Computational Study of Multi-Louvered Fin Heat Exchangers

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Computational Study Of Multilouvered Fin Heat Exchangers
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NOMENCLATURE

A^*_{fin} dimensional fin surface area,

b non-dimensional fin thickness (b^* / L^*_P),

f frictional factor, $f = \dfrac{2(\Delta p_{fin} / (F_p)) D_h}{4 F_d V_c{}^2}$,

F_p non-dimensional fin pitch (F^*_p / L^*_p),

F_d non-dimensional flow depth,

h^* dimensional heat transfer coefficient,

j Colburn factor, $j = \dfrac{< Nu^2 >_{fin}}{\mathrm{Re}_L P_r^{0.4}}$,

k thermal conductivity,

L^*_p dimensional louver pitch (characteristic length scale),

$<Nu^1>$ non-dimensional heat flux, $< Nu^1 > = q = -\dfrac{\partial T}{\partial n}$,

$<Nu^2>$ non-dimensional heat transfer coefficient, $< Nu^2 > = \dfrac{h^* L^*_p}{k} = \dfrac{-\partial T / \partial n}{(1 - T_{ref})}$,

P^* dimensional pumping power,

Pr Prandtl number,

Δp_{fin} non-dimensional total pressure force,

ΔP^* dimensional total pressure drop,

q non-dimensional heat flux,

Q^* dimensional total heat capacity,

Re Reynolds number, $\mathrm{Re}_{in} = U^*_{in} L^*_p / \nu$,

T temperature,

u,v non-dimensional Cartesian velocity in x-, and y- direction, respectively,

U^*_{in} dimensional inlet velocity (characteristic velocity scale),

V_c Non-dimensional Average velocity at minimum cross-sectional area

Greek symbols

θ louver angle,

ν kinematic viscosity

Superscripts

* dimensional quantities,

1 Nusselt number one,

2 Nusselt number two,

Subscripts

fin based on fin,

in based on inlet,

louv based on louver.

SUMMARY

The report gives a summary of ACRC project 94. Project 94 carried out detailed high-resolution time-dependent simulations of several multilouvered geometries. The effect of two fin pitch ratios (F_p = 1.0 and F_p = 1.5), and four louver angles (θ = 30, 25, 20 and 15 degrees) was investigated. Three thickness ratios, b=0.05, 0.10, and 0.15 for F_p =1.0 and θ= 20 and 30 degrees were also studied. In addition, the effect of flow depth for F_p = 1.5, b=0.1 and θ = 30 was studied. The nominal Reynolds number in the calculations ranged from Re_{in} = 50 to 1200. The louvered fin is shown in Figure 1 and the geometrical parameters simulated are summarized in Table 1.

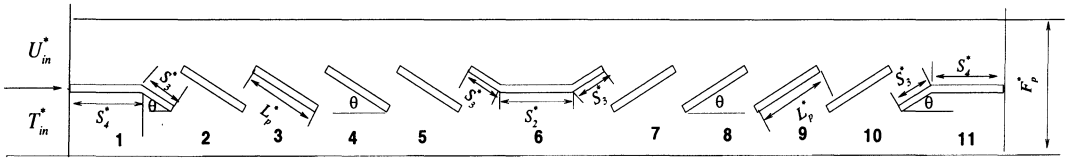

Figure 1: Multilouvered fin geometry.

Table 1 Summary of non-dimensional geometrical parameters for the basic cases investigated.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
1-a	1.0	30	0.05	19	1.0	0.5	1.0
1			0.1				
1-b			0.15				
2	1.0	25	0.1	19			
3-a	1.0	20	0.05	19			
3			0.1				
3-b			0.15				
4	1.0	15	0.1	19			
5	1.5	30	0.1	19			
5-a				23			
6	1.5	25	0.1	19			
7	1.5	20	0.1	19			
8	1.5	15	0.1	19			

The numerical method, algorithm, code validation and verification can be found in [1,2]. A summary of results and accomplishments can be found in the first (1999) and second year (2000) reports for project 94. More detailed information on the effect of fin pitch, thermal wake interference, and flow transition can be found in [3] *ACRC TR-166* [4] and *ACRC TR-174* [5].

The Appendix summarizes the results in tabular form for all the calculations. Table x gives the geometrical parameters for Case x, followed by Table x-1 which tabulates the non-dimensional heat flux, $<Nu^1>_{fin}$, for the fin, non-dimensional heat transfer coefficient, $<Nu^2>_{fin}$, j factor, non-dimensional pressure force Δp_{fin} and f factor. Table x-2 to x-4 tabulate the louver by louver non-dimensional heat flux, non-dimensional heat transfer coefficient, and pressure force[1] respectively.

[1] Negative values of pressure force indicate a pressure recovery or a positive pressure gradient.

INTERPRETATION OF TABULATED VALUES

The values in the Tables (In Appendix) are non-dimensionalized by the characteristic length L_P^*, the characteristic velocity scale u_{in}^*, and the temperature scale $(T_{fin}^* - T_{in}^*)$. To obtain the equivalent dimensional values the following equations should be used.

Dimensional heat transfer coefficient ($W/m^2/K$) is given by

$$h^* = < Nu^2 >_{fin} \, k / L^*_p \tag{1}$$

The dimensional pressure drop (N/m^2) is given by

$$\Delta P^* = \rho \frac{\mathrm{Re}^2_{in} \, \nu^2 \Delta p_{fin}}{F^*_p L^*_p} \tag{2}$$

The dimensional pumping power (W/m^2) per unit fin pitch per unit fin height is given by

$$P^*_{fin} = \rho \frac{\mathrm{Re}^3_{in} \, \nu^3 \Delta p_{fin}}{L^{*2}_p F^*_p} \tag{3}$$

Finally, the dimensional heat capacity (W/m^2) per unit fin pitch per unit fin height is given by:

$$Q^*_{fin} = \frac{< Nu^1 >_{fin} \, k(T^*_{fin} - T^*_{in}) A^*_{fin}}{L^*_p \, F^*_p} \tag{4}$$

The values of $< Nu^1 >_{fin}$, $< Nu^2 >_{fin}$, Δp can be found in the Appendix. The operating conditions, T_{fin}^* and T_{in}^*, are dimensional fin temperature and inlet air temperature respectively. L_p^* , F_p^* and A_{fin}^* are dimensional louver pitch, fin pitch, and fin surface area per unit fin height, respectively, and Re_{in} is Reynolds number based on louver pitch and inlet velocity.

Here we show a hypothetical example of extracting dimensional values from the Tables given in the Appendix. Consider a louvered fin heat exchanger operating under the conditions:

$$T_{in}^* = 5^o C = 278K \, , \; T_{fin}^* = 33^o C = 310K \, , \; U_{in}^* = 3.4 m/s \, ,$$

with geometrical parameters

$$L_p^* = 1.5mm \, , \; F_p^* = 1.5mm \, , \; A_{fin}^* = 3300 \, (mm)^2 , \theta = 30^o , \text{and } b^* = 0.15mm \, ,$$

and fluid properties (based on T=308K):

$$Pr=0.706, \rho = 1.135 \, kg/m^3 , \quad \nu = 1.67 \times 10^{-5} m^2/s , \quad \kappa = 2.69 \times 10^{-2} w/mK \, .$$

The non-dimensional parameters fin pitch and thickness are $F_p = 1.0, b = 0.1$. The Reynolds number based on louver pitch and inlet velocity is

$$\mathrm{Re}_{in} = \frac{L^*_p U^*_{in}}{\nu} = \frac{1.5 \times 10^{-3} \times 3.4}{1.67 \times 10^{-5}} = 305.38 \approx 300 \, .$$

For this geometry ($F_p = 1.0, b = 0.1, \theta = 30^o$), the corresponding non-dimensional results (for the fin) can be found in Table 1-1 in the Appendix. The values, corresponding to the Reynolds number of 300, of total non-dimensional heat flux, heat transfer coefficient and pressure force are $< Nu^1 >_{fin} = 6.257$, $< Nu^2 >_{fin} = 13.67$, $\Delta p_{fin} = 3.48$, respectively.

Using equation (1), the dimensional heat transfer coefficient can be calculated as

$$h^* = < Nu^2 >_{fin} \; k / L^*_p = \frac{13.67 \times 2.69 \times 10^{-2}}{1.5 \times 10^{-3}} = 245.15 (w / m^2 / K).$$

From equation (2), the dimensional pressure drop can be calculated,

$$\Delta P^* = \rho \frac{\mathrm{Re}^2_{in} \nu^2 \Delta p_{fin}}{F^*_p L^*_p} = 1.135 \times \frac{305^2 \times (1.67 \times 10^{-5})^2 \times 3.48}{1.5 \times 10^{-3} \times 1.5 \times 10^{-3}} = 45.54 (N / m^2).$$

Dimensional pumping power in equation (3) is,

$$P^*_{fin} = \rho \frac{\mathrm{Re}^3_{in} \nu^3 \Delta p_{fin}}{F^*_p L^{*2}_p} = 1.135 \times \frac{305^3 \times (1.67 \times 10^{-5})^3 \times 3.48}{1.5 \times 10^{-3} \times (1.5 \times 10^{-3})^2} = 1.546 \times 10^2 (w / m^2),$$

and finally, from equation (4), the dimensional heat capacity can be obtained,

$$Q^*_{fin} = \frac{< Nu^1 >_{fin} \; k (T^*_{fin} - T^*_{in}) A^*_{fin}}{L^*_p \; F^*_p} = \frac{6.257 \times 2.69 \times 10^{-2} \times (310 - 278) \times 0.0033}{1.5 \times 10^{-3} \times 1.5 \times 10^{-3}}$$
$$= 7.899 \times 10^3 (w / m^2)$$

The following interpolations can be used to extract the approximate values of $< Nu^1 >_{fin}$, $< Nu^2 >_{fin}$, Δp_{fin}, for a given Reynolds number, $\mathrm{Re}_{in,0}$, which is located between two adjacent Reynolds numbers ($\mathrm{Re}_{in,1} < \mathrm{Re}_{in,0} < \mathrm{Re}_{in,2}$).

$$< Nu^1 >_{fin,0} = \frac{< Nu^1 >_{fin,2} - < Nu^1 >_{fin,1}}{\mathrm{Re}_{in,2} - \mathrm{Re}_{in,1}} \times (\mathrm{Re}_{in,0} - \mathrm{Re}_{in,1}) + < Nu^1 >_{fin,1}$$

$$< Nu^2 >_{fin,0} = \frac{< Nu^2 >_{fin,2} - < Nu^2 >_{fin,1}}{\mathrm{Re}_{in,2} - \mathrm{Re}_{in,1}} \times (\mathrm{Re}_{in,0} - \mathrm{Re}_{in,1}) + < Nu^2 >_{fin,1}$$

$$\Delta p_{fin,0} = \frac{\Delta p_{fin,2} - \Delta p_{fin,1}}{\mathrm{Re}_{in,2} - \mathrm{Re}_{in,1}} \times (\mathrm{Re}_{in,0} - \mathrm{Re}_{in,1}) + \Delta p_{fin,1}$$

Here, $< Nu^1 >_{fin,2}$, $< Nu^2 >_{fin,2}$ and $\Delta p_{fin,2}$ are the values correspond to the Reynolds number of $\mathrm{Re}_{in,2}$, and $< Nu^1 >_{fin,1}$, $< Nu^2 >_{fin,1}$ and $\Delta p_{fin,1}$ are the values correspond to the Reynolds number of $\mathrm{Re}_{in,1}$.

