Appendix of 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	51.563	53.193	3.042	–
		ACS	3.267	3.360	0.068	176.640	58.271	54.067	2.991	2.60E-03
		IMMAS	3.280	3.366	0.063	176.960	53.470	53.949	3.002	1.89E-02
1	250	GA	3.259	3.363	0.051	174.200	49.440	53.454	2.980	1.79E-03
		SA	3.247	3.356	0.071	173.800	51.803	53.531	2.969	9.31E-03
		PSO	3.255	3.355	0.059	174.400	50.853	53.581	2.977	1.11E-03
		Greedy	2.992	3.315	0.165	206.200	672.043	68.928	2.789	3.32E-05
		THACS	3.337	3.465	0.065	194.260	43.340	58.219	3.073	–
		ACS	3.284	3.392	0.067	195.100	43.860	59.405	3.029	6.26E-03
		IMMAS	3.285	3.384	0.080	195.400	43.600	59.484	3.030	6.16E-02
2	275	GA	3.265	3.381	0.076	192.420	41.760	58.941	3.009	1.08E-02
		SA	3.238	3.383	0.094	191.080	42.760	59.005	2.985	7.66E-04
		PSO	3.275	3.385	0.078	191.120	42.320	58.357	3.017	5.32E-02
		Greedy	3.033	3.283	0.142	227.200	569.480	74.903	2.843	5.15E-05
		THACS	3.315	3.416	0.061	212.100	35.760	63.984	3.075	–
		ACS	3.238	3.303	0.054	209.460	38.740	64.687	3.006	1.14E-02
		IMMAS	3.274	3.359	0.050	210.600	36.740	64.332	3.038	5.92E-02
3	300	GA	3.233	3.375	0.088	207.260	33.960	64.117	2.999	1.68E-02
		SA	3.218	3.283	0.046	205.180	33.400	63.759	2.984	3.83E-03
		PSO	3.234	3.359	0.060	205.680	334.640	63.607	2.998	1.74E-03
		Greedy	2.990	3.262	0.121	257.700	520.820	86.183	2.826	7.25E-06
		THACS	3.346	3.457	0.045	231.240	29.580	69.110	3.120	–
		ACS	3.302	3.352	0.040	229.260	31.940	69.438	3.080	1.59E-02
		IMMAS	3.317	3.410	0.045	231.300	30.920	69.735	3.095	9.29E-02
4	325	GA	3.270	3.345	0.066	227.260	29.620	69.499	3.051	1.39E-02
		SA	3.263	3.326	0.037	227.020	29.080	69.571	3.044	2.27E-03
		PSO	3.287	3.328	0.032	229.160	29.700	69.710	3.067	7.54E-03
		Greedy	2.945	3.135	0.146	265.500	403.820	90.159	2.790	3.11E-06
		THACS	3.377	3.459	0.040	246.600	25.900	73.015	3.161	–
		ACS	3.323	3.403	0.060	246.240	27.080	74.106	3.113	2.36E-02
		IMMAS	3.340	3.425	0.043	246.800	26.380	73.897	3.128	2.01E-02
5	350	GA	3.292	3.387	0.047	243.160	25.080	73.855	3.084	2.79E-03
		SA	3.273	3.371	0.046	242.060	25.740	73.961	3.066	6.94E-04
		PSO	3.286	3.389	0.053	245.660	25.280	74.764	3.080	2.49E-03
		Greedy	3.105	3.358	0.122	281.180	366.560	90.570	2.942	8.92E-05

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	4.808	4.937	0.075	166.740	86.520	34.678	4.202	1.45E-04
		IMMAS	4.818	4.939	0.056	167.520	83.820	34.773	4.212	9.29E-03
1	250	GA	4.792	4.901	0.053	163.500	74.260	34.121	4.179	2.17E-03
		SA	4.729	4.787	0.055	162.320	84.560	34.323	4.128	7.49E-06
		PSO	4.787	4.850	0.058	164.560	76.260	34.375	4.179	8.39E-04
