

Online Supplement to “A Simulated Annealing Enhancement of the Best-Fit Heuristic for the Orthogonal Stock Cutting Problem”

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A. 1. Metaheuristic Parameters (see section 2.1 of the main article)

We hybridise the bottom-left-fill heuristic with metaheuristic search techniques by employing the metaheuristics to produce orderings and then these orderings are ‘decoded’ into a solution and evaluated through the use of the bottom-left-fill heuristic. In order to obtain input sequences we assign a numerical identification to each rectangle. Therefore a sequence such as: 4,2,5,1,3 describes the solution obtained by the bottom-left-fill heuristic packing the 4th rectangle first, 2nd rectangle second, and so forth. In the problem studied in this paper, we allow rotations of 90° and encode rectangle orientation by using a boolean flag for each rectangle within a solution sequence. We investigate and evaluate three metaheuristic enhancements: tabu search, simulated annealing and genetic algorithms. Due to the experiments of Hopper and Turton (2001) into different input orderings, we seed our metaheuristic approaches using the decreasing height sequence.

Tabu Search

We implemented a tabu search algorithm that uses a neighbourhood size of 5 and a tabu list of 1,000 solutions. A suitable value for the neighbourhood size was found by preliminary experiments and the tabu list was set to a large size to discourage revisiting previously seen solutions. A neighbour is defined as a swap of two randomly selected rectangles within the solution sequence. During the swap, we also rotate the first randomly selected rectangle with a probability of 50%.

The process is summarised as follows: create five neighbours of the current solution that are not found within the tabu list, evaluate these neighbours using the bottom-left-fill heuristic and add them to the tabu list. The current solution becomes the neighbour with the best evaluation and the process repeats. At the end of the search the best solution seen is returned. For our experiments we initialise the tabu search with an initial solution containing rectangles sorted by decreasing height.

Simulated Annealing

Our simulated annealing cooling scheme is reliant on the progress of the search. We accept worse solutions with a probability of: $P(\text{accept}) = 1 - (\Delta E/T)$ where ΔE is the change in solution evaluation quality from the current solution and T is the temperature. Initially, we set $T = 3$. This value was established after a series of experiments. Better solutions are always accepted. The cooling operates after every iteration based on whether we accept a neighbouring solution. If we accept, then we geometrically cool the temperature using a multiplier of 0.999. However, if the neighbouring solution is not accepted then we heat the temperature by a multiplier of 1.0001. These values were chosen through initial testing and have the effect of cooling quickly if we are accepting many solutions (high temperature) and cooling more slowly when fewer solutions are accepted. As the search progresses, the temperature may become stable due to the rejection of more solutions thus generating a more frequent heating process. However, when the search moves to explore a different area of the search space the temperature may increase or decrease to reflect the acceptance occurring within this new region. We find a neighbouring solution by a random swap and an orientation flip with a probability of 50% of the first random rectangle chosen. The process is summarised as follows: find one neighbour of the current solution, evaluate the neighbour using bottom-left-fill and find the change in solution quality. If we accept the neighbour, we store it as the current solution and cool. If rejected, we keep the current solution and heat. Once again, the initial solution supplied is that of the input rectangles sorted by decreasing height and the best solution seen during the

search is returned at the end. Simulated annealing techniques have also been applied to the orthogonal stock cutting problem in Lai and Chan (1996).

Genetic Algorithm

The genetic algorithm we employed was created using a population size of 30 individuals where each individual is a sequence of rectangles. Initially we fill the population with randomly generated orderings except one individual that is seeded with a height decreasing sorted ordering. All of the individuals are decoded and evaluated using the bottom-left-fill heuristic. We improve the population by breeding pairs of individuals to produce a new population by favouring better solutions to act as parents. The population is sorted by evaluation order which goes from best to worst and then we use linearly normalised roulette wheel selection to choose parents so that better solutions are favoured but worse solutions may still have a small chance of being selected. These parent solutions then undergo crossover with a probability of 0.6. We use two crossover techniques: i) partially-matched crossover and ii) order-based crossover with each crossover method having an equal chance of being chosen when breeding. Then we use two mutation operators each with a probability of 0.03. The first mutation operator randomly swaps two rectangles within an ordering and the second flips the orientation of a rectangle. The values for population size, crossover, mutation, and elitism have been chosen based on initial testing. The process is summarised as follows: evaluate every individual in the population using bottom-left-fill, keep the five best individuals, fill remaining elements by selection and crossover and apply mutation to the new population. The best solution encountered during the process is returned when the genetic algorithm is terminated. Other orthogonal approaches that utilise genetic algorithms can be found in Kroger (1995), Falkenauer (1996), Jakobs (1996), Ramesh Babu and Ramesh Babu (1999), Hopper and Turton (1999) and Valenzuela and Wang (2001).

A. 2. Value of the m Variable (see section 2.3 of the main article)

The first experiments varied the value of the phase switch variable, m , in order to test our assumption that a value in the range $0 < m < 50$ should produce better results. We used the following values: 0, 5, 10, 20, 30, 40, 50, 60, and 70 on a subset of the test problems using tabu search, simulated annealing, and genetic algorithms. We have chosen four different data sets to ensure a range of problems sizes, sheet widths, and rectangle sizes. For each test, we allow each metaheuristic method a 60 second duration and report the average solution evaluation of 10 runs. Table A displays the results for each method where the best average is shown in bold type. From these results, the best setting for m is consistently between 20 and 40 for these sets of data and a 60 second run. The average result returned over the range of m values is shown in the graphs of figure A. At lower values, the metaheuristics are not given enough shapes to be able to make significant improvements on the best-fit result. Larger values of m seem to impair the metaheuristic's ability because of the larger search spaces but may produce better solutions if a greater execution time were allowed (see sections 4.2 and 4.3 of the main article).

Problem	Optimal Evaluation	m Value	Average Evaluation (10 runs)					
			Tabu		SA		GA	
			Eval	% Over Opt	Eval	% Over Opt	Eval	% Over Opt
Hopper C6P1 (97 shapes)	240	0	244.01	1.67	244.01	1.67	244.01	1.67
		5	243.98	1.66	243.98	1.66	243.98	1.66
		10	243.88	1.62	243.88	1.62	243.88	1.62
		20	242.70	1.13	242.69	1.12	242.73	1.14
		30	242.66	1.11	242.71	1.13	243.15	1.31
		40	243.03	1.26	243.47	1.45	244.08	1.70
		50	243.57	1.49	244.05	1.69	244.95	2.06
		70	243.25	1.35	244.54	1.89	245.95	2.48
Hopper C7P1 (196 shapes)	480	0	489.12	1.90	489.12	1.90	489.12	1.90
		5	489.12	1.90	489.12	1.90	489.12	1.90
		10	489.71	2.02	489.71	2.02	489.71	2.02
		20	487.72	1.61	487.65	1.59	487.71	1.61
		30	487.70	1.60	487.74	1.61	488.11	1.69
		40	487.59	1.58	487.69	1.60	488.50	1.77
		50	488.10	1.69	488.58	1.79	488.26	1.72
		70	487.63	1.59	488.89	1.85	489.29	1.93
Valenzuela Nice P4 (200 shapes)	200	0	209.63	4.82	209.63	4.82	209.63	4.82
		5	209.54	4.77	209.54	4.77	209.54	4.77
		10	209.11	4.55	209.11	4.55	209.11	4.55
		20	207.50	3.75	207.14	3.57	207.64	3.82
		30	207.48	3.74	207.38	3.69	208.07	4.03
		40	207.81	3.91	208.21	4.10	208.39	4.19
		50	208.01	4.00	208.51	4.26	208.94	4.47
		70	208.52	4.26	209.80	4.90	209.41	4.71
NewData MT2 (150 shapes)	Optimal Not Known (Lower Bound Eval =1521.8)	0	1557.27	2.33	1557.27	2.33	1557.27	2.33
		5	1552.70	2.03	1552.70	2.03	1552.70	2.03
		10	1552.77	2.03	1552.77	2.03	1552.77	2.03
		20	1553.47	2.08	1549.90	1.85	1553.30	2.07
		30	1544.01	1.46	1544.06	1.46	1545.14	1.53
		40	1546.37	1.61	1544.71	1.51	1548.27	1.74
		50	1548.63	1.76	1547.78	1.71	1556.38	2.27
		70	1548.67	1.77	1549.93	1.85	1557.56	2.35
		70	1549.80	1.84	1552.92	2.04	1561.85	2.63

Table A. Varying the phase switch parameter, m

Other problem specific factors may also be important such as the sheet width, rectangle sizes, and more importantly the quantity of wasted space that is inherited from the result given by the best-fit heuristic. Due to these results we fix the value of m at 30 for our experiments on the literature benchmark problems in section 4.1 of the main article.

