Dissimilar Heat Transfer in Turbulent Channel Flow

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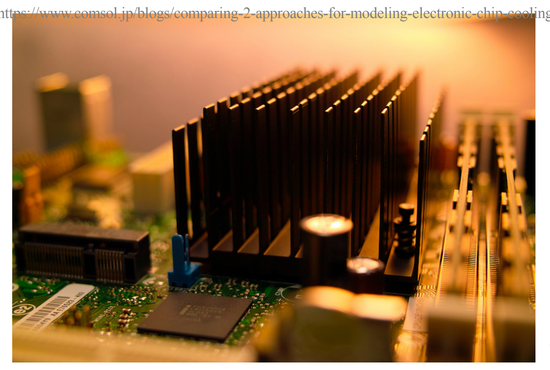
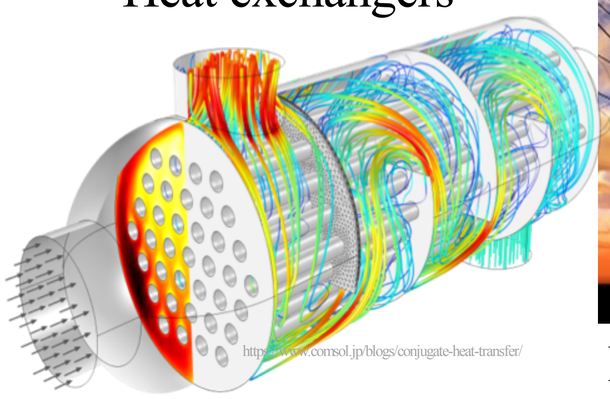
Needs for Smart Control of Heat and Fluid Flow



Electronic device cooling

Heat exchangers

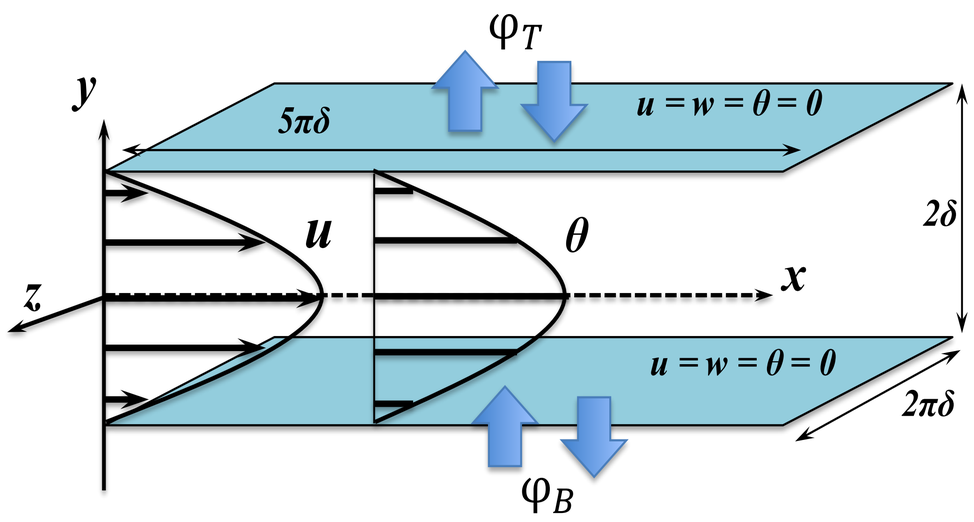


Power generation sector

Gas turbines

Aim: To achieve '*dissimilar control*' (higher heat transfer with less pressure drop)

