

# AIR CURTAIN CONTROL

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## Abstract

This article deals with the control of air curtain (AC) in the air-conditioning subsystem of intelligent buildings or buildings in general. It describes the sequence steps of air curtain simulation in Comsol Multiphysics. The goal of this paper is proposition of the control function (CF) of air curtain, which would meet the selected global conditions and would be effective in terms of energy consumption.

The model was created and defined in the Chemical Engineering Module (Variable Density Flow → Weakly Compressible Momentum Transport → Weakly Compressible Navier-Stokes), in which was possible to simulate the interaction and airflow.

The criteria for control function of power AC were determined by values, which were acquired from simulation. Speed of flow AC has to be bigger than the speed of outside airflow into the room due to ensuring an effective separation of thermal zones. The measured values showed the dependence between outdoor airflow and AC.

AC will work in three working modes. First mode (for entrance wind speed 0-5 m/s) the CF regulates the performance of AC. The second mode (for entrance wind speed 5-9 m/s) AC performance will be maximum (output of air curtain will be 9 m/s). AC will be deactivated in the third mode – for entrance wind speed is 0 or bigger than 9 m/s, because here is AC inefficient.

**Keywords:** air curtain, COMSOL, air flow simulation, control function

## 1 Introduction

Air curtains (AC) come under the air - conditioning subsystem and create invisible barriers between indoor and outdoor space. In the winter they keep a heat in a room (cold in the summer) and they prevent dust, smoke, pollen or insect to get into the room through open doors, windows or balconies and this way they save energy. These separated compartments are called termozones. They are suitable for open doors, department stores, bars, cafes, restaurants and more. In the restaurant they can create the border between smoking and non-smoking area and prevent the passage of smoke and odor.

## Principle and advantages of AC



*Fig. 1: Options of installation and the principle of air curtain*

Air curtain substantially reduces losses of heated / air – conditioned air. Consumption of energy can be reduced by up to 80% with properly installed air curtains [1]. If openings of doors are larger, the time

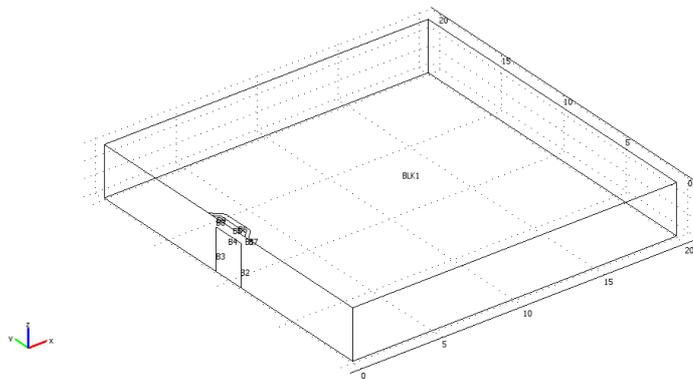
for returning of investments will be shorter. Air curtain is suitable for openings, which can have different width and different height to 8 meters. Air can flow from the bottom, top or side. There are many different termozones - termozones with electric and hot - water heating or termozones without heating.

## 2 Model assembly and simulation

Model and simulation were created in simulative tool COMSOL Multiphysics. With this tool is possible to create many different kinds of physical models and simulate various physical processes [2].

The model was created and defined within the Chemical Engineering Module (Variable Density Flow whit  $\rightarrow$  Weakly Compressible Momentum Transport  $\rightarrow$  Weakly Compressible Navier-Stokes), in which was possible to simulate the interaction and airflow. The model represents the entrance hall of the building with the entrance door, above which is an outlet aperture of air curtain. The dimensions of the model were determined according to real solution (20x20x3 dimensions of entrance hall). Air curtain was situated in the ceiling of the entrance hall.

