Calculation of Air Conditioning in the Building Interiors (ANSYS/CFX 10.0 Software Package)

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At the stage of designing, house building and operation of office buildings, hypermarkets, culture, sport and other buildings there are strict requirements of construction, assembling and working of air conditioning and ventilation systems in the building interiors.

ANSYS/CFX software package allows virtual numerical simulating of air flow and air convection in building interiors inclusive of air stratification and technical parameters of conditioners, air-fans, air-ducts, air-coolers; inclusive of heat conduction of walls and separating walls and sunny heat radiation through glassed-in windows.

Numerical calculations are carried out on modern personal computers and computer clusters and allow to obtain three-dimensional distributions of air temperature, pressure, velocity; to visualize air flow streamlines and trajectories of foreign substances particles (smoke and soot diffusion and etc.).

To solve the problem of air circulation it is necessary to form full 3D CAD model of the building with the outer outlines and with the precise inner geometry of rooms and corridors (Figure 1).
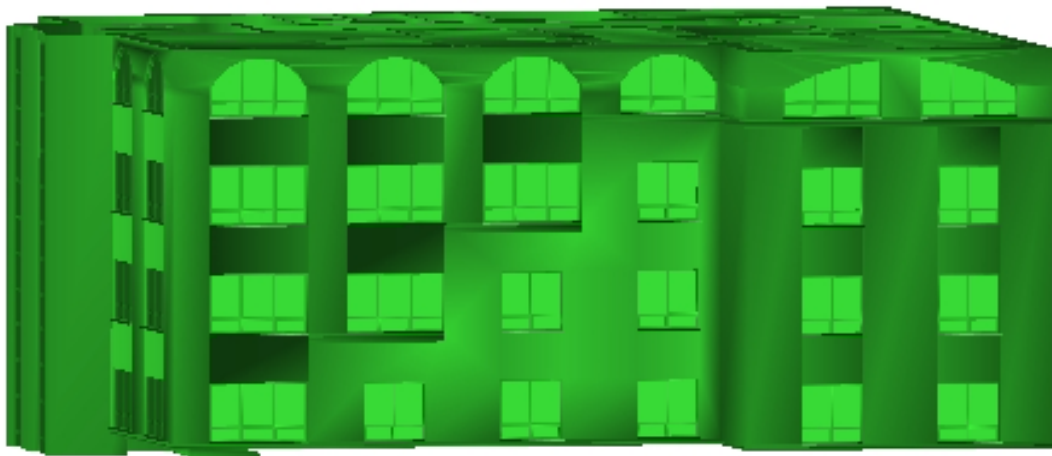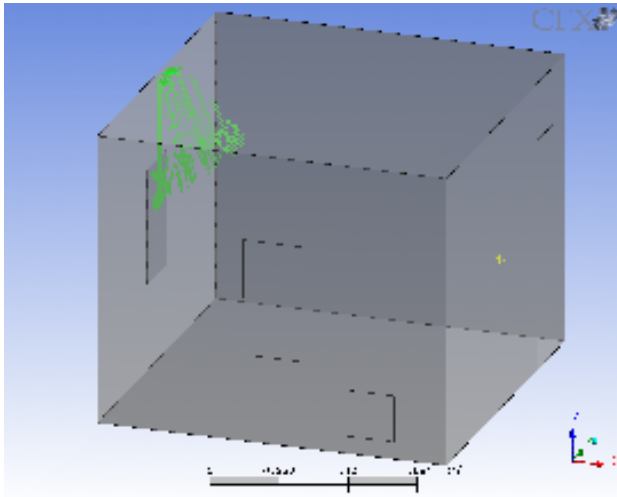

Figure 1.

Then from full geometrical model the needed inner part of building is split, volume tetrahedral or hexahedral mesh is generated, the boundaries and boundary conditions (including power parameters of air conditioning systems) are defined.

The calculation of air dynamics and visualization of various variables (pressure, velocity, temperature, streamlines, isolines, isosurfaces and etc.) are executed.

Problem description, geometry and grids

To demonstrate the abilities of ANSYS/CFX 10.0 software package we consider the model problem of air conditioning in schematized 3m × 3m × 2.5m room with two windows and air conditioning system with an inlet vent for cooled air and an outlet vent for removing ambient heated air from the room. Figure 2 shows room geometry and computational domain, green needles demonstrate cooled air flux from inlet vent on the room ceiling. On the two adjacent walls there are two windows (elongate rectangles), on the floor adown there is an outlet vent for ambient air. Figure 3 demonstrates insolation flux through windows.

