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Correlation of Pressure Drop along the Length of Channel flow using Modified Delta winglet Vortex Generator

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ABSTRACT

This paper enumerates the pressure drop in a channel flow using a Modified Delta winglet Vortex Generator (MDWVG) by partial correlation. The pressure drop was determined by using Frictional factor (f) that was found significant (p<.05) in correlation to the effect of Modified Delta winglet by using SPSS 16.0 software analysis. The partial correlation was determined to be 0.9 which depicts the close relation between the pressure drop and Reynolds numbers at every point, i.e. Common Flow Down and Common Flow Up configuration at up stream and down stream locations.

Keywords - Modified delta winglet vortex generator, Channel flow, Partial Correlation, Reynolds number, frictional factor

1. INTRODUCTION

Most Industries have faced the problem of earlier cooling. Even though the components producing the 1% cooling effect is an excellent achievement by researchers nowadays. For cooling or changing the temperature, the traditional methods are used where the Heat Exchangers play a important role in obtaining this goal. Heat Exchangers are in refrigeration, air-cooled condensers, aerospace, Automobile, HVAC system, Dry cooling towers, oil heaters, Car-radiators, cryogenics process industries, Chemicals, Electronics & transportation equipment & other lots of areas of sectors. Where the traditional methods of heat transfer Augmentation as using of Heat Exchangers possess a lot of limitations as the fin efficiency gets lower with enhancing the fin area, so by enhancing the fin area for reducing gas side thermal resistance the potential is constrained & the system become spacious, heavier & cost lies because fins are higher in number.

Even though a lot of research was carried out on traditional methods, in recent years, the Heat Exchangers are designed using vortex Generators. A lot of vortex generator are used nowadays for getting high performance of heat transfer & reduction of pressure while as much as the pressure reduce, the heat transfer performance increases. Whereas (1)Studied and concluded that the Delta winglet type vortex generator posses more heat transfer performance compare than rectangular winglet type vortex generator. So for getting more heat transfer performance, further investigation is done by this Delta winglet vortex generator after a modified form. Conclude a hole in the centre in the delta winglet type vortex generator, So this modified Delta winglet type vortex generator is now ready to getting more heat transfer performance while the heat transfer performance is totally depends on Reduction of pressure drop. So this modified Delta winglet type vortex generator will work towards for the pressure reduction.

Although a lot of researchers [2-10] works for the pressure drop for different types shapes vortex generators found experimentally the pressure loss in fin-tube Heat Exchangers. Whereas [11-14] solve numerically the vortex generators problem. And [15-16] performed experimentally heat transfer performance of winglet. [17-19] works on the Delta winglet type vortex generator whereas in our research, we use a modified delta winglet type vortex generator to obtain more pressure reduction . Variation of drop in pressure of fluid with various values of Reynolds numbers has been examined by [20-22]. They performed the Experimental modelling and analysis of fluid-structure interaction have been done using critical statistical tools. Also, this paper uses statistical agencies to obtain the correlation between the Reynolds numbers and pressure drop.

2. EXPERIMENTATION

In this research paper, the Modified Delta winglet with a circular hole is used on the rectangular plate. This Modified Delta winglet Vortex Generator (MDWVG) is attached to the rectangular plate. The rectangular channel plate without a winglet possesses 300 mm length, 200 mm width and 4 mm height as shown in figure 2.1. Such 23 rectangular channel plate is used for performing the experiments. The material used for the rectangular channel plate is aluminium. Two Modified Delta winglet Vortex

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Generators (MDWVG) are attached on the mid rectangular plate where both the MDWVG are 60 mm away from centre of the rectangular as shown in figure 2.2. Figure 2.3 shows the experimental setup named wind tunnel. The wind tunnel measures the temperature and pressure drop on the mid rectangular channel plate with MDWVG. All 23 Aluminium rectangular channel plates are mounted parallel to each other, and for producing the heating effect, a 300 KW heater is used nearby the mid-plate. The test prototype is fitted in the mid section of the wind tunnel as shown in figure 2.3. The range of Reynolds numbers is 1400 to 9000.

In this experimental work the experiments are performed on MDWVG on the rectangular plate surface in Common Flow Down (CFD) and Common Flow Up (CFU) configuration at downstream as well as upstream locations of flow in a fin -tube heat exchanger. This happened to lie after thewinglets in all of the four cases CFD and CFU configuration at downstream as well as upstream locations, i.e. CFDD, CFUD, CFDU,CFUU configurations.

The flow resistance and Heat transfer characteristics have been compared for all the four configurations of the winglet, viz., CFD and CFU configurations in downstream and upstream locations using friction factor (f).