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APPENDIX

Table 1-a Summary of non-dimensional geometrical parameters for the Case 1-a.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
1-a	1.0	30	0.05	19	1.0	0.5	1.0

Table 1-a-1 Global coefficients of heat transfer and friction for Case1-a.

Re_{in}	$<Nu^1>_{fi}$	$<Nu^2>_{fi}$	j	Δp_{fin}	f
	n	n			
50	1.3669	10.0158	0.2203	9.9068	0.6402
100	2.6889	11.793	0.1297	5.838	0.3773
300	6.7408	14.8163	0.0543	2.6937	0.1741
400	8.0406	15.4085	0.0424	2.2957	0.1484
500	9.2856	16.3902	0.036	2.0693	0.1337
600	10.415	17.3502	0.0318	1.8984	0.1227
800	12.44	19.1825	0.0264	1.6409	0.106
1000	14.249	20.886	0.023	1.4401	0.0931
1100	15.091	21.6912	0.0217	1.3004	0.084
1200	15.894	22.4619	0.0206	1.3843	0.0895

Table 1-a-2 Local Nusselt number $<Nu^1>_{louv}$ for Case1-a

Louver	R50	R100	R300	R400	R500	R600	R800	R1100	R1200	R1000
1	4.7595	6.3086	10.344	11.3666	12.515	13.5363	15.3075	16.8196	17.5055	18.1526
2	4.4731	7.5679	13.203	14.899	16.324	17.569	19.663	21.349	22.066	22.711
3	2.717	5.0828	8.7585	10.069	11.067	11.973	13.608	15.091	15.79	16.467
4	1.5403	3.7482	9.0553	10.795	12.265	13.615	16.126	18.497	19.652	20.792
5	0.9087	2.7116	7.0588	8.6406	9.9924	11.268	13.674	15.944	17.035	18.098
6	0.3945	1.533	5.5283	7.0459	8.3794	9.6302	11.9538	14.0546	15.024	15.9385
7	0.2498	1.3194	5.9224	7.7543	9.3458	10.824	13.49	15.766	16.763	17.675
8	0.1679	0.9047	4.4269	5.7807	6.8383	7.7131	9.1298	10.327	10.893	11.451
9	0.1127	0.6645	4.2413	5.6923	6.8394	7.8173	9.5033	11.023	11.75	12.463
10	0.0822	0.4881	3.4299	4.8251	6.052	7.1648	9.1525	10.989	11.885	12.777
11	0.0452	0.2794	2.7866	3.5468	4.5543	5.4941	7.2203	8.792	9.5358	10.2146

Table 1-a-3 Local Nusselt number $<Nu^2>_{louv}$ for Case1-a

Louver	R50	R100	R300	R400	R500	R600	R800	R1100	R1200	R1000
1	6.1152	7.3315	11.1776	12.0247	13.1319	14.1215	15.8463	17.3247	17.9967	18.6317
2	9.3497	11.8274	16.3813	17.6047	18.819	19.9046	21.7643	23.2754	23.9171	24.4917
3	9.7317	10.8853	12.1049	12.9096	13.6077	14.3006	15.6459	16.9335	17.5554	18.1648
4	9.4759	11.0645	14.5499	15.6998	16.8612	18.0016	20.2626	22.503	23.6205	24.7359
5	9.6007	10.987	12.7662	13.7932	14.8531	15.9556	18.1929	20.4028	21.4836	22.5433
6	8.7259	9.845	12.5492	13.6752	14.8572	16.0527	18.3884	20.5325	21.5197	22.4437
7	10.129	12.5263	16.0695	17.4352	18.826	20.2185	22.8207	25.0071	25.9409	26.7787
8	10.527	11.87	13.8138	14.5661	15.1999	15.7391	16.6669	17.5411	17.9954	18.4667
9	10.243	11.9683	15.0113	15.8366	16.5111	17.1342	18.3788	19.6741	20.3389	21.0112
10	10.321	11.9143	13.9105	14.9815	16.0267	17.0149	18.8653	20.6875	21.615	22.5575
11	7.6292	8.82	12.7497	12.1067	13.0663	14.0023	15.7852	17.4321	18.2177	18.906

Table 1-a-4 Local pressure force Δp_{louv} for Case1-a

Louver	R50	R100	R300	R400	R500	R600	R800	R1100	R1200	R1000
1	0.9666	0.6772	0.46	0.4161	0.3946	0.3797	0.3617	0.3515	0.3478	0.3464
2	0.8938	0.5748	0.3316	0.2932	0.2683	0.2505	0.2247	0.2079	0.202	0.1985
3	0.8962	0.5212	0.2191	0.1797	0.1542	0.1366	0.1094	0.0888	0.0799	0.0708
4	0.8807	0.5002	0.2123	0.1753	0.1532	0.1381	0.1184	0.1051	0.1001	0.096
5	0.8887	0.5189	0.2197	0.1804	0.157	0.1406	0.1216	0.1084	0.1031	0.0993
6	1.1339	0.6255	0.2362	0.1951	0.173	0.158	0.1409	0.1283	0.1241	0.1195
7	0.8641	0.5501	0.2875	0.2473	0.2231	0.2079	0.1886	0.1779	0.1751	0.1727
8	0.9031	0.5278	0.219	0.1741	0.1459	0.127	0.098	0.0774	0.0682	0.0607
9	0.8781	0.4958	0.2059	0.164	0.138	0.1208	0.0999	0.0881	0.0843	0.0812
10	0.8895	0.5204	0.2177	0.1754	0.1495	0.1314	0.1103	0.0972	0.0942	0.0884
11	0.7123	0.3261	0.0846	0.095	0.1126	0.1079	0.0673	0.0094	-0.0782	0.051

Table 1 Summary of non-dimensional geometrical parameters for the Case 1.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
1	1.0	30	0.1	19	1.0	0.5	1.0

Table 1-1 Global coefficients of heat transfer and friction for Case 1.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.2881	8.7627	0.184	12.7026	0.6865
100	2.5459	10.8953	0.1144	7.5616	0.4087
200	4.6296	12.6923	0.0666	4.5345	0.2451
300	6.2569	13.6754	0.0479	3.4879	0.1885
400	7.5761	14.4973	0.0381	2.9553	0.1597
600	9.7045	16.0077	0.028	2.255	0.1219
700	10.63	16.7526	0.0251	2.0714	0.1119
800	10.964	16.6794	0.0219	1.9726	0.1066
900	12.799	19.0854	0.0223	1.8783	0.1015
1000	13.454	19.7654	0.0208	1.9364	0.1047
1100	14.515	21.0014	0.02	1.866	0.1008
1200	15.386	21.9354	0.0192	1.8493	0.0999
1300	15.856	22.2539	0.018	1.8581	0.1004

Table 1-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 1.

Louver	R50	R100	R200	R300	R400	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	4.89	6.489	8.6669	10.3038	11.6606	13.8894	14.852	14.252	16.5424	15.6736	16.3166	16.9205	17.4922
2	4.02	7.0459	10.467	12.526	14.053	16.357	17.288	18.124	18.893	19.618	20.316	20.997	21.729
3	2.402	4.7511	7.0836	8.4094	9.4246	11.091	11.833	12.52	13.182	13.784	14.338	14.822	14.979
4	1.288	3.3097	6.3142	8.3708	9.9381	12.452	13.571	14.622	15.623	16.545	17.417	18.331	23.263
5	0.7273	2.3899	4.9342	6.5803	7.8492	9.9753	10.951	11.893	12.803	13.673	14.688	15.817	16.169
6	0.2949	1.258	3.2795	4.8634	6.1209	8.1462	9.0298	8.0737	10.601	9.2658	9.8355	10.601	11.764
7	0.1726	1.0785	3.4301	5.403	6.9979	9.5717	10.701	11.69	13.611	16.175	18.942	20.509	18.796
8	0.1056	0.7707	2.5572	4.1701	5.4865	7.4312	8.1871	8.7922	10.268	13.674	15.341	16.294	12.206
9	0.0571	0.5592	2.18	3.8398	5.2112	7.2546	8.0985	8.8113	11.836	13.091	15.733	17.139	17.995
10	0.0342	0.4454	1.7251	3.12	4.3783	6.5212	7.4932	8.4765	10.26	13.245	12.413	13.456	14.147

Table 1-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 1.

