TECHNIKA TRANSPORTU SZYNOWEGO

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TEST FIRE OF A PASSENGER CAR

Abstract

The research presents results results of tests of the development of passanger car fire conducted in the Main School of fire Service. The aim of the research was to determine the mechanism of fire, threats for the driver, passengers and rescures working at the accident place. The article depicts the the full scale of a passenger car test fire. It presents the graphs the graphs of of temperature taken in selected places of the inside and outside of the the car. The temperature results were compared with the use of thermal image camera and thermocouples. During the test one observed on explosion and tearing of the opening mechanism of the boot cover, which was a potential danger for the rescuers. Fire development depended on the air supply, and it was very dynamic when the air supply was unlimited.

INTRODUCTION

A car fire is a phenomenon that is dangerous to the driver and the passengers.The number of fires of passenger cars in Poland exceeds 7 thousand incidents a year.This comes up to ca.4% of all fires.In the past decade the number of fires in passenger cars has been slowly growing, but at the same time the overall number of cars has also grown.The number of fires of passenger cars per a million of passenger cars registered in Poland gas decreased from 557 in 2001 to 408 in 2010 [3, 4, 8].It may be presumed that this arises from the gradually improving technical state of the vehicles, lower number of modifications executed outside of professional workshops and a smaller number of repairs carried out by laymen. New cars are being introduced on the market, the servicing of which requires specialist equipment and qualified specialists, and so it is impossible to do anything on one's own.

Knowledge of the process of fire spreading in a car and of the phenomena that accompany that process is of great importance of users of cars and for the firemen.It is indispensable to allow working out ways of reducing to a minimum of adverse consequences of those fires. It is also needed to specialists who work out expert opinions related to fires for needs of investigation bodies.

Studies of the development of fires in cars are being carried out in Slovakia and in the Czech Republic [2, 7] in cooperation with the KIA passenger car manufacturing plant. These studies are aimed at enhancing the level of fire safety in cars.

1. RESEARCH STAND

The tests were carried out on two passenger cars:Renault 19 Chamade, sedan with a sunroof (car No.1) and Opel Kadett E, hatchback with sunroof (car No. 2). The cars were set up on a yard parallel to each other at a distance of 1 m. The cars were equipped with petrol engines.The fuel tanks were emptied.Batteries and radio sets were dismantled, and spare tyres were taken out.

The course of the experiment was recorded with the use of a digital camera, digital photographic camera, type SD 1000 ISG Thermal System Ltd. thermal camera and six thermal elements type K.

In car No.1 five thermal elements were installed, and one in car 2. They were provided in the following places:

T1 – at the head trim in the central part of car no. 1,
T2 – on the floor in the central part of car no. 1,
T3 – near the floor in in the luggage boot of car no. 1,
T4 – in the engine room, in the upper part under the bonnet of car no. 1,
T5 – on the external panel, close to floor of the door in car no.1, under the handle,
T6 – on the external panel of front door in car no.2, under the handle.

A thermographic camera was used to measure the temperature of the front door in car no.1, under the handle, on the place where thermal element T5 was installed.Measurements executed concurrently in the same place with the use of different devices allow making a comparison of the results.This was mainly connected with the credibility of readings obtained with the use of the thermographic camera.The accurate value of the car body emissivity is not known [1, 5, 6, 9].The measurements were carried out at the emissivity set on the standard value of $\varepsilon = 0{,}95$.

2. COURSE OF THE EXPERIMENT

The following atmospheric conditions prevailed during the experiment:air temperature 7°C, wind speed 3 to 5 m/s, small cloud cover 3/8, no precipitation.

The place where the fire was initiated in car no.1 was the driver's seat.The ignition was achieved with the use of 10 dm^3 of lighting kerosene, which was spilled over the seat and the door of the car was then closed.

As of the second minute of the fire, small amounts of greyish-white smoke were observed to permeate out of the car interior.The smoke drifted out through gaps between the chassis and the door seals.In the third minute product released during combustion covered the internal side of the car windows to an extent which rendered impossible the observation of the way that the fire spread in its interior.The further stages of the fire in the car did not entail any visible symptoms which could prove the progress of the combustion process taking place inside.Such a situation was maintained until the 50th minute since commencement of the experiment.

