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Associating Statistical Relationship among Stock-sheet and Pieces in Rectangle Packing

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***Abstract*—In the rectangle packing problem different ordered items (rectangular) compete for a stock sheet with an objective so that maximum sheet utilisation is obtained. The bill of material and stock sheet can be classified into three different categories (and so are objects) as regular when length/ width ratio is uniformly distributed (1.25±0.25) (Wood, Glass industry), standard (length/ width ratio is uniformly distributed (3±0.3) (Paper Industry) and tapered (length/ width ratio is uniformly distributed (6±1) (VLSI Circuits, Adhesive Tapes). Likewise stock sheets can be the categorised as regular, standard or tapered. Thirty rules (heuristics) have been suggested by the authors in the revised/ reworked rectangle-packing algorithm suggested by Cheok-AYC Nee so as to generate different 120 feasible patterns and to draw various statistical inferences. In this paper, synthetically normally distributed bill of material has been generated to test the hypothesis if the nature of items and sheet put up with any correlation.**

***Index Terms*—Greedy Approach, Heuristics algorithm, industrial applications, NP-complete problems, Rectangle Packing, Sheet Layout.1**

I. INTRODUCTION

In the rectangle-packing problem, rectangular parts are placed onto a rectangular stock sheet, which is bigger in size in comparison to items with the aim of minimizing the unused space. This problem belongs to NP-complete problems class [1] where computation time for an exact solution increases with N and becomes rapidly prohibitive in cost as N increases [2]. The solution approach to these problems lies in reducing the exhaustive search of all possible arrangements of nesting the parts and subsequently checking upon the execution time. Usually, various heuristic rules are proposed to generate different patterns, which are generally the priority rules used to allocate patterns to the stock sheet sequentially. In this paper revised heuristic algorithm [3] is used to generate different pattern to sequence items both in ascending and in descending order on the basis of breadth, length, perimeter, area and aspect ratio (length/ width ratio). These sequenced items are then placed one-by-one onto the object from bottom-lower corner (sheet reference point) till the solution continues to be feasible. Both length-wise and breadth-wise orientations of the object and then first item placed onto it have been considered.

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Industrial practice and literature survey substantiate for varied distribution of length and breadth of the rectangular parts. This is because of numeral manufacturers in a job in wide-ranging industrial application areas. The wood [4], the glass [5] and the paper industry [6], [7] are mainly concerned with the cutting of regular figures (Fig. 1). On the other hand, in shipbuilding, textile [8] and leather industry [9], [10] irregular and arbitrary shaped items need to be packed [11] (Fig. 2 & Fig. 3). In the VLSI applications the rectangular parts are generally skinny (aspect ratio of length/ width is large); whereas in furniture industry majority parts are regular (lengths and widths are of comparable dimensions). In sheet metal industry, a major portion of ordered pieces are generally standard in nature. In the simulation study, accordingly the items are classified into three different categories (and so are the objects) as *regular, standard* and *tapered* (defined later on in the research study). Literature survey substantiates that some researchers have suggested the uniform distribution [12] and others have suggested beta distribution [13] as shape distribution for length and width of rectangular parts. In the present study it is assumed that since the normal distribution comes close to fitting the actual observed frequency distributions of many phenomena, including human characteristics (weights, heights, IQs), outputs from physical processes (dimensions and yields) and other measures of interest related to industrial problems, accordingly, it is assumed that: -

- Breadth of each item is normally distributed with a presumed mean and the standard deviation as ¼th of it.
- Length of each item is related to breadth as regular, standard and tapered.

There are three null hypotheses, one for different nature of objects; second for different nature of items laid on these objects and third one regarding the interaction. These are stated as follows: -

H_{01}: The means of the utilisation factor of sheet do not differ significantly with the nature of object (row factor).

H_{02}: The means of the utilisation factor of sheet do not differ significantly with the nature of the items laid on different nature of the objects (column factor).

H_{03}: The interaction between the two above stated factors is not significant.

The three stated hypothesis are tested for nine different combinations of objects and Items.

