Numerical Analysis of Conjugate Heat Transfer in a Combustion Chamber and Firetubes

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Introduction: COMSOL was used to verify handbook predictions from Heat Transfer Research Inc. (HTRI) for the heat transfer coefficient for a combustion chamber and its firetubes.

Figure 1. Picture of combustion chamber modeled

Computational Methods: Conjugate heat transfer (conduction, convection + surface radiation) was used. The Navier Stokes solver in COMSOL was used in conjunction with the Heat Transfer Equations:

$$\rho c_p \vec{u}\cdot\nabla T + \nabla\cdot\vec{q} = Q, \vec{q} = -k\nabla T$$

$$-\hat{n}\cdot\vec{q} = \varepsilon\left(G - e_b(T)\right)$$

$$(1-\varepsilon)G = J - \varepsilon e_b(T)$$

$$G = G_m(J) + G_{amb} + G_{exit}$$

$$G_{amb} = F_{amb} e_b(T_{amb})$$

$$e_b(T) = n^2\sigma T^4$$

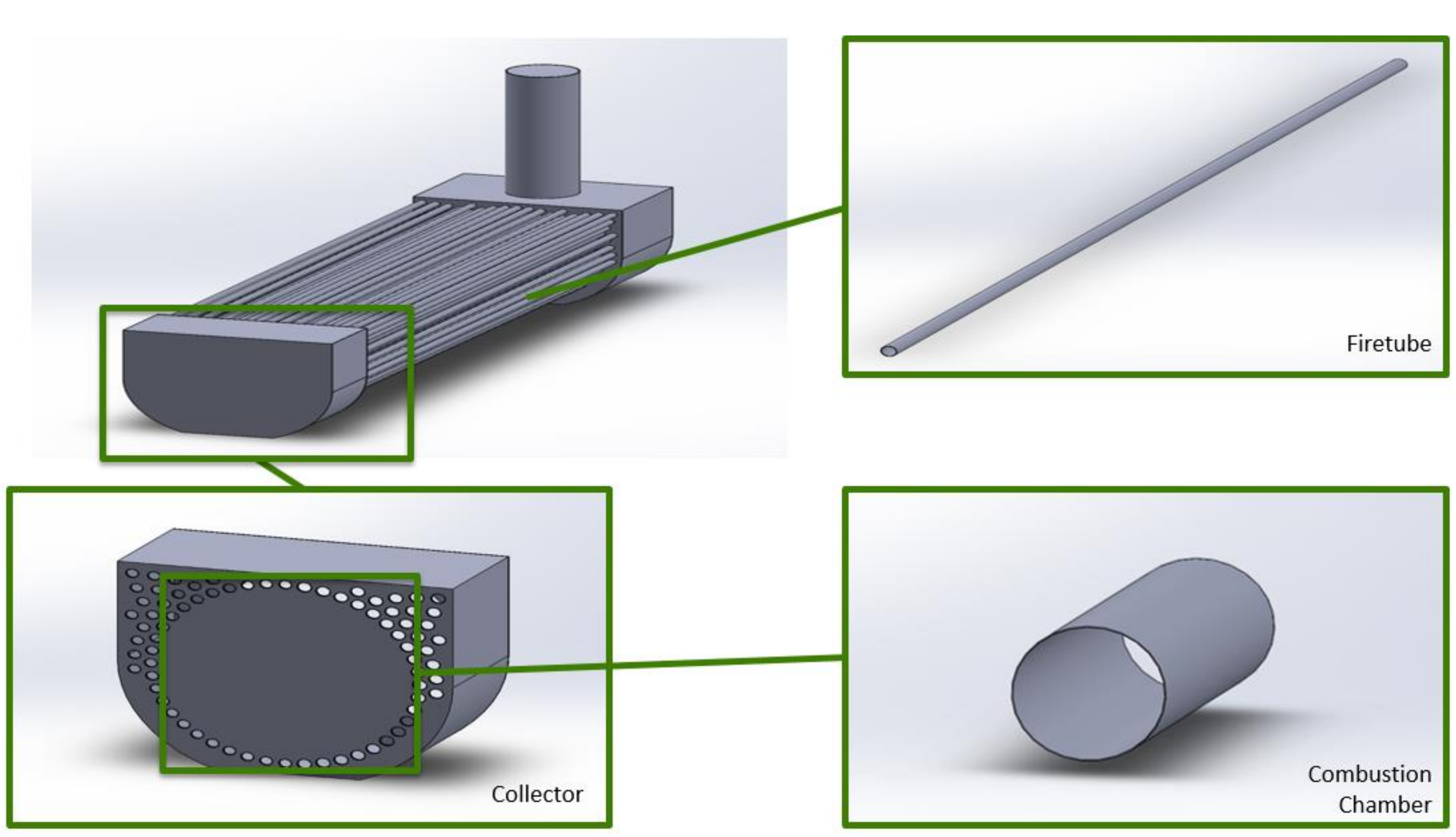

Figure 2. COMSOL model geometry.

