Heat Exchanger design & optimization tool

Objective

- Create a tool to aid the **design of shell & tube heat exchangers**, with **built-in optimization functionality**.

Methodology

- A **genetic algorithm** (GA) finds the dimensions that **minimize the annual cost**, while meeting the **required heat transfer rate**.
- Unknowns: tube length, shell diameter, tube diameter, number of passes, number of tubes, and baffle spacing.

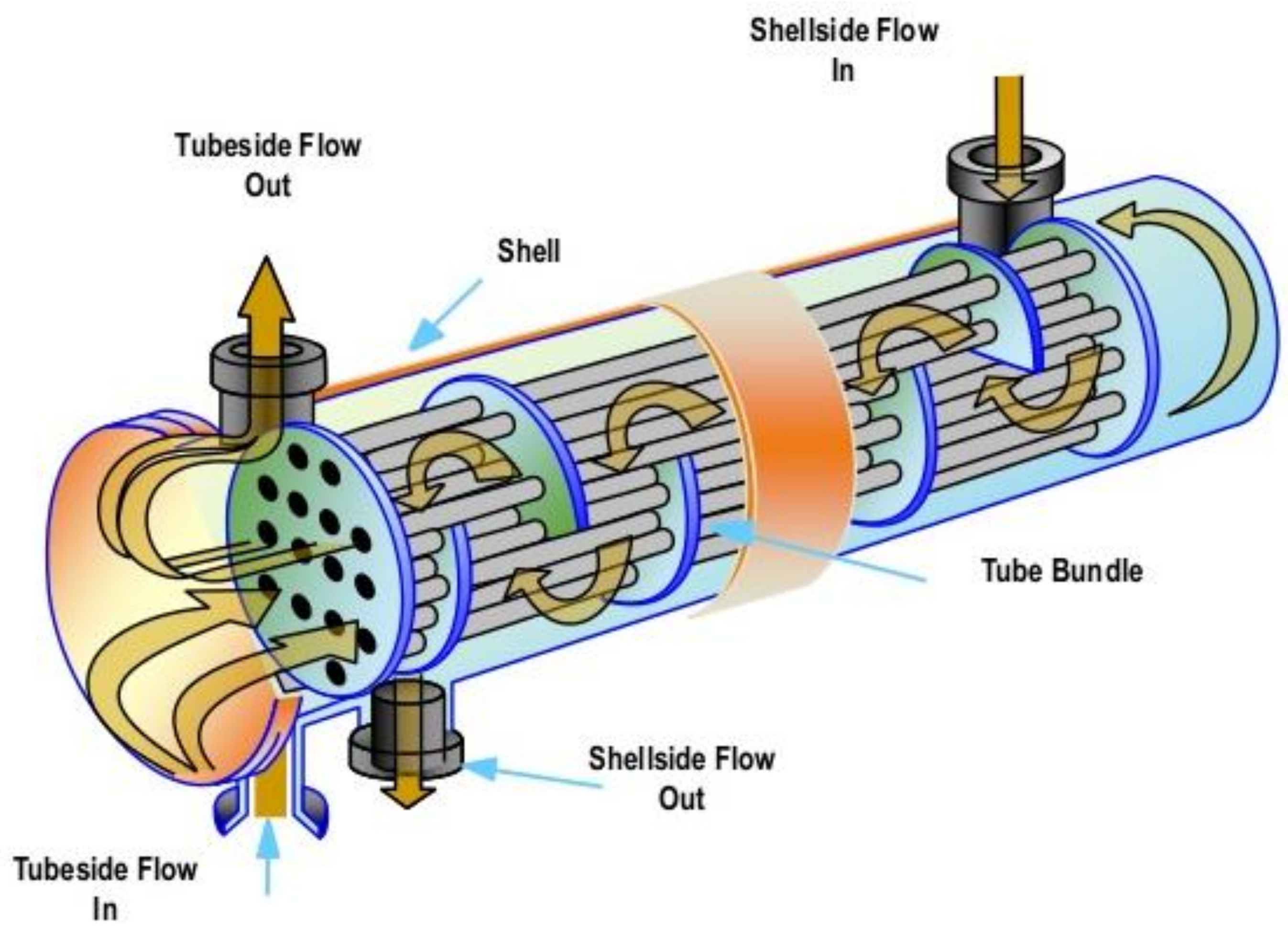

Figure 1: A Shell and Tube Heat Exchanger with one shell pass and one tube pass (cross counter flow)

