QUANTITATIVE CALCULATION OF CHARACTERISTIC VOLUME OF SURFACE-FIRE BEHAVIOR

Ju En-de and Chen Da-wo
(Northeast Forestry University Harbin, China)

ABSTRACT

In the description of the charecteristic volume of fire behavior, fire intensity I, rate of spread r, and flame length L, etc. all have their scientific definitions, while the bound between the fireline and the residual region of a fire scene is not yet scientifically defined. This paper tries to find out theoretically the basis for dividing the bound, to give the fireline thickness D a scientific definition, and to propose a method of quantitative calculation.

According to the generality of fuels, the time-dependent curves of fuels combustion rate are utilized to work out a formula by experience. On the basis of defining scientifically the fireline thickness, the Byram's formula is corrected, and a new one for calculating the fire intensity of surface fire, i. e. $I=0.788HWr$, is presented. In this formula, H is the combustion value of fuels, the calculating method of the thermal current intensity J is given, and $J_{max}=1.25\ HWr/D$ the calculating formula of flame length is revised, and a new one $L=0.775\sqrt{I}$ is proposed. In the spreading process of the forest fire, when the time needed for getting over a fireline thickness is T, it is called residence time. It is given out in this paper the method for estimating and determining the rate of spread r and the residence time T in the combustor. And on this basis the characteristic volume (W, I, R, D, T, L and J_{max}, etc.) of surface fire behavior can be evaluated.

KEY WORDS: Fireline thickness, Residence time, Thermal current intensity, Point source, Line scurce, Instantaneous rate of combustion, Average combustion rate.

1. Instantaneous Rate of Combustion, Average Combustion Rate and Residual Combustion Stage

The combustion process of fuels inside the combustor may be expressed by the following figures and lines: In Fig(1-1)curve 1 and 2 are used to show respectively the time-dependent process of instantaneous and average combustion rate; $B(t)$ and $\overline{B}(t)$, the intantaneous and average combustion rate of fuels in a unit area; σ_0、$\sigma_{(t)}$、σ_s, the surface density of fuels before kindling, during combustion process, and of surplus materials after combustion. If a fire is kindled at t_0, let $\omega_{(t_0)}$ and $\omega(t)$ indicate separately the surface density of available fuels before the kindling of fuels and during the process of combustion. Thus obviously:

$$\sigma_0 = \sigma(t_0) \qquad (1\text{-}1) \qquad\qquad W = \omega(t_0) \qquad (1\text{-}2) \qquad\qquad \omega(t) = \sigma(t) - \sigma_s \qquad (1\text{-}3)$$

During the combustion process the quality of fuels reduces with the lapse of time, on condition that the area occupied by fuels inside the combustor remained unchanged:

$$B(t) = -\lim_{\substack{\Delta t\to 0\\ \Delta s\to 0}} \frac{\Delta m}{\Delta t\cdot\Delta s} = -\frac{d\sigma}{dt} = -\frac{d\omega}{dt} \qquad (2\text{-}1)$$

During the period from $t_0 \rightarrow t$, the average rate of combustion of fuels in a unit area is shown by the following equation

$$\overline{B}(t) = \frac{1}{t-t_0}\int_{t_0}^{t} B(t)dt = \frac{1}{t-t_0}[\omega(t_0) - \omega(t)] = \frac{1}{t-t_0}[W - \omega(t)] \qquad (2\text{-}2)$$

It is seen from curve 1 that if a fire is kindled at t_0, $B(t)$ reaches the maximum at t (instant), to be put down as $B_{max} = B(t_1)$. During the period from t_0 to t_1, $B(t)$ increases as time goes on, the quantity of heat released by the available fuels on a unit area in a unit time is trending to be on the rise and it burns to the utmost at t_1 instant its, flame reaches the climax. From curve 2, we see that $\overline{B}(t)$ gets to the maximum at t_2 instant, noted as $\overline{B}_{max} = \overline{B}(t_2)$. Contrasting curve 1 to curve 2, we find that during the period from $t_1 \rightarrow t_2$, though $B(t)$ decreases with the lapse of time, $\overline{B}(t)$ still increases. During the period of $t > t_2$, we make out from curve 1 that when the fire behavior decreases, the fuels extinguish gradually.