In the fiftieth minute the left back door was opened and left that way.At the time when the door was being opened, the car interior was considerably smoke logged.No flames were observed.Air inflow from the outside to the combustion zone caused the appearance of flames and increased intensity of the combustion process.Combustion inside the passenger area turned from surface combustion into surface and spatial combustion and in the fifty-third minute flashover took place.In the same time also the window glazing in the doors and of the rear window cracked.As those windows were made of chiller glass, the cracking was accompanied by a characteristic cracking sound.

The wind direction and force made the flame bend towards the opposite side as car no. 2. This reduced the thermal impact of car no.1 on car no.2 (fig. 1.).

Fig. 1. Impact of the wind on the flame direction and the thermal impact of the burning car on the nearby car.

Source: own

In the fifty-seventh minute on car no.2 blisters appeared on the paint coat and smoke was released from elements made of plastic (lateral strips, air intake, bumpers, door handle).Changed took place on the entire surface of the right side of car no. 2. Fig. 2. presents the view of car no.1 in the phase of full fire development in the 57^{th} minute of the test (photograph and thermogram).

In car no. 1, after one hour from the commencement of the experiment (10 minutes after opening the door), the combustion intensity decreased mainly in the central part of the passenger area. During that time, fire spread in the engine room and the boot. Tyres and bumpers, as well as other plastic components in the area of the header panel ignited. A loud explosion could be heard in the 62^{nd} minute. The boot lid damper broke apart. The moment of explosion is shown in Fig. 3.

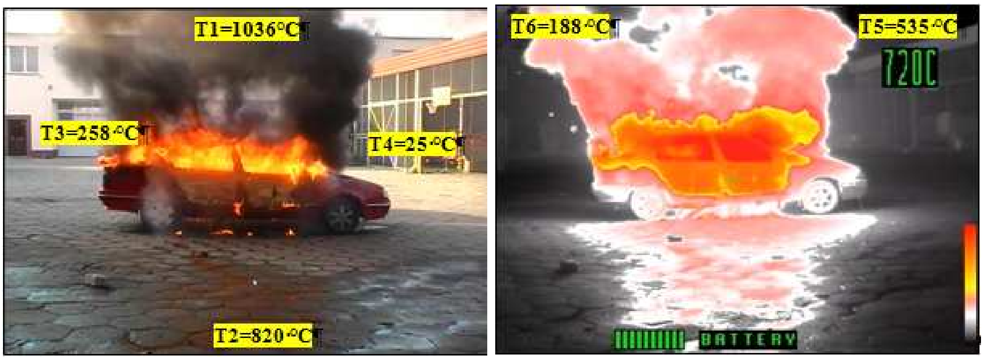

Fig. 2. A photograph and thermogram of car no. 1 in the phase of full fire development.

Source: own

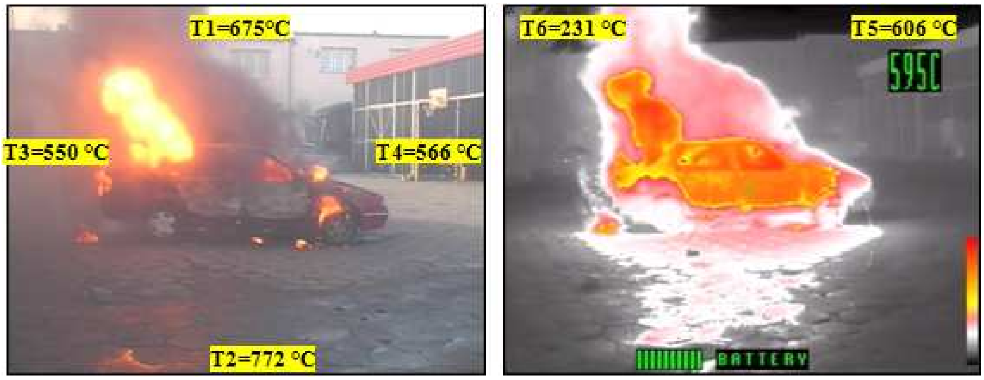

Fig. 3.A photograph and thermogram of car no. 1 at the time of explosion of the boot lid dumper.

Source: own

As observed, tyres started to leak from the 63rd to 71st minute. They started leaking one by one. A whiz of released air could be heard. Burning of tyres was one of the final phases of the car fire. When flames extinguished in their vicinity, the only flame combustion could be seen on the melted plastic components and in the engine room. These included melted bumpers, laying on the yard surface, and melted dashboard in the front part of the passenger area near the floor. That phase of the fire is shown in Fig. 4.

