OPTIMAL CONTROL OF HEAT AND FLUID FLOW

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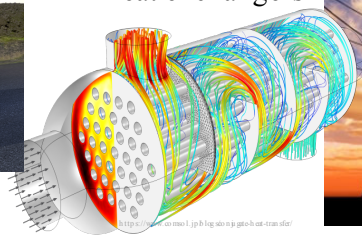
Need for energy efficient thermo-fluid devices

Automobile sector

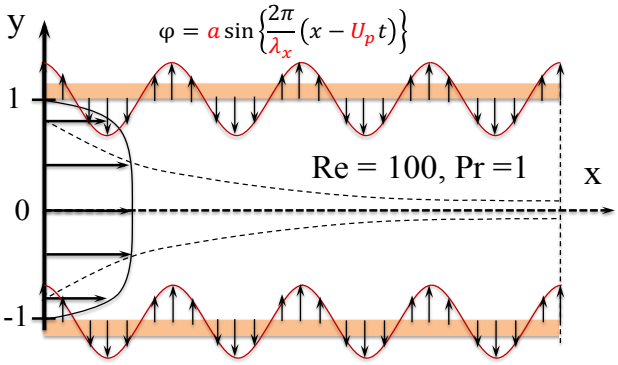
Heat exchangers



Power generation sector

Objective

Achieve dissimilar control in the developing region of a channel at low Reynolds numbers



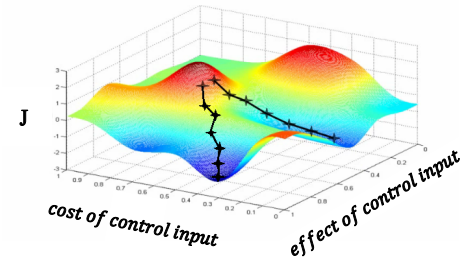
Methodology

Optimal control analysis: minimize the cost functional (J)

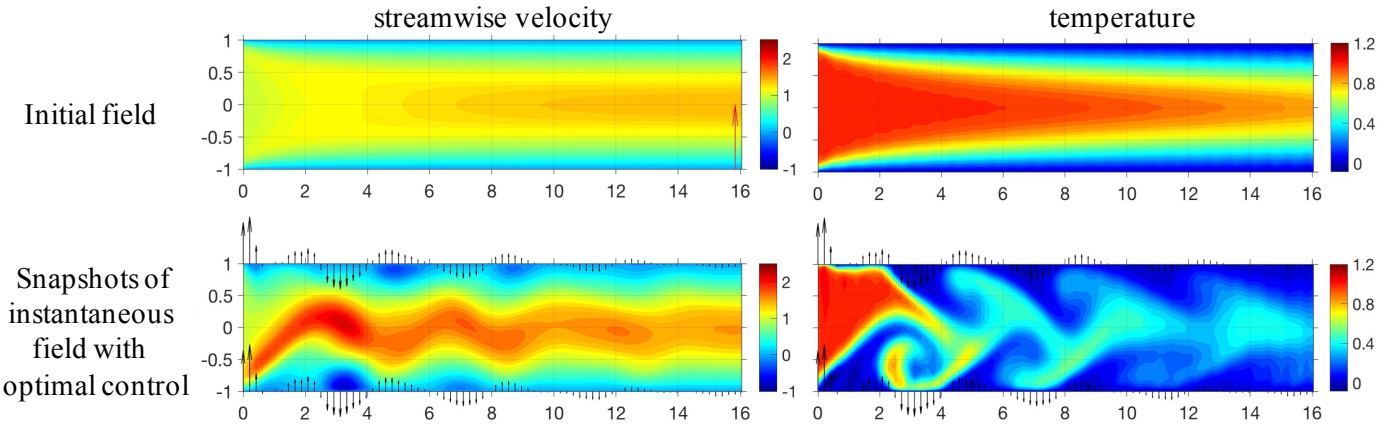
$$J = \frac{1}{T \cdot S}\int_0^T \int_S \left\{\frac{1}{2}\phi^2 + \left(\frac{1}{Re}\frac{\partial u}{\partial x_j} - \frac{1}{Pe}\frac{\partial \theta}{\partial x_j}\right)\right\} dSdt$$

cost of control input　　effect of control input

Idea of gradient decent method



Results



Performance indices:

$$C_{f_x}^0 = \frac{\tau_w^*(x)}{\frac{1}{2}\rho^* U_b^{*2}} = \frac{2}{Re}\frac{\partial u}{\partial y},$$

$$St_x^0 = \frac{q_w^*(x)}{\rho^* C_p^* U_b^* \Theta_b^*} = \frac{1}{Pe}\frac{\partial \theta}{\partial y},$$

$$DR = \frac{C_{f_0} - C_f}{C_{f_0}}, \quad HTA = \frac{St - St_0}{St_0}, \quad A = \frac{St/St_0}{C_f/C_{f_0}},$$

Control Performance:

	$C_f/2$	DR	St	HTA	A
Uncontrolled flow	0.0358	—	0.0193	—	—
sinusoidal traveling wave control with $\lambda_x = 4$ and $U_p = 0.60$	0.0448	-25.13%	0.0284	+47.15%	1.178
Optimal control	0.0025	+93.01%	0.0419	+117.09%	31.08