Owing to the time taken up in the extinct stage being longer, the change in quality of fuels rather small, and the area occupied by it graduatlly narrows in irregularity, it is therefore very hard to determine precisely the $\sigma(t)$ value, and thus unable to calculate accurately the $B\ (t)$ value. During the period from t_0 to t_2, various data may all be determined precisely and $\overline{B}_{max}$ has a clear physical meaning. That is, referring to the time on the average, the quantity of heat released in a unit time is the maximum. For this reason, the combustion stage is defined as residual stage. But the residual stage is not to be discussed here in this paper. From equation (2-2) we may have

$$\overline{B}_{max} = \overline{B}(t_2) = \frac{1}{t_2 - t_0}\int_{t_0}^{t_2} B(t)dt = \frac{1}{t_2 - t_0}[W - \omega(t_2)] \tag{2-3}$$

2. The Instantaneous Combustion Rate in the Region And the Fireline Thickness.

Before the surface-fire occurs, the surface density of available fuels is expressed as $W(\xi,\eta)$. In the spreading process of surface fire, the fireline usually moves forward with the wind. In Fig. (2-1), strip 1 shows the position in which the fireline lies at t' instant. Take, at will, a small region Δs on the fireline. In process of investigating surface fuels, owing to the specimen area used for sampling is $1m \times 1m$ and $2m \times 2m$, but under general conditions, the fireline thickness is $<2m$. Therefore, the surface densities of available fuels in region Δs before kindling (the fire) may be looked on as the same, and put down as $\overline{W} = W\ (\xi_0,\ \eta_0)$; as the time used for the fireline to go across with the wind, a fireline width is far less than the fire-scene combustion time, the rate of spread for the fireline to get across the Δs region with the wind during the process, maybe looked on as the same and put down as $r = \bar{r}\ (\xi_0,\ \eta_0)$; Choose a natural coordinate, let the head wind direction be the axis x direction and the tangential be the axis y direction. As the rate of spread of the fireline in the x direction is far greater than that of it in the y direction, the direction of the rate of spread of each point in region Δs may be looked on as the same and being along the axis x direction.

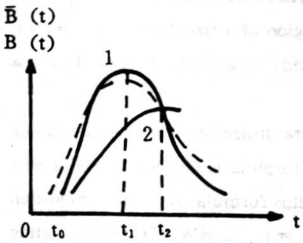

Fig. (1-1) The time-dependent curves of instantaneous and average combustion rates.

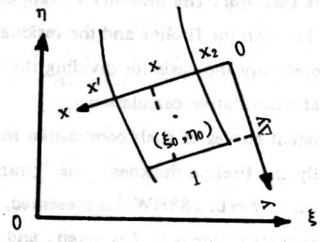

Fig. (2-1) Firelines spread along the x direction.

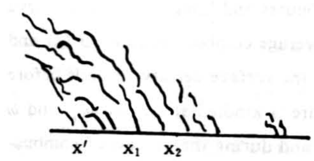

Fig. (2-2) Fire behaviors of each line-source in the fireline.

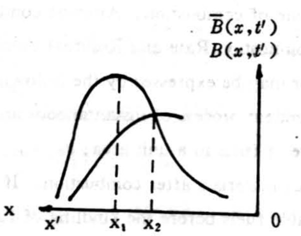

Fig. (2-3) Instantancus combustion rates of line-source at x and of the fireline at t' instant.

