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FIRES OF PASSENGER CARS IN POLAND

The main causes of fires of passengers car in Poland were presented in this paper. The paper depicts results of tests of the development of passenger car fires. Temperature measurements were taken with the use of thermocouples, en infrared pyrometer and a thermal camera.

Key words: car fire, infrared pyrometer, thermal camera.

1. INTRODUCTION

A passenger car fire is a dangerous phenomenon both for a driver and for passengers. As a rule it tends to appear in unfavourable conditions: during a collision or while driving. Fires happen both in old cars, which have been inappropriately maintained or modified, as well as new ones, which have manufacturing defects. The phenomenon of a passenger car fire proceeds in a very dynamic way due to significant concentration of flammable materials in a relatively small car space. The conducted tests will widen the knowledge about the phenomenon of a passenger car fire and will encourage the use of the required extinguishing tactics and selection of correct extinguishing agents for these types of fires.

2. FREQUENCY OF OCCURRENCE AND CAUSES OF PASSENGER CAR FIRES

In the opinion of firemen the main causes of car fires include the technical faults of cars, in particular those of the electrical system. To a large extent, they result from unprofessional repairs and unpermitted changes. Most frequently, fires are caused by a short circuit of the electrical system, a fuel leak from systems damaged in the course of a collision, an untight gas pipe (in LPG-fired cars) and a deliberate act, like a car arson.

In Poland, the SWD ST reporting programme is in use, where an officer commanding a fire fighting and rescue operation records all incidents. Car fires are treated in the same way as all other fires. The programme does not take into account the specific nature of a car fire. Moreover, quite often without a prior reflection, the reporting firemen quote the same cause of a fire in different columns. Therefore, the data contained in the SWD ST programme are ambiguous and do not always contain the real cause of a car fire. Table 1 shows the causes of passenger car fires in 2010 as included in EWID ST.

Table 1. Causes of passenger car fires in 2010 as included in EWID ST

Item	Cause of fire	Number of fires
1	Human carelessness	130
2	Faults of electrical and heating equipment and systems	1 036
3	Incorrect operation of electrical and heating equipment and systems	28
4	Faults of mechanical equipment	115
6	Faults of means of transport	2 468
7	Incorrect operation of means of transport	123
8	Arson, including terrorist acts	668
9	Fires resulting from other local threats	75
10	Other causes	437
11	Unidentified	1 992
12	Total	7 072

After 1989, along with the transformation of the political system, the number of vehicles on Polish roads began to grow. Due to changes in customs regulations in recent years, a very large number of cars was imported to Poland. Usually, the service period of these vehicles exceeded 10 years and many of them were in a poor technical condition. A large part of these vehicles which were brought into our country in the 1990's was registered as "non-factory assembled". This accounted for the fact that the engine and the remainder of the vehicle were imported separately. Very often, these were the cars which had been involved in accidents and were subsequently repaired by unqualified persons. Many cars were brought from Great Britain and adjusted to right-hand traffic. These changes were made cheaply at unprofessional workshops. This resulted in a larger number of vehicle fires. After 2000 the situation stabilised, and since then, in general, the technical condition of cars authorised for traffic has been improve.

Car collisions are daily events on our roads. In contrast, passenger car fires can rarely be seen. They represent about 5% of the total number of fires. In quantitative terms, there are many of them. The Department of Information and Promotion of the National Headquarters of the State Fire Service informs that in 2010 there were 135 554 fires, with 8879 involving means of transport, including 7072 fires of passenger cars. Table 2 shows the number of registered passenger cars against the number of fires in 1999 to 2010. Fig. 1 shows diagrams representing the number of fires per 1 million registered passenger cars in 1999 to 2010.

Table 2. The number of registered passenger cars against the number of fires in 1999 to 2010

Item	Year	Number of registered passenger cars (in million)	Number of passenger car fires	Number of fires per 1 million registered passenger cars
1	1999	9 282	6 094	656
2	2000	9 991	6 095	610
3	2001	10 503	5 845	557
4	2002	11 029	6 203	562
5	2003	11 244	5 892	524
6	2004	11 975	5 737	479
7	2005	12 339	6 295	555
8	2006	13 384	6 642	496
9	2007	14 588	6 279	430
10	2008	16 080	6 425	400
11	2009	16 495	6 390	387
12	2010	17 353	7 072	408

It follows from the data presented in Table 1 and Fig. 1 that the annual number of passenger car fires slightly grows, but so does the number of registered vehicles. Compared tothe number of registered vehicles, the number of fires decreases.

