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Investigation of Performance of Heat Transfer with the Help of Coiled Wire Inserts and Dimpled Tube

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Abstract: ***Heat transfer enhancement is classified into active and passive methods. Active techniques require external power to type in the process; in comparison, passive methods don't require any extra power to enhance the thermo hydraulic overall performance of the product. Passive techniques are popular in each numerical and experimental uses when investigating heat transfer enhancement and friction losses to help save costs and power. The numerous passive ways for increasing heat transfer rate include different elements placed in the fluid flow path, like coiled wire, coiled and tangled cables, as well nozzle tabulator's. The existing paper belongs to an extensive review which centered on heat transfer enhancement techniques with coiled wire plus coiled wire inserts because the assembly of inserts is simpler and much more efficient. The study work involves experimentation and numerical evaluation of dimpled tube built with frequently spaced coiled wire inserts. In this paper, the explanation of the experimental set in place and instrumentation used, together with the experimental data and process reduction is presented. The primary goal of the testing is obtaining experimental data pertaining to heat transfer and fluid flow. Unique trials had been carried out with mixtures of dimpled tubes and coiled wire with different Reynolds number for warm fluid and by holding regular flow of cool fluid through annulus.***

Index Term : Heat, existing, presented, Reynolds, Unique ,comparison,

I. INTRODUCTION

Heat exchangers are utilized in various tasks ranging from conversion, recovery and utilization of thermal power in different industrial, domestic and commercial applications. A few typical examples include steam generation, condensation in power & cogeneration plants, smart heating & cooling in winter processing of substance, agricultural and pharmaceutical products, and fluid heating in producing & waste heat healing etc. Increase in heat exchanger's efficiency is able to result in less expensive look of heat exchanger that will assist with generate power, materials & cost savings associated with a heat exchange system. The requirement to boost the winter functionality of heat exchangers, therefore affecting power, materials & cost savings have resulted in use and growth of countless methods called as heat transfer augmentation. These methods can also be known as heat transfer enhancement and also intensification.

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Augmentation strategies grow convective heat transfer by decreasing the winter opposition in a heat exchanger. Use of Heat transfer enhancement methods lead increasing in heat transfer coefficient but in the price of increased pressure fall. Thus, while developing a heat exchanger through these strategies, evaluation of heat transfer rate & pressure fall must be completed. Aside from this, problems like long term efficiency & detailed financial evaluation of heat exchanger must be studied. In order to attain higher heat transfer rate in a current or maybe new heat exchanger while caring for the greater pumping electricity, a few methods are recommended in recent years. Coiled wire a kind of passive heat transfer augmentation methods show drastically excellent outcomes in previous studies. For experimental work, various layouts of coiled wire utilized are normal coiled wire (TT). All these tapes are analyzed with 3 distinct twist proportions (y = 4.213, 5.337, 6.4606) as well as level of cut (d = six mm) for notched coiled wire.

II. REVIEW ON HEAT TRANSFER TECHNIQUES

2.1 Heat Transfer Enhancement with Coiled Wire Inserts

The enhancement of heat transfer rate by making use of coiled wire inserts is commonly studied both numerically and experimentally by a lot of scientists. Garcia et al. (2012) [1] analyzed the thermo hydraulic functionality of 3 kinds of passive heat transfer development dependent on synthetic roughness. Based on the end result, the usage of coiled wire in a reduced Reynolds number was much more useful compared to dimpled and corrugated tubes. Ozceyhan (2005) [2] numerically examined conjugate heat transfer as well as winter pressure in a tube with coiled wire inserts. Gunes et al. (2010) [3] investigated the consequences of coiled wire on heat transfer enhancement as well as pressure fall in a tube. It was discovered that top overall enhancement effectiveness was attained because of the configuration with P/D = one. In an additional study Gunes et al. (2010) [4] found on the characteristics of heat transfer as well as pressure fall in a tube with coiled wire inserts separated from the tube wall by 2 various distances. The results demonstrated that the Nusselt quantity as well as pressure fall expansion with minimizing distance between the coiled wire as well as the tube wall. Promvonge (2007) [5] given the experimental success because of the heat transfer as well as flow friction qualities in a circular tube where coiled wire with a square cross part was introduced. The winter functionality of helically coiled wire was experimentally examined by Eiamsaard et al. (2012) [6].

