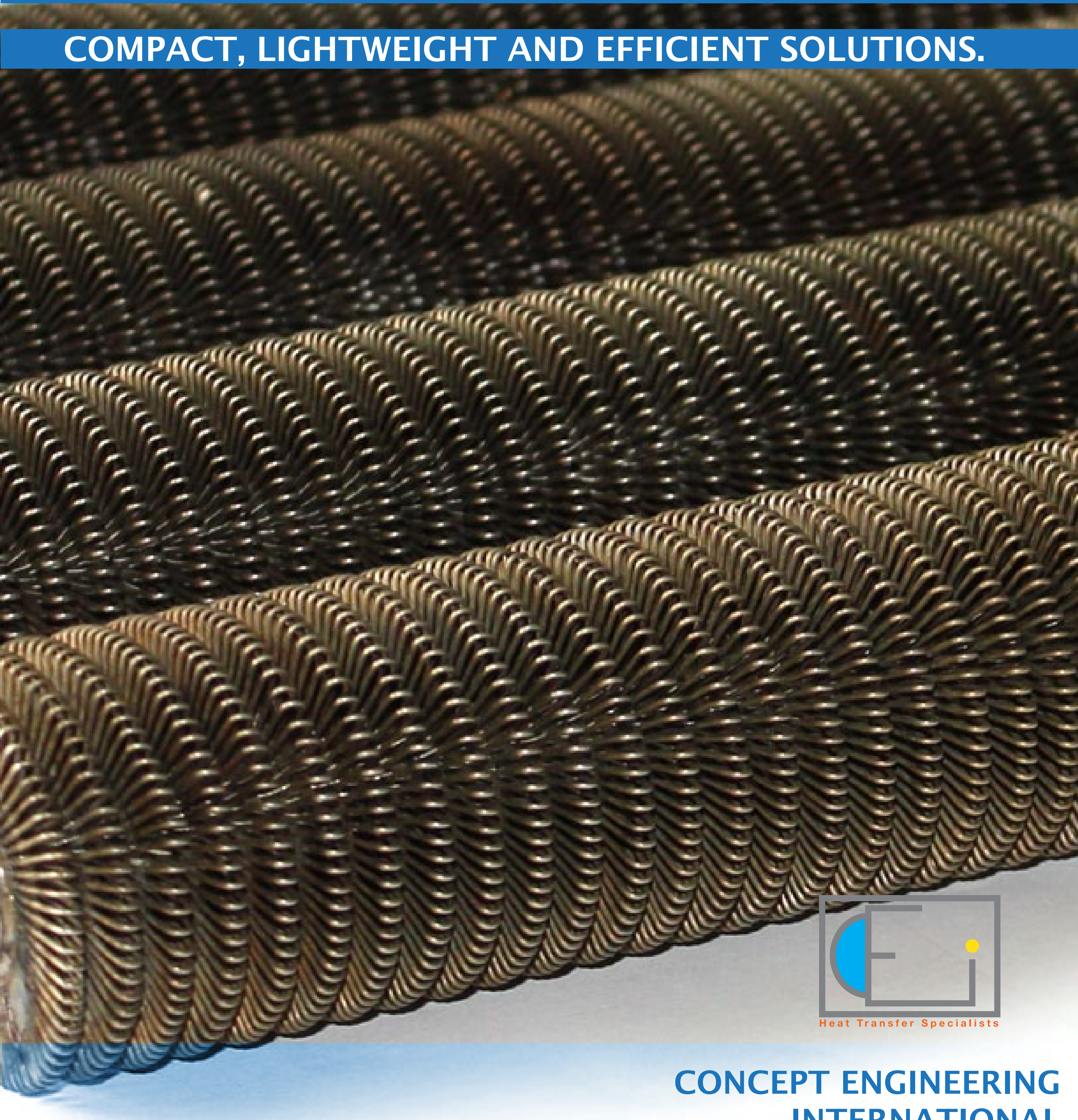
BUILDING SUPERIOR

STEAM AIR HEATERS

COMPACT, LIGHTWEIGHT AND EFFICIENT SOLUTIONS.



Heat Transfer Specialists

CONCEPT ENGINEERING INTERNATIONAL

Saturated steam condensing in tubes has a very high heat transfer coefficient. To harness its true potential you need a very efficient fin tube as the airside is the limiting factor.

Our PIN Fin tube fits the bill. It consists of wire loops fastened to the tube with a flattened wire soldered to the tube. The soldering(lead free solder is an option) gives 100% bonding and strength and the wire loops provide very high airside turbulence. The result is an extremely high airside coefficient enhancing significantly the overall heat transfer coefficient.

These fin tubes can be provided with carbon steel, stainless steel or copper wire fins on steel, stainless steel or copper/copper alloy tubes. To demonstrate the performance of these tubes against helical fin tubes we have done the following:

1. Designed a 1 meter by 1 meter 3 row panel using ¾" OD steel tubes with 10 FPI L type Aluminum fins. We have used 57 tubes in this panel. (19 tubes/row) The fin thickness was 0.5 mm and the fin height was 13 mm giving a heat transfer area of 3.51 ft2/ft. The transverse pitch was 50.8 mm and the longitudinal pitch was 38 mmv

2. Using HTRI software, we calculated the heat transfer and pressure drop of this panel under different air flow rate conditions, 25 deg C ambient air temperature and saturated steam at 3 kg/cm2 pressure in the tubes. We calculated all the parameters like air outlet temperature, LMTD, linear heat transfer coefficient, heat load and airside pressure drop. We also isolated the airside heat transfer coefficient.

3. We then repeated this exercise using the same tube size but substituting the L type fins with our Pin fins in 5 different wire-winding configurations. The design was done using our in house design data proven over 2 decades of use. Since Aluminum cannot be used in wire wound fin tubes, we have considered stainless steel wire fins.

4. We also used panels with the same 1 meter by one meter 3 row configuration but changed the tube OD. We have adjusted the number of tubes to fit this configuration. We have selected the most commonly used winding configuration for each tube OD selected. We thus had panels with 1" OD at 51 tubes per panel, 5/8" tubes at 60 tubes per panel and 3/8" tubes at 77 tubes per panel.

5. We thus arrived at 9 panels, One of ¾" L type fin tubes, five of different windings of ¾" wire wound fin tubes and one each of 3/8", 5/8" & 1" wire wound tubes. The idea of comparing one meter by one-meter panels was to be able to compare the performance of similarly sized heat exchangers across the tube options.