What's in the cost function?

$$P = \frac{1}{\eta}\left(\frac{m_t}{\rho_t}\Delta P_t + \frac{m_t}{\rho_t}\Delta P_s\right)$$

$$A = \frac{Q}{U * LMTD}$$

$$L = \frac{A}{\pi d_o N_t}$$

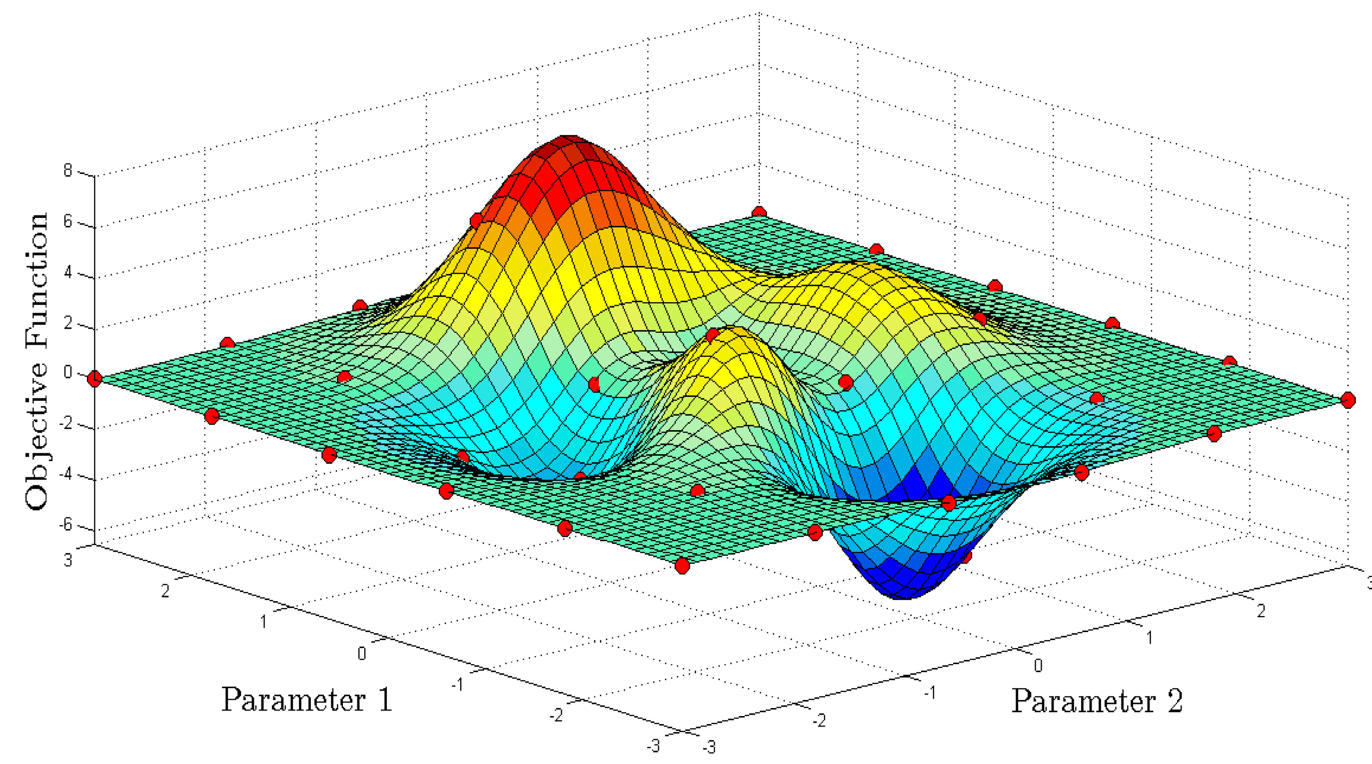

Figure 2: Hypothetical cost function

Heat Exchanger PDEs

$$\frac{\partial T_{tube}}{\partial t} = -v\frac{\partial T_{tube}}{\partial x} - \frac{2\pi U(T_{in} - T_{out})}{\rho \widehat{C_p} r}$$

$$\frac{\partial T_{shell}}{\partial t} = -v\frac{\partial T_{shell}}{\partial x} - \frac{2\pi U r_{tube}(T_{in} - T_{out})}{\rho \widehat{C_p}(r_{shell}^2 - r_{tube}^2)}$$

