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Design and Manufacturing of Vortex Tube

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Abstract: In this seminar by a new delta winglet array fluid efficiency by a circular tube at distance 0.5cm efficiency is 56% and rectangular tube at distance 2.5cm. 51% is the best effect of winglet array design. Liquid-to-air and phase-change heat exchanger performance crucial to meet efficiency standards with low cost and environmental impact in numerous end-use energy applications. Research on performance improvement of heat exchangers often focuses on the air side because transport coefficients are inherently lower for air than for liquid or two-phase flow. Vortex generation has emerged as a promising method for enhancing airside heat transfer. Compared to fin interruption, this technique has the advantage of low cost and ease of implementation, and is usually accompanied by a modest pressure drop penalty. In this study, a new vortex-generator array deployed in a "V" is proposed, aiming to utilize favorable interaction between generators and produce strong vortices even at low Reynolds numbers. A preliminary investigation of vortex strength in a water tunnel shows that boosting effects occur in a V-array which makes the design superior to an offset arrangement. The strongest vortex is measured for a two-row zero-spacing V-array deployed at 30º. The impact of V-formation arrays on heat transfer is assessed in a developing channel flow using infrared thermography.
Keywords: Boiler, Heat Exchanger, Vortex, V-Array.

I. INTRODUCTION

High heat-exchanger performance is crucial to meet efficiency standards with low cost and environmental impact in numerous end-use energy applications, especially in heating, ventilation, air-conditioning and refrigeration (HVAC&R) systems. According to recent statistics by the U.S. Department of Energy, HVAC&R systems account for 54% of the total energy consumed in residential buildings (~11×1015 Btu) and 57% in commercial buildings (~9×1015 Btu). Achieving even a small amount of performance enhancement in heat exchangers could have profound implications in technical, economical and ecological aspects. Because transport coefficients are inherently lower for air than for liquid or two-phase flow, the air-side convective resistance is usually dominant in typical liquid-to-air and phase-change heat exchangers, representing 75-90% of the total thermal resistance. This limitation, along with the desire to improve heat exchanger performance with reduced volume and manufacturing and operating costs, continues to motivate research in air-side heat transfer enhancement.[1] Two widely used techniques are interrupted fins and vortex generation. Fin interruption causes boundary layer restarting and periodic vortex shedding above some critical Reynolds number. The former reduces average boundary-layer thickness and the latter promotes flow oscillation and unsteadiness. Both result in increased heat transfer coefficient (DeJong and Jacobi, 1997). Common interruptions appear in slit-fin, offset-strip and louvered-fin patterns. Kays and London (1998) provided a comprehensive database of heat transfer and flow friction for a variety of modified surfaces.[2] More recent studies can be found in Webb and Kim (2005). Vortex generation is another technique that holds promise in surface convection enhancement. In this method, a passive flow manipulator, known as vortex generator (VG), is punched or mounted on a heat-transfer surface. As the flow encounters the VG, the adverse pressure gradient causes the boundary layer to separate along the leading edge and form a vortex system as shown in Fig. 1.1. The vortices are advected downstream and persist for a length of many VG sizes. Presence of the vortices improves thermal transport by boundary layer modification, enhanced mixing or unsteadiness, and flow destabilization. This enhancement technique has the advantage of low cost and ease of implementation, and is usually accompanied by a modest pressure drop penalty. Considerable research has been undertaken on heat transfer augmentation by vortex generation for different generator shapes, surface geometries, and flow conditions. The study in this dissertation focuses on vortex-enhanced channel flows because of their relevance to heat-exchanger configuration.[2]

II. LITERATURE SURVEY

1) *Abdulmajeed A. Ramadhan*: Presented a numerical study of fluid flow and heat transfer over a bank of oval-tubes heat exchanger with vortex generators, his study represented a two-dimensional numerical investigation of forced laminar flow heat transfer over a 3-rows oval-tube bank in staggered arrangement with rectangular longitudinal vortex generators placed behind each tube. The effects of Reynolds number (from 250 to 1500), the positions (3 in x-axis and 2 in y-axis) and angles of attack (30o and 45o) of rectangular vortex generator are examined. His results showed increasing in the heat transfer and skin friction

coefficient with the increasing of Re number and decreasing the relative distance of positions of longitudinal vortex generators. It has been observed that the overall Nu average number of three oval-tubes increases by 10–20.4% and by 10.4–27.7% with angles of 30o and 45o respectively, with increasing in the overall average of skin friction coefficient of three oval-tubes reached to 53% and 72% with two angles used respectively, in comparison with the case without vortex generator.[1]

