

Handbook

NOODEL - 33 NDe COMfort MoDEL

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NOODEL

NOODEL (33 NOde COMfort MoDEL) consists of a thermo-physiological human body model and a psychological model for predicting thermal sensation and comfort derived from the physiological state of the body. NOODEL allows the analysis of thermal comfort within different indoor environments. The model was developed using literature data and own test person experiments in mixed and displacement ventilation systems. The test cases represent only a part of interior situations. Validation cases show a good agreement between calculated and experimental data for temperature drifts and temperature jumps at medium temperature levels. For more complex interior situations, no conclusive statement on the quality of the model can be made with the current data sets. However, the model is continuously extended by new experimental data.

NOODEL Library

The Modelica NOODEL library consists of different packages.

BaseClasses

The package *BaseClasses* includes the main basic classes for the passive system of the human body including convective and conductive heat transfer.

Components

The package *Components* integrates the packages compartments and segments.

Compartments

NOODEL is a multi segment thermal comfort model. Each body segment is subdivided into a skin and a core layer. All segments are interconnected by a central blood compartment. The two layers include the basic functions of the passive system and the local calculation of the error signal to activate the active system.

Segments

NOODEL consists of 16 body parts ((head, chest, back, pelvis, shoulder, arm, hand, thigh, leg, foot). Based on a partial bodypart model the specific body parts are described with its specific surface area, weight, set point temperatures and coefficients for the active and passive system.

Functions

The package *Functions* includes the functions of the psychological model. The psychological model used here derives the feeling of comfort from the skin temperature determined by the physiological model. A distinction is made between the local thermal sensation TSI of the individual body parts and the thermal sensation for the entire body TSo. The evaluation is based on a 7-point scale from -3 for cold to 3 for warm, as in the survey of the test group.

The local thermal comfort TCI and the global comfort TCo can be derived from the thermal sensation. The evaluation is also based on a 7-point scale from -3 for very uncomfortable to 3 for very comfortable.

Interfaces

The package *Interfaces* includes all different kinds of connectors. It also includes the *Parameter* component which provides system-wide settings, such as ambient conditions, initial skin and core temperature and position of the human body.

Model

The *Model* package includes the NOODEL model

Non SI units

The model includes several non SI units which are defined in this package.

Application

The given model *NOODEL standalone* in the package *Model* is developed to run as a standalone model which means all boundary conditions of the environment are specified.