**Figure 2. Computational domain
(green needles – cooled air flux)**
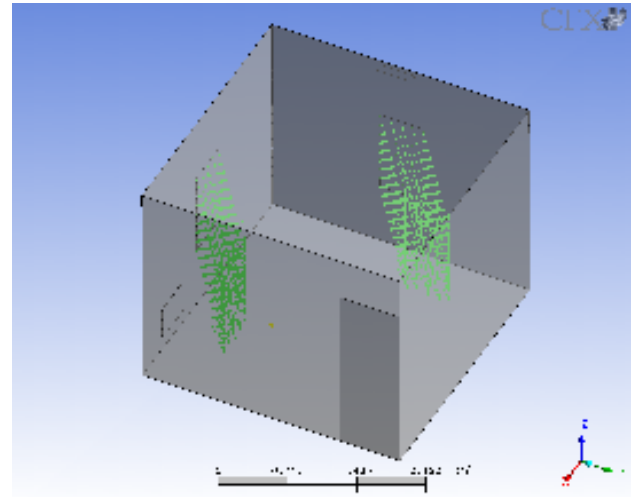
**Figure 3. Insolation flux through windows
(green needles)**

The following parameters have been downloaded in the numerical calculation:

- 1000 W – the air-conditioner power
- 600 W/m^2 – heat radiation flux through windows
- 0.06 m^3/c – the flowrate of air through the room

Computational triangular grid on the walls, floor and ceiling surfaces is shown in the Figure 4. Volume grid in the computational grid consists of 19,000 nodes 62,000 elements (tetrahedral, hexahedra, wedges).
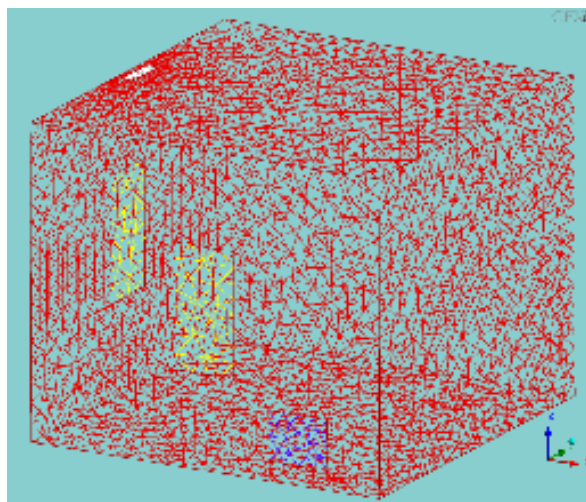

Figure 4. Computational grid

Calculations results

ANSYS/CFX 10.0 calculations were carried out on the Pentium IV PC under Windows 2000 operation system.

Air flow was calculated by solving three-dimensional Navier-Stokes equations describing compressible viscous turbulent flows.

The finite volume method, node centered high-resolution scheme for convective and viscous parts and k-ε turbulence model were used.

Figure 5 (left column) depicts calculation results for temperature fields at the two horizontal planes (near the floor and at the height of man head) and at the vertical plane in the middle of the room.

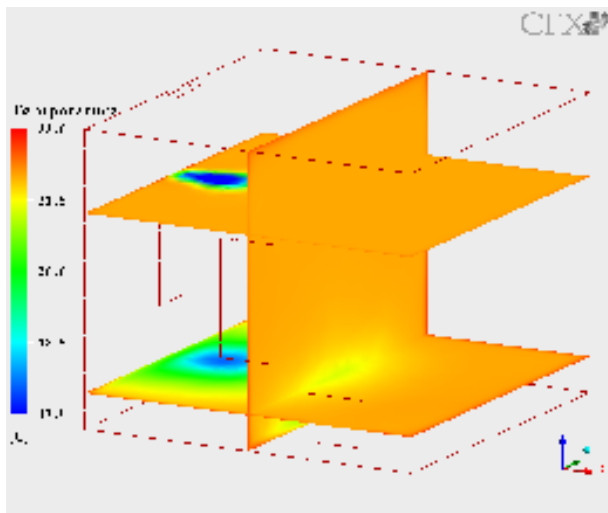Air streamlines are shown in the right column.

The results are presented for various time intervals t=10 s, 1 min, 2 min, 3 min, 4 min from air –conditioner starting. Initial temperature of cooled air jet is 7°C.

