SAT-9.2-2-HT-09

Numerical simulation development of fire in RTV

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Abstract: By using a programming environment PyroSim is made simulation of a fire in the engine compartment of the car. Observe the evolution of fire during and penetration into the passenger compartment. The results give an idea of the alternatives for action by passengers and rescue teams.

Key words: Fire, crash, PyroSim.

Construction of the geometric model and generating mesh.

The numerical simulation is done on a vehicle (car). The simulation includes all flammable components inside the vehicle and other plastic and metal components which influence the direction of fire and smoke spread over time (Figure 1).

In the simulation precision of the resolution of the mesh is defined as a dimensionless expression D/δ_x, where the D - typical diameter of the fire, and δ_x - a nominal pore size of 1 The dimension should be seen as a number of calculation cells is not taken into account the physical diameter fire.

$$D = \left[\frac{Q}{p_\infty c_\alpha T_\infty \sqrt{g}} \right]^{\frac{2}{5}} \qquad (1)$$

After building a 3D model of the vehicle, proceed to procedure "cross-linking" of the cubature. The location of generating fire, short circuit on the dashboard

After successfully linking fluid cubature are set initial and boundary conditions of the task.

Boundary conditions for volume: It is assumed that the volume of the car fills generated from flue gases. Figure.1.

The numerical simulation of the processes of distribution of a fire in a road vehicle takes place in the workplace FDS.

In calculating the processes in a limited space, and especially when are combined currents with different density is better to use a corresponding turbulent model, solved numerically by dividing the physical space where the the fire simulated in a large number of rectangular cells.

Under each cell, rate of gas, temperature, etc., is assumed to be constant over time. The precision with which the dynamics of the fire simulation model depends on the number of cells that can be included in the calculation.

Analyzed is interior of the modern car that is contained within the seats, instrument panel, roof, door panels, consoles and armrests.

It is made simulation model in case of short circuit in a vehicle. Short circuit is unpredictable and is related to the state of the vehicle (at rest or in motion) and further mounted consumers. Most often short circuit occurs on the dashboard and spread to the passenger compartment. Less frequently occurs in engine compartment and trunk.

The interior of the vehicle (Fig.1) is absorbed by the flames of the fire within a 4min.