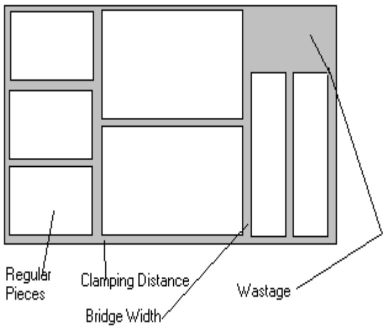

Fig1. Cutting of Regular Parts (All rectangular parts) from a Rectangular Sheet

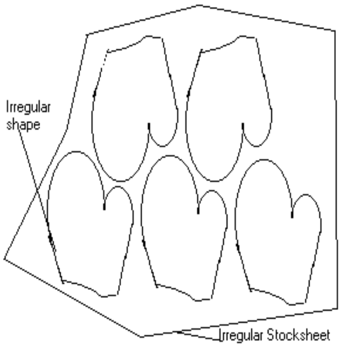

Fig 2. Cutting of Irregular Parts from an Irregular Stock Sheet

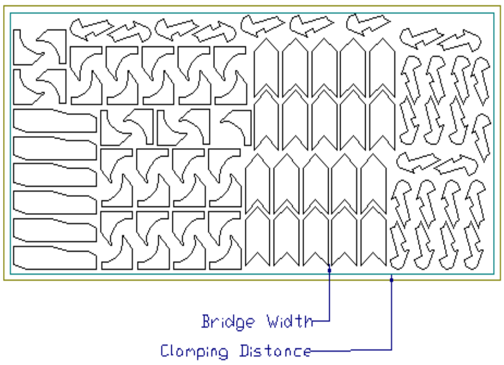

Fig 3. Cutting of Irregular Parts from a Rectangular Stock Sheet

II. Details of Experimentation

The classification criteria to categorise items/ objects as regular, standard or tapered is suggested on the basis of length/ breadth(l/ b) ratio. The item/ object is categorised as regular if (l/ b) ratio is in the range (1.25±0.25); standard if (l/ b) ratio is in the range (3±0.3) and tapered if (l/ b) ratio ranges between (6±1). Accordingly, nine different combinations of object/ items are investigated. For each combination of items and stock sheet, five set of samples are generated where breadth of the each rectangular part is normally distributed with mean $\mu = 20$ and standard deviation $\sigma = 5$. Thus, length of the items is calculated by multiplying breadth and uniformly distributed l/b ratio in the ranges (1-1.5), (3±0.3) and (6±1).Table I lists the objects (stock sheets) of three different categories. Tables II-IV show the length and breadth of regular, standard and tapered items thus generated. Table V represents the quantity of different items. The total ordered items thus comes to 129, which is a sufficiently large sample size. For an illustration, Table VI represents the performance of different heuristics for Sample 2 of regular items which are placed on regular sheet. Heuristic **OL**, **OB** indicates Orientation of **O**bject in Length-wise and Breadth-wise direction. Heuristic **IL**, **IB** indicates Orientation of first item in Length-wise and Breadth-wise direction. **PPL, PPB, PPD** indicates sequencing Pivot Points along the **L**ength, **B**readth and **D**iagonal of the sheet and Heuristic OL-IL-D-SL-PPL indicates Orientation of **O**bject is Length-wise and that of first **I**tem placed is **L**ength-wise; pieces are sequenced in **D**ecreasing order on the basis of **S**equencing basis **L**ength and **P**ivot **P**oints are sequenced in increasing order along the **L**ength of the sheet; TPP is Total Piece Placed; UF is Sheet Utilization factor. Consequently, maximum sheet utilization factor 96.9% is obtained by applying heuristic OB-IL-D-SB-PPL, OB-IL-D-SB-PPB and OB-IL-D-SB-PPD. Bold values in the tables identify the maximum utilization factor.

TABLE: I Length and Breadth of Different Type of Object

Object	L	W
REGULAR	225	150
STANDARD	330	110
TAPERED	490	70

L: Length W: Width

TABLE II: Different Five Data Sets for Regular Items

Sample :1		**Sample :2**		**Sample :3**		**Sample :4**		**Sample :5**	
L	**B**	**L**	**B**	**L**	**B**	**L**	**B**	**L**	**B**
7	6	18	14	19	15	12	10	18	12
11	11	22	15	23	17	15	12	13	13
16	13	23	17	27	18	18	14	21	14
19	14	25	18	21	19	15	15	22	15
26	18	20	19	21	20	21	17	23	16
23	19	25	20	26	21	24	18	23	17
20	20	26	21	27	22	25	19	28	20
29	21	25	22	29	23	29	20	24	21
29	22	29	23	28	24	40	27	23	22
25	23	25	24	27	25	42	29	32	23
35	24	35	25	32	29	32	30	31	25