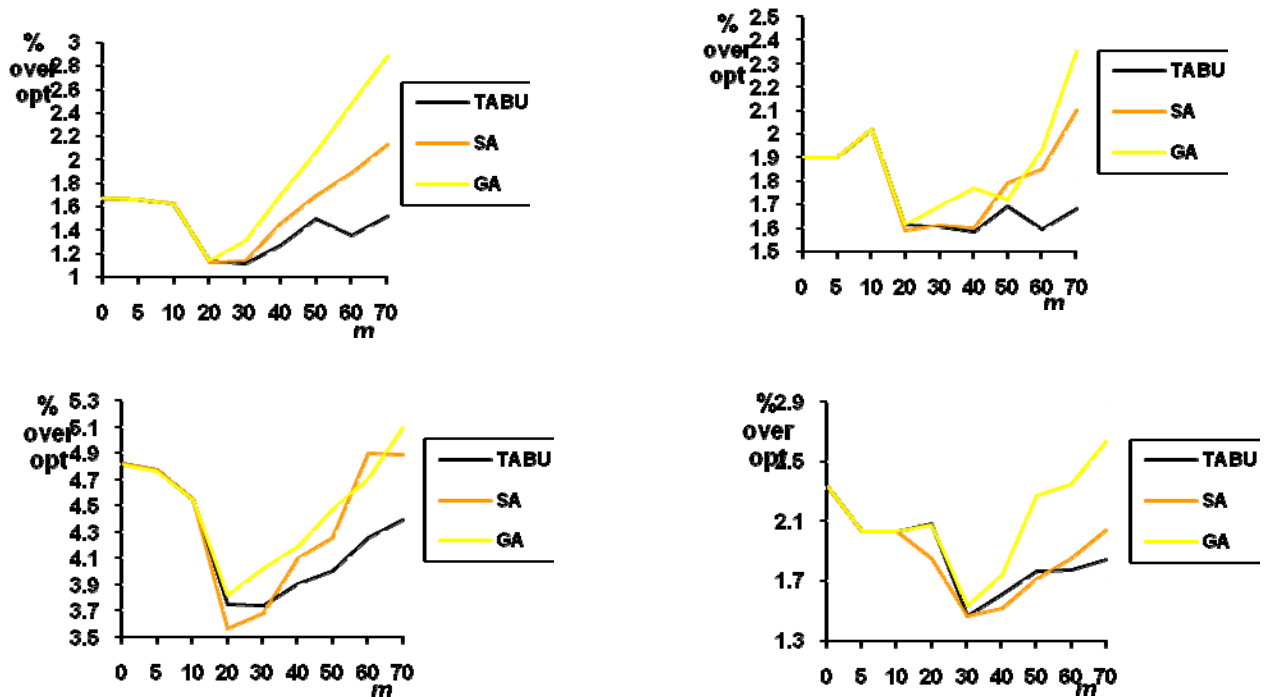


Figure A. Comparison graphs of the percentage above optimal when varying phase switch, m

A. 3. Full Experiments on Literature Benchmark Problems (see section 4.1 of the main article)

Data Set	Cat.	Prob	No. Shapes	Opt Height	Opt Eval	Best-Fit + Metaheuristic Bottom-Left-Fill														Best Sol. % Over Optimal				
						Best-Fit			Tabu Search				Simulated Annealing				Genetic Algorithms				BF	BF + Tabu	BF + SA	BF + GA
						Solution Obtained			Best Solution			Avr. Eval	Best Solution			Avr. Eval	Best Solution			Avr. Eval				
						Height	Area	Eval.	Height	Area	Eval.		Height	Area	Eval.		Height	Area	Eval.		Height	Area	Eval.	
Hopper and Turton (2001)	C1	P1	16	20	40	21	410	41.50	20	400	40.00	40.71	20	400	40.00	40.00	20	400	40.00	40.60	3.75	0.00	0.00	0.00
		P2	17	20	40	22	400	42.00	21	400	41.00	41.02	20	400	40.00	40.50	21	400	41.00	41.00	5.00	2.50	0.00	2.50
		P3	16	20	40	24	400	44.00	20	400	40.00	40.61	20	400	40.00	40.00	20	400	40.00	40.70	10.00	0.00	0.00	0.00
	C2	P1	25	15	30	16	609	31.23	16	600	31.00	31.02	16	600	31.00	31.00	16	600	31.00	31.02	4.08	3.33	3.33	3.33
		P2	25	15	30	16	600	31.00	16	600	31.00	31.01	16	600	31.00	31.00	16	600	31.00	31.00	3.33	3.33	3.33	3.33
		P3	25	15	30	16	604	31.10	16	600	31.00	31.00	16	600	31.00	31.00	16	600	31.00	31.01	3.67	3.33	3.33	3.33
	C3	P1	28	30	60	32	1814	62.23	31	1810	61.17	61.95	31	1818	61.30	61.59	31	1823	61.38	61.98	3.72	1.94	2.17	2.31
		P2	29	30	60	34	1801	64.02	32	1800	62.00	62.06	31	1814	61.23	61.72	32	1809	62.15	62.49	6.69	3.33	2.06	3.58
		P3	28	30	60	33	1806	63.10	31	1826	61.43	61.98	31	1808	61.13	61.46	31	1826	61.43	62.15	5.17	2.39	1.89	2.39
	C4	P1	49	60	120	63	3623	123.38	62	3622	122.37	122.51	61	3621	121.35	122.08	62	3623	122.38	122.75	2.82	1.97	1.13	1.99
		P2	49	60	120	62	3621	122.35	62	3617	122.28	122.46	61	3618	121.30	122.20	62	3624	122.40	122.90	1.96	1.90	1.08	2.00
		P3	49	60	120	62	3621	122.35	61	3616	121.27	122.01	61	3608	121.13	121.53	62	3610	122.17	122.34	1.96	1.06	0.94	1.81
	C5	P1	72	90	180	93	5444	183.73	92	5415	182.25	182.40	91	5419	181.32	182.33	92	5432	182.53	182.74	2.07	1.25	0.73	1.41
		P2	73	90	180	92	5413	182.22	92	5414	182.23	182.52	91	5410	181.17	182.18	92	5422	182.37	182.94	1.23	1.24	0.65	1.31
		P3	72	90	180	93	5469	184.15	92	5437	182.62	182.72	92	5438	182.63	182.79	92	5446	182.77	182.91	2.31	1.45	1.46	1.54
	C6	P1	97	120	240	123	9681	244.01	122	9648	242.60	242.75	122	9652	242.65	242.80	122	9678	242.98	243.33	1.67	1.08	1.10	1.24
		P2	97	120	240	122	9632	242.40	121	9632	241.40	241.93	121	9632	241.40	241.42	121	9634	241.43	241.84	1.00	0.58	0.58	0.59
		P3	97	120	240	124	9664	244.80	122	9645	242.56	242.60	122	9647	242.59	242.63	122	9649	242.61	242.68	2.00	1.07	1.08	1.09
	C7	P1	196	240	480	246	38899	489.12	245	38818	487.61	487.70	244	38839	486.74	487.75	245	38855	487.84	488.47	1.90	1.59	1.40	1.63
		P2	197	240	480	244	38715	485.97	244	38663	485.64	485.73	244	38667	485.67	487.02	244	38699	485.87	486.70	1.24	1.18	1.18	1.22
		P3	196	240	480	245	38864	487.90	245	38853	487.83	488.74	245	38850	487.81	488.17	245	38858	487.86	488.75	1.65	1.63	1.63	1.64
Valenzuela and Wang (2001)	Nice	P1	25	100	200	107.99	10267.7	210.67	106.93	10242.0	209.35	210.70	104.024	10049.5	204.52	207.25	108.42	10190.1	210.33	211.30	5.33	4.67	2.26	5.16
		P2	50	100	200	109.69	10423.8	213.93	106.64	10388.5	210.53	211.10	104.413	10221.0	206.62	208.24	106.87	10409.4	210.97	212.59	6.97	5.26	3.31	5.48
		P3	100	100	200	107.92	10273.2	210.65	105.23	10276.1	207.99	208.45	105.04	10335.0	208.39	208.69	105.94	10336.3	209.31	211.11	5.33	4.00	4.19	4.65
		P4	200	100	200	106.89	10274.1	209.63	104.21	10288.1	207.09	207.39	104.743	10266.7	207.41	207.59	104.89	10307.8	207.97	208.90	4.82	3.55	3.71	3.98
		P5	500	100	200	103.39	10195.4	205.35	103.18	10193.4	205.11	205.89	103.507	10199.3	205.50	206.01	103.48	10197.7	205.46	206.25	2.67	2.56	2.75	2.73
		P6	1000	100	200	103.84	10267.6	206.52	103.80	10268.2	206.48	206.73	103.756	10269.8	206.45	206.72	103.80	10271.7	206.52	207.02	3.26	3.24	3.23	3.26
	Path	P1	25	100	200	110.19	10253.7	212.73	105.82	10345.9	209.28	209.87	103.09	10038.3	203.47	207.21	108.17	10250.6	210.68	212.88	6.36	4.64	1.74	5.34
		P2	50	100	200	113.65	10285.1	216.50	103.66	10080.2	204.46	204.79	103.4	10060.9	204.01	204.59	103.66	10085.0	204.51	204.92	8.25	2.23	2.00	2.26
		P3	100	100	200	106.75	10180.6	208.56	104.73	10084.9	205.58	206.47	103.037	10125.7	204.29	205.92	104.37	10217.6	206.55	207.52	4.28	2.79	2.15	3.27
		P4	200	100	200	104.12	10157.4	205.70	103.53	10058.3	204.11	204.51	103.419	10116.1	204.58	204.63	103.85	10068.3	204.53	204.73	2.85	2.06	2.29	2.26
		P5	500	100	200	103.81	10189.0	205.70	103.15	10210.4	205.25	205.38	103.479	10200.1	205.48	205.60	103.41	10209.0	205.50	206.22	2.85	2.63	2.74	2.75
		P6	1000	100	200	103.09	10173.0	204.82	102.80	10162.1	204.42	204.69	102.867	10165.0	204.52	204.68	102.90	10169.1	204.59	205.11	2.41	2.21	2.26	2.30
Ramesh Babu	P1	50	375	750	400	378125	778.13	400	367875	767.88	767.88	400	367875	767.88	767.88	400	367875	767.88	767.96	3.75	2.38	2.38	2.38	
Burke, Kendall, Whitwell (2004)	N1	10	40	80	45	1800	90.00	40	1600	80.00	80.00	40	1600	80.00	80.00	40	1600	80.00	80.00	12.50	0.00	0.00	0.00	
	N2	20	50	100	53	1542	104.40	50	1500	100.00	101.68	50	1500	100.00	101.68	50	1500	100.00	102.01	4.40	0.00	0.00	0.00	
	N3	30	50	100	52	1525	102.83	51	1503	101.10	101.51	51	1500	101.00	101.32	52	1508	102.27	102.13	2.83	1.10	1.00	2.27	
	N4	40	80	160	86	6547	167.84	83	6437	163.46	163.70	82	6455	162.69	163.50	83	6443	163.54	163.82	4.90	2.16	1.68	2.21	
	N5	50	100	200	105	10154	206.54	103	10124	204.24	204.34	103	10122	204.22	204.29	104	10112	205.12	205.48	3.27	2.12	2.11	2.56	
	N6	60	100	200	102	5061	203.22	102	5047	202.94	202.95	102	5047	202.94	202.94	102	5047	202.94	202.97	1.61	1.47	1.47	1.47	
	N7	70	100	200	108	8230	210.88	105	8094	206.18	206.26	104	8117	205.46	205.97	104	8113	205.41	206.30	5.44	3.09	2.73	2.71	
	N8	80	80	160	83	8116	164.16	82	8097	162.97	162.97	82	8097	162.97	162.97	82	8097	162.97	162.97	2.60	1.86	1.86	1.86	
	N9	100	150	300	152	7556	303.12	152	7544	302.88	317.88	152	7544	302.88	317.88	152	7544	302.88	317.92	1.04	0.96	0.96	0.96	
	N10	200	150	300	152	10567	302.96	152	10570	303.00	303.00	152	10570	303.00	303.00	152	10570	303.00	303.00	0.99	1.00	1.00	1.00	
	N11	300	150	300	153	10586	304.23	153	10586	304.23	304.23	153	10586	304.23	304.23	153	10586	304.23	304.23	1.41	1.41	1.41	1.41	
	N12	500	300	600	306	30431	610.31	306	30431	610.31	610.31	306	30431	610.31	610.31	306	30431	610.31	610.31	1.72	1.72	1.72	1.72	
	N13	3152	960	1920	964	615637	1925.9	964	615637	1925.9	1925.9	964	615629	1925.9										