They found the heat transfer rate as well as the friction component increase as the twist ratio as well as helical pitch ratio increase. In an additional study, Eiamsaard et al. (2010) [7] studied the winter functionality of a tube equipped with both coiled wire& a coiled wire. Heat transfer as well as friction component analyses of coiled wire introduced tube utilizing several types of nanofluid as dealing fluid were carried out by SyamSundar et al. (2012) [8]. Promvonge (2007) [9] conducted a further study of thermo-hydraulic functionality in a tube with coiled wire insert along with a snail entry.

The high temperature transfer as well as the friction component attributes of the laminar flow of oil in rectangular and square ducts with transverse ribs & coiled wire had been analyzed by Saha (2010) [10].

2.2 Heat Transfer Enhancement with Dimple Tubes

Heat sink functionality may be examined by a few factors: information, surface area, flatness of touch surfaces, setup, and fan demands. Though there are some investigations because of the usage of dimples below laminar airflow problems, there is available zero experimental information with regard to the utilization of various dimple shapes for heat sink apps. Thus, this particular study evaluated the heat transfer attributes that uses 2 distinct dimple shapes on a heat sink fin by numerical and experimental methods: one) circular (spherical) dimples, moreover two) oval (elliptical) dimples. The typical heat transfer coefficient as well as heat transfer efficiency were obtained experimentally. Heat transfer coefficient, pressure drop, winter performance as well as flow attributes were simulated numerically. Many variables have been picked to assess the appearance of dimples: Reynolds quantity (ReH), family member channel level (H/D), family member dimple level (δ/D), and turbulent intensity. A lot of investigations have been performed for a rectangular channel.Idarioet. al (2017) [11] performed tests to improve the heat transfer rate in streamlined heat exchangers by utilizing superficial square dimples in dull plate tubes. By utilizing dimple smooth tubes it improved the heat transfer augmentation component. A very good correlation was discovered among the experimental as well as the predicted bodily coefficient of friction. The technique is a passive method of heat transfer enhancement method. It was observed that the assembly provided a heat transfer augmentation aspect between 1.37 as well as 2.28.Wanget. al (2014) [12] examined the semi dimple vortex turbine. The setup does apply to fin as well as tube heat exchanger. The study examines the environment side functionality of the fin as well as tube heat exchangers having straightforward dimple vortex generator. A lot of samples were been shot, out of the countless conclusions among the conclusions would be that the experimental arrangement is ten % more effective compared to the basic fin geometry. Li et. al (2015) [13] labored on the geometric seo for thermal hydraulic functionality of dimpled tubes for individual stage flow. Improved surfaces have bigger heat transfer surface area and also offer enhanced turbulence amount thus allowing higher heat exchange efficiency. In this particular research, numerical simulations are performed to simulate geometric design seo of enhanced tubes for optimum thermal- Hydraulic overall performance. The simulations are validated with experimental data. J . Chen et.al. (2001) [14], they conducted an experimental work to learn the high temperature transfer coefficient, friction element as well as development index qualities inside a dimpled tube at various depth/pitch of dimples. Their results demonstrated that the high temperature transfer rates have been increased from twenty five % to 137 % at frequent Reynolds number, along with fifteen % to eighty four % at frequent pumping energy. P. G. Vicente (2002) [15], they found the consequences of the three dimensional helically dimpled tubes (dimpled level, h/d=0.08 to 0.12 as well as helical pitch, p/d=0.65 to 1.1) on the high temperature transfer as well as isothermal friction in turbulent flow region.

III. OBJECTIVES OF THE STUDY

The main aim of this paper is to obtain experimental data pertaining to heat transfer and fluid flow. For this purpose various experiments were implemented using dimpled tubes and coiled wire with varying Reynolds number for hot fluid and by keeping constant flow of cold fluid through annulus.