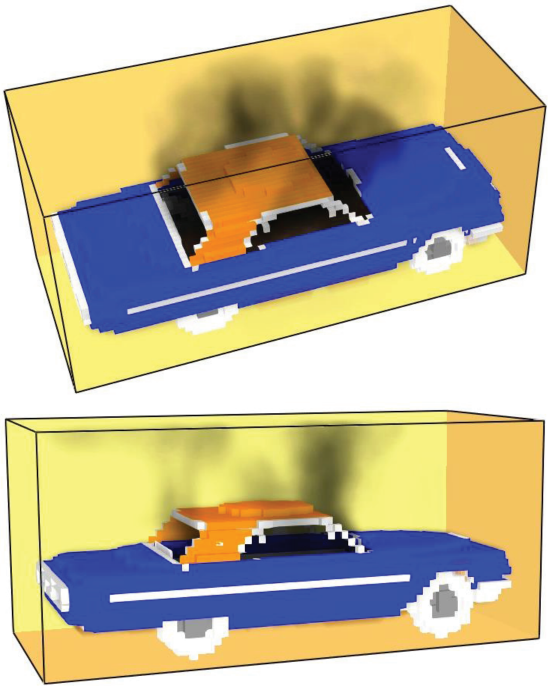


Figure 1. Simulation of the evolution of fire in the interior of the vehicle

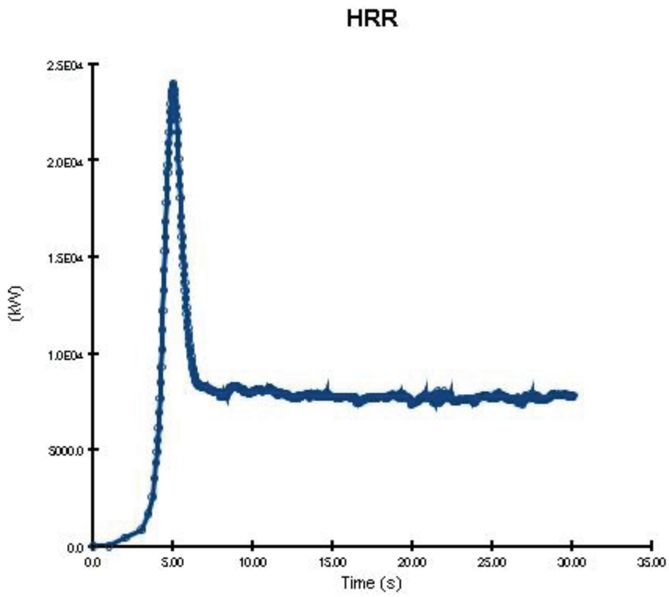


Figure. 2 Power of fire

Conclusions A significant number of electrically mechanisms and apparatus are concentrated in the engine compartment, in which the conditions and exploitation of mesh itself are - negative: fever temperature , high heat radiation, availability of fuel. At crossing of electrical power in the wires increases the temperature of the leads and insulation of the wire. In most critical temperatures is possible ignition of the insulation and located near routes wires flammable materials. If the temperature does not reach critical, but is high enough speed increases of aging of the insulation of the wires. . It is also possible in loose connections and bad contact to cause the aforementioned processes. Cause of fire electrical systems can be overwhelmed and large transient resistance in places of compounds branch contacts of devices etc. The process simulation of a fire caused by the dashboard at a set temperature 8000 C. could make the following conclusion: Strong burns close to the the steering system and starter motor which is the live, burning insulation, melting plastics shows the spread of fire in the passenger compartment.

Combustion spreads to at body to 4min. The combustion in the engine is only on top (not filled the entire size of smoke products) of the cabin. This proves that combustion has evolved and disseminate at temperatures of 400 – 550C that are sufficient to melt and burn insulation other plastic materials very quickly.

By comparing the obtained numerical results in real fire occurred in the town. Sofia (Figure 3). There were no significant differences. The fire occurs as a result of short circuit (according to fire technical expertise of the sector "Investigation and testing of fire" of Sofia City management of FSPP-MI). The wires found with burned insulation and adhered each other at the electric network crossing in close proximity to the structural elements of the engine performed by combustible materials (plastic, rubber). Burning of insulation and wires adhered each other shows that they were heated up. This is typical precisely in transition resistance. The heating was caused by loose connection to its contact and along the conductor.

As the main source of fires in vehicles are connected to ignition of fuel as a result of runoff on the hot parts of the engine and exhaust manifold or sparks.With such a goal is a rapid evaporation of the fuel, without it catch fire. Ignition of vapour most often is caused by sparking parts (dynamo, starter, etc.), where the blast occurs.

Figure. 3 Fire in a car arisen from inside the vehicle

The local fires run when vapour from flammable and volatile liquids ignite. The burning rate is determined by the evaporation of the liquid, wherein the heat is withdrawn from the radiation of the fire above the liquid.

Trait of fire as a result of leakage is significant overheating of the metal in the area of the leakage of the fuel. This is accompanied with strong deformation of sheet metal, usually in car crash (Figure 4)