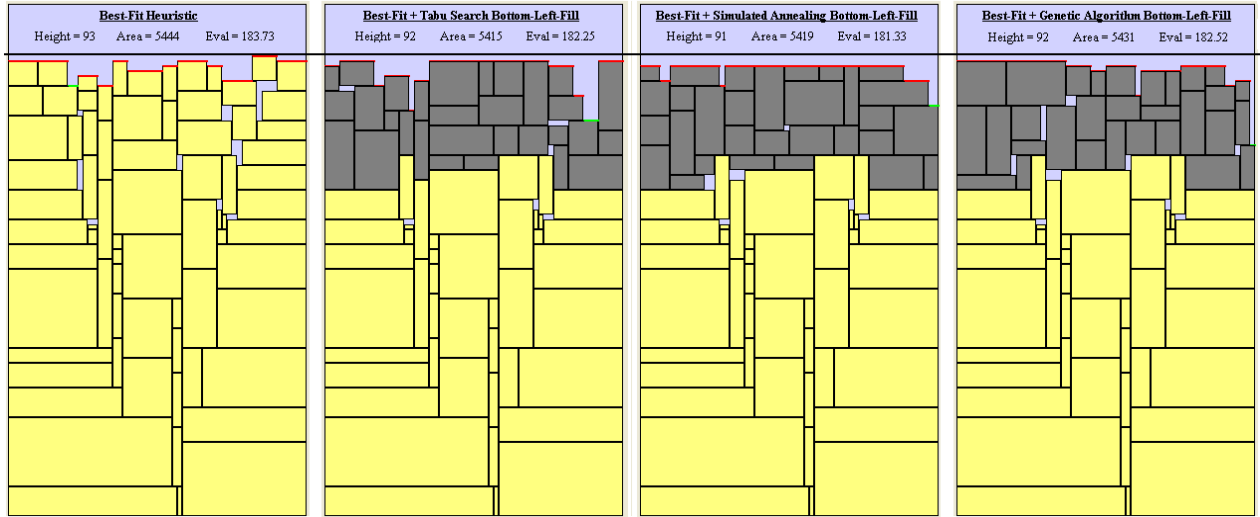


Figure B. Solutions obtained by solitary best-fit heuristic, best-fit with tabu bottom-left-fill, best-fit with simulated annealing bottom-left-fill, and best-fit with genetic algorithm bottom-left-fill on problem C5P1.

A. 4. Full Extended Experiments on Literature Benchmark Problems (see section 4.2 of the main article)

Test Data Set	Size	Best-Fit Heuristic			Best-Fit + Metaheuristic Bottom-Left-Fill ($m = 150$, 5 min run)											
		Best Solution			Tabu Search				Simulated Annealing				Genetic Algorithm			
		Height	Area	Eval	Height	Area	Eval	Avr. Eval	Height	Area	Eval	Avr. Eval	Height	Area	Eval	Avr. Eval
C2P2	25	16	600	31.00	15	600	30.00	30.90	15	600	30.00	30.80	16	600	31.00	31.00
N10	200	152	10567	302.96	151	10530	301.43	302.07	152	10551	302.73	302.77	152	10590	303.29	303.36
N11	300	153	10586	304.23	152	10585	303.21	303.23	152	10581	303.16	303.20	152	10589	303.27	303.30
N12	500	306	30431	610.31	304	30281	606.81	606.86	304	30288	606.88	607.00	304	30291	606.91	607.20
N13	3152	964	615637	1925.9	964	615637	1925.9	1925.9	964	615637	1925.9	1925.9	964	615637	1925.9	1925.9

Table C. Results of extended experiments using $m = 150$ and run times of 5 minutes