Each point in region Δs is burning, burning point like this is called point source. Each point source on axis y direction has the same regular pattern, forming a line source of Δy length shown by dotted line in Fig. (2-1). Thus, after the choice of a natural coordinate, the plane problem is simplified as a straight line one on which the line sources spread along the x direction. At $x = x'$ the expressing formula for the line source kindled at $t = t'$ instant is:

$$B(x',t')\delta(x - x')\delta(t - t')\ ^{2}$$

The line source at $x = x'$, during the period of $t \geq t'$, the expressing equation for its instantaneous combustion rate at t instant is

$$B(x',t) = \int_{t=t'}^{t}\int_{x=x'-\epsilon}^{x'+\epsilon} B(x',t')\delta(x - x')\delta(t - t')dx'dt' \tag{3-1}$$

The line source at $x = x'$, The expressing formula for its average combustion rate in the period of t' to t, is:

$$\overline{B}(x',t) = \frac{1}{t-t'}\int_{t'}^{t} B(x',t)dt$$

If the fuels at (ξ_0, η_0) are put into a combustor having similar burning conditions for burning, rewrite W (ξ_0, η_0) as W, and let kindling instant $t' = t_0$, then B (x', t), ie. B (t), and from (2-2) we have

$$\overline{B}(x',t) = \frac{1}{t-t_0}\int_{t_0}^{t} B(t)dt = \frac{1}{t-t_0}[W - w(t)]$$

If at $t = t_2$ instant, $\overline{B}$ (x', t) reaches its maximum, put down as $\overline{B}_{max}$ (t_2), and the surface density of available fuels at t_2 instant in the combustor, noted down as ω (t_2), then from the above formula we may have

$$\overline{B}_{max}(t_2) = \overline{B}max = \overline{B}(x',t_2) = \frac{1}{t_2-t_0}\int_{t_0}^{t_2} B(t)dt = \frac{1}{t_2-t_0}[W - \omega(t_2)] \qquad (3\text{-}2)$$

Then obviously, W, ω (t_2) bear a relation not only to position (ξ_0, η_0) of region Δs, but to the nearly meteriologica conditions at t_2 instant.

At $t = t'$ instant in region $x \leqslant x'$, the expressing formule of the instantaneous combustion rate of the line source at x is

$$B(x,t') = \int_{x'=x}^{x}\int_{t=t'-\epsilon}^{t'+\epsilon} B(x',t')\delta(x-x')\delta(t-t')dx'dt' \qquad (3\text{-}3)$$

Fig (2-2) shows the fire scene at t' intstant in the direction of axis x. As soon as the forward point A is kindled the instantaneous combustion rate B (x', t') has a trend to rise; Point B being Kindledprior to Point A, burns to the utmost, its flame reaches the climax, i. e. $B_{max} = B(x_1, t')$; Point C being kindled prior to point B, its instantanous combustion rate has had a trend to decline. Thus it can be seen that the instantaneous combustion rate of each line source in region Δs at an identical instant is different from one another.

The expressing equation of the instantaneous combustion rate of the region in the stage from x to x' at $t = t'$ instant is

$$\overline{B}(x,t') = \frac{1}{x'-x}\int_{x}^{x'} B(x,t')dx$$

It is seen from Fig. (2-3) that the line source with Δy for its length, the value of the instantaueous combustion rate in the burning region composed of continuous distribution in x direction has relation to the width taken in x direction. Calculating from the front edge, we found that the value of instantaneous combustion rate in the region too narrow in width is small, and that it is also small in the region unduly wide in width; while the value of it in the region from x_2 to x' is maximum, noted down as follows:

$$\overline{B}_{max}(x_2) = \overline{B}(x_2,t') = \frac{1}{x'-x_2}\int_{x_2}^{x'} B(x,t')dx \qquad (3\text{-}4)$$

where $\overline{B}_{max}(x_2)$ has a clear physical meaning. It expresses that the heat power of released in per untit area, which is referred to on the average, in the region from x_2 to x', is maximum. Obviously, as to the scene of fire, this region is defined as fireline. $\overline{B}_{max}$ (x_2) is defined as instantaneous combustion rate of the fireline. From Fig. (2-3) it may be seen that the region of $x < x_2$ whose instantaneous combustion rates are all smaller than those of the fireline is therefore defined as the residual region. The width $x' - x_2$ is called fireline thickness, put down as D. The residence time is noted down as T. then

$$D = x' - x_2 = r(t' - t_2) \qquad (3\text{-}5) \qquad\qquad T = t' - t_2 = D/r \qquad (3\text{-}6)$$

where D, r and T whose values relate not only to position (ξ_0, η_0) of region Δs, but to the nearly meteorological conditions at t' instant.

