Appendix of Section 5.2.4 (A Two-layer Heterogeneous Ant Colony System with Applications in Tape Carrier Packaging)

Appendix A. The experimental results of the 3×1 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	3.328	3.367	0.033	177.020	51.560	53.193	3.042	—
		ACS	3.044	3.292	0.115	174.260	6.030	57.245	2.800	1.67E-05
		IMMAS	3.054	3.285	0.149	176.960	6.820	57.949	2.811	7.80E-05
1	250	GA	3.024	3.281	0.161	172.600	6.260	57.073	2.781	3.19E-04
		SA	3.037	3.301	0.145	172.510	5.790	56.808	2.791	2.57E-04
		PSO	3.053	3.321	0.153	171.960	6.060	56.330	2.804	2.09E-01
		Greedy	2.992	3.315	0.165	206.200	672.040	68.928	2.789	3.32E-05
		THACS	3.305	3.383	0.037	194.260	43.340	58.780	3.046	—
		ACS	3.037	3.281	0.103	195.110	4.120	64.253	2.817	3.88E-05
		IMMAS	3.054	3.285	0.149	193.650	4.090	63.415	2.831	4.98E-04
2	275	GA	3.024	3.281	0.161	190.100	3.920	62.860	2.801	7.90E-04
		SA	3.037	3.301	0.145	189.360	4.020	62.357	2.811	5.26E-04
		PSO	3.053	3.321	0.153	188.990	3.970	61.911	2.825	9.08E-04
		Greedy	3.033	3.283	0.142	227.200	569.480	74.903	2.843	1.18E-04
		THACS	3.303	3.406	0.047	212.100	35.760	64.223	3.064	—
		ACS	3.048	3.312	0.137	208.310	3.540	68.343	2.840	3.67E-04
		IMMAS	3.058	3.291	0.164	210.160	3.350	68.731	2.850	1.10E-03
3	300	GA	3.064	3.285	0.138	205.230	3.100	66.981	2.851	9.76E-04
		SA	3.068	3.321	0.156	203.150	3.050	66.227	2.852	2.81E-03
		PSO	3.073	3.320	0.155	202.970	30.540	66.049	2.857	3.74E-03
		Greedy	2.990	3.262	0.121	257.700	520.820	86.183	2.826	2.40E-05
		THACS	3.346	3.457	0.045	231.240	29.580	69.110	3.120	—
		ACS	3.090	3.315	0.117	229.310	2.790	74.203	2.895	1.73E-04
		IMMAS	3.092	3.301	0.148	228.990	2.710	74.049	2.897	3.50E-04
4	325	GA	3.079	3.318	0.125	226.510	2.590	73.576	2.883	9.50E-05
		SA	3.090	3.265	0.160	227.020	2.540	73.476	2.893	1.77E-03
		PSO	3.087	3.294	0.156	229.330	2.600	74.287	2.892	8.30E-04
		Greedy	2.945	3.135	0.146	265.500	403.820	90.159	2.790	6.21E-06
		THACS	3.377	3.459	0.040	246.600	25.900	73.015	3.161	—
		ACS	3.140	3.341	0.121	246.120	2.330	78.392	2.951	1.51E-04
		IMMAS	3.130	3.312	0.158	244.980	2.270	78.261	2.942	5.56E-04
5	350	GA	3.108	3.307	0.106	241.120	2.160	77.580	2.920	3.43E-05
		SA	3.106	3.271	0.142	241.350	2.220	77.694	2.919	5.45E-04
		PSO	3.110	3.315	0.161	243.620	2.180	78.327	2.924	6.00E-04
		Greedy	3.105	3.358	0.122	281.180	366.560	90.570	2.942	1.78E-04

Appendix B. The experimental results of the 3×2 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	4.898	4.961	0.053	168.820	86.460	34.464	4.278	—
		ACS	4.208	4.341	0.120	161.320	10.120	38.337	3.722	7.30E-09
		IMMAS	4.244	4.362	0.113	163.150	10.130	38.441	3.756	5.48E-08
1	250	GA	4.164	4.321	0.107	158.320	9.810	38.018	3.680	5.26E-09
		SA	4.115	4.308	0.132	158.660	8.690	38.557	3.643	2.87E-08
		PSO	4.126	4.312	0.137	159.840	9.900	38.743	3.654	2.06E-01