A. 5. Full Experiments on New Test Problems (see section 4.3 of the main article)

Data Set	No. of Shapes	Phase Switch m	Best-Fit + Metaheuristic Bottom-Left-Fill											
			Tabu Search				Simulated Annealing				Genetic Algorithms			
			Best Solution			Avr. Eval	Best Solution			Avr. Eval	Best Solution			Avr. Eval
			Height	Area	Eval.		Height	Area	Eval.		Height	Area	Eval.	
MT1	100	30	505.05	198672.2	1001.73	1002.52	503.08	198729.6	999.90	1001.28	506.10	199240.2	1004.20	1004.80
		50	502.50	198926.4	999.82	1001.97	501.38	199053.4	999.01	1001.31	508.30	200137.3	1008.64	1009.30
		100	504.30	199886.0	1004.02	1007.24	504.50	199437.8	1003.09	1006.92	516.40	200379.8	1017.35	1017.35
MT2	150	30	773.70	231121.1	1544.10	1545.99	775.20	231146.9	1545.69	1549.14	776.50	231554.6	1548.35	1549.88
		50	775.00	231083.9	1545.28	1548.12	774.00	230946.8	1543.82	1548.40	783.20	231162.7	1553.74	1555.70
		100	783.40	232513.5	1558.45	1562.37	781.50	232762.1	1557.37	1560.56	798.50	235898.6	1584.83	1592.19
MT3	200	30	795.70	314251.7	1581.33	1583.14	793.20	313991.5	1578.18	1582.21	798.90	314288.2	1584.62	1586.73
		50	795.80	314391.0	1581.78	1583.07	794.00	313337.4	1577.34	1581.23	803.60	314885.5	1590.81	1594.01
		100	791.00	313942.5	1575.86	1578.53	793.00	313505.3	1576.76	1580.67	801.70	316915.2	1593.99	1594.43
MT4	300	30	1201.00	714758.0	2392.26	2393.45	1199.00	714773.0	2390.29	2390.97	1201.00	715017.0	2392.70	2393.43
		50	1199.00	714822.0	2390.37	2392.27	1200.00	715022.0	2391.70	2392.79	1202.00	715905.0	2395.18	2396.07
		100	1208.00	717337.0	2403.56	2411.83	1211.00	720719.0	2412.20	2414.83	1220.00	722800.0	2424.67	2424.67
MT5	500	30	1286.60	1020366.1	2562.06	2564.07	1286.60	1020656.6	2562.42	2563.63	1290.70	1021301.9	2567.33	2568.57
		50	1283.40	1020694.3	2559.27	2561.12	1283.10	1021290.7	2559.71	2563.03	1288.60	1022191.4	2566.34	2568.91
		100	1286.20	1021081.4	2562.55	2564.61	1285.00	1022023.3	2562.53	2564.48	1289.90	1023482.0	2569.25	2569.25
MT6	100	30	513.83	203341.3	1022.18	1023.74	512.25	203351.0	1020.63	1022.84	516.03	203903.0	1025.79	1027.58
		50	516.81	203893.8	1026.54	1028.87	518.06	204174.6	1028.49	1029.95	518.68	204745.5	1030.55	1032.03
		100	526.54	206505.4	1042.80	1048.83	530.39	206802.9	1047.39	1050.49	542.82	209445.3	1066.43	1066.68
MT7	150	30	508.34	201766.2	1012.75	1012.87	508.16	201621.9	1012.22	1012.67	510.05	201876.6	1014.74	1015.14
		50	509.37	201756.8	1013.76	1014.59	509.29	202175.7	1014.73	1015.69	512.98	202053.9	1018.11	1018.76
		100	511.99	202735.2	1018.83	1019.77	514.16	202695.8	1020.90	1022.02	516.50	203308.2	1024.77	1024.77
MT8	200	30	819.02	406547.5	1632.12	1632.64	818.10	406701.3	1631.50	1632.51	820.96	407041.2	1635.04	1635.34
		50	821.99	406758.8	1635.51	1637.07	821.05	406762.7	1634.57	1635.83	825.00	407762.5	1640.53	1641.29
		100	825.45	407336.5	1640.12	1642.73	823.86	406911.6	1637.69	1642.60	830.75	409210.7	1649.17	1650.55
MT9	300	30	816.18	485304.1	1625.02	1625.52	815.44	485287.6	1624.26	1624.85	817.60	485334.1	1626.49	1627.07
		50	816.41	485611.2	1625.77	1628.11	816.41	485544.2	1625.65	1627.76	820.16	485996.8	1630.16	1631.09
		100	896.13	485051.5	1704.55	1705.21	896.13	487239.4	1708.19	1709.21	823.74	489353.5	1639.33	1643.10
MT10	500	30	1515.78	906963.9	3027.38	3028.89	1516.00	906931.1	3027.55	3028.31	1517.75	907106.3	3029.59	3030.54
		50	1517.34	906915.1	3028.87	3030.13	1520.56	907169.7	3032.51	3032.99	1521.41	907982.3	3034.71	3035.82
		100	1524.82	908585.9	3039.13	3040.60	1526.27	908840.3	3041.00	3042.56	1530.77	910407.6	3048.12	3048.77

Table D. Best and average results using phase two durations of 60 seconds on the new benchmark problems

Data Set	No. of Shapes	Phase Switch m	Best-Fit + Metaheuristic Bottom-Left-Fill											
			Tabu Search				Simulated Annealing				Genetic Algorithms			
			Best Solution			Avr. Eval	Best Solution			Avr. Eval	Best Solution			Avr. Eval
			Height	Area	Eval.		Height	Area	Eval.		Height	Area	Eval.	
MT1	100	30	502.78	198569.3	999.20	1000.36	502.78	198626.9	999.34	1001.36	502.78	198830.6	999.85	1002.09
		50	501.38	198663.1	998.04	1000.49	502.50	199153.5	1000.38	1001.49	505.68	199635.2	1004.77	1006.24
		100	505.50	199195.6	1003.49	1006.93	504.50	199024.8	1002.06	1004.70	513.00	200670.3	1014.68	1016.82
MT2	150	30	773.70	231121.1	1544.10	1544.60	773.70	231126.6	1544.12	1544.80	774.00	231287.3	1544.96	1545.82
		50	774.00	230771.8	1543.24	1545.41	773.20	230840.4	1542.67	1545.88	782.30	231121.1	1552.70	1553.47
		100	782.40	232019.1	1555.80	1560.46	780.90	231832.8	1553.68	1558.23	796.70	235685.0	1582.32	1587.04
MT3	200	30	795.10	313719.0	1579.40	1580.43	793.00	313508.1	1576.77	1579.05	798.90	313646.3	1583.02	1585.10
		50	796.50	313715.2	1580.79	1582.78	796.00	313531.9	1579.83	1582.36	799.60	315657.6	1588.74	1590.43
		100	790.70	313718.7	1575.00	1576.29	790.60	312996.5	1573.09	1578.56	802.80	314891.6	1590.03	1593.11
MT4	300	30	1199.00	714827.0	2390.38	2391.88	1198.00	715312.0	2390.19	2390.45	1199.00	714839.0	2390.40	2390.78
		50	1198.00	714600.0	2389.00	2390.13	1197.00	714443.0	2387.74	2390.25	1200.00	715764.0	2392.94	2394.92
		100	1199.00	715191.0	2390.99	2392.19	1198.00	715015.0	2389.69	2392.50	1205.00	718542.0	2402.57	2403.67
MT5	500	30	1286.60	1020264.6	2561.93	2562.72	1285.60	1020681.0	2561.45	2561.83	1289.50	1020601.9	2565.25	2566.71
		50	1282.50	1020156.8	2557.70	2558.95	1283.20	1020722.6	2559.10	2559.75	1288.80	1021177.9	2565.27	2566.14
		100	1284.10	1021141.7	2560.53	2561.91	1283.40	1021242.7	2559.95	2562.39	1289.90	1023482.0	2569.25	2569.25
MT6	100	30	515.03	203354.7	1023.41	1023.76	512.93	203303.9	1021.19	1022.29	514.46	203798.8	1023.96	1025.59
		50	517.43	204089.1	1027.66	1028.71	518.07	204032.7	1028.15	1029.32	515.85	204121.6	1026.15	1029.95
		100	524.08	206168.9	1039.50	1046.21	527.48	206714.3	1044.27	1047.22	533.90	209937.2	1058.74	1063.47
MT7	150	30	508.05	201628.7	1012.12	1012.61	507.19	201631.8	1011.27	1011.75	508.84	201698.2	1013.09	1013.78
		50	508.77	201837.4	1013.36	1014.23	508.56	201864.1	1013.22	1014.55	511.86	202116.2	1017.15	1017.56
		100	511.39	202443.2	1017.50	1018.40	512.02	203152.6	1019.91	1021.52	516.59	202982.6	1024.05	1024.58
MT8	200	30	818.73	406615.6	1631.96	1632.11	817.93	406622.6	1631.18	1631.53	819.74	406706.7	1633.16	1633.80
		50	819.76	406629.7	1633.02	1634.14	818.11	406667.9	1631.45	1633.72	823.59	407370.1	1638.33	1639.70
		100	820.62	407242.2	1635.10	1637.84	823.91	407206.7	1638.32	1640.44	829.48	408452.6	1646.39	1647.62
MT9	300	30	815.00	485178.9	1623.63	1624.08	814.67	485194.4	1623.32	1623.69	816.00	485144.7	1624.58	1625.77
		50	815.81	485471.6	1624.93	1626.19	814.21	485310.4	1623.07	1626.03	817.52	486130.0	1627.74	1629.06
		100	896.13	484926.6	1704.34	1704.98	820.84	485492.0	1629.99	1676.41	824.47	488191.5	1638.13	1640.62
MT10	500	30	1515.76	906799.0	3027.09	3027.48	1514.95	906697.6	3026.11	3026.62	1517.71	906998.5	3029.37	3029.85
		50	1516.68	906829.1	3028.07	3029.48	1517.93	907245.6	3030.01	3030.71	1520.99	907669.6	3033.78	3034.81
		100	1521.59	908957.4	3036.52	3037.49	1523.89	909188.6	3039.21	3040.59	1527.53	910011.8	3044.21	3045.48

