Journal of Engineering and Sustainable Development
Vol. 22, No.05, September 2018
ISSN 2520-0917
https://doi.org/10.31272/jeasd.2018.5.2

EFFECT OF ADDED VARIED ANGLE WINGLET TO ENHANCE HEAT TRANSFER IN HEATED CHANNEL

Dr. Aseel Khleel Shyaa

Lecturer, Mechanical Engineering Department, Mustansiriyah, University, Baghdad, Iraq.

Abstract: An experimental study to enhancement heat transfer by generate longitudinal vortex with rectangular winglet has been investigated. Two angles presented ($70^{\circ}, 35^{\circ}$ **)** in rectangular winglet placed at the entrance of heated channel the study shows the pointing (Down and Upstream) and the effect of attack angle depends on the heat transfer (Nu)and the friction factor(f) for each angle and two sides ,the Reynolds number range from 5000 – 23000. It was found that angle was significant effect on the heat transfer coefficient and the 70° angle more efficient in heat transfer in high velocity and the pointing downstream make good result in heat transfer.

Keywords: *Winglet, rectangular heated duct, Nusselt number, angle of attack, enhancement heat transfer*

تأثير اضافة مولد للدوامات بزوايا مختلفة لتحسين انتقال الحرارة داخل مجرى هوائي ساخن

الخلاصة: دراسة عملية.لتحسين انتقال الحرارة بواسطة استحداث وتوليد دوامات طولية عن طريق اضافة شريط مستطيل وتم تثبيته بزاويتين **(** $70^{\circ}, 35^{\circ}$) في الجناح المستطيلة تم وضعها داخل وبداية المجرى الهوائي المسخنوكان اتجاه جريان الهواء بأتجاه زوايا المقطع بأتجاهين (Up and Downstream)وتأثير الزوايا له تأثير عل انتقال الحرارة ومعامل الاحتكاك لكل زاوية وجانبين، وتتراوح مجموعة رينولدز من 5000 - 23000.وتم الاستنتاج ان الزاوية 70° أكثر كفاءة في نقل الحرارة بسرعات عالية.

1. Introduction

wide range of application have to enhance heat transfer such as, compact heat exchanger, AC for domestic, the use of winglet to improve efficiency and to have device with low cast, weight and improve manufacture .the winglet position caused vortex generation that make turbulent flow with separation in impingement flow. Many researches study the effect of tabulator [1], Cho et al. [2] study two angle of attack and concluded that high heat transfer an high angle but the thermal performance improve in low angle of attack. that the goal of added varied angle winglet at the entrance of the heated channel to enhance the performance of the thermal system by inserting (zigzag) with three angle to reduce the temperature on the heated side with the effect of swirl and

*Corresponding author aseelkhshyaa@yahoo.com

Studying the inclination of angle for the winglet and shows the influence on the heat transfer from wall to the environment.

2. Experimental Setup

First, the open loop channel used and manufacture in six parts: exit duct, test suction, winglet section, entrance duct and blower as shown in figure (1) the rectangular duct size is (76*195) mm with aspect ratio 0.4,the test section(heated suction) is (510) mm long . The test section made with Plexiglas duct insulated with fiber glass and wood to prevent thermal losses.

The heated plate have (40) stainless steel foil(iso flux heaters)all the same size and sealed on the upper side of the duct each strip heater size with 10 mm width and 0.035mm thickness with 0.5 mm space between each strip to avoid short circuit these heaters connected varied voltage to have constant heat flux as can show in figure 2,to measure the temperature distribution on the heated plate (10) thermocouple type k used and location on the wood to make touch to the stainless steel heater figure (3), the winglet with three angle($35^{\circ}, 70^{\circ}$) as shown in figure (4)_are used to enhance the heat transfer along the duct by generate longitudinal vortices [4] study that the entrance region is important for enhancement heat transfer and thermal performane .

These two rectangular winglet glue at the entrance of the test section to increase turbulent flow and to interruption the development of boundary layer. Figure (5) shows the behavior of the enhancement with angle winglet in two directions up streams and down streams.

