Storage Location Allocation Model for a Just In Sequence (JIS) production System

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Abstract

For the automotive industry, satisfying the specific demands of customers using differentiation strategies in product and service has become successful in increasing competitive global markets. Therefore, supply chain management and logistics capabilities play a key role in achieving competitive advantage. One of the key success factors for automotive companies is to have Tier 1 suppliers that have the logistic capability to provide the wide variety of components using Just in Time. The present paper focuses on a Storage Location Allocation Problem for a level 1 supplier company with a Just In Sequence production system. The problem is defined with linear programming formulation to find the optimal allocation of items at a minimum operating cost.

Key words: JIS, Inventory, Storage location, Allocation, Tier 1 Supplier

1. Introduction

With constant innovation and increasingly demanding customers, manufacturing companies require strategies that generate a competitive advantage in order to meet customer needs and compete in an evermore globalized economy. This has led to the majority of companies producing a wider range of products and customization. These changes have created inevitable challenges and presented new optimization issues for many manufacturers. Due to intense competition, companies are looking for operational efficiency through Supply Chain Management and Logistics Optimization, as most companies include multiple suppliers, multiple manufacturers, multiple customers, different products to manufacture, as well as multiple issues in uncertain environments (Gholamian, Mahdavi, Tavakkoli-Moghaddam, & Mahdavi-Amiri, 2015) (Mirzapour Al-e-hashem, Malekly, & Aryanezhad, 2011).

A factory is usually equipped with more than one production line to produce various products, which raises the problem of how to effectively allocate limited resources to manufacture each item in order to maximize profits, another of the basic problems to be Companies are faced with the uncertainty of demand, since it affects the production system of a company generating problems in the planning and scheduling of production, as well as in inventory management (Ho & Fang, 2013) (Altendorfer, 2014).

For the automotive industry, meeting the specific demands of customers using differentiation strategies in product and service has become successful in increasing competitive global markets. Therefore, supply chain management and logistics (ACS) capabilities play a key role in achieving competitive advantage. One of the key success factors for automotive companies is to have Tier 1 suppliers who have the logistical capability to provide the wide variety of Just

In Time components that make up the manufacturing of a car, as well as the ability to cope with the development of Market and the uncertainty of demand. Therefore, a flexible organization that is also efficient in its operations and that adds value to all processes of the supply and production chain is required (Meissner, 2010).

The main problems faced by tier one suppliers in the automotive industry are: 1) the uncertainty of demand (the short time in changing demand), causing unstable material flow, high stock levels and Poor inventory location (Meissner, 2010); 2) production scheduling, tier one suppliers are faced with the challenge of producing the different orders (product type and lot size) of the automotive company, this becomes a complex problem since the sequence must be determined efficiently Of production for each type order, in addition to producing a just-in-time philosophy to meet deadlines, therefore, production scheduling seeks to maximize the efficiency of operations and reduce costs (Çevik Onar, Öztaysi, Kahraman, Yanık, & Senvar, 2016) (Low, Chang, Li, & Huang, 2014) (Carvalho, Scavarda, & Lustosa, 2014).

Because of these issues, Just-In-Time (JIT) and Lean Manufacturing are required at all levels of the production chain to efficiently manage and synchronize information exchange and material flow across all manufacturing activities. The different levels of suppliers and customers (Ramírez-Granados, Hernández, & Lyons, 2014). Therefore, tier one suppliers in the automotive industry are using the production control and logistics approach by sequencing stable orders to achieve their objectives, in other words they are using the Just-in Sequence (JIS) philosophy, the Which consists of the flow of material only in sequence for orders of production and supply, the above for the purpose of facilitating mass production of customized components and products in a cost-effective manner and keeping inventories low. The JIS system must have an information system that integrates everyone involved in the production chain with the objective of providing real-time information on demand so that the supplier can execute the production on a daily basis that allows him to schedule the production weekly. This information system will allow the supplier to react instantaneously to fluctuations in the actual levels of production of the automobile manufacturing plant, enabling the supplier to produce and deliver the correct product, at the right time, at the right point of the process Of the main plant (Meissner, 2010) (Wagner & Silveira-Camargos, 2011) (Infiniti Technology / JIT & JIS).

An important factor to be taken into account by tier one providers is their efficient management of inventory and inventory control. (Horta, Coelho, & Relvas, 2016) Mention that warehouses are an essential component of any supply chain, since the main function is: a) to cushion the flow of materials along the supply chain; B) consolidate products from multiple suppliers; And c) perform value-added activities.