Mesh:

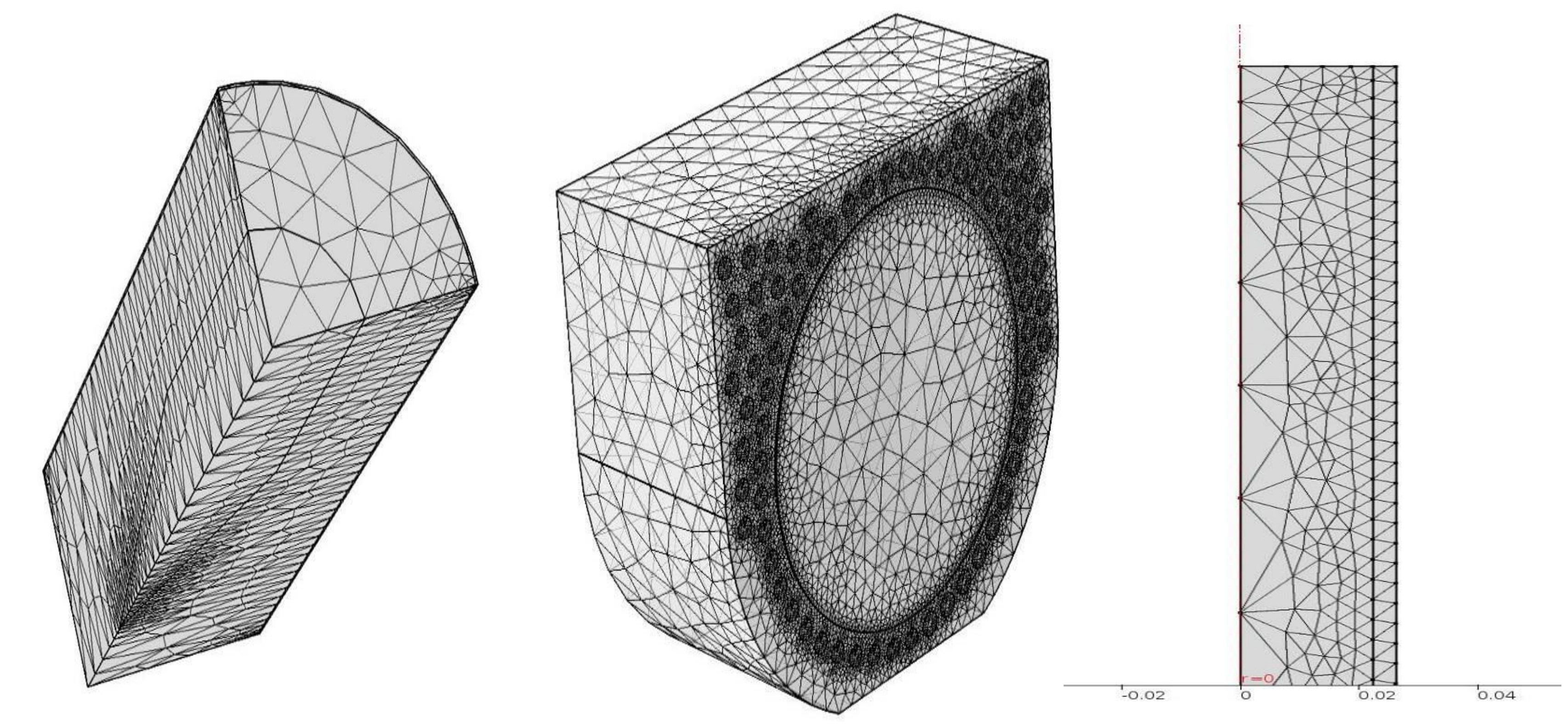

Figure 3. COMSOL Physics based mesh.