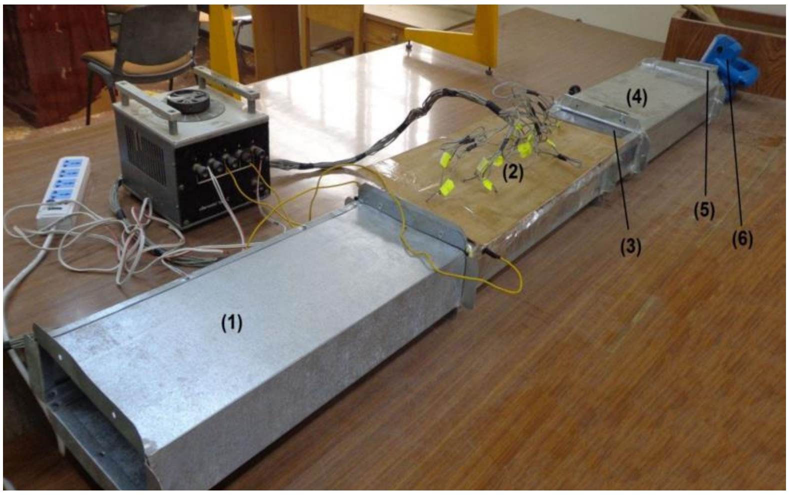

Figure (1) shows the experimental rig component

Figure (2) 40 strip heater (still steel foil)

Figure (3) Thermocouple location.

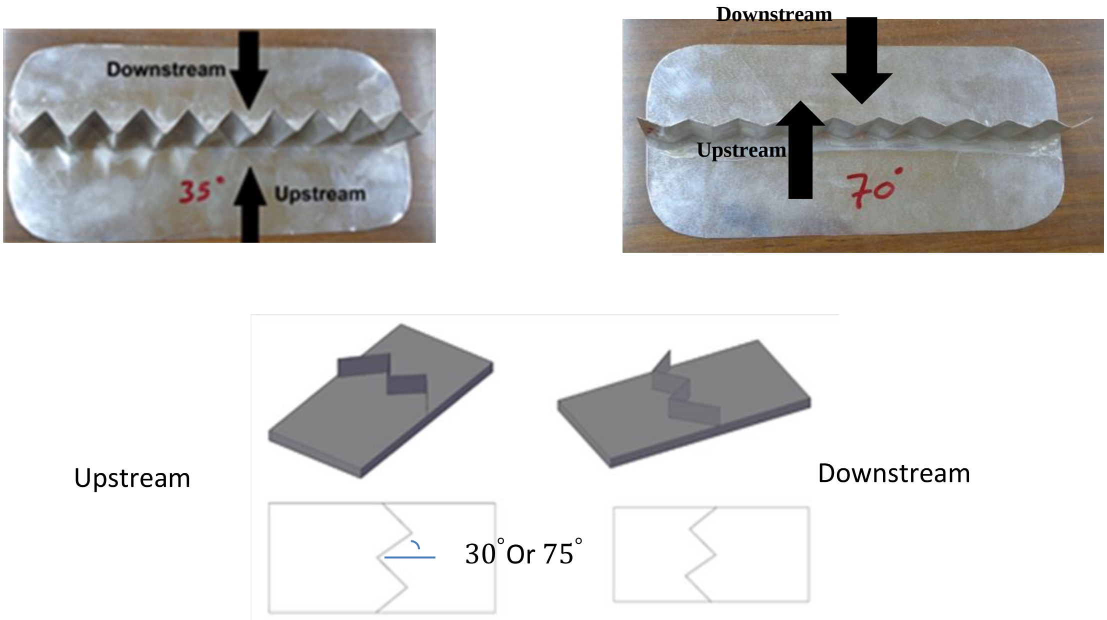

Figure (4 a) the rectangular winglet

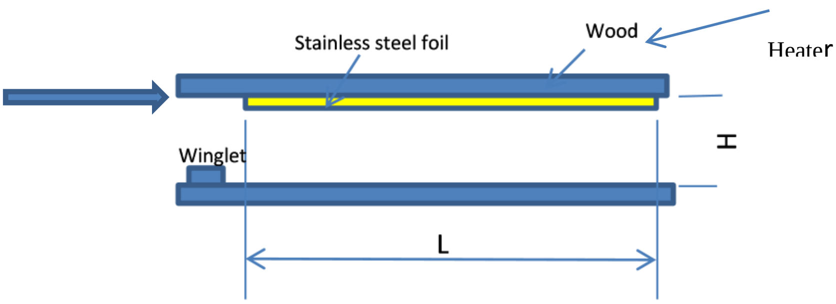

Figure (4b) the test section

3. Data Reduction

in order to calculate Nusselt number inside the heated duct depend on the hydraulic diameter is given by [5]

$$Re=\frac{U\ Dh}{\nu} \quad (1)$$

Where U the mean velocity, ν kinematics viscosity of air, the heat transfer coefficient (h) can be evaluated from the temperatures measured on the iso flux side the equation can be given by [6].