In a dynamic storage environment, material flow changes dynamically due to factors such as demand uncertainty, product variety, and component (material) life cycles. Therefore, storage policies influence most of the key performance indicators of a warehouse, such as: time and cost of picking orders, productivity, inventory level, shipment accuracy, and storage density. In this sense, one of the storage problems is to efficiently assign the location of the input elements (article) to reduce handling costs, improve space utilization and minimize the route to the production line (Chen, Langevin, & Riopel, 2011) (Zhang, Nishi, Turner, Oga, & Li, 2016).

Methods for storage allocation determine how items (input parts) should be located in storage locations. Articles can be randomly assigned to empty spots in the warehouse, by their specific characteristics or by their frequency of use, which could lead to specific locations for each element (Calzavara, Glock, Grosse, Persona, & Sgarbossa, 2016). Therefore, this work focuses on a Storage Location Allocation Problem (SLAP) for a level 1 supplier company belonging to the production network of the Volkswagen Puebla Plant, Mexico.

In Section 1, general aspects of Just-in Sequence, tier-one providers and warehouse management were analyzed; In section 2, a review of the mathematical models that have been used to solve problems of allocation of inventory in warehouses; In section 3, the problem of the company under study is presented; In section 4, a linear programming model for the relocation problem is presented; In section 5, the computational results are presented; And finally conclusions.

2. Literature Review

 (John J. Bartholdi III, 2016) explains in his book that the movements of the forklifts does not add value with routes with no load on them, so he finds a way to solve the problem of finding the place of pairings of storage and the recovery of said ones to thus diminish the movement and slack time with the following mathematical expression:

$$\min \sum_{i,j} d_{ij} x_{ij}$$

$$\sum_{i} x_{ij} = 1$$

$$\sum_{j} x_{ij} = 1$$

$$x_{ij} \in \{0, 1\}$$

Where indicates that the forklift i should proceed in the most direct way to recover in j.

A popular $x_{ij} = 1$ attribute for assigning an element to a storage location is the ratio of the storage space required by its demand frequency, which is also called the cube-per-order-index. Another common storage allocation method is class-based storage, which combines random features and nearby locations. Here, items are classified into a number of classes, for example, A. B and C, where fast moving elements are class A and are usually assigned to locations close to the production or storage line. Another method that can help reduce travel distances is correlated storage allocation, where products that are often ordered together are mapped to locations close to each other (Calzavara, Glock, Grosse, Persona, & Sgarbossa, 2016).

Therefore, SLAP focuses on minimizing the frequency-weighted total distance from the storage locations of the elements to the picking area or production line, subject to constraints of correlation and constraints based on specific cases (Xie , Mei, Ernst, Li, & Song, 2014).

In this sense, in the last 2 decades, different methods of mathematical programming have been proposed for solving problems of allocation of inventory positions in warehouses, as well as for the management of the supply chain where the (Zhang, Zhang, Cai, & Huang, 2010). In addition to the In general, any optimization problem P can be described as a triplet (S, Ω, f), where:

1. S is the search space defined on a finite set of decision variables Xi, i = 1..., n. In the case where these variables have a discrete domain, discrete optimization (or combinatorial optimization) will be used, and in the case of continuous domains P is called a continuous optimization problem. There are also problems of mixed variables. Ω is a set of constraints between variables;

    F: S → R + is the objective function that assigns a positive cost value to each element (or solution) of S.

The objective is to find a solution s ∈ S such that f (s) ≤ f (s'), ∀ s' ∈ S (in case of minimizing the objective function), of (s) ≥ f (s'), ∀ s '∈ S (in case the objective function is maximized). In real-life problems the goal is often to optimize several objective functions at the same time. This form of optimization is labeled multi-objective optimization (Blum & Li, 2008).

Under this premise of optimizing the spaces to locate the inventory in a warehouse, we present a look at the mathematical models that have been used in the last five years to solve and optimize a "storage location allocation problem".

(Xie, Mei, Ernst, Li, & Song, 2014) They solve a SLAP under constraints of grouping by genetic programming, for formulation of the problem we use a model of whole linear programming, whose objective is to minimize the total cost of displacement of the frequency Picking. (Chen, Langevin, & Riopel, 2011) consider a problem to determine an optimal relocation strategy in a dynamic storage environment where a single command mode is assumed, in which the machine performs a single operation (storage or retrieval) In each trip, the authors propose a formulation of whole linear programming, whose objective function is to minimize the total time of relocation, therefore, they develop a two stage heuristic method to generate an initial solution and propose a taboo search algorithm to improve the solution. (Ene & Öztürk, 2012) They designed a system of allocation of storage and order selection, using a mathematical model of whole programming and a stochastic evolutionary optimization approach. The objective function minimizes the total time of the routes for storage and the picking orders in the assembly supply. Due to the computational time required to solve the entire programming problem, they developed a faster genetic algorithm to form optimal bundles and optimal paths for order selection.