IV. MATERIAL AND METHODS

The experiments are performed using water as being a working medium. The warm water moves with the internal tube (Copper tube, di=20mm, do=22mm & the heat and l=1200mm) transfer moderate passes in the countertop flow with the annulus. The pressure drop throughout the test portion is measured by working with strain differential gauge. 2 Rota meters are used to calculate the flow rates of fluid. The working medium is maintained at persistent temperature of 60oC utilizing thermostat. The functioning moderate is warmed up in 500 liters of container that uses 6 immersion style heating units (2KW each). The coiled wire is comprised of Aluminum strips of thickness 1.0mm plus breadth of 15mm. The tapes are fabricated by twisting the straight strips, concerning the longitudinal axis of its, while being kept under tension. The various kinds of coiled wire can also be fabricated, with various pitches, twist ratio as well as spacer length. Each often spaced coiled wire components are associated with Aluminum rod. The dimpled tubes are fabricated on milling piece of equipment. The dimples are designed on the examination tubes, utilizing the blows produced- Positive Many Meanings - - Positive Many Meanings- of S.S. material. The 9 dimpled tubes of various mixtures dimple level, dimple pitch along with repaired 4mm dimple diameter are fabricated. The warm water container is loaded with the cool water from the tank utilizing the pump and heated until finally the heat reaches 60^{o}C. All the specifications were given in table 1 and table 2.

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Table 1: Specifications of dimpled tubes

Sr No.	Specification	Plain tube	Dimpled tube1	Dimpled tube2	Dimpled tube3
1	Length of test tube (mm)	1200	1200	1200	1200
2	Dimple diameter (mm)		4.0	4.0	4.0
3	Dimple depth (mm)		1.2	1.6	2.0
4	Dimple pitch (mm)		30	60	90

Table 2: Specifications of Coiled Wire

Sr No.	Specification	Full length	Tape 1	Tape 2	Tape 3
1	Length of Coiled Wire	1200	1200	1200	1200
2	Coiled Wire pitch (mm)	30,45,60,	30	45	60
3	Space length (mm)	0.0	90	180	270

5.1 Heat Transfer Performance of Dimpled Tube Equipped With Full Length and Regularly Spaced Coiled Wire Inserts

The tests on dimpled tubes built with full length and also frequently spaced coiled wire inserts have been done and also talked about in the next portion.

Heat Transfer Performance of Dimpled Tube (h=0.5, p=1.5) with Coiled wire Inserts

The experimental outcomes for heat transfer, winter results and friction aspect revealed within the Tables 3 and 4 respectively. The outcomes of dimpled tube experiencing dimple level ratio h= 0.5, dimple pitch ratio p=1.5 and then furnished with various coiled wire inserts having several coiled wire pitch ratio (y= two, three, four) as well as room ratios (s=0.0, 9, 4.5, 13.5) are talked about.

V. RESULT & DISCUSSION

Table 3: Results of Nusselt number for Dimpled tube (h=0.5, p=1.5) with coiled wire

Geometry	Nusselt Number					
	4568	6802	9036	12170	13504	15600
PT	27.91	38.23	47.87	57.02	66.80	80.56
h=0.5,p=1.5,y=2,s=0	91.02	120.49	150.94	165.61	191.32	110.89
h=0.5,p=1.5,y=3,s=0	85.30	113.78	149.24	160.28	177.31	195.47
h=0.5,p=1.5,y=4,s=0	85.32	112.21	135.20	145.92	162.63	178.70
h=0.5,p=1.5,y=2,s=4.5	90.23	120.00	143.00	154.00	170.00	188.00
h=0.5,p=1.5,y=2,s=9	83.50	97.58	127.60	140.25	156.20	175.32
h=0.5,p=1.5,y=2,s=13.5	73.00	95.00	113.50	129.80	140.89	157.85
h=0.5,p=1.5,y=3,s=4.5	86.00	113.20	137.81	149.80	160.30	177.50
h=0.5,p=1.5,y=3,s=9	81.50	101.20	125.80	135.40	144.70	162.34
h=0.5,p=1.5,y=3,s=13.5	73.52	95.60	111.32	126.50	133.54	151.35
h=0.5,p=1.5,y=4,s=4.5	78.00	81.32	125.40	138.30	154.71	172.34
h=0.5,p=1.5,y=4,s=9	71.34	93.00	114.30	125.60	138.81	156.70
h=0.5,p=1.5,y=4,s=13.5	68.89	91.30	88.20	119.70	130.40	145.74