$$Q_{air} = Q_{conv} = conv = m^{\circ}\ C_p\ \dot{\Delta T} = I\ V\ [7] \quad (2)$$

Where

Q = heat added to the fluid

$\Delta T = (T_{\circ} - T_i)$ the temperature difference of in and out temperature

$$h=\frac{Q\ conv}{A(Tw-Tb)} \quad (3)$$

$$Tb=\frac{Ti+To}{2} \quad (4)$$

$$Ts=\Sigma\frac{Ts}{10} \quad (5)$$

Where: A is the area of convection heat transfer

Ts is the surface a average depends on the measured temperature

$$Nu = \frac{h\ Dh}{k} \quad (6)$$

Where $Dh = \frac{2\ b\ a}{a+b}$ (7)

$$f = \frac{2\ \Delta p}{\left(\frac{L}{Dh}\right)\rho U^2} \quad [8] \quad (8)$$

Where f is the friction factor [8]

$$\eta = \left(\frac{Nu}{Nu_{\circ}}\right) = \left(\frac{f}{f_{\circ}}\right)^{-1/3} \quad (9)$$

Where η is the thermal enhancement factor

4. Result and Discussion

The enhancement of heat transfer can be shown by study the effect of adding two different angles (35° $and 70^{\circ}$) in the entrance of the rectangular duct to make of the test section to increase turbulent flow and to interruption the development of boundary layer and to generate longitudinal vortex in order to enhance heat transfer along the heated plate. The degree of the flow with the fin attack angle aligned with it direction [9]

Figure (6) shows the behavior of the temperature and heat transfer coefficient inside the heated duct, this figure presented the effect of added rectangular winglet in two directions pointing up stream (PU) and pointing downstream (PD) and compare with smooth duct. The local Nusselt number in the duct increase with increase Reynolds number and the winglet at angle (70°) the enhancement at the centerline is clear than the angle (35°) and the pointing down winglet can make visible impingement along the heated wall. Figure (7) and figure (8) illustrate the relation of heat transfer coefficient inside the iso flux duct and position in the centerline of the heated plate for two cases pointing downstream and upstream, the figure shows that the heat transfer coefficient is very high at the entrance of the duct because of the effect of (35°)angle winglet pointing downstream and the heat transfer increase with increase of velocity.

Figure (9) and figure (10) study the effect of heat transfer with position for each pointing downstream and upstream for angle (70°) and illustrate the effect of varied velocity into the heat transfer and for each location of temperature measured. The figures shows for the high velocity high influence on the two pointing stream(PU,PD)because of the vortices of the flow impingement on the heated plate make high enhancement in heat transfer .

Figure (11) depicted the(Nu/Nuo)and the variation of the Re number ,the Nu increase with increase velocity and the angle (70)display good and high enhancement in heat transfer. The downstream pointing has been noted high result in enhancement heat transfer. Figure (12) shows the variation of thermal enhancement factor with Reynolds number.