(Zhang, Nishi, Turner, Oga, & Li, 2016) Develop a mixed integer linear programming model to formulate an integrated strategy that combines storage location allocation with the trained batch size problem. The objective function minimizes the total cost of travel, storage space, handling, production, cost of maintaining inventory and preparation costs. However the problem with real data is a large-scale instance that is beyond the capacity of optimization solvers, therefore, they propose a new heuristic approach of lagrangian relaxation and fixation and its variants to solve the problem on a large scale.

(Wisittipanich & Kasemset, 2015) They develop a model of mixed integer programming, whose objective function is to minimize the total displacement distance along the displacement distance of three axes: two horizontal axes and one vertical axis, however by size Of the instance present two metaheuristic approaches to solve the problem: a) Differential Evolution, and b) Global Local and Near-Neighbor Particle Swarm Optimization.

(Horta, Coelho, & Relvas, 2016) in their article presents a mathematical programming model based on a min-max formulation that returns the optimized design of a cross-docking store that feeds a Just-In- Time. In this case, the design requires the allocation of spaces in the warehouse according to the demands of the customers. Therefore, the objective function of the model aims to minimize the total distance traveled in the warehouse.

The Hungarian method is used to solve the problem of location optimization for warehouse systems, this method is used as assignment of tasks but being a similar problem can be provided to optimize the spaces to solve these types of problems (Yuzehn Hu , 2015).

The authors (Zanjirani Farahani, Behnamian, Behnamian, & Eghtedari, 2009) explain the use of a dedicated warehouse, where products are assigned to store / withdraw locations to minimize the time required for warehouse performance and the collection operation the products. With this criterion a model was formulated for the allocation of a dedicated warehouse.

s = Number of spaces and locations in the warehouse.
n = Number of products to be stored.
m = Number of points in / out.
S_j = Storage requirement for product j, expressed in number of storage spaces.
T_j = Performance requirement or activity level for j, expressed by the storage / retrieval number made per unit of time i.
$P_{i,j}$ = Percentage of the warehouse / travel recovery for the product j that are by inputs / outputs put at the point = to the time required to travel $t_{i,k}$ between the entry / exit of point i and the store / recovery located in k.
X_{ik} = 1, if product j is assigned to store / recovery located at k = 0, otherwise
$I(x)$ = The time required to satisfy the system performance requirement is required, the formulation of the storage allocation problem is:

$$\text{Min} \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{s} \frac{T_j}{S_j} (p_{i,j} \, t_{i,k} \, x_{j,k}). \qquad (18.6)$$

Subject to

$$\sum_{j=1}^{n} x_{j,k} = 1 \qquad k = 1,\ldots,s, \qquad (18.7)$$

$$\sum_{j=1}^{s} x_{j,k} = S_j \qquad j = 1,\ldots,n, \qquad (18.8)$$

$$x_{j,k} = 0, 1 \qquad \forall j, k. \qquad (18.9)$$

3. Description of the problem

The assembly company of automobile front modules. Being a JIS company, its main characteristic is that the parts that are stored have returns of inventory of days, even hours, that is, the parts of the assembly remain very little time in the warehouse of the plant before being mounted to the module and sent to the final customer in the city of Puebla.

Warehouse management to control and assign an inventory location (components of the front modules) are considered the following variables:
1. Type of packaging
2. Frequency of arrival
3. Maximum amount of material to be stored
4. Frequency of consumption in production line

In this context, the company does not have a defined and optimal process to assign the positions of each component (article), since the current management of the warehouse places the inventory of entry to an available space or relocates the inventory to enable spaces where the components that can only be stored in the warehouse can be stored, the warehouse layout is shown in figure 1.

The company converges in rework problems by rearrangement to enable positions where the entry inventory (components) can be located, generating times of delay in the loading and unloading of the transports in the receiving / loading zone. One of the main problems is the picking area (figure 1, shaded area in blue), since in this area the 9 components that have the highest consumption frequency in the production lines must be concentrated, in addition they must be located (figure 1 , Area in orange) as close as possible to the picking area to minimize travel distances to fill the buffer.

