

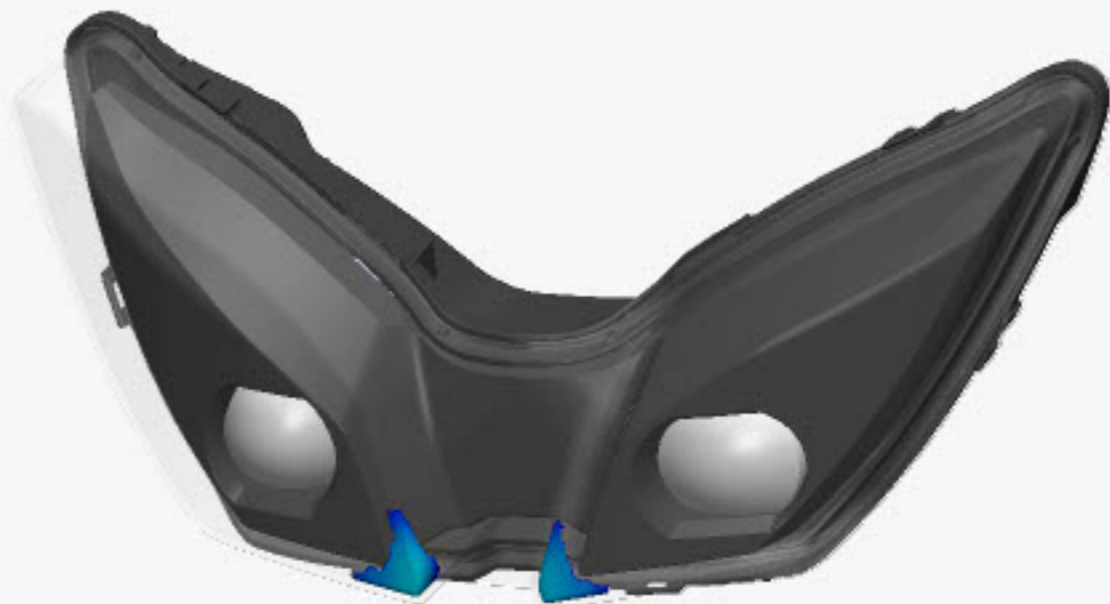


# Headlamp Fogging Simulation

Simcenter FloEFD

Application Engineer

Allen Li 12/01/2022



# Agenda

- Motivation
- Literature Review
- What's Simcenter FloEFD
- Simulation Condition
- Result & Discussion