		Greedy	3.354	3.613	0.147	186.300	1196.720	55.546	3.077	9.93E-12
		THACS	4.843	4.935	0.060	185.900	73.280	38.385	4.285	—
		ACS	4.192	4.326	0.133	182.360	7.000	43.499	3.760	4.09E-08
		IMMAS	4.220	4.351	0.136	179.210	7.050	42.464	3.776	3.87E-07
2	275	GA	4.139	4.315	0.126	178.000	6.500	43.010	3.708	4.88E-08
		SA	4.124	4.312	0.132	181.310	6.670	43.967	3.703	1.20E-07
		PSO	4.126	4.312	0.137	183.100	6.480	44.380	3.708	2.04E-07
		Greedy	3.383	3.783	0.221	212.700	936.340	62.875	3.134	1.29E-08
		THACS	4.760	4.852	0.077	203.120	54.98	42.672	4.261	—
		ACS	4.146	4.401	0.115	197.260	5.28	47.578	3.752	1.09E-06
		IMMAS	4.190	4.385	0.123	202.310	5.12	48.284	3.797	9.63E-08
3	300	GA	4.115	4.295	0.101	194.990	4.37	47.391	3.722	3.28E-07
		SA	4.107	4.322	0.125	192.320	5.36	46.832	3.710	3.99E-07
		PSO	4.121	4.306	0.112	193.750	4.39	47.015	3.725	2.35E-07
		Greedy	3.741	4.125	0.157	235.520	605.32	62.950	3.466	9.17E-08
		THACS	4.870	4.997	0.079	214.620	51.900	44.074	4.373	—
		ACS	4.202	4.326	0.138	216.530	4.570	51.530	3.830	6.47E-08
		IMMAS	4.227	4.365	0.137	214.210	4.680	50.673	3.848	4.16E-07
4	325	GA	4.140	4.325	0.127	213.320	4.440	51.532	3.773	1.03E-08
		SA	4.135	4.321	0.135	215.620	4.510	52.149	3.773	9.90E-08
		PSO	4.129	4.351	0.140	215.170	4.450	52.118	3.767	5.30E-08
		Greedy	3.292	3.772	0.217	257.380	573.400	78.180	3.094	1.22E-09
		THACS	4.886	4.968	0.066	233.740	44.460	47.834	4.424	—
		ACS	4.241	4.398	0.117	237.220	3.920	55.468	3.893	5.49E-07
		IMMAS	4.277	4.389	0.126	235.620	3.990	55.563	3.921	1.59E-07
5	350	GA	4.169	4.331	0.122	232.420	3.600	54.346	3.826	6.20E-08
		SA	4.148	4.356	0.128	234.150	3.690	56.169	3.810	7.31E-08
		PSO	4.152	4.366	0.137	230.110	3.810	55.480	3.809	5.57E-08
		Greedy	3.437	3.775	0.169	279.620	502.000	81.353	3.238	8.08E-11

Appendix C. The experimental results of the 3×3 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	5.407	5.549	0.074	160.420	87.390	29.670	4.627	—
		ACS	4.632	4.812	0.101	158.120	10.230	34.136	4.040	2.20E-08
		IMMAS	4.630	4.825	0.146	159.320	9.560	34.408	4.043	1.19E-07
1	250	GA	4.616	4.815	0.128	160.310	11.120	34.729	4.035	2.22E-08
		SA	4.590	4.765	0.129	157.520	9.940	34.322	4.006	1.35E-08
		PSO	4.601	4.781	0.150	158.110	10.180	34.368	4.016	3.05E-01
		Greedy	3.423	4.047	0.326	181.620	1506.020	53.055	3.128	4.48E-09
		THACS	5.450	5.607	0.111	176.400	77.220	32.366	4.721	—
		ACS	4.671	4.822	0.126	173.210	7.980	37.080	4.116	6.17E-08
		IMMAS	4.670	4.831	0.151	175.620	7.580	37.608	4.122	1.02E-07
2	275	GA	4.648	4.832	0.118	172.320	6.880	37.073	4.096	3.08E-08
		SA	4.609	4.810	0.128	171.880	7.060	37.296	4.064	9.00E-08
		PSO	4.614	4.781	0.126	173.000	6.920	37.491	4.071	1.45E-08
		Greedy	3.295	3.549	0.204	201.200	1225.490	61.062	3.046	3.18E-10
		THACS	5.448	5.570	0.071	191.400	67.330	35.134	4.769	—
		ACS	4.619	4.794	0.087	188.450	7.480	40.796	4.115	9.56E-10