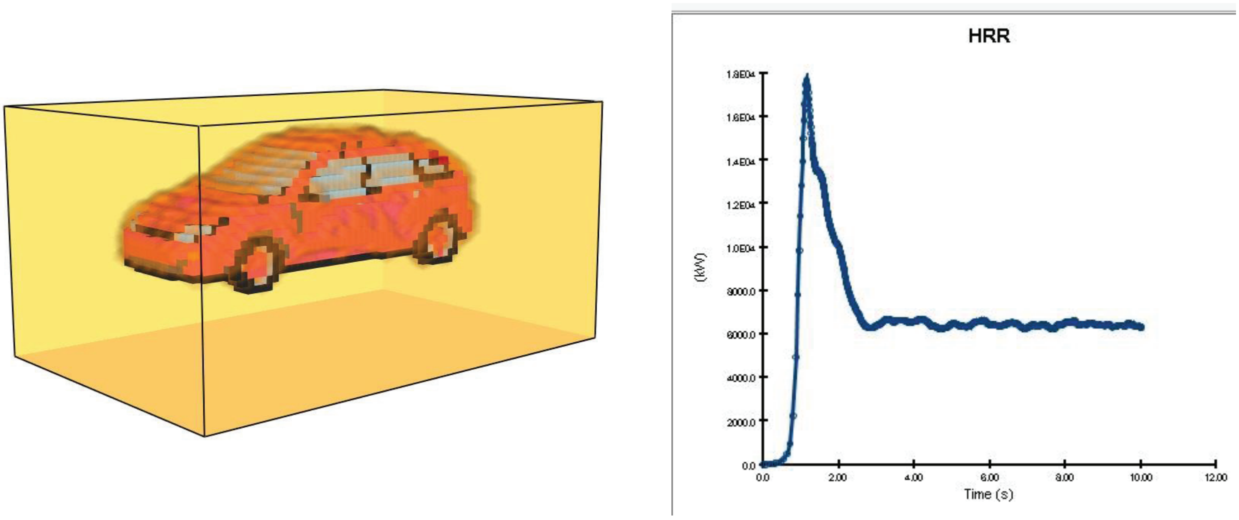


Figure.4 Simulation of ignition of fuel as a result of runoff on the hot parts of the engine and exhaust manifold or sparks

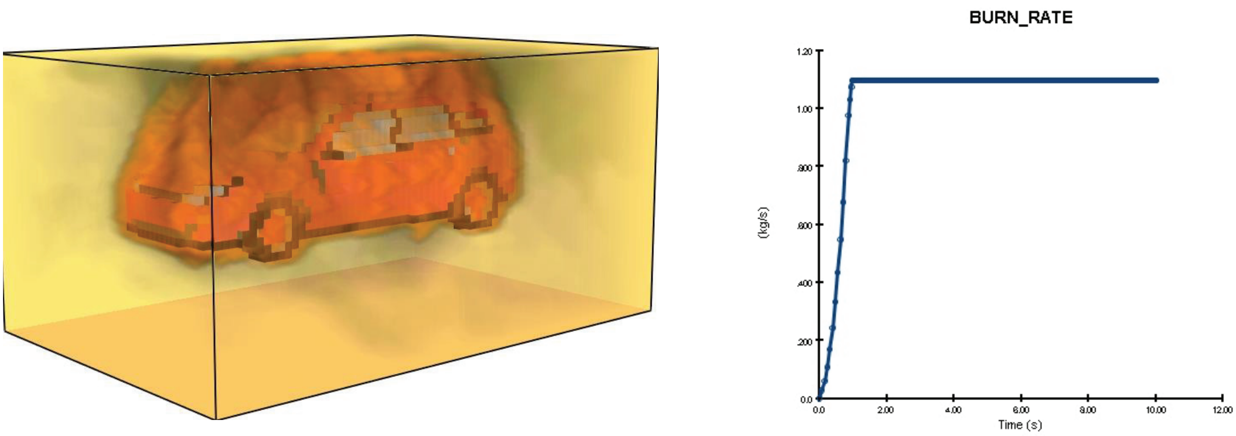


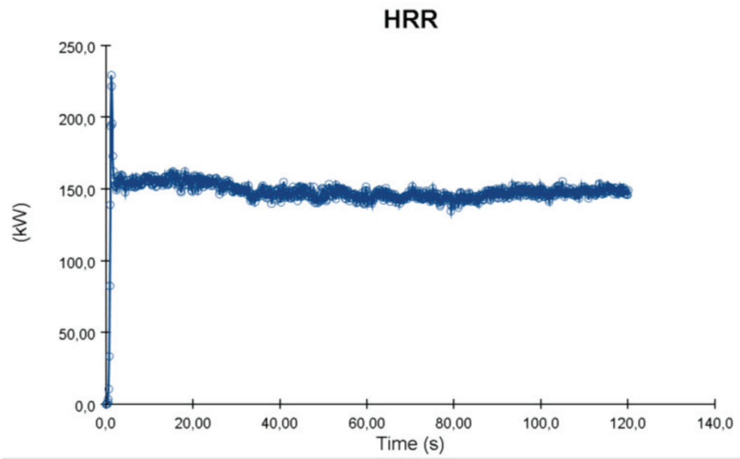
Figure. 5 Simulation of ignition of fuel - the explosion of cloud vapor