		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	4.753	4.913	0.066	186.520	74.520	39.243	4.216	1.40E-02
		IMMAS	4.778	4.854	0.050	184.560	75.120	38.629	4.230	9.15E-03
2	275	GA	4.749	4.895	0.066	182.260	69.200	38.378	4.202	1.01E-03
		SA	4.660	4.883	0.096	184.320	71.020	39.554	4.137	8.45E-04
		PSO	4.738	4.836	0.062	184.200	68.980	38.880	4.198	4.40E-03
		Greedy	3.383	3.783	0.221	212.700	936.340	62.875	3.134	6.46E-09
		THACS	4.760	4.852	0.076	203.120	54.980	42.616	4.266	–
		ACS	4.678	4.809	0.086	199.860	57.840	42.708	4.189	2.10E-03
		IMMAS	4.683	4.827	0.092	204.220	56.140	43.600	4.202	5.97E-02
3	300	GA	4.659	4.785	0.083	196.540	47.920	42.175	4.166	2.23E-02
		SA	4.621	4.731	0.084	193.200	58.740	41.809	4.127	3.23E-03
		PSO	4.645	4.751	0.091	195.660	48.120	42.112	4.153	1.57E-02
		Greedy	3.741	4.125	0.157	235.520	605.320	62.956	3.466	4.59E-08
		THACS	4.870	4.997	0.079	214.620	51.900	44.074	4.373	–
		ACS	4.779	4.913	0.087	218.820	52.200	45.791	4.308	2.22E-02
		IMMAS	4.787	4.912	0.065	214.700	53.540	44.855	4.307	1.73E-02
4	325	GA	4.720	4.775	0.033	214.800	50.760	45.513	4.252	8.71E-04
		SA	4.708	4.902	0.110	212.060	51.540	45.047	4.237	2.68E-03
		PSO	4.767	4.842	0.054	213.460	50.860	44.783	4.288	2.76E-03
		Greedy	3.292	3.772	0.217	257.380	573.400	78.180	3.094	6.09E-10
		THACS	4.886	4.968	0.066	233.740	44.460	47.834	4.424	–
		ACS	4.804	4.933	0.065	236.220	45.460	48.931	4.380	7.61E-03
		IMMAS	4.828	4.944	0.078	235.000	46.320	48.923	4.358	8.57E-02
5	350	GA	4.798	4.918	0.097	234.660	41.760	48.607	4.377	2.18E-03
		SA	4.738	4.936	0.104	234.200	42.780	48.809	4.352	2.38E-03
		PSO	4.754	4.938	0.095	233.720	44.200	49.332	4.302	1.12E-03
		Greedy	3.437	3.775	0.169	279.620	502.000	81.353	3.238	4.04E-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	87.399	29.670	4.627	–
		ACS	5.325	5.448	0.070	159.800	101.704	30.010	4.564	2.10E-02
		IMMAS	5.333	5.466	0.120	161.320	95.007	30.251	4.576	7.78E-02
1	250	GA	5.287	5.405	0.045	160.260	84.967	30.313	4.538	1.28E-03
		SA	5.307	5.395	0.057	158.260	86.947	29.822	4.545	1.67E-03
		PSO	5.309	5.426	0.107	158.600	84.881	29.875	4.548	3.87E-02
		Greedy	3.423	4.047	0.326	181.620	1506.024	53.055	3.128	4.48E-09
		THACS	5.450	5.607	0.111	176.400	77.217	32.366	4.721	–
		ACS	5.369	5.531	0.106	175.340	85.036	32.657	4.656	7.48E-02
		IMMAS	5.379	5.461	0.059	179.400	80.690	33.351	4.678	6.62E-02
2	275	GA	5.346	5.518	0.110	173.260	73.271	32.408	4.632	2.58E-02
		SA	5.169	5.394	0.130	172.060	75.163	33.288	4.494	5.53E-04
		PSO	5.257	5.427	0.137	174.000	73.712	33.098	4.567	1.18E-03