3. Making Use of Combustor to Calculate $\overline{B}_{max}$ (x_2), and to Revise Byram's Formula

When surface-fire spreads to region Δs, the region Δs may be divided into several elemens of surface ds_i and we have

$$ds_i = \Delta y \cdot \Delta x_i \qquad\qquad \Delta s = \sum_{i=1}^{n} ds_i$$

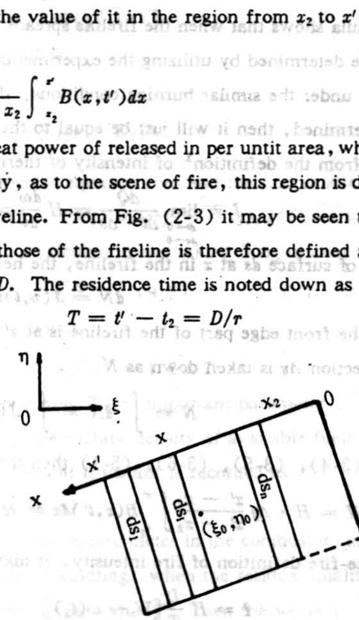

Fig. (3-1)

As W in region Δs is the same, D and T are in small quantity as compared with the scale corresponding to the scene of fire. Therefore, the physical and chemical properties of fuels in each element of sarface are identical and theri topographic and meteorological conditions are in similar manner, too. Thus it can be seen that the regular patterns of burning of fuels in each region of ds_i are the same, only the instants to kindle the frie are in order of priority. They are kindled successively along the axis x direction. The element of surface at x' is kindled at t' instant, and that at x at $t'-\tau$, from Fig. (3-1) we see

$$\tau = \frac{x' - x}{r} = t' - t \quad (4\text{-}1) \qquad dx = rd(t' - \tau) = rdt \quad (4\text{-}2)$$

If they are put in several combustors and to be kindled simultaneously at t' instant, their time-dependent curves of instantaneous combustion rates are identical and all represented by curves $B(t)$ [see Fig. (1-1)]. Imitating the process of spread, the combustor where ds_1 is kindled at t' instant, the combustor where ds_2 is at $t'-\tau_1$, ··· and the combuster where ds_n is at $t'-\tau_{n-1}$, their time-dependent curves of instantaneous combustion rates are $B(t)$, $B(t-\tau_1)$, ··· $B(t-\tau_{n-1})$ respectively. If we watch several combustors simultaneously at t' instant, the combustion rates of fuels in each combustor are found different from one another, put down separately as $B(t')$, $B(t'-\tau_1)$, ··· $B(t'-\tau_{n-1})$.

When $n\rightarrow\infty$, $\Delta x\rightarrow 0$, element of surface ds may be regarded as line source. when the line-source at t' is kindled at t' instant, then the instautaneous combustion rates at t moment is $B(x', t)$ [see formula (3-1)], and $B(x', t) = B(t)$; when the linesource at x must be kindled at $t'-\tau$ instant then the instantaneous combustion rate at t instant is $B(x, t)$ and $B(x, t) = B(t-\tau)$. At t instant and in the region $x \leqslant x'$, the instantancous combustion rate of the line-source at x is noted down as $B(x, t')$ [see formula (3-3)], and $B(x, t') = B(t'-\tau)$. The instantancous combustion rate of the fire line at t' instant may be given from formula (3-4).

