TRNSYS 15 – A SIMULATION TOOL FOR INNOVATIVE CONCEPTS

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ABSTRACT

Just in time for the 25th anniversary a new version of the international well-known simulation tool TRNSYS is released: TRNSYS 15. New developments of both user-friendly interfaces and mathematical models have been implemented responding to a growing commercial application of TRNSYS. For example, the graphical input interface IISiBat has been completely rewritten in C++ and offers now all the comfortable features of modern window programs. In addition, suggestions of users such as layer techniques, reading ASCII-Input files and improved project and component management and exchange are realised. Also, the multi-zone building model has been improved significantly. A new model for the simulation of a thermally activated slab for heating / cooling is integrated into the building model. In addition, comfort evaluation is incorporated in the standard version. The improvements of the solar radiation distribution within a zone and through an internal window into an adjacent zone yield to a significant reduction of the effort of modelling double facades and air flow windows. The flexibility and openness of TRNSYS 15 is increased by the ability to call external programs and external DLL's (Dynamic Link Libraries). Thereby, components which are not programmed in Fortran and/or not specially customised for TRNSYS can be easily added. Due to these new features TRNSYS is an even more powerful tool for the thermal simulation of buildings and energy systems that satisfies new demands of innovative and forward-looking energy concepts.

1. INTRODUCTION

In the planing process the application of building simulation for developing and evaluating energy concepts is increasing. The growing commercial usage make new demands on the software. The new version of TRNSYS, TRNSYS 15, considers these demands by improving both, user interfaces and modeling capacity. For the building simulation, the main novelties concern the simulation of thermo-activated building components and solar buffer zones. These new models provide not only a higher accuracy but allow a simple user-friendly input and therewith reduce the error-prone.

2. NEW: SIMULATION OF THERMO-ACTIVE BUILDING COMPONENTS

Thermo-active building components (slabs or walls of a building) are used to condition buildings by integrating a fluid system into massive parts of the building itself. Examples are radiant floor heating or cooling systems, radiant ceilings or wall heating or cooling systems.

Due to the fluid pipes a multi-dimensional heat transfer problem has to be solved for calculating thermo-active construction elements. Usually, a Finite Element Method (FEM) or Finite Difference Method (FD) is applied for such problems e.g. TRNSYS component TYPE 160 [1]. Therefore, the building component to be examined needs to be transformed into small three-dimensional grid cells. In order to achieve a sufficiently high level of precision, the grid must be sufficiently dense. In general, this leads to complex calculations and long calculation time. In addition, a certain level of experience is required for creating the geometric input and an effective grid design.

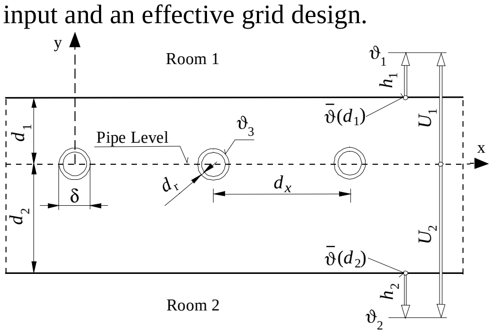

Figure 1: Typical structure of a thermo-active construction element

For this reason, a more powerful alternative method for modeling thermo-active construction element systems was developed by EMPA [2] and integrated in the multi-zone building model TYPE 56 of TRNSYS 15. The integrated model is based on solving the stationary differential equation for heat conduction.

The heat conduction through the element is reduced to a one dimensional form by applying resistance models. Thereby, the existing transfer function method of the building model TYPE 56 for walls can be used for solving the one dimensional heat conduction problem. The developed theory can be applied for dynamic simulation by a smart approximation. Due to the large thermal mass of thermo-active components a dynamic (time-dependent) simulation of its behavior is important.