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# Acknowledgement



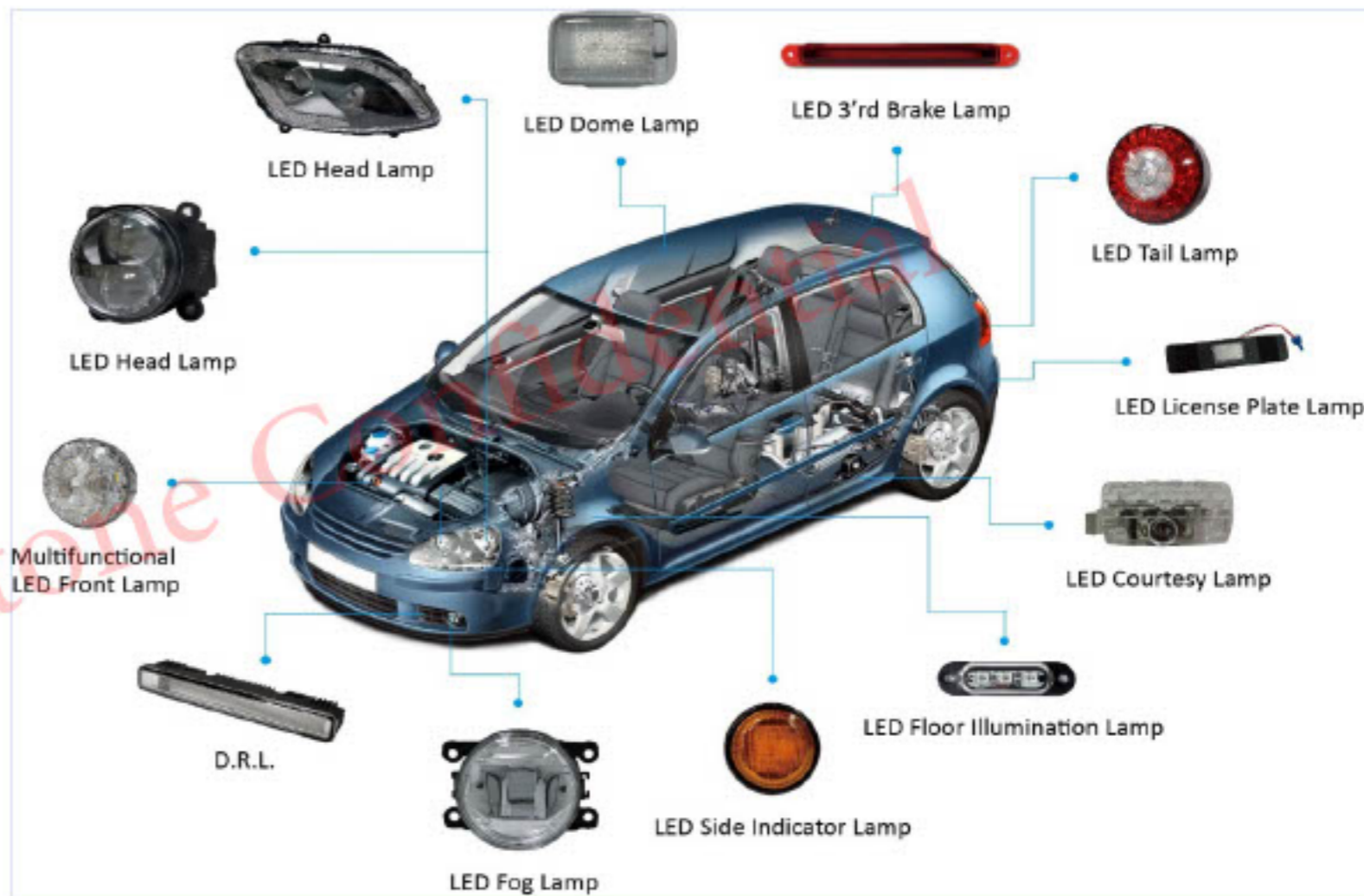
IATF 16949 : 2016



ISO 9001 : 2015



ISO 14001 : 2015



**LED Automotive Lighting / MANUFACTURER / - Since 1982 -**



# Motivation

Swimming goggle



Windscreen



Mirror



Camera Lens



GoPro Lens



Headlamp



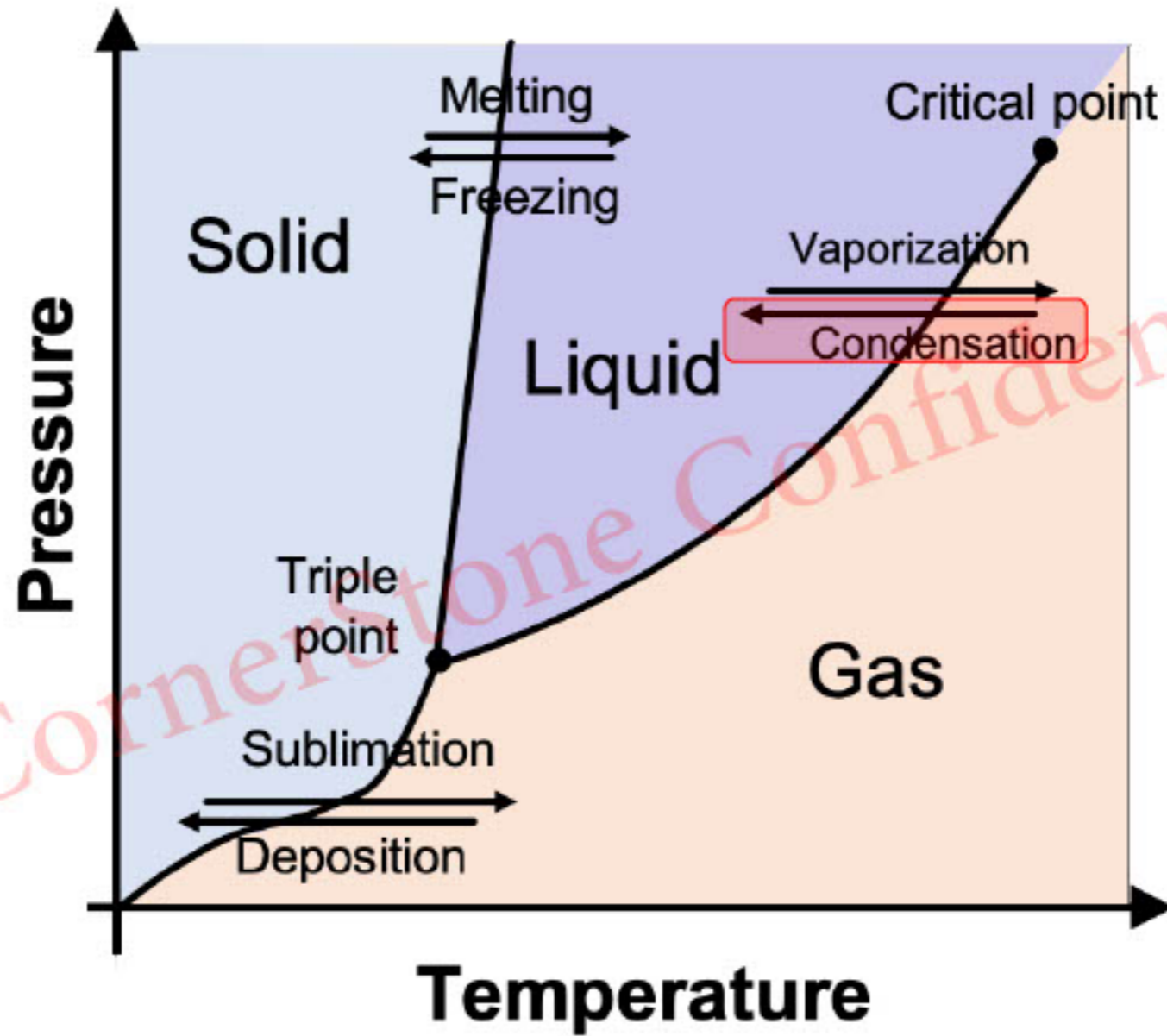


# Motivation



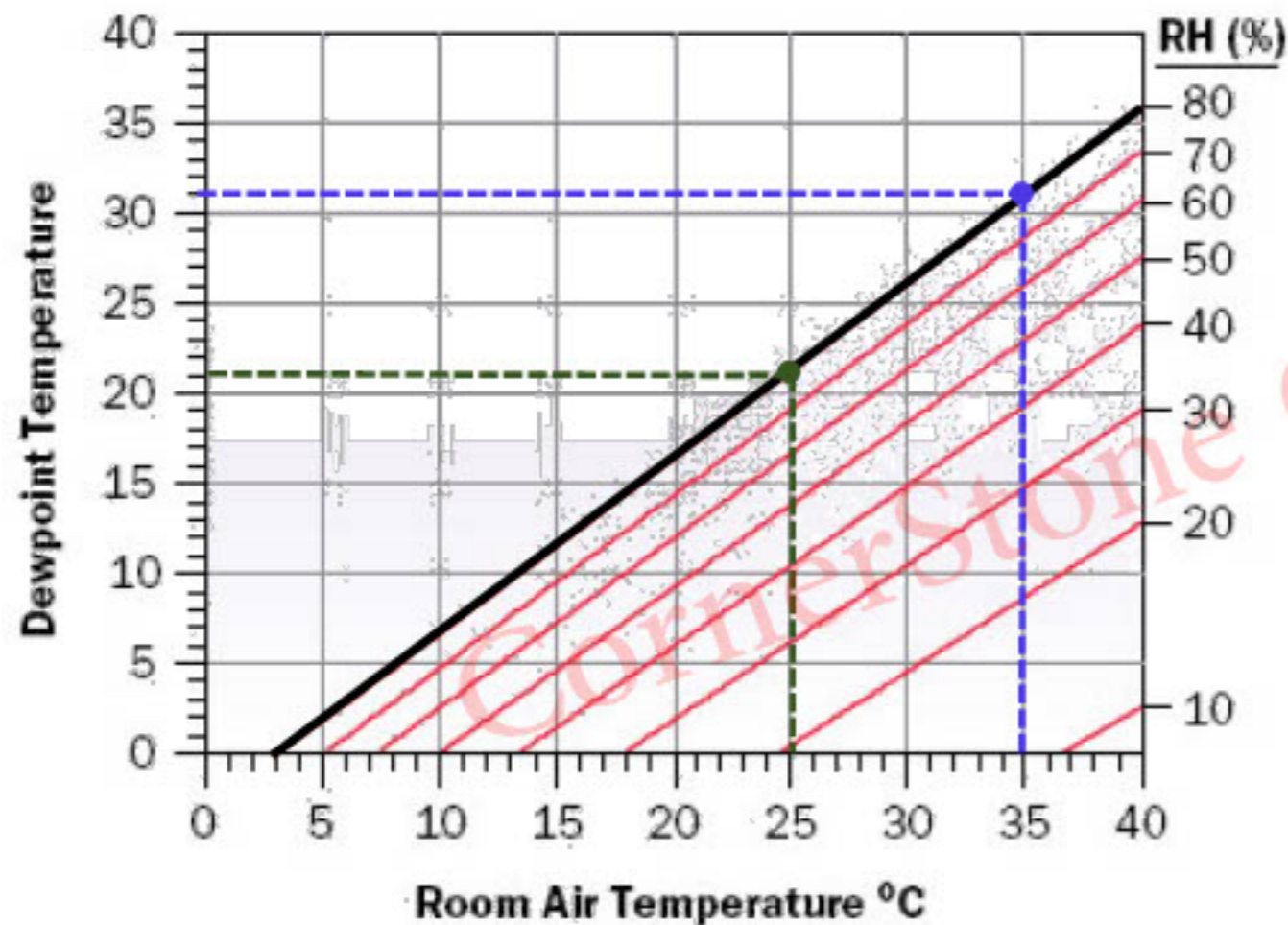
Image from <https://www.popsautoelectric.com/automotive-headlights/>