		IMMAS	4.641	4.822	0.121	189.320	6.340	40.791	4.134	1.48E-07
3	300	GA	4.625	4.817	0.108	186.150	5.820	40.250	4.114	3.53E-08
		SA	4.596	4.798	0.134	185.710	6.030	40.408	4.090	8.13E-08
		PSO	4.603	4.805	0.153	187.260	5.990	40.683	4.099	6.33E-08
		Greedy	3.370	3.900	0.324	225.260	1157.410	66.850	3.135	1.13E-08
		THACS	5.476	5.685	0.125	208.860	60.220	38.144	4.841	—
		ACS	4.635	4.811	0.116	209.560	5.910	45.212	4.174	5.49E-08
		IMMAS	4.654	4.835	0.125	207.150	5.700	44.513	4.184	8.72E-08
4	325	GA	4.642	4.832	0.112	206.320	4.980	44.446	4.173	3.23E-07
		SA	4.614	4.780	0.100	205.150	5.190	44.461	4.148	1.40E-07
		PSO	4.591	4.761	0.139	207.550	5.080	45.204	4.134	4.67E-07
		Greedy	3.371	3.879	0.304	245.620	1131.220	72.860	3.155	5.46E-09
		THACS	5.510	5.674	0.077	222.800	53.810	40.436	4.904	—
		ACS	4.699	4.832	0.115	223.150	5.390	47.494	4.251	9.79E-08
		IMMAS	4.746	4.901	0.122	222.610	5.050	46.904	4.289	1.17E-07
5	350	GA	4.672	4.832	0.130	219.320	4.390	46.943	4.222	3.35E-08
		SA	4.669	4.810	0.084	218.150	4.560	46.727	4.217	2.38E-10
		PSO	4.611	4.788	0.117	221.510	4.420	48.038	4.176	1.42E-09
		Greedy	3.443	3.773	0.174	268.700	1008.070	78.054	3.235	3.96E-11

Appendix D. The experimental results of the 3×4 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	6.225	6.306	0.108	154.300	59.800	24.788	5.180	—
		ACS	5.426	5.615	0.165	151.150	8.400	27.859	4.600	3.27E-09
		IMMAS	5.434	5.713	0.130	153.620	7.600	28.270	4.617	7.29E-09
1	250	GA	5.274	5.431	0.101	153.450	6.750	29.098	4.500	1.58E-08
		SA	5.260	5.410	0.121	149.820	6.910	28.481	4.475	2.89E-08
		PSO	5.272	5.425	0.100	151.320	6.780	28.702	4.490	4.65E-01
		Greedy	4.029	5.564	0.594	170.120	766.880	42.224	3.602	7.14E-07
		THACS	6.076	6.228	0.085	169.500	42.780	27.897	5.152	—
		ACS	5.315	5.531	0.159	166.420	5.640	31.312	4.583	4.45E-07
		IMMAS	5.318	5.566	0.164	167.320	5.260	31.461	4.589	5.23E-07
2	275	GA	5.303	5.485	0.148	167.230	4.770	31.536	4.577	3.05E-07
		SA	5.289	5.477	0.149	164.550	4.960	31.111	4.557	1.41E-07
		PSO	5.290	5.486	0.149	164.780	4.870	31.152	4.558	3.01E-07
		Greedy	4.075	5.316	0.591	195.200	619.360	47.896	3.690	4.16E-06
		THACS	6.065	6.250	0.101	185.100	45.500	30.521	5.211	—
		ACS	5.285	5.475	0.138	183.540	5.150	34.730	4.620	3.21E-07
		IMMAS	5.288	5.459	0.135	182.210	4.720	34.459	4.618	2.43E-07
3	300	GA	5.284	5.451	0.137	185.140	4.200	35.039	4.624	4.33E-07
		SA	5.277	5.463	0.157	183.230	4.350	34.722	4.613	2.03E-06
		PSO	5.288	5.472	0.147	184.540	4.280	34.897	4.625	6.51E-07
		Greedy	3.529	4.558	0.410	219.000	578.700	62.051	3.266	2.29E-08
		THACS	6.073	6.243	0.105	198.700	41.560	32.718	5.268	—
		ACS	5.334	5.491	0.143	198.260	3.980	37.170	4.701	2.02E-08
		IMMAS	5.313	5.510	0.144	200.150	3.820	37.672	4.690	3.97E-08
4	325	GA	5.305	5.488	0.139	195.240	3.440	36.806	4.670	7.61E-09
		SA	5.293	5.471	0.141	194.230	3.360	36.695	4.658	3.17E-08
