STUDY OF CHANGES FOR SELECTED FIRE PARAMETERS AT ACTIVATION OF DEVICES FOR SMOKE AND HEAT REMOVAL AND AT ACTIVATION OF FIXED EXTINGUISHING DEVICE

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This article demonstrates changes of the selected parameters of fire development using a fire model, which is applied in the case of chosen fire example (simulated fire). There is analysed an influence of the active fire-safety devices on the fire parameter changes (in the Part No. 3 – Discussion of Results). The main purpose of this article is to present a basic importance of the active fire-safety devices for a realistic description of the course of fire using the chosen example of fire. Such description is important for performing of the fire-engineering evaluations.

KEYWORDS

course of fire, change of conditions, active fire safety devices, CFAST

1 INTRODUCTION

In the past as well as at present, the course of fire has been the subject of interest of professionals engaged in fire safety. A lot of literary sources deal with description of the individual fire stages. In some cases, a simple fire description seems to be insufficient and therefore it is required a more detailed evaluation of the individual fire stages and their parameters. A characteristic example of using a more detailed description of the fire course is the *fire engineering applications* 0.

The course of fire as well as its stages is influenced by many factors. One of them is also the activation of some fire safety devices. These devices include the Devices for Smoke and Heat Removal (DSHR) and the Fixed Extinguishing Devices (FED), which have a significant impact on the fire course after activation. Moreover, attention must be paid to the Electric Fire Signalling (EFS) devices.

The devices described are also designated as the so-called *active fire safety devices*, which are generally expected to start up automatically pursuant to selected parameters, perform certain tasks automatically and create conditions to limit fire development, ensure safety of persons and conditions for the intervention of fire brigades, etc. [Kucera 2013], [Hosser 2009].

The main problem definition

There are occurring sometimes such situations, which are requiring a more detailed description of the course of fire. Such situations are typical for the so-called fire-engineering solutions. A presence of the active fire-safety devices as well as their importance is often perceived only "passively" and usefulness of these devices applied during the fire-fighting intervention is usually underestimated. The FED (Fixed Extinguishing Devices) is able to reduce development of the fire or to extinguish it, of course, however there are also other related factors and parameters, for example amount of the developed smoke, changes of the smoke level in the affected area etc. Thus, in the case of a detailed description of the fire course it is also necessary to consider the related influences caused by the active fire-safety equipment. However, there is topical problem, which consists in a fact that importance of the active fire-safety equipment is sometimes neglected during description of the course of fire.

Solution of the problem by the other authors

The given problem is analysed by the other authors or it is mentioned at least in several publications, for example in the German publication Hosser, D.: "Leitfaden Ingenieurmethoden des Brandschutzes" (Handbook of Engineering Methods in Fire Prevention, see the list of references). However, this problem is rather mentioned than analysed and solved.

Contribution of article to the problem solution

This article demonstrates changes of the selected parameters of fire development using a fire model, which is applied in the case of chosen fire example (simulated fire). There is analysed an influence of the active fire-safety devices on the fire parameter changes (in the Part No. 3 – Discussion of Results). The main purpose of this article is to present a basic importance of the active fire-safety devices for a realistic description of the course of fire using the chosen example of fire. Such description is important for performing of the fire-engineering evaluations.

The presented results are able to discover also other related aspects that are not always evident or they are not visible "in the first moment", for example a substantial increase of the smoke amount in the case of the DSHR (Devices for Smoke and Heat Removal) activation or only a minimal positive influence of the FED. Taking into consideration the above-mentioned facts, it is necessary to be careful with a description of the developing fire parameters in view of the possible evacuation of persons.

The scientific methods applied in solution of the problem

Nowadays it is possible to apply the fire simulation models in order to describe or to solve problems arising in the given area. There was applied the two-zone fire model CFAST (Consolidated Model of Fire Growth and Smoke Transport) in order to emphasize an influence of the active fire-safety devices. This model was developed by the National Institute of Standards and Technology.

The zonal model CFAST is considered to be perspective in its category and it seems to be useful for application in this article. Application of a suitable simulation tool, together with a demonstrative example, is a "modern" form used in the area of the applied sciences, which enables to draw attention to some problem or to solution of it.