Therefore, the storage location allocation problem is formally defined as follows:

- Information about the storage area, including its physical configuration and storage arrangement.
- Information about storage locations, including availability, physical dimensions and location.
- Information about the set of articles to be stored, including their physical dimensions, demand, quantity, time of arrival and departure.
- Information about the set of articles that are in line of production, including their physical dimensions, demand, quantity, time of arrival and departure.
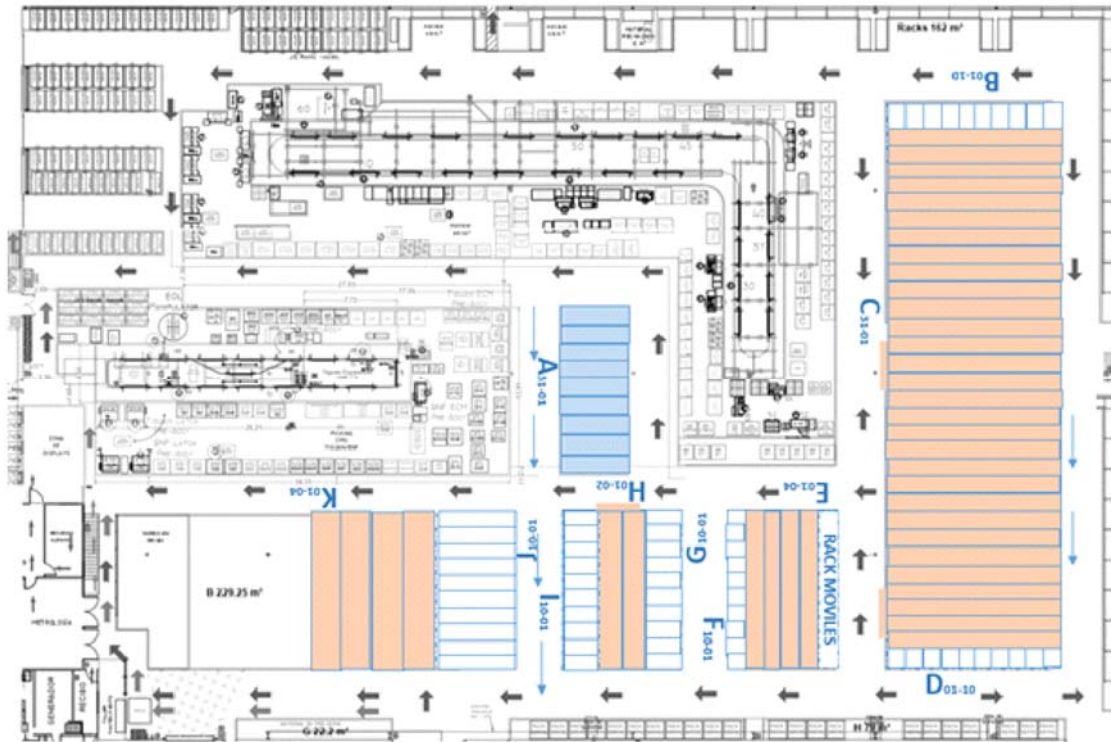
Figure 1. Warehouse layout

4. Model

The developed model delivers a solution to the storage problem of a "tier one vendor with a JIS production system", so that the location of components within the buffer are mapped to the production line and minimize distance from the buffer to its location in the warehouse.

In SLAP the company, 91 frontals with different characteristics must be assembled, each of them consists of a series of different parts with their own frequencies of consumption in the area of picking (AP), which must be located In a specific storage space. The warehouse has L spaces and each of the spaces consists of C storage capacity. Each L is labeled with a unique integer from 1 to L. The distance Dl from L to AP is defined as the Manhattan distance between these two points, which can be calculated by Vl + Hl (Vl and Hl are the vertical distance and Horizontal between position 1 and point of AP). Therefore, the objective of the problem is to minimize the distance of the consumption frequency, which is defined as $\sum_{=1}$, where P_i represents the picking frequency or production line of item i and D_i indicates the distance from the AP to the location of item i. In this way, the same objective was used to accommodate from the production line to the buffer only taking into account that it is the same amount of space between the line and the buffer.

The following restrictions must be satisfied:
- Maximum amount of material to be stored on the islands.
- Frequency (demand) consumption in production line and picking area.

The sets, indices, parameters and decision variables used in the formulation of the Integer Linear Programming Model (PLE) are described below.

Index Set
- L: Set of warehouse locations, where l ε L.
- P: Frequency of consumption of the part (item) i in the picking area or production line, i ε N.

Parameter
- Dl = Vl + Hl: Distance between the location l and the point of arrival of the order (picking area or production line).