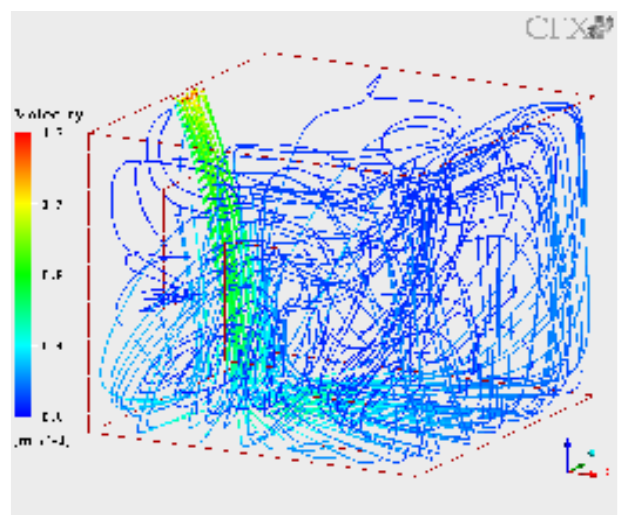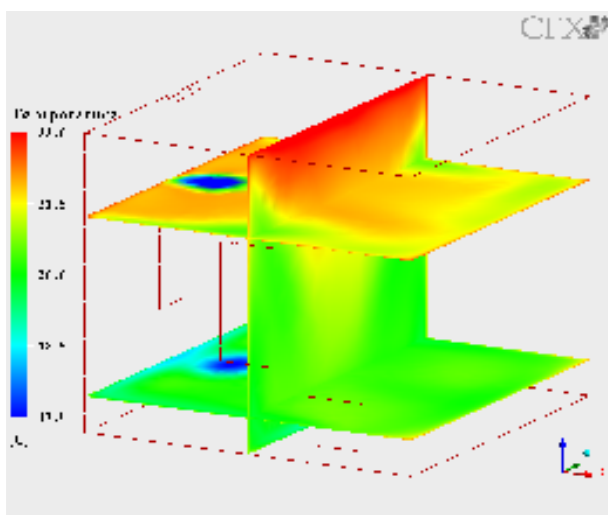Before conditioner actuation air in the room was not disturbed and his temperature was 22°C.

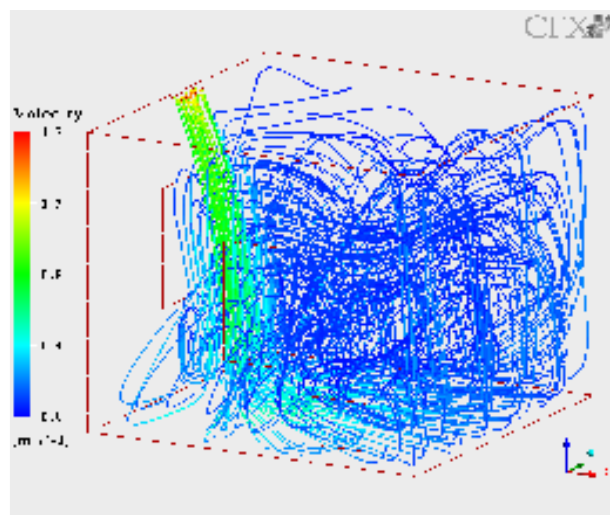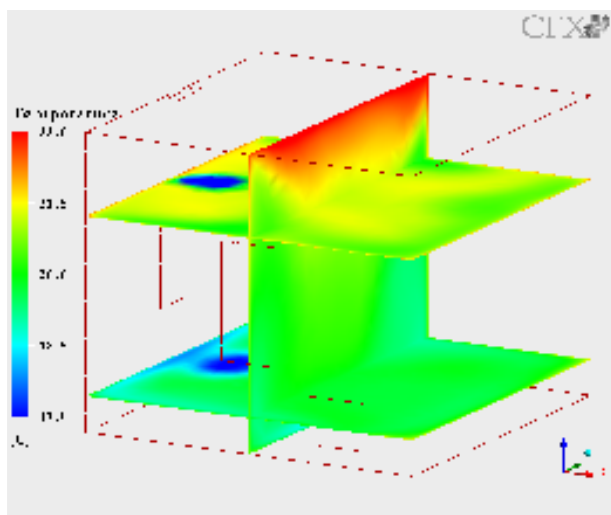**Temperature   distribution**   **Streamlines**

