Geometrical Optimization of the Flue Gas Path With Regard to Particulate Matter Reduction

Katarina Sulovcova; Radovan Nosek; Jozef Jandacka; Michal Holubcik

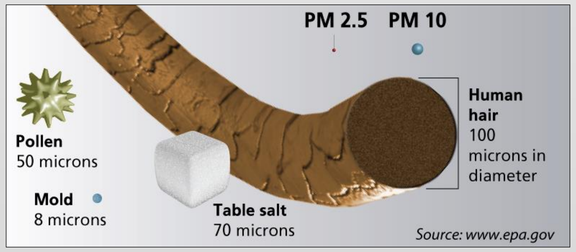
University of Zilina, Faculty of Mechanical Engineering, Zilina, SLOVAKIA

What is Particulate Matter (PM)?

Particulate matter is the general term used for a mixture of solid particles and liquid droplets in the air. It includes aerosols, smoke, fumes, dust, ash and pollen.

Classification of PM:

- **PM_{10}** : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- **$PM_{2.5}$** : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.



What are the effects of PM?

The greatest effect on health is from particles 2.5 microns or less in diameter. Exposure to fine particulate matter has been associated with hospital admissions and several serious health effects, including premature death.

What are the sources of PM?

PM is primarily formed from chemical reactions in the atmosphere and through **fuel combustion** - motor vehicles, power generation and industrial facilities). Residential **fire places and wood stoves** with biomass combustion are also significant producer of particulate matter.

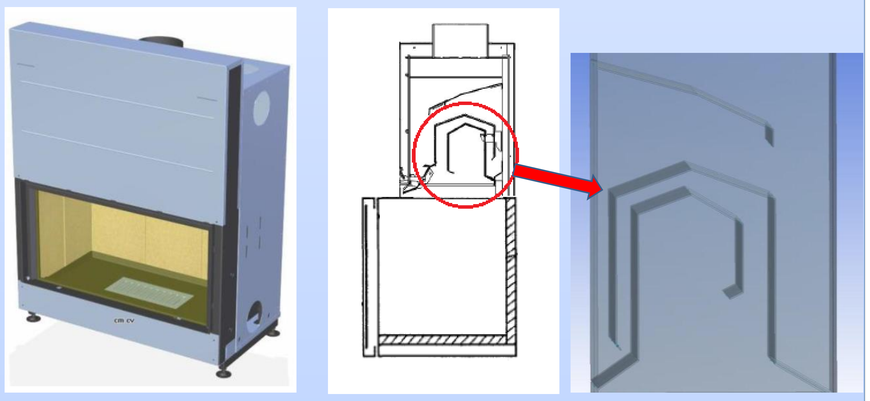
The aim of this research

With regard to decrease PM formation in small heat sources are used various kinds of methods and devices.
This work deals with the changes of flue gas path in laboratory scale. A special tunnel labyrinth was produce in order to investigate the behaviour of PM emitted into the ambient air from combustion process in the fire place.

Methodology to reduce PM

Various kind filters and external separators can be used in order to decrease PM concentrations, but the disadvantage is high price. Therefore are searched other solution…

The paper deals with the reduction of PM in fire place (Fig. 1a) with biomass combustion by **modification of geometric parameters in flue gas path.** A fireplace type HT BRILANT BL, that contains an emission capture device, was chosen to optimize the geometric parameters of flue gas extraction. **The aim is to optimize and observe the flow in the tunnel labyrinth, which is located at the top of the fireplace** (Fig. 1b,c).



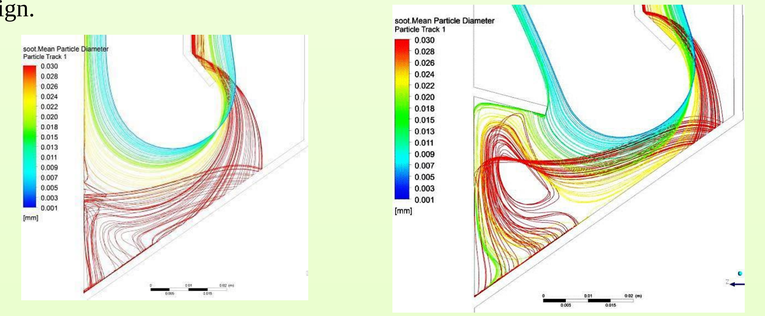
a) **b)** **c)**
Fig.1 a) Model of fire place **b)** Scheme of fire place **c)** Detail of tunnel labyrinth

Simulation of particulate matter`s flow

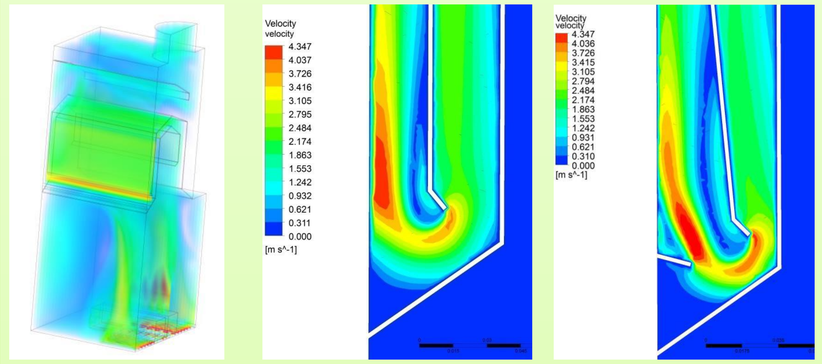
The simplified model of fire place, based on real condition was created for simulation. With the intention to simplify the model, the **combustion was not considered** and model included just air flow in the simulation. Very important is to consider gravity force, which has a major impact on the PM separation in this case.
Particle`s diameters were determined by various sizes to observe behaviour of the particles with different diameters. The Particulate matter distribution diameters were specified by Rosin-Rammler distribution.
Various construction of labyrinth were created in order to simulate the flow of PM and the best options are further analysed.

Results of Simulation

In this research was important to evaluate the amount of trapped particles. The flow of particles is result of simplified simulation**. Particles were flowing in the tunnel labyrinth, in place, where is the biggest change of flow direction**. There is separation zone of tunnel labyrinth where is lover velocity. **The bigger particles are almost all separated at the bottom**, in the trapping place after wall crash. **The smaller particles were not influenced by tunnel construction** and flown away into the chimney (Fig. 2a, 3b).
According to the results was chosen the best modified construction (Fig. 2b, 3c). This construction is theoretically able to trap more particles compare to original design.



a) **b)**
Fig.2 a) Flow of PM in original construction **b)** Flow of PM in optimized construction



a) **b)** **c)**
Fig.3 a) Velocity profile in fire place **b)** Velocity profile in original construction **c)** Velocity profile in optimized construction

Conclusions

The results indicate that modification of **geometrical parameters has an influence on PM concentration** in flue gas and on its separation. This can lead to reduction of emitted particulate matters. In the future more tests and experiments are necessary to do in order to improve construction of heat source and reduce PM concentration. This way of observation seems to be good possibility of finding optimal solution of various problems also decreasing of PM. Using of numerical simulation is also financially more convenient than experimental searching by itself.

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