Louver	R50	R100	R200	R300	R400	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	6.51	7.6993	9.6337	11.1691	12.4655	14.6206	15.5579	14.8735	17.2091	16.2649	16.8949	17.4869	18.0479
2	9.18	9.1811	14.327	15.9157	17.1292	19.0322	19.8248	20.5513	21.2202	21.8687	22.499	23.1229	23.8137
3	9.85	9.8511	11.6062	12.0136	12.5126	13.6285	14.2101	14.7758	15.3433	15.8696	16.361	16.7922	16.9035
4	9.49	10.889	12.688	13.9739	15.0365	16.9778	17.9345	18.8651	19.7709	20.6094	21.4176	22.3075	28.2195
5	9.64	11.108	11.9417	12.4509	13.0526	14.519	15.3324	16.1695	17.0072	17.8215	18.8702	20.0869	20.5269
6	8.63	9.441	10.5734	11.4258	12.1891	13.6795	14.4218	12.4022	15.8102	13.4768	14.0516	14.9071	16.484
7	10.02	12.1411	14.0745	15.1311	16.044	17.851	18.7819	19.5937	22.066	25.5808	29.2189	31.038	28.2919
8	10.89	11.991	12.7994	13.4767	14.0947	15.0585	15.4748	15.7524	17.8561	23.1971	25.4243	26.4534	19.3323
9	10.45	11.6610	13.2354	14.2152	14.8879	15.8616	16.3778	16.7834	21.9364	23.9446	28.1842	29.9748	30.1495
10	10.55	11.878	12.7098	13.2839	13.9842	15.4534	16.2779	17.2451	20.3932	25.9548	23.8391	25.2108	25.3317
11	8.67	9.7706	10.8754	11.6746	12.4454	14.0161	14.8504	14.1668	19.5284	17.8088	20.505	20.8137	21.1467

Table 1-4 Local pressure force Δp_{louv} for Case 1

Louver	R50	R100	R200	R300	R400	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	1.253	0.8764	0.671	0.5947	0.5531	0.5088	0.4955	0.4807	0.4776	0.4674	0.4627	0.4589	0.455
2	1.154	0.7539	0.5407	0.4652	0.4258	0.3877	0.3791	0.3717	0.3719	0.3683	0.3682	0.3683	0.3657
3	1.167	0.6969	0.4052	0.2981	0.2409	0.1732	0.1487	0.1272	0.1078	0.0907	0.0746	0.0584	0.0011
4	1.154	0.6632	0.3803	0.2819	0.2331	0.1867	0.1745	0.1657	0.1596	0.1552	0.1497	0.1458	0.1939
5	1.157	0.6872	0.4024	0.2952	0.2408	0.1887	0.1746	0.1644	0.1556	0.1489	0.1417	0.1347	0.07
6	1.42	0.7805	0.3921	0.2605	0.2014	0.1536	0.1423	0.1373	0.1257	0.116	0.0939	0.0902	0.1705
7	1.166	0.719	0.4931	0.4011	0.3524	0.3085	0.3	0.2957	0.2846	0.2545	0.2297	0.2268	0.4216
8	1.1772	0.7088	0.4155	0.3025	0.239	0.1645	0.1383	0.1147	0.0663	0.0791	0.0835	0.0786	-0.0706
9	1.152	0.6568	0.3745	0.2726	0.2171	0.1576	0.141	0.1249	0.1655	0.1625	0.2494	0.254	0.2355
10	1.16	0.6909	0.4041	0.2944	0.2369	0.1777	0.1598	0.1353	0.0927	0.1399	0.0458	0.0477	0.043
11	0.789	0.3279	0.0556	0.0217	0.0149	-0.1519	-0.1825	-0.1452	-0.1289	-0.0461	-0.0331	-0.0143	-0.0277

Table 1-b Summary of non-dimensional geometrical parameters for the Case 1-b.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
1-b	1.0	30	0.15	19	1.0	0.5	1.0

Table 1-b-1 Global coefficients of heat transfer and friction for Case1-b.

Re_{in}	$<Nu^1>_{fi}$ n	$<Nu^2>_{fi}$ n	j	Δp_{fin}	f
50	1.2408	8.9319	0.1787	16.8943	0.7596
100	2.4488	11.2647	0.1127	10.3044	0.4633
200	4.5434	13.0953	0.0655	6.3361	0.2849
300	6.1616	13.9562	0.0465	4.9507	0.2226
500	8.5217	15.1907	0.0304	3.7491	0.1686
600	9.4549	15.752	0.0263	3.3387	0.1501
800	11.879	18.2953	0.0229	3.305	0.1486
1000	14.031	20.5494	0.0206	3.1813	0.143

Table 1-b-2 Local Nusselt number $<Nu^1>_{louv}$ for Case1-b.

Louver	R50	R100	R200	R300	R500	R600	R800	R1000
1	4.7196	6.265	8.3426	9.8928	12.2717	13.2456	14.9089	16.28
2	4.0035	7.2027	10.872	13.022	15.831	16.946	18.958	20.806
3	2.3722	4.9664	7.5564	8.9331	10.707	11.353	12.248	12.592
4	1.213	3.2275	6.3213	8.4657	11.286	12.325	13.958	14.999
5	0.6518	2.3267	5.107	6.8236	8.9879	9.8513	11.423	12.804
6	0.2203	1.009	2.7482	4.1275	6.022	6.7251	7.883	9.1043
7	0.1362	0.9426	3.2919	5.3478	8.3814	9.6128	12.421	15.262
8	0.0862	0.6831	2.5589	4.3145	7.0092	8.031	9.7877	15.249
9	0.0552	0.4346	2.0127	3.7089	6.3491	7.3305	13.199	15.764
10	0.0481	0.3169	1.6696	3.1175	5.4987	6.4827	11.336	17.292
11	0.0399	0.153	0.9633	1.9868	3.9339	4.8352	8.2703	9.4729

Table 1-b-3 Local Nusselt number $<Nu^2>_{louv}$ for Case1-b

Louver	R50	R100	R200	R300	R500	R600	R800	R1000
1	6.4466	7.5306	9.3217	10.7478	12.9953	13.9264	15.5235	16.843
2	9.726	12.2798	15.1036	16.6855	18.8153	19.7193	21.4447	23.1093
3	10.8201	12.3795	12.7897	12.9949	13.6736	14.027	14.5342	14.5864
4	10.412	11.6118	13.2347	14.4624	16.1883	16.875	17.9563	18.4892
5	10.5381	12.2336	13.1546	13.3691	13.9345	14.3787	15.4329	16.4641
6	8.245	8.8748	9.6039	10.1664	11.0096	11.3817	12.0842	13.1165
7	10.63	12.8816	14.9693	15.9894	17.5229	18.3262	21.0729	24.174
8	11.8513	13.5407	14.3783	15.0007	16.1439	16.6119	17.7217	25.7241
9	11.1784	12.5962	13.9868	14.9746	16.1042	16.4782	25.9272	28.6947
10	11.0357	13.2971	14.2409	14.5555	15.3419	15.8169	24.2949	34.7131
11	8.2151	9.3796	10.0554	10.632	11.9612	12.6982	19.6237	20.6055

Table 1-b-4 Local pressure force Δp_{louv} for Case1-b.

Louver	R50	R100	R200	R300	R500	R600	R800	R1000
1	1.6495	1.1638	0.9043	0.8107	0.7297	0.708	0.6796	0.6623
2	1.5275	1.0019	0.738	0.6535	0.6004	0.5928	0.5863	0.5799
3	1.5469	0.9553	0.5707	0.4215	0.2817	0.2383	0.1771	0.1399
4	1.5436	0.9085	0.524	0.3896	0.2832	0.2592	0.2349	0.2269
5	1.5431	0.9382	0.567	0.4198	0.2945	0.2641	0.2255	0.1963
6	1.8515	1.0372	0.5034	0.3033	0.1517	0.1198	0.084	0.0609
7	1.48	0.9523	0.6799	0.572	0.4861	0.4725	0.4769	0.4726
8	1.5582	0.9749	0.5911	0.4377	0.2911	0.2454	0.0902	0.1207
9	1.5403	0.8978	0.5128	0.3769	0.2549	0.2207	0.2817	0.1849
10	1.5438	0.9429	0.5723	0.4225	0.2892	0.2555	0.2014	0.5712
11	1.1098	0.5313	0.1724	0.1433	0.0864	-0.0376	0.2673	-0.0343

Table 2 Summary of non-dimensional geometrical parameters for the Case 2.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
2	1.0	25	0.1	19	1.0	0.5	1.0

Table 2-1 Global coefficients of heat transfer and friction for Case 2.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.348	10.024	0.2088	11.30	0.5961
100	2.565	12.2266	0.1278	6.6202	0.3531
200	4.7721	14.3744	0.0751	4.0751	0.2173
300	6.5931	15.8192	0.0551	3.129	0.1669
400	8.1422	17.069	0.0446	2.6401	0.1408
500	9.5049	18.1949	0.038	2.339	0.1247
600	10.724	19.2051	0.0335	2.1236	0.1133
700	11.822	20.1005	0.03	1.9139	0.1021
800	12.816	20.8898	0.0273	1.7568	0.0937
900	13.716	21.5802	0.0251	1.6388	0.0874
1000	14.531	22.1887	0.0232	1.5456	0.0824
1100	15.276	22.7446	0.0216	1.4707	0.0784
1200	16.28	23.8292	0.0208	1.4445	0.077

Table 2-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 2.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
8	4.98	6.625	8.828	10.48	11.853	13.045	14.107	15.072	15.959	16.7814	17.549	18.2675	18.943
2	3.54	6.304	9.816	12.08	13.741	15.058	16.16	17.111	17.952	18.71	19.41	20.07	20.706
3	2.52	5.497	8.996	11.18	12.872	14.297	15.535	16.625	17.587	18.433	19.165	19.777	20.258
4	1.43	3.329	5.788	7.727	9.5312	11.233	12.817	14.266	15.572	16.731	17.753	18.652	19.456
5	0.83	2.393	5.695	8.409	10.668	12.591	14.245	15.666	16.885	17.928	18.821	19.586	20.242
6	0.434	1.316	3.486	5.06	6.3274	7.4297	8.4219	9.3253	10.153	10.915	11.618	12.2646	12.846
7	0.268	0.821	3.023	5.004	6.615	7.9307	9.0383	10.001	10.862	11.65	12.392	13.827	17.506
8	0.237	0.821	2.936	4.863	6.5467	8.0257	9.3319	10.491	11.524	12.449	13.278	14.264	15.632
9	0.164	0.547	1.869	3.344	4.8052	6.2194	7.5708	8.8446	10.026	11.103	12.062	12.418	14.425
10	0.1088	0.462	1.801	3.568	5.3397	7.045	8.651	10.138	11.494	12.713	13.904	14.003	15.284
11	0.0663	0.381	1.198	2.347	3.3742	4.2985	5.1456	5.9397	6.6994	7.4347	8.0688	9.068	8.969

