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Assessment of Storage and Retrieval System in Bulk Storage Area

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Abstract: An efficient storage and retrieval system helps in reducing the cost of operation of the industry. Demand, warehouse layout, location of items and picking methods are factors that affect to the storage and retrieval system efficiency. The aim of this research is to assess the storage and retrieval system in Bulk Storage Area (BSA) of an apparel accessories industry. The method operators carried out their tasks, the facilities layout and structure were observed and working procedures were examined through interview. The available rack and occupied rack space were measured to determine the storage utilization. Time and motion study were carried out to evaluate efficiency in retrieving operations. The study concluded that average only 22.5% of rack spaces were utilized. The average retrieving efficiency of one item was 72.4% while 75.1% for two items. The highest value added (VA) operation time was untie and weight the items which occupied 31.4% whereas highest non-value added (NVA) time was transportation with 67.2%. The interview and observation also revealed that Standard Operating Procedures (SOPs) were not available for storing and retrieving process. Thus, the SOPs was proposed for storage and retrieval system to increase the system efficiency. Implementation of SOPs for retrieving operation of order with one item showed reduction of VA time by 31.4% while 62.1% for NVA time. The total time was decreased by 42.4%.

Keywords: Efficiency, retrieval, storage, utilization, value-added.

I. INTRODUCTION

Storage and retrieval system is a system that stores the material for a period of time and provides access to retrieve material when required [1]. Storage assignment is critical as it will directly impact to the retrieving process [2]. Retrieving is costly process that occupied 55% of the total operating cost of warehouse [3]. Many factors affect the efficiency of storage and retrieval system, which are warehouse layout, demand, location of items and picking methods [4].

Layout planning plays an important role in determining the efficiency of warehouse operation [5]. In layout planning, philosophies factors such as popularity, similarity, size, characteristics and space utilization are considered in order to store and retrieve the product [6]. Size of the aisle is also one of the critical parts during layout design [7]. Optimum aisle width is necessary as narrow aisles restrict daily operations while large aisles waste space.

The performance of storage area depends on the space allocation for material and handling time required [8]. Storage policies can be classified into random, dedicated and class-based [9]. These policies are needed when assigning storage location to minimize the travel distance [10]. Random storage results better space utilization as it requires less than 50% of space for fixed storage [11]. Class based storage policies comply with Pareto's principle that states that 20% of the items stored account for approximately 80% of the picking activities [12].

Picking methods refer to the assignment of tasks among the operators and the route taken to perform the picking task. The picking policies are divided into strict, batch, sequential, batch zone and wave [13]. Each policy works well in different operating conditions. The route taken by the operators has great impact on cost [12]. Two main types of routing are optimal and heuristic. Optimal routing concerns on finding the shortest possible route, while heuristic comes out with route that is easily understood. The heuristic routing is categorized into traversal, return, midpoint, largest gap and composite strategy [14]. Traversal strategy is the simplest in planning the route for the operator [15].

This research focused to identify the problems of current BSA storage and retrieval system in one of the apparel industry in Malaysia. Its effectiveness was evaluated and an alternative storage and retrieval system was proposed to increase the efficiency.

II. METHODOLOGY

A total of four respondents, one planning executive and three operators from Bulk Storage Area (BSA) participated in this study. Checklist which consists of different assessment criteria was used during observation and interview with material planner. All operators at BSA were required to fill up the questionnaire through question and answer (Q&A) method. Survey questions asked about current available facilities in BSA, practices of operators and problems faced during storing and retrieving process. The results from checklist and questionnaires were then checked to ensure no contradiction exists for the accuracy of results.

The effectiveness of storage and retrieval system depends on how efficient the available storage space utilized and also efficiency of retrieving operation. Storage utilization which represents the efficiency of current storage system is computed as:

$$Strorage\ Utilization = \frac{Total\ space\ Occupied\ on\ Rack}{Toatal\ available\ Space\ on\ Rack} x\ 100\% \ldots (1)$$

Time and motion study was carried out to evaluate the value added and non-value added elements in retrieving operation. The retrieving operation was classified into order with one item and order with two items. The processes were recorded through video tapping. The work elements were identified and recorded in time and motion study sheet prepared. The work elements were then categorized into value added or non-value added. Value added is steps that are valuable and necessary in a process while non-value added is work that is unnecessary to the process [16]. The efficiency of retrieving operation is expressed by dividing the value added time to total retrieving time:

$$Retrieving\ Efficiency = \frac{Total\ Value\ Added\ Work\ (VA)}{Total\ Work} \times 100\% \quad (2)$$

From time and motion study, the activities that contributed to the largest value added and non-value added time were identified respectively. Solutions focused on reducing these activities in order to increase the efficiency.