Table E. Best and average results using phase two durations of 300 seconds on the new benchmark problems

Data Set	No. of Shapes	Phase Switch m	Best-Fit + Metaheuristic Bottom-Left-Fill											
			Tabu Search				Simulated Annealing				Genetic Algorithms			
			Best Solution			Avr. Eval	Best Solution			Avr. Eval	Best Solution			Avr. Eval
			Height	Area	Eval.	Eval	Height	Area	Eval.	Eval	Height	Area	Eval.	Eval
MT1	100	30	503.08	198616.3	999.62	1000.61	503.08	198574.8	999.51	1000.79	505.80	198630.2	1002.38	1002.93
		50	502.60	198995.1	1000.09	1001.58	502.50	198559.3	998.90	999.85	504.08	199835.3	1003.67	1005.70
		100	504.78	199031.6	1002.36	1007.23	502.88	199352.5	1001.26	1002.63	516.40	200379.8	1017.35	1017.35
MT2	150	30	774.00	231117.6	1544.39	1544.46	774.00	231059.3	1544.20	1544.50	774.00	231126.6	1544.42	1546.39
		50	774.30	230803.5	1543.65	1545.86	772.80	230876.5	1542.39	1545.30	779.10	231039.2	1549.23	1551.19
		100	781.00	232070.6	1554.57	1558.70	779.70	232071.8	1553.27	1557.91	796.10	236024.1	1582.85	1588.56
MT3	200	30	792.60	313922.3	1577.41	1579.66	794.10	313836.8	1578.69	1579.80	797.40	313929.2	1582.22	1584.12
		50	797.30	313759.2	1581.70	1582.84	794.00	313368.5	1577.42	1581.48	799.40	314650.1	1586.03	1588.58
		100	791.80	312864.3	1573.96	1576.73	790.30	312690.7	1572.03	1575.14	800.70	315384.6	1589.16	1590.92
MT4	300	30	1199.00	714748.0	2390.25	2390.75	1198.00	715012.0	2389.69	2390.21	1198.00	715133.0	2389.89	2390.46
		50	1198.00	714250.0	2388.42	2389.62	1197.00	715158.0	2388.93	2390.13	1200.00	715988.0	2393.31	2393.97
		100	1198.00	715013.0	2389.69	2393.16	1199.00	714488.0	2389.81	2391.65	1206.00	717656.0	2402.09	2403.15
MT5	500	30	1286.60	1020295.3	2561.97	2562.05	1286.60	1020261.4	2561.93	2563.60	1286.60	1020758.7	2562.55	2564.69
		50	1283.20	1020484.0	2558.81	2559.26	1282.50	1020353.7	2557.94	2559.29	1288.08	1021134.3	2564.50	2565.79
		100	1283.10	1021257.1	2559.67	2561.09	1282.80	1020929.0	2558.96	2561.89	1289.90	1023482.0	2569.25	2569.25
MT6	100	30	513.00	203521.4	1021.81	1023.18	512.77	203451.1	1021.40	1022.17	514.15	203616.0	1023.19	1024.34
		50	516.97	204263.1	1027.62	1029.26	517.17	203872.5	1026.85	1028.06	518.83	204077.2	1029.02	1029.78
		100	526.24	206319.8	1042.03	1046.47	525.25	206668.7	1041.93	1048.11	533.59	209332.3	1056.92	1062.14
MT7	150	30	507.71	201642.4	1011.82	1012.36	507.08	201600.3	1011.08	1011.45	508.54	201697.6	1012.79	1013.61
		50	509.67	201798.9	1014.17	1014.74	508.49	202030.2	1013.57	1014.27	510.61	202105.7	1015.87	1016.49
		100	511.54	202572.1	1017.97	1019.55	512.87	203155.2	1020.76	1022.40	515.42	203108.3	1023.19	1024.29
MT8	200	30	817.83	406818.4	1631.47	1631.72	817.82	406520.0	1630.86	1631.09	819.94	406634.7	1633.21	1633.39
		50	819.41	406432.1	1632.27	1633.95	817.85	406691.2	1631.24	1632.99	821.80	407189.2	1636.18	1638.06
		100	823.98	406826.9	1637.63	1639.38	823.91	407351.6	1638.61	1639.88	829.40	407566.9	1644.54	1646.12
MT9	300	30	814.91	485146.4	1623.49	1623.92	814.20	485107.0	1622.71	1623.25	816.78	485207.4	1625.46	1625.81
		50	814.82	485298.6	1623.65	1624.61	815.46	485521.1	1624.66	1626.56	818.12	486059.5	1628.22	1628.94
		100	890.89	486519.3	1701.76	1704.95	820.64	487090.6	1632.45	1662.91	824.55	488241.2	1638.28	1639.96
MT10	500	30	1516.20	906891.7	3027.69	3028.09	1514.91	906824.1	3026.28	3026.53	1517.30	907073.6	3029.08	3029.95
		50	1517.48	906813.8	3028.84	3029.62	1517.44	906775.1	3028.73	3029.87	1519.49	907608.6	3032.18	3033.99
		100	1521.20	908621.9	3035.57	3037.12	1522.51	908946.6	3037.42	3037.98	1528.09	910557.0	3045.69	3046.27

Table F. Best and average results using phase two durations of 600 seconds on the new benchmark problems

A. 6. New Benchmark Problem Data

MT1 – Rectangles=100, Sheet=400x600

Width	Height	Quantity
49.5	49.5	10
12.5	24.1	8
45.9	80.1	10
32.8	45.2	12
15.7	10.2	8
35.2	29.777	10
30.5	176.8	5
7.5	105.8	3
20.5	22.8	7
31.4	10.8	9
70.4	93.4	10
10	30	8

MT2 – Rectangles=150, Sheet=300x900

Width	Height	Quantity
44.7	60	15
31	20.3	15
50.6	5	15
10	20	15
30	58.8	15
60.5	50	15
44.2	85	15
32.3	30	15
21	50.2	15
30.5	29	15

MT3 – Rectangles=200, Sheet=400x900

Width	Height	Quantity
42.5	65.5	10
90.3	80.3	9
52.5	24.1	16
45.9	80.1	10
32.8	15.2	15
15.7	10.2	8
31.2	9.777	10
60.5	36.8	7
70.5	55.8	12
20.5	22.8	7
11.4	40.8	15
50.4	56.4	10
14	28	8
30.3	125.1	2
8.3	12.4	14
14.1	20.1	4
5.9	6.1	12
130.4	114.8	1
13.2	8.1	7
3.4	20.3	6
40.3	10.2	5
40.2	30.6	5
34.8	22.5	7

MT4 – Rectangles=300, Sheet=600x1300

Width	Height	Quantity
20	70	5
43	71	10
80	20	8
25	26	20
101	76	5
30	13	19
170	20	9
10	15	20
37	13	15
99	55	12
111	52	4
40	50	10
50	60	10
10	15	20
95	37	17
67	87	24
43	82	10
34	57	20
10	169	5
15	90	2
18	18	5
20	15	10
32	39	20
62	80	20