Combustion products into vehicles, during operation of the internal combustion engine, characterized by the gas temperature to 1100 ° C, which in the presence of cracks, leaks from the fuel and other quickly and combustion products are powerful ignition source.

Structurally provided combustible elements at the front of the car belonging to the group of solid combustible materials, which normally do not have the a tendency to self-ignition. The ignition them in normal conditions is possible only by the action of a particular source heat output.

In case of explosion of the smudge of importance (Figure 5) are the mass of the cloud and the amount barriers in the area, that hinder the movement of the gases, causing a higher an excess pressure, while also increasing the rate of the flame by an additional turbulence.

Taking into account that fire load in the engine compartment of the vehicle and the flow of oxygen in the initial stage of the fire in this area and continuing impact of fire and high temperature (Figure 6). It can be based on the existing method for determining the location of the fire in the theory of John A. Kennedy - "theory of the arrow" based on that fire evolve and spreads combustible materials of the - large damage to their gradual fading i.e. from the outbreak of the fire to the periphery thereof.



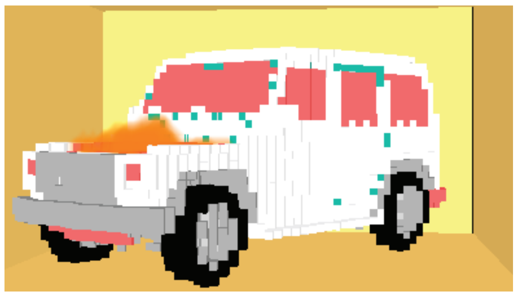


Figure. 6

The above signs outline the location of the fire - engine compartment as part of the car.

The temperature characteristics of combustible materials are fundamental parameters outlining the situation of the fire. The main thermal characteristics of certain materials applicable in the equipment of the car have the following indicators:

designation	t^0 of ignition	t^0 of self-ignition.	t^0 of the flame
Petrol	-37 – 27^{o}C	350 -370^{o}C	1040^{o}C
Diesel	64 -71^{o}C,	310 - 330^{o}C	877^{o}C
Polystirol	187^{o}C	393^{o}C	1087^{o}C
Paperboard	227^{o}C	399^{o}C	850^{o}C
Gum (rubber)	340^{o}C	390^{o}C	1037^{o}C

The heat from the combustion products and combustible materials, which are flammable, contribute to increase the area for burning surface. Temperature 350-400 ° C in any case is crucial for solid combustible auto parts. At this temperature, most of materials of organic origin, are degraded with evolution of heat, which creates conditions conducive to ignition and self-ignition.

CONCLUSION

At the results thus obtained can be used in engineering practice in the development of a concept for fire safety assessment of the risk of fire in parking lots and other facilities to road transport, as well as fire and technical expertise.

At parametric modeling fire, the results do not always match the common view among ideas. So is this experience should be studied really well and is not a 'negative' to it but to be refracted through the prism of existing knowledge and experience.

One of the strengths of FDS simulation, that it can be a useful tool for expert who investigate fires. The challenge is that this can lead to a huge range of options in terms of the modeling of the combustion process

Sources

[1] PyroSim 2012 Thunderhead Engineering Technical university Sofia, Bulgaria

[2] Grozdanov .К, Моделиране на възникване и разпространение на пожар в ПТС, Booklet of the 56th Science Conference of Ruse University, Ruse, Bulgaria, 2016

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This paper has been reviewed.