# Phase Change Diagram





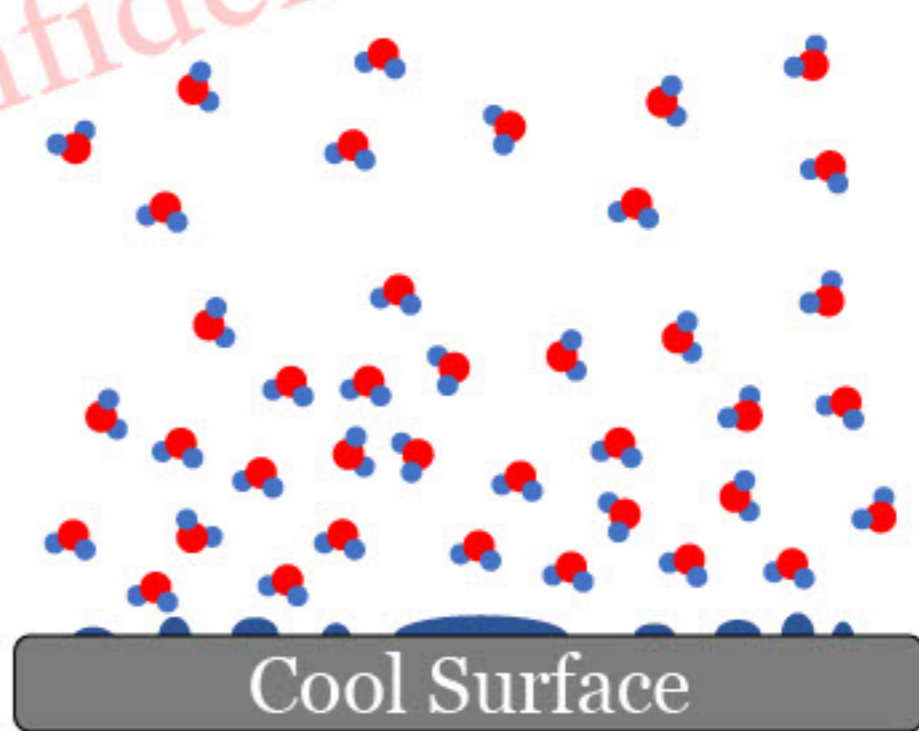
# Dew Point



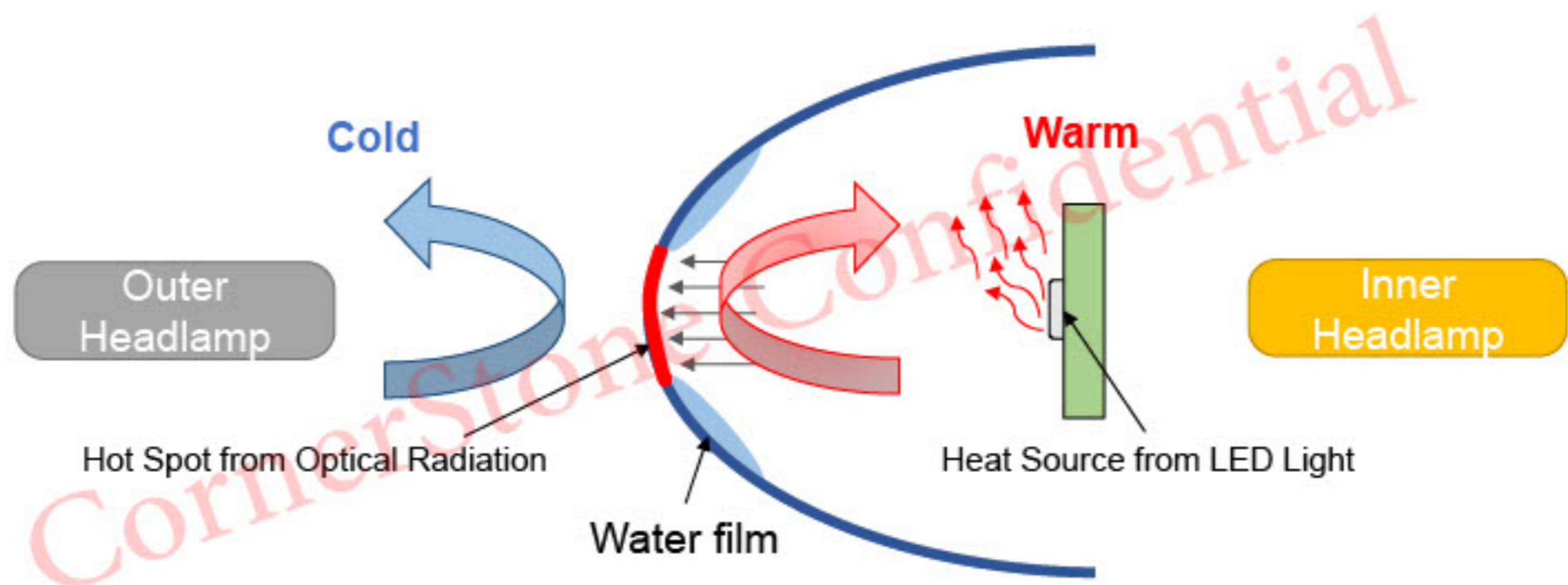
$$T_d = \frac{br(T, RH)}{a - r(T, RH)}$$

T<sub>d</sub>: Dew point temperature

1. Relative Humidity
2. Ambient Temperature
3. Surface Temperature



# Literature Review





# Literature Review

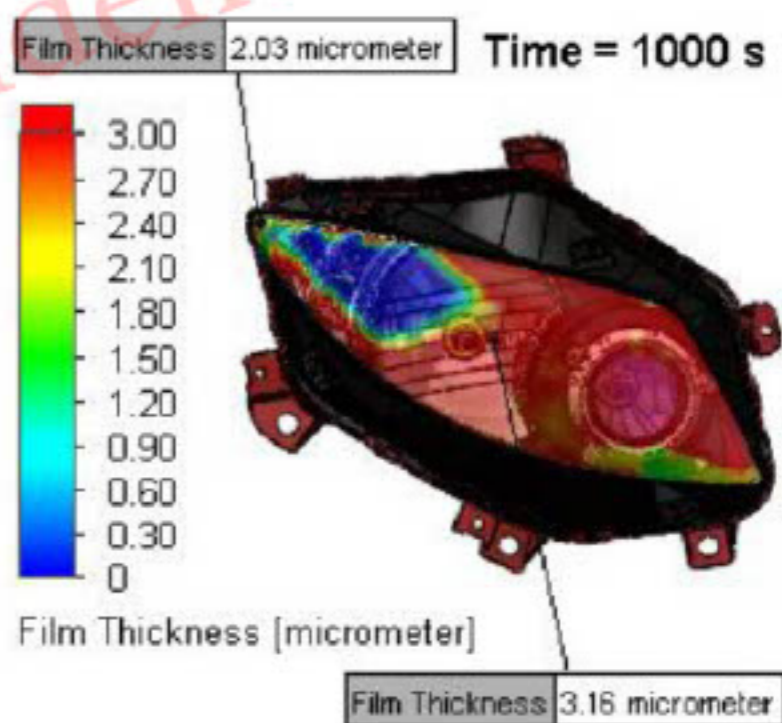
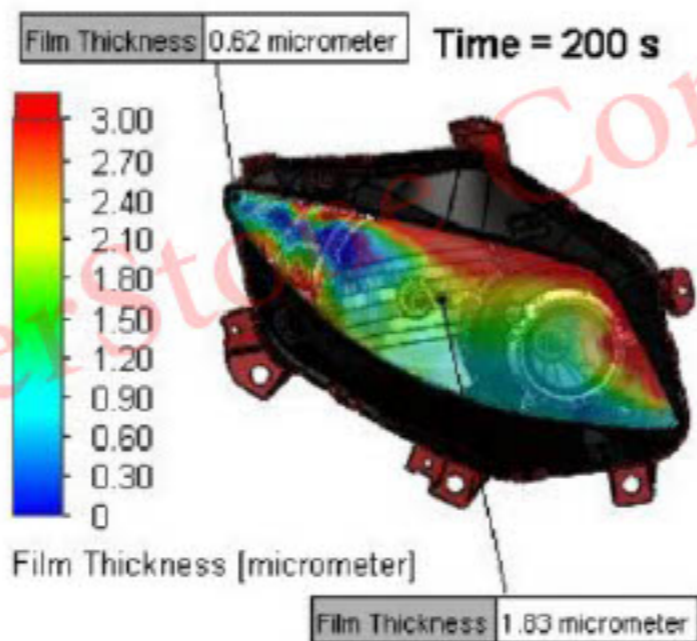
Ambient Temperature :  $-10\text{ }^{\circ}\text{C}$