Table 2-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 2.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	6.73	7.931	9.8616	11.4005	12.703	13.845	14.871	15.805	16.666	17.466	18.214	18.914	19.573
2	7.744	10.149	13.2299	15.1831	16.602	17.734	18.686	19.512	20.244	20.907	21.524	22.111	22.685
3	9.477	12.867	15.3346	16.6983	17.844	18.885	19.833	20.689	21.454	22.127	22.703	23.171	23.516
4	9.451	11.052	11.8418	13.1266	14.666	16.246	17.755	19.139	20.373	21.447	22.37	23.158	23.845
5	9.353	11.612	14.6651	17.2037	19.288	21.036	22.5	23.707	24.687	25.472	26.096	26.588	26.975
6	8.975	10.82	12.1141	12.9246	13.696	14.472	15.223	15.921	16.561	17.142	17.67	18.144	18.572
7	8.164	10.077	13.3727	15.3012	16.555	17.472	18.201	18.817	19.366	19.874	20.369	22.04	27.219
8	9.975	13.38	16.031	17.4218	18.637	19.72	20.657	21.454	22.125	22.692	23.168	24.113	25.87
9	9.986	11.77	12.7651	14.1692	15.732	17.27	18.704	19.989	21.103	22.038	22.799	22.595	25.562
10	9.995	11.974	15.1014	17.523	19.696	21.64	23.334	24.765	25.938	26.87	27.859	26.992	28.938
11	9.309	10.913	12.8137	13.6085	14.284	14.906	15.494	16.063	16.627	17.189	17.604	18.698	18.085

Table 2-4 Local pressure force Δp_{louv} for Case 2.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	1.259	0.8549	0.6284	0.5442	0.4985	0.4693	0.4488	0.4335	0.4216	0.4121	0.4044	0.3979	0.3925
2	0.945	0.6012	0.4118	0.342	0.3054	0.2833	0.2691	0.2597	0.2538	0.2502	0.2483	0.2473	0.2468
3	1.0075	0.6559	0.4236	0.3234	0.2644	0.2246	0.1953	0.1722	0.153	0.1365	0.122	0.1091	0.0978
4	1.0296	0.6411	0.3742	0.2769	0.2285	0.1996	0.1806	0.1675	0.1584	0.1523	0.1487	0.1468	0.1462
5	1.0131	0.6307	0.3977	0.3174	0.2777	0.2538	0.237	0.2239	0.2125	0.202	0.1916	0.1812	0.171
6	1.3595	0.8269	0.4666	0.3376	0.2737	0.2339	0.2044	0.1807	0.1607	0.1437	0.1292	0.1165	0.0944
7	0.8811	0.5353	0.375	0.3083	0.2705	0.2478	0.234	0.2254	0.2197	0.216	0.2136	0.2093	0.2036
8	1.016	0.6622	0.4341	0.3318	0.2686	0.2247	0.1923	0.1672	0.147	0.1305	0.1166	0.1083	0.1275
9	1.0283	0.639	0.3723	0.276	0.2268	0.1954	0.1734	0.1574	0.1459	0.138	0.1329	0.1226	0.1247
10	1.014	0.6282	0.394	0.3141	0.2768	0.2554	0.2407	0.229	0.2186	0.2087	0.197	0.1811	0.2193
11	0.748	0.4021	0.1527	0.0692	0.0356	0.0205	0.0049	-0.055	-0.0949	-0.1179	-0.1304	-0.126	-0.1592

Table 3-a Summary of non-dimensional geometrical parameters for the Case 3-a.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
3-a	1.0	20	0.05	19	1.0	0.5	1.0

Table 3-a-1 Global coefficients of heat transfer and friction for Case 3-a.

Re_{in}	$<Nu^1>_{fi}$	$<Nu^2>_{fi}$	j	Δp_{fin}	f
	n	n			
50	1.6806	7.0385	0.1542	7.674	0.4902
100	3.5496	9.5294	0.1044	4.9658	0.3172
300	6.5338	14.4403	0.0527	2.3715	0.1515
500	9.3937	16.8165	0.0368	1.6641	0.1063
800	12.444	19.2166	0.0263	1.2416	0.0793
1000	14.043	20.4808	0.0224	1.098	0.0701
1100	14.759	21.0534	0.021	1.0447	0.0667

Table 3-a-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 3-a

Louver	R50	R100	R300	R500	R800	R1000	R1100	R1200
1	4.6798	6.2335	8.9067	12.4294	15.2713	16.8335	17.5433	18.2136
2	3.3806	5.8092	11.645	15.154	18.647	20.487	21.313	22.089
3	2.6708	5.8003	12.357	15.762	19.34	21.277	22.157	22.99
4	1.7224	3.9928	8.5687	11.209	13.793	15.185	15.824	16.434
5	1.1018	2.8255	7.375	10.746	14.247	16.003	16.77	17.484
6	0.6971	1.9396	4.9362	7.3594	9.6763	10.8201	11.3262	11.801
7	0.8687	2.3032	4.6947	8.132	11.88	13.866	14.762	15.605
8	1.0429	3.3387	5.2608	8.5737	12.193	14.166	15.059	15.903
9	1.0365	3.2635	4.0468	6.7745	9.9826	11.652	12.391	13.08
10	0.9463	2.7682	3.0692	5.5657	9.0713	10.801	11.557	12.254
11	0.7239	2.095	2.4385	4.7522	7.0418	8.2696	8.8149	9.3152

Table 3-a-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 3-a.

Louver	R50	R100	R300	R500	R800	R1000	R1100	R1200
1	6.0574	7.2914	9.6826	13.1111	15.8811	17.4116	18.108	18.766
2	6.5452	8.7147	14.3443	17.5035	20.7461	22.4706	23.2484	23.9807
3	8.0528	12.1014	18.2747	20.7327	23.6511	25.3144	26.0842	26.8189
4	8.4155	11.8759	14.5104	16.0378	17.7919	18.8601	19.3734	19.8742
5	8.3123	10.9249	14.4178	17.0463	19.8739	21.295	21.9181	22.5014
6	6.3079	7.8926	12.2508	13.8362	15.2627	15.9977	16.3392	16.6695
7	7.0412	8.3899	13.9723	17.4192	20.59	22.2212	22.963	23.6637
8	8.2567	11.571	17.9586	20.2559	22.7456	24.2096	24.8921	25.5478
9	8.4924	11.7884	16.3461	18.0562	20.1559	21.2989	21.8113	22.293
10	8.6007	11.4906	14.4447	16.8576	19.7271	21.0148	21.5543	22.0412
11	6.9684	8.9199	13.2933	15.1723	16.3815	17.007	17.3034	17.5708

Table 3-a-4 Local pressure force Δp_{louv} for Case 3-a.

Louver	R50	R100	R300	R500	R800	R1000	R1100	R1200
1	0.9084	0.6061	0.3755	0.3011	0.2607	0.2456	0.2397	0.2347
2	0.5865	0.3739	0.1926	0.1452	0.1153	0.1042	0.0998	0.0958
3	0.6463	0.418	0.2085	0.1512	0.1156	0.103	0.0981	0.0935
4	0.6762	0.4493	0.2073	0.1409	0.1021	0.0892	0.0843	0.0798
5	0.6704	0.433	0.1855	0.1254	0.0918	0.0804	0.076	0.072
6	1.0179	0.6659	0.2939	0.1957	0.1373	0.1185	0.1118	0.1063
7	0.53	0.3168	0.1795	0.1318	0.0979	0.0852	0.0803	0.0758
8	0.6467	0.4041	0.2	0.1428	0.1037	0.0896	0.0841	0.0791
9	0.6766	0.4547	0.2152	0.1487	0.1075	0.093	0.0874	0.0823
10	0.6707	0.433	0.1813	0.1216	0.0883	0.0759	0.071	0.0664
11	0.6443	0.411	0.1322	0.0596	0.0213	0.0137	0.0121	0.0123

Table 3 Summary of non-dimensional geometrical parameters for the Case 3.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
3	1.0	20	0.1	19	1.0	0.5	1.0

Table 3-1 Global coefficients of heat transfer and friction for Case 3.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.27	7.94	0.1654	9.2868	0.4899
100	2.5087	10.6261	0.1107	5.9046	0.3115
200	4.5386	13.4715	0.0702	3.7585	0.1983
300	6.2912	15.0626	0.0523	2.8421	0.1499
400	7.7527	16.1998	0.0422	2.3279	0.1228
500	9.0023	17.1056	0.0356	2.0003	0.1055
600	10.094	17.8769	0.031	1.7763	0.0937
700	11.065	18.5593	0.0276	1.6127	0.0851
800	11.939	19.1717	0.025	1.4882	0.0785
900	12.731	19.7225	0.0228	1.3856	0.0731
1000	13.452	20.2175	0.0211	1.2704	0.067
1100	14.111	20.6623	0.0196	1.1834	0.0624
1200	14.742	21.1077	0.0183	1.1116	0.0586

Table 3-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 3.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.5189	6.0482	8.0797	9.5997	10.861	11.957	12.934	13.822	14.639	15.396	16.103	16.766	17.39
2	2.9414	5.166	8.5484	11.012	12.895	14.384	15.599	16.618	17.49	18.248	18.917	19.518	20.072
3	2.255	5.0442	9.3797	11.964	13.781	15.189	16.353	17.352	18.226	18.992	19.656	20.21	20.639
4	1.5162	3.7158	7.2589	9.3309	10.81	11.971	12.944	13.793	14.551	15.24	15.871	16.456	17.006
5	0.9899	2.5442	4.9721	6.727	8.2088	9.538	10.766	11.912	12.984	13.982	14.907	15.758	16.535
6	0.4825	1.2271	2.939	4.568	5.9542	7.1133	8.0917	8.9313	9.6628	10.309	10.887	11.411	11.897
7	0.3224	0.8866	2.2081	3.8755	5.4762	6.9066	8.1581	9.2538	10.221	11.084	11.861	12.565	13.221
8	0.2784	1.1254	2.9158	4.8807	6.5441	7.9606	9.1899	10.272	11.231	12.084	12.841	13.507	14.089
9	0.2037	0.9936	2.5195	4.3911	6.0514	7.497	8.763	9.8844	10.889	11.797	12.624	13.385	14.121
10	0.1439	0.8169	1.5615	2.7434	3.8935	5.0394	6.1747	7.2869	8.3633	9.3927	10.365	11.272	12.051
11	0.0908	0.5047	1.016	2.1121	3.1607	4.1168	4.9768	5.7549	6.4667	7.1247	7.7424	8.3219	9.146