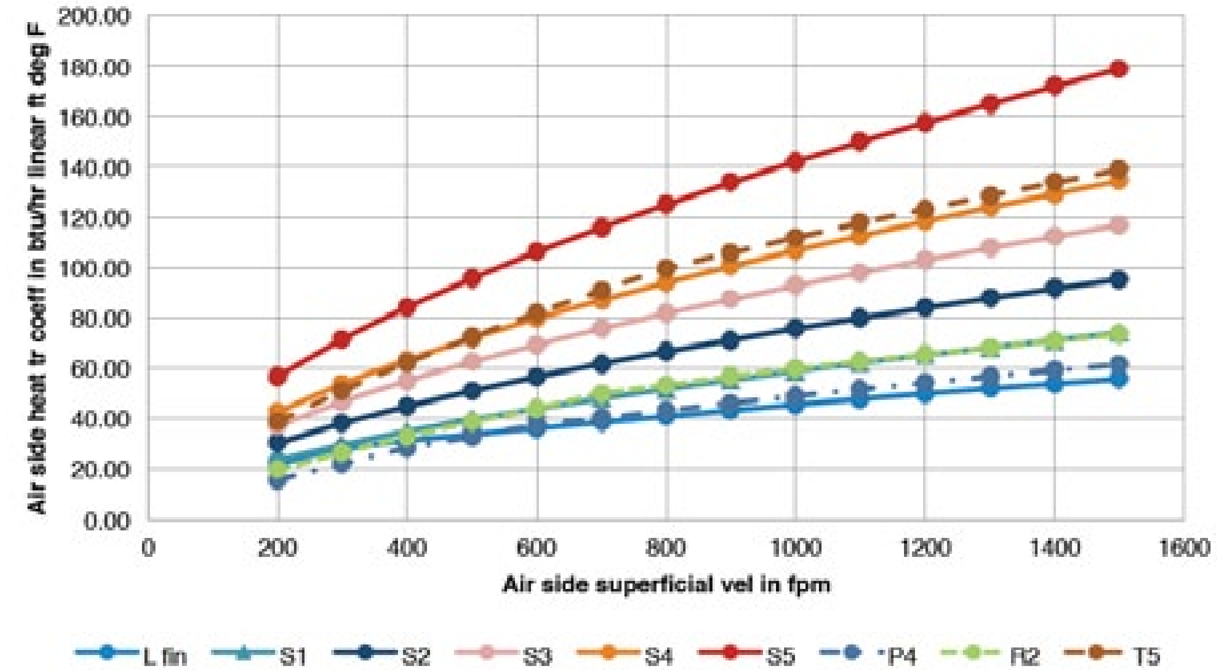
6. When comparing coefficients we have decided to use a linear coefficient (Per length of tube) instead of the generally used surface area. This gives a more straightforward comparison between tubes and is easier to use.One must keep in mind that with lower OD tubes a larger number of tubes can be fitted in a panel which will gives a higher panel coefficient. (Linear coefficient x length of tube in panel).

7. Due to its fin geometry and efficiency the weight of the wire fin tube is very low both in absolute per meter terms and more so when the total length is adjusted for higher performance. To compare, S1 and the higher efficiency S2 and S3 stainless steel fin tubes are lower in weight than the 10 FPI Aluminum fin steel tube combination. The S4 & S5 are only slightly higher. When comparing against the stainless steel L fin tube, the S1 is 40% of the weight. The S5 stainless steel is only 2.9 kgs/vs. 4.7 kgs for the stainless steel fin L tube. When you consider that the S1 is 30% more efficient and the S5 is 3 times the efficiencyof the L tube great new possibilities open up. The weight chart that follows is worth studying.

Weight of different fin configurations of fintubes

Winding	Code	Tube OD	Weight per meter (kg/mtr)				Total weight
			Tube	Fins	Tension wire	Solder wire	Kg/mtr
S1	A	¾"	1.01	0.91	0.062	0.09	2.072
S2	B	¾"	1.01	1.1	0.07	0.093	2.273
S3	C	¾"	1.01	1.25	0.08	0.11	2.45
S4	D	¾"	1.01	1.38	0.083	0.12	2.593
S5	E	¾"	1.01	1.68	0.083	0.12	2.893
P4	F	3/8"	0.16	0.45	0.05	0.06	0.72
R2	G	5/8"	0.34	0.88	0.08	0.09	1.39
T5	H	1"	0.75	1.63	0.12	0.14	2.64
L fins SS	L 10 FPI	¾"	1.01	3.71	–	–	4.72
L fins AL	L 10 FPI	¾"	1.01	1.41	–	–	2.42

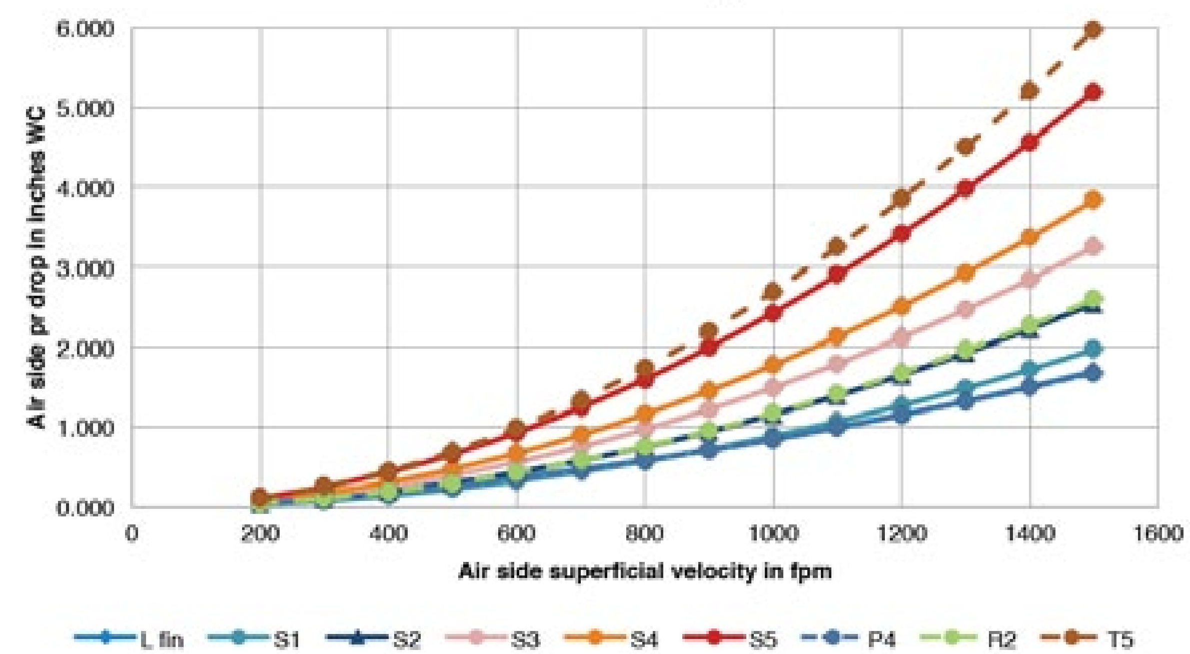
Air side heat transfer coeff linear basis at diff air velocities for diff windings

