Heat Transfer Enhancement：Mechanism, Evaluation and Applications

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In this keynote lecture a comprehensive review of convective heat transfer enhancement studies conducted in the past decade in China will be presented through following three parts:.

In the first section the basic mechanism of enhancing single phase convective heat transfer will be discussed in detail. The field synergy principle, first proposed by Guo and his co-workers and later enhanced by many other researchers including the authors' group will be briefly presented. The validity of this principle will be demonstrated by a number of both numerical and experimental results. And the impact of this principle to the heat transfer fundamentals will be discussed through examples, including why the stagnation point of jet impingement has so high heat flux and why uniform wall heat flux has a higher Nusselt number than that of uniform wall temperature for fully developed laminar flow and heat transfer.

In the second part a unified performance evaluation method aimed at energy conservation is presented. The general expressions showing the relationship between heat transfer enhancement and pressured drop penalty of three types of constraints, i.e, identical pump power , identical pressure drop and identical flow rate are established. A unified log-log plot is provided which takes the ratios of heat transfer enhancement and friction factor increase as its two coordinates. This new plot divides the entire plane into four quadrants: in the first one heat transfer is enhanced and pressure drop also increased; in the second one ,heat transfer is enhanced while pressure drop is decreased; in the third one heat transfer is deteriorated and pressure drop is also decreased, and in the fourth one, heat transfer is deteriorated while pressure drop is increased. The first quadrant is the most encountered situation which , in tern can be divided into four sub-regions, they are: heat transfer is deteriorated based on identical pumping power, heat transfer is enhanced based on identical pumping power, heat transfer is enhance based on identical pressure drop and finally heat transfer is enhance based on identical flow rate. The performance of any enhancing technique can be clearly indicated when expressed in this plot.

In the third part a lot of enhanced techniques are analyzed by FSP and expressed in this new plot, including variety of longitudinal vortex generators, different fin-and-tube heat transfer surfaces (plain, wavy slotted, etc.), longitudinal finned tubes , dimpled fin surfaces, and shell-side heat transfer for heat exchanger with helical baffles. All these examples show that the FSP is an important theory for analyzing existing techniques and developing new ones, and the log-log plot for performance evaluation is quite useful for developing new technology oriented for energy saving.