The Nusselt quantity perturbation with Reynolds number just for the dimpled tube built with total length coiled wire of different twist proportions (y/D=2, three, four) are provided in the Figure 1 It reveals the variation of Nusselt quantity with Reynolds number for various twist proportions as well as these variants are in contrast to basic tube experimental data. It's been observed the Nusselt quantity increases with Reynolds quantity in all of the instances of total length coiled wire as well as frequently spaced coiled wire. Hence the high temperature transfer rate is bigger for the dimpled tube built with total length coiled wire compared to that of the plain tube, due to the swirl produced by the coiled wire is incredibly powerful. Because of the reduced cross sectional location together with the tangential velocity element the blending of the fluid in between the fluid in the core region as well as the fluid at the wall structure area has considerable power to boost the rate of heat transfer.It's additionally observed the rate of heat transfer improves with reduction in the twist ratio. Due to the bigger turbulent intensity found for reduced twist ratio causes greatest heat transfer rate as well as heat transfer rate decreases with increased twist ratio. For any learned twist ratios(y=2,3,4) of total length coiled wire the Nusselt quantity observed are 234%,213.2 % along with 179.3 % respectively better compared to plain tube acting alone. Similar to the total length coiled wire heat transfer rate increases with increased Reynolds quantity for routinely spaced coiled wire.

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It's found that, smaller twist ratio yields better heat transfer rate compared to every other combination shown in the figure. It is found the dimpled tube equipped with routinely spaced coiled wire with twist ratio y=2, with s=4.5, 9.0& 13.5 the Nusselt quantity are 198.3%, 173.2 % along with 134 % respectively superior to the basic tube.