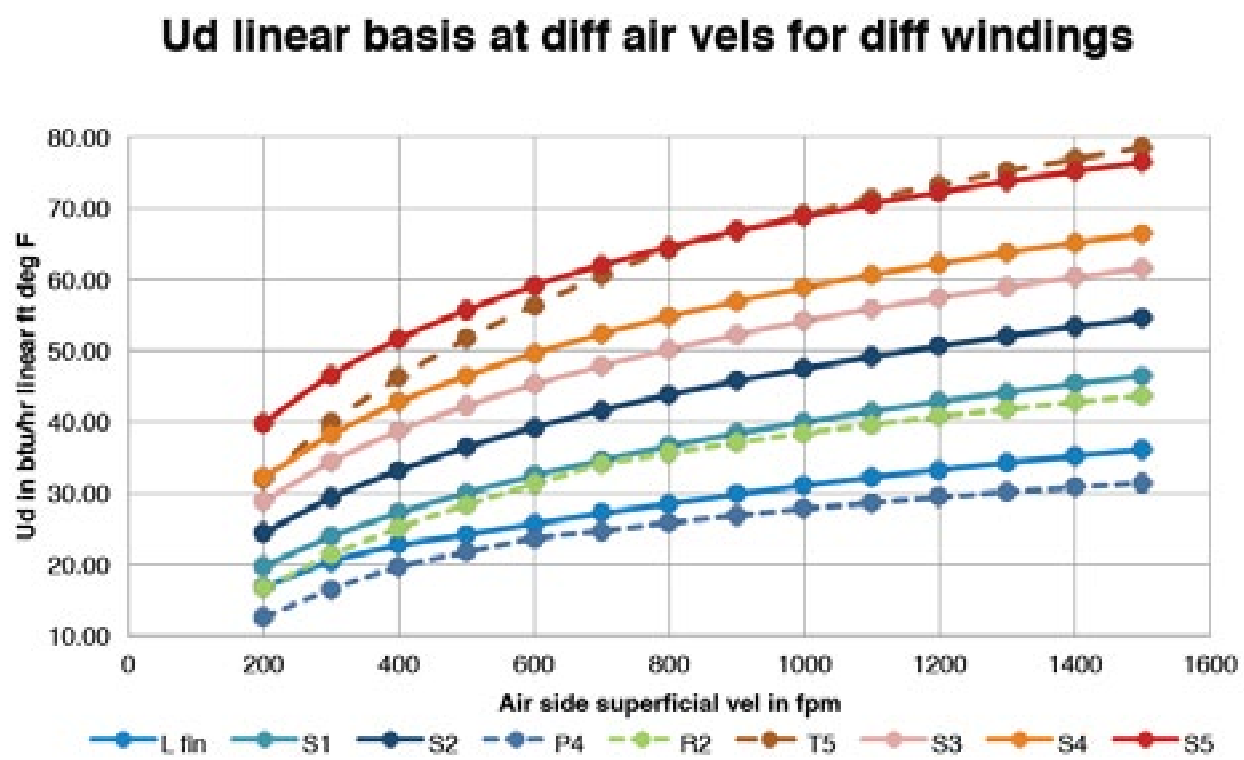


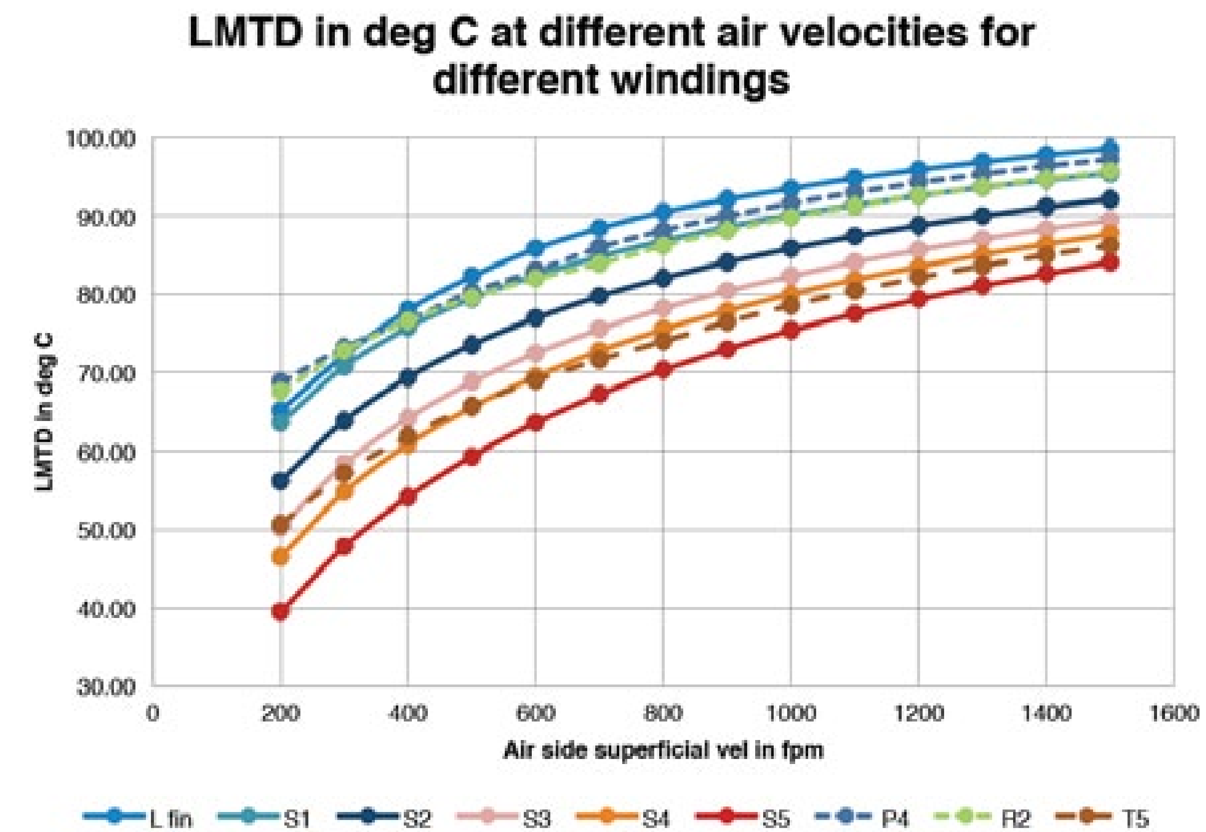
Design Parameter

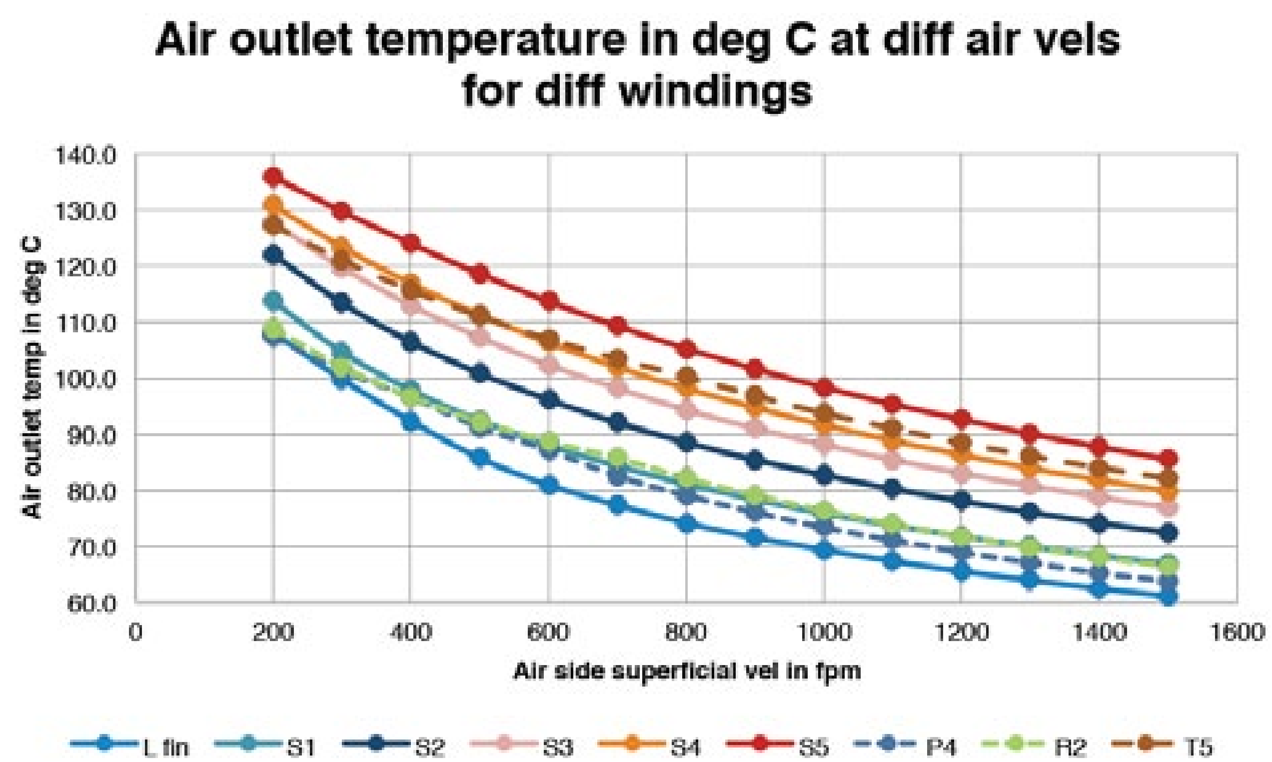
Model No	Units	L 10, S1,S2,S3,S4,S5	T5	R2	P4
Air inlet temperature	deg C	25	25	25	25
Steam Pressure	kg/cm^2g	3	3	3	3
Dirt factor outside (Rdo)	hr. ft2 F/btu	0.002	0.002	0.002	0.002
Dirt factor inside (Rdi)	hr. ft2 F/btu	0.0005	0.0005	0.0005	0.0005
Face Area	M^2	1	1	1	1
Heat Transfer Coefficient					
Tube side (hi)	btu/hr. ft^2 F	1500	1500	1500	1500
When referred to tube ID/OD (hio)	btu/hr. ft^2 F	1180	–	–	–