		PSO	5.323	5.475	0.116	196.350	3.500	36.889	4.687	4.28E-09
		Greedy	3.704	3.893	0.161	235.120	517.600	63.470	3.434	3.14E-12
		THACS	6.131	6.252	0.127	215.100	38.700	35.085	5.366	—
		ACS	5.323	5.513	0.148	215.310	3.770	40.447	4.738	1.25E-09
		IMMAS	5.323	5.498	0.120	213.660	3.510	40.143	4.733	9.91E-10
5	350	GA	5.305	5.500	0.141	211.160	3.210	39.803	4.713	2.15E-09
		SA	5.203	5.461	0.337	210.540	3.290	40.469	4.630	1.64E-05
		PSO	5.320	5.470	0.112	213.140	3.240	40.066	4.729	1.49E-09
		Greedy	3.591	4.142	0.255	257.200	482.620	71.632	3.356	2.70E-09

Appendix E. The experimental results of the 3×5 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	6.318	6.424	0.110	150.100	41.090	23.759	5.219	—
		ACS	5.415	5.631	0.140	141.230	5.060	26.083	4.544	2.42E-09
		IMMAS	5.438	5.655	0.134	144.610	4.970	26.593	4.577	2.62E-09
1	250	GA	5.372	5.561	0.121	142.310	4.730	26.490	4.519	4.32E-10
		SA	5.221	5.461	0.105	141.230	4.800	27.053	4.406	4.82E-10
		PSO	5.321	5.471	0.115	132.510	4.770	24.905	4.431	2.88E-02
		Greedy	3.486	4.829	0.718	162.800	418.060	46.702	3.149	2.72E-07
		THACS	6.372	6.513	0.090	160.320	36.020	25.160	5.316	—
		ACS	5.472	5.654	0.131	158.310	3.560	28.930	4.666	4.22E-08
		IMMAS	5.459	5.637	0.110	161.510	3.450	29.587	4.670	8.62E-09
2	275	GA	5.413	5.573	0.103	158.410	3.350	29.264	4.623	8.40E-10
		SA	5.261	5.471	0.100	159.320	3.370	30.284	4.515	1.33E-09
		PSO	5.350	5.477	0.114	158.410	3.370	29.608	4.577	1.11E-08
		Greedy	3.484	4.936	0.682	187.900	382.260	53.932	3.188	4.06E-07
		THACS	6.299	6.410	0.099	177.300	32.940	28.149	5.349	—
		ACS	5.449	5.621	0.115	173.210	3.200	31.788	4.708	1.13E-08
		IMMAS	5.448	5.605	0.120	175.330	3.130	32.181	4.716	7.32E-09
3	300	GA	5.404	5.521	0.104	174.410	2.970	32.272	4.679	7.11E-10
		SA	5.264	5.500	0.107	173.440	3.020	32.949	4.570	4.64E-09
		PSO	5.349	5.465	0.081	174.230	2.990	32.572	4.637	7.33E-10
		Greedy	3.691	5.092	0.692	210.320	333.780	56.982	3.393	1.07E-06
		THACS	6.325	6.457	0.115	192.100	31.480	30.372	5.431	—
		ACS	5.454	5.676	0.125	187.260	2.930	34.332	4.761	8.30E-09
		IMMAS	5.459	5.637	0.110	189.310	2.850	34.680	4.771	5.68E-09
4	325	GA	5.412	5.562	0.102	186.630	2.700	34.484	4.727	8.75E-09
		SA	5.261	5.468	0.100	188.320	2.740	35.798	4.616	5.24E-10
		PSO	5.338	5.435	0.071	187.210	2.730	35.071	4.672	2.03E-09
		Greedy	3.626	4.325	0.392	227.300	319.290	62.679	3.359	1.13E-08
		THACS	6.212	6.431	0.098	211.400	25.400	34.030	5.416	—
		ACS	5.279	5.432	0.099	205.310	2.280	38.894	4.677	9.05E-09
		IMMAS	5.294	5.368	0.055	208.410	2.270	39.370	4.697	3.59E-09
5	350	GA	5.218	5.322	0.064	207.160	2.170	39.702	4.634	1.18E-10
		SA	5.213	5.315	0.070	208.530	2.200	40.004	4.634	3.58E-09
		PSO	5.290	5.433	0.068	209.420	2.200	39.586	4.697	4.97E-09
		Greedy	3.512	4.576	0.528	249.600	267.950	71.065	3.281	4.88E-08

Appendix F. The experimental results of the 3×6 sucker matrix configuration.