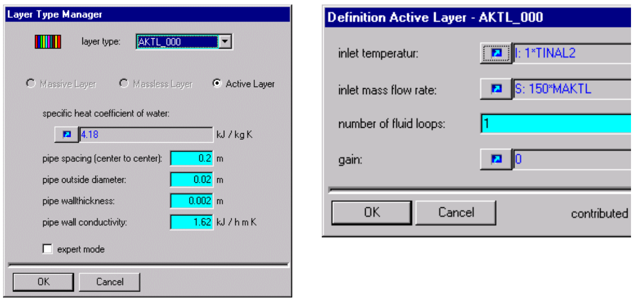

Figure 2: Input data for the new model

The model is defined easily within the building description as a “wall” with an so-called active layer. As input data for the active layer geometric data e.g. pipe spacing and property data e.g. pipe wall conductivity and fluid data e.g. inlet temperature are required only (see figure 2).

A validation of this new model by comparison to detailed FEM calculations and measured data is provided by EMPA [3]

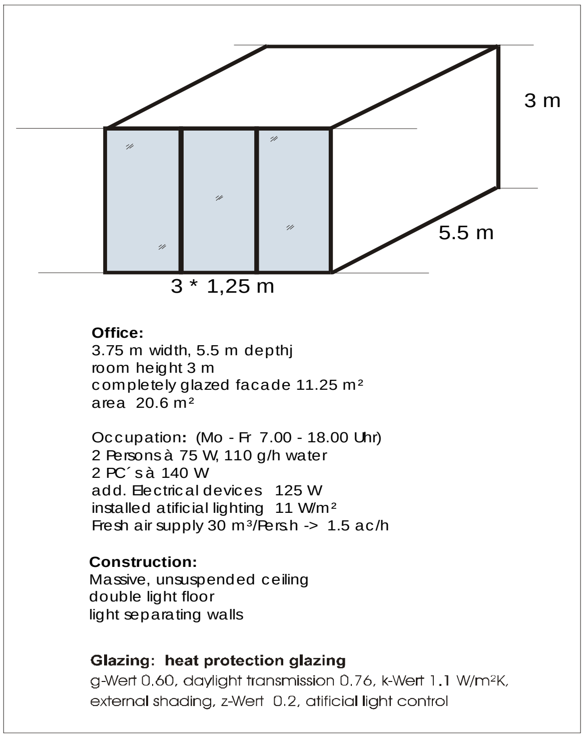

Figure 3: Boundary conditions of the simulation

In the following, a comparison of both models, the new integrated model and the finite difference model TYPE 160, has been performed for a continuously operating concrete core cooling system. The boundary conditions are shown in Figure 3.

The simulation is performed for 8 hot summer days according to VDI 2078. For TYPE 160, the ceiling with the concrete core cooling is modeled by 500 temperature nodes. The ambient temperature, the air temperature, ceiling temperature and supply and return temperature are shown for the last 4 days in figure 4.

The resulting temperatures of both model indicate a good agreement. The simulation time of the integrated model of TYPE 56 is only 1/5 compared to the simulation time of the finite difference model TYPE 160. Therefore, TRNSYS 15 includes now a building model offering an easy-to-use and efficient way of modeling thermo-active building components.

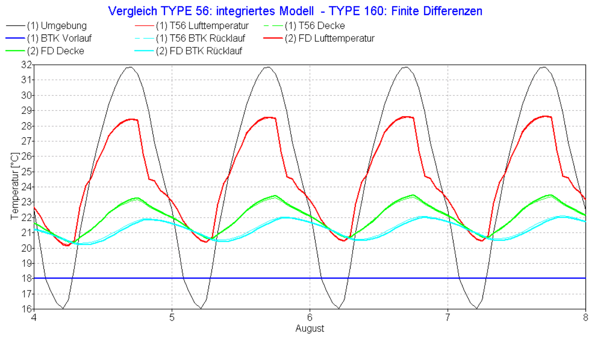

Figure 4: Resulting temperatures of comparison

3. IMRPOVED: SIMULATION OF SOLAR BUFFER ZONES

For the simulation of solar buffer zones the modeling of solar short wave radiation is important. Therefore, significant improvements have been integrated in TRNSYS 15.

a) Incoming solar radiation (external windows)

Since version 14.2, a standard library of typical window and glazing systems is included. This library contains detailed data like angular dependent transmission, reflection and absorption of single window panes based on WINDOW 4.1. The standard library may be extended by the user. In addition, external and internal shading devices can be defined. In TRNSYS 15, the modeling of internal devices is detailed including multiple reflection between the window pane and the shading device.

