FACULTY OF ENGINEERING AND ARCHITECTURE

DEPARTMENT OF FLOW, HEAT AND COMBUSTION MECHANICS

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DEVELOPMENT OF A TWO-ZONE MODEL FOR THE HEATING AND EVAPORATION OF A DROPLET

Context and motivation

- Fire Safety Engineering (FSE)
- Improved modelling of the effect of sprinklers on fire

→ Fast and reliable calculation methods
→ Avoid lengthy CFD calculations

https://www.expressplumbingidaho.com/blog/fire-sprinklers/

http://www.delfafire-egy.com/productsdetails.php?id=11

Main equations and concept two-zone model

Mass Transfer

$$\frac{d\,m_d}{dt} = -\,\pi\, d_d^2\, h_m\, \rho_g \ln(1 + B_M)$$

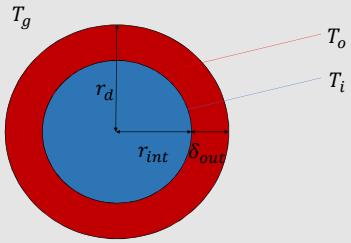
Heat Transfer

Outer layer

$$m_o c_{p,L} \frac{d\,T_o}{dt} = A_d h\left(T_g - T_o\right) + \frac{d\,m_d}{dt} L_v + \frac{d\,m_d}{dt} \frac{A_i}{A_d} c_{p,L}(T_o - T_i)$$

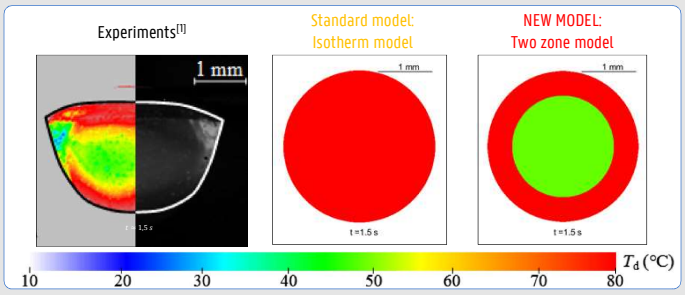
Inner layer

$$m_i c_{p,L} \frac{d\,T_i}{dt} = -\frac{d\,m_d}{dt} \frac{A_i}{A_d} c_{p,L}(T_o - T_i)$$

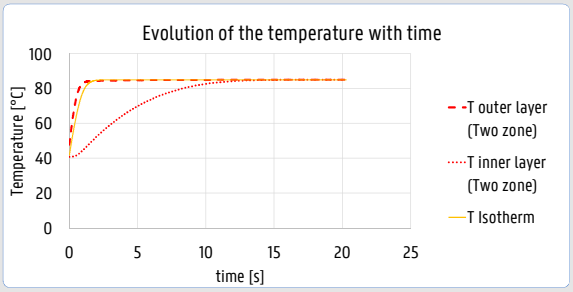


Results for the case: "Initial conditions : $U_a = 3\ m/s$, $T_{amb} = 800\ °C$"

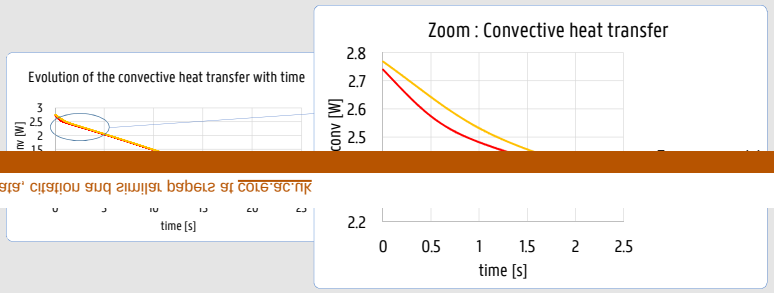
Comparison temperature fields



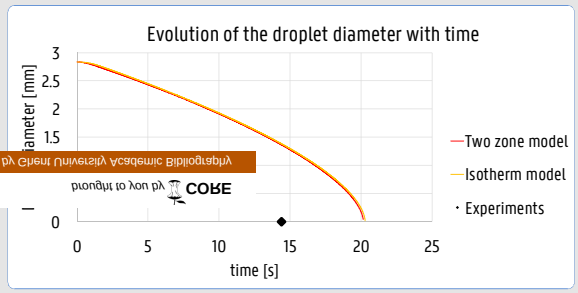
Saturation temperature



Heat exchange with surrounding



Droplet lifetime



Conclusion

- Better representation of the instantaneous temperature fields
- Almost no impact on saturation temperature → still overpredicted
- Almost no impact on droplet life time → still overpredicted
- Very small impact on convective heat exchange BUT in sprinklers millions of droplets
  - ↳ may have an impact

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[1] Volkov, R. and Strizhak, P. (2017) Planer laser-induced fluorescence diagnostics of water droplets heating and evaporation at high-temperature, Applied Thermal Engineering, 127:141-156, https://doi.org/10.1016/j.applthermaleng.2017.08.040

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Opening new horizons

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