Table 3-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 3.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	6.1249	7.2624	9.0447	10.459	11.656	12.707	13.65	14.51	15.303	16.039	16.728	17.374	17.982
2	6.06	8.0422	11.277	13.642	15.419	16.805	17.922	18.852	19.642	20.323	20.921	21.455	21.948
3	7.086	11.184	15.735	17.973	19.366	20.393	21.235	21.962	22.605	23.168	23.648	24.03	24.292
4	7.4342	12.067	15.34	16.499	17.199	17.755	18.259	18.737	19.194	19.63	20.045	20.44	20.822
5	7.5166	12.043	12.864	13.69	14.578	15.515	16.47	17.414	18.325	19.184	19.982	20.709	21.362
6	6.2168	8.7596	10.393	11.892	13.005	13.853	14.529	15.089	15.565	15.977	16.339	16.664	16.965
7	6.259	7.4788	9.802	12.131	13.992	15.419	16.531	17.427	18.17	18.803	19.352	19.835	20.285
8	7.563	11.123	15.39	17.381	18.566	19.434	20.149	20.766	21.301	21.759	22.142	22.445	22.676
9	7.971	12.11	16.963	18.73	19.812	20.609	21.266	21.842	22.357	22.822	23.243	23.63	24.055
10	8.08	12.111	13.472	14.021	14.79	15.742	16.78	17.829	18.841	19.786	20.643	21.401	22.001
11	6.78	10.053	11.173	12.491	13.421	14.094	14.631	15.094	15.515	15.904	16.276	16.625	17.519

Table 3-4 Local pressure force Δp_{louv} for Case 3.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	1.253	0.8435	0.6011	0.5094	0.4602	0.4287	0.4071	0.3908	0.3781	0.3679	0.3595	0.3525	0.3465
2	0.765	0.4856	0.3278	0.2662	0.2326	0.2117	0.1979	0.1881	0.1813	0.1767	0.1737	0.172	0.1712
3	0.781	0.5191	0.3429	0.2711	0.2289	0.2002	0.1794	0.1631	0.1498	0.1383	0.128	0.1183	0.1091
4	0.8151	0.5804	0.3934	0.3043	0.252	0.2174	0.1928	0.1744	0.1604	0.1495	0.141	0.1347	0.1302
5	0.8068	0.5763	0.358	0.2588	0.2047	0.1725	0.1515	0.1372	0.1268	0.1189	0.1126	0.1073	0.1027
6	1.1857	0.8763	0.5218	0.3772	0.2979	0.2493	0.2164	0.1927	0.1744	0.1597	0.1474	0.137	0.1282
7	0.703	0.3776	0.2759	0.2313	0.2035	0.1828	0.1672	0.1553	0.1461	0.1392	0.1339	0.1299	0.127
8	0.7811	0.5048	0.3131	0.2468	0.208	0.1803	0.1595	0.143	0.1296	0.1184	0.1088	0.1003	0.0925
9	0.8134	0.576	0.4061	0.3223	0.2729	0.2396	0.215	0.1959	0.1807	0.1684	0.1586	0.151	0.1451
10	0.8056	0.5693	0.3592	0.2557	0.2005	0.1685	0.1485	0.1348	0.1246	0.1163	0.109	0.1024	0.0915
11	0.5759	0.4521	0.2134	0.1095	0.052	0.017	-0.004	-0.017	-0.026	-0.036	-0.0756	-0.0999	-0.114

Table 3-b Summary of non-dimensional geometrical parameters for the Case 3-b.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
3-b	1.0	20	0.15	19	1.0	0.5	1.0

Table 3-b-1 Global coefficients of heat transfer and friction for Case 3-b.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.2208	6.6102	0.1305	11.3855	0.4927
100	2.3941	9.3166	0.092	7.9759	0.3451
300	6.1831	14.3841	0.0473	4.3948	0.1902
400	7.5975	15.4816	0.0382	3.7414	0.1619
500	8.7732	16.2511	0.0321	3.3269	0.144
600	9.7506	16.7893	0.0276	3.0476	0.1319
700	10.558	17.1535	0.0242	2.8213	0.1221
800	11.267	17.4886	0.0216	2.6703	0.1156
1000	13.528	19.9632	0.0197	2.5943	0.1123
1200	16.196	23.4383	0.0193	2.7136	0.1174

Table 3-b-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 3-b

Louver	R50	R100	R300	R400	R500	R600	R700	R800	R1000	R1200
1	4.5752	6.1585	9.7663	11.0335	12.1309	13.1078	13.9905	14.7957	16.2137	17.4137
2	2.7714	4.9057	10.547	12.365	13.764	14.891	15.857	16.739	18.355	19.791
3	2.0382	4.723	11.396	13.101	14.246	14.948	15.332	15.623	16.366	17.297
4	1.3768	3.7427	9.8842	11.512	12.72	13.679	14.476	15.159	16.539	17.957
5	0.9123	2.6311	6.9298	8.2285	9.2931	10.141	10.728	11.159	12.167	14.494
6	0.4512	1.2467	4.2494	5.5478	6.6731	7.622	8.3782	8.9226	9.7248	13.133
7	0.2681	0.6794	3.4594	4.8931	6.2057	7.3829	8.4374	9.3813	11.528	16.348
8	0.2179	0.7802	4.4836	6.1181	7.4536	8.5177	9.3821	10.138	13.554	18.84
9	0.1782	0.6864	4.5019	6.3273	7.895	9.2422	10.392	11.391	17.869	20.292
10	0.1652	0.5591	2.946	4.0711	5.0859	5.9959	6.7898	7.7509	12.475	15.355
11	0.1527	0.4339	1.8427	2.7503	3.6204	4.416	5.1186	5.7576	8.3654	11.4131

Table 3-b-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 3-b

Louver	R50	R100	R300	R400	R500	R600	R700	R800	R1000	R1200
1	6.2682	7.4381	10.6562	11.8515	12.8976	13.8348	14.6846	15.4615	16.8314	17.9908
2	5.8458	7.7055	13.1396	14.8596	16.1485	17.169	18.0429	18.8511	20.3624	21.722
3	6.4658	10.1504	17.2385	18.5396	19.2456	19.5034	19.4662	19.4103	19.7124	20.3993
4	6.6403	11.425	17.9984	18.8169	19.3055	19.6616	19.968	20.2647	21.1732	22.3387
5	6.7083	11.5116	14.6681	15.0306	15.4028	15.685	15.7607	15.768	16.3237	18.8461
6	5.9857	8.8379	11.4179	12.3488	13.1092	13.6743	14.0162	14.1412	14.3868	18.8432
7	6.1022	6.7463	11.1532	12.7196	13.9661	14.9569	15.7605	16.4475	18.5962	25.8128
8	7.0462	9.9894	16.3808	17.555	18.1995	18.4918	18.6212	18.7821	23.0577	31.5588
9	7.3628	11.695	19.708	20.959	21.7063	22.188	22.4886	22.7692	32.9741	36.8129
10	7.4805	11.6669	15.7347	15.8569	16.0181	16.1588	16.2408	16.9496	25.3954	30.6371
11	6.5235	9.091	11.5072	12.0566	12.5536	12.918	13.1355	13.3962	18.338	24.7353

Table 3-b-4 Local pressure force Δp_{louv} for Case 3-b.

Louver	R50	R100	R300	R400	R500	R600	R700	R800	R1000	R1200
1	1.6045	1.1043	0.6877	0.628	0.5915	0.5667	0.5491	0.5358	0.5172	0.5046
2	1.0038	0.6549	0.3784	0.3435	0.3272	0.3217	0.3224	0.3261	0.3356	0.3447
3	0.9627	0.6381	0.3411	0.2867	0.2457	0.2115	0.1808	0.1562	0.1244	0.1062
4	0.9852	0.7116	0.4297	0.377	0.3457	0.3274	0.3199	0.3176	0.3135	0.3082
5	0.9701	0.7123	0.3849	0.3101	0.2582	0.2182	0.185	0.1542	0.1163	0.1106
6	1.3475	1.0328	0.5068	0.3997	0.3331	0.2899	0.2575	0.2328	0.1845	0.1896
7	0.9373	0.5143	0.3057	0.2786	0.2626	0.2532	0.2521	0.2566	0.2901	0.3499
8	0.9643	0.6095	0.2992	0.2529	0.22	0.1927	0.1696	0.1482	0.1069	0.1608
9	0.9844	0.7085	0.4521	0.4104	0.3866	0.372	0.3603	0.351	0.3847	0.3889
10	0.9705	0.7162	0.3901	0.306	0.2456	0.1996	0.1663	0.1443	0.1969	0.2455
11	0.6555	0.5733	0.2192	0.1485	0.1107	0.0948	0.0583	0.0475	0.0242	0.0046

Table 4 Summary of non-dimensional geometrical parameters for the Case 4.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
4	1.0	15	0.1	19	1.0	0.5	1.0

Table 4-1 Global coefficients of heat transfer and friction for Case 4.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.2596	6.1138	0.127	7.1493	0.3738
100	2.4545	7.6542	0.0797	4.2829	0.2259
200	4.4379	11.7657	0.0613	3.231	0.1704
300	6.2594	14.4326	0.0501	2.6151	0.1379
400	7.8265	16.2235	0.0422	2.2135	0.1168
500	9.1781	17.5144	0.0365	1.9312	0.1019
600	10.351	18.5063	0.0321	1.722	0.0908
700	11.379	19.3004	0.0287	1.5609	0.0823
800	12.288	19.954	0.026	1.4334	0.0756
900	13.097	20.5007	0.0237	1.3302	0.0702
1000	13.817	20.955	0.0218	1.2431	0.0656
1100	14.457	21.3275	0.0202	1.1497	0.0606
1200	15.021	21.6212	0.0188	1.0737	0.0566