No.	Amount	Methods	e_n	e_{max}	*std*	$\bar{n}$	$\overline{N_c}$	t_w	e_t	p-value
		THACS	6.418	6.530	0.111	132.000	15.920	20.567	5.163	—
		ACS	5.520	5.731	0.116	130.150	1.940	23.578	4.554	7.36E-09
		IMMAS	5.544	5.702	0.118	130.640	1.890	23.564	4.574	1.02E-09
1	250	GA	5.471	5.650	0.126	131.250	1.850	23.990	4.527	4.50E-10
		SA	5.469	5.631	0.123	129.450	1.860	23.669	4.515	4.07E-10
		PSO	5.496	5.710	0.133	129.860	1.850	23.628	4.536	5.71E-02
		Greedy	4.181	4.671	0.467	146.280	190.020	34.985	3.658	4.44E-08
		THACS	6.288	6.393	0.089	145.800	13.940	23.186	5.173	—
		ACS	5.306	5.463	0.104	143.350	1.370	27.017	4.477	9.39E-10
		IMMAS	5.321	5.465	0.114	146.330	1.360	27.503	4.502	2.35E-09
2	275	GA	5.298	5.420	0.118	145.840	1.220	27.525	4.484	5.70E-09
		SA	5.237	5.417	0.083	145.630	1.290	27.805	4.439	5.44E-10
		PSO	5.294	5.453	0.113	146.660	1.220	27.705	4.484	2.27E-08
		Greedy	4.194	4.874	0.697	158.120	164.880	37.703	3.703	6.40E-06
		THACS	6.203	6.331	0.078	159.260	13.180	25.674	5.192	—
		ACS	5.267	5.437	0.089	259.740	1.260	49.311	4.782	3.38E-09
		IMMAS	5.296	5.453	0.100	160.740	1.220	30.349	4.547	8.68E-09
3	300	GA	5.277	5.398	0.089	159.440	1.080	30.214	4.528	3.33E-09
		SA	5.227	5.387	0.077	158.260	1.180	30.278	4.486	1.09E-09
		PSO	5.299	5.432	0.074	159.140	1.100	30.033	4.543	1.25E-09
		Greedy	3.512	4.576	0.528	184.700	141.540	52.587	3.207	6.88E-08
		THACS	6.428	6.530	0.095	171.400	12.080	26.666	5.413	—
		ACS	5.544	5.745	0.115	170.310	1.270	30.721	4.768	1.57E-09
		IMMAS	5.560	5.775	0.132	171.160	1.120	30.785	4.783	1.75E-09
4	325	GA	5.493	5.661	0.114	171.230	1.070	31.171	4.734	2.08E-08
		SA	5.472	5.655	0.127	169.410	1.130	30.962	4.711	2.87E-08
		PSO	5.498	5.730	0.137	170.550	1.100	31.020	4.735	3.65E-08
		Greedy	4.181	4.671	0.467	204.260	127.460	48.852	3.793	8.45E-08
		THACS	6.383	6.527	0.099	187.800	11.000	29.420	5.456	—
		ACS	5.509	5.688	0.126	184.630	1.230	33.513	4.794	5.78E-08
		IMMAS	5.532	5.702	0.131	185.410	1.120	33.519	4.813	6.22E-08
5	350	GA	5.479	5.621	0.098	183.020	1.050	33.406	4.765	2.40E-08
		SA	5.465	5.638	0.128	171.000	1.110	31.293	4.712	6.65E-08
		PSO	5.494	5.685	0.129	183.780	1.060	33.453	4.779	7.35E-08
		Greedy	4.078	5.541	0.760	222.060	115.940	54.447	3.735	3.03E-06