$$\overline{B}_{max}(x_2) = \frac{1}{x' - x_2}\int_{x_2}^{x'} B(x,t')dx$$

Substituting in $B(x, t') = B(t'-\tau)$, formulae (4-1), (4-2) and (3-6) we have

$$\overline{B}_{max}(x_2) = \frac{r}{x'-x_2}\int_{T}^{0} B(t'-\tau)d(t'-\tau) = \frac{1}{t'-t_2}\int_{t_2}^{t'} B(h)dh = \frac{1}{t_2-t'}\int_{t'}^{t_2} B(h)dh$$

Let $t' = t_0$ and substituting in equation (3-2).

$$\overline{B}_{max}(x_2) = \overline{B}_{max}(t_2) = \overline{B}_{max} = \frac{1}{t_2-t_0}[W - \omega(t_2)] \quad (5\text{-}1)$$

As time index fixed in the combustor is $t_2 > t'$ and time index of spread is $t' > t_2$, so

$$T = (t' - t_2)_{\text{spread time index}} = (t_2 - t')_{\text{combustor time index}} \quad (5\text{-}2)$$

The above formula shows that when the fireline spreads to the place (ξ_0, η_0) the instantancous combustion rate of the fireline here may be determined by utilizing the experimental method. Take fuels from (ξ_0, η_0), put them into the combustor and kindle them under the similar burning conditions; if the maximum average combustion rate of the unit-area fuels can precisely be determined, then it will just be equal to the instantancous combustion rate at (ξ_0, η_0).

It may be seen from the definition[3] of intensity of thermal current that its value is

$$J = \lim_{\substack{\Delta t\rightarrow 0\\ \Delta s\rightarrow 0}} \frac{\Delta Q}{\Delta t \cdot \Delta s} = H\frac{d\omega}{dt} = H \cdot B \qquad J(x,t) = HB(x,t) \quad (5\text{-}3)$$

On the element of surface ds at x in the fireline, the heat power produced by fuels is put down as dN, then

$$dN = J(x,t)ds = H \cdot \Delta y \cdot B(x,t)dx$$

If at t' instant the front edge part of the fireline is at x', then at t' moment the instantancous calorifie power produced in the fireline of section Δy is taken down as N

$$N = \int dN = \int J(x,t')ds = H \cdot \Delta y \int_{x_2}^{x'} B(x,t')dx$$

Substituting in (3-4), (3-5), (3-6), (5-1) then the above equation becomes

$$N = H \cdot \Delta y \frac{x' - x_2}{x' - x_2}\int_{x_2}^{x'} B(x,t')dx = H \cdot \Delta y \cdot (x'-x_2)\overline{B}_{max}(x_2) = H \cdot \Delta y \frac{D}{T}[W - \omega(t_2)]$$

From the surface-fire definition of fire inteusity, it may be known that $I = N/\Delta y$, then from the above equation we get

$$I = H\frac{D}{T}[W - \omega(t_2)] \quad (6\text{-}1) \qquad I = Hr[W - \omega(t_2)] \quad (6\text{-}2)$$

Evidently, from Fig. (2-3) we make out that $\omega(t_2) \neq 0$, therefore on the basis of scientifically defining the fireline, Byram's formula must be revised.

4. Experimental Curves and Their Mathematical Expressing Formulae

After the fuels in the combustor are kindled, their total amount reduces with the lapse of time, and the available fuels burnt are increasing. Their surface density is noted down as Ω (t), then

$$\Omega(t) = \omega(t_0) - \omega(t) = W - \omega(t)$$

If we start taking down the time from the instant of kindling, i. e. let $t_0 = 0$, then the above form is rewritten as

$$\Omega(t) = \omega(0) - \omega(t) = W - \omega(t) \qquad (7\text{-}1) \qquad \Omega(0) = 0; \quad \Omega(\infty) = W \qquad (7\text{-}2)$$

Substituting (7-1) in (2-1), (2-2). (6-1), and (6-2) we have

$$B(t) = \frac{d\Omega}{dt} \quad (7\text{-}3) \qquad \overline{B}(t) = \frac{\Omega(t)}{t} \quad (7\text{-}4) \qquad I = Hr\Omega(t_2) \quad or \quad I = HD\Omega(t_2)/T \; (7\text{-}5)$$