Figure 2.1 Rectangular Channel Plate

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Figure 2.2 Location of the Winglet

Figure 2.3 Experimental setup

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3. RESULT AND DISCUSSION

Diagram 3.1 shows the Variation of Pressure Drop with Renolds Number. As per experimentation at the Renolds Number value of 1400, all Pressure Drop value is 2. And at the Renolds Number value of 3000, the Pressure Drop at CFD_D value 4; and others all factors value of Pressure Drop are 4.5. When the Renolds Number value of 4500 is taken, the Pressure Drop at CFD_D becomes 9; and the other factors value of Pressure Drop becomes 10. The Renolds Number value of 6000, the Pressure Drop at CFD_D value 16; other factors value pressure Drop at CFD_U is 18; Pressure Drop at CFU_D value is 18 and Pressure Drop at CFU_U value is 18.5. Next, for the Renolds Number value of 7500, the Pressure Drop at CFD_D becomes 24; other factors value pressure Drop at CFD_U is 27; Pressure Drop at CFU_D value is 27 and Pressure Drop at CFU_U value is 27.5. At last, as per experimentation, the Renolds Number value of 9000 Pressure Drop at CFD_D value is 34; other factors value Pressure Drop at CFD_U, and CFU_D value is 38 and Pressure Drop at CFU_U value is 39.

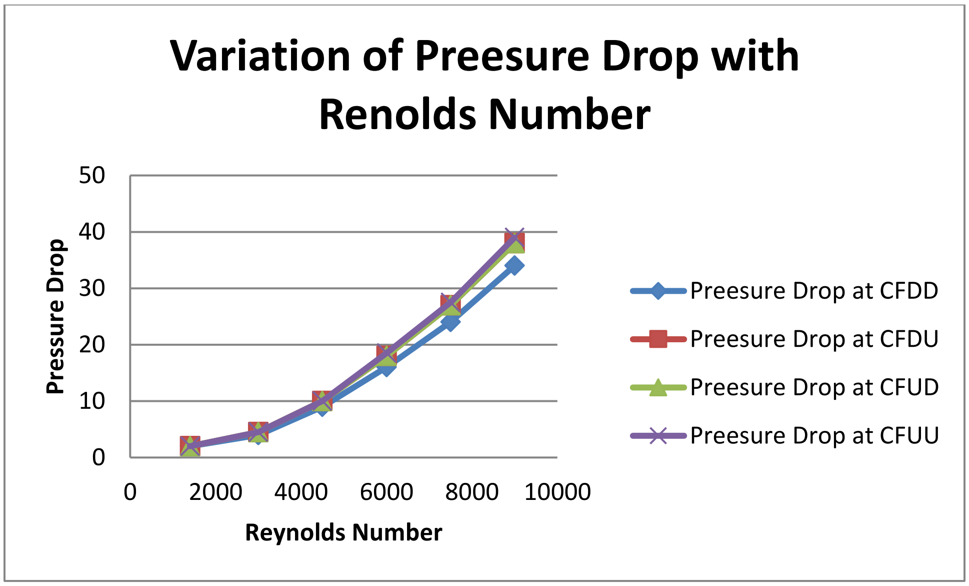

Diagram 3.1: Variation of Pressure Drop with Renolds Number

Diagram 3.2 shows the Variation of Friction factor with Renolds Number. As per experimentation, the Renolds Number value of 1400 Friction Factor at CFD_D value is 0.039; other factors value Friction Factor at CFU_D value is 0.042, CFD_U value is 0.043, and Friction Factor CFU_U value is 0.0435. Next, the Renolds Number value of 3000 Friction Factor at CFD_D value is 0.0325; other factors value Friction Factor at CFU_D value is 0.0365, and CFD_U value is 0.036, and Friction Factor CFU_U value is 0.037. Further, the Renolds Number value of 4500 Friction Factor at CFD_D value is 0.0315; other factors value Friction Factor at CFU_D value is 0.0295, and CFD_U value is 0.029, and Friction Factor at CFU_U value is 0.036. Further, the Renolds Number value of 6000 Friction Factor at CFD_D value is 0.0305; other factors value Friction Factor at CFU_D value is 0.0345, and CFD_U value is 0.034, and Friction Factor at CFU_U value is 0.0345. Next, the Renolds Number value of 7500 Friction Factor at CFD_D value is 0.0295; other factors value Friction Factor at CFU_D value is 0.034, and CFD_U value is 0.0335, and Friction Factor at CFU_U value is 0.034. At last, as per experimentation, the Renolds Number value of 9000 Friction Factor at CFD_D value is 0.029; other factors value Friction Factor at CFU_D value is 0.0335, and CFD_U value is 0.033, and Friction Factor CFU_U value is 0.0335.