with dirt factor (hiod)	btu/hr. ft^2 F	742	742	742	742
linear heat transfer coefficient	btu/hr. ft F	145.64	202.27	122.20	70.29
Tube					
OD	in	0.75	1	0.625	0.375
thk	in	0.08	0.08	0.064	0.048
ID	in	0.59	0.84	0.497	0.279
No.of rows		3	3	3	3
No. of tubes		57	51	60	77
Pitch in row (pir)	mm	50.8	57.2	48	38
row pitch (Rp)	mm	38	44	36	28

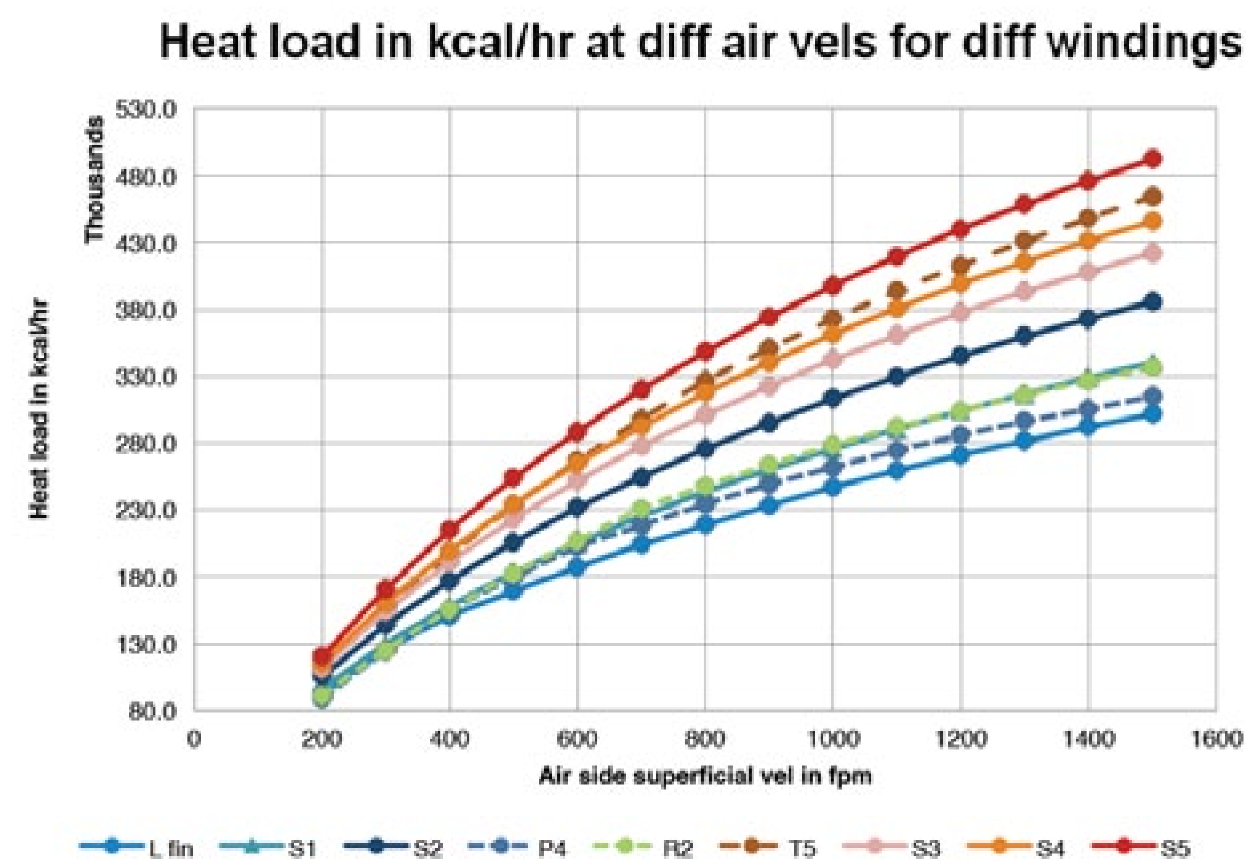
Air side pr drop in inches of WC at diff air vels for diff windings




Ud linear basis at diff air vels for diff windings
Ud in btu/hr linear ft deg F
Air side superficial vel in fpm
L fin
S1
S2
P4
R2
T5
S3
S4
S5