MT5 – Rectangles=500, Sheet=800x1400

MT6 – Rectangles=100, Sheet=400x500

Width	Height	Quantity
20	70	5
43	71	10
80	20	8
25	26	20
101	76	5
30	13	19
170	20	9
10	15	20
37	13	15
99	55	12
111	52	4
40	50	10
50	60	10
10	15	20
95	37	17
67	87	24
43	82	10
34	57	20
10	169	5
15	90	2
18	18	5
20	15	10
32	39	20
62	80	20

Width	Height	Width	Height	Width	Height
27.512	234.999	39.306	31.992	39.306	40.183
199.36	33.779	31.982	39.161	35.069	44.195
196.456	35.04	39.306	31.492	42.063	37.106
180.646	41.972	44.37	26.295	33.478	45.057
177.68	42.868	28.545	41.972	35.625	41.972
170.417	37.106	44.37	25.494	33.478	43.542
33.478	172.228	35.51	33.779	34.089	42.868
39.306	159.304	26.956	41.972	33.478	42.717
31.982	157.449	44.531	23.544	32.177	42.868
106.471	81.204	42.603	25.451	41.07	33.575
25.378	160.305	33.328	33.779	44.37	29.863
158.302	19.435	33.153	33.779	31.819	41.972
41.07	135.208	39.306	27.559	39.306	33.717
139.246	33.795	42.496	23.544	39.306	33.59
137.903	25.451	22.971	42.868	44.37	27.992
115.684	44.195	42.209	23.544	38.418	33.779
32.775	126.51	21.769	42.868	33.478	37.925
44.37	109.042	19.971	44.195	44.37	27.017
106.471	45.306	41.07	22.685	37.644	19.435
111.667	36.305	38.817	23.544	37.579	19.435
17.658	125.495	36.809	25.451	34.182	19.435
104.507	23.544	38.595	23.544	29.92	23.544
47.236	41.972	24.477	37.106	17.808	35.04
44.44	44.195	24.354	37.106	17.658	34.81
40.17	44.195	26.753	33.779	26.195	25.451
47.525	36.305	23.07	37.106	33.478	18.102
44.37	38.539	16.851	42.868	27.512	23.895
39.421	42.868	23.09	36.305	33.478	16.433
38.791	42.868	16.251	42.868	23.756	25.451
41.07	40.182	17.063	41.972	33.478	15.612
44.37	36.489	16.514	41.972	22.697	23.544
42.835	37.106	15.596	41.972	27.512	16.951
18.669	23.544	15.58	25.451		
17.559	23.544	15.139	19.435		

MT7 – Rectangles=150, Sheet=400x500

Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height
202.076	33.656	37.913	12.586	27.544	35.951	16.711	33.656	7.302	25.987	14.725	21.891
17.307	199.243	37.913	24.104	17.425	35.951	19.55	33.656	25.208	25.987	8.172	21.891
26.547	197.95	37.913	30.366	13.814	35.951	16.388	33.656	25.922	21.339	10.01	21.891
197.837	21.891	37.913	35.627	30.359	35.951	33.566	21.891	25.754	10.646	16.5	21.891
193.599	21.756	37.913	12.889	31.091	35.951	32.804	25.578	24.034	25.578	17.517	21.891
16.023	193.293	37.913	17.879	33.608	35.951	32.592	19.854	14.79	25.578	11.937	21.756
190.63	28.737	37.913	12.162	14.279	35.951	32.508	25.987	19.477	25.578	20.915	21.756
190.63	177.112	37.913	18.428	35.444	35.951	8.393	31.436	6.61	25.578	14.659	21.756
23.793	187.358	37.913	27.532	35.851	31.436	18.788	31.436	18.738	25.578	6.919	21.339
186.312	25.177	37.908	10.646	35.427	10.266	6.096	31.436	19.083	25.177	17.307	21.275
185.174	19.854	37.473	19.854	34.974	21.339	15.889	31.436	23.094	25.177	20.212	10.646
184.718	10.614	37.154	11.027	34.839	25.578	31.162	25.987	21.316	25.177	8.307	19.854
34.457	184.483	37.154	28.582	23.793	34.602	30.954	21.339	20.426	25.177	12.866	19.854
183.673	25.987	37.154	11.165	34.457	24.599	30.29	25.578	21.269	25.177	18.025	19.854
181.449	25.578	37.154	22.976	34.457	17.647	17.307	27.967	24.503	10.646	8.683	19.854
16.176	180.713	37.154	6.785	16.176	34.04	27.336	25.987	24.228	19.854	11.245	19.854
178.305	10.646	37.154	6.75	33.905	25.177	26.547	26.855	23.793	22.539	16.176	18.205
37.913	177.419	37.154	11.989	22.309	33.656	26.547	6.365	23.793	14.862	16.588	10.646
176.29	35.951	37.154	10.495	6.897	33.656	26.547	17.964	23.793	10.598	16.176	9.681
174.217	21.339	36.969	25.578	21.813	33.656	26.547	14.298	23.793	17.671	16.176	10.348
173.4	31.436	16.176	36.758	14.269	33.656	26.547	18.662	23.793	13.63	16.023	12.556
171.226	10.266	36.555	25.177	8.266	33.656	26.547	23.889	23.494	19.854	13.898	10.646
37.154	170.152	16.176	36.494	31.774	33.656	26.547	17.168	16.176	22.899	13.719	10.614
38.572	10.646	36.316	10.646	18.591	33.656	15.029	25.987	22.585	21.339	7.944	10.646
38.04	25.177	20.146	35.951	21.356	33.656	23.693	25.987	21.037	21.891	8.216	10.614

MT8 – Rectangles=200, Sheet=500x800

Width	Height	Width	Height	Width	Height	Width	Height
345.889	367.32	40.963	32.484	43.229	19.342	21.938	32.151
29.314	367.32	40.344	33.069	21.033	41.48	23.624	30.393
38.752	332.136	35.817	36.728	25.437	36.728	20.869	33.069
325.393	31.617	40.787	30.393	26.039	35.984	20.786	33.069
45.082	278.932	40.963	29.819	31.417	30.393	20.614	33.069
288.682	30.713	26.548	43.956	29.523	32.151	20.55	33.069
40.963	154.009	40.963	29.31	34.781	26.83	23.088	30.393
103.746	41.48	41.476	28.511	24.862	36.728	21.11	32.151
115.92	28.511	50.594	19.342	19.53	41.906	24.613	28.511
98.582	43.956	45.082	24.833	34.489	26.83	29.589	23.522
82.801	41.906	36.479	33.069	39.076	22.217	26.218	26.83
87.041	35.984	40.647	28.511	34.268	26.83	19.955	33.069
88.961	32.151	40.963	28.037	28.451	32.151	33.554	19.342
51.745	43.956	32.112	36.728	24.524	35.984	24.382	28.511
45.082	47.894	36.4	32.151	23.6	36.728	22.156	30.393
62.51	30.393	36.29	32.151	31.706	28.511	19.32	33.069
50.979	41.906	26.627	41.48	40.963	19.159	19.286	33.069
45.082	47.278	37.457	30.393	29.421	30.393	19.159	33.069
47.76	43.956	30.935	36.728	27.005	32.151	20.051	32.151
50.141	41.48	30.817	36.728	38.752	20.333	32.842	19.342
49.463	41.906	23.537	43.956	22.321	36.728	21.79	30.393
40.963	48.607	38.752	28.737	26.833	32.151	19.029	33.069
46.989	41.48	25.273	41.906	25.853	33.069	21.557	30.393
46.907	41.48	36.775	30.393	22.895	35.984	19.53	32.151
45.518	41.48	25.32	41.48	39.076	19.689	23.048	28.511
49.747	36.728	25.237	41.48	38.752	19.981	24.68	26.83
50.219	35.984	24.704	41.906	21.862	36.728	31.603	19.505
49.466	36.728	24.703	41.906	28.126	30.393	19.693	31.155
44.015	41.906	35.297	30.713	39.173	19.342	31.372	19.156
40.963	44.058	22.007	43.956	22.268	35.984	19.059	31.155
40.963	43.085	29.946	35.984	27.735	30.393	29.589	20.434
40.963	42.93	38.905	26.83	30.726	26.83	23.183	26.83
39.195	43.956	21.521	43.956	21.486	35.984	20.564	28.511
41.135	41.906	28.727	36.728	38.011	19.342	19.628	28.511
49.859	33.069	23.007	41.906	30.218	26.83	25.296	22.832
46.517	35.984	37.916	26.83	24.738	32.151	20.232	26.83
49.81	31.617	32.484	32.151	26.427	30.393	25.854	20.976
44.709	35.984	38.752	25.819	24.578	32.151	19.843	26.83
44.454	35.984	33.988	30.393	37.267	19.342	27.318	19.342
46.633	33.069	31.213	33.069	19.617	36.728	19.723	26.83
48.971	30.713	22.101	41.906	19.359	36.728	25.296	21.124
46.303	33.069	22.468	41.48	27.571	28.511	25.854	20.504
37.767	41.48	22.393	41.48	31.603	24.451	19.313	26.83
50.73	28.511	21.841	41.906	19.863	35.984	26.439	19.342
47.335	30.713	40.963	22.647	19.027	36.728	24.285	19.342
33.585	43.956	33.142	30.393	28.835	26.83	24.113	19.342
43.748	33.069	19.403	43.956	36.317	19.342	23.059	19.342
39.969	36.728	31.065	32.151	19.076	35.984	23.031	19.342
49.41	26.83	31.043	32.151	31.372	22.75	21.668	19.342
29.629	43.956	26.325	36.728	27.26	26.83	19.1	19.342