III. RESULTS

Analysis was performed based on the results of checklist and questionnaires. Verification of problems identified from checklist and questionnaires showed no contradiction existed. The unavailability of Standard Operating Procedure (SOP) in current system was identified through interview. The order picking policies such as routing and picking policies were not adopted and applied in daily operations. Working procedures for verifying the picked items and sorting the picking order list were not available too. The ineffective of the current replenishment, identification and tracking system effected to the efficiency of storage and retrieval system.

The storage system was assessed in term of space utilization. In BSA, racking system was used for storing raw material and manufactured items to improve the accessibility. The storage utilization of each rack was calculated using Formula (1) and the result was presented in Table 1. It was found that average only 22.5% of the rack space was utilized. The current rack system was sufficient to store the available raw material and manufactured items but it was not used optimally. Tompkins et al. [3] recommend utilization of 80% the space available.

Table 1 Result of Storage Utilization of Each Rack

Rack	Total Available Space (m^3)	Total Occupied Space (m^3)	Storage Utilization (%)
A	34.61796	5.90782	17.5
B	34.61796	5.24366	15.1
C	34.51656	6.74915	19.6
D	34.51656	10.10316	29.3
E	29.93328	7.86975	26.3
F	29.93328	3.35455	11.2
G	34.49628	7.23343	21.0
H	37.24616	14.96502	40.2
Total	Σ= 269.87804	**Σ= 61.42654**	**Σ= 180.2**
Average rack space utilization $= \frac{180.2}{8} = 22.5\%$			

For assessing current retrieval system, two approaches were applied. First the processes of retrieving were classified into value added (VA) and non-value added (NVA). This classification follows the definition of waste in lean manufacturing. Table 2 shows the results of classification of VA and NVA for single order.

Table 2 Value- Added and Non-Value Added Work Elements for single order

Seq#	Work Content	VA	NVA	Time (s)
1	Read order list	✓		7
2	Get down item from rack	✓		3
3	Read order list		✓	1
4	Untie and weigh item	✓		43
5	Put remaining item on rack	✓		6
6	Go and get rubber band		✓	4
7	Return location		✓	1
8	Tie the retrieved item	✓		6
9	Do markings on order list	✓		3
10	Attach order list with items retrieved and put aside	✓		5
11	Return to rack	✓		4
Total value-added time				77
Total retrieving time				83
Efficiency of retrieving process				92.8%

The efficiency of retrieving operation was determined using Formula (2) and the result for order with one and two items is showed in Table 3. The average retrieving efficiency for order with one item was 72.4% while for two items was 75.1%. The operators supposed to spend only average 72.3% of current total time to perform the retrieving operation for order of one item. Hence, average 27.6% of the total time was inefficiency due to non-value added activities. The process of retrieving order with two items was better that one item due to higher percentage of value added elements.

Table 3 Result of Retrieving Efficiency

Reading	Order with One Item (%)	Order with Two Items (%)
1	48.0	79.6
2	24.5	66.2
3	95.9	68.1
4	72.6	77.3
5	97.5	51.3
6	92.8	80.4
7	83.8	90.6
8	71.5	88.9
9	55.0	62.2
10	77.6	87.2
11	82.9	73.6
12	84.0	61.7
13	67.6	74.7
14	72.7	82.6
15	81.9	65.6
16	49.8	90.8
Total	**Σ= 1158.1**	**Σ= 1200.8**
Average Efficiency (%)	**72.4**	**75.1**

Table 4 and 5 show the VA elements in retrieving for order with one and two items respectively while non-value added elements are presented in Table 6 and 7. Tying and weighing item was found to have the highest percentage by occupying up to 42% of the total VA time. For the non-value added elements, unnecessary transportation contributed to the highest percentage by occupying up to 67% of the total NVA time. The alternative proposed was focused on reducing these activities in order to increase the efficiency of system.

Table 4 Result of Average Value-Added Time for Order with One Item

Work Element	**Time (S)**	**Percentage (%)**
Untie and Weigh Item	30.1	31.4
Take Down Item from Rack	17.6	18.4
Go Location	10.3	10.8
Attach Order List to Retrieved Item	8.9	9.3
Tie Retrieved Item and Put Aside	7.8	8.1
Do Markings on Order List/ Plastic Bag	7.1	7.4
Calculate Amount of Item Required	4.3	4.5
Tie and Put Back Remaining Item	2.6	2.7
Get/ Read Order	3.1	3.2
Get Tool	1.7	1.8
Return	1.7	1.8
Put Tool on Cart/ Rack	0.6	0.6
Total Value-Added Time (s)	**95.8**	