		Greedy	3.295	3.549	0.204	201.200	1225.490	61.062	3.046	1.59E-10
		THACS	5.448	5.570	0.071	191.400	67.327	35.134	4.769	–
		ACS	5.324	5.501	0.112	189.920	81.923	35.669	4.670	1.36E-02
		IMMAS	5.337	5.532	0.114	190.800	69.501	35.750	4.682	3.36E-03
3	300	GA	5.316	5.492	0.086	187.620	63.749	35.295	4.656	3.45E-03
		SA	5.233	5.486	0.152	186.200	66.116	35.582	4.588	2.41E-04
		PSO	5.263	5.329	0.039	188.260	65.600	35.770	4.618	1.77E-05
		Greedy	3.370	3.900	0.324	225.260	1157.407	66.850	3.135	5.64E-09
		THACS	5.476	5.685	0.125	208.860	60.222	38.144	4.841	–
		ACS	5.373	5.513	0.101	210.000	67.496	39.084	4.764	8.02E-03
		IMMAS	5.402	5.569	0.131	208.200	65.183	38.543	4.781	1.55E-01
4	325	GA	5.347	5.483	0.072	207.260	56.918	38.765	4.736	4.81E-03
		SA	5.223	5.397	0.093	206.220	59.291	39.483	4.636	1.28E-03
		PSO	5.252	5.472	0.119	207.680	58.053	39.545	4.662	2.36E-03
		Greedy	3.371	3.879	0.304	245.620	1131.222	72.860	3.155	2.73E-09
		THACS	5.510	5.674	0.077	222.800	53.813	40.436	4.904	–
		ACS	5.424	5.622	0.129	224.880	62.521	41.459	4.840	2.22E-02
		IMMAS	5.464	5.651	0.128	223.620	58.591	40.930	4.869	7.47E-02
5	350	GA	5.390	5.540	0.121	220.240	50.893	40.861	4.802	2.19E-02
		SA	5.209	5.440	0.124	219.180	52.843	42.076	4.656	6.22E-07
		PSO	5.359	5.499	0.134	222.120	51.302	41.452	4.782	3.08E-03
		Greedy	3.443	3.773	0.174	268.700	1008.065	78.054	3.235	1.98E-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	6.090	6.265	0.111	152.420	71.780	25.029	5.076	4.59E-03
		IMMAS	6.110	6.256	0.116	154.900	64.900	25.353	5.103	2.26E-02
1	250	GA	6.010	6.164	0.112	154.120	57.660	25.645	5.029	2.61E-03
		SA	5.950	6.091	0.126	150.560	59.060	25.306	4.968	4.38E-04
		PSO	6.008	6.165	0.114	152.200	57.940	25.332	5.018	3.01E-03
		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	52.780	27.897	5.152	–
		ACS	5.931	6.049	0.107	167.700	60.060	28.275	5.040	6.91E-03
		IMMAS	5.936	6.082	0.117	168.800	56.000	28.435	5.049	2.00E-02
2	275	GA	5.893	6.098	0.125	167.260	50.780	28.383	5.010	3.49E-03
		SA	5.823	5.965	0.107	165.100	52.800	28.354	4.950	2.55E-05
		PSO	5.866	6.010	0.119	165.220	51.820	28.164	4.982	3.22E-03
		Greedy	4.075	5.316	0.591	195.200	619.360	47.896	3.690	2.08E-06
		THACS	6.065	6.250	0.101	185.100	45.500	30.521	5.211	–
		ACS	5.919	6.102	0.078	184.200	56.460	31.119	5.100	1.94E-03
		IMMAS	5.904	6.115	0.093	183.300	51.700	31.047	5.085	2.05E-03
3	300	GA	5.863	6.012	0.098	185.660	46.000	31.666	5.063	1.57E-03
		SA	5.778	6.002	0.129	185.140	47.660	32.043	4.998	3.14E-04
		PSO	5.804	5.942	0.111	185.160	46.860	31.903	5.017	1.21E-05