TABLE III: Different five data sets for Standard items

Sample :1		**Sample :2**		**Sample :3**		**Sample :4**		**Sample :5**	
L	**B**	**L**	**B**	**L**	**B**	**L**	**B**	**L**	**B**
19	6	43	14	41	15	29	10	34	12
30	11	43	15	51	17	39	12	36	13
42	13	53	17	50	18	43	14	43	14
39	14	57	18	52	19	47	15	48	15
52	18	61	19	55	20	56	17	46	16
54	19	62	20	58	21	55	18	50	17
58	20	64	21	71	22	53	19	60	20
60	21	66	22	75	23	64	20	62	21
65	22	63	23	71	24	82	27	69	22
69	23	66	24	72	25	91	29	72	23
76	24	71	25	85	29	90	30	69	25

TABLE IV: DIFFERENT FIVE DATA SETS FOR TAPERED ITEMS

Sample :1		Sample :2		Sample :3		Sample :4		Sample :5	
L	**B**	**L**	**B**	**L**	**B**	**L**	**B**	**L**	**B**
35	6	79	14	79	15	69	10	66	12
70	11	79	15	101	17	77	12	78	13
76	13	96	17	114	18	85	14	98	14
89	14	122	18	133	19	103	15	79	15
107	18	114	19	136	20	117	17	84	16
117	19	108	20	137	21	93	18	109	17
133	20	113	21	125	22	100	19	130	20
130	21	137	22	141	23	127	20	121	21
121	22	133	23	167	24	161	27	119	22
139	23	148	24	157	25	173	29	159	23
145	24	152	25	159	29	159	30	172	25

TABLE V: QUANTITY VECTOR FOR DIFFERENT TYPE OF ITEMS

QTY	11	8	15	13	14	13	10	14	9	13	9

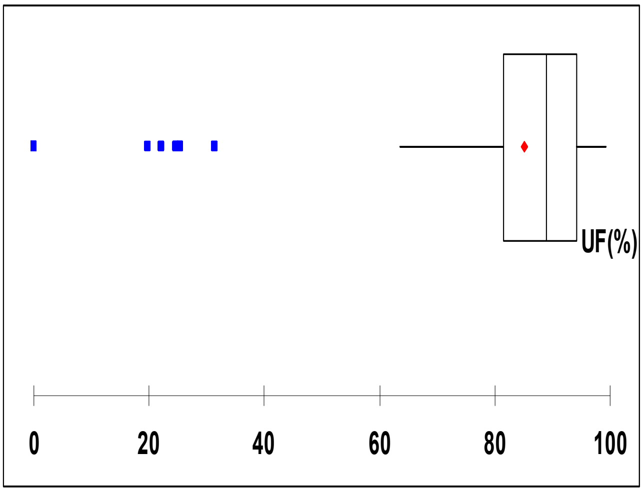

Fig 4. Box plot (of 5400 values)

III. RESULTS AND DISCUSSIONS

Five different samples for each form of object-item combination have been considered in this empirical study. The best UF% for all 120 heuristics for the 45 sets has been tabulated. Refer to the Table VII. Corresponding statistical summary is available in the Table VIII. The Box-Plot graph has been obtained for 5400 such sheet utilisation factors (Fig 4). Few outliers were observed indicating inferior sheet utilisation factors. It has been observed that among the set of 5400 UF% values, just 3.56% values are outliers and 96.44% values are similar in nature (Fig 5). Fig 6 shows the Histogram for all 5400 cases with their UF (%). A few mock-up cases in which items are tapered and breadth of the tapered object is small have proved to be failure. On scrutinising it has been found that these poor results are because of erroneous data sets where items to be placed happen to be larger in comparison to the object on which these are to be placed. So as to carry out the study, best UF% of each experiment has been considered. Fig 7-9 represents the layouts of maximum Utilization Factor (UF %) when regular items laid on regular object, standard object and Tapered Object. Whereas Fig 10-12 represent the layouts of maximum Utilization Factor (UF %) when Standard items laid on regular object, standard object and Tapered Object. Fig 13-15 represent the layouts of maximum Utilisation Factor (UF%) when Tapered items laid on regular object, standard object and Tapered Object .Refer to the Table-VII that contains top UF% value of each of the 45 simulations. The data about sheet utilizations has been classified according to two characteristics/ factors. These are the nature of the object vis-à-vis different forms of items that are to be laid on these objects. For this two-way classified data there are five different data values related to sheet utilisation factors associated with five different data cases/ replications that belong to a particular normally distributed population. So, the empirical study involved observing the sheet utilisation factor for different combinations of objects and items and five observations/ responses has been obtained from the experiment. The populations, from which the samples were selected, are assumed to be normally distributed and have the same variance. Also, all the five samples are assumed to be random and independent of each other. A statistical test for comparing the means of more than two groups so as to investigate that means are likely to be same or different is exactly the scope of problem. Also, it is possible to estimate the interaction or the joint effect of the nature of the object/ items on the sheet utilization factor. Two-way ANOVA with replication is exactly the statistical test case that is applicable to study [14], [15]. There are three null hypotheses, one for each factor and another one regarding the interaction states as H_{01}, H_{02} and H_{03}. From the summary table (Table VIII) we can read the mean and variance of the sheet utilization factor corresponding to the three different forms of items to the three different types of objects. The last table having the title TOTAL gives the mean and variance of all the nine observations under each column for Regular, Standard and Tapered. These column headings are common to all the tables. In the ANOVA table (Table IX), the first source of variation is given as SAMPLE, which corresponds to the nature of the object and the second source corresponds to the nature of ITEM. The F-value corresponding to the Objects and Items are lower than the corresponding critical values and hence we conclude that the both Object and Item have no significant effect on the sheet utilisation factor. The third source of variation is the Interaction, which is an indication of the joint effect of Object and Items on the sheet utilisation factor. The effect is not significant as the F-value obtained is lower than critical value. Note that for all sort of statistical graphs/ analysis demo versions/ supporting disks along with books as Minitab, StatPro and Excel have been used.