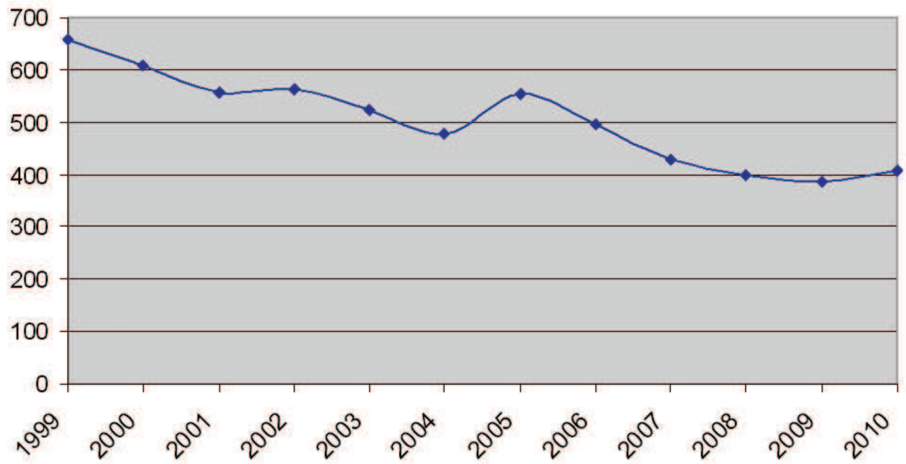

Fig. 1. *Number of fires per 1 million registered passenger cars in 1999 to 2010*

3. RESEARCH ON THE DEVELOPMENT OF A PASSENGER CAR FIRE

The tests are carried out to determine the development of a passenger car fire, using a thermal camera and an infrared pyrometer for temperature measurements. Temperatures are also measured by means of thermocouples (Fig. 2). In the first experiment, the fires of three passenger cars were simulated. The experiment was carried out at a parking lot in the windless and rainless weather conditions, at an ambient temperature of about 20°C. The temperature was continuously measured by means of K type thermocouples, the infrared pyrometer Raytek PM50 and the thermal camera VIGOcam V50. Two thermocouples were placed inside the car at the highest and lowest points of its interior, one was situated inside the engine chamber in the middle, about 2 cm over the valve cover, and another in the boot (Fig. 2). The pyrometer was used to measure the temperature of the external surface of the car door, under the window pane. The tests were carried out at the Sub-officer School of the State Fire Service in Bydgoszcz. In the course of the experiment, three FSO Polonez cars with complete equipment were burned.

Fig. 2. *Location of the thermocouple in a car*

A fire was started inside car A, by lighting a petrol-saturated sponge placed on the floor under the dashboard, in front of the passenger seat (Fig. 3). After five minutes the rear doors were opened, since the fire diminished. At car B, a fire was started near the engine, by lighting a tray with a fuel on a cushion pool, placed on the road under the engine. At car C, a fire was started inside the car, just as in the case of car A, and its course was observed with closed windows.

Car A Car B

Car C

Fig. 3. *The seat of the fire*

Fig. 4 shows the temperature dependence on the fire duration, inside the car, at its ceiling bottom, as measured by thermocouple T1, for cars A, B and C. The temperature inside the car, close to the floor, reached the maximum value of 1 017°C in the 14th minute of the fire, in car A, 995°C in the 22nd minute of the fire, in car B and 1 008°C in the 70th minute of the fire in car C.