Headlamp's interior Temperature :  $25\text{ }^{\circ}\text{C}$

Atmosphere : 1 atm

Relative Humidity :  $95\%$

LED Light : Turn **Off**



Mentor Graphics Corp, SAE International. (2018)



# Literature Review

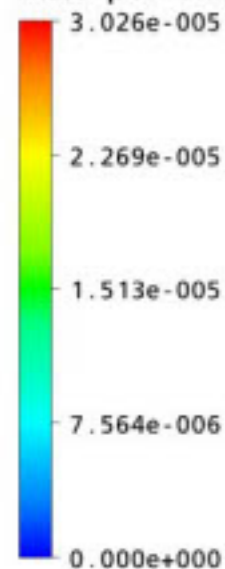
Ambient Temperature : 6 °C

Atmosphere : 1 atm

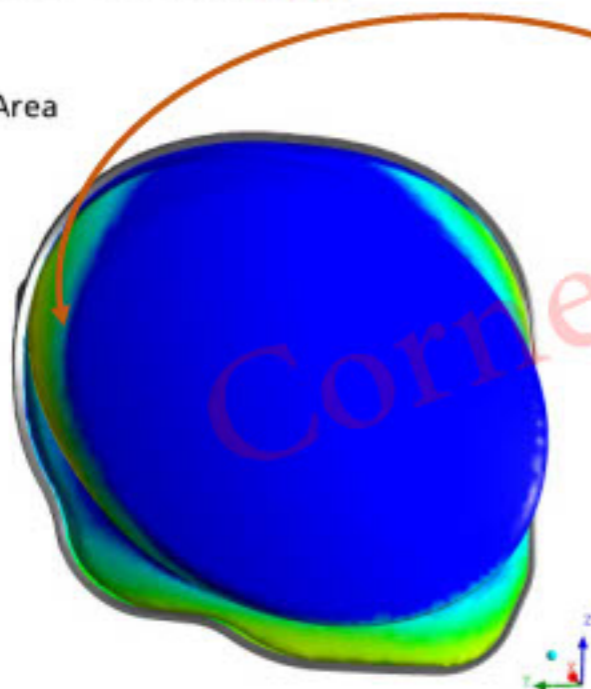
Relative Humidity : 95 %

LED Light : Turn On

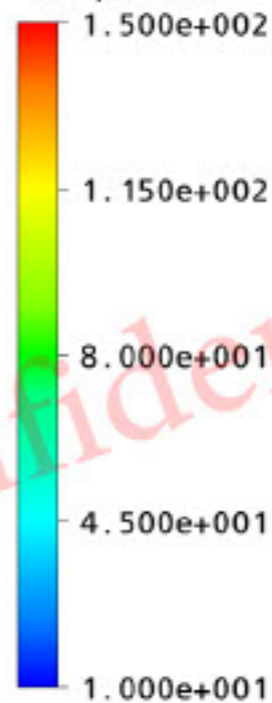
Mass per Unit Area



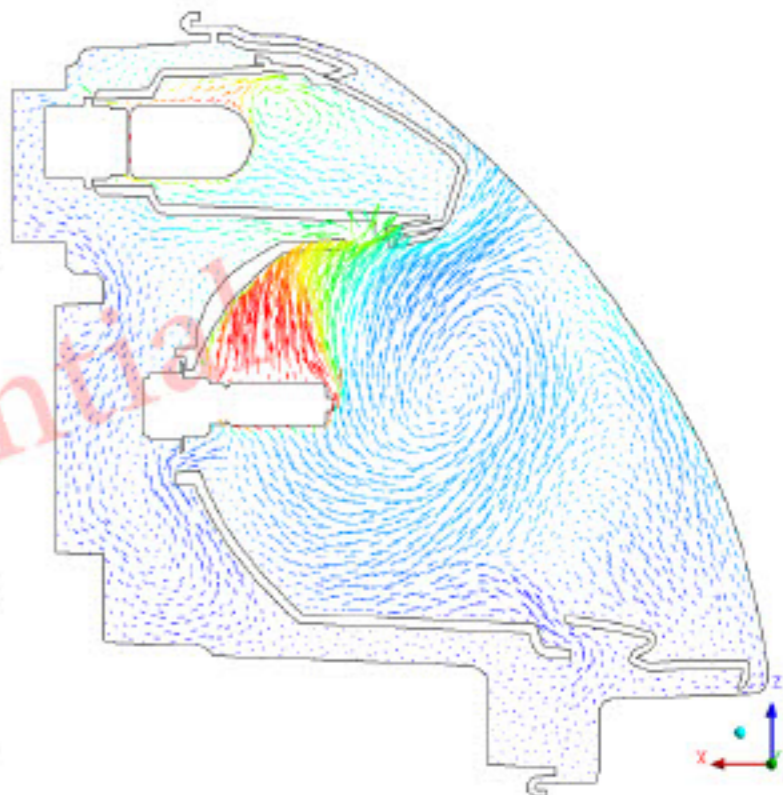
[kg m<sup>-2</sup>]



Temperature



[C]



Alberto et al., Physics. (2011)









# Simulation Condition

Ambient Temperature : 26 °C (Room Temperature)

Atmosphere : 1 atm

Relative Humidity : 80 %

Physical time: 1800 s

LED Light : Turn On (Consider optical radiation on lens)