TABLE VI: PERFORMANCES OF DIFFERENT HEURISTICS FOR SAMPLE 2
(Regular Items placed on Regular Sheet)

#	ORDER	SPP	OL-IL		OB-IL		OL-IB		OB-IB	
			TPP	UF (%)	TPP	UF (%)	TPP	UF (%)	TPP	UF (%)
I.	D-SA	PPL	53	96.65	53	96.65	45	87.01	49	92.47
II.	D-SA	PPB	53	96.65	53	96.65	45	87.01	49	92.47
III.	D-SA	PPD	53	96.65	53	96.65	45	87.01	49	92.47
IV.	D-SAR	PPL	65	90.38	62	85.94	64	89.89	63	86.92
V.	D-SAR	PPB	63	86.43	62	85.94	64	89.89	63	86.92
VI.	D-SAR	PPD	65	90.38	62	85.94	64	89.89	63	86.92
VII.	D-SB	PPL	51	94.47	52	**96.93**	50	92.99	50	94.36
VIII.	D-SB	PPB	51	94.47	52	**96.93**	50	92.99	50	94.36
IX.	D-SB	PPD	51	94.47	52	**96.93**	50	92.99	50	94.36
X.	D-SL	PPL	53	95.21	49	92.68	48	88.55	50	92.77
XI.	D-SL	PPB	53	95.21	53	95.9	48	88.55	50	92.77
XII.	D-SL	PPD	53	95.21	49	92.68	48	88.55	50	92.77
XIII.	D-SP	PPL	53	96.65	53	96.65	45	87.01	49	92.47
XIV.	D-SP	PPB	53	96.65	53	96.65	45	87.01	49	92.47
XV.	D-SP	PPD	53	96.65	53	96.65	45	87.01	49	92.47
XVI.	I-SA	PPL	73	84.29	75	87.39	71	81.32	74	85.77
XVII.	I-SA	PPB	73	84.29	75	87.39	71	81.32	74	85.77
XVIII.	I-SA	PPD	73	84.29	75	87.39	71	81.32	74	85.77
XIX.	I-SAR	PPL	62	91.96	67	93.49	62	91.96	67	93.49
XX.	I-SAR	PPB	62	91.96	67	93.49	62	91.96	67	93.49
XXI.	I-SAR	PPD	62	91.96	67	93.49	62	91.96	67	93.49
XXII.	I-SB	PPL	72	82.51	75	87.39	72	82.81	71	81.32
XXIII.	I-SB	PPB	72	82.51	75	87.39	72	82.81	72	82.81
XXIV.	I-SB	PPD	72	82.51	75	87.39	72	82.81	72	82.81
XXV.	I-SL	PPL	70	84.14	66	80.14	69	84.58	71	87.4
XXVI.	I-SL	PPB	70	84.14	66	80.14	69	84.58	72	89.62
XXVII.	I-SL	PPD	70	84.14	66	80.14	69	84.58	71	87.4
XXVIII.	I-SP	PPL	73	84.29	75	87.39	71	81.32	74	85.77
XXIX.	I-SP	PPB	73	84.29	75	87.39	71	81.32	74	85.77
XXX.	I-SP	PPD	73	84.29	75	87.39	71	81.32	74	85.77

TABLE VII: BEST UTILIZATION FACTOR (%) (ALL 45 SETS)