Results:

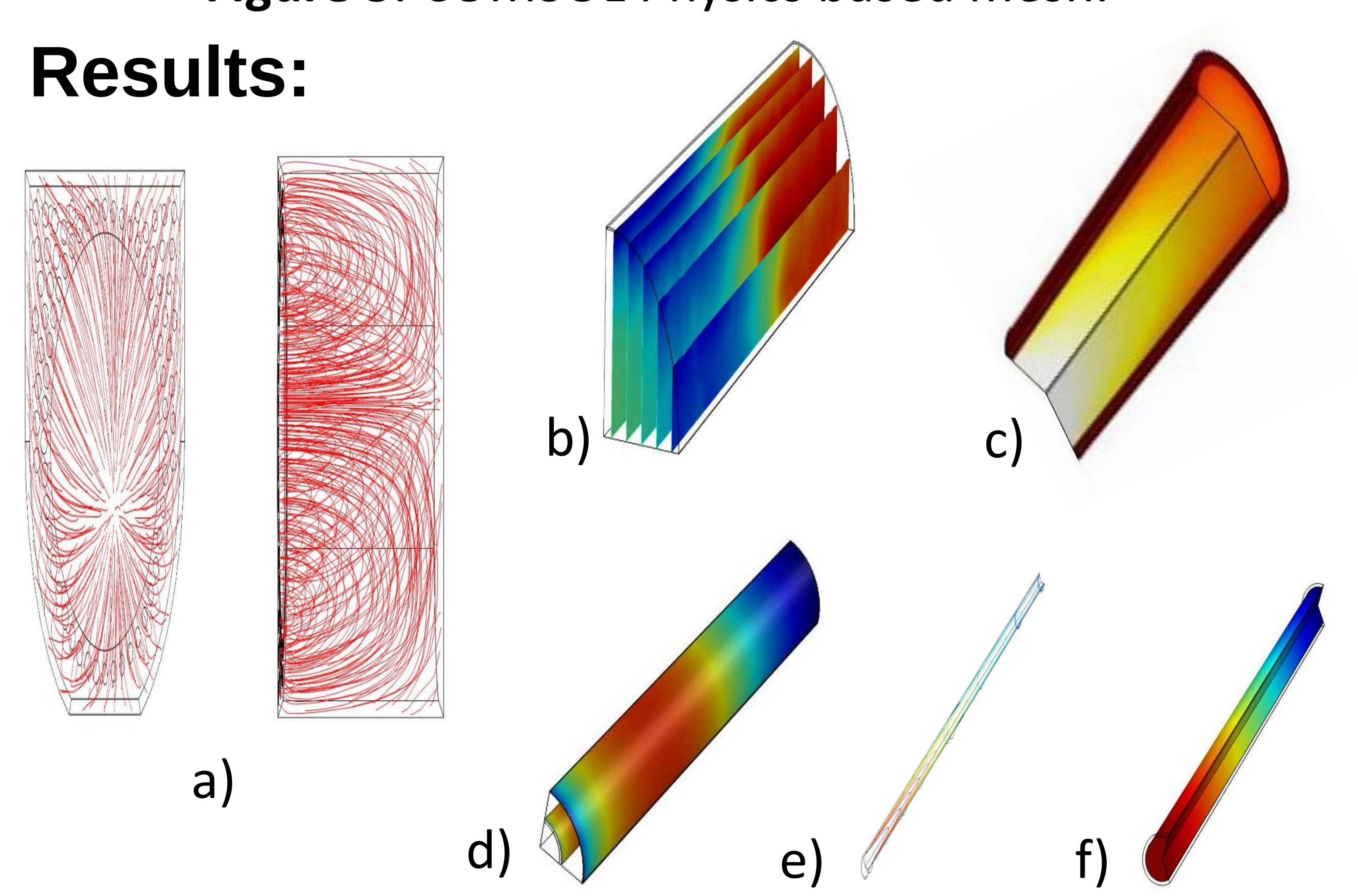

Figure 4. a) Collector velocity streamlines, b) chamber velocity magnitude, c) chamber isotherms, d) chamber radiosity, e) firetubes isotherms, f) firetubes isobars