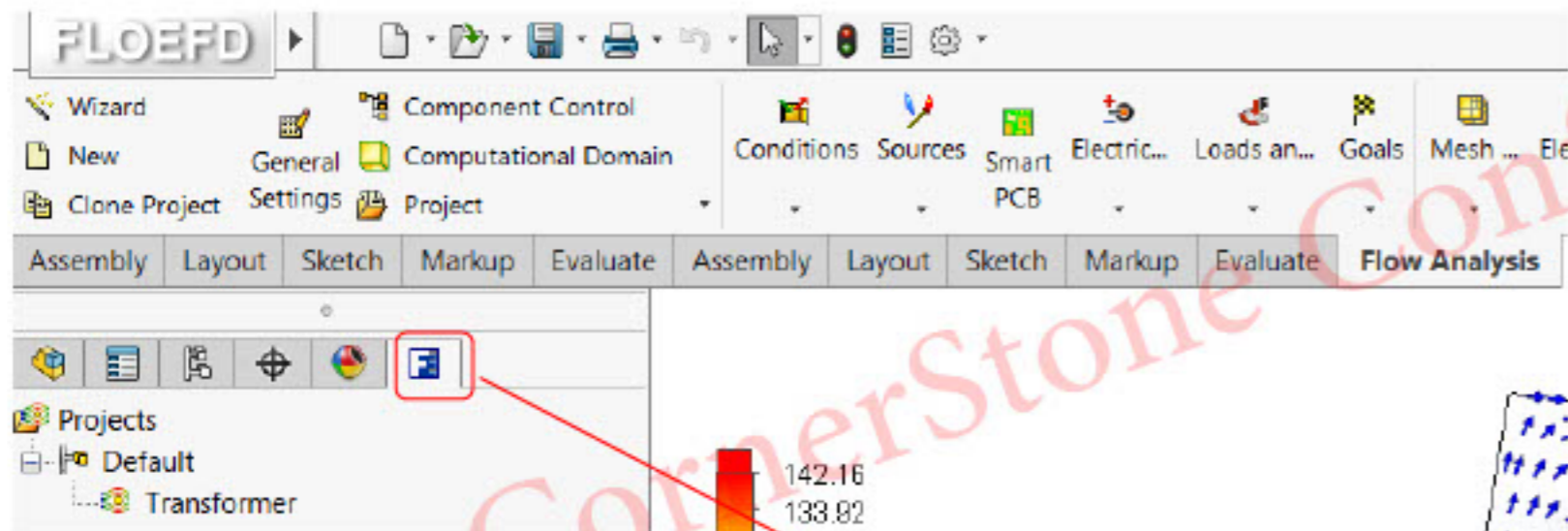
CFD Tool : Simcenter FloEFD

Easy Verification



# What's Simcenter FloEFD

No more switching between solutions from Geometry to CFD



Use your MCAD directly in FloEFD

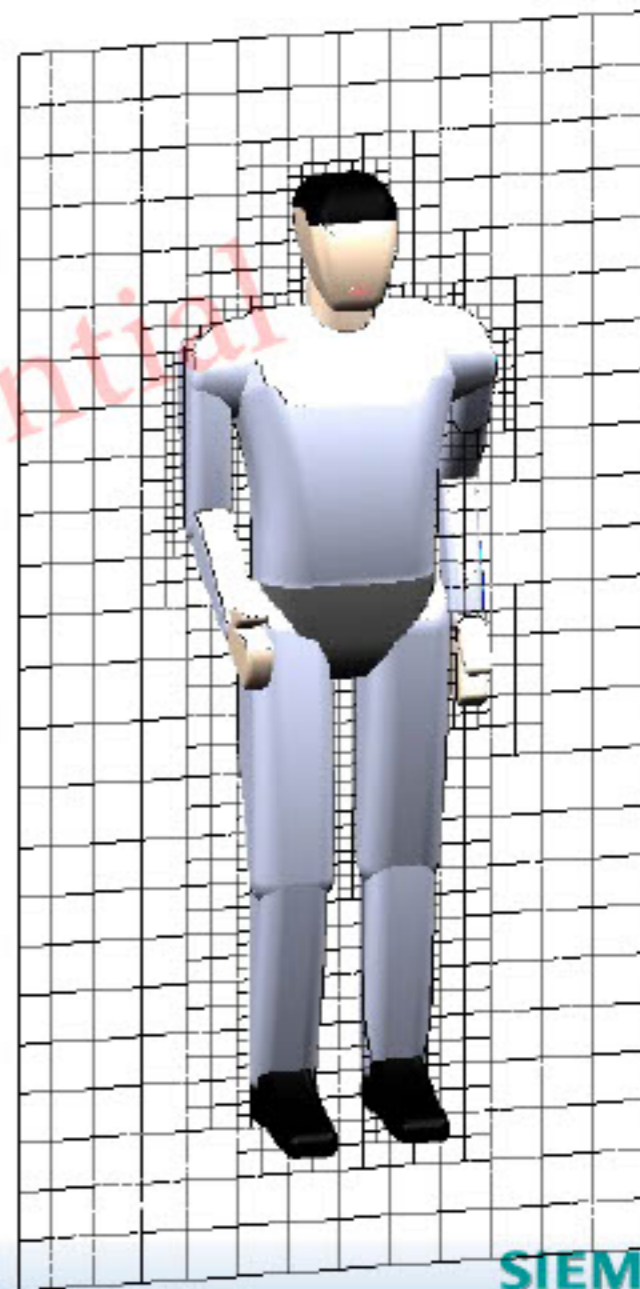
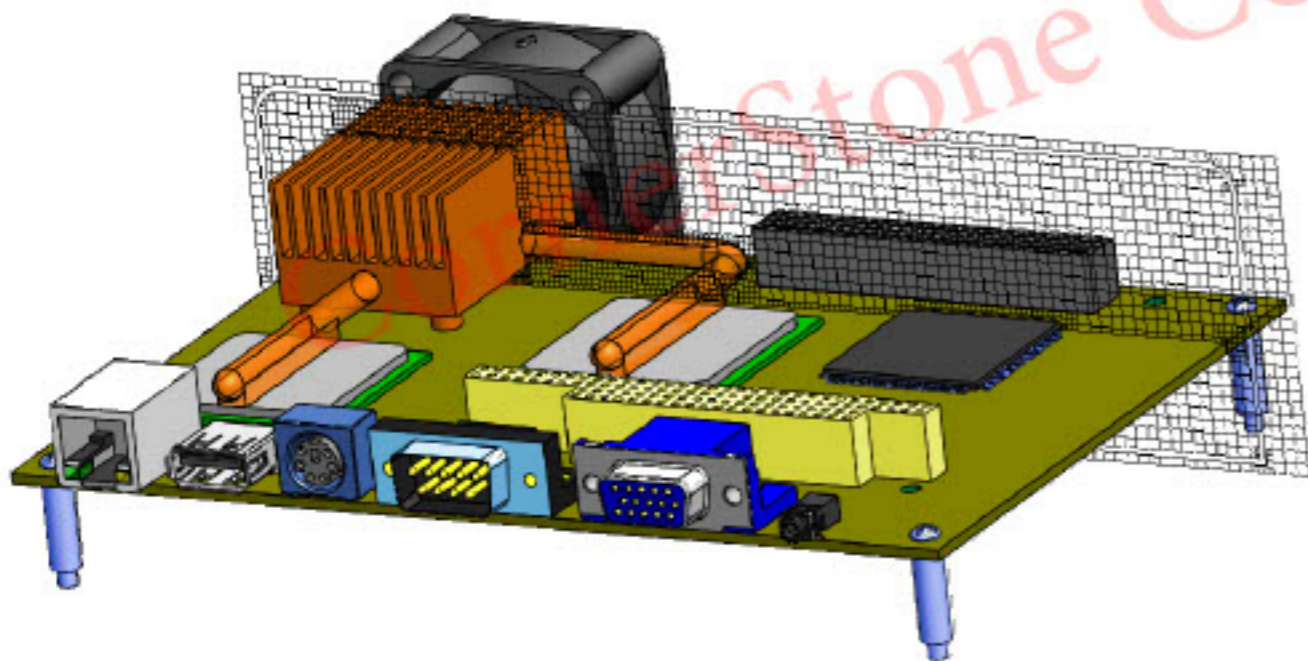