1.1 The course of fire without operation of active fire safety devices and example of device for forced smoke and heat removal

The course of fire can be described by means of the following phases:

- Initial phase,
- Development of fire,
- Phase of a fully developed fire,
- Burning out phase.

In the case of an idealized description of the course of fire the initial stage of fire, together with the phase of fire development are usually integrated into one phase, which is described as the development phase of a fire.

Phases of fire development can be divided into three time periods:

- phase of fire free development (time interval between fire occurrence and activation of the fire alarm device),
- phase of deployed fire or homogenous fire (time interval from activation of the fire alarm device till initiation of fire rescue intervention or till burning out of 70% of the material),
- burning out phase or cooling or fire (the time interval from the start of intervention for fire protection, or from burning out of 70% of the material until extinction).

The technical device, which is applied for forced smoke and heat removal, utilises the physical principle of under-pressure effect created in the room due to airflow generated by means of an active device, i.e. by means of suction fire fan. Equipment specified for forced smoke and heat removal is a system of installations determined for suction of smoke from the given area.

This system consists of:

- Fire fan (exhauster),
- Pipeline for air,
- Ventilation shafts used for smoke and heat removal,
- Regulation elements,
- Power supply.

Fire suction fan is an active element in the whole system, which is arranged for forced smoke and heat removal. This exhauster is placed either on the roof of the building (in the case of axial flow fan) or (in the case of radial flow fan) it is installed directly into pipelines leading to the peripheral wall. [Bebcak, 2004]

2 REPRESENTATION OF FIRE COURSE CHANGE AT DSHR AND FED ACTIVATION BY MEANS OF A FIRE MODEL STUDY

The change in the fire course at activation of the DSHR and FED can be demonstrated in the form of the following study. The fire was simulated in a single-storey object with geometrical dimensions of 40/20/7 m. The centre of the fire was situated on the floor in the centre of the object. The fire was simulated in the development stage by the so-called "t-quadratic fire" characterized by the fire development parameter (time for achievement of the reference speed) of 300 s and heat release speed of 500 $kW.m^{-2}$.

The fire development was evaluated in three variants:

- without activation of the DSHR and FED,
- at activation of the DSHR,
- at the FED activation.

The comparison included mass quantity of the smoke, the smoke layer descent, temperature of the upper layer of gases and temperature of the lower layer of gases in the space. The solid line represents the course of fire uninfluenced by fire safety devices, the dashed line that at activation of the DSHR, and the dotted line that at activation of the FED (influence of the devices has been evaluated separately). According to the principles [CSN P CEN/TR 12 101-5, 2008], the DSHR was designed as a natural one. The influence of FED was simulated by a single sprinkler head of standard parameters, located at the ceiling height above the centre of fire. The CFAST [NIST 2013] zone model of fire was used for this presented study. Results of the study are illustrated in Figures 1 and 2. The both presented figures (Fig. 1 and Fig. 2) are originating from the own source, namely from the previous article of the main author, [Pokorny 2015].

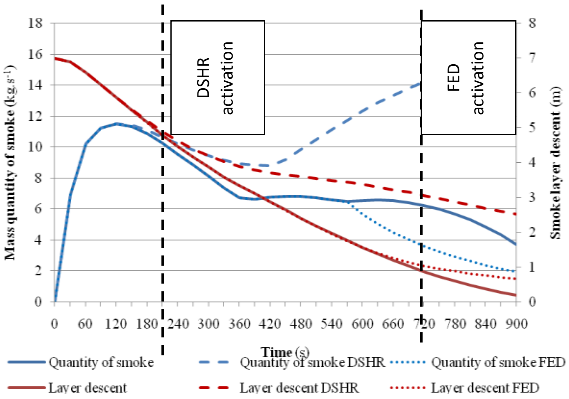

Figure 1. Mass quantity of smoke and descent of the smoke layer with/out the influence of the DSHR and FED [Pokorny, 2015]