2) *Ahmed Khafeef Obaid Albdoor:* Studied numerically the effect of vortex generator over tube bank heat exchanger with different shapes on heat transfer and fluid flow characteristics. The study was with three different shaped of vortex generators mounted behind the tubes with Reynolds number ranging (7000 ≤ Re ≤ 11000).The effects of three shapes of winglets is looked at (airfoil, rectangle and triangle) with different angles of attack (30˚ and 45˚) has been investigated on average heat transfer (Nu), friction coefficient and pressure drop. His results showed that there is an effect for using winglet pairs on heat transfer, friction coefficient and pressure drop, also, heat transfer depends on the shape, angle of attack of winglet. The triangle is the best shape for enhancing heat transfer and (α = 45) is the best angle of attack for enhancing heat transfer.[2]
3) *Fiebig et al.:* Experimentally compared the effect of vortex generators on the heat transfer and flow losses in fin-flat/round tube heat exchangers for the Reynolds number between 600 and 3000. For the staggered fin-tube arrangement, their results showed that the heat exchanger element with round tubes and vortex generators increase heat transfer only 10%, but about 100% for flat tube. They also showed that pressure drop in flat tube bank with vortex generator is nearly half that for the round tube bank with vortex generator.[3]
4) *K. Torii et al.:* Proposes a novel technique that can augment heat transfer but nevertheless can reduce pressure-loss in a fin-tube heat exchanger with circular tubes in a relatively low Reynolds number flow, by deploying delta winglet-type vortex generators. Following the same arrangement as discussed in many papers above, “common flow up” configuration as well as the “common flow down”.[5]
5) *K.Thirumalai kannan, et al:* Studied the numerical study of heat transfer and fluid flow analysis in plate-fin and tube heat exchangers with different shaped vortex generators mounted behind the tubes. The effects of different span angles a (α = 30°, 45° and 60°) are investigated in detail for the Reynolds number ranging from 500 to 2500.His results indicated that the triangle shaped winglet is able to generate longitudinal vortices and improve the heat transfer performance in the wake regions. The case of α = 45° provides the best heat transfer augmentation than rectangle shape winglet generator in case of inline tubes. Common flow up configuration causes significant separation delay, reduces form drag, and removes the zone of poor heat transfer from the near wake of the tubes.[6]
6) *M. mirzaei el al.:* Numerically studied the augmentation of heat transfer by using vortex generator on flat/round tube heat exchangers The simulations are performed with the steady three-dimensional incompressible conditions and a RNG K-ε turbulence model is used. The Reynolds numbers based on the bulk velocity and the height of channel are selected from 600 to 4050. To compare the effectiveness of vortex generator on the round and flat tubes for tube-fin heat exchangers, two different configurations are investigated with two and four delta winglet vortex generators for each tube. The streamlines, vorticity, the averaged Nusselt number, the friction factor and the performance factor (JF) are provided to evaluate the effectiveness of vortex generator for the heat exchangers employed. It is found that the flat tube with vortex generator provides better thermal performance than the round one, especially at the lower Reynolds numbers.[7]
7) *Wisam Abed Kattea:* Conducted an experimental study on the effect of vortex generators (Circular and square) on the flow and heat transfer at variable locations at (X = 0.5, 1.5, 2.5 cm) ahead of a heat exchanger with Reynolds number ranging from 62000< Re < 125000 and heat flux from 3000 ≤ q ≤ 8000 W/m2. His results show that there is an effect for using vortex generators on heat transfer. Also, heat transfer depends on the shape and location. The circular is found to be the best shape for enhancing heat transfer at location [Xm=0.5 cm] distance before heat exchanger is the best location for enhancing heat transfer. The square is the best shape for enhancing heat transfer at location [Xm=2.5 cm] distance before heat exchanger is the best location for enhancing heat transfer. The results of flow over heat exchanger with vortex generators are compared with the flow over heat exchanger without vortex generators. Heat transfer around heat exchanger is enhanced (56%, 50%, 36%) at location (X=0.5, 1.5, 2.5cm) respectively by using circular vortex generators without tabulator and heat transfer around heat exchanger is enhanced (39%, 42%, 51%) at location (X=0.5, 1.5, 2.5cm) respectively by using square shape vortex generators without tabulator.[8]

III. IDEA FROM LITERATURE SURVEY

A. An analogous numerical study was performed to evaluate the impact of vortex generation in forced convection between parallel plates. Delta wings and winglets were considered, and the impact of the hole under the wing was included.

B. A delta wing with an aspect ratio of one was considered for attack angles varying from (10˚ to 50˚), while the Reynolds number varied from 1000 to 4000.
C. The computations predicted maximum cross flow velocities in the vortex on the same order as the mean axial velocity.
D. The cross-section of the vortex produced by the delta wing was reported to be elliptical because the turning of the vortex by the wall distorted its cross-section.
E. With the delta winglets at a 30˚ angle of attack and a Reynolds number of 4000, an average increase in the Nusselt number of 84 percent was predicted.

IV. CONCLUSIONS

A. The rate of heat transfer is increases because more turbulence of fluid is occur.
B. As more turbulence occurs means that Reynolds's no. decrease ,so Nussult no. increases.
C. This increases heat transfer coefficient, so by using $Q = ha\,(T_s - T_\infty)$ heat transfer rate Increases.

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