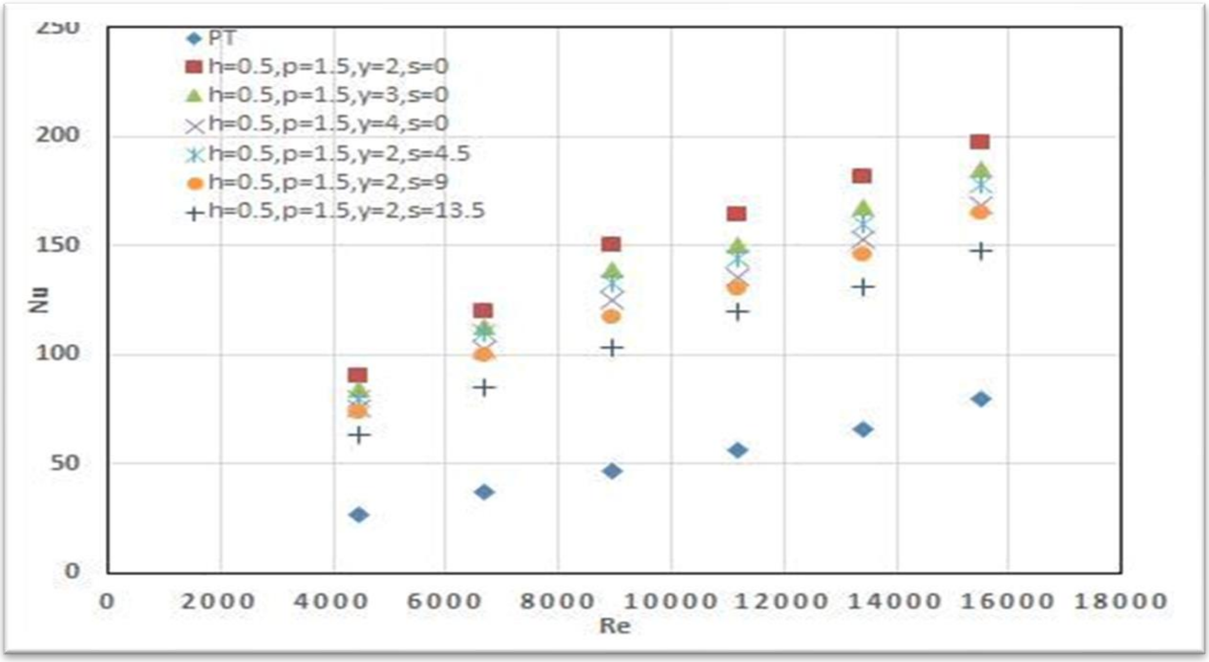

Figure 1: Variation of Nusselt number with Reynolds number for (h=0.5, p=1.5) (Kumbhar, 2017)

Fluid flow performance of dimpled tube with coiled wire inserts able 4 reveals the experimental success of friction element for dimpled tube with coiled wire inserts. Figure 2 displays the friction component variation with Reynolds quantity for various twist proportions and also for basic tube. It's been observed that friction component decreases with Reynolds quantity in all of the instances such as basic tube. It's found the friction elements in dimpled tube built with total length coiled wire are above all those of plain tube. Because of good swirl sereneness of tiny twist ratio results in higher friction element leads to higher tangential communication between the dimple tube as well as swirling flow. The coiled wire with twist ratio y=2 has larger friction element with regard to various other combinations studied. It's found at the figure which the friction element is more for twist ratio y=2 which reduces with increased twist ratio and also Reynolds number. It is found the friction element for total length coiled wire inserts differs through 5.34 to 5.89 times greater compared to basic tube. Just in case of routinely spaced coiled wire inserts with y=2, the friction element differs through 4.9 to 5.4 occasions in contrast to basic tube.

Table 4:Results of Friction factor for dimpled tube (h=0.5, p=1.5) with coiled wire inserts

Geometry	**Friction Factor**					
	4568	**6802**	**8836**	**12170**	**14404**	**16500**
PT	0.062	0.06	0.055	0.052	0.05	0.048
h=0.5,p=1.5,y=2,s=0	0.378	0.363	0.351	0.343	0.333	0.324
h=0.5,p=1.5,y=3,s=0	0.363	0.354	0.344	0.337	0.324	0.31
h=0.5,p=1.5,y=4,s=0	0.351	0.343	0.332	0.32	0.31	0.305
h=0.5,p=1.5,y=2,s=4.5	0.358	0.348	0.339	0.321	0.316	0.307
h=0.5,p=1.5,y=2,s=9	0.344	0.334	0.325	0.316	0.305	0.296
h=0.5,p=1.5,y=2,s=13.5	0.335	0.321	0.311	0.303	0.294	0.283
h=0.5,p=1.5,y=3,s=4.5	0.3543	0.34	0.335	0.321	0.313	0.301
h=0.5,p=1.5,y=3,s=9	0.347	0.333	0.321	0.313	0.305	0.296
h=0.5,p=1.5,y=3,s=13.5	0.335	0.321	0.304	0.29	0.283	0.275
h=0.5,p=1.5,y=4,s=4.5	0.343	0.331	0.321	0.313	0.304	0.29
h=0.5,p=1.5,y=4,s=9	0.34	0.335	0.31	0.301	0.293	0.283
h=0.5,p=1.5,y=4,s=13.5	0.321	0.313	0.301	0.293	0.285	0.272