MT9 – Rectangles=300, Sheet=600x800

Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height
19.532	36.64	32.646	40.085	21.805	40.085	37.77	15.477	17.811	19.724	15.883	21.714
31.32	31.678	15.769	8.611	37.77	14.441	17.627	32.348	35.505	28.834	31.531	15.098
37.77	318.604	297.215	38.57	31.32	28.832	13.251	39.678	35.437	17.443	134.869	199.671
19.532	36.704	31.851	18.53	39.982	38.57	38.608	40.085	21.786	33.574	28.049	31.194
31.32	323.323	296.857	19.201	27.682	32.156	31.851	20.963	33.358	15.115	28.049	12.482
20.043	32.725	31.851	14.541	19.54	40.085	15.238	10.084	33.679	32.725	17.811	29.487
320.724	25.985	27.682	12.495	31.531	27.984	31.851	36.29	25.455	328.907	17.317	32.185
312.159	33.574	38.574	31.4	20.894	38.57	31.851	20.665	27.682	347.555	18.743	17.443
37.77	24.023	25.455	8.721	28.049	9.243	37.77	22.987	27.659	17.443	37.185	28.834
17.627	26.323	31.32	38.204	19.532	324.538	17.627	32.353	252.745	31.668	20.42	15.115
334.163	9.373	15.238	27.424	37.77	16.174	307.25	8.498	28.638	40.085	16.29	19.201
17.627	323.76	33.86	15.115	31.749	27.329	11.869	40.085	25.455	19.276	26.695	8.498
37.77	15.832	31.851	35.765	37.77	22.867	30.159	25.985	27.682	22.034	28.049	28.852
320.796	15.115	31.32	21.439	31.531	40.333	13.16	38.57	31.531	12.824	25.455	9.332
19.532	32.309	31.531	17.958	248.426	31.4	17.627	10.008	30.042	15.115	31.531	33.621
22.331	15.115	19.532	15.567	25.455	33.022	25.455	25.97	31.531	36.641	28.049	30.586
8.636	25.985	31.531	35.371	31.531	17.44	8.371	38.57	31.851	11.295	25.455	8.998
35.074	40.085	15.883	39.931	37.77	20.129	17.811	33.048	31.851	11.087	31.851	37.69
28.049	35.227	31.851	40.596	27.682	12.29	8.091	35.113	9.741	12.281	15.883	18.071
28.049	22.245	31.851	34.789	20.381	37.01	28.049	14.467	25.455	8.115	13.251	17.534
30.788	38.57	19.532	39.174	37.77	35.893	11.916	9.755	28.049	14.309	15.784	15.115
9.536	11.55	31.851	12.732	33.694	26.512	25.455	22.867	28.049	14.264	31.32	13.91
31.531	40.021	17.811	12.621	13.151	25.985	15.091	34.899	22.9	210.408	15.238	16.725
31.846	33.885	27.682	8.408	25.455	31.342	37.77	23.087	13.251	301.511	28.049	18.538
13.251	25.887	34.255	31.668	18.215	38.57	19.532	33.523	15.883	25.441	26.027	40.085
31.846	281.883	10.69	19.201	37.77	37.147	23.926	25.985	27.682	13.505	31.32	9.3
31.851	279.375	27.682	37.948	19.532	36.856	37.77	13.089	17.627	33.091	15.238	14.37
15.883	293.938	37.77	27.606	37.77	18.569	31.531	13.948	37.77	14.363	19.532	18.287
25.455	21.132	300.699	32.185	31.32	24.966	316.172	40.085	35.434	27.329	31.32	21.119
259.938	32.725	31.851	38.22	34.108	25.985	37.77	11.585	23.134	15.115	16.87	32.185
288.937	28.834	24.627	32.185	31.851	27.296	11.916	37.37	17.627	22.288	15.883	22.529
17.627	27.392	31.851	16.82	19.173	9.528	13.86	15.317	28.049	32.77	11.415	17.081
8.506	25.985	37.77	8.75	36.98	199.671	31.531	29.923	31.274	8.745	17.627	10.804
258.097	12.294	11.916	325.991	271.909	34.899	17.627	40.701	31.274	8.698	28.049	9.866
29.809	25.985	15.238	357.933	31.851	23.689	27.682	21.091	37.77	16.051	17.627	10.388
248.356	12.281	31.32	19.811	15.238	40.184	15.238	13.646	13.484	15.115	18.525	9.373
222.857	34.471	31.32	30.86	12.606	15.115	17.627	28.436	31.32	8.41	31.32	22.526
28.108	210.408	30.188	30.369	13.251	13.51	31.531	287.962	15.238	24.277	37.77	13.87
37.77	29.076	15.919	11.55	19.958	35.113	31.32	16.564	16.987	24.575	17.811	326.744
39.164	27.329	25.455	36.184	15.238	39.407	21.877	25.985	24.075	32.725	11.595	15.317
27.867	25.985	19.532	25.441	31.851	40.276	8.939	9.373	28.049	11.084	31.531	14.533
192.669	12.36	174.264	27.329	19.532	27.97	15.238	32.54	23.324	15.115	28.049	8.629
31.851	26.83	33.767	27.329	28.049	12.846	37.77	9.952	19.532	19.454	34.099	32.725
20.381	311.531	31.851	29.041	31.851	8.395	31.32	16.298	31.531	39.145	13.251	9.136
13.251	40.599	14.04	17.081	22.658	32.725	31.32	27.788	19.05	19.201	13.091	15.115
13.251	23.228	31.32	33.718	28.049	25.785	15.238	21.302	28.049	12.362	31.32	30.069
171.849	10.737	254.703	32.773	18.858	38.57	37.77	16.387	18.74	19.201	222.857	40.52
36.567	38.57	25.455	35.267	312.91	17.443	19.567	27.329	28.049	290.855	8.876	9.528
33.694	22.947	27.682	33.002	15.009	38.57	192.669	18.009	25.455	16.212	25.455	22.341
34.979	32.185	37.77	26.947	19.532	33.782	37.77	27.094	11.616	25.985	9.686	8.611