Case Study: Crude Oil & Kerosene Heat Exchanger (Kumar, 2016)

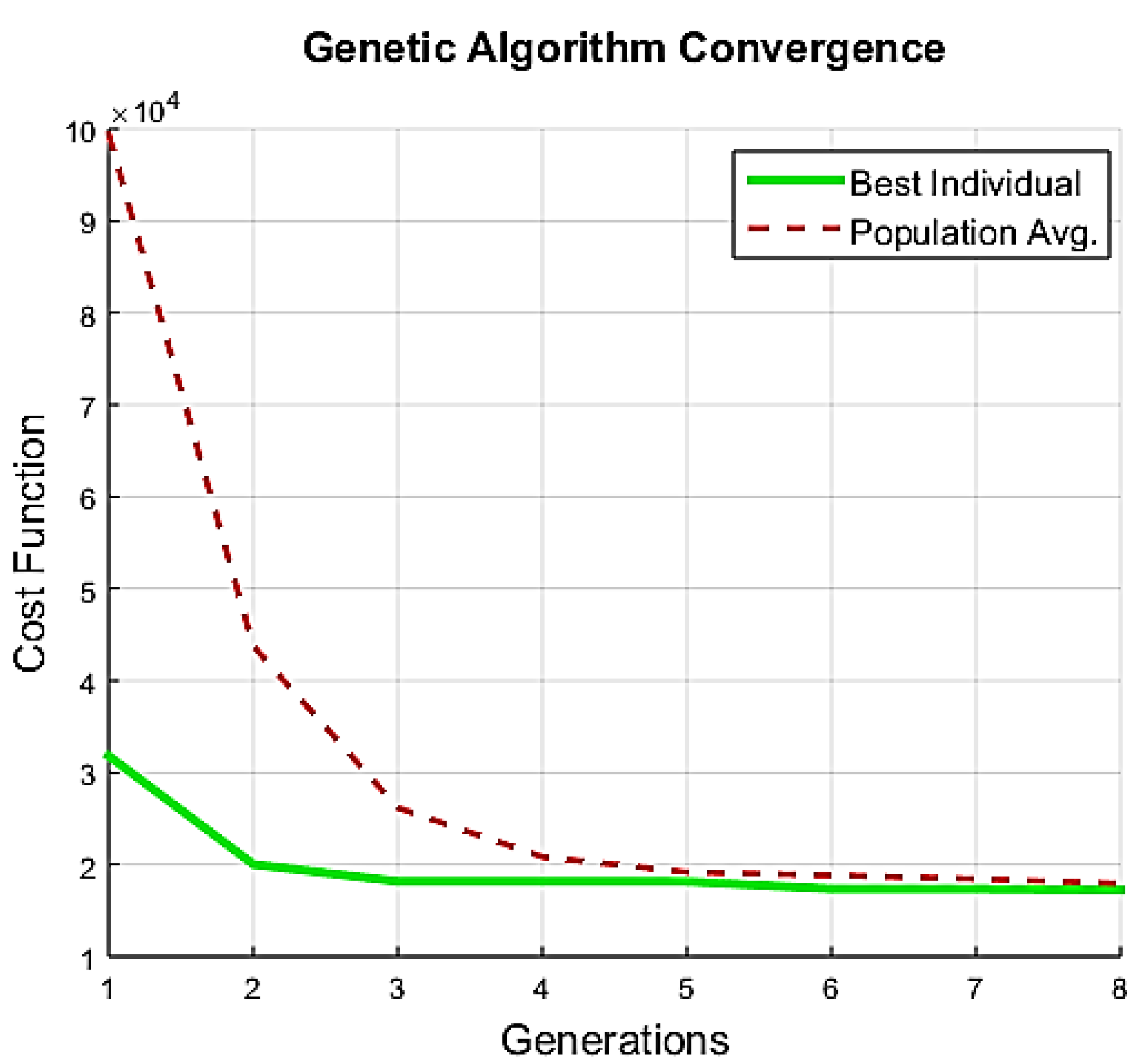

Figure 3: Evolution of the cost function value through the GA iterations.