		Greedy	3.529	4.558	0.410	219.000	578.700	62.051	3.266	1.14E-08
		THACS	6.073	6.243	0.105	198.700	41.560	32.718	5.268	–
		ACS	5.933	6.114	0.105	199.000	45.540	33.543	5.163	1.59E-02
		IMMAS	5.963	6.153	0.078	201.480	43.700	33.788	5.194	1.48E-02
4	325	GA	5.869	5.945	0.069	196.360	39.340	33.455	5.106	7.10E-04
		SA	5.769	5.942	0.084	195.160	38.360	33.829	5.026	1.11E-04
		PSO	5.840	5.953	0.082	197.220	39.980	33.771	5.087	3.77E-04
		Greedy	3.704	3.893	0.161	235.120	517.600	63.470	3.434	1.57E-12
		THACS	6.131	6.252	0.127	215.100	38.700	35.085	5.366	–
		ACS	5.967	6.224	0.129	216.220	43.740	36.234	5.244	2.75E-03
		IMMAS	5.995	6.243	0.121	215.400	40.760	35.927	5.263	2.17E-02
5	350	GA	5.883	6.124	0.143	213.160	37.180	36.233	5.170	8.27E-04
		SA	5.796	5.945	0.078	212.000	38.200	36.578	5.099	3.74E-06
		PSO	5.854	6.042	0.133	214.880	37.640	36.707	5.152	1.65E-04
		Greedy	3.591	4.142	0.255	257.200	482.620	71.632	3.356	1.35E-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	41.085	23.759	5.219	–
		ACS	6.214	6.401	0.108	143.800	43.275	23.143	5.110	7.55E-04
		IMMAS	6.246	6.410	0.115	145.500	42.446	23.294	5.142	7.85E-03
1	250	GA	6.122	6.325	0.099	144.160	40.414	23.546	5.050	5.52E-04
		SA	5.912	6.125	0.123	143.260	41.017	24.233	4.901	4.95E-05
		PSO	6.016	6.245	0.130	143.880	40.750	23.916	4.976	1.78E-04
		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	36.017	25.160	5.316	–
		ACS	6.253	6.455	0.138	159.400	37.966	25.493	5.228	3.53E-02
		IMMAS	6.284	6.435	0.139	163.240	36.773	25.977	5.270	6.47E-02
2	275	GA	6.191	6.351	0.099	159.260	35.653	25.725	5.183	2.75E-03
		SA	5.979	6.165	0.138	160.000	35.940	26.759	5.038	1.16E-05
		PSO	6.062	6.264	0.168	159.480	35.858	26.307	5.094	2.53E-04
		Greedy	3.484	4.936	0.682	187.900	382.263	53.932	3.188	2.03E-07
		THACS	6.299	6.410	0.099	177.300	32.936	28.149	5.349	–
		ACS	6.179	6.371	0.117	175.880	35.011	28.466	5.255	1.21E-02
		IMMAS	6.211	6.357	0.117	176.400	34.249	28.402	5.281	3.30E-02
3	300	GA	6.087	6.294	0.086	175.260	32.514	28.793	5.186	3.14E-04
		SA	5.877	6.105	0.123	174.200	33.060	29.640	5.029	1.61E-06
		PSO	5.960	6.156	0.144	175.000	32.795	29.362	5.093	1.18E-05
		Greedy	3.691	5.092	0.692	210.320	333.778	56.982	3.393	5.34E-07
		THACS	6.325	6.457	0.115	192.100	31.483	30.372	5.431	–
		ACS	6.226	6.439	0.129	189.400	33.485	30.421	5.347	2.12E-03
		IMMAS	6.253	6.435	0.124	191.100	32.631	30.560	5.374	9.14E-03
4	325	GA	6.108	6.245	0.072	188.440	30.883	30.854	5.256	1.71E-04
		SA	5.900	6.045	0.105	187.240	31.309	31.734	5.097	2.26E-05
		PSO	6.002	6.125	0.108	189.600	31.230	31.589	5.182	8.04E-05