t=10 s
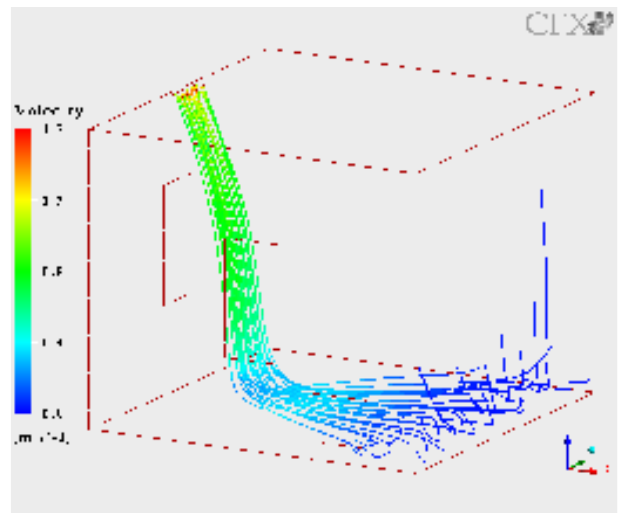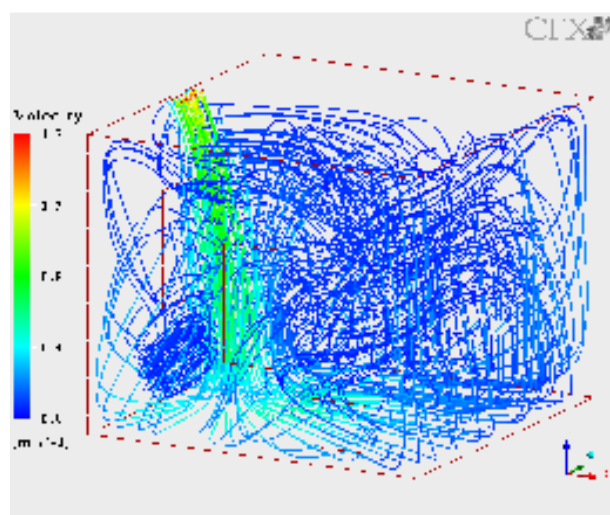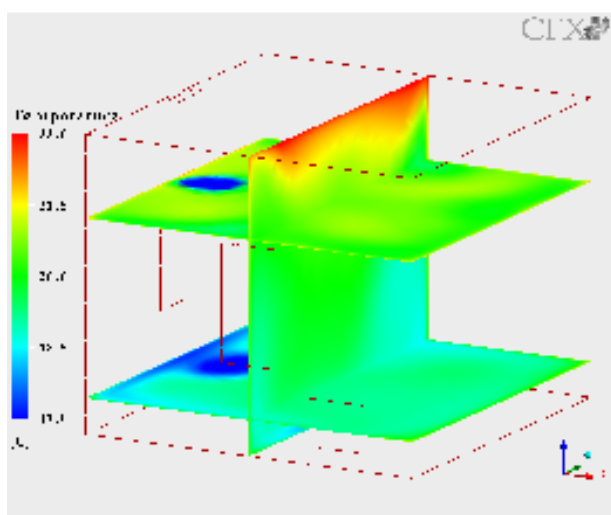

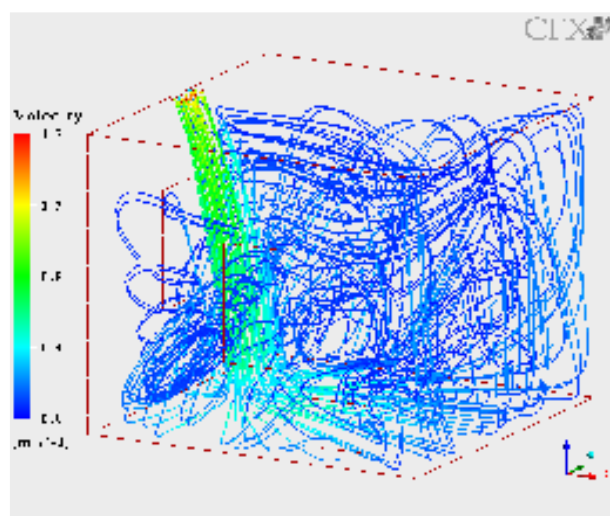**t=1 min**
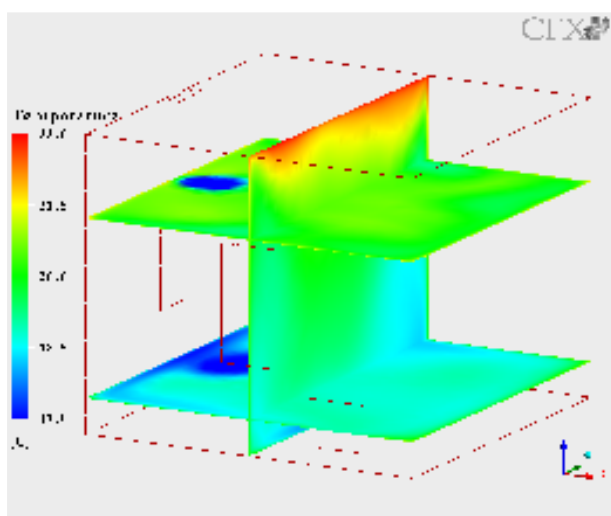
t=2 min

t=3 min

t=4 min

Figure 5. Temperature fields and streamlines

Calculations show that already after 3-4 minutes from conditioner actuation moment air is cooled from 22°C to 18.5-19°C in the whole room volume practically, under the ceiling warmer air with 23°C and higher temperature is agglomerated. Streamlines pictures show that the local air vortex is generated in the room corner between two windows.

This phenomenon is provided by interference of cooled air jet flowing from room ceiling with air at rest, air heat transfer and heat radiation through the windows.