Table 4-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 4.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.4	5.9335	7.9802	9.4885	10.738	11.824	12.794	13.675	14.485	15.237	15.939	16.597	17.217
2	2.4	3.8862	6.4877	8.7569	10.727	12.421	13.874	15.12	16.189	17.106	17.888	18.55	19.107
3	1.84	3.7212	7.2267	9.9811	12.118	13.81	15.182	16.319	17.275	18.082	18.761	19.314	19.738
4	1.369	3.3787	7.3771	10.363	12.562	14.256	15.613	16.729	17.663	18.451	19.112	19.656	20.084
5	1.022	2.9158	6.54	9.3061	11.388	13.036	14.387	15.524	16.494	17.328	18.042	18.644	19.134
6	0.6625	1.7702	3.455	4.83	5.9004	6.7919	7.5631	8.2479	8.8665	9.4346	9.9628	10.46	10.935
7	0.4791	1.0648	1.6372	3.0625	4.575	6.0154	7.339	8.5388	9.622	10.602	11.493	12.312	13.077
8	0.4043	1.158	2.0316	3.6667	5.4155	7.0503	8.5282	9.8537	11.039	12.096	13.029	13.84	14.53
9	0.3321	1.1336	2.4612	4.2209	6.028	7.7023	9.1991	10.519	11.679	12.694	13.578	14.34	14.979
10	0.277	1.0504	2.5014	4.1592	5.759	7.2105	8.5045	9.663	10.705	11.645	12.491	13.243	13.898
11	0.2209	0.781	1.6768	2.5786	3.4062	4.193	4.9125	5.5801	6.2063	6.7989	7.3646	7.9125	8.449

Table 4-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 4.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	5.99	7.1519	8.9661	10.372	11.561	12.604	13.541	14.3953	15.183	15.914	16.599	17.241	17.846
2	4.688	5.8018	8.3694	10.68	12.679	14.381	15.826	17.051	18.091	18.973	19.716	20.334	20.845
3	4.90	6.8305	11.041	14.101	16.322	17.986	19.274	20.299	21.131	21.81	22.356	22.774	23.056
4	4.97	7.6944	13.897	17.533	19.775	21.283	22.374	23.199	23.843	24.348	24.733	25.006	25.163
5	5.03	8.1967	15.557	19.055	20.98	22.224	23.116	23.804	24.351	24.788	25.127	25.369	25.507
6	4.8122	6.7869	11.268	12.612	13.205	13.616	13.969	14.2946	14.604	14.903	15.192	15.472	15.75
7	4.9377	5.1291	6.4981	9.4455	11.821	13.693	15.194	16.4186	17.434	18.291	19.024	19.667	20.247
8	5.248	6.5405	9.0029	12.574	15.403	17.486	19.066	20.3056	21.3	22.103	22.738	23.215	23.542
9	5.3625	7.6404	12.603	16.616	19.404	21.317	22.678	23.6696	24.407	24.95	25.338	25.588	25.701
10	5.4319	8.3791	15.378	19.52	21.663	22.861	23.645	24.2193	24.667	25.023	25.296	25.481	25.563
11	5.1117	7.3747	12.761	14.8	15.264	15.37	15.46	15.5842	15.747	15.937	16.147	16.377	16.625

Table 4-4 Local pressure force Δp_{louv} for Case 4.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	1.2605	0.8608	0.6074	0.5051	0.4482	0.4118	0.3865	0.3679	0.3536	0.3422	0.333	0.3253	0.3189
2	0.616	0.3991	0.2791	0.226	0.1946	0.1741	0.1597	0.1492	0.1413	0.1355	0.1312	0.1283	0.1267
3	0.5809	0.373	0.2635	0.2114	0.1812	0.1607	0.1452	0.1327	0.1221	0.1129	0.1046	0.0968	0.089
4	0.5849	0.3928	0.29	0.2349	0.201	0.1776	0.1603	0.1471	0.1366	0.1282	0.1215	0.1162	0.1123
5	0.578	0.3992	0.3175	0.2661	0.2323	0.2084	0.1904	0.1764	0.165	0.1557	0.1478	0.1409	0.1344
6	0.909	0.6619	0.5696	0.452	0.3658	0.304	0.2589	0.2252	0.1994	0.1792	0.1629	0.1496	0.1386
7	0.5791	0.3022	0.2182	0.1969	0.1791	0.1643	0.1519	0.1413	0.1324	0.1248	0.1186	0.1135	0.1096
8	0.5772	0.3423	0.2144	0.176	0.1539	0.1385	0.1267	0.1169	0.1086	0.1013	0.0947	0.0886	0.0827
9	0.5834	0.3739	0.2525	0.2048	0.1797	0.1629	0.1504	0.1404	0.1322	0.1254	0.1196	0.1147	0.1107
10	0.577	0.3918	0.3055	0.2606	0.2323	0.2114	0.1948	0.1814	0.1704	0.1611	0.1533	0.1463	0.1397
11	0.3022	0.2403	0.266	0.1908	0.1295	0.0844	0.0513	0.0268	0.0084	-0.006	-0.019	-0.0498	-0.072

Table 5 Summary of non-dimensional geometrical parameters for the Case 5.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
5	1.5	30	0.1	19	1.0	0.5	1.0

Table 5-1 Global coefficients of heat transfer and friction for Case 5.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.9577	7.085	0.1535	8.4277	0.5000
100	3.3718	9.3995	0.1018	5.345	0.3171
200	5.6881	11.4121	0.0618	3.4683	0.2058
300	7.3990	12.7432	0.0460	2.7902	0.1656
400	8.7851	13.8257	0.0374	2.3869	0.1416
500	9.9637	14.7628	0.0320	2.0638	0.1225
600	10.9880	15.5863	0.0281	1.8784	0.1115
700	12.0680	16.6062	0.0257	1.7394	0.1032
800	13.3670	18.0995	0.0245	1.7463	0.1036
900	14.4030	19.1581	0.0231	1.7292	0.1026
1000	15.3840	20.1388	0.0218	1.6102	0.0955
1100	16.4560	21.3398	0.0210	1.5225	0.0903
1200	17.4320	22.3808	0.0202	1.4799	0.0878
1300	18.2800	23.2696	0.0194	1.4852	0.0881

Table 5-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 5.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	4.167	5.5838	7.49	8.9082	10.075	11.083	11.979	12.794	13.525	14.194	14.8183	15.4108	15.96	16.4553
2	3.348	5.8246	8.975	10.951	12.303	13.307	14.104	14.873	15.945	17.117	18.141	18.998	19.872	21.05
3	3.617	6.7603	10.09	12.066	13.541	14.72	15.639	16.268	17.035	17.733	18.374	19.373	20.763	22.213
4	3.246	6.0754	8.938	10.76	12.245	13.593	14.923	16.262	17.327	18.381	19.402	20.473	21.228	21.593
5	2.37	4.0078	6.059	7.8063	9.4493	10.973	12.399	13.774	15.523	16.443	16.935	18.215	19.372	20.231
6	1.118	2.0655	4.085	5.4983	6.4809	7.2156	7.815	8.4812	10.083	10.752	12.3007	13.6745	14.969	16.154
7	0.69	1.4986	3.864	6.1014	7.9558	9.4338	10.582	12.342	14.785	17.166	17.308	18.7	19.331	20.317
8	0.952	2.0909	4.619	6.407	7.8509	9.0887	10.093	11.524	14.133	15.344	16.154	17.517	17.938	18.031
9	1.029	2.279	5.356	7.7456	9.7288	11.458	12.978	13.772	13.428	14.817	16.447	17.477	19.099	21.701
10	0.8362	1.4763	3.122	4.6243	6.1419	7.6194	9.0128	10.308	11.363	12.424	14.189	15.075	16.18	18.036
11	0.4614	0.7725	2.177	3.3615	4.3436	5.206	5.9837	7.3567	8.8078	9.5893	10.4094	11.3571	12.241	11.2024

Table 5-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 5.

louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	4.96	6.2207	8.0214	9.3918	10.529	11.5145	12.3932	13.1937	13.9129	14.5709	15.1856	15.7694	16.3101	16.7985
2	5.14	7.509	10.5897	12.4524	13.694	14.6024	15.3275	16.0599	17.1206	18.292	19.3147	20.168	21.0428	22.2171
3	7.055	10.8361	13.8614	15.4305	16.593	17.5292	18.2449	18.6976	19.3864	19.9941	20.5814	21.5971	23.0558	24.5623
4	8.7488	12.368	14.0558	15.1071	16.126	17.1807	18.337	19.5904	20.5433	21.5141	22.4873	23.606	24.3086	24.5197
5	8.887	9.9697	10.5259	11.7708	13.201	14.6028	15.946	17.271	19.2074	20.0686	20.4046	21.7394	22.9176	23.7305
6	5.9466	6.7779	8.5224	9.5646	10.194	10.6344	11.0029	11.562	13.5301	14.1174	15.8888	17.4906	18.9559	20.26
7	4.32	5.9863	9.2819	11.8681	13.74	15.0955	16.0708	18.0447	21.1513	24.038	23.8373	25.418	25.9741	27.0933
8	6.619	9.6564	12.1831	13.4319	14.452	15.3575	16.0392	17.5569	20.986	22.2512	22.9754	24.6285	24.8869	24.8457
9	8.6559	13.0917	16.0917	17.8043	19.232	20.5223	21.6498	21.9488	21.1102	22.7199	24.5903	25.8096	27.7868	31.088
10	9.2	10.9049	10.9561	11.9878	13.43	14.9102	16.288	17.6598	18.9969	20.1859	22.3248	23.3775	24.6594	27.1402
11	6.756	7.1624	8.5206	9.4207	10.109	10.7501	11.3479	13.2076	15.3598	16.2065	17.0846	18.3384	19.4157	17.5123