Object	Item			
Regular		Regular	Standard	Tapered
	Sample I	97.680	96.630	97.780
	Sample II	96.930	95.130	99.130
	Sample III	97.290	97.030	96.050
	Sample IV	98.570	98.200	95.270
	Sample V	98.360	97.410	97.200
Standard		Regular	Standard	Tapered
	Sample I	98.840	98.730	97.600
	Sample II	96.970	95.510	98.120
	Sample III	94.480	96.940	94.080
	Sample IV	98.260	98.360	99.180
	Sample V	97.630	97.750	98.970
Tapered		Regular	Standard	Tapered
	Sample I	97.720	98.860	98.650
	Sample II	99.210	96.520	96.170
	Sample III	97.520	96.210	91.880
	Sample IV	99.060	97.740	97.520
	Sample V	98.300	97.570	98.910

TABLE VIII: STATISTICAL SUMMARY
(For each Combination of Item and Object)

Summary	Regular Item	Standard Item	Tapered Item
		Object: Regular	
Count	5	5	5
Sum	488.83	484.4	485.43
Average	97.766	96.88	97.086
Variance	0.48303	1.2927	2.26093
		Object: Standard	
Count	5	5	5
Sum	486.18	487.29	487.95
Average	97.236	97.458	97.59
Variance	2.86073	1.64497	4.2584
		Object: Tapered	
Count	5	5	5
Sum	491.81	486.9	483.13
Average	98.362	97.38	96.626
Variance	0.58282	1.11615	8.21123
		TOTAL	
Count	15	15	15
Sum	1466.82	1458.59	1456.51
Average	97.788	97.23933	97.1007
Variance	1.34855	1.228492	4.37479

TABLE IX: TWO WAY ANOVA TABLE

ANOVA: Two-factor with Replication						
Source of variation	SS	DF	MS	F	p-value	F crit
Sample	0.39792	2	0.19896	0.07885	0.92434	3.25944
Columns	3.96345	2	1.98173	0.78533	0.46363	3.25944
Interaction	6.08387	4	1.52097	0.60274	0.66313	2.63353
Within	90.8438	36	2.52344			
Total	101.289	44				

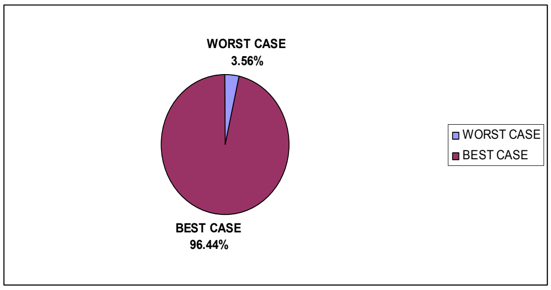

Fig 5. Pie –Graph erroneous/successful test cases for empirical study

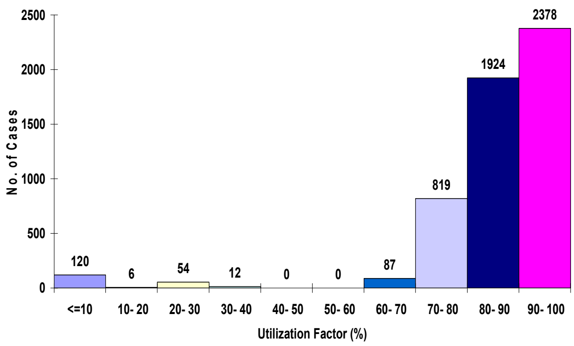

Fig 6. Histogram (of 5400 Values)