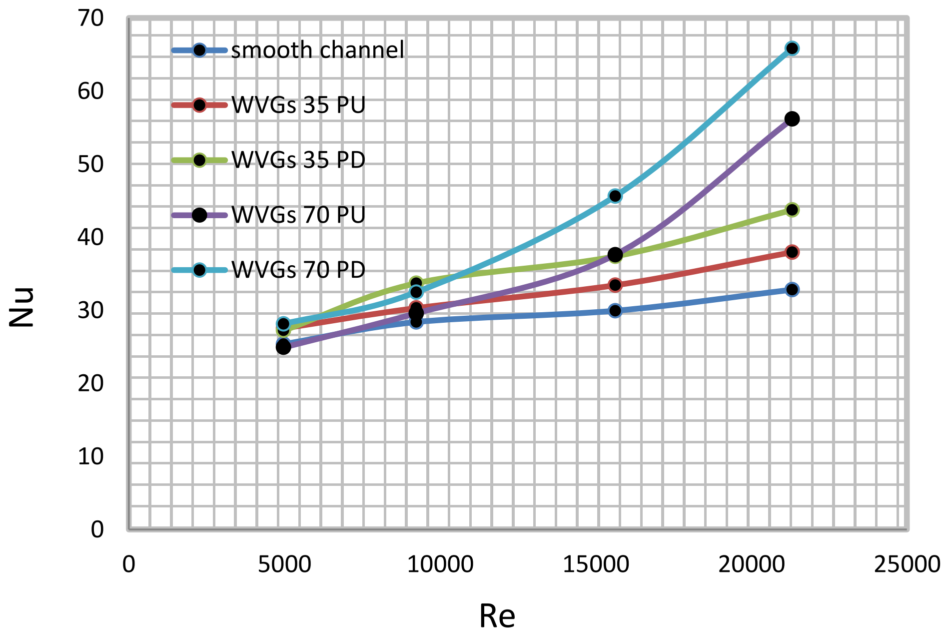

Figure (6) variation of Nusslet number and Reynolds number for angles (35° $and 70^{\circ}$) pointing down and up stream

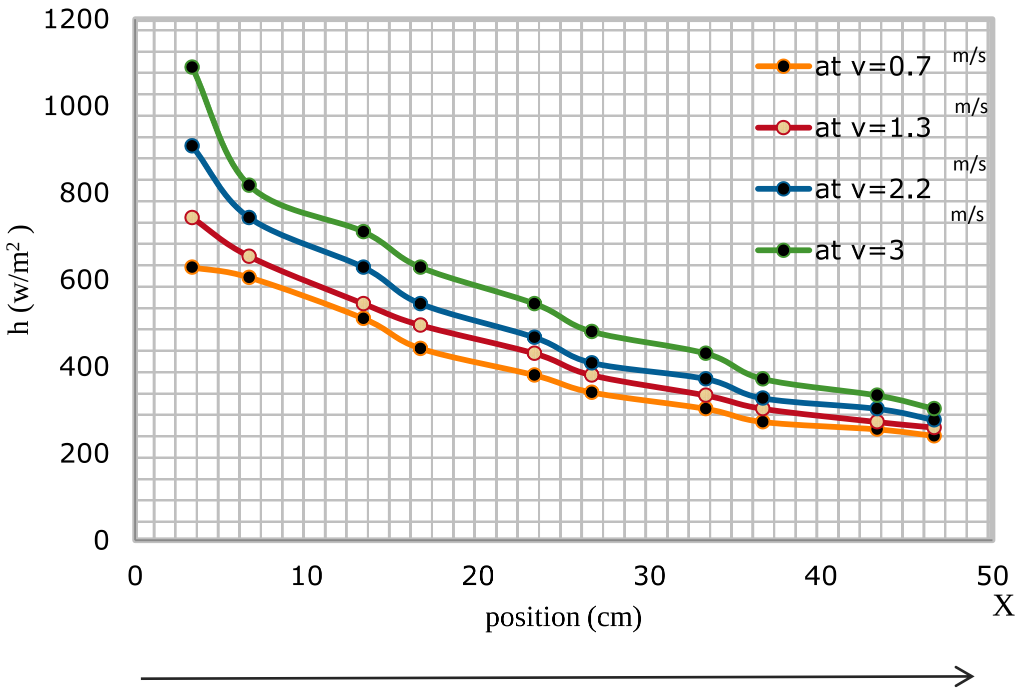

Figure (7) variation of heat transfer coefficient with position along the duct for angles (35°)pointing downstream in four velocities.