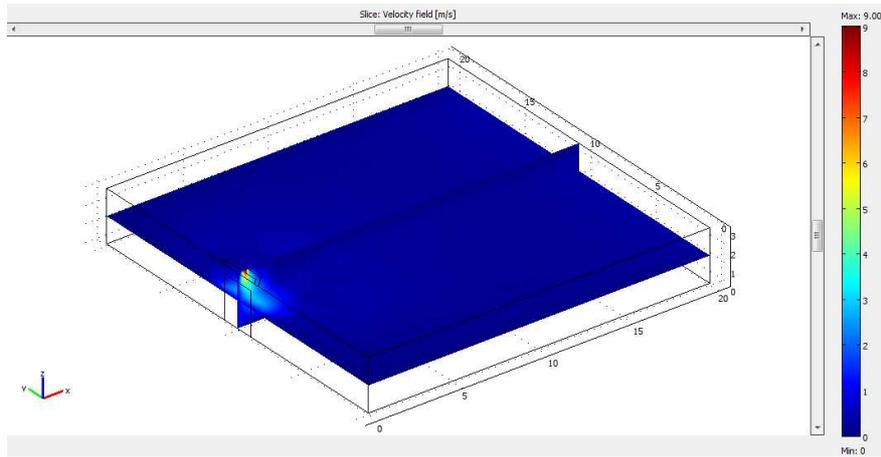
Physical properties of the model were adjusted for normal atmospheric pressure (101 325Pa). At this point setting of simulation is necessary to determine the density and dynamic viscosity of air. It is important to set the value of diffusion Crosswind ( $c_k$ ) and isotropic diffusion ( $\delta_{id}$ ).



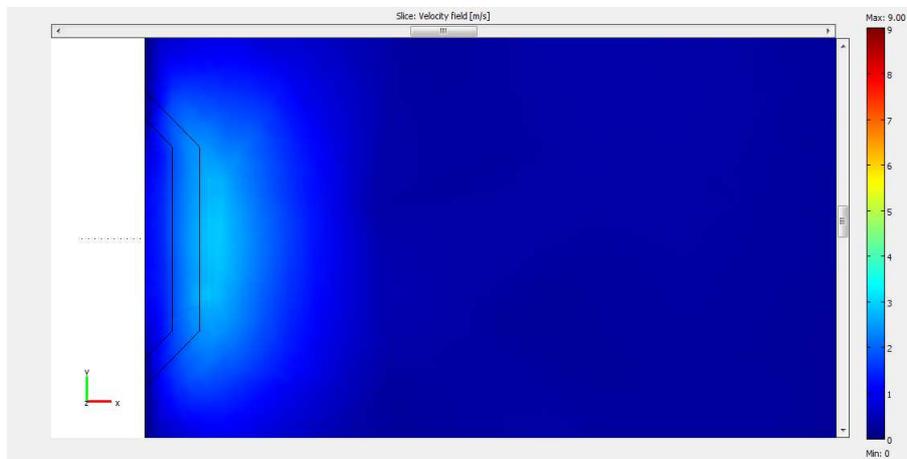
*Fig. 2: Geometric model, which is created in the space*

## 3 Simulation and results

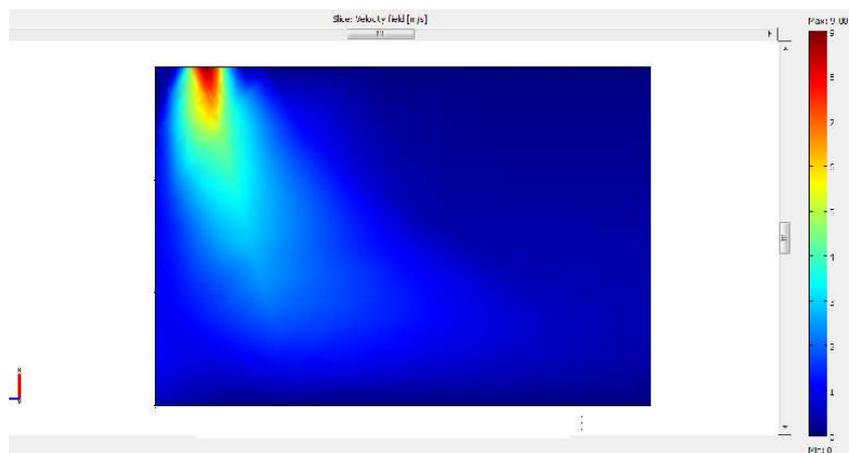
The first simulation illustrates the process of flow near the air curtain with a maximum power and his values are appropriate to compare with the final control function. The speed of airflow from the air curtain is 9 m / s, which is a normal maximum value of air curtains, which are accessible on the market. Values of wind speed, which affects on the door, were adjusted from 1 to 9 m / s on the basis of unit step. We studied the values of airflow velocity at a distance of 1-5 meters from the door.