Table 5 Result of Average Value-Added Time for Order with Two Items

Work Element	**Time (S)**	**Percentage (%)**
Untie and Weigh Item	83.4	41.7
Tie Retrieved Item and Put Aside	23.6	11.8
Go Location	20.3	10.1
Do Markings on Order List/ Plastic Bag	19.4	9.7
Take Down Item from Rack	15.1	7.5
Tie and Put Back Remaining Item	14.2	7.1
Attach Order List to Retrieved Item	11.9	5.9
Get/ Read Order	7.5	3.7
Calculate Amount of Item Required	1.8	0.9
Put Tool on Cart/ Rack	1.6	0.8
Return	1.0	0.5
Get Tool	0.4	0.2
Total Value-Added Time (s)	**200.2**	

Table 6 Result of Average Non- Value Added Time for Order with One Item

Work Element	**Time (S)**	**Percentage (%)**
Transportation	35.8	67.2
Search Item/ Location	10.4	19.5
Get/ Reread Order List	3.4	6.4
Set Up Weight Machine	2.3	4.3
Repeated Calculation	1.1	2.1
Unnecessary Action	0.3	0.6
Ask Location	0.0	0.0
Remove Obstacles	0.0	0.0
Put Back Tool on Cart/ Rack	0.0	0.0
Total Non-Value Added Time (s)	**53.3**	

Table 7 Result of Average Non- Value Added Time for Order with Two Items

Work Element	**Time (S)**	**Percentage (%)**
Transportation	40.0	55.8
Search Item/ Location	12.2	17.0
Get/ Reread Order List	9.7	13.5
Unnecessary Action	4.8	6.7

Remove Obstacles	2.8	3.9
Ask Location	1.9	2.6
Put Back Tool on Cart/ Rack	0.3	0.4
Repeated Calculation	0.0	0.0
Set Up Weight Machine	0.0	0.0
Total Non-Value Added Time (s)	**71.7**	

The unavailability of SOPs in BSA was identified through interview and observation. Workers were observed to back and forth in storing and retrieving process due to unavailability of SOPs to guide them to carry out their daily operations in more efficient way. Thus, the study proposed SOPs. SOPs were constructed for major activities involved in storage and retrieval system such as storing, replenishing, retrieving and kitting process. Strategies such as strict picking and return strategy were adopted in retrieving process. Small items were unitized into weight of 1kg, 5kg and 10kg to eliminate weighing step in retrieving.

By the SOPs proposed for retrieving process, the work elements of set up weight machine, untie and weigh item and put back tool on cart or rack can be eliminated. The unnecessary transportation can also be minimized as SOPs standardize the way operators carry out their task includes the route taken in retrieving process. The estimation of time spent on unnecessary transportation after implementation of SOPs was based on the lowest time achieved during retrieving process. The predicted results for retrieving process after implementation of SOPs are shown in Table 8 and 9.

By implementing SOPs, the total VA time for retrieving process was expected to decrease by 31.4% for order with one item while 41.7% for order with two items. Total NVA time was able to reduce by 62.1% for order with one item while 43.7% order with two items. Overall, the total time estimated to be lowered by 42.4% for order with one item while 42.2% for order with two items. Thus, SOPs constructed are able to increase the system efficiency as total time spent on retrieving process was reduced.

Table 8 Predicted Result of Retrieving Process with One Item after Improvement

	Work Element	Average Time (s) Before	After
Value Added	Get/ Read Order	3.1	3.1
	Go Location	10.3	10.3
	Take Down Item from Rack	17.6	17.6
	Untie and Weigh Item	30.1	0.0
	Get Tool	1.7	1.7
	Put Tool on Cart/ Rack	0.6	0.6
	Calculate Amount of Item Required	4.3	4.3
	Tie Retrieved Item and Put Aside	7.8	7.8
	Tie and Put Back Remaining Item	2.6	2.6
	Do Markings on Order List/ Plastic Bag	7.1	7.1
	Attach Order List to Retrieved Item	8.9	8.9
	Return	1.7	1.7
Total Value Added Time (s)		**95.8**	**65.7**
Reduced Total Value Added Time (%)		**31.4**	
Non-Value Added	Ask Location	0.0	0.0
	Get/ Reread Order List	3.4	3.4
	Repeated Calculation	1.1	1.1
	Remove Obstacles	0.0	0.0
	Set Up Weight Machine	2.3	0.0
	Search Item/ Location	10.4	10.4
	Transportation	35.8	5.0
	Unnecessary Action	0.3	0.3
	Put Back Tool on Cart/ Rack	0.0	0.0
Total Non-Value Added Time (s)		**53.3**	**20.2**
Reduced Total Non-Value Added Time (%)		**62.1**	
Total Time (s)		**149.1**	**85.9**
Reduced Total Time (%)		**42.4**	

