CFD Modeling Of Water Vapor Fogging and Defogging Inside Automotive Headlamps

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PRESENTATION TOPICS

• Company Overview;

• Problem Description;

• Methodology;

• Results;

• Conclusion and next steps.
Company Overview

Foundation Date: 1976

Number of employees: 22,377

Annual capacity of production: 800,000 vehicles

Annual sales: R$ 20.6 billion

Fiat Automobiles Brazil is the main market of the Fiat Group Automobiles out of Italy. The production of the Brazilian plant represents 30% of the total production of the FGA.
Problem Description

• When the Headlamps lens started to be produced completely transparent, the condensation becomes more visible to the clients and beginning to be a quality problem.

• Nowadays this problem can be detected only when the project is concluded and the manufacture tools are completely done. At this time is very difficult and expensive doing any modification.

• For this reasons is necessary develop a methodology to simulate water vapor fogging and defogging on the interior of automotive headlamps.
Methodology

- Code: ANSYS FLUENT 12.1
  - Linked with fogging/defogging DFM modulus (Fluent Inc)
- Laminar flow
  - The fluid is moved only by natural convection
- Discrete ordinates radiation model (Fiveland & Jamaluddin, 1989)
- Fluid: Humid air as ideal gas
  - Volumetric fraction according the relative humidity prescribed calculated by the balance equation.
Methodology

Boundary Conditions to Simulate the Fogging and Defogging

<table>
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<tr>
<th>Time Period</th>
<th>Condition</th>
<th>Description</th>
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| 0 min                | Start condition  | • Temperature: 25 °C  
                      |                                                | • Relative Humidity: 95%  
                      |                                                | • All the lamps off  |
| 0 min → 30 min       | Heating          | • Temperature: 25 °C  
                      |                                                | • Relative Humidity: 95%  
                      |                                                | • All the lights on with the direction indicator flashing at the frequency 1,5Hz.  
                      |                                                | • Engine working temperature: 90°C  |
| 30 min → 35 min      | Fogging          | • Water temperature (focusing on external lens): 25 °C  
                      |                                                | • Temperature: 25 °C  
                      |                                                | • Relative Humidity: 100%  
                      |                                                | • All the lamps off  |
| 35 min → 60 min      | Defogging        | • Temperature: 25 °C  
                      |                                                | • Relative Humidity: 95%  
                      |                                                | • All the lamps off  |
Results - Heating

Temperature on the External Surface of the Lens
Results - Heating

Temperature on the Internal Surface of the Lens
Results - Heating

Relative Humidity on the Internal Surface of the Lens

High relative humidity points
Results - Heating

Air gets into the Headlamp
Results - Heating

Air get into the Headlamp

Air get out the Headlamp
Results - Condensation
Results - Condensation

Temperature on the Internal Surface of the Lens
Results - Condensation

Fogging on the lens after a condensation test
Results - Evaporation

The water film evaporate quickly at this step because of two reasons:
- The temperature of the lens increase (internal heat exchange).
- The relative humidity decrease to 95%.
Results - Evaporation

Temperature at the Internal Surface of the Lens
Conclusion and next steps.

- The CFD simulation were capable to represent the three steps of the automotive headlamps condensation test: heating, condensation and evaporation.

- Some boundary conditions: heating time and water temperature, must be adjusted to simulated better the most severe conditions that could be found during the vehicle life.

- Will be necessary modify the actual condensation standard test to achieve a better correlation between physical test and CFD simulation.