*Fig. 3: Illustration of graphical result of simulation (view in space)*



*Fig. 4: Result of the first simulation, axis XY (a detailed view from top)*



*Fig. 5: Result of the first simulation, axis XZ (detail view in side )*

Table 1: Values of airspeed at the points with a maximum power of air curtain (9 m / s)

distance from air curtain [m]	1	2	3	4	5
wind speed [m / s]					
1	1,67	0,42	0,35	0,32	0,32
2	2,31	1,15	0,84	0,66	0,61
3	2,91	1,93	1,46	1,17	1,02
4	3,57	2,62	2,04	1,66	1,42
5	4,27	3,25	2,58	2,13	1,8
6	5	3,86	3,1	2,57	2,17
7	5,74	4,47	3,61	3	2,54
8	6,49	5,06	4,11	3,43	2,89
9	7,25	5,66	4,61	3,86	3,25

From the results of simulations and measurements were created "cross" set of results, which consisted of all possible combinations of values of air flow aperture and weather conditions.

#### 4 Control function of air curtain

The criteria for the regulation of power AC were determined by values, which were acquired by simulation. Speed of flow AC must be bigger than the speed of outside airflow into the room for the sake of ensure an effective separation of thermal zones. The measured values show that at a point, which is three meters distant from the door at the constant effect of wind on the AC with increasing speed of airflow AC, increases the speed at this watched point to a certain (maximum) value and then decreases. The value of airflow speed AC, which causes decline beyond the maximum value to decrease, as will be determined by the value of the control function of the wind speed acting on the AC.

Control function was created according to the determined criteria and it determines the efficient management of air curtains.

Table 2: values of air speeds and wind screens identifying the final control function

wind speed [m / s]	0	1	2	3	4	5	6	7	8	9
Speed of air curtain [m / s]	0	3	5	6	8	9	9	9	9	9

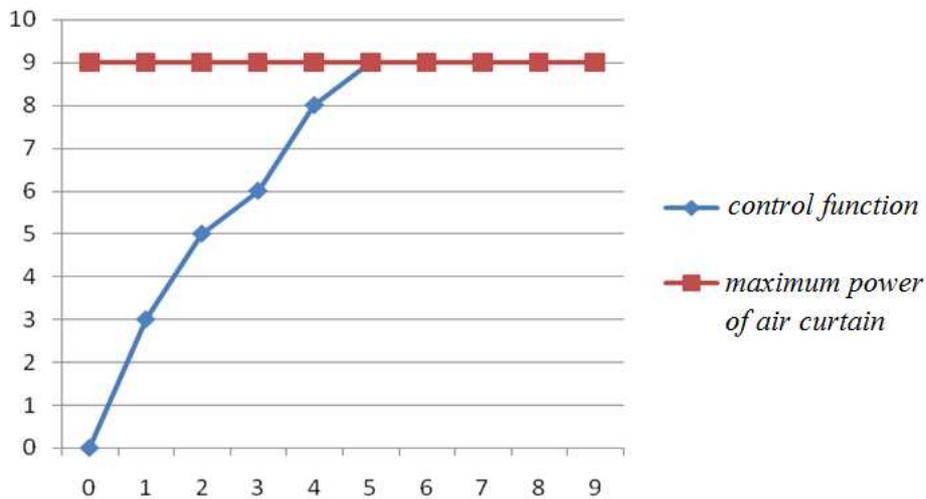


Fig. 6: Control function and maximum power of air curtain

Fig. 6 shows, that control is possible only after the load of wind speed 5 m / s, where air curtain reaches maximum power. According to the Beaufort scale and the results of simulation is possible to conclude, that the regulation will be used for weaker gusts of wind. The regulation will be realized by obtaining input data, which were obtained from the detector, which observe the speed of wind acting on the door. This information will be processed by control unit (this control unit is inbuilt in air curtain or it is inbuilt distantly) so, that the corresponding performance of air curtain is determined and adjusted according to this information.

## 5 Conclusion

According the values, which were obtained by simulation of created virtual model AC, was created control function, which is determined by the table 1 and table 2. Graph of control function shows, that introduction of control function will reduce costs, which are determined for operation of AC (unlike its maximum power) and the rate of savings will depend on weather conditions in the area and in the place, where it will be located. AC will work in three working modes. In the first mode [ for entrance values of wind speed in the range 0-5 m / s ] the intended function will regulate the power of AC. In the second mode [ for entrance values of wind speed in the range 5-9 m / s ] power will be maximum, so speed of air curtain will be 9 m / s. AC will be deactivated in the third mode – for the entrance values of wind speed, which equal 0 or are bigger than is 9 m / s, because activity of AC is unnecessary for these values.

## References

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