The longer the burning time of fuels, the greater the percentage occupied by the fuels burnt, and the percentage of the fuels burnt within a unit-time is recorded as

$$\left[\frac{\Delta\Omega}{W}\right]/\Delta t \qquad \lim_{\Delta t\to 0}\frac{\Delta\Omega}{W\Delta t} = f(t) \quad \text{i. e.} \quad \frac{d\Omega}{\omega dt} = f(t) \qquad (8\text{-}1)$$

Integrating the two sides aginst (8-1), we have the "including in one" condition: $\int_0^\infty f(t)dt = 1$ When W-value is smaller than 5kg/m^2, the experimental curve of fuels in the combustor is represented by the dotted line in Fig. (1-1)[4], while the theoretically formed curve by the real line. The theoretical curve may be expressed by the following equation:

$$\frac{d\Omega}{W} = \frac{4}{\sqrt{\pi}}\lambda t^2 e^{-\lambda t^2} d(\sqrt{\lambda}\, t) \qquad (8\text{-}2) \qquad B(t) = \frac{d\Omega}{dt} = W\frac{4}{\sqrt{\pi}}\lambda^{\frac{3}{2}} t^2 e^{-\lambda t^2} \qquad (8\text{-}3)$$

Taking against (8-3), the values whose first grade differential quotient is equal to zero, and the second smaller than zero.

$$\sqrt{\lambda}\, t_1 = 1.00 \quad (8\text{-}4) \qquad B_{max} = B(t_1) = 0.830\sqrt{\lambda}\, W \quad (8\text{-}5) \qquad J_{max} = 0.830\sqrt{\lambda}\, HW \quad (8\text{-}6)$$

Integrating the two sides against (8-3) we have

$$\Omega(t) = W\left[\frac{2}{\sqrt{\pi}}\int_0^t e^{-\lambda t^2} d(\sqrt{\lambda}\, t) - \frac{2}{\sqrt{\pi}}\sqrt{\lambda}\, t \; e^{-\lambda t^2}\right]$$

$2/\sqrt{\pi}\int_0^x e^{-x^2}dx$ is generally called error function, noted down as erfx; $(2/\sqrt{\pi})\; e^{-x^2}$ is called Gauss function, put down as G (x), the above formula is rewritten as

$$\Omega(t) = W[erf(\sqrt{\lambda}\, t) - \sqrt{\lambda}\, tG(\sqrt{\lambda}\, t)] \qquad (9\text{-}1)$$

Through consulting the table we may get it[5] $\quad \Omega(t_1) = 0.428W \qquad (9\text{-}2)$

Let (9-1) be substituted in (7-4) we have

$$\overline{B}(t) = \frac{W}{t}[erf(\sqrt{\lambda}\, t) - \sqrt{\lambda}\, tg(\sqrt{\lambda}\, t)] \qquad (9\text{-}3)$$

Taking against (9-3) the values whose 1st grade differential quotient is equal to zero and the 2nd smaller than zero, and noted down as t_2 [see Fig. (1-1)]. $\quad \sqrt{\lambda}\, t_2(1 + 2\lambda t_2^2) = erf(\sqrt{\lambda}\, t_2)/g((\sqrt{\lambda}\, t_2)$

Consulting the tables of Gauss function and error function, making a calculation and taking 3 significant figures we obtain

$$\sqrt{\lambda}\, t_2 = 1.50 \quad (9\text{-}4) \qquad \overline{B}_{max} = \overline{B}(t_2) = 0.525\sqrt{\lambda}\, W \quad (9\text{-}5) \qquad \Omega(t_2) = 0.788W \quad (9\text{-}6)$$

Let (9-4) be substituted in (5-2). From (9-4), (9-7) we again obtain

$$T = t_2 - t_0 = t_2 \qquad (9\text{-}7) \qquad \sqrt{\lambda} = 1.50/T \qquad (9\text{-}8)$$

