ecology*

1. INTRODUCTION

Forest fires have a large impact on nature (trees, grass and animals) and humans every year. Once arises of any source the fire can spread on a larger area from one part in the forest to the next trees and other objects (Figure 1). Some of the basic parameters in this process are the power of the fire and is there any wind. The wind velocity and its direction influence on the fire setting.

The fire is spread generally in the same direction as the wind direction with a level of speed depending on the wind velocity. In this paper some parameters like: geometry of the burning object; barriers as rivers, roads etc. are ignored.

The algorithm presents the steps of computing and understanding the deformation and raising gas burning flow over the fire. Some analyses of many experimental results are given in sources [1], [2], [3]. The mathematical model in this paper will be used as a base of the computer algorithm. It can be developed in Matlab environment [4].

2. MATHEMATICAL MODEL

For the purposes of calculating the parameters mentioned above the first step is to calculate the speed of the convective flow above the burning zone:

$$V_0 = 1,9Q^{0,2} \tag{1}$$

where Q is the power of the fire measured in kW.

Wind speed affects the axis of the upward flow over the fire and the length of the flow (Figure 2) is determined by:

$$l = \int_0^x \sqrt{1+y'^2}\,dx \tag{2}$$

where x and y show the length of the trace (coordinates) in meters.

After transforming the equation (2) it can be presented as:

$$l = x\sqrt{1+y'^2} \tag{3}$$

$$y'^2 = \frac{1}{Kx} \tag{4}$$

where K is a constant calculated for simplicity:

$$K = \frac{\rho_w W w^2}{b_0 \rho_0 V_0^2} \tag{5}$$

where $b_0[m]$ is the width of the fire surface; $\rho_w = 1,2[kg/m^3]$ is the density of the wind; $\rho_0 = 0,4[kg/m^3]$ is the initial density of the flame; $T = 873[K]$ is the temperature of the fire; Ww[m/s] is the wind velocity.

The damping of the maximal velocity by l is described by:

$$\overline{Um} = A_u n^{-\frac{1}{2}} \left(\frac{l}{b_0}\right)^{-\frac{1}{2}} \tag{6}$$

$$n = \frac{\rho_w}{\rho_0} \qquad (7)$$

$$Um = V_0 \overline{Um} \qquad (8)$$

where $A_u = 2,48$ is an integral value after integration of the cross section.

The damping of the density of the gas flow along the length l is defined by:

$$\Delta\overline{\rho_m} = \frac{\Delta\rho_m}{\Delta\rho_0} = A_\rho n^{\frac{1}{2}} \left(\frac{l}{b_0}\right)^{-1} \qquad (9)$$

$$\Delta\overline{\rho_m} = \frac{\rho_w - \rho_l}{\rho_w - \rho_0} \qquad (10)$$

Then:

$$\rho_l = \rho_w - 0,8\Delta\overline{\rho_m} \qquad (11)$$

The calculations related to l start when $\rho_l > \rho_0$. In other case it is assumed that the temperature of the gas flow is a constant, i.e. the temperature is not reducing.

The temperature of the gas flow along the center line of the jet is obtained in Kelvins by:

$$T_l = \frac{p}{\rho_l R} \qquad (12)$$

Where $p = 10^5 [Pa]$ is the atmospheric pressure; $R = 287$ is a gas constant.

The width of the gas flow over the fire is obtained by the equation:

$$b = b_0 + 0,22l \qquad (13)$$

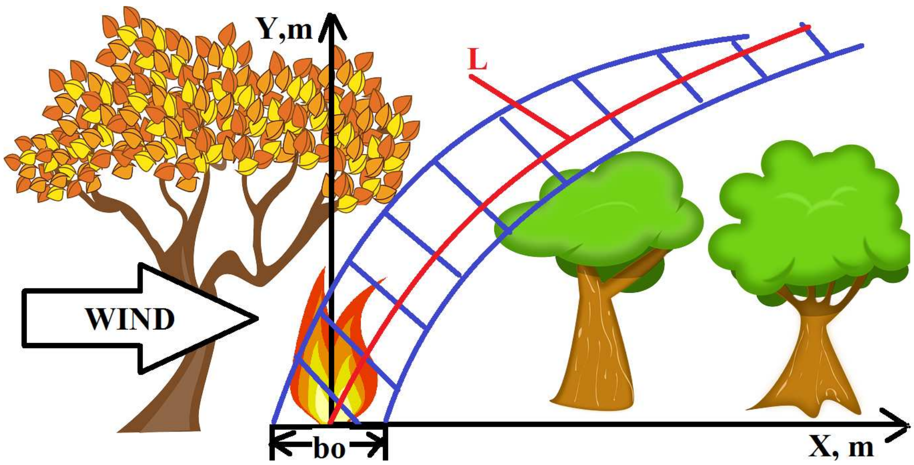

Figure 1. Forest fire scheme

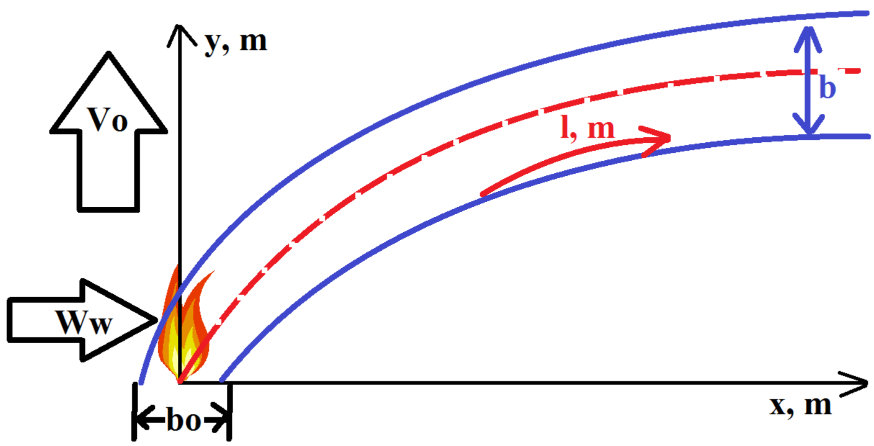

Figure 2. Forest fire calculated parameters

3. COMPUTER ALGORITHM

The mathematical model described above can be implemented in a computer system through developing an algorithm which is showed on Figure 3. This will give the possibility to use the model in emergency cases as fires in forest and to predict the gas burning flow position and its temperature. The initial data is listed as:

- ✓ the power of the fire in 3 cases- $Q1 = 400KW$, $Q2 = 600KW$, $Q3 = 800KW$;
- ✓ the distance from the fire source is $x \in [2, 20]m$;
- ✓ the wind velocity is $Ww1 = 2m/s$, $Ww2 = 4m/s$, $Ww2 = 6m/s$, $Ww2 = 8m/s$, $Ww2 = 10m/s$;
- ✓ $\rho_w = 1,2kg/m^3$;
- ✓ $T = 873K$;
- ✓ $\rho_0 = 0,4kg/m^3$;
- ✓ the atmospheric pressure $p = 10^5 Pa$;
- ✓ the gas constant is $R = 287J/kg^oK$.

For the purposes of this paper the above parameters are mentioned to show that the algorithm can use different input data and to calculate different combinations of initial data.

5. CONCLUSION

The proposed computer algorithm is very easy to learn and understand and then to implement it in any operational system and any laptop or a smartphone. This is useful for the people when fighting the forest fires to predict the direction of the high temperature gas flow over the flame and the possible enlargement of the disaster.

The algorithm can be used to obtain and to transfer information for the fire setting in real time by an electronic device. The source code can be written in different environment such as Matlab, Java, C etc.

The automatic processing of the inputted data save time and allows saving human lives, animals and trees in forests. This is the main reason to renew the methods of planning and performing rescue and extinguishing activities.

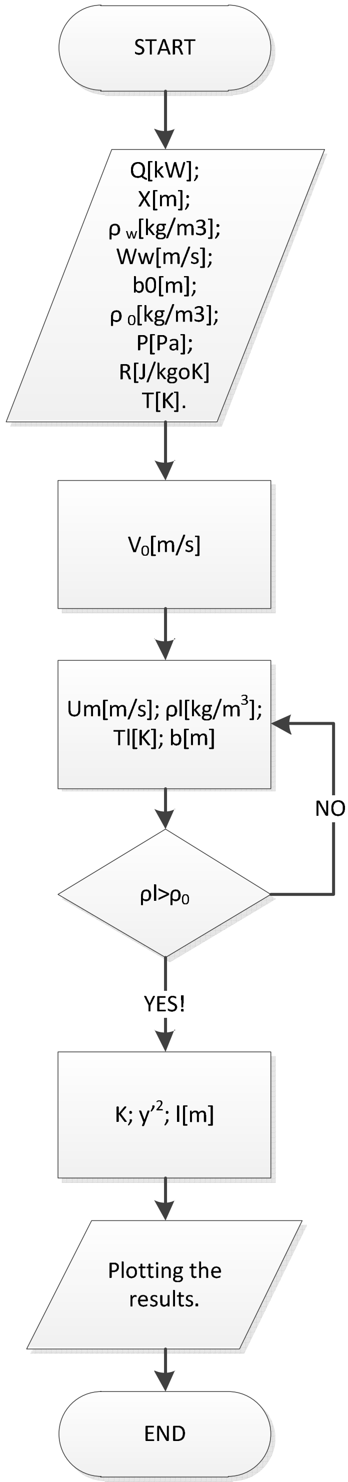

Figure 3. A simple computer algorithm

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