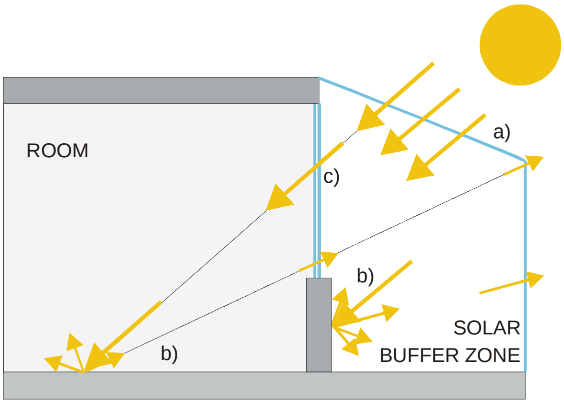

Figure 5: Modeling of solar shortwave radiation

b) Solar distribution with a room

The new distribution model enables a separate treatment of beam and diffuse radiation within a room. The diffuse radiation is distributed by area absorptance weighted ratios to all surfaces of a room. For beam radiation distribution factors are introduced. The distribution factor of a surface represents the percentage of incoming beam radiation that strikes this surface. The movement of the sunlit parts within a room, from an east oriented wall in the morning, over the floor at noon to the west oriented wall in the evening hours can be modeled by time-dependent distribution factors.

c) Forwarding solar radiation (internal windows)

In general, solar buffer zones are placed in front of the “real” rooms whereas the separating wall is mainly transparent. Therefore, a large amount of the incoming solar radiation is forwarded from the buffer zone to the room behind it. In TRNSYS 15, the user simply defines an adjacent window between the buffer zone and the room. The same detailed window model is applied as for external windows taking into account the angular dependencies. In addition, shading devices can be defined.

The introduction of internal windows together with explicit distribution factors for beam radiation reduces the effort of the simulation of solar buffer zones drastically. Thereby, the accuracy is increased and the error-proneness is reduced.

4. INTEGRATED: COMFORT VALUATION

For consulting work the evaluation of thermal comfort in buildings is a common task. Temperatures only are insufficient as an indicator of thermal comfort. The degree of activity, the clothing and the possible heat exchange by radiation and evaporation influences the judgement. In addition, thermal comfort depends on corporeality, body mass, age and sex. Therefore, a certain situation is always judged different from various persons: an ideal climate with 100 % satisfied persons does not exist. [4]

Due to these facts a comfort evaluation according to EN ISO 7730 [5] is integrated in the multi-zone building model TYPE 56 of TRNSYS 15. The method presented in EN ISO 7730 is based on a statistical description proposed by P.O.Fanger:

PMV (Predicted Mean Vote)

PMV represents the comfort of the majority of test persons in an environment. A PMV equals 0 means that most people feel comfortable with the boundary conditions, but some are still dissatisfied. Therefore, the percentage of dissatisfied is never smaller than 5 %.

PPD (Predicted Percentage of Dissatisfied)

The evaluation of “warm” or “ slightly cold” given by the PMV value is transformed into a percentage of dissatisfied persons. Thereby, a quantitative comparison of various situations and measures can be performed.

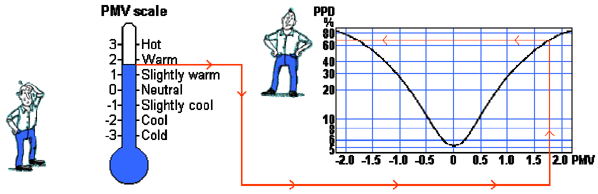

Figure 6: Comfort evaluation with PMV and PPD

5. FURTHER IMPROVEMENTS

Besides the multi-zone building model other models have been improved and new components have been added. (A complete list is available on our web page http://www.transsolar.com). An interesting new feature of TRNSYS 15 is possibility to call external DLL’s (Dynamic Link Libraries). This feature provides a comfortable integration of new components which are not written in FORTRAN or not directly for TRNSYS.

IISIBat – graphical input interface

For users especially in commercial application the program interfaces play an important role. The graphical input interface **IISiBat** has been completely rewritten in C++ and offers now all the comfortable features of modern window programs. In addition, suggestions of users such as layer techniques, improved project and component management and exchange are realised. A new feature is the so called “DCK reader”. Therewith, IISiBat is not only able to create a TRNSYS Input file (in ASCII) but also to read in a TRNSYS input file and to recreate a graphical display of the defined system.