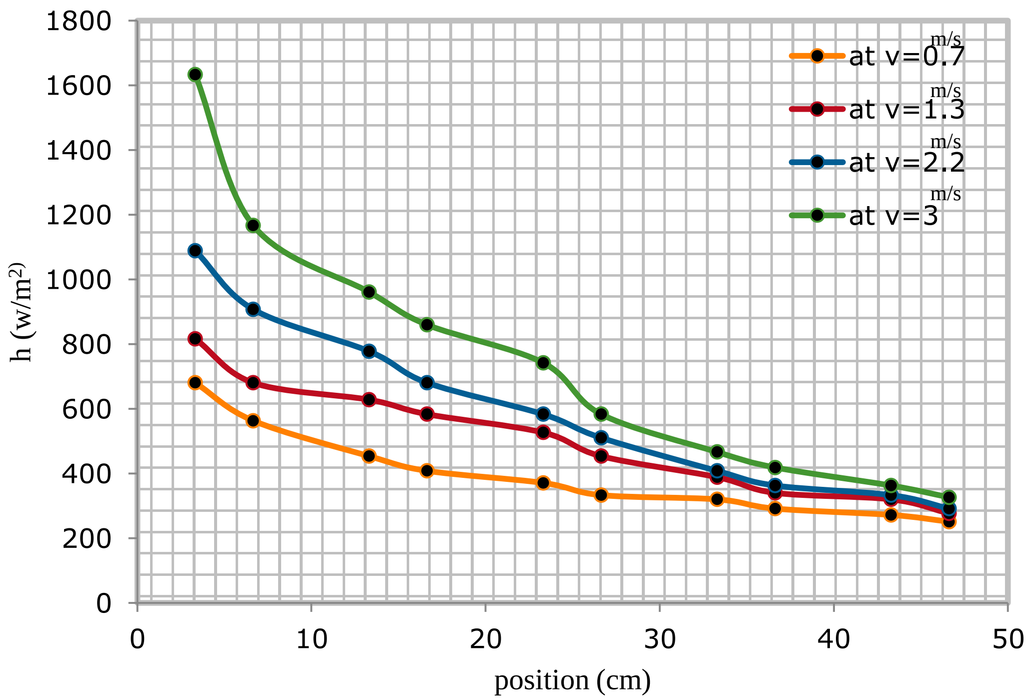

Figure (8) variation of heat transfer coefficient with position along the duct for angles (35°)pointing upstream in four velocities

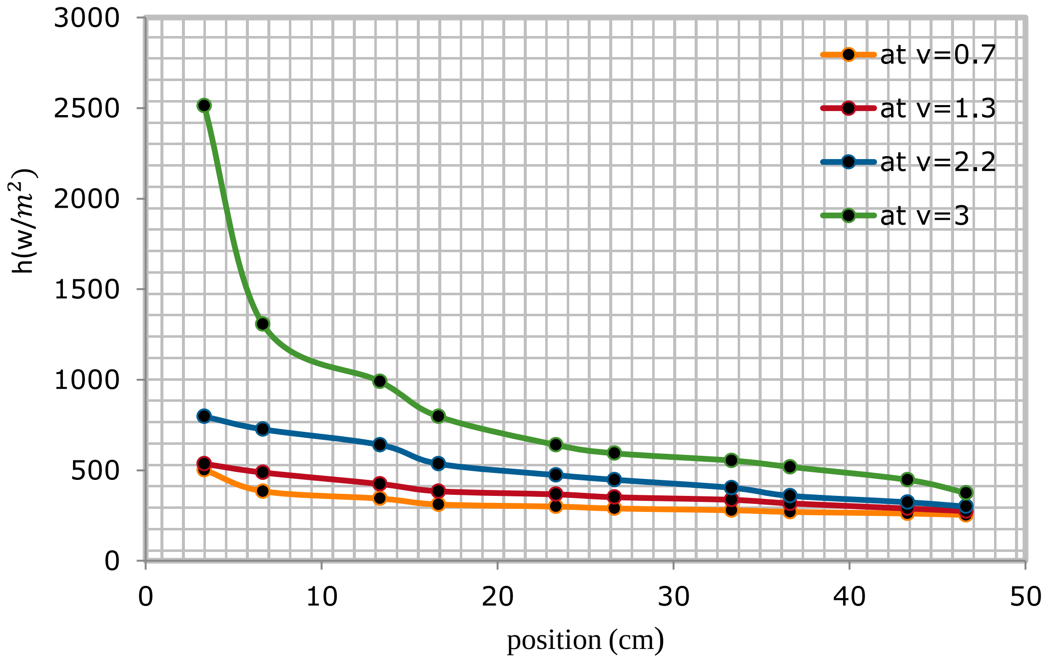

Figure (9) variation of heat transfer coefficient with position along the duct for angles (70°)pointing downstream in four velocities