Table 5-4 Local pressure force Δp_{louv} for Case 5.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200	R1300
1	1.1212	0.801	0.618	0.5506	0.5151	0.4932	0.4781	0.4668	0.4608	0.4581	0.4564	0.4545	0.4543	0.4582
2	0.7384	0.5494	0.4397	0.4084	0.4048	0.4169	0.443	0.4837	0.4833	0.4708	0.4649	0.4734	0.4795	0.4233
3	0.6243	0.4427	0.2898	0.2079	0.1477	0.0949	0.0425	-0.0095	-0.0337	-0.0382	-0.0458	-0.054	-0.0741	-0.033
4	0.7624	0.5605	0.3862	0.3079	0.2624	0.2325	0.2101	0.1866	0.1861	0.1832	0.1759	0.1668	0.1622	0.1714
5	0.7939	0.5451	0.3169	0.2377	0.2031	0.1848	0.1743	0.1655	0.1166	0.0926	0.0636	0.0645	0.0718	0.0649
6	1.1625	0.6891	0.3583	0.2447	0.1898	0.1583	0.1394	0.1366	0.1839	0.1827	0.1516	0.1289	0.121	0.125
7	0.5311	0.4464	0.3808	0.353	0.3477	0.3589	0.3819	0.3288	0.2547	0.2898	0.3246	0.3068	0.2978	0.267
8	0.5549	0.3724	0.2452	0.172	0.109	0.048	-0.0103	0.0084	0.124	0.1075	0.0765	0.0718	0.0491	0.0633
9	0.7474	0.5539	0.4104	0.3453	0.306	0.2786	0.2556	0.2472	0.2156	0.2283	0.1875	0.1793	0.1947	0.1756
10	0.8015	0.5625	0.3168	0.2312	0.1948	0.1748	0.1604	0.1191	0.1275	0.1395	0.1136	0.098	0.0924	0.0889
11	0.5901	0.2652	0.0556	0.0406	-0.008	-0.1077	-0.1388	-0.1451	-0.1309	-0.1494	-0.1279	-0.1407	-0.1453	-0.098

Table 6 Summary of non-dimensional geometrical parameters for the Case 6.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
6	1.5	25	0.1	19	1.0	0.5	1.0

Table 6-1 Global coefficients of heat transfer and friction for Case 6.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.7736	5.4279	0.172	6.538	0.3846
100	3.3297	8.7754	0.0948	4.6488	0.2735
200	5.7029	11.4926	0.0621	3.1581	0.1858
300	7.4439	12.8566	0.0463	2.4805	0.1459
400	8.8221	13.9079	0.0376	2.1246	0.125
500	9.9827	14.8073	0.032	1.8705	0.11
800	12.699	16.9534	0.0229	1.3861	0.0815
900	13.405	17.4969	0.021	1.2897	0.0759
1000	14.066	18.0232	0.0195	1.2064	0.071
1100	14.883	19.0029	0.0187	1.1758	0.0692
1200	15.872	19.8322	0.0178	1.1095	0.0653
1300	16.986	21.115	0.0175	1.1159	0.0656

Table 6-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 6.

Louver	R50	R100	R200	R300	R400	R500	R800	R900	R1000	R1100	R1200	R1300
1	4.1366	5.5921	7.521	8.9562	10.142	11.167	13.655	14.349	14.9912	15.533	16.144	16.663
2	2.773	4.8177	8.0073	10.276	11.928	13.181	15.803	16.533	17.256	18.006	18.706	19.423
3	2.6855	5.5058	9.2212	11.449	13.034	14.286	16.86	17.355	17.633	17.936	17.651	18.087
4	2.5713	5.9245	9.7016	11.873	13.456	14.745	17.669	18.419	19.067	19.639	20.063	20.798
5	2.2778	5.2003	8.1541	9.8745	11.153	12.211	14.76	15.5	16.215	16.8	17.584	18.428
6	1.3241	2.4676	3.7088	4.7688	5.7751	6.7176	9.0354	9.6349	10.1569	10.6354	11.06	12.328
7	0.6734	1.2666	3.3383	5.0163	6.4132	7.624	10.625	11.554	12.496	14.282	15.929	19.119
8	0.7985	1.5451	4.3226	6.5281	8.3031	9.786	12.834	13.265	13.699	16.092	17.939	19.139
9	0.8353	1.982	5.1123	7.6967	9.6718	11.259	14.733	15.564	16.233	17.404	18.98	21.975
10	0.7786	1.9904	4.3455	6.3498	7.9337	9.2898	12.666	13.69	14.676	15.057	16.485	17.673
11	0.5486	1.0975	1.961	2.8786	3.6929	4.4437	6.6449	7.3117	8.0992	8.6653	10.622	10.481

Table 6-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 6.

Louver	R50	R100	R200	R300	R400	R500	R800	R900	R1000	R1100	R1200	R1300
1	4.9425	6.2476	8.0689	9.4555	10.611	11.614	14.058	14.741	15.3726	15.9058	16.5068	17.017
2	4.0343	6.1394	9.3928	11.645	13.247	14.44	16.913	17.609	18.3065	19.0498	19.7216	20.426
3	4.7415	8.2902	12.319	14.416	15.818	16.9	19.075	19.455	19.6151	19.8563	19.3951	19.783
4	5.66	11.077	15.153	16.829	17.962	18.895	21.1	21.671	22.1526	22.6535	22.8404	23.563
5	6.3525	12.375	14.688	15.406	15.995	16.57	18.273	18.834	19.398	19.9392	20.5351	21.424
6	5.0524	7.9116	7.9096	8.4264	9.187	9.9864	12.004	12.506	12.9269	13.4326	13.6635	15.107
7	3.1419	4.8553	8.0954	9.818	11.141	12.265	15.065	15.963	16.8906	19.1368	20.7742	24.66
8	4.3233	6.5931	11.508	13.692	15.246	16.487	18.699	18.747	18.891	22.1327	23.9308	25.352
9	5.4842	9.9713	15.563	17.775	19.166	20.212	22.411	22.859	23.1761	24.8771	26.2539	30.28
10	6.3485	12.663	15.779	16.636	17.422	18.212	20.523	21.301	22.1204	22.743	23.9768	25.631
11	5.6412	9.704	8.4734	8.3699	8.7685	9.3039	11.298	11.902	12.7455	13.6836	16.0846	15.812

Table 6-4 Local pressure force Δp_{louv} for Case 6.

Louver	R50	R100	R200	R300	R400	R500	R800	R900	R1000	R1100	R1200	R1300
1	1.139	0.7999	0.5938	0.516	0.4745	0.4482	0.4058	0.3975	0.3909	0.386	0.3812	0.3777
2	0.6214	0.4554	0.3449	0.303	0.284	0.2763	0.28	0.2827	0.2837	0.2827	0.2816	0.2802
3	0.4892	0.3573	0.2505	0.193	0.1519	0.1199	0.048	0.0296	0.0134	0.0004	-0.0133	-0.0254
4	0.5397	0.4159	0.2993	0.244	0.2114	0.1903	0.1576	0.1528	0.1508	0.1508	0.1537	0.1528
5	0.5456	0.4684	0.3446	0.275	0.2312	0.2016	0.1515	0.1409	0.1313	0.1202	0.1104	0.0959
6	0.9523	0.7777	0.4193	0.279	0.2128	0.1751	0.1169	0.1056	0.0971	0.0963	0.0903	0.1023
7	0.4059	0.365	0.3134	0.276	0.2528	0.2424	0.2485	0.2498	0.2494	0.2276	0.2318	0.1908
8	0.4304	0.2842	0.2112	0.163	0.1284	0.0983	0.0153	-0.009	-0.0312	0.0077	0.0159	0.0597
9	0.5149	0.3502	0.2764	0.237	0.212	0.1955	0.1695	0.1681	0.1693	0.1585	0.1477	0.1659
10	0.5357	0.4559	0.3555	0.291	0.2484	0.2201	0.1709	0.1585	0.1413	0.138	0.1074	0.1149
11	0.3632	0.3598	0.0963	0.012	-1E-04	-0.031	-0.1394	-0.1539	-0.1617	-0.1683	-0.1766	-0.1812

Table 7 Summary of non-dimensional geometrical parameters for the Case 7.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
7	1.5	20	0.1	19	1.0	0.5	1.0

Table 7-1 Global coefficients of heat transfer and friction for Case 7.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.5587	3.9915	0.086	5.0126	0.2928
100	2.8382	6.5986	0.0711	3.5426	0.2069
200	5.3123	10.6642	0.0575	2.7596	0.1612
300	7.427	12.9169	0.0464	2.2061	0.1289
400	8.9677	14.3898	0.0388	1.8585	0.1086
500	10.214	15.4479	0.0333	1.6208	0.0947
600	11.263	16.282	0.0292	1.4495	0.0847
700	12.172	16.9794	0.0261	1.3218	0.0772
800	12.97	17.5774	0.0237	1.2232	0.0714
900	13.678	18.0973	0.0217	1.1369	0.0664
1000	14.309	18.5497	0.02	1.0438	0.061
1100	14.873	18.9448	0.0186	0.9718	0.0568
1200	15.434	19.3711	0.0174	0.9176	0.0536

Table 7-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 7.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.07	5.525	7.4664	8.9014	10.089	11.119	12.037	12.868	13.631	14.336	14.9924	15.6056	16.1797
2	2.29	3.7992	6.5793	8.8771	10.728	12.213	13.412	14.395	15.221	15.938	16.588	17.2	17.791
3	2.048	4.0084	7.6384	10.192	12.021	13.417	14.539	15.471	16.249	16.88	17.351	17.646	17.79
4	1.63	3.8227	7.5237	9.8222	11.425	12.664	13.689	14.576	15.363	16.068	16.704	17.271	17.772
5	1.734	4.4831	8.6137	11.097	12.86	14.241	15.389	16.379	17.252	18.028	18.72	19.329	19.847
6	1.279	2.8233	5.2699	6.6967	7.7181	8.5265	9.2044	9.7963	10.33	10.823	11.2931	11.7554	12.2198
7	0.7667	0.995	2.9678	5.2691	7.2614	8.8843	10.212	11.32	12.274	13.13	13.927	14.693	15.462
8	0.7714	1.1566	3.0757	5.4768	7.3556	8.8992	10.21	11.334	12.28	13.018	13.52	13.866	14.536
9	0.75	1.3764	3.1768	5.7827	7.6967	9.2844	10.622	11.771	12.776	13.659	14.421	15.056	15.668
10	0.7142	1.5258	3.4137	6.113	7.8241	9.272	10.547	11.699	12.741	13.691	14.555	15.321	15.961
11	0.6168	1.2219	2.8784	4.7192	5.781	6.6384	7.384	8.0685	8.6866	9.2708	9.8639	10.4584	11.1644