Numerical Conditions

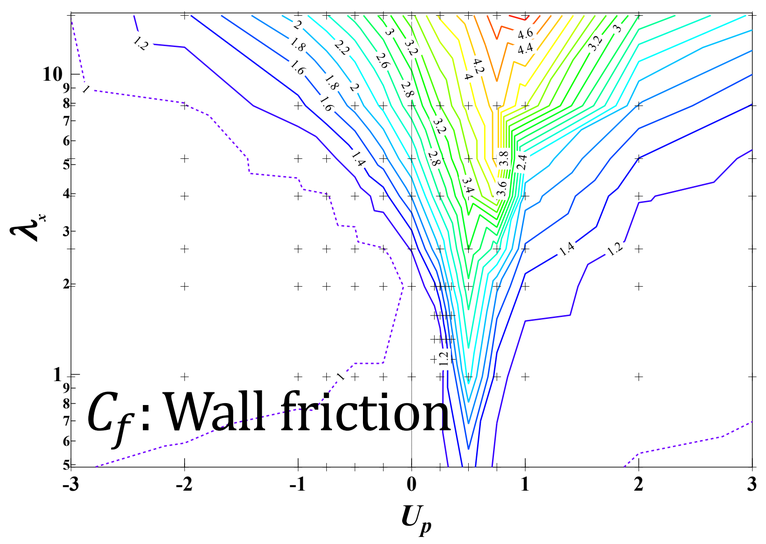


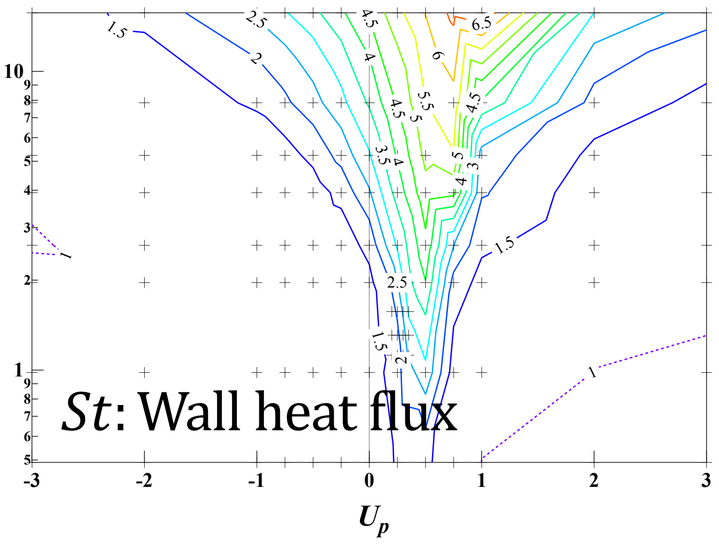
$$\varphi_{T/B} = a \sin\left\{\frac{2\pi}{\lambda_x}\left(x - U_p t\right)\right\}$$

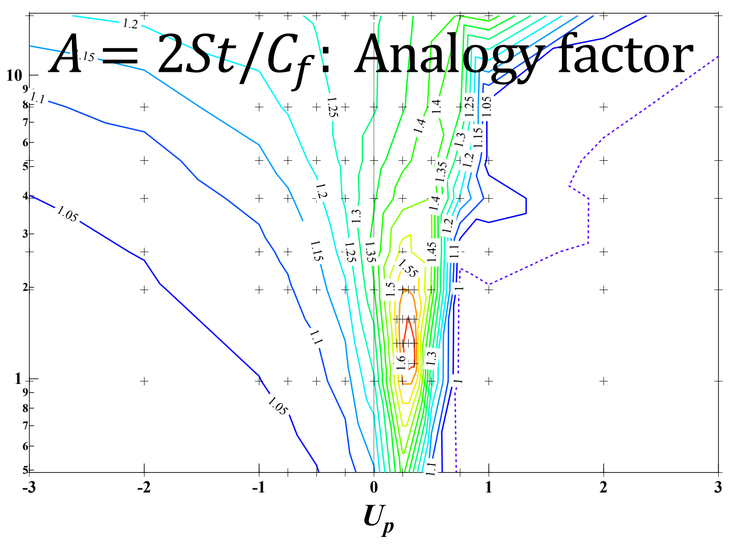
- A fully developed turbulent channel with $Re_\tau = 150$
- $Pr = 1$, Uniform heat generation in fluid
- Governing Equations
  - Velocity: Navier-Stokes and continuity equations
  - Temperature: scalar transport equation
- Control input:
  - traveling-wave-like wall blowing and suction[1]
- Parametrically changed λ_x and U_p, while a is kept constant as 5% of bulk mean velocity U_b

[1]A. Yamamoto, Y. Hasegawa, and N. Kasagi, J. Fluid Mech., vol. 733, pp. 189-220, 2013.

Results





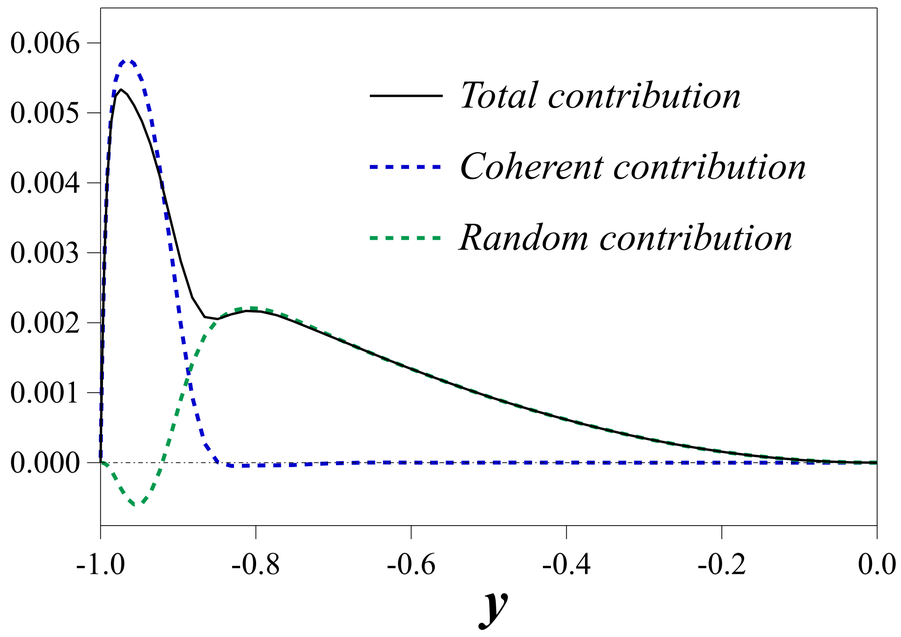


FIK Identity[2]:

$$2St - C_f = 3\left\{\int_{-1}^{1} y\overline{(\tilde{\theta}\tilde{v} - \tilde{u}\tilde{v})}dy + \int_{-1}^{1} y\overline{(\theta''v'' - u''v'')}dy\right\}$$

Coherent contribution **Random contribution**

	U_p/U_b	λ_x/δ	A
Optimal control analysis[1]	0.3	1.96	1.55
Present study	0.3	1.12	1.69



- Coherent contributions: 32%
- Random contributions: 68 %

[2]K. Fukagata, K. Iwamoto, and N. Kasagi, Phys. Fluids 14, L73–L76, 2002.