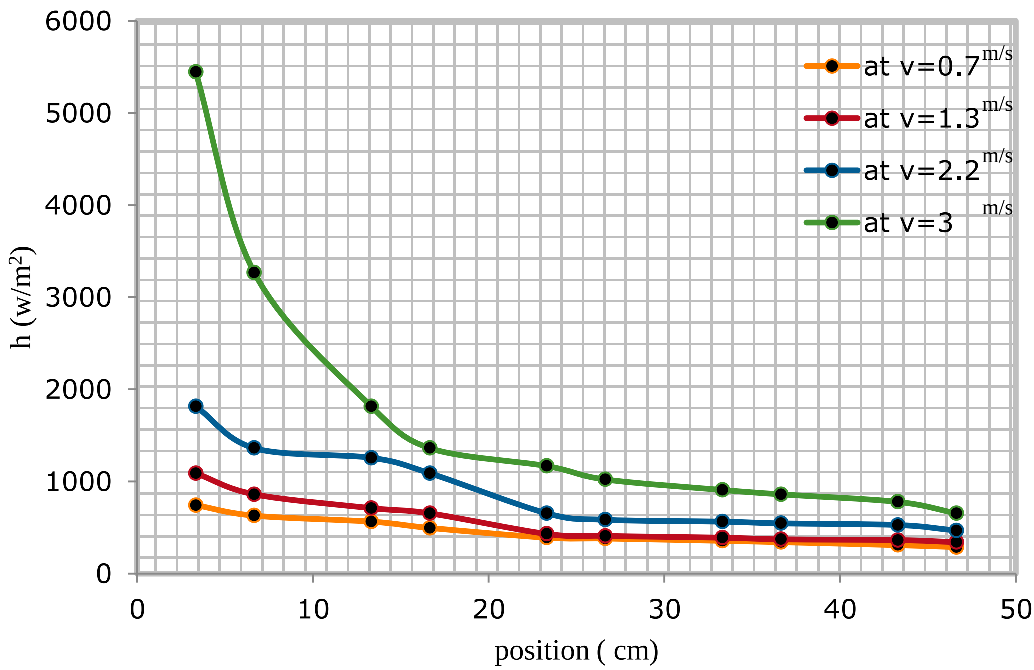

Figure (10) variation of heat transfer coefficient with position along the duct for angles (70°)pointing upstream in four velocities

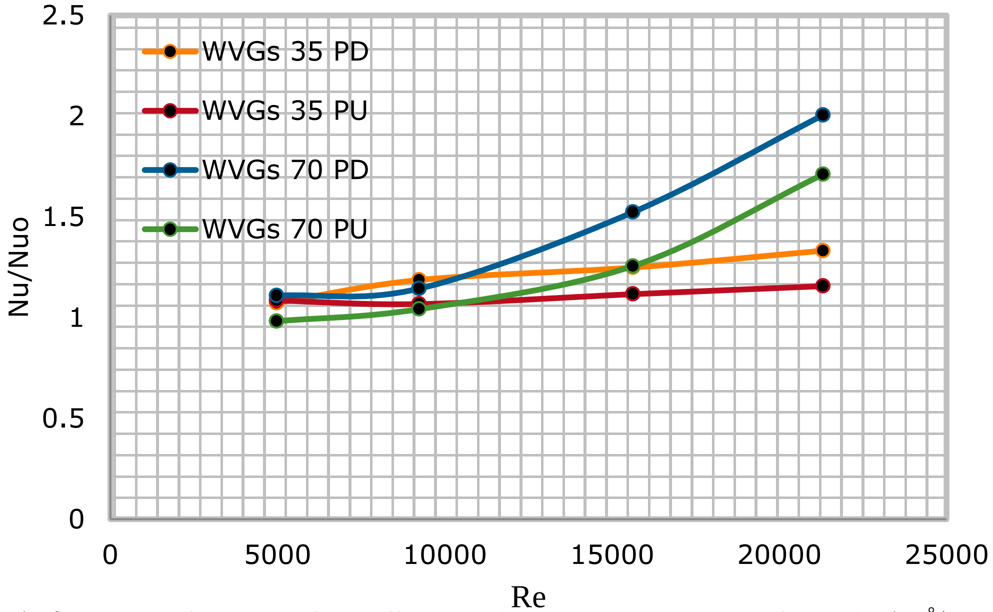

Figure (11) variation of heat transfer coefficient with position along the duct for angles (70°)pointing upstream in four velocities