LMTD in deg C at different air velocities for different windings
LMTD in deg C
Air side superficial vel in fpm
L fin
S1
S2
S3
S4
S5
P4
R2
T5


Air outlet temperature in deg C at diff air vels for diff windings
Air outlet temp in deg C
Air side superficial vel in fpm
L fin
S1
S2
S3
S4
S5
P4
R2
T5


Heat load in kcal/hr at diff air vels for diff windings
Thousands
Heat load in kcal/hr
Air side superficial vel in fpm
L fin
S1
S2
P4
R2
T5
S3
S4
S5

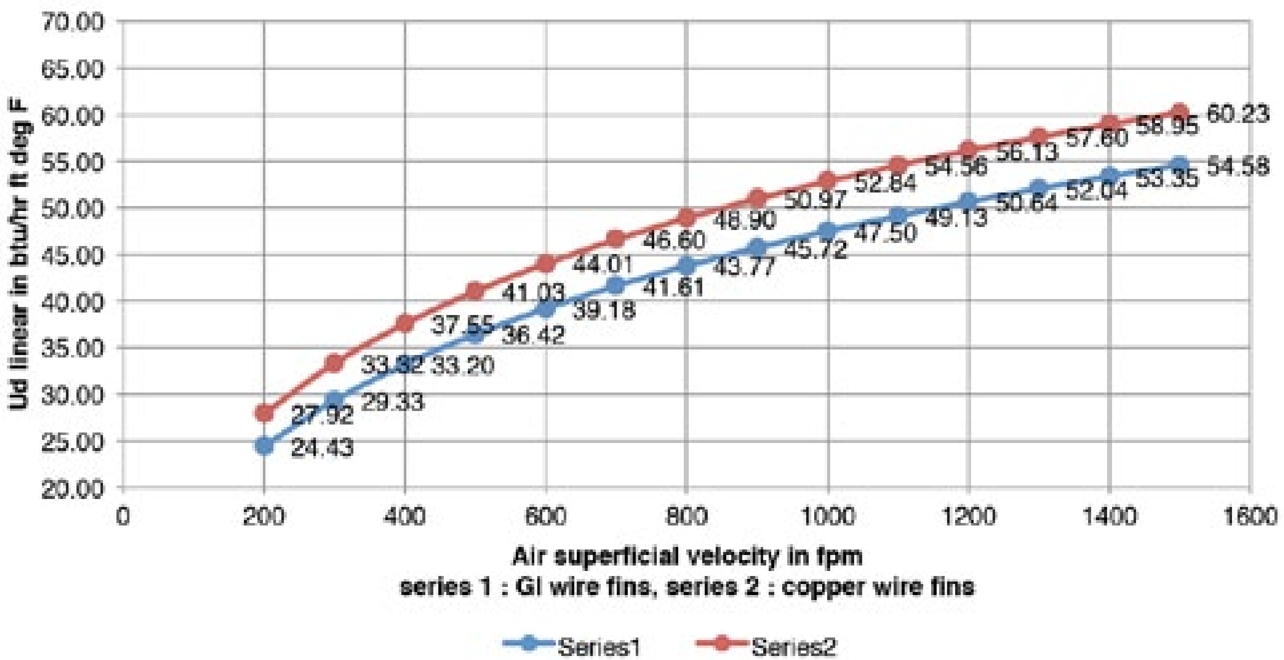
Air sup velocity fpm	Udlinear btu/hr. ft F									Air coefficient btu/hr. ft deg C								
	P4	R2	L fin	S1	S2	S3	S4	S5	T5	P4	R2	L fin	S1	S2	S3	S4	S5	T5
200	12.61	16.69	16.80	19.76	24.43	28.86	32.19	39.79	31.92	15.68	19.75	22.32	23.48	30.21	37.05	42.61	56.70	38.76
300	16.47	21.30	20.40	23.91	29.33	34.38	38.13	46.53	39.82	22.13	26.55	27.86	29.58	38.07	46.68	53.69	71.44	51.06
400	19.65	25.11	22.67	27.24	33.20	38.68	42.71	51.61	46.22	28.26	32.75	31.22	34.85	44.85	55.00	63.26	84.17	62.09
500	21.73	28.38	24.20	30.04	36.42	42.21	46.45	55.68	51.64	32.79	38.55	33.63	39.59	50.93	62.45	71.83	95.55	72.27
600	23.63	31.25	25.71	32.48	39.18	45.24	49.62	59.11	56.33	37.32	44.04	36.04	43.90	56.51	69.31	79.73	106.12	81.81
700	24.70	34.01	27.17	34.63	41.61	47.86	52.35	62.01	60.47	40.06	49.73	38.45	47.95	61.70	75.67	87.04	115.82	90.85
800	25.85	35.62	28.53	36.57	43.77	50.17	54.76	64.53	64.18	43.17	53.25	40.85	51.74	66.58	81.65	93.91	124.94	99.48
900	26.88	37.07	29.82	38.33	45.72	52.26	56.92	66.77	66.74	46.12	56.55	43.23	55.33	71.20	87.32	100.44	133.64	105.78
1000	27.81	38.38	31.09	39.94	47.50	54.15	58.86	68.79	69.11	48.92	59.67	45.56	58.75	75.61	92.73	106.68	141.96	111.85
1100	28.65	39.59	32.23	41.43	49.13	55.86	60.62	70.58	71.28	51.60	62.64	47.78	62.04	79.83	97.89	112.60	149.81	117.65
1200	29.43	40.71	33.29	42.81	50.64	57.45	62.24	72.23	73.28	54.18	65.48	49.89	65.20	83.89	102.87	118.32	157.42	123.20
1300	30.15	41.75	34.28	44.10	52.04	58.91	63.74	73.75	75.14	56.66	68.21	51.90	68.23	87.81	107.68	123.86	164.81	128.54
1400	30.82	42.72	35.20	45.31	53.35	60.27	65.12	75.13	76.87	59.06	70.84	53.82	71.18	91.60	112.32	129.20	171.90	133.69
1500	31.44	43.63	36.09	46.45	54.58	61.55	66.41	76.43	78.49	61.39	73.38	55.65	74.02	95.27	116.84	134.41	178.86	138.67