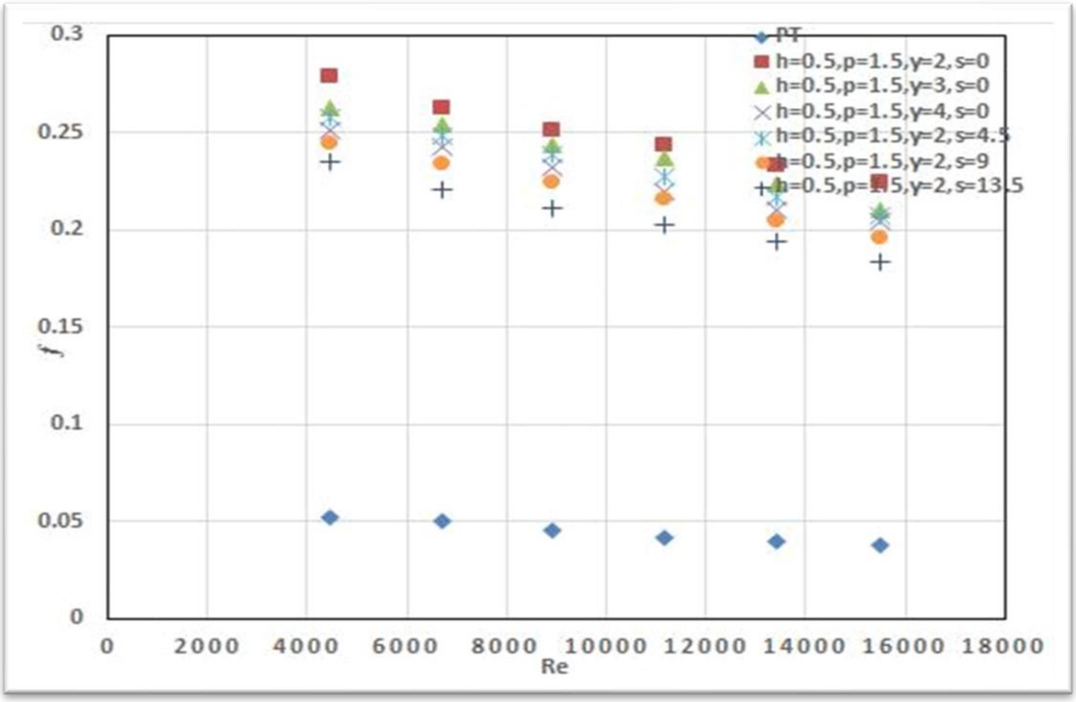

Figure 2: Variation of Friction factor with Reynolds number for (h=0.5, p=1.5) (Kumbhar, 2017)

Result tables for different experiments on dimpled tube with coiled wire insertsThe end result tables for various combinations of dimpled tubes built with full length and frequently spaced coiled wire inserts are provided. The end result as well as discussion with respect to various parameters is completed. The following tables exhibits the outcomes for various dimpled tubes (h=0.5, p=4.5), (h=0.4, p=1.5), (h=0.4, p=3.0), (h=0.4, p=4.5), and (h=0.3, (h=0.3, p=3.0), (h=0.3, p=1.5), p=4.5) furnished with full length and also frequently spaced coiled wire inserts.

Table 5: Results of Nusselt number for Dimpled tube (h=0.5, p=4.5) with coiled wire inserts

Geometry	**Nusselt Number**					
	4568	**6802**	**8836**	**12170**	**14404**	**16500**
PT	36.91	47.23	56.87	66.02	75.8	89.56
h=0.5,p=4.5,y=2,s=0	75.30	98.50	114.30	130.11	145.60	168.30
h=0.5,p=4.5,y=3,s=0	72.00	91.98	107.54	119.20	137.81	156.00
h=0.5,p=4.5,y=4,s=0	65.41	84.50	97.00	110.20	125.30	144.00
h=0.5,p=4.5,y=2,s=4.5	68.70	86.80	101.30	111.20	130.30	150.21
h=0.5,p=4.5,y=2,s=9	60.00	77.40	93.40	107.50	120.20	137.50
h=0.5,p=4.5,y=2,s=13.5	57.50	74.30	85.80	98.90	112.30	128.70
h=0.5,p=4.5,y=3,s=4.5	64.41	79.75	92.23	108.04	121.32	138.70
h=0.5,p=4.5,y=3,s=9	60.21	74.50	86.00	101.23	115.20	131.20
h=0.5,p=4.5,y=3,s=13.5	56.50	69.70	82.10	92.39	106.00	125.00
h=0.5,p=4.5,y=4,s=4.5	60.35	78.03	89.79	106.09	115.00	133.50
h=0.5,p=4.5,y=4,s=9	58.54	71.40	84.00	100.40	100.40	125.00
h=0.5,p=4.5,y=4,s=13.5	55.00	68.30	81.30	90.20	102.00	118.20