# What's Simcenter FloEFD

## Smart Cartesian Meshing Technology

- ✓ Unique SmartCell technology featuring multi control volume cells
- ✓ Automatically refines in regions based on geometry or flow conditions
- ✓ No need to be a CFD meshing expert to use FloEFD

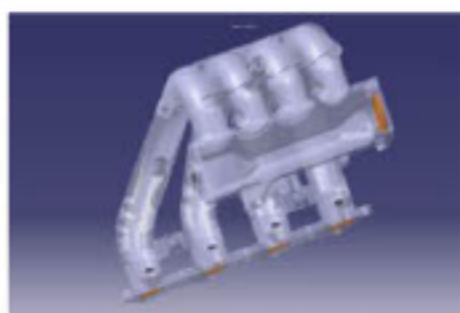




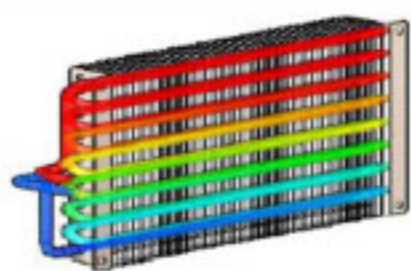
# What's Simcenter FloEFD

## Physics Range

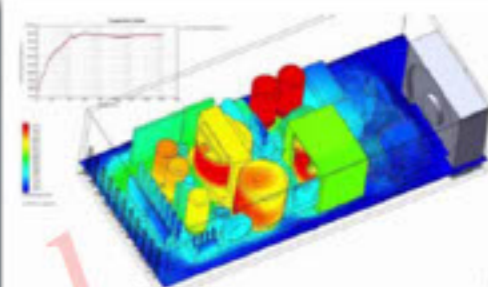
1. Fluid Flow
2. Heat Transfer
3. Real Gas Flows
4. Non-Newtonian Flows
5. Compressible Liquids
6. Free Surface Flows
7. Rotating Flows
8. Radiation & Optical Effects
9. Condensation
10. Steam and Humidity
11. Water Films
12. Sorption of Vapor
13. Surface Icing and De-icing
14. Equilibrium Combustion
15. Cavitation
16. Joule Heating
17. Aerothermal Heating
18. Hypersonic
19. Particle Tracking



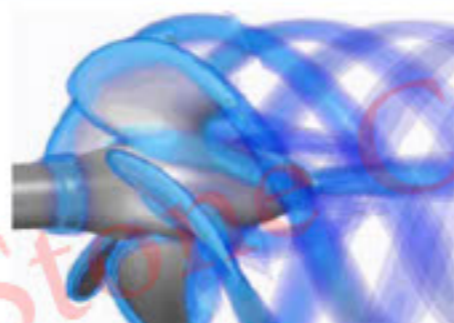
MIXING FLUIDS



REFRIGIRANTS (Real Gas)