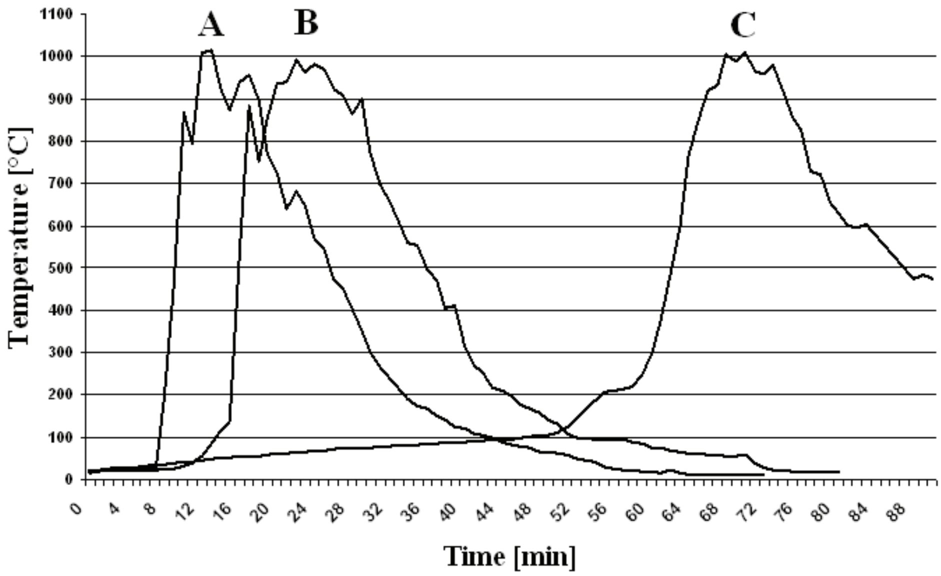

Fig. 4. *The temperature dependence on the fire duration, measured by thermocouple T2, for cars A, B and C*

The performed experiments indicate that the development dynamics of a car fire depends mainly on ventilation. In the case where the doors and windows are closed, the fire develops slowly or is suppressed. In the case of the car C fire only 45 minutes passed from the start of the fire when the seal melted and the windscreen became flexible and cracked on the passenger's side. The flames penetrated out of the car and the fire became more dynamic. In each of the cases, the maximum fire temperature inside the car cabin was about 1000°C. It was reached within 11 to 67 minutes, depending on the possibility of air supply.

In a tightly closed passenger car, the fire is suppressed in its initial stage by the absence of oxygen. Several experiments were carried out where fire did not develop. A lighted newspaper placed on the front or rear seat did not set fire to the car. The seat partly burned, but the fire died out after 3 to 5 minutes. The car was filled with black smoke and the panes were covered by soot.

In the course of the fire of vehicle B, after an incidental self-opening of the bonnet, the servos were exposed to the direct impact of temperature. In the 34th minute of the fire, as the pressure of the oil contained in the servos increased, they were blown apart with a great force, which could be heard as the sound of a gunshot.

Fig. 5 shows the temperature dependence on the fire duration, measured by thermocouples placed as in Fig. 1: T1 (top), T2 (bottom), T3 (engine) and T4 (boot), and the infrared pyrometer (the front door under the window pane) for car A.

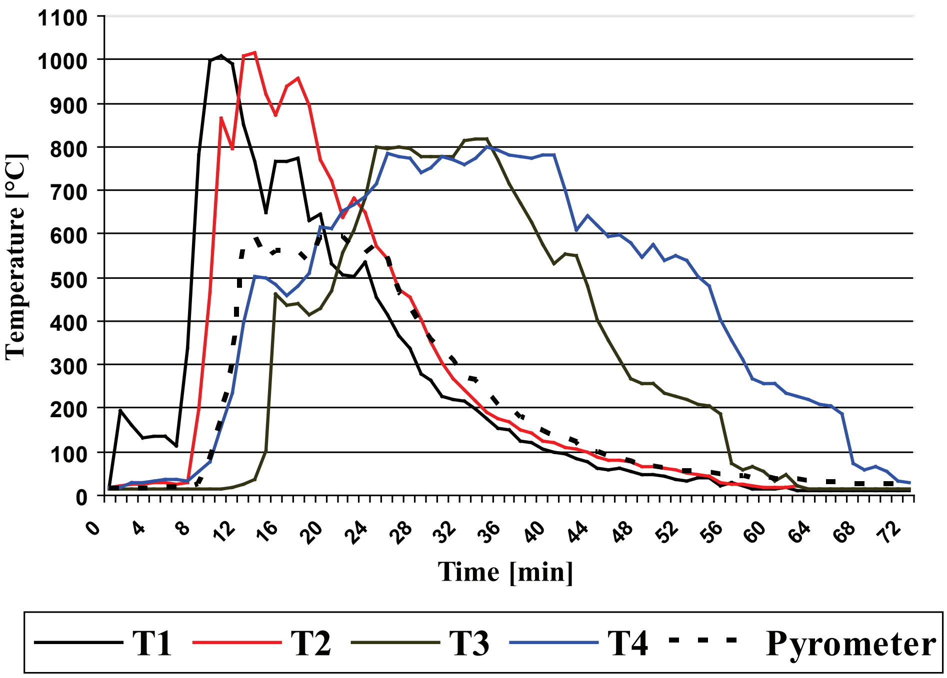

Fig. 5. The temperature dependence on the fire duration for car A, measured by thermocouples: T1 (top), T2 (bottom), T3 (engine), T4 (boot) and the infrared pyrometer

The figure shows a very fast temperature increase in the car cabin up to about 1000°C. After this temperature had been reached, in a matter of several minutes the fire almost to the whole car. The dynamics of the fire and temperature were higher inside the cabin than in the engine chamber and the boot. Probably, it was so because in a short time the window panes were damaged and there was a good air supply. The course of the fire in the engine chamber and the boot was less dynamic and reached a lower temperature, of about 800°C, which persisted for about 20 minutes.