Air sup velocity fpm	Air outlet temp deg C									Heat load kcal/hr.								
	P4	R2	L fin	S1	S2	S3	S4	S5	T5	P4	R2	L fin	S1	S2	S3	S4	S5	T5
200	107.3	108.8	108.1	113.6	121.9	127.60	130.80	135.80	127.2	89234.	90860.	92400.	96065.	105064	111245	114714	120135	110811
300	101.3	101.9	99.7	104.6	113.3	119.60	123.30	129.70	120.9	124093	125069	124950	129460	143610	153856	159874	170282	155970
400	96.5	96.6	92.3	97.8	106.4	112.90	116.80	123.90	115.6	155049	155265	150150	157868	176517	190612	199070	21446	19646
500	91.2	92.2	85.7	92.4	100.8	107.20	111.20	118.50	111.0	179444	182155	169050	182697	205467	22281	23365	253445	233115
600	87.1	88.6	80.9	88.0	96.1	102.30	106.30	113.60	106.9	201997	20687	186900	204925	23127	251439	264450	28819	26640
700	82.5	85.7	77.3	84.3	92.0	98.10	101.90	109.20	103.4	21820	230350	20370	22503	254258	277407	29182	319531	29752
800	79.0	82.1	74.1	81.1	88.5	94.30	98.10	105.20	100.2	234200	247644	218400	243307	275401	30055	317037	34783	326145
900	76.0	79.0	71.5	78.3	85.4	91.00	94.70	101.60	96.8	248837	26347	233100	260059	29470	322025	34007	37374	35032
1000	73.3	76.3	69.3	75.8	82.7	88.10	91.60	98.30	93.7	261848	278112	246750	275401	312808	34208	361058	397381	372443
1100	71.0	73.9	67.3	73.7	80.2	85.40	88.80	95.30	91.0	27431	29161	25935	29041	32918	360191	38046	419228	393586
1200	68.9	71.7	65.5	71.7	78.0	83.00	86.30	92.60	88.4	285593	303809	270900	303809	344794	37732	398790	439775	412452
1300	67.0	69.8	63.9	69.9	76.0	80.80	83.90	90.00	86.1	296002	31573	281400	31644	35943	393260	415108	458099	430613
1400	65.2	68	62.4	68.3	74.1	78.70	81.80	87.70	84.0	30511	326362	29190	328639	372660	407573	431101	475881	447799
1500	63.7	66.4	61.1	66.8	72.4	76.90	79.80	85.50	82.1	314706	336662	301350	33991	385454	422048	445630	491982	464334

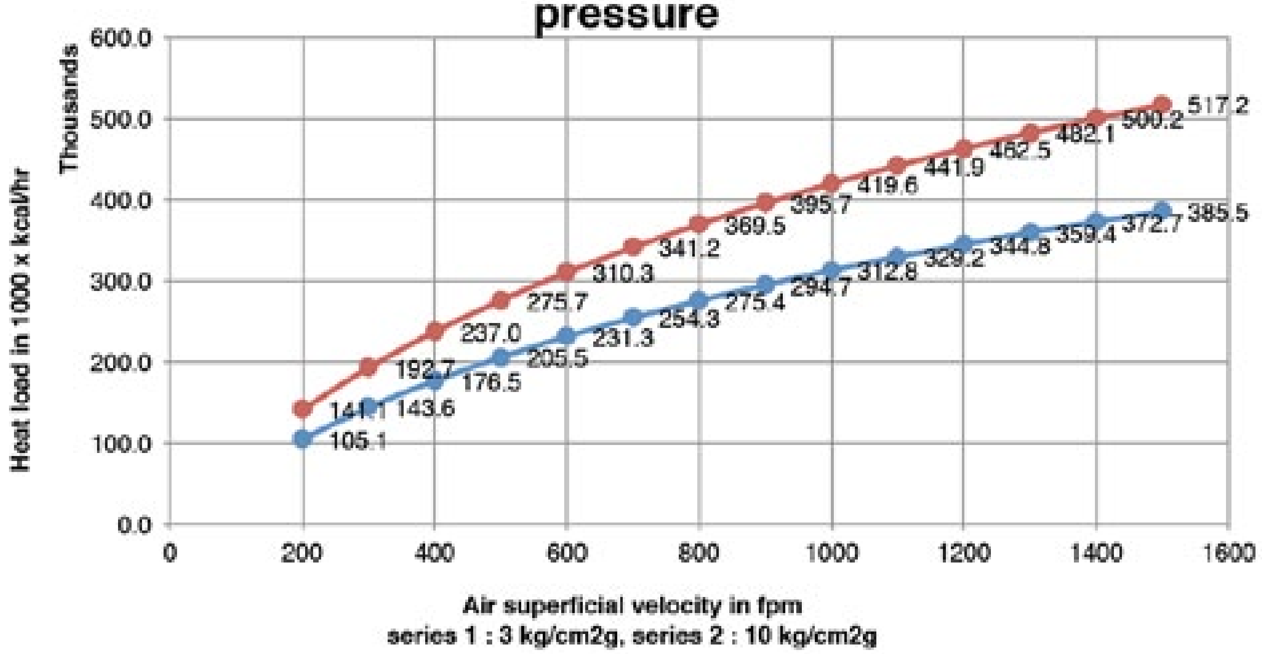
Air sup velocity fpm	LMTD deg C									Air side pr drop in wc								
	P4	R2	L fin	S1	S2	S3	S4	S5	T5	P4	R2	L fin	S1	S2	S3	S4	S5	T5
200	68.71	67.54	65.2	63.63	56.15	50.24	46.46	39.43	50.68	0.055	0.049	0.07	0.038	0.051	0.067	0.081	0.115	0.113
300	73.23	72.79	72.2	70.78	63.88	58.33	54.77	47.81	57.11	0.11	0.11	0.128	0.083	0.112	0.147	0.178	0.25	0.253
400	76.66	76.59	78	75.74	69.41	64.21	60.87	54.17	61.92	0.18	0.194	0.194	0.147	0.196	0.257	0.309	0.432	0.446
500	80.29	79.61	82.3	79.48	73.59	68.79	65.61	59.34	65.78	0.262	0.301	0.273	0.227	0.302	0.394	0.473	0.66	0.692
600	83	82.02	85.8	82.41	76.94	72.5	69.49	63.63	69.02	0.357	0.43	0.368	0.325	0.43	0.56	0.671	0.93	0.99
700	85.95	83.91	88.4	84.81	79.75	75.53	72.79	67.22	71.68	0.463	0.583	0.471	0.44	0.58	0.753	0.9	1.243	1.341
800	88.14	86.21	90.5	86.84	82.08	78.18	75.53	70.33	74.03	0.58	0.758	0.587	0.572	0.751	0.973	1.161	1.598	1.743
900	89.99	88.14	92.1	88.58	84.1	80.42	77.91	73.01	76.45	0.708	0.954	0.711	0.721	0.944	1.22	1.453	1.994	2.195
1000	91.62	89.81	93.5	90.11	85.83	82.35	80.02	75.39	78.6	0.846	1.173	0.847	0.887	1.158	1.493	1.775	2.429	2.697
1100	93	91.26	94.8	91.38	87.4	84.1	81.88	77.49	80.42	0.994	1.414	0.996	1.07	1.393	1.792	2.128	2.904	3.25
1200	94.24	92.58	95.9	92.58	88.76	85.64	83.52	79.34	82.15	1.152	1.678	1.153	1.269	1.649	2.118	2.511	3.419	3.853
1300	95.35	93.71	96.9	93.65	89.99	87.02	85.06	81.09	83.65	1.319	1.963	1.323	1.485	1.927	2.47	2.926	3.974	4.506
1400	96.39	94.76	97.8	94.59	91.14	88.33	86.4	82.61	85	1.495	2.27	1.505	1.718	2.225	2.847	3.368	4.565	5.209
1500	97.25	95.7	98.6	95.46	92.16	89.44	87.65	84.04	86.21	1.681	2.6	1.695	1.968	2.544	3.25	3.842	5.196	5.963