Later in the experiment it was observed that the fire was extinguishing - flames disappeared and smoke release intensity decreased. The observation and measurements were performed to the 120th minute from the commencement of the fire. Fig. 4 shows the wrecked car no. 1 after the fire stopped.

Fig. 4. Wrecked car no. 1, door of car no. 2 after the fire.

Source: own

3. RESULTS OF MEASUREMENTS

Fig. 5 shows diagrams of temperature in various spots inside car no. 1.Until opening of the door, the fire was dampened due to the fact that there was no access of air. The temperature in the upper part of the cabin initially rose to 350°C, then dropped a bit and oscillated within the range from 100°C to 200°C.Temperature near the floor as well as in the engine room and the boot hardly changed. When the door was opened, the fire developed violently and flashover occurred (Fig. 2).Maximum temperatures measured during the fire were as follows: in the cabin near the ceiling - 1036°C, near the floor - 990°C, in the boot - 820°C, near the engine, under the bonnet - 805°C.

Fig. 6 shows relations between temperature and time for the thermal element T5, placed on the external door panel of car no. 1 and temperature measured with thermal camera in the same spot. A concurrence of the results of measurements with use of the thermal camera and the thermal element is visible. Sudden increase of temperature measured by the thermal camera after 1 hour 10 minutes was caused by the occurrence of flames.

Fig. 7 shows relations of temperature and time for the thermal element T6 installed on the door of car no. 2.It shows the impact of the course of fire of car no. 1 on heating of a car parked beside.

In the 90th minute of the experiment, temperature dropped on all the measuring elements. Materials in the engine room and melted components of the rear bumper were burning down.

Having analysed the material recorded on cameras and the photographs taken during the experiment, it was found out that the reason for the sudden increase in temperature on thermal element T6 (car no. 2) was that some melted plastic dropped on the thermal element from the car handle (Fig. 4).According to the above, it seems that in the 80th minute, the thermal element T6 indicated the temperature of the melted plastic.

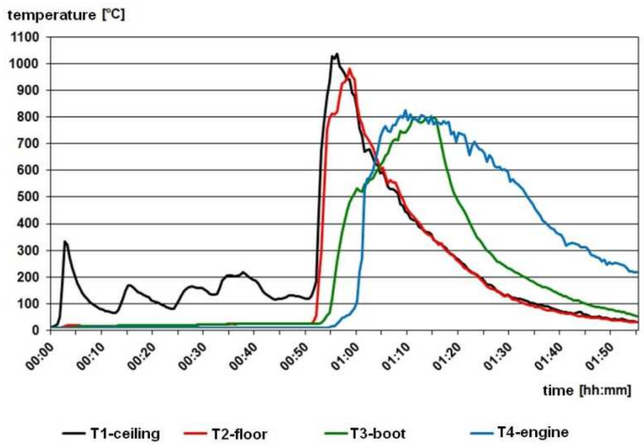

Fig. 5. Relation between temperature and time for thermal elements placed on car no. 1.

Source: own

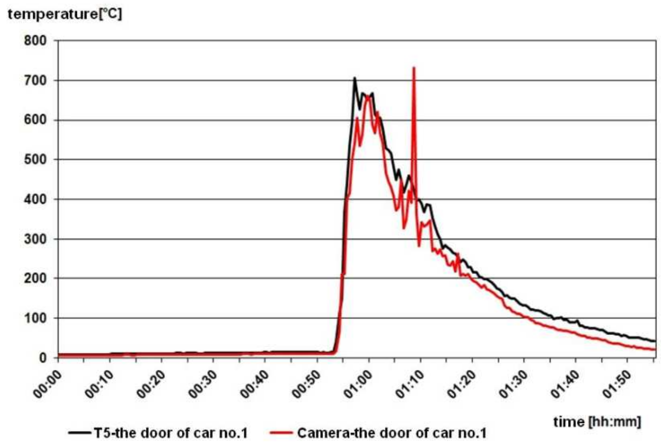

Fig. 6. Relation between temperature and time for the thermal element T5 and for thermal camera on the door of car no. 1.

Source: own

When the fire extinguished and after visual inspection of the cars, it was found that car no. 2 was partially damaged as a result of the fire of the adjacent car. However, the adjacent car did not ignite.

