FUNCTIONAL AUTOMOTIVE GLASS AND ITS CONTRIBUTION TO THERMAL MANAGEMENT

Lisa Goebbels, Saint Gobain Sekurit
Marek Lehockey, Gamma Technologies
AGENDA

1. How does High Performance glazing work?
2. What influence does High Performance Glazing have?
3. How is glass considered in the GT-SUITE simulation?
AGENDA

1. How does High Performance glazing work?
2. What influence does High Performance Glazing have?
3. How is glass considered in the GT-SUITE simulation?
**HOW DOES HIGH PERFORMANCE GLAZING WORKS?**

**Total Transmission of Solar Energy (TTS)**
Part of solar energy that gets inside the vehicle, direct and indirect

Direct energy input: Transmission (T)
Indirect energy input: Emission (E_{in})

---

**Increase of energy reflection**

**Decrease of re-emissivity**

---

**ClimaCoat (IR reflecting windshield)**

**SGS Comfort Sky (LowE sunshine roof)**

Part of solar energy that gets inside the vehicle, direct and indirect

Direct energy input: Transmission (T)
Indirect energy input: Emission (E_{in})
1. How does High Performance glazing work?
2. What influence does High Performance Glazing have?
3. How is glass considered in the GT-SUITE simulation?
WHAT INFLUENCE DOES HIGH PERFORMANCE GLAZING HAVE?

Different glazing combinations

Changing orientation of the sun

Comfort

Cooling need at a drive cycle
WHAT INFLUENCE DOES HIGH PERFORMANCE GLAZING HAVE?

→ All influences and cases cannot be simultaneously and repeatably investigated using measurements.
Different glazing combinations

Changing orientation of the sun

Comfort

Cooling need at a drive cycle

Need for a simulation tool that simultaneously accounts for relevant influences on comfort and energy consumption:
- which provides repeatability
- which is usable as internal standard tool (fast and flexible)
Influence of the high-performance glazing on indoor climate and comfort:

- Reduction of the air temperature by 10°C after parking in the sun
- Shortening Time-to-Comfort by 5 minutes - Comfort achieved after 15 instead of 20 minutes
WHICH INFLUENCE HAS HIGH PERFORMANCE GLAZING?

Influence of the high-performance glazing with standard air temperature-based control:

- Reduction of the power requirement by 40% when reaching the target temperature of 20 °C
- Reduction of the required HVAC energy by 10% over WLTC drive-cycle
WHAT INFLUENCE DOES HIGH PERFORMANCE GLAZING HAVE?

Influence of high-performance glazing with comfort-based control:

- Reduction of the power requirement by 50% when comfort is achieved
- Reduction of the required HVAC energy by 19% over WLTC drive cycle
WHAT INFLUENCE DOES HIGH PERFORMANCE GLAZING HAVE?

Influence of the reduced radiant heat by high performance glazing:

- Significant savings in cooling energy and early reduction of cooling capacity in the standard case
- Great potential for further savings in cooling energy through comfort control or sensitive users
WHAT INFLUENCE DOES HIGH PERFORMANCE GLAZING HAVE?

AIR TEMPERATURE & COMFORT

Temperature reduction at the end of the heating phase: 10°C*
After switching on the air conditioning: Time-to-Comfort in ¾ of time – 5 minutes faster*

REduced COOLING DEMAND

Up to 50% * reduced cooling capacity

EV Compact class
• 1 Volume
• 0D Simulation

Glazing sets:
• Standard
• High performance Set

Driving cycle
• Sun Soak + WLTC

ENERGY SAVING

Up to 19% * Energy saving of air conditioning

Changing sunlight:
• Ride on circular path, at 25°C and 1000 W/m²

Control
• Standard control
• Simplified Comfort-based control

*Results are based on a highly simplified model that can not be translated to real vehicle.
1. How does High Performance glazing work?
2. What influence does High Performance Glazing have?
3. How is glass considered in the GT-SUITE simulation?
Objectives of the simulation model:

- Influence of the air-conditioning system on the energy consumption of the electric vehicle
- Fast evaluation of different glazing concepts
- Variation of the boundary conditions
Objectives of the simulation model:

• Influence of the air-conditioning system on the energy consumption of the electric vehicle
• Fast evaluation of different glazing concepts
• Variation of the boundary conditions
HOW IS GLASS CONSIDERED IN THE GT-SUITE SIMULATION?

Cabin modeling
Choice depending on simulation focus

System oriented
Component-oriented

0D-1D
3D Coarse-Grid
3D Detailed CFD

Increased resolution and accuracy
Increased simulation time

HIGH PERFORMANCE SOLUTIONS • SAINT-GOBAIN SEKURIT
Advantages of the 1-volume cabin model

- Parameterized cabin geometry
  - GT-SUITE includes predefined cabin models
- Negligible simulation time
- Correct thermal behavior for the heating and cooling phases
- Suitable for system-oriented studies
- Simple model adjustment
Current model status in GT-SUITE:

- Glass properties without dependency on angle of incidence
- Simplified representation of the position of the sun
Necessary model adjustments

- Angle of incidence dependent glass properties
- Time-dependent driving direction and sun position
- Integration of roof window
HOW IS GLASS CONSIDERED IN THE GT-SUITE SIMULATION?

Necessary model adjustments

\[ \gamma = \left| (\phi - \Psi) \right| \]

\[ \cos \theta = \cos \beta \cos \gamma \sin \Sigma + \sin \beta \cos \Sigma \]
Validation of the simulation

- ISO 13837
- Sun position
- Driving direction
Implementation of the 3D-Based cabin model

- Software tool GT-TAITherm
- High-resolution solution
  - Local air and component temperature
  - Detailed internal radiation
  - Physiology-based comfort modeling
- Wavelength-dependent glass properties
- Integration into thermal management systems
Temperature reduction at the end of the heating phase: 10°C*
After switching on the air conditioning: Time-to-Comfort in 3/4 of time – 5 minutes faster*

Up to 50% * reduced cooling capacity

Up to 19% * Energy saving of air conditioning

Vehicle driveline model
• Drive-cycle selection

Solar-boundary conditions
• vehicle direction
• sun’s position

HVAC
• Integrated refrigeration circuit

Glazing sets:
• Interchangeable glazing

EV compact class
• 1 Volume cabin

SUMMARY