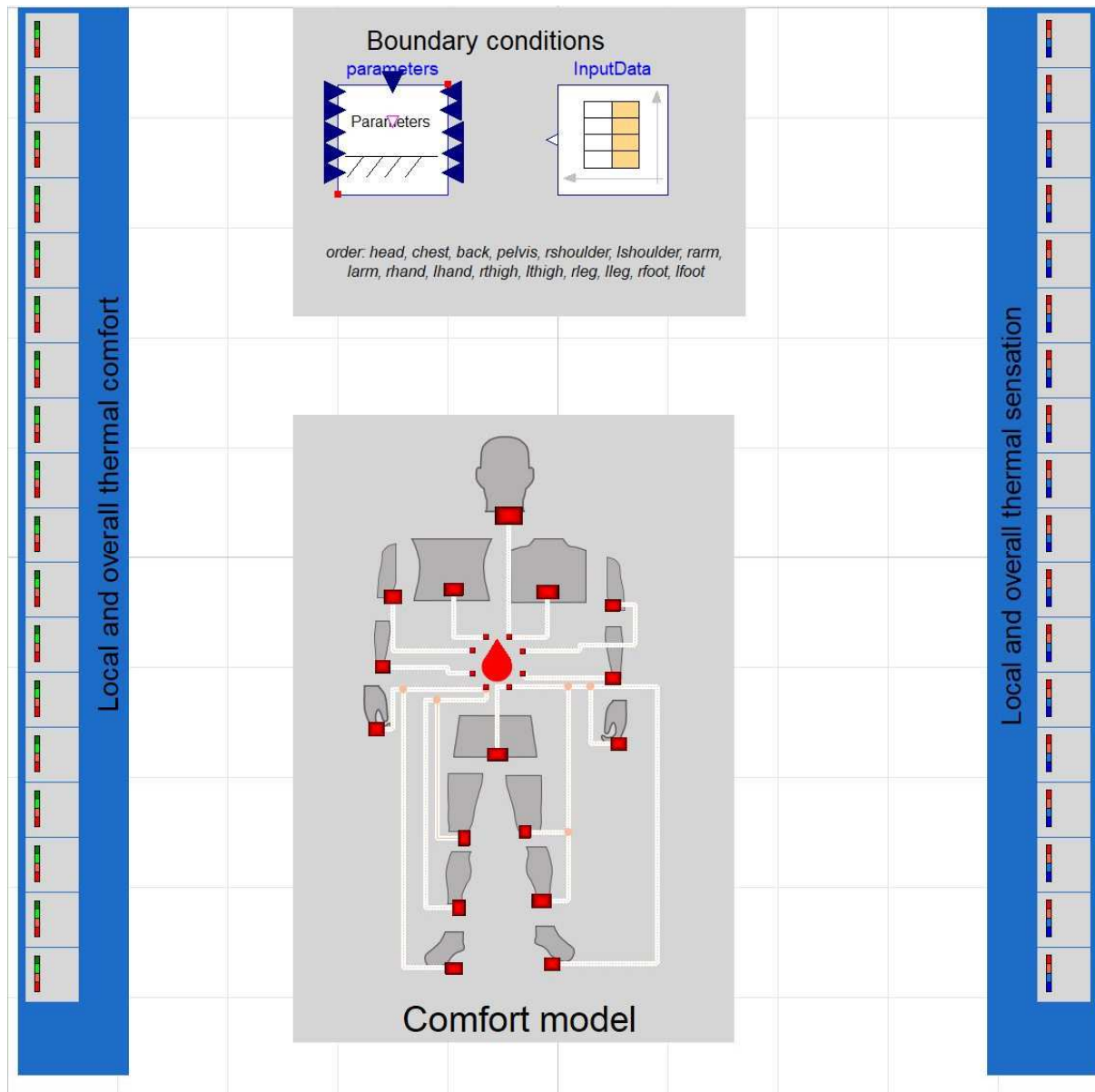


Figure 1: Nodel model in the graphical user interface

The boundary conditions are specified within a text file. The file has to be defined within the *InputData* block under *FileName*. Some examples of text files can be found within the folder *DataBase*. The text files specify the boundary conditions of different validation test cases from literature.

InputData in NOODEL.Model.NOODEL_standalone

General Add modifiers Attributes

Component

Name InputData

Comment

Model

Path Modelica.Blocks.Sources.CombiTimeTable

Comment Table look-up with respect to time and linear/periodic extrapolation methods (data from matrix/file)

Icon

CombiT...

Table data definition

tableOnFile true ▾ = true, if table is defined on file or in function usertab

table fill(0.0, 0, 2) [] = Table matrix (time = first column; e.g., table=[0,2])

tableName "table" = Table name on file or in function usertab (see docu)

fileName EL/DataBase/BC_Jacquot_24-16_degree.txt [] = File where matrix is stored

verboseRead true ▾ = true, if info message that file is loading is to be printed

Table data interpretation

columns 2:132 [] = Columns of table to be interpolated

smoothness Modelica.Blocks.Types.Smoothness.LinearSegment ▾ = Smoothness of table interpolation

extrapolation Modelica.Blocks.Types.Extrapolation.LastTwoPoint ▾ = Extrapolation of data outside the definition range

offset [0] [] = Offsets of output signals

startTime 0 s = Output = offset for time < startTime

timeScale 1 s = Time scale of first table column

OK Cancel Info

Figure 2: Definition of the file with the input data

Structure of the *InputData* text file

The first two lines are fixed. With table(x,y) the dimensions of the matrix are given. X has to be adjusted for the individual cases as it gives the number of rows which correspond to the number of given timesteps.

```
#1
```

```
double table(x, 132)
```

The matrix has 132 columns. Within the matrix the order of the 16 body segments is always the following

head, chest, back, pelvis, right shoulder, left shoulder, right arm, left arm, right hand, left hand, right thigh, left thigh, right leg, left leg, right foot, left foot

```
#1
double table(5, 134)
0 21 21 21 21 21 21 21 21 21 21 21 21 21 21 21 :
3600 21 21 21 21 21 21 21 21 21 21 21 21 21 21 21 :
3600 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24 :
6300 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24 :
13500 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16
```

Figure 3: Extraction of the input text file

The columns have the following data:

1	Time step in seconds
2 – 17	Air temperature in °C at all 16 body segments
18 – 33	Radiative temperature in °C at all 16 body segments
34 – 49	Air velocity in m/s at all 16 body segments
50	relative air humidity
51	Metabolic rate in met
52 – 67	Local clothing value in clo at all 16 body segments
68 – 83	Relative local surface area in contact with material
84 – 99	Local contact temperature of material in °C
100 – 115	Relative local surface area exposed to solar irradiation
116 – 131	Solar irradiation on local body part in W
132Position:	0 – sitting, 1 - standing

Under *Parameters* the initial skin and core temperature can be given.

parameters in NOODEL.Model.NOODEL_standalone ? X

General Add modifiers Attributes

Component

Name parameters

Comment

Model

Path NOODEL.Interfaces.Parameters

Comment BC human body

Icon

Param. Parameters

Parameters

T0sk	34.2	° C	Initial skin temperature
T0cr	35.2	° C	Initial core temperature

OK Cancel Info

Figure 4: Specification of initial skin and core temperature within Parameters

Evaluation

TC Overall – Overall thermal comfort on a seven point scale with -3 very uncomfortable to 3 very comfortable

TS overall – Overall thermal sensation on a seven point scale with -3 cold to 3 hot

TCI – Local thermal comfort for all 16 body parts

TSI – Local thermal sensation for all 16 body parts