Air sup Velocity fpm	ud/panel btu/hr panel F									Air Coefficient btu/hr paneldeg C								
	P4	R2	L fin	S1	S2	S3	S4	S5	T5	P4	R2	L fin	S1	S2	S3	S4	S5	T5
200	3185	3284	3141	3694	4568	5396	6019	7438	5339	3960	3886	4173	4390	5648	6926	7967	10600	6483
300	4161	4191	3814	4470	5483	6427	7129	8699	6661	5590	5225	5208	5531	7117	8728	10039	13357	8541
400	4962	4942	4239	5093	6207	7231	7985	9649	7732	7138	6446	5837	6516	8385	10283	11827	15737	10387
500	5489	5585	4524	5617	6808	7892	8684	10410	8638	8282	7586	6288	7401	9522	11676	13429	17864	12089
600	5969	6150	4806	6072	7325	8457	9278	11051	9423	9426	8666	6738	8208	10565	12958	14907	19839	13685
700	6239	6693	5080	6475	7779	8947	9788	11592	10116	10118	9787	7189	8964	11536	14147	16273	21653	15197
800	6529	7010	5333	6836	8184	9381	10238	12064	10736	10904	10480	7638	9674	12448	15264	17557	23360	16641
900	6789	7295	5575	7165	8548	9770	10641	12484	11165	11647	11129	8082	10345	13312	16325	18778	24986	17694
1000	7023	7554	5812	7467	8881	10123	11005	12861	11561	12355	11743	8518	10984	14136	17338	19944	26541	18711
1100	7237	7792	6026	7745	9186	10444	11333	13196	11924	13033	12328	8933	11599	14925	18302	21051	28008	19680
1200	7433	8012	6225	8004	9468	10740	11636	13504	12258	13683	12887	9327	12189	15684	19233	22121	29430	20609
1300	7614	8216	6409	8245	9730	11014	11916	13788	12569	14311	13424	9704	12757	16417	20132	23158	30814	21502
1400	7783	8407	6581	8472	9974	11269	12175	14047	12859	14917	13941	10061	13308	17125	21000	24155	32139	22363
1500	7940	8586	6748	8685	10204	11507	12417	14290	13130	15505	14441	10404	13840	17812	21845	25129	33440	23196

Overall heat transfer coefficient SS fins vs Copper fins



Heat loads 3 kg/cm2g vs 10 kg/cm2g steam pressure



Tables giving maximum air velocity and performance for various tubes at different pressure drop points. (Measured in inches of water column.)

We have after analysis generated the following tables where we have generated the maximum airflow rate possible for every panel given a pressure drop limit. We have set the limit at .5”, 1”, 1.5” and 2” of water column. For this maximum airflow, we have given the corresponding heat transfer parameters. These tables allow us to optimize the tubes and airflow rates to get the desired results.

0.5” Water Column

Tube	Air Velocity	Air side Pr Drop	Air Co efficient	Udlinear	LMTD	Heat Load	Outlet temp
P4	700	0.463	40.06	24.70	85.95	218207.2	82.5
R2	600	0.430	44.04	31.25	82.02	206876.7	88.6
L fin	700	0.471	38.45	27.17	88.40	203700.0	77.3
S1	700	0.440	47.95	34.63	84.81	225038.0	84.3
S2	600	0.430	56.51	39.18	76.94	231272.5	96.1
S3	500	0.394	62.45	42.21	68.79	222815.3	107.20
S4	500	0.473	71.83	46.45	65.61	233657.9	111.20
S5	400	0.432	84.17	51.61	54.17	214466.5	123.90
T5	400	0.446	62.09	46.22	61.92	196467.8	115.60

1” Water Column

Tube	Air Velocity	Air side Pr Drop	Air Co efficient	Udlinear	LMTD	Heat Load	Outlet temp
P4	1100	0.994	51.60	28.65	93.00	274317.6	71.0
R2	900	0.954	56.55	37.07	88.14	263475.0	79.0
L fin	1100	0.996	47.78	32.23	94.80	259350.0	67.3
S1	1100	1.070	62.04	41.43	91.38	290418.9	73.7
S2	900	0.944	71.20	45.72	84.10	294701.7	85.4
S3	800	0.973	81.65	50.17	78.18	300556.7	94.30
S4	700	0.900	87.04	52.35	72.79	291828.4	101.90
S5	600	0.930	106.12	59.11	63.63	288196.1	113.60
T5	600	0.990	81.81	56.33	69.02	266402.5	106.90

1.5” Water Column

Tube	Air Velocity	Air side Pr Drop	Air Co efficient	Udlinear	LMTD	Heat Load	Outlet temp
P4	1400	1.495	59.06	30.82	96.39	305110.6	65.2
R2	1100	1.414	62.64	39.59	91.26	291611.6	73.9
L fin	1400	1.505	53.82	35.20	97.80	291900.0	62.4
S1	1300	1.485	68.23	44.10	93.65	316441.1	69.9
S2	1100	1.393	79.83	49.13	87.40	329181.2	80.2
S3	1000	1.493	92.73	54.15	82.35	342083.8	88.10
S4	900	1.453	100.44	56.92	77.91	340078.0	94.70
S5	800	1.598	124.94	64.53	70.33	347830.4	105.20
T5	700	1.341	90.85	60.47	71.68	297520.8	103.40

2” Water Column

Tube	Air Velocity	Air side Pr Drop	Air Co efficient	Udlinear	LMTD	Heat Load	Outlet temp
P4	1500	1.681	61.39	31.44	97.25	314706.3	63.7
R2	1300	1.963	68.21	41.75	93.71	315736.3	69.8
L fin	1500	1.695	55.65	36.09	98.60	301350.0	61.1
S1	1500	1.968	74.02	46.45	95.46	339915.3	66.8
S2	1300	1.927	87.81	52.04	89.99	359432.0	76.0
S3	1200	2.118	102.87	57.45	85.64	377322.3	83.0
S4	1100	2.128	112.60	60.62	81.88	380466.6	88.80
S5	900	1.994	133.64	66.77	73.01	373744.2	101.60
T5	900	2.195	105.78	66.74	76.45	350324.2	96.80

Analysis of the Data generated:

Performance of any Fin tube cooler is a combination of its Air side Coefficient and tubeside coefficient as given by the general formula:

Ud = h’fi*h’i/h’fi+h’i

Where:
Ud = overall heat transfer Coefficient
h’fi = Heat transfer coefficient on fin side of the tube.
h’i = Heat transfer coefficient inside the tube

From this formula we can see that any increase of the coefficient on one side (Air or tube) will lead to a less than proportional increase in the overall coefficient.

So to get a fair idea of the performance of a fin tube we have to look at both the Airside performance as well as the overall performance to see its individual impact as well as composite impact. We have accordingly in the interest of transparency given both the airside coefficient as well as the overall coefficient.

The lower material consumption per meter of tube offsets in part its greater labor cost giving a surprisingly economical tube. When the lower length of tube required in any equipment is factored in it becomes definitely very cost effective.