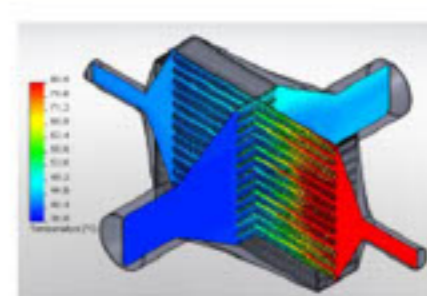
ELECTRONICS COOLING



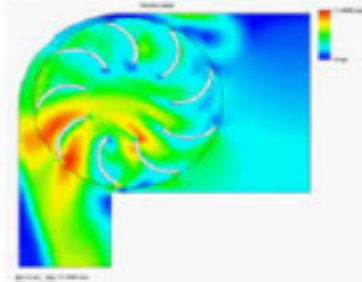
CAVITATION



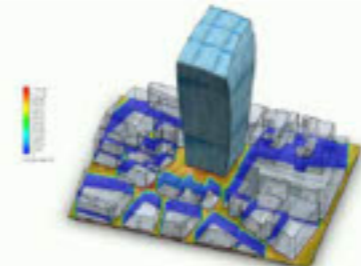
CONDENSATION



HEAT EXCHANGER



ROTATING EQUIPMENT



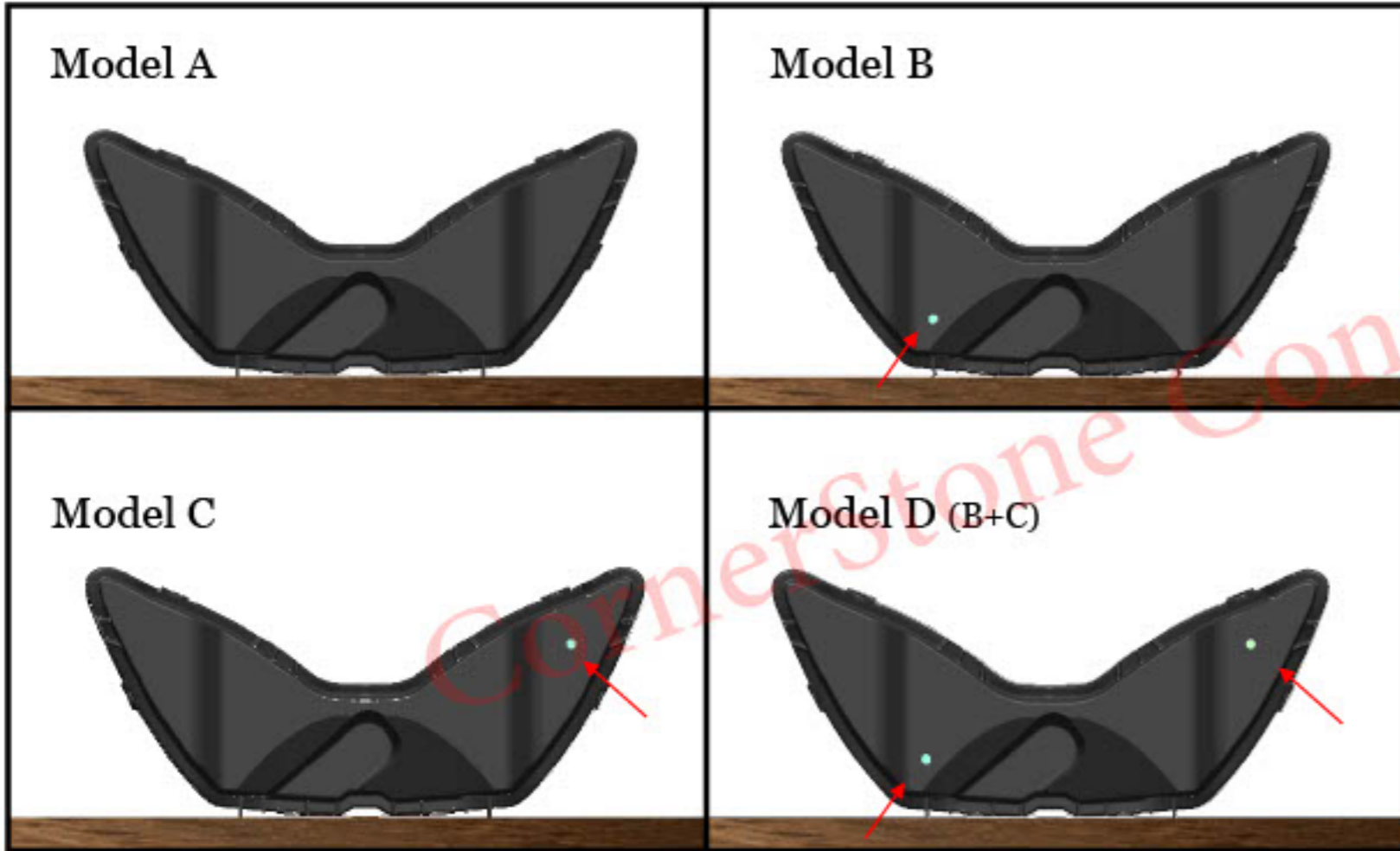
RADIATION



AERODYNAMICS



# Simulation Models

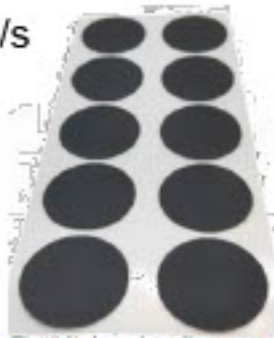


## Vent-Membrane Property

Gas permeability coefficient:  $1.14 \times 10^{-9} \text{ m}^3\text{m}/\text{m}^2\text{s}/\text{Pa}$

Vapor diffusion coefficient:  $2.41 \times 10^{-7} \text{ m}^2/\text{s}$

Thickness: 0.16 mm





# Result & Discussion

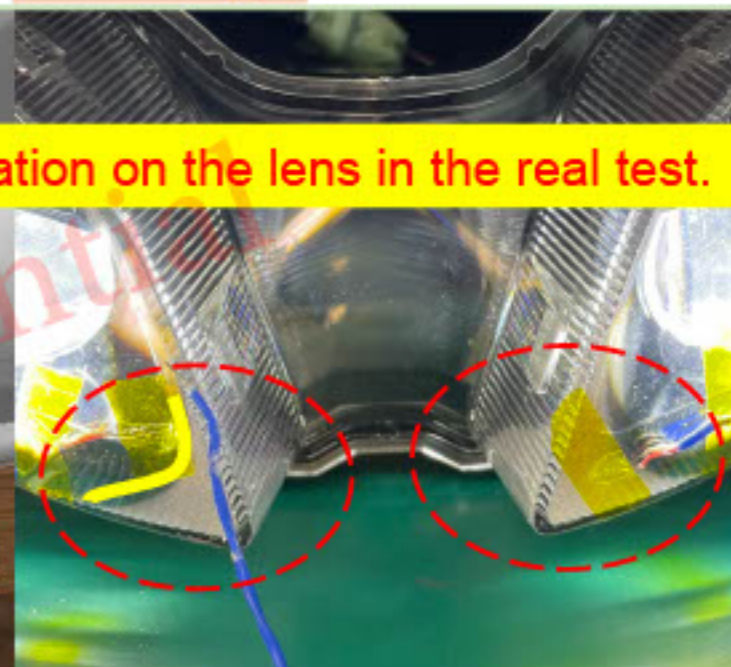
Model A



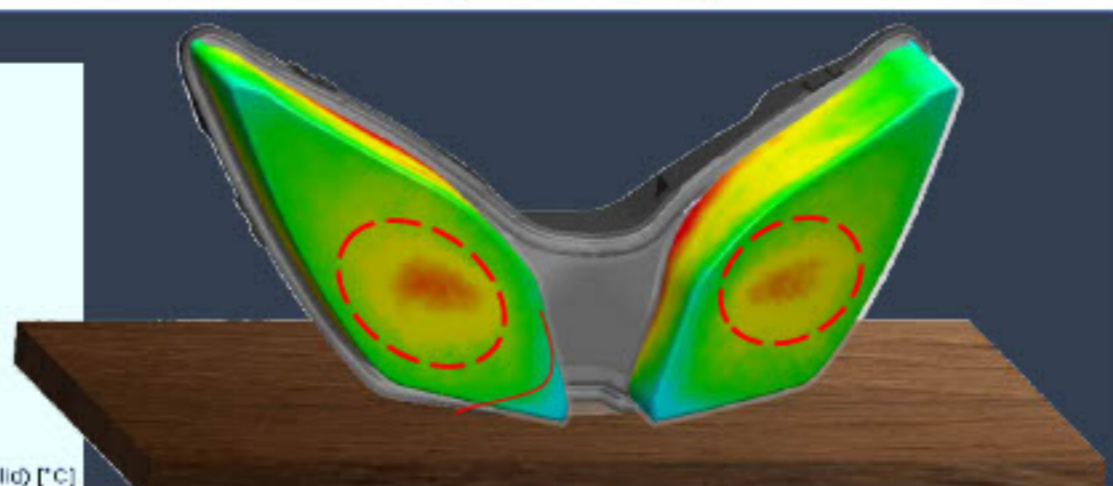
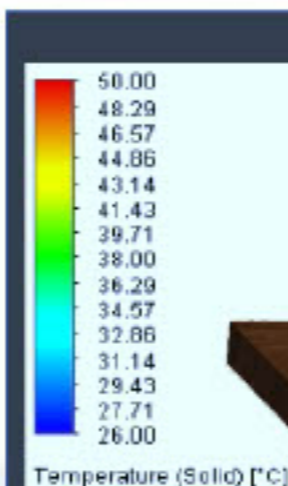
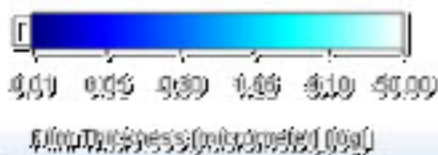
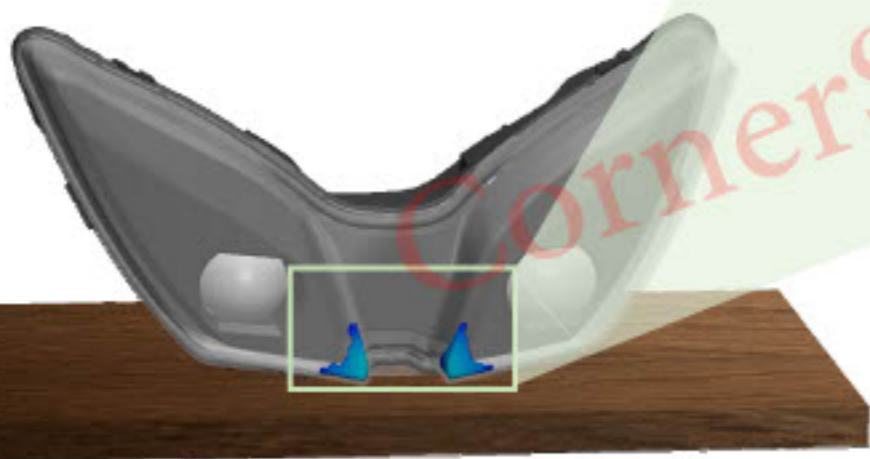
Simulation



Test Image



The simulated fogging area happens in the same location on the lens in the real test.