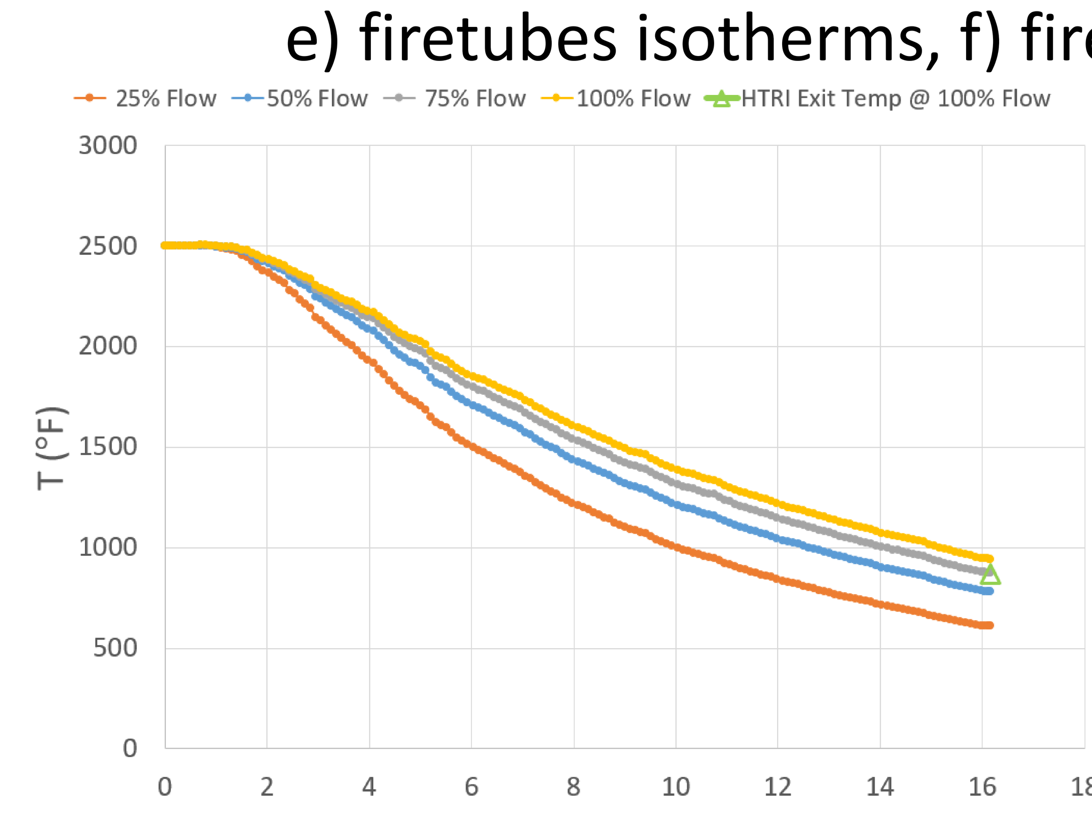

Figure 5. Flue gas temperature vs. firetubes length, for given flowrate

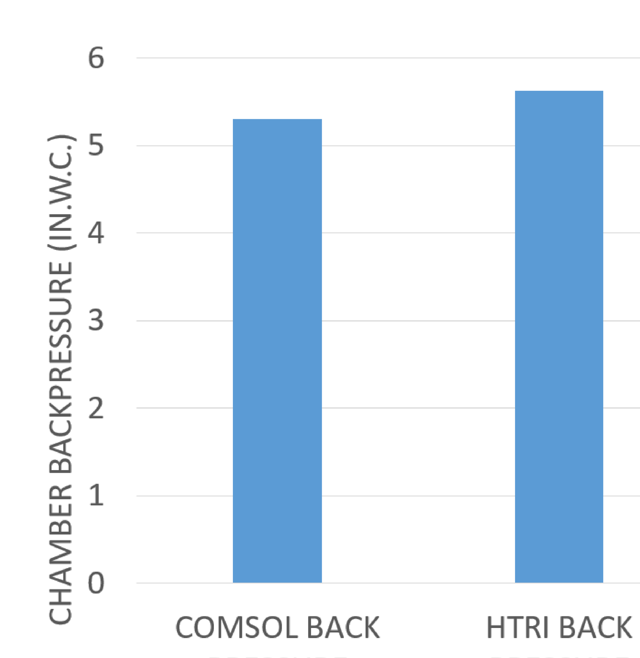

Figure 6. Back pressure COMSOL vs. HTRI

Table 1. COMSOL vs. HTRI heat transfer coefficient

Component	h (W/m^2-K) COMSOL / HTRI
Chamber	44.8 / 45.2
Firetubes	62.5 / 62.06

Conclusions: COMSOL heat transfer coefficient agrees within 2%. COMSOL back pressure agrees within 6%.