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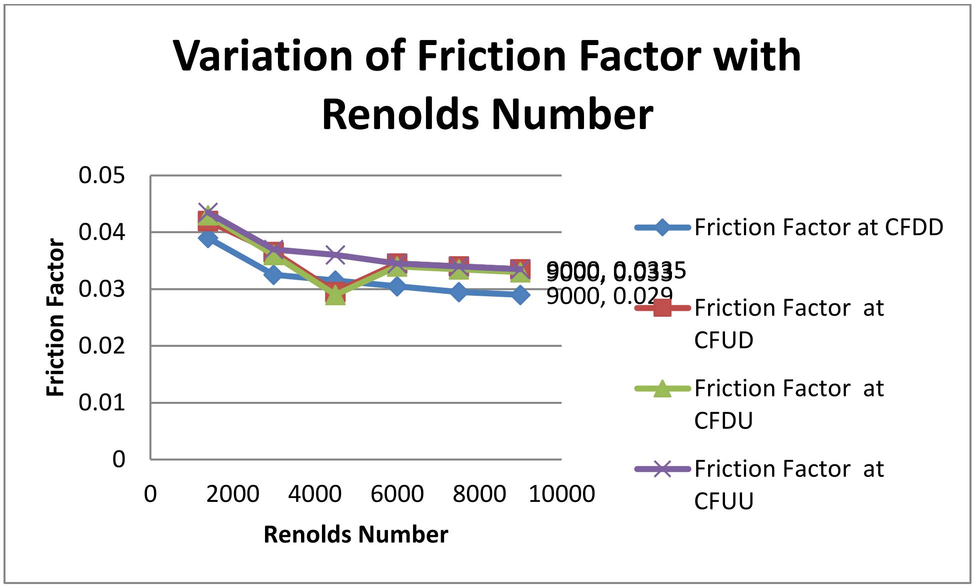

Diagram 3.2: Variation of Friction Factor with Renolds Number

3.2 Descriptive Statistics

Using statistical analysis techniques, find out the variance, standard deviation, mean and range for friction factor and pressure drop with the help of SPSS 16.0 software, as shown in Table 3.2.1.

Table 3.2.1: Descriptive Statistics for Pressure Drop

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
PressureDropatCFDd	6	32.00	2.00	34.00	14.8333	12.40027	153.767
PressureDropatCFDu	6	36.00	2.00	38.00	16.5833	13.93706	194.242
PressureDropatCFUd	6	36.00	2.00	38.00	16.5833	13.93706	194.242
PressureDropatCFUu	6	37.00	2.00	39.00	16.9167	14.32975	205.342
ReynoldsNumber	6	7600.00	1400.00	9000.00	5.2333E3	2833.13725	8.027E6
Valid N (listwise)	6						

3.3 Partial Correlations

The statistical analysis techniques find the partial correlation between friction factor and pressure drop with the help of SPSS 16.0 software, as shown in Table 3.2.2. as we know, if the correlation value is one or nearby, the correlation will be high bonding. As per our result, the correlation value is mostly one and close to 1. It means our bonding is high.

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Control Variables			PressureDropatCFDd	PressureDropatCFUd	PressureDropatCFDu	PressureDropatCFUu	ReynoldsNumber
-none-[a]	PressureDropatCFDd	Correlation	1.000	1.000	1.000	1.000	.977
		Significance (2-tailed)	.	.000	.000	.000	.001
		df	0	4	4	4	4
	PressureDropatCFUd	Correlation	1.000	1.000	1.000	1.000	.978
		Significance (2-tailed)	.000	.	.000	.000	.001
		df	4	0	4	4	4
	PressureDropatCFDu	Correlation	1.000	1.000	1.000	1.000	.978
		Significance (2-tailed)	.000	.000	.	.000	.001
		df	4	4	0	4	4
	PressureDropatCFUu	Correlation	1.000	1.000	1.000	1.000	.977
		Significance (2-tailed)	.000	.000	.000	.	.001
		df	4	4	4	0	4
	ReynoldsNumber	Correlation	.977	.978	.978	.977	1.000
		Significance (2-tailed)	.001	.001	.001	.001	.
		df	4	4	4	4	0
ReynoldsNumber	PressureDropatCFDd	Correlation	1.000	1.000	1.000	.999	
		Significance (2-tailed)	.	.000	.000	.000	
		df	0	3	3	3	
	PressureDropatCFUd	Correlation	1.000	1.000	1.000	.999	
		Significance (2-tailed)	.000	.	.000	.000	
		df	3	0	3	3	
	PressureDropatCFDu	Correlation	1.000	1.000	1.000	.999	
		Significance (2-tailed)	.000	.000	.	.000	
		df	3	3	0	3	
	ssureDropatCFUu	Correlation	.999	.999	.999	1.000	
		Significance (2-tailed)	.000	.000	.000	.	
		df	3	3	3	0	

a. Cells contain zero-order (Pearson) correlations.

Table 3.2.2: Pressure Drop control variables

4. CONCLUSION

This paper enumerates the pressure drop in a channel flow using a Modified Delta winglet Vortex Generator (MDWVG) by partial correlation. The friction factor also finds out because the pressure drop and friction factor correlate. The Descriptive Statistics and partial correlation are also calculated between the pressure drop and Reynolds Numbers found by the SPSS 16.0 software. The partial correlation result is nearby one, showing the close relationship between the pressure drop and Reynolds Numbers at every point, i.e. Common Flow Down and Common Flow Up configuration at upstream and downstream locations.

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