Equations (9—6), (9—7) and (9—8) give the method of determining T and important parameter $\sqrt{\lambda}$. First of all, the effectuation degree factor α of fuels is deteimined, now $W = \alpha\,\sigma_0$, the surface density of available fuels burnt is computed as Ω (t_2) $= 0.788\alpha\,\sigma_0$, thus the surface density of residual fuels at t_2 instant is recorded as Σ.

$$\Sigma(t_2) = \sigma_0(1 - 0.788\alpha) \qquad (9\text{-}9)$$

Then putting the fuel on one square meter at (ζ_0, η_0) into an area of one square meter in the combustor, initating the burning conditions at (ξ_0, η_0). Start taking down the time at the instant of kindling, when the residual quality is indicated by the display as value Σ, we note down the instant t_2 and thus determine the value T. Then the value $\sqrt{\lambda}$ is calculated. There are at present various methods for calculating the spread rate of the surface fire. Making use of the combustor to estimate the spread rate of fuels is a more accurate methed.[6] $\quad r = r_0 k_1 k_2/\cos\varphi \qquad (9\text{-}10)$

r_0 is the rate of spread at windless moment, k_1 is the altered factor of windspeed, k_2 of compacness, and φ is the topographic angle of slope. T, $\sqrt{\lambda}$ and r be substituted in the formulae of (3-5), (7-5) and (8-6), we respectively have

$$D = rT \qquad I = 0.788WHr = 0.788WHD/T \qquad J_{max} = 1.25WHr/D = 1.60I/D$$

According to Byram's definition, the relation between the fire intensity and the length of flame is $L = 0.0755I^{0.46}$ [r].
Where as defined in this paper the relation between them is $L = 0.0755\sqrt{I}$

To sum up (the above mentioned), collecting beforehand the fuel specimen all around the surface and marking their locations (ξ_0, η_0); Each specimen is put into the combustor to be tesled under various burning conditions then the data groupings under different burning conditions at (ξ_0, η_0) are obtained: i. e. $\{r|(\xi, \eta)\}$, $\{T|(\xi, \eta)\}$, $\{\sqrt{\lambda}|(\xi, \eta)\}$, and from them other data groupings of characteristic volume of fire behavior at (ξ, η) are calculated: i. e. $\{I|(\xi, \eta)\}$, $\{J_{max}|(\xi, \eta)\}$, $\{D|(\xi, \eta)\}$, $\{L|(\xi, \eta)\}$. Under the changeable meteorological comditions, an estimation is to be made for the sitication of the scene of fire. And among different burning conditions. the pre-ignition conditions of fuels must well be considereed. [8]

5. Visual Fireline Thickness D on The Scene of Fire

The bounds between the fireline and residual fire region as defined in tthis paper is very hand to be visual, but the front edge part x' of the fireline and the producing position x_1 of the highest flame are easy fo be visual, and the distance between them is noted down as l, and from formula (8—4), (9—4) we have comparing Fig. (1—1) with Fig. (2—3) we have

$$l = x' - x_1 \qquad (10-1) \qquad\qquad t_2/t_1 = 1.50 \qquad (10-2)$$

$$\frac{x' - x_2}{x' - x_1} = \frac{t_2 - t_0}{t_1 - t_0} \qquad (10\text{-}3)$$

Let $t_0 = 0$, and substituting in fosmula (3—5), (10—1), and (10—2), we get $D = 1.5l$ (11)

The fireline thickness is (equal to) 1. 5 times as the distance from the fire head to the peak of flame.

If L and r are further visual, then I, J_{max}, and T can right be estimated from formula (10—1) to (10—5).

As the limits between residual region and extinguishing regions inside the scene of fire is very hard to decide, the features of the method introduced here in this paper are foumd expression as follows.

A. To estimate the fireline thickness D;

B. To calculate the important parameters of the fire behavior— $J_{max} \approx I/D$, the thermal current intensity at the peak of flame in the fireline;

C. No matter what it is, to calculate or to estimate on the scene of fire, the main characteristic volume of fire behavior can exactly be calculated.

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