Fig. 6 shows the temperature dependence on the fire duration, measured by thermocouples placed as in Fig. 2: T1 (top), T2 (bottom), T3 (engine) and T4 (boot), and the infrared pyrometer (the front door under the window pane) for car B.

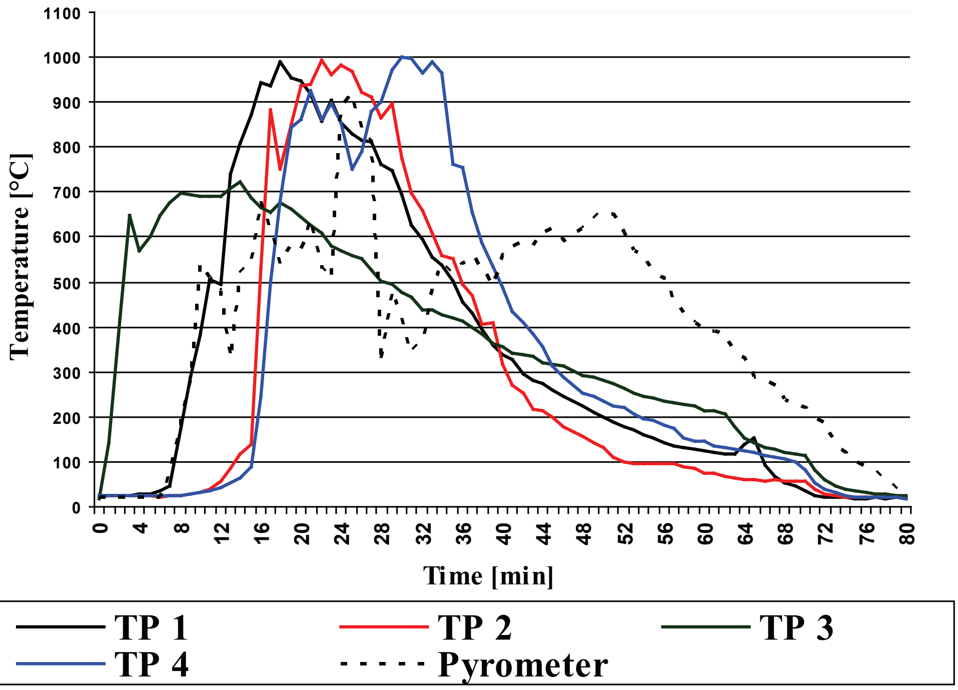

Fig. 6. *The temperature dependence on the fire duration for car B, measured by thermocouples: T1 (top), T2 (bottom), T3 (engine), T4 (boot) and the infrared pyrometer*

The fire in car B was initiated in the engine chamber. At the beginning the fire developed under the hood, then spread into the car interior and at the end to the boot. Values of the fire temperature were similar as for the fire of car A.