MT10 – Rectangles=500, Sheet=700x800

Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height
19.499	19.803	45.522	43.102	44.592	19.211	41.627	28.916	17.156	48.523	19.813	35.089	22.675	35.089	29.44	17.364
24.349	369.233	40.017	42.207	32.06	28.129	40.017	30.497	20.341	45.337	32.784	37.653	25.267	36.77	27.398	19.346
40.193	38.178	46.281	42.141	43.241	34.171	24.367	28.129	40.017	35.95	68.631	191.739	31.125	23.263	27.007	19.552
34.878	314.222	40.017	16.742	29.44	47.905	31.125	271.041	21.483	44.033	47.729	25.521	34.878	18.066	26.163	20.351
40.017	16.016	17.267	42.141	40.017	37.304	40.017	38.606	26.697	38.729	25.267	26.923	35.815	18.389	24.501	21.711
144.76	44.427	41.694	25.318	34.878	42.189	144.76	27.943	23.044	42.141	40.55	18.389	31.125	21.373	25.85	20.351
29.292	176.546	40.017	47.512	29.973	47.059	39.097	36.981	17.935	47.245	22.372	37.426	34.878	21.623	47.134	22.943
298.58	25.521	44.592	42.746	40.017	21.77	28.021	42.141	21.98	43.102	29.255	40.856	25.878	27.652	42.413	20.298
285.122	37.426	43.986	43.327	32.88	43.327	25.878	40.967	31.125	33.88	32.836	26.803	34.878	19.977	250.273	20.351
47.134	269.997	29.44	25.1	45.373	43.102	126.825	47.245	273.429	34.171	44.592	18.385	34.878	18.311	20.161	25.583
270.36	39.989	48.034	38.729	22.308	38.306	20.309	33.029	22.723	34.171	40.017	19.32	34.878	18.102	22.146	19.346
25.878	38.901	29.44	45.649	44.592	31.399	42.488	19.979	25.878	27.897	26.181	33.029	244.818	43.996	276.139	28.916
42.488	22.494	29.44	46.162	20.341	45.321	42.488	27.202	34.878	24.905	25.878	33.323	42.4	34.171	42.488	19.232
44.592	28.418	36.62	38.548	29.44	46.424	40.017	44.475	42.413	30.264	19.187	39.989	19.828	33.029	40.017	30.275
38.913	38.729	30.169	18.664	42.488	33.346	20.341	32.264	20.448	25.521	25.878	33.228	16.118	20.351	23.388	43.102
19.203	46.777	44.592	19.219	45.482	41.13	31.125	37.911	68.631	28.516	19.147	25.521	40.017	44.542	20.341	24.803
22.873	27.258	42.488	42.806	42.488	27.456	20.341	41.708	144.76	27.084	41.694	38.734	29.44	20.122	25.641	19.42
20.341	282.291	144.76	18.681	26.316	41.13	37.956	28.916	24.309	42.141	48.278	25.189	18.767	38.729	20.341	24.701
38.477	20.351	37.166	19.346	42.488	30.716	25.878	43.002	20.341	47.991	31.125	27.743	19.248	43.102	24.656	20.351
272.463	28.129	46.238	38.729	31.748	44.033	42.488	25.954	44.081	19.346	29.973	44.369	31.125	21.287	19.978	22.655
23.781	20.351	40.017	44.788	25.878	46.776	26.065	28.916	41.694	21.723	44.592	43.125	19.303	33.029	36.043	44.465
23.249	34.171	42.413	42.381	20.653	34.171	44.592	23.772	34.878	47.284	16.194	19.346	31.125	42.709	42.488	30.522
25.878	270.435	28.143	20.351	43.277	43.102	20.341	25.479	47.22	38.178	37.826	41.13	29.44	22.669	21.716	22.655
275.81	18.389	26.973	25.583	42.488	44.159	31.125	47.517	20.341	42.549	41.694	16.852	25.878	25.803	260.276	38.548
268.605	25.189	22.937	33.029	29.44	45.556	25.878	42.442	25.878	36.933	20.18	38.306	23.436	24.831	29.44	38.125
259.574	30.463	41.694	40.813	16.846	43.102	29.44	38.808	32.888	25.189	44.592	35.285	29.44	21.891	41.358	34.171
20.341	25.114	40.017	44.171	44.592	24.918	38.258	28.916	40.954	44.033	230.319	40.856	32.919	18.389	20.341	22.522
41.694	29.302	41.694	42.464	31.125	43.629	23.653	44.465	20.341	42.217	25.878	28.738	25.878	17.898	22.989	19.803
29.973	26.921	44.731	34.171	31.993	38.178	42.488	46.492	17.744	21.901	40.017	17.637	20.341	30.602	40.017	35.661
261.119	26.803	41.694	42.325	44.592	46.079	246.811	36.189	42.488	33.285	34.878	22.743	34.878	47.461	42.249	38.627
249.873	36.981	34.878	37.716	40.017	34.519	29.44	38.405	25.878	36.511	29.44	20.885	28.763	33.029	20.341	21.629
40.017	21.673	39.458	43.327	41.37	33.029	31.125	36.448	42.689	41.13	18.139	369.233	30.169	20.065	16.608	25.189
40.017	34.527	44.592	38.143	42.488	37.944	163.562	44.037	19.127	43.102	27.007	23.55	34.878	33.299	25.878	19.843
235.971	44.465	44.592	39.887	31.125	43.183	29.44	48.055	29.039	42.141	25.878	31.568	16.851	21.977	22.056	19.359
40.017	239.954	34.878	47.481	25.267	29.866	20.341	19.844	42.413	288.09	259.574	38.552	43.267	27.683	16.581	24.831
240.328	38.627	41.694	19.648	40.017	34.058	29.973	275.225	29.44	46.254	31.822	25.521	34.878	23.713	20.341	21.055
231.695	44.033	41.694	261.502	25.878	19.732	48.65	20.351	34.878	34.152	25.878	29.601	20.341	29.62	20.526	20.351
255.094	19.346	40.017	45.681	17.679	44.465	29.44	32.34	45.921	41.13	20.341	25.323	30.56	19.169	42.488	33.56
245.939	27.683	42.413	39.698	41.694	31.723	18.759	34.171	31.125	30.771	20.341	30.928	20.168	19.346	47.134	21.19
293.955	16.299	17.158	43.102	16.708	19.346	47.134	40.777	47.742	18.389	25.878	40.338	30.232	19.346	20.341	19.553
28.9	28.916	20.341	18.624	23.285	46.777	31.125	33.135	31.125	26.486	29.973	26.856	29.44	24.412	25.267	36.846
16.463	44.465	34.878	29.042	22.895	37.653	39.056	27.683	34.104	27.683	47.134	41.195	30.081	19.169	17.987	21.711
46.837	220.255	233.868	37.653	30.973	42.141	20.341	25.036	34.878	39.891	44.592	37.079	20.341	28.523	20.48	19.169
21.243	28.916	41.797	17.207	41.694	25.346	40.017	19.146	20.341	46.653	40.017	30.461	29.973	36.975	239.714	42.141
244.774	43.327	39.655	19.346	20.341	24.302	40.017	17.576	21.926	38.627	27.529	28.916	29.973	38.074	33.476	28.129
191.937	38.729	46.132	20.351	34.878	31.121	29.44	33.104	32.826	28.916	29.44	26.708	17.722	48.523	29.44	17.774
208.479	19.169	34.878	45.117	42.488	30.476	23.03	43.327	42.488	41.619	44.592	301.283	20.341	28.25	29.44	423.136
41.694	23.196	42.413	21.551	29.44	43.473	29.44	43.473	29.44	19.314	31.125	30.685	32.081	38.729	34.878	26.048
27.86	44.465	42.488	37.355	34.345	38.548	29.44	36.799	21.722	33.083	17.255	38.627	20.341	28.078	19.638	19.359
40.017	45.274	40.017	44.726	31.125	33.016	18.295	33.083	29.973	44.214	36.661	19.169	21.791	20.351	44.592	18.033
144.76	36.05	40.608	38.627	33.096	25.521	40.017	33.215	23.747	37.426	29.44	26.159	22.872	25.521	21.696	25.521
17.134	21.901	40.017	17.028	29.92	43.709	208.724	41.13	44.592	16.574	29.973	35.9	25.878	22.459	40.017	34.905
25.267	34.91	16.131	19.042	28.332	44.037	22.83	43.327	20.341	27.491	29.44	26.033	46.883	19.346	21.061	16.725
25.878	36.34	20.341	22.881	291.007	38.178	34.878	31.278	20.341	17.152	25.878	29.458	27.796	20.206	256.348	33.029
29.44	17.916	42.488	36.165	25.878	46.392	25.267	22.482	40.017	20.841	36.105	19.169	29.44	18.536	34.878	28.525
44.592	37.02	18.027	21.977	40.017	31.49	32.984	33.029	16.8	44.033	17.023	33.029	19.686	44.033	25.878	18.904
33.37	44.465	21.563	18.152	29.066	42.141	44.592	45.892	35.153	25.521	41.694	26.672	20.341	17.26	29.44	18.973
44.592	46.074	20.341	29.779	27.119	43.102	34.878	39.831	16.28	38.102	31.125	23.798	34.878	23.916	42.736	36.189
34.878	17.56	34.878	22.323	20.341	17.202	20.341	19.173	29.44	48.001	25.878	34.326	20.341	26.999	18.454	18.152
42.488	47.632	28.312	38.102	34.878	36.084	42.413	23.44	40.017	21.758	20.341	17.31	25.267	277.925		
41.694	26.368	44.592	33.166	45.497	33.029	40.579	25.189	18.747	19.042	42.488	33	31.125	18.5		
44.729	43.996	18.924	27.258	42.271	36.981	29.44	36.293	42.488	23.749	42.488	39.502	27.751	19.346		
18.956	16.725	25.878	34.195	16.053	19.42	16.796	20.206	22.423	38.178	40.017	20.105	16.524	19.346		