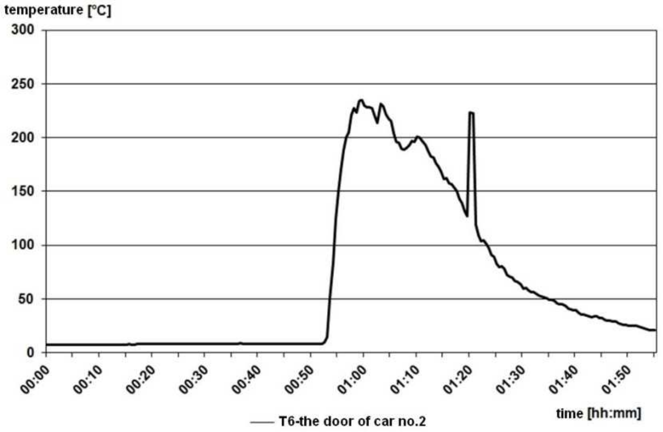

Fig. 7. Relation between temperature and time for the thermal element T6 placed on the door of car no. 2.

Source: own

4. SUMMARY AND CONCLUSIONS

A passenger car fire is a type of fire restricted by ventilation.

In a closed car it develops very slowly, as it is dampened. At the time when access of air becomes possible (once the doors are opened or the window gaskets unseal), the fire develops violently. Within a few minutes the temperature inside the cabin rises to approximately 1000°C.The temperature at the ceiling hardly differs from the temperature at the floor (after flashover).The fire in the engine room and the boot develops more slowly and temperature rises to 800°C there. The temperature causes partial melting of aluminium engine components.

The engine chamber is separated from the passenger seats and has been provided with acoustic and thermal insulation, which limited the heat exchange.For this reason the fire that started in the cabin spreads with a certain delay to the engine (in the conducted test after ca.10 minutes).

The experiment showed that the temperature of the body measured with thermal camera and by the thermal element were similar. In order to measure temperature with a thermal camera, the surface emissivity value must be known. There is no data concerning the emissivity of car body in the reference books. The problem is difficult to solve, since the emissivity depends on the surface structure. The panel surface structure changes as it heats up. Lacquer cracks, it is covered with black, it peels off, etc. The value of emissivity ($\varepsilon = 0.95$) is assumed in excess. If we assume that the values indicated by the thermal element are reliable (and there is no reason to question them), then, in accordance with the Stefan-Boltzmann law, we can estimate that during the fire the body emissivity was ranging from 0.7 to 0.8.

The fire did not spread onto the adjacent car parked in a parallel way at a distance of 1 m. The heat impact heated up the sheet of the car's door to a temperature of approximately 240°C, causing plastic to melt and leak outside. This is due to favourable weather conditions. However, it confirms that fire does not spread easily onto adjacent cars. There is a plenty of time for efficient rescue action. Furthermore, fire does not develop easily in a closed car.

In similar tests performed by the authors of the paper, fire initiated in the passenger cabin was dampened for nearly an hour until gaskets went soft and the air got inside, thus enhancing the combustion process [3].It is important information for experts drawing up fire investigation reports for investigative arms. Car arsonists have plenty of time to get away from the scene of the crime until the car fire develops outside.

A car fire is accompanied by exploding dampers, which is dangerous for rescuers and any people present nearby. It had been observed in almost all of other similar tests. Car users and rescuers must keep that danger in mind.

TESTOWY POŻAR SAMOCHODU OSOBOWEGO

Streszczenie

W pracy przedstawiono wyniki badań rozwoju pożaru samochodu osobowego prowadzonych w Szkole Głównej Służby Pożarniczej. Badania mają na celu poznanie mechanizmu pożaru, zagrożeń dla kierowcy, pasażerów i ratowników niosących pomoc. W artykule opisano przebieg testowego pożaru samochodu osobowego w pełnej skali. Przedstawiono wykresy temperatury mierzonej w wybranych miejscach wnętrza samochodu i zewnętrznej powierzchni karoserii. Porównano wyniki pomiarów temperatury za pomocą kamery termowizyjnej i za pomocą termoelementów. Podczas testu zarejestrowano wybuch i rozerwanie siłowników pokrywy bagażnika, stanowiące zagrożenie dla ratowników. Rozwój pożaru ograniczony był dopływem powietrza i od momentu zaistnienia swobodnego dopływu powietrza rozwijał się z ogromną dynamiką.

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