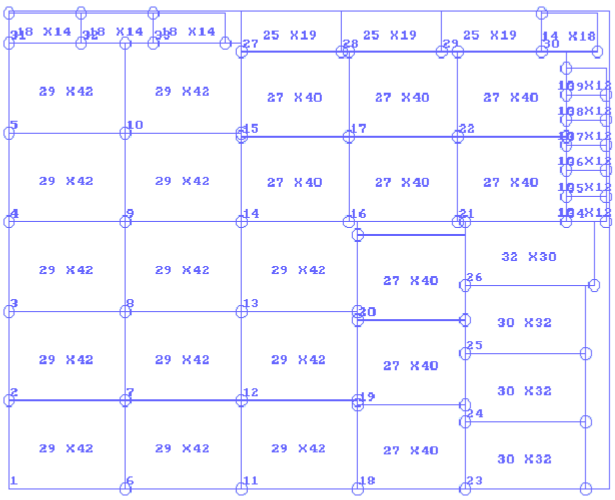

Fig 7. Regular items lay on regular object
UF (%): 98.57% TPP: 39

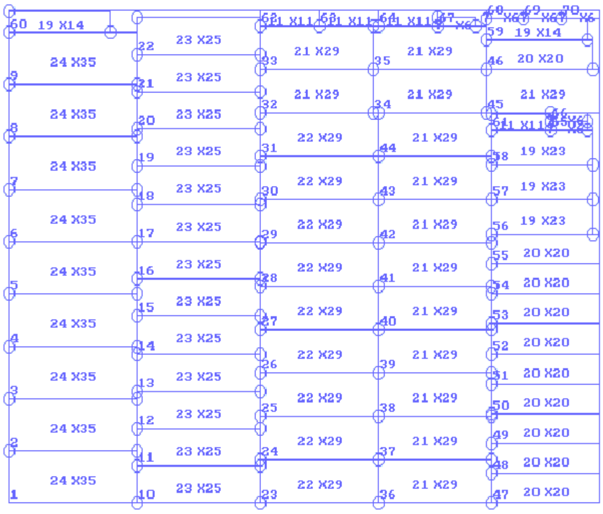

Fig 8. Regular Items lay on standard sheet
UF (%): 98.84% TPP: 70

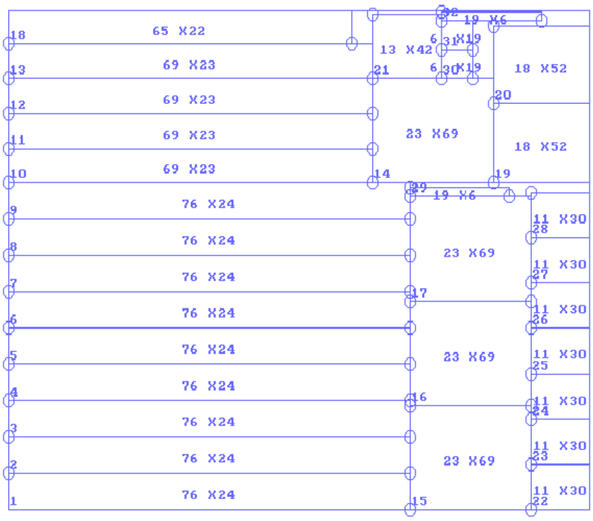

Fig 11. Standard items lay on standard Sheet
UF (%): 98.42% TPP: 32

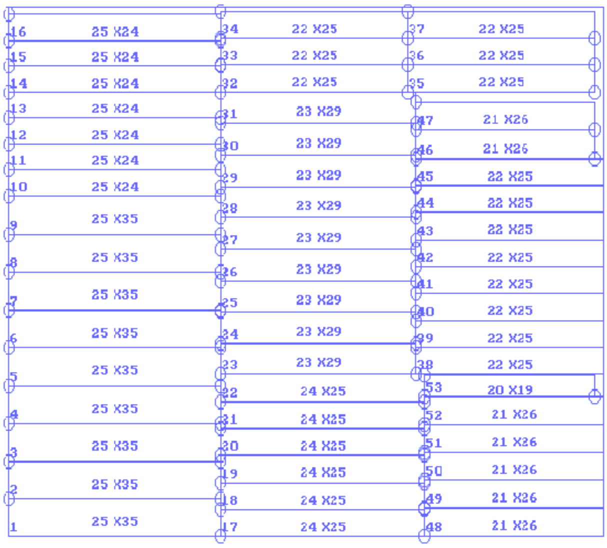

Fig 9. Regular items lay on Tapered Sheet
UF (%): 99.210 % TPP: 53

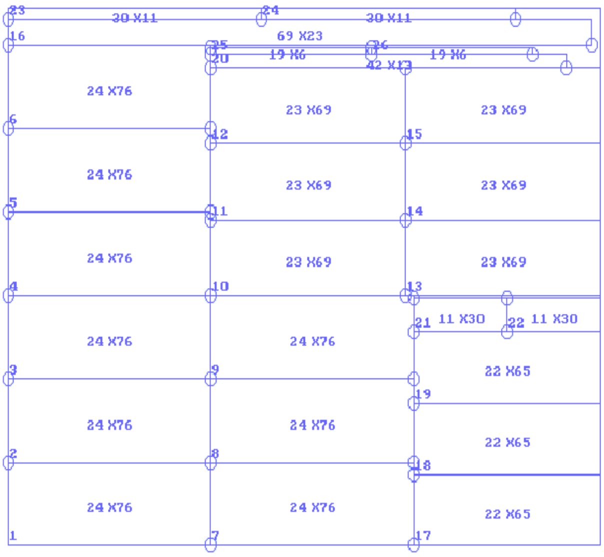

Fig 12. Standard items lay on tapered Sheet
UF (%): 98.86% TPP: 26

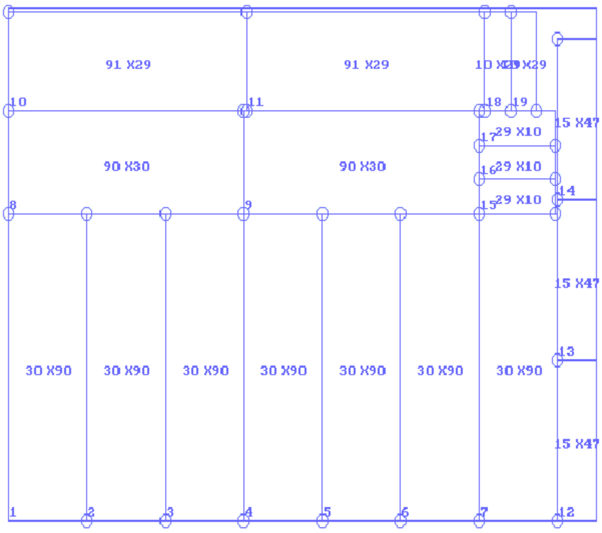

Fig 10. Standard items lay on Regular Sheet
UF (%): 98.20 % TPP: 19

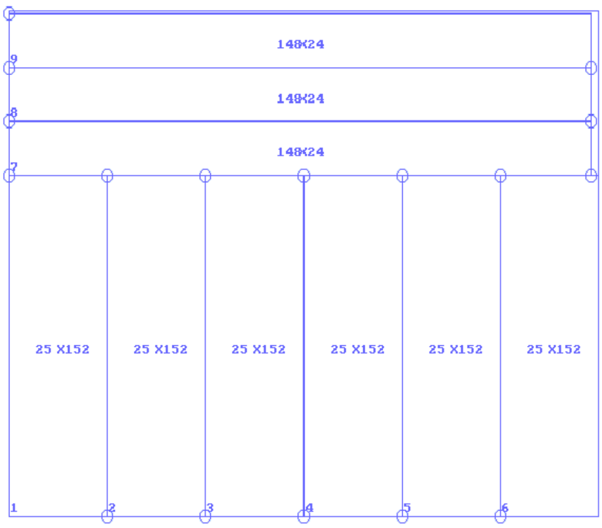

Fig 13. Tapered items lay on regular sheet
UF (%): 99.13% TPP: 9

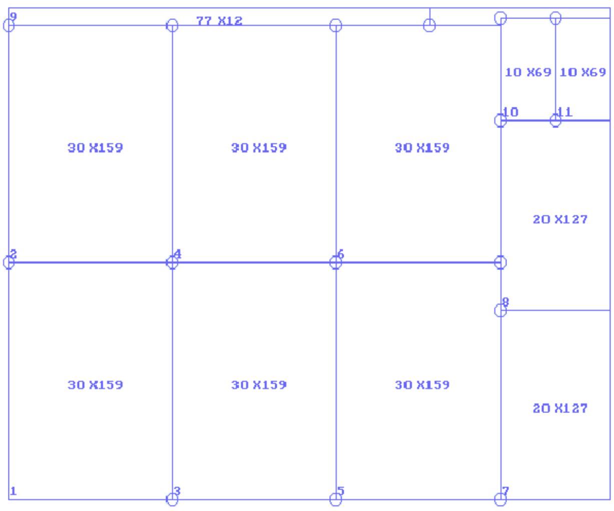

Fig 14. Tapered items lay on Standard Sheet
UF (%): 99.18% TPP: 11

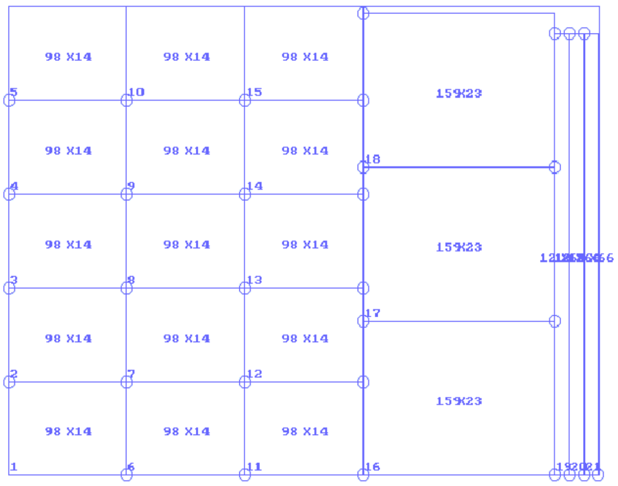

Fig 15. Tapered items lay on Tapered Sheet
UF (%): 98.910% TPP: 21

IV. Conclusion

It is common in the rectangle packing problem to observe different forms of objects/ items. Intuitively, the bill of material and stock sheet can be classified into three different categories (and so are objects) as *regular* when length/ width ratio is uniformly distributed (1.25±0.25) (Wood, Glass industry), *standard* (length/ width ratio is uniformly distributed (3±0.3) (Paper Industry) and *tapered* (length/ width ratio is uniformly distributed (6±1) (VLSI Circuits, Adhesive Tapes). Likewise stock sheets can be the categorised as regular, standard or tapered. In this paper, synthetically normally distributed bill of material had been generated to test the hypothesis