		Greedy	3.626	4.325	0.392	227.300	319.285	62.679	3.359	5.67E-09
		THACS	6.217	6.431	0.102	211.400	25.403	34.001	5.420	–
		ACS	6.121	6.345	0.115	206.300	26.428	33.702	5.330	4.19E-02
		IMMAS	6.159	6.342	0.126	209.400	26.385	33.997	5.370	5.07E-02
5	350	GA	5.993	6.164	0.112	208.160	25.143	34.731	5.239	2.18E-03
		SA	5.841	6.095	0.114	209.820	25.549	35.920	5.128	2.56E-05
		PSO	5.928	6.137	0.152	210.120	25.469	35.446	5.195	9.89E-05
		Greedy	3.512	4.576	0.528	249.600	267.953	71.065	3.281	2.00E-07

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	6.315	6.517	0.111	131.960	16.560	20.896	5.096	9.52E-04
		IMMAS	6.347	6.523	0.117	131.800	16.140	20.764	5.116	8.90E-03
1	250	GA	6.314	6.523	0.106	131.920	15.800	20.892	5.095	3.41E-02
		SA	6.016	6.212	0.115	130.200	15.920	21.644	4.887	4.26E-05
		PSO	6.122	6.375	0.141	130.980	15.820	21.393	4.963	2.85E-04
		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	6.169	6.273	0.093	145.220	14.560	23.541	5.088	4.18E-03
		IMMAS	6.198	6.342	0.104	147.100	14.460	23.733	5.120	8.42E-03
2	275	GA	6.076	6.290	0.086	146.760	13.020	24.152	5.034	2.28E-04
		SA	5.898	6.113	0.135	146.460	13.720	24.832	4.909	3.57E-06
		PSO	5.940	6.151	0.152	147.020	13.040	24.752	4.941	6.95E-05
		Greedy	4.194	4.874	0.697	158.120	164.880	37.703	3.703	3.20E-06
		THACS	6.210	6.331	0.080	159.260	13.180	25.647	5.197	–
		ACS	6.111	6.247	0.096	159.660	13.760	26.125	5.130	1.85E-02
		IMMAS	6.149	6.325	0.113	161.120	13.420	26.205	5.163	6.91E-02
3	300	GA	5.962	6.059	0.099	160.220	11.820	26.874	5.027	3.83E-04
		SA	5.817	6.051	0.125	159.420	12.980	27.406	4.919	2.93E-06
		PSO	5.913	6.059	0.132	160.100	12.080	27.074	4.992	1.05E-04
		Greedy	3.512	4.576	0.528	184.700	141.540	52.587	3.207	2.70E-07
		THACS	6.428	6.530	0.095	171.400	12.080	26.666	5.413	–
		ACS	6.347	6.531	0.119	171.380	14.480	27.004	5.355	4.78E-02
		IMMAS	6.366	6.510	0.111	172.440	12.400	27.087	5.374	1.33E-01
4	325	GA	6.316	6.538	0.109	172.360	11.280	27.291	5.338	4.61E-02
		SA	6.027	6.331	0.141	170.060	12.220	28.214	5.120	1.46E-05
		PSO	6.146	6.413	0.133	171.620	11.800	27.922	5.213	7.30E-04
		Greedy	4.181	4.671	0.467	204.260	127.460	48.852	3.793	4.22E-08
		THACS	6.383	6.527	0.099	187.800	11.000	29.420	5.456	–
		ACS	6.277	6.493	0.140	185.440	11.440	29.545	5.368	2.96E-02
		IMMAS	6.290	6.495	0.148	186.620	11.240	29.669	5.383	6.14E-02
5	350	GA	6.204	6.425	0.122	184.260	9.800	29.701	5.310	6.30E-03
		SA	6.001	6.347	0.177	182.200	10.840	30.361	5.153	1.32E-04
		PSO	6.073	6.275	0.163	184.400	10.020	30.362	5.215	4.61E-04
		Greedy	4.078	5.541	0.760	222.060	115.940	54.447	3.735	1.52E-06