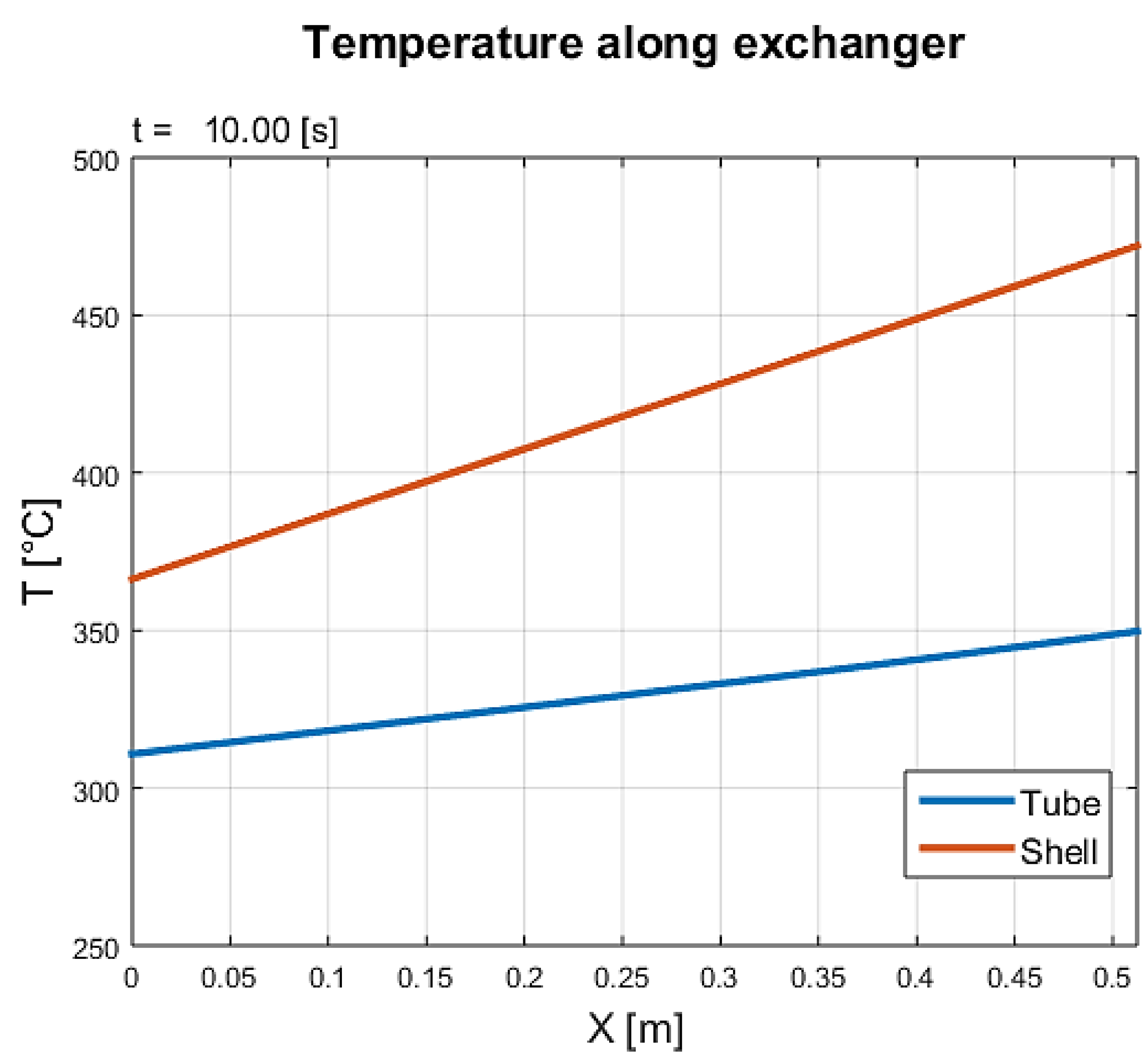

Figure 4: Temperature distribution of the two fluids along the exchanger (Steady State).