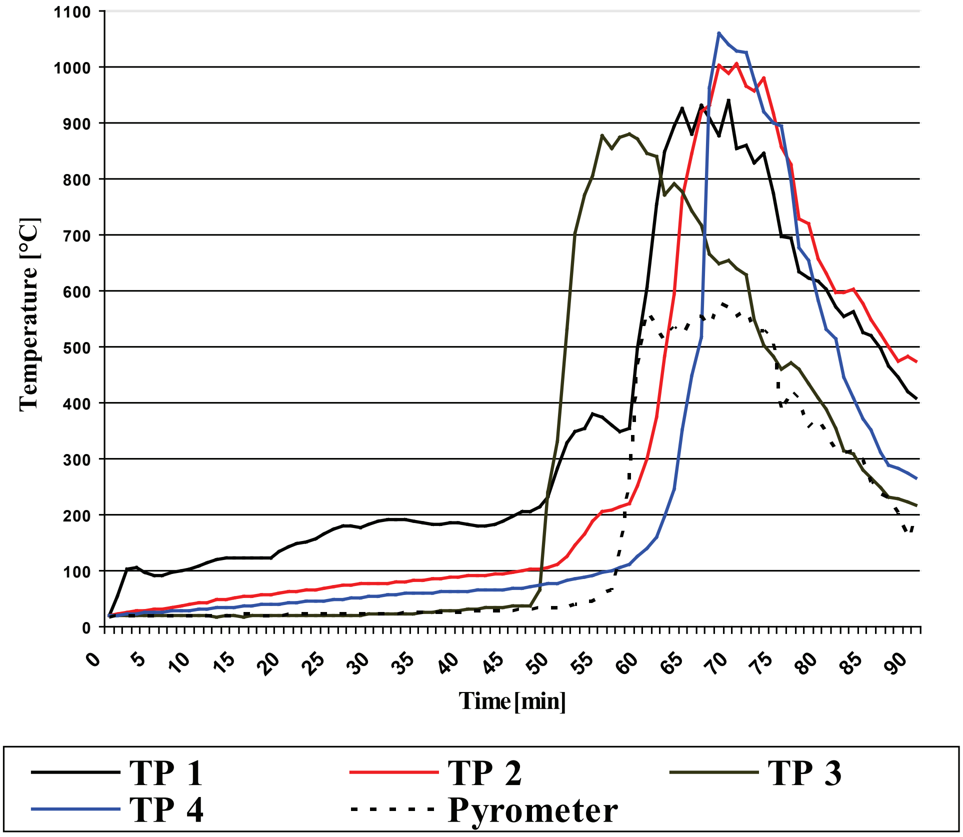

Fig. 7. *The temperature dependence on the fire duration for car C, measured by thermocouples: T1 (top), T2 (bottom), T3 (engine), T4 (boot) and the infrared pyrometer*

Fig. 7 shows the temperature dependence on the fire duration, measured by thermocouples placed as in Fig. 2: T1 (top), T2 (bottom), T3 (engine) and T4 (boot), and the infrared pyrometer (the front door under the window pane) for car C. The temperature inside grows very slowly. Only after ca. 50 minutes, once the temperature grew above 200°C, the window panes became unsealed which led to a dynamic temperature growth.

The Raytek PM50 type infrared pyrometer was used to measure the temperature of the external surface of the car. The pyrometer was placed at the upper part of the car door (under the window pane). It was assumed that the emissivity of the varnished sheet metal of the car body was equal to 0.95. It seems that the temperature results obtained using the pyrometer are underestimated. In the literature there are no data on the values of the emissivity of the varnished sheet metal of the car body at a high temperature, of several hundred degrees centigrade [1, 2]. The Raytek PM50 pyrometer is equipped with a sight aiming at the centre of the measuring circle. When set at a distance of 20 m, the pyrometer measures the mean temperature of a circle with a 20 cm diameter. If a part of this circle covers the window pane, the measured result is underestimated, since the emissivity of glass is less than 0,95, about 0.92 [2]. Moreover, in the course of the fire there was an intense smoke emission. Smoke absorbs and disperses infrared radiation. Its presence causes the pyrometer indications to be underestimated. The same applies to temperature measurements by means of a thermal camera. It is difficult to determine the emissivity value for the car body surface which is inhomogeneous and changes in the course of a fire. It must be considered that the surface is covered by soot, thus the emissivity is equal to 0.98. It is very difficult to run a series of experiments where the smoke level round the car and the soot cover on the sheet metal and window panes would be repeatable. Therefore, temperature measurements by means of a thermal camera should be treated as auxiliary. The camera is very useful for determining a temperature difference, but it is hardly a reliable tool, when we want to measure its value, particularly in an experimental car fire.

A thermal camera enables the exact determination of the measurement point. In practice, an infrared pyrometer does not ensure this. It seems that the pyrometer is hardly useful for such measurements. Certainly, the temperatures measured inside the vehicle by means of thermocouples are reliable.

The figure 8 presents a photo and thermagram of burning car C in the 68th minute from the fire beginning.

Fig. 8. *The photo and the thermagram of burning car*

SUMMARY

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The results of the research on the development dynamics of passenger car fires as presented in this study resemble those given in articles [3] and [4]. The following conclusions can be drawn from the analysis of its results:
1. The dynamics of a car fire development mainly depends on ventilation.
2. It is difficult to start a fire in a tightly closed car.
3. The maximum temperature of a car fire in each experiment exceeded 1,000°C (by not more than several dozen °C).
4. Under the engine cover, plastic elements are damaged, while parts from an aluminium alloy partly melt.
5. After the fire damages window panes or the car is opened the temperature inside the vehicle grows very fast to more than 1000°C. This takes 2 to 5 minutes.
6. In the course of the fire, dangerous phenomena take place, posing risks for persons near the car, such as e.g. the breakup of servos.
7. A passenger car fire can last for more than an hour.

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