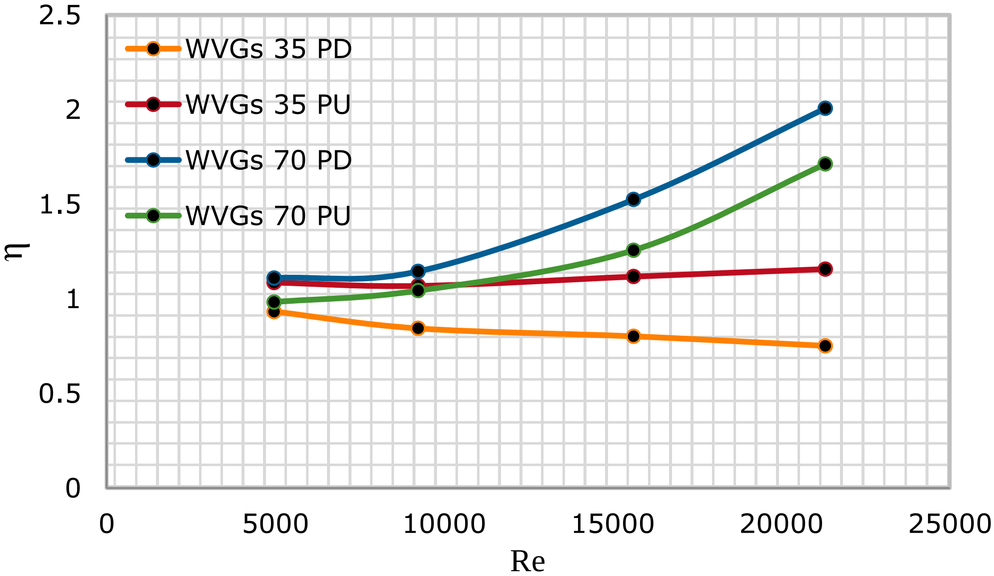

Figure (12) variation of thermal enhancement factor with Reynolds number.

5. Conclusions

The important conclusion from the experimental study the effect of adding rectangle winglet to improve heat transfer coefficient by generate longitudinal vortex inside the heated duct. The 70° angle more efficient in heat transfer in high velocity and the pointing downstream make good result in heat transfer.

Abbreviations

U the mean velocity

ν kinematics viscosity of air
h heat transfer coefficient
v voltage
Dh hydraulic diameter
f friction factor
Re Reynolds Number
Ts Surface temperature
η Thermal enhancement factor
PU Pointing up stream
PD pointing down stream

6. References

1. Han JC, Park JS, Lei CK (1985) Heat transfer enhancement in channels with Turbulence promoters. J Eng Turbines Power 107:628–635.
2. Cho HH, Wu SJ, Kwon HJ (2000) Local heat/mass transfer measurements in a rectangular duct with discrete ribs. ASME J Turbomach 122:579–586
3. S.V. Patankar,C.H. Liu and E.M. Sparrow, (1977) *“Fully developed flow and heat transfer in ducts having streamwise-periodic variations of cross-sectional area,” ASME Journal Heat Transfer*, pp. 180-186.
4. C.H. Cheng and W.H. Huang, (1991) *“Laminar forced convection flows in horizontal channels with transverse fins placed in entrance regions,” Int. J. Heat Mass Transfer*. pp. 1315–1324,
5. F. Incropera and P.D. Dewitt,(2006) *“Introduction to heat transfer 5rd edition,”* John Wiley & Sons Inc.
6. Promvonge, P., Chompookham, T.,Kwankaomeng, S., Thianpong, C.(2010). Enhanced heat transfer in a triangular ribbed channel with lngitudinal vortex generators, Energy Conversion and Management, 51: 1242-1249.
7. Li-Ting Tian, Ya-Ling He, Yong-Gang Lei, Wen- Quan Tao.(2009). Numerical study of fluid flow and heat transfer in a flat-plate channel with longitudinal vortex generators by applying field synergy principle analysis, Int. Commun. Heat Mass Transf. 36: 111–12
8. Holman, (1986)*"heat transfer "*book
9. Jalal M.Jalil,Aseel k.shyaa (2010) *"anumerical and experimental study of louverd fin heat exchanger performance"*Eng&Tech journal vol 28,No.6.