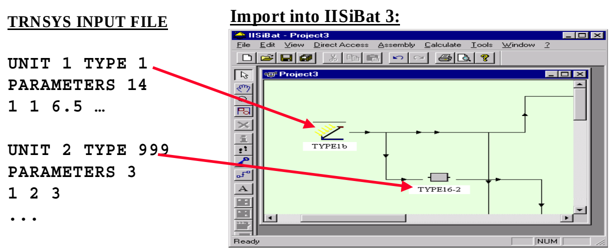

Figure 7: "DECK-reader" of IISiBat for recreating a graphical display form an ASSCII input file

SIMCAD for TRNSYS

SIMCAD is an object oriented CAD tool designed specially for generating building description data for the simulation with TRNSYS. Besides the reduced effort for creating the building geometry data the possibility of visualization the entered data is a major advantage.

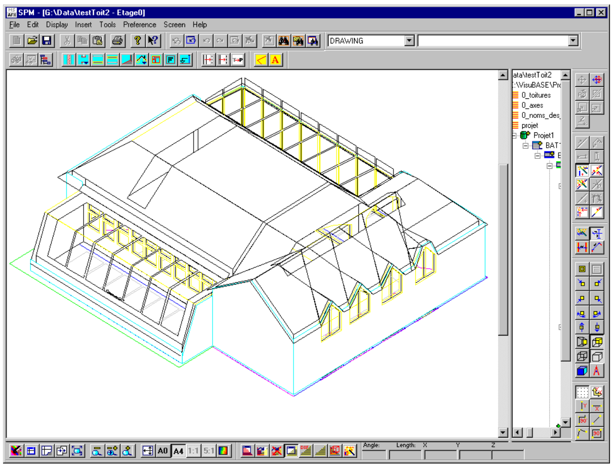
Figure 8: 3D view of building input

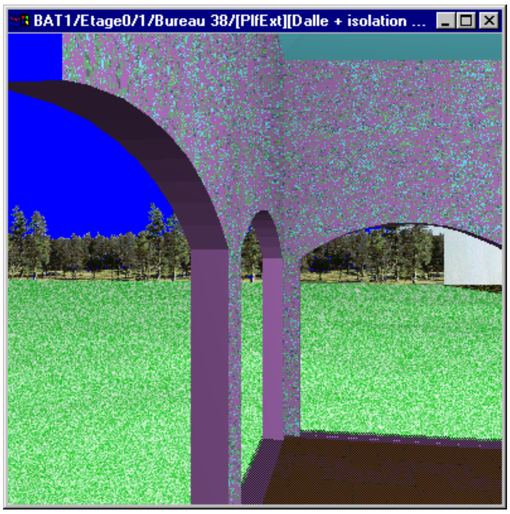

Figure 9: Virtual reality with the interactive "walk through" mode

Although SIMCAD is not to replace existing CAD tools, it offers all necessary tools to efficiently draw, visualize, print and export floor plans in 2D, 3D or an interactive "walk through" mode. While the user defines walls, doors and windows –by either creating it from scratch or by importing it from some other CAD tool – the program automatically generates an internal, object orientated data model. A TRNSYS building description file is generated by a simple push on a button. This file can then be further processed with the building module PREBID of the TRNSYS package. Since SIMCAD is a standalone program it does not require any licenses of other CAD packages.

6. CONCLUSIONS

Responding to a growing commercial application new developments of both user-friendly interfaces and mathematical models have been implemented into TRNSYS 15. For the building simulation, the main novelties concern the simulation of thermo-activated building components and solar buffer zones. These new models provide not only a higher accuracy but allow a simple user-friendly input and therewith reduce the error-prone significantly. Also, interfaces like the new IISiBat and SIMCAD for TRNSYS add to the reduction of input errors. For the advanced users features for calling external programs or DLL's increase the flexibility of the program. Due to these new features TRNSYS is an even more powerful tool for the thermal simulation of buildings and energy systems that satisfies new demands of innovative and forward-looking energy concepts.

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