if the nature of items and sheet put up with any correlation. Almost 96% of the synthetic cases have been found to be well-matched to work out the relationship among the different form of objects and items. Two-way ANOVA test with replications was applied to look for the acceptance of null hypothesis. It is concluded that the nature of Object and/ or Item (or even their joint effect) have no significant effect on the sheet utilisation factor. Hence, it is recommended strongly to obtain UF% value for all proposed (120) heuristics irrespective to the nature of the object/ item.

References

[1] M. Garey, and D. Johnson, "Computers and intractability, a guide to the theory of NP- Completeness," Freeman, New York, 1979.

[2] K. Singh, and L. Jain, "An improved Heuristic for 2D Rectangular packing problem," *Proceeding of IEEE International Advance Computing Conference*, 2009, pp. 1185-1190.

[3] K. Singh, and L. Jain, "An empirical study of a modified Cheok-Nee's heuristic for 2d rectangular packing problem," *Appejay. J Management and Technology,* Vol. 4, 2009, pp. 53-64.

[4] R. Morabito, and V. Garcia, "The cutting stock problem in a hardboard industry: a case study," *Computers and Operations Research*, Vol. 25(6), 1997, pp. 469-485.

[5] J. Puchinger, G.R. Raidl, G. Koller, "Solving a real-world glass cutting problem," *In Proceedings of the 4th International Conference on Combinatorial Optimization (EvoCOP 2004)*, Coimbra, Portugal, Springer-Verlag. 2004, pp. 162-173.

[6] M.P. Johnson, and Z.E. Rennick, "Skiving addition to the cutting stock problem in the paper industry", *SIAM REV 39*, 1997, pp 472-483.