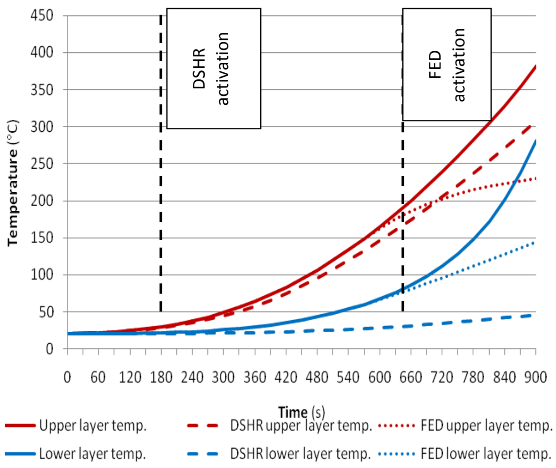

Figure 2. Temperature of upper and lower layer of gases with/out the influence of the DSHR and FED [Pokorny, 2015]

3 DISCUSSION OF RESULTS

The results of the presented studies show the change of all monitored parameters at activation of the DSHR or FED.

The FED influences the mass quantity of arising smoke positively. During its activation, the mass quantity of produced smoke is reduced. Conversely, during the DSHR activation, the quantity of produced smoke increases. The smoke, however, is exhausted outside the burning space; the negative significance of this phenomenon is disputable.

The DSHR has a significant positive influence on the descent of the smoke layer in the space. For the purpose of smoke removal, higher height of the smokeless space has been kept. The FED also slows down the smoke layer descent. However, the influence is not fundamental in the time interval monitored.

Temperatures of the upper and lower gas layers are significantly influenced by the activation of the DSHR as well as FED. At the end of the interval monitored, the upper gas layer temperature is influenced by FED more than by the DSHR, which is caused by the significant reduction of the heat released during FED activation.

It must be stated that the *results* presented correspond to the initial presumptions of the study and calculation principles of the fire model used and they *cannot be applied in all situations generally*. Quite *apparently, however, they present the connection between the change of conditions in the space*, where the fire develops, *and the activity of the specified fire safety devices.*

4 CONCLUSION

In order to determine more detailed characteristics of the fire course and its individual stages, it is necessary to take into account the activation of the electric fire signalling devices, smoke and heat removal devices and fixed extinguishing devices. As a rule, attention will be paid to the time of activation of the described devices and change of characteristics in connection with their activation. In most cases, the changes will have a crucial influence on the course of fire.

Note: This problem is not new, but it is always topical as well as it is widely discussed on the corresponding scientific forums. There was applied a fire simulation model within the frame of the study presented in this article. This simulation model, which was applied to the chosen example of fire, demonstrates and emphasizes an importance of the active fire-safety devices. This form of notification concerning a certain problem is not fully conventional, but in this case it is a suitable and completely valid form.

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REFERENCES

Standards:

0 ISO/TR 13387-1: Fire safety engineering - Part 1: Application of fire performance concepts to design objectives. Geneva: International Organization for Standardization. 1999.

[Kucera 2013] Kucera, P., Pokorny, J., Pavlik, T.: Fire engineering – active fire safety elements. SPBI SPEKTRUM EDITION 84. Ostrava: Association of Fire and Safety Engineering, 2013, 109 p., ISBN 978-80-7385-136-1.

Book:

[Hosser 2009] Hosser, D. Leitfaden Ingenieurmethoden des Brandschutzes. Braunschweig: Vereinigung zur Förderung des Deutschen Brandschutzes e. V. (vfdb), Technisch-Wissenschaftlicher Beirat (TWB), 2009, 386 p.

[Bebcak 2004] Bebcak P. Fire safety equipment. SPEKTRUM EDITION 17. Ostrava: Association of Fire and Safety Engineering, 2004, 130 p., ISBN 80 -86634-34-5 p.

Standards:

[CSN P CEN/TR 12 101-5 2008] CSN P CEN/TR 12 101-5, Devices for direction of smoke and heat movement - Part 5: Directive to functional recommendations and calculation methods for ventilation systems of smoke and heat removal. Prague: Czech Standards Institute, 2008.

WWW page:

[NIST 2013] Fire growth and smoke transport Modeling with CFAST. In NIST, Fire Research Division, CFAST. [online]. 2013 [cit. 2015-06-05]. Available at WWW: <http://www.nist.gov/el/fire_research/cfast.cfm>.

Paper in a journal:

[Pokorny 2015] Pokorny, J., Tomaskova, M. Change of fire course conditions at the devices for smoke and heat removal activation and at the fixed extinguishing devices activation THE SCIENCE FOR POPULATION PROTECTION.

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