Table 9 Predicted Result of Retrieving Process with Two Items after Improvement

	Work Element	Average Time (s) Before	After
Value Added	Get/ Read Order	7.5	7.5
	Go Location	20.3	20.3
	Take Down Item from Rack	15.1	15.1
	Untie and Weigh Item	83.4	0.0
	Get Tool	0.4	0.4
	Put Tool on Cart/ Rack	1.6	1.6
	Calculate Amount of Item Required	1.8	1.8
	Tie Retrieved Item and Put Aside	23.6	23.6
	Tie and Put Back Remaining Item	14.2	14.2
	Do Markings on Order List/ Plastic Bag	19.4	19.4
	Attach Order List to Retrieved Item	11.9	11.9
	Return	1.0	1.0
Total Value Added Time (s)		**200.2**	**116.8**
Reduced Total Value Added Time (%)		**41.7**	
Non-Value Added	Ask Location	1.9	1.9
	Get/ Reread Order List	9.7	9.7
	Repeated Calculation	0.0	0.0
	Remove Obstacles	2.8	2.8
	Set Up Weight Machine	0.0	0.0
	Search Item/ Location	12.2	12.2
	Transportation	40.0	9.0
	Unnecessary Action	4.8	4.8
	Put Back Tool on Cart/ Rack	0.3	0.0
Total Non-Value Added Time (s)		**71.7**	**40.4**
Reduced Total Non-Value Added Time (%)		**43.7**	
Total Time (s)		**271.9**	**157.2**
Reduced Total Time (%)		**42.2**	

IV. CONCLUSION

The findings of the research were concluded as below:

a) Current system did not adopt any procedure for storing and retrieving activities in Bulk Storage Area (BSA).
b) Rack system utilization reached 22.5%. The utilization of rack space was undesirable and ineffective.
c) Retrieving efficiency with one item in average was 72.4%, while average for two items order was 75.1%.
d) The system efficiency was proven increment through implementing Standard Operating Procedures (SOPs) for retrieving process. The total time spent

for retrieving order with one item was estimated to reduce by 42.4% while 42.2% for order with two items

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REFERENCES

[1] Groover, M. P. (2008). "Automation, Production Systems, and Computer-Integrated Manufacturing," New Jersey: Pearson Education Inc., 3rd ed.

[2] Chan, F. T. and Chan, H. K. (2011). "Improving the Productivity of Order Picking of a Manual-Pick and Multi-Level Rack Distribution Warehouse through the Implementation of Class-Based Storage," *Expert Systems with Applications*, *38*(3), pp. 2686-2700.

[3] Tompkins, J. A., White, J. A., Bozer, Y. A. and Tanchoco, J. M. A. (2010). "Facilities Planning," John Wiley & Sons.

[4] Gattorna, J. (1997). "Handbook of Logistics and Distribution management," Gower Publisher Company, 4th ed.

[5] Saxena, J. P. (2003). "Warehouse Management and Inventory Control," Vikas Publishing House PVT LTD.

[6] Wu, B. (2000). "Manufacturing and supply systems management: a unified framework of systems design and operation," Springer.

[7] Heragu, S. S. (2008). "Facilities design," CRC Press.

[8] Battista, C., Fumi, A., Giordano, F. and Schiraldi, M. M. (2011). "Storage Location Assignment Problem: Implementation in a Warehouse Design Optimization Tool," *Conference of breaking down the barriers between research and industry.*

[9] Manzini, R. (2012). "Warehousing in the Global supply Chain," Springer.

[10] Dukic, G. and Opetuk, T. (2008). "Analysis of Order-Picking in Warehouses with Fishbone Layout". *Proceeding of International Conference on Industrial Logistics 2008*, pp. 197-205.

[11] Vercillo, T. (2014). "Using your Supply Chain as a Competitive Weapon: A Practitioner's Guide to Supply Chain Management," IFMC, Inc.

[12] Huber, C. (2014). "Throughput Analysis of Manual Order Picking Systems with Congestion Consideration," KIT Scientific Publishing.

[13] Frazelle, E. H. and Apple, J. M. (1994). "The Distribution Management Handbook: Warehouse operations," New York: McGraw-Hill.

[14] Petersen, C. G. (1997). "An Evaluation of Order Picking Routeing Policies," *International Journal of Operations & Production Management*, *17*(11), pp.1098-1111.

[15] Galazka, M. and Jakubiak, M. (2010). "Choice of Order Picking Concepts by Means of Simulation Tools," *Total Logistic Management*, (3), pp. 29.

[16] DeCarlo, N. (2007). "The Complete Idiot's Guide to Lean Six Sigma," Penguin.