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Table 6: Results of Friction factor for Dimpled tube (h=0.5, p=4.5) with coiled wire inserts

Geometry	Friction Factor					
	4568	6802	8836	12170	13504	15600
PT	0.062	0.060	0.055	0.052	0.050	0.048
h=0.5,p=4.5,y=2,s=0	0.272	0.261	0.254	0.241	0.230	0.221
h=0.5,p=4.5,y=3,s=0	0.260	0.251	0.243	0.231	0.221	0.214
h=0.5,p=4.5,y=4,s=0	0.250	0.241	0.234	0.225	0.213	0.199
h=0.5,p=4.5,y=2,s=4.5	0.256	0.244	0.231	0.222	0.214	0.198
h=0.5,p=4.5,y=2,s=9	0.241	0.223	0.226	0.205	0.199	0.190
h=0.5,p=4.5,y=2,s=13.5	0.231	0.221	0.213	0.199	0.190	0.185
h=0.5,p=4.5,y=3,s=4.5	0.251	0.240	0.230	0.220	0.205	0.199
h=0.5,p=4.5,y=3,s=9	0.244	0.231	0.222	0.210	0.199	0.192
h=0.5,p=4.5,y=3,s=13.5	0.232	0.221	0.213	0.198	0.192	0.195
h=0.5,p=4.5,y=4,s=4.5	0.244	0.231	0.225	0.217	0.199	0.195
h=0.5,p=4.5,y=4,s=9	0.231	0.227	0.215	0.199	0.195	0.185
h=0.5,p=4.5,y=4,s=13.5	0.227	0.221	0.199	0.191	0.184	0.173

VI. FINDINGS

- For the analyzed twist proportions (y=2,3,4) of total length coiled wire the heat transfer rate is elevated by 234 %, 213.2 % along with 179.3 % respectively better compared to plain tube acting alone.? The heat transfer rate is bigger for the dimpled tube built with total length coiled wire compared to that of the plain tube, due to the swirl produced by the coiled wire is incredibly powerful. It's additionally observed the rate of heat transfer improves with reduction in twist ratio.
- Similler to the total measurements coiled wire inserts heat transfer rate improves with increased Reynolds quantity for routinely spaced coiled wire inserts.
- It is observed that, scaled-down twist ratio yields better heat transfer rate compared to every other combination.
- It is found the dimpled tube built with routinely spaced coiled wire with smaller sized twist ratio y=2, with s=4.5,9,13.5 the high temperature transfer rate is elevated by 198.3%,173.2 % along with 134 % respectively better compared to the basic tube.

VII. CONCLUSION

The present paper concluded both important and recent investigations on the enhancement of heat transfer using dimple tube and coiled wire inserts in turbulent flow region and laminar. The majority of the experiments for equally coiled wire and coiled wire inserts highlight the enhanced heat transfer rate as well as fluid friction or maybe pressure fall. The primary goal to develop a heat exchanger is enhancing the high temperature transfer without causing additional pressure drop. It's found the Nusselt quantity perturbation with Reynolds quantity as well as friction component variation with Reynolds number just for the dimpled tube built with total length coiled wire of different twist proportions the Nusselt quantity increases with Reynolds quantity in all of the instances of total length coiled wire as well as in case of routinely spaced coiled wire inserts. The high temperature transfer rate is bigger for the dimpled tube built with total length coiled wire compared to that of the plain tube, due to the swirl produced by the coiled wire is incredibly powerful. It's additionally observed the rate of heat transfer improves with reduction in twist ratio.

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