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# Modelling of occurrence and spread of fire in RTV

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**Abstract**: Statistic data shows that in 3% of road accidents might occur fire. On the other hand, about 30 percent of fires are due to car accidents. This article presents a mathematical model based on thermal and gas dynamics that are based on fire in car.

**Key words:** fire, road accidents, thermal and gas dynamics, statistic data, mathematical model

## INTRODUCTION

Each country in EU leads internal statistic on the number of fires and those fires occurring in vehicles. In the last few years there is statistics that compare the fire accidents situations in more than one country - in the Member States of the European Union. This makes it possible. To conduct a research to identify the causes of fires and the establishment of safety standards. In car accidents, the fires are associated with other damages, representing a danger for the people. Damages in system in car accidents helps for starting the fire, some problems with car doors etc. Injured people also slow down the evacuation from the car on fire.

## NUMERICAL METHODS

The processes of fire are very complicated and complex, consisting of a combustion radiation, turbulence, gas dynamics and other physical and chemical processes. Using computer models for modeling fire and analyzes fire protection is becoming very popular in the last few years with prognostic capabilities covering a wide range of deployments.

Modeling of fire usually divided into three categories.

First, one is empirical method, which involves costly experimentation and physical element of risk.

The second method is the zonal method that assumes some features of fire as it is stratification

The last method is through the use of computational fluid dynamics Fire Dynamics Simulator (FDS) through the program PyroSim are created and predict complex models of development of fire

FDS solves a form of conservation equations for low speed,

Use the equations of Navier-Stokes equations in a suitable form of the passage of smoke and heat from a fire. This equations, momentum and energy via equation table

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \rho u = 0 \tag{1}$$

impulse:

$$\frac{\partial}{\partial t}(\rho u) + \nabla \cdot \rho u u + \nabla p = \rho f + \nabla \cdot t_{ij} \tag{2}$$

energy:

$$\frac{\partial}{\partial t}(\rho h) + \nabla \cdot \rho h u = \frac{Dp}{Dt} + \dot{q}^{m} - \nabla \cdot q + \Phi \tag{2}$$

The equations in the FDS as a set of partial differential equations, with appropriate simplifications and approximations noted.

Numerical methods the basic conservation equations for mass, momentum and energy for a Newtonian fluid. These are the same equations that can be found in almost any textbook on fluid dynamics or CFD. A particularly useful reference for a description of the equations, the notation used, and the various approximations employed is Anderson et al. Note that this is a set of partial differential equations consisting of six equations for six unknowns, all functions of three spatial dimensions and time: the density r, the three components of velocity $v = [u, v, w]$, the temperature $T$ , and the pressure $p$ .

The overall computation can either be treated as a Direct Numerical Simulation (DNS), in which the dissipative terms are computed directly, or as a Large Eddy Simulation (LES), in which the large-scale eddies are computed directly and the subgrid-scale dissipative processes are modeled. The numerical algorithm is designed so that LES becomes DNS as the grid is refined. Most applications of FDS are LES. For example, in simulating the flow of smoke through a large, multi-room enclosure, it is not possible to resolve the combustion and transport processes directly. However, for small-scale combustion experiments, it is possible to compute the transport and combustion processes directly.

In FDS version it is assumed that the pressure may be different from volume to volume. In the case of a volume in the computing field he is isolated from other volumes, unless leak fluid, for example ventilation ducts, this is referred to as "pressure zone" and commissioned by setting own home pressure.

$$p(x,t) = \overline{p}_m(z,t) + \tilde{\rho}(x,t) \tag{4}$$

Note that the background pressure is a function of $z$, the vertical spatial coordinate, and time. For most compartment fire applications, $\overline{p}_m$ changes very little with height or time. However, for situations where the pressure increases due to a fire in a tightly sealed enclosure, or when the height of the domain is significant, $\overline{p}_m$ takes these effects into account. The ambient pressure field is denoted $\overline{p}_0(z)$. Note that the subscript *0* denotes the exterior of the computational domain, not time 0. This is the assumed atmospheric pressure stratification that serves as both the initial and boundary condition for the governing equations. *W* molecular weight of the gas mixture.

For low gas content, it may be assumed that the temperature and density are inversely proportional, and thus the equation of state can be approximated according to the equation:

$$\overline{p}_m = \rho TR \sum_{\alpha} \tfrac{Y_\alpha}{W_\alpha} = \frac{\rho TR}{W} \tag{5}$$

Pressure $\overline{p}_m$ in the energy equation is replaced by pressure filtration of sound waves, which are much faster than the typical velocities at development of a fire.