Now the findings:

1. In the general Airflow velocity range of 800 to 1200 the pressure drop of S1 pin fin tube is almost identical to the 10 FPI L fin tube. However the airside coefficient is higher by 26-30% similarly the overall coefficient is higher by 28% in the case of 3-bar steam in the tubes.
2. For S5 the overall coefficient is 220% and airside coefficient is 300% of the coefficient of the 10 FPI L fin tube. This implies a reduction to 40% in panel size for the same performance.
3. The wire fin tube hits the pressure drop limit at a lower airflow rate as compared to the L fin tube. However at this lower air flow it has a much higher coefficient than the L fin tube operating at the higher airflow rate giving a higher total heat load. This translates into significant power saving.
4. The outlet Air temperature achieved at different flow rates is higher for the S5 Panel by about 25 degrees centigrade. Again this implies that one can achieve the desired air temperature with a lower number of fin tube rows.
5. Again with the log mean temperature difference we are able to achieve an improvement of about 18-24 degrees between the 10 FPI L fin tube and S5. A tighter LMTD means a much more efficient heat exchanger.
6. Notwithstanding the tight LMTD achieved, the heat load for S5 is higher by 60-61% for S5 compared to the 10 FPI L panel.
7. While the difference is very large for S5 and 10 FPI L fin, it is also substantial when compared with S1, the lowest configuration.
8. Copper fins give a 15% higher airside coefficient and an 8-10% higher overall coefficient as compared to stainless steel or steel fins.

In a nutshell, we can achieve a reduction in number of rows of the steam air heater, by approximately 50%. We can achieve a further reduction in weight as the wire fin tube is much lighter than the L fin tube. (If the same metal is used by over 50%, In case the L fin is made of aluminum the weight may be about the same.) A significant reduction in power consumption is also achieved. We are able to substitute aluminum fins with stainless steel without an increase in cost or weight.

Designing your own exchangers

We have made it easy to design your own exchangers by providing extensive data. Also by presenting the data in the form of 1x1 meter 3 row Panels, and expressing the coefficient in linear terms we have made it easy to predict performance by scaling up these panels in face area or number of rows. We have tried to make it intuitive.

For easy reference we have also given a graph comparing the same panel 3 kgs with 10 kgs steam.

By isolating the airside coefficient, we have made it possible for designers to use the data for any other type of heat exchanger like oil coolers, water coolers or any other air-cooled heat exchangers.

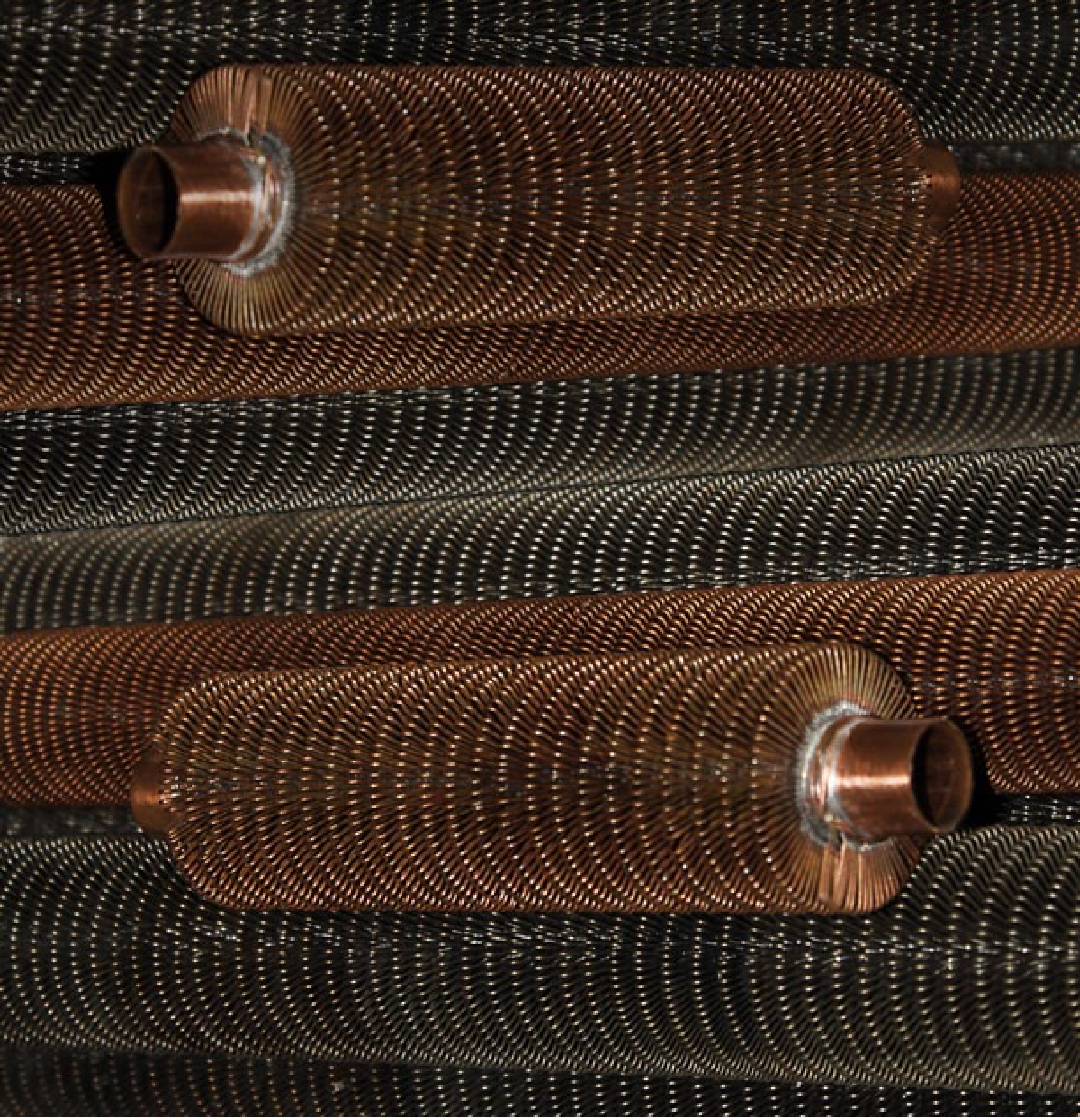
The Data tables have given a color code to values where the typical allowable pressure drops are reached. (.5, 1, 1.5 & 2) inches of water column. This allows you to select the most appropriate tube and airflow rate for a given allowable pressure drop. This allows you to easily optimize your tube type and panel sizing.

Assistance with design

We are willing to work together with you to design your equipment. We charge a very nominal design fee, which we are willing to rebate at the time of order conclusion. Our design capability covers all types of heat exchangers and fin tubes. We generally limit ourselves to process design but can also assist in mechanical design.

Partnership

Concept engineering wishes to work with local companies in all countries. We encourage our local partners to fabricate the heaters themselves using our fin tubes, turbulators, components and design capability. This makes it possible for companies with Fabrication capacity but limited heat exchanger design capability to partner with us to successfully make and market heat exchangers. Of course we are looking at sustained partnerships with a win win perspective.



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