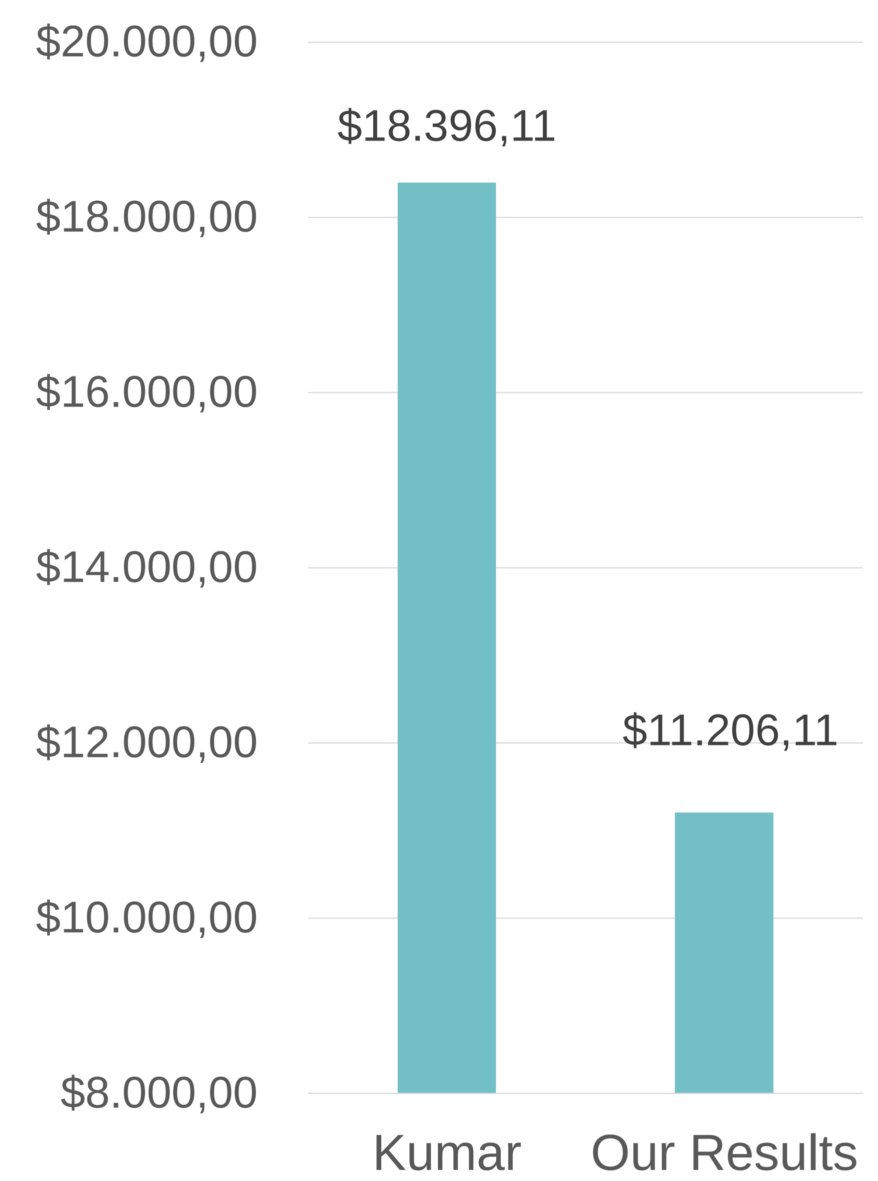

Figure 5: Minimum cost function value. SQP (right) vs. GA (left)

Conclusions & Remarks

- The case study results showed a **39% decrease in costs** with respect to the SQP method used by Kumar (2016).
- The tool developed allows to find dimensions that **satisfy heat exchanger design goals** while **keeping the costs at a minimum**. However, **mechanical properties** of the heat exchanger **should be assessed for safety**.

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