Table 7-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 7.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.87	6.1866	8.0253	9.4128	10.571	11.58	12.48	13.297	14.048	14.742	15.3885	15.9925	16.5578
2	3.28	4.7822	7.6685	10.024	11.892	13.37	14.548	15.502	16.298	16.985	17.6077	18.1961	18.7671
3	3.4	5.683	9.8768	12.594	14.422	15.758	16.8	17.646	18.338	18.883	19.2655	19.468	19.5179
4	3.144	6.25	11.104	13.554	15.054	16.132	16.992	17.726	18.372	18.948	19.4629	19.9131	20.3006
5	3.9	8.6986	14.84	17.288	18.707	19.721	20.536	21.234	21.852	22.399	22.882	23.2944	23.6234
6	3.62	7.3553	11.209	12.152	12.667	13.053	13.389	13.703	14.007	14.309	14.6152	14.9378	15.2828
7	2.66	3.1644	7.3696	10.714	13.121	14.78	15.988	16.919	17.686	18.369	19.0119	19.6441	20.3025
8	3.05	4.1527	8.5822	12.04	14.245	15.74	16.879	17.781	18.476	18.925	19.1017	19.1287	19.6605
9	3.41	5.8498	10.228	13.876	16.09	17.558	18.631	19.474	20.17	20.747	21.2005	21.5246	21.9065
10	3.734	7.8804	13.2	16.228	17.822	18.895	19.766	20.538	21.226	21.842	22.3823	22.8256	23.1978
11	3.78	8.2793	14	14.357	14.617	14.748	14.904	15.115	15.34	15.596	15.9275	16.3094	16.9243

Table 7-4 Local pressure force Δp_{louv} for Case 7.

Louver	R50	R100	R200	R300	R400	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	1.1209	0.7909	0.574	0.4871	0.4394	0.4093	0.3884	0.3726	0.3607	0.3509	0.3428	0.336	0.3301
2	0.5047	0.3706	0.2761	0.233	0.2091	0.1949	0.1866	0.182	0.1801	0.1799	0.1806	0.1818	0.1831
3	0.4107	0.3007	0.2223	0.1811	0.1536	0.1319	0.1137	0.0977	0.0831	0.0696	0.0568	0.0443	0.0317
4	0.3995	0.3174	0.2398	0.1962	0.1685	0.1495	0.1361	0.126	0.1185	0.1129	0.1091	0.1073	0.1077
5	0.3812	0.3097	0.2483	0.2073	0.181	0.1628	0.1495	0.1391	0.1306	0.1233	0.1166	0.1099	0.1027
6	0.6692	0.6721	0.4973	0.354	0.2688	0.2167	0.1821	0.158	0.14	0.1261	0.1153	0.1067	0.1003
7	0.3396	0.2234	0.2503	0.241	0.2243	0.2099	0.1991	0.1924	0.1889	0.1877	0.1881	0.1898	0.1917
8	0.3432	0.2257	0.1933	0.167	0.143	0.1214	0.1019	0.0841	0.0671	0.0502	0.0325	0.014	-0.0017
9	0.3688	0.2645	0.2036	0.1743	0.1578	0.1453	0.1354	0.1276	0.1219	0.1181	0.117	0.1188	0.1216
10	0.3634	0.2607	0.2101	0.1845	0.1667	0.1523	0.1407	0.1313	0.123	0.1153	0.1073	0.0979	0.0873
11	0.1113	0.2463	0.1897	0.0854	0.0269	-0.009	-0.031	-0.0458	-0.055	-0.067	-0.0972	-0.1135	-0.1192

Table 8 Summary of non-dimensional geometrical parameters for the Case 8.

Case	F_p	θ	b	F_d	S_2	S_3	S_4
8	1.5	15	0.1	19	1.0	0.5	1.0

Table 8-1 Global coefficients of heat transfer and friction for Case 8.

Re_{in}	$<Nu^1>_{fin}$	$<Nu^2>_{fin}$	j	Δp_{fin}	f
50	1.5626	3.4482	0.0742	4.0384	0.2346
100	2.2557	4.531	0.0487	2.4075	0.1398
200	4.0824	6.5524	0.0352	2.035	0.1182
500	9.0488	12.9799	0.0279	1.4765	0.0858
600	10.325	14.405	0.0258	1.3424	0.078
700	11.434	15.5679	0.0239	1.2318	0.0715
800	12.404	16.5299	0.0222	1.1395	0.0662
900	13.257	17.3337	0.0207	1.0615	0.0617
1000	14.007	18.0059	0.0194	0.9948	0.0578
1100	14.662	18.5606	0.0181	0.9371	0.0544
1200	15.229	19.0106	0.017	0.8859	0.0515

Table 8-2 Local Nusselt number $<Nu^1>_{louv}$ for Case 8.

Louver	R50	R100	R200	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.0359	5.4665	7.4511	11.137	12.062	12.9016	13.672	14.386	15.0516	15.674	16.2597
2	2.078	3.0333	5.0664	10.461	11.906	13.171	14.268	15.211	16.016	16.698	17.279
3	1.785	2.8079	5.3964	12.02	13.503	14.731	15.752	16.598	17.281	17.797	18.15
4	1.599	2.7741	5.8362	12.752	14.166	15.335	16.32	17.16	17.879	18.487	18.986
5	1.457	2.8444	6.2055	13.181	14.569	15.72	16.691	17.518	18.224	18.818	19.298
6	1.2434	2.198	4.5815	9.5393	10.57	11.4464	12.205	12.87	13.4595	13.986	14.4585
7	1.0057	0.9906	1.2125	5.6572	7.1948	8.5991	9.8447	10.934	11.882	12.705	13.421
8	0.9491	0.8931	1.131	5.7198	7.1547	8.4206	9.5375	10.525	11.394	12.144	12.775
9	0.8959	0.9183	1.5388	5.9264	7.3479	8.642	9.8121	10.866	11.811	12.653	13.394
10	0.8458	1.0514	2.3247	6.4579	7.767	8.9403	10.002	10.965	11.838	12.626	13.326
11	0.7922	0.9783	2.7381	6.4591	7.5812	8.5278	9.3643	10.113	10.7861	11.3962	11.9543

Table 8-3 Local Nusselt number $<Nu^2>_{louv}$ for Case 8.

Louver	R50	R100	R200	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	4.8367	6.1312	8.0226	11.6132	12.522	13.3478	14.1069	14.8101	15.466	16.0796	16.6568
2	2.9358	3.7767	5.8595	11.4248	12.8958	14.1741	15.2742	16.2122	17.0061	17.6726	18.2355
3	2.86	3.7963	6.6881	13.886	15.4117	16.6469	17.6509	18.4636	19.1	19.5583	19.8455
4	2.889	4.1209	7.8442	15.7453	17.1867	18.331	19.261	20.0275	20.6608	21.173	21.5672
5	2.941	4.8331	9.1797	17.5471	18.9223	19.9942	20.8507	21.5442	22.1047	22.5441	22.8606
6	2.934	4.5833	7.9411	14.1211	15.088	15.8476	16.4659	16.9808	17.4171	17.7887	18.1065
7	2.75	2.4625	2.3458	9.0262	11.0177	12.7145	14.1242	15.282	16.2305	17.0051	17.639
8	2.82	2.499	2.2773	9.5122	11.4174	12.9596	14.2196	15.2589	16.1132	16.7955	17.3166
9	2.89	2.9273	3.1448	10.2629	12.2076	13.8305	15.1881	16.3271	17.2804	18.0716	18.714
10	2.96	3.9674	4.7734	11.6562	13.4359	14.8732	16.0649	17.0651	17.9079	18.6136	19.1871
11	3.01	4.3796	5.8184	12.2927	13.7734	14.8494	15.6926	16.3736	16.9295	17.3902	17.7774

Table 8-4 Local pressure force Δp_{louv} for Case 8.

Louver	R50	R100	R200	R500	R600	R700	R800	R900	R1000	R1100	R1200
1	1.0949	0.7877	0.5774	0.3953	0.3695	0.3506	0.3364	0.3248	0.3153	0.3075	0.3009
2	0.4045	0.2925	0.2283	0.1547	0.1434	0.1354	0.1296	0.1257	0.1235	0.1229	0.1239
3	0.3237	0.2273	0.191	0.1278	0.1169	0.1074	0.0986	0.0902	0.0816	0.0725	0.0624
4	0.3058	0.218	0.1973	0.1351	0.1236	0.1144	0.107	0.101	0.0963	0.0929	0.0909
5	0.2906	0.2171	0.1772	0.121	0.11	0.1012	0.0939	0.0877	0.0823	0.0773	0.0723
6	0.4894	0.4203	0.4364	0.2878	0.2513	0.223	0.2009	0.1836	0.1698	0.1586	0.1496
7	0.3041	0.154	0.1311	0.1497	0.1473	0.1434	0.1392	0.1352	0.1318	0.1292	0.1277
8	0.2833	0.1569	0.1147	0.1093	0.1029	0.0959	0.0887	0.0813	0.0737	0.0659	0.0576
9	0.2855	0.1585	0.1071	0.1076	0.1026	0.0981	0.0943	0.0909	0.088	0.0856	0.0837
10	0.2813	0.2064	0.0875	0.0837	0.0788	0.0746	0.0705	0.0668	0.0633	0.0599	0.0565
11	-0.0245	0.0063	0.1302	0.0671	0.0462	0.0287	0.0144	0.0023	-0.0079	-0.0165	-0.0242

Note: "RX" = "$\mathrm{Re}_{in} = X$", for example, "R100"= "$\mathrm{Re}_{in} = 100$"