Model validated on Clean Sky Ground Thermal Test Bench
The thermal model development is accompanied by a wide temperature and pressure range validation on the Clean Sky Ground Thermal Test Bench (GTTB).

Within Clean Sky eco DESIGN® for systems the GTTB is designed and installed by Fraunhofer IBP. It features unique conditions for environmental testing on ground ranging from hot and humid ground conditions to cold low pressure flight conditions. Tests can be conducted on this test facility according to the Do160 and beyond. The GTTB consists of three Business Jet fuselage mock-ups and the Aircraft calorimeter.

Possible areas of application
– Optimization of ventilation performance of the aircraft air conditioning system
– Optimization of aircraft architectures for better thermal management
– Thermal comfort assessment
– Development of technologies to improve aircraft acclimatization

Customer benefits
– Efficient creation of thermal models
– Quick thermal simulation of various architectures
– Conclusive presentation of results

Contacts

Thermal Model
Gunnar Grün
Fraunhofer Institute for Building Physics
Phone +49 8024 643 228
gunnar.gruen@ibp.fraunhofer.de

Clean Sky Project Management
Markus Siede
Fraunhofer Institute for Building Physics
Phone +49 8024 643 674
markus.siede@ibp.fraunhofer.de
Thermal model generation tool
The tool enables the user to set up a geometrically correct thermal model for complex architectures that allows predicting the impact of heating and cooling devices and their location both in terms of airflow pattern and radiation distribution. Using a geometry file exported from CAD software, the tool distributes wall facets, air nodes and computes the long wave radiant view factor matrix for obstructed and unobstructed surfaces. This information is exported as ready to use Modelica code.

- The generated thermal model includes:
  - airflow by the Velocity Propagating Zonal Model (VEPZO)
  - Radiation Model based on Zonal grid (RADZO)
  - Enclosures Model based on Zonal grid (ENCZO)

VEPZO model
The aim of the zonal model is to perform quick simulations of the airflow pattern and temperature distribution in aircraft. Therefore an air volume is subdivided into several discrete zones. Zonal models are an optimization between the more complex CFD calculations and the approximation of a perfectly mixed air volume. A new approach of such models has been developed, the Velocity Propagating Zonal Model (VEPZO). The VEPZO model is using the airflow velocity as a property of a zone and a viscous loss model in order to match the physics of airflows.

Two main components of the VEPZO model are the volume model and the flow model.
- The volume model provides:
  - Mass Conservation
  - Enthalpy Conservation

The flow model calculates the mass flow rate from the pressure difference.
- The advantages of the VEPZO model are:
  - moderate computational cost
  - local resolution

RADZO model
The RADZO model calculates long wave radiant heat exchange between “n” surfaces. It contains “n” thermal ports, surface properties and it generates a “n x n” view factor matrix. Each port connects to the corresponding surface model. The incoming and outgoing radiations for each surface are computed using the view factor matrix, the temperature at each thermal port and surface properties.

The RADZO model contains:
- computation of radiative heat exchange from e.g.
  - hot equipment
  - passengers
  - enclosures
- check for obstructions
- export of the view factor matrix

ENCZO model
Convective heat transfer coefficients are calibrated for specific applications. The convection model uses correlations of convective heat transfer coefficients to simulate convective heat exchange. Wall models are based on a suite of thermal capacitances and thermal resistances. The parameterization of these models yields the different materials that can be used.

The ENCZO model includes:
- heat exchange between inner and outer aircraft environment
- heat transfer coefficients for aircraft enclosures
- materials library for aircraft application

Thermal model results visualization
- Export of simulation results
- Visualization of
  - air temperatures and airflow pattern
  - surface temperatures
  - equipment temperatures