[7] S. Menon, and L. Schrage, "Order allocation for stock cutting in the paper industry," *Operations Research,* Vol. 50, 2002, pp. 324-332.

[8] G. Chryssolouris, N. Papakostas, and D. Mourtzis, "A decision-making approach for nesting scheduling: a textile case", *Inter. J. Production Research*," Vol. 38, 2000, pp. 4555-6427.

[9] A.J. Crispin, P. Clay, and G.E. Taylor, "Genetic Algorithm Coding Methods For Leather Nesting," *Applied Intelligence,* Vol. 23, 2005, pp. 9–20.

[10] A.J. Crispin, P. Clay, G.E. Taylor, T. Bayes, and D. Reedman, "Genetic algorithms applied to leather lay plan material utilisation," *J. Engineering Manufacture,* Vol. 217, 2003, pp. 1753-1756.

[11] Q. Weishuang, and J.L. Sanders, *"A nesting algorithm for* irregular *parts and factors affecting trim losses,"* Int. J. Production Research. Vol. 25 No. 2, 1987, pp. 175-190.

[12] Christofides and C. Whitlock, "An Algorithm for Two-dimensional Cutting problems," *Operations Research,* Vol. 25 No.1, 1997, pp 30-44.

[13] S.S. Israni, and Sander, J.L., "Performance testing of rectangular parts-nesting heuristic", *Int. J. Production Research,* Vol. 23 No. 3, 1985, PP. 437-456.

[14] S.C. Albright, W. Winston, and C.J. Zappe, "Data Analysis & Decision Making with Microsoft Excel", Second Edition, International Student edition, Reprint Edition for sale in the in the Indian subcontinent only with CD of StatPro included in it, First Reprint 2004 by Thomson Asia Pte. Ltd., Singapore ISBN: 981-243-543-3, 2004

[15] K.V.S. Sharma, "Statistics Made Simple Do it Yourself on PC", ISBN-81-203-1741-6, 3rd Printing, Eastern Economy Edition, Prentice-Hall of India Pvt. Ltd., October 2003.

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