Filtering the acoustic waves means that the time step in the numerical algorithm is connected to only one of the speed and flow rate, as opposed to the speed of sound. The equation leads to a reduction in the number of dependent variables in the system of equations of edenichni. Breaking the atmosphere is obtained from the relationship:

$$\frac{d\overline{p}_0}{d_z} = \rho_0(z) g \tag{6}$$

where: $\rho_0$, is the background density and, $g = 9{,}8 m / s^2$ .Equation (6), the background pressure can be written as a function of the background temperature, $T_0(z)$.

$$\bar{p}_0(z) = \rho_\infty \exp\left( -\int_{z_\infty}^{z} \frac{\bar{W}g}{RT_0(z')} dz' \right) \quad (7)$$

where the subscript infinity generally refers to the ground. A linear temperature stratification of the atmosphere may be specified by the user such that $T_0(z) = T_\infty + G_\infty$ where $T_\infty$ is the temperature at the ground and G is the lapse rate (*e.g., G = 0:0098 K/m is the adiabatic lapse rate*). In this case $\bar{p}_0$ and $\rho_0$ are derived are derived from Eqs. (7) and (5), respectively. It can then be shown that for $G \neq 0$ the pressure stratification become:

$$\bar{p}_0(z) = p_\infty \left( \frac{T_0(z)}{T_\infty} \right)^{\bar{W}g/RG} \quad (8)$$

Porting on heat of flame on surface of condensed fuel (liquid и rigid substances It includes a mixture by convection and radiation, although latter is, dominate the, диаметър when the effective diameter the fire exceed 1m. The burning rate can be expressed with the equation:

$$m = \frac{Q_f'' - Q_l''}{L_v} \cdot A_г \quad g/s \quad (9)$$

wherein:

$Q_f''$ is a stream of the flame on the surface (kV/m$^2$);

$Q_l''$ e heat loss from the surface of by broadcasting their from thermal conductivity by solid substance (kV/m$^2$);

$A_г$ is area of spilled the fuel (m$^2$);

$L_V$ is heat gasification (equivalent to latent heat of evaporation of the liquid ($kJ/g$).

If fire is developing in a confined space, hot gases powered by the buoyancy diverge below the upper surfaces. The resultant laden flue layer and hot surfaces radiate heat the bottom of the housing, in particular the surface of the fuel, thereby increasing the combustion speed equation:

$$m = \frac{Q_f'' + Q_{д.m}'' - Q_l''}{L_v} \cdot A_г \quad g/s \quad (10)$$

wherein: $Q_{д.m}''$ additional heat by radiation from the upper part of the casing -$kW/m^2$. This additional a feedback leads to a significant increase in burning and up to arcing confined spaces where there is a ample supply of air and enough fuel for maintaining the fire (Drysdale 1985).

The burning rate is determined by the magnitude of the value of $L_V$, the heat of gasification. This trend is low for fluids and the comparatively high for the solidsTherefore, solid particles are inclined can burn much slowly than liquids. Perimetric that defines the behavior of flame speed of the exotherm RHR, which is connected with the combustion speed expressed in the equation:

$$RHR = m\square H_c, \quad kW \quad (11)$$

wherein: $m_\Delta H_c$ is the heat of fuel combustion ($kJ/g$).

For the determination of gases for the development of fire, in road vehicles while dimensioning of the system is applied the dependence:

$$\Delta p = \frac{U^2}{20.16.T_o} \tag{12}$$

wherein: $U^2$ - wind velocity, m/min; $T_o$ - ambient temperature in $^0$K; $\Delta p$ - a pressure drop of in N/m$^2$

Notwithstanding the terms of air exchange environmental dynamics of a fire at freely combustion includes three periods: I – *growth*); II - *fully-developed*; III – *decoy*. The border point between I and II period is a moment of a heat outbreak or temperature a blast (*flashover*).

At modeling of the various processes the phenomenon is considered as a collection of both modes increase and full development where the state of decay be included for in the second.

In the period of development the temperature $\Theta_g$ increases, the gas density $\rho_g$ downturn. The quantity of the gases exceeds the quantity of entry into space air. The duration of the period of development is equal to the time of occurrence of combustion until the moment of intensification of a fire.

In the period of the active combustion $\Theta_g$ and $\rho_g$ practically did not hereby amended effluent gas Fuel is approximately equal to the sum of expenditure of the incoming air and burning rate. The duration of the period of active combustion depends on: area / location of the holes (in a limited an air exchange), on the density / behavior of the fire load, constructive and planning characteristics and thermal physical parameters of the material / tives of the enclosing structures (for sufficient air exchange).

In the period of fading $\Theta_g$ the decline the density $\rho_g$ grows. The quantity of effluent gases is less from that of the incoming air and burns per unit time substances.

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**This paper has been reviewed.**