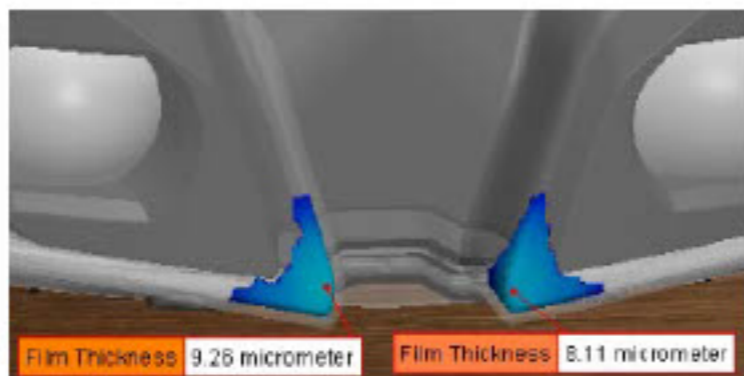


The lens are heated by LED light shows on hot spot.

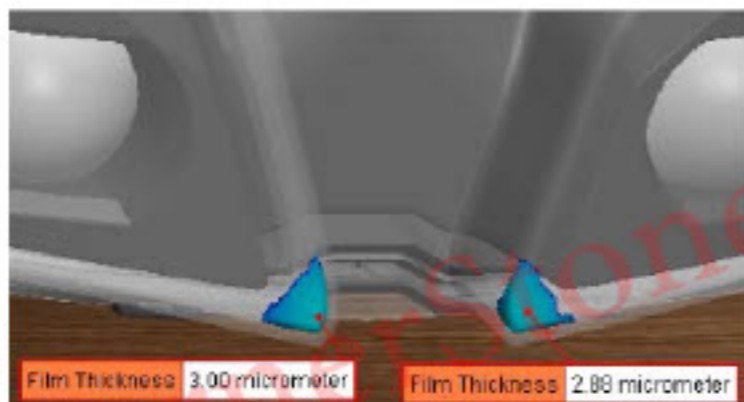


# Result & Discussion

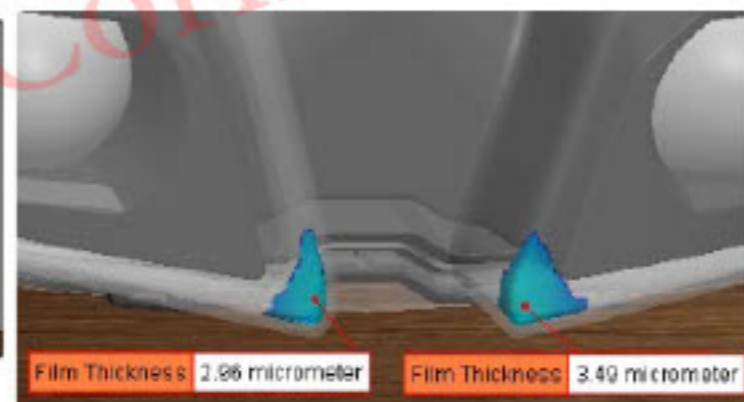
Model A



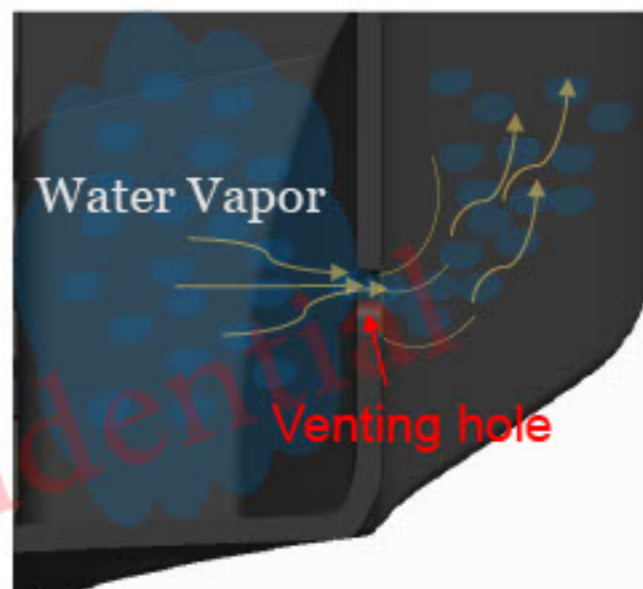
Model B



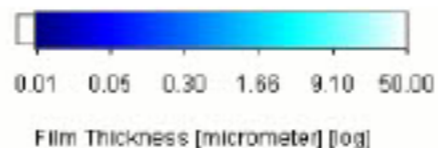
Model C



Model D (B+C)



No fogging happens on inner lens

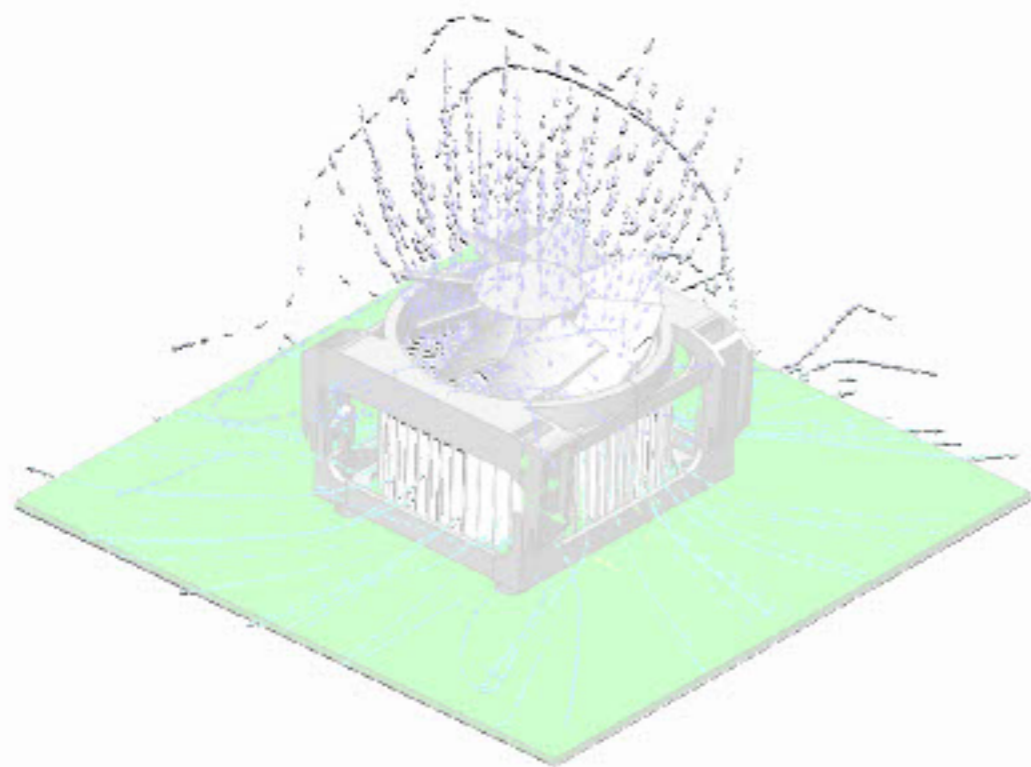


# Result & Discussion

- a. Simcenter FloEFD simulate a precise prediction for fogging phenomena.
- b. Simcenter FloEFD can help to accelerate the time from design to production.
- c. Simcenter FloEFD can easily cost down and save the money.

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