Decision Variable
- X_{li}: number of units to be stored in the location l, l ε L, of the consumption frequency i, i ε P.
  The decision variable xli (l = 1, ..., L, i = 1, ..., N) is defined to develop the PLE model describing the SLAP, where l is the number of location ei is the part number (item). Therefore, x_{li} is equal to 1 if item i is assigned to location l and 0 otherwise. The PLE model for PAUA can be expressed as follows:

$$\text{Min } Z(x) = \sum_{l=1}^{L} \sum_{i=1}^{N} P_i * D_l * X_{li} \tag{1}$$

Subject to:

$$\sum_{l=1}^{L} X_{li} = 1, \qquad l = 1, \dots, L \tag{2}$$

$$\sum_{i=1}^{N} X_{li} = 1, \qquad i = 1, \dots, N \tag{3}$$

$$X_{il} \in \{0,1\} \tag{4}$$

The objective function minimizes the total displacement distance of the consumption frequency in the picking area or production line. The distance from position 1 to the picking point or production line is calculated by the vertical and horizontal distance of these two points. Constraint (2) ensures that each part is assigned exactly to a storage location. Constraint (3) ensures that a storage location is occupied by exactly one part.

5. Results
The proposed model for solving the rearrangement within the buffer was solved using the software lingo 11.0, next the model in lingo and its results is presented.

```
model:
sets:
producto;
ubicacion;
arco(producto,ubicacion):costo,x;

endsets

data:

producto= p1 p2 p3 p4 p5 p6 p7 p8 p9 ;
ubicacion= u1 u2 u3 u4 u5 u6 u7 u8 u9 ;

costo=
```

1472	1000	960	1064	1024	612	680	616	588
1564	1050	1000	1102	1056	629	697	630	588
2070	1325	1220	1311	1232	722.5	790.5	707	654
2898	1775	1580	1653	1520	875.5	943.5	833	762
3624.8	2170	1896	1953.2	1772.8	1009.8	1077.8	943.6	856.8
8464	4400	3360	3040	2432	1224	1156	896	720
8004	4150	3160	2850	2272	1139	1071	826	660
7636	3950	3000	2698	2144	1071	1003	770	612
7268	3750	2840	2546	2016	1003	935	714	564

```
;
enddata
```

```
min=@sum(arco(i,j): costo(i,j)*x(i,j));

@for(producto(i):@sum(ubicacion(j):x(i,j))=1);
@for(ubicacion(j):@sum(producto(i):x(i,j))=1);
@for(arco (i,j):@bin(x));
end
```

```
X( P1, U6)        1.000000            660.7059
X( P2, U7)        1.000000            752.4706
X( P3, U4)        1.000000            283.2632
X( P4, U3)        1.000000            308.1000
X( P5, U2)        1.000000            270.8160
X( P6, U1)        1.000000            312.0000
X( P7, U5)        1.000000            692.2500
X( P8, U8)        1.000000            1225.714
X( P9, U9)        1.000000            1222.000
```

Comparison of current status with proposed model

Current location of the 9 components with the most frequency			
Material	Frequency	Current location	Distance per Frequency
5C6805588R	92	A1	54
5C0121251L	50	A2	131
5C0121251M	40	A3	238
5C0820411K	38	A4	357
5QM121251A	32	A5	540
5C6805588Q	17	A6	1,321
5QM816411	17	A7	1,156
5GM807109A	14	A8	1,226
5C0145803E	12	A9	1,222
		Total	6,246

Location proposed by the model for the 9 components			
Material	Frequency	Current location	Distance per Frequency
5C6805588R	92	A6	660
5C0121251L	50	A7	752
5C0121251M	40	A4	283
5C0820411K	38	A3	308
5QM121251A	32	A2	270
5C6805588Q	17	A1	312
5QM816411	17	A5	692
5GM807109A	14	A8	1,225
5C0145803E	12	A9	1,222
		Total	5,724

With the proposed model optimized 8% of the routes of the locations in the production line made the 9 products with the highest frequency of consumption that are in the buffer.

Therefore a new model was proposed for the routes of the locations towards the picking area considering the 9 products of greater frequency of consumption in the line of production taking into account now the new location of these products. The proposed model was made in the Lingo 11.0 software, and the model in the lingo and its result is presented below.

```
model:
sets:
producto;
ubicacion;
arco(producto,ubicacion):costo,x;

endsets
data:

producto= p1 p2 p3 p4 p5 p6 p7 p8 p9 ;
ubicacion= u1 u2 u3 u4 u5 u6 u7 u8 u9 u10
           u11 u12 u13 u14 u15 u16 u17 u18 u19 u20
           u21 u22 u23 u24 u25 u26 u27 u28 u29 u30
           u31 u32 u33 u34 u35 u36 u37 u38 u39 u40
           u41 u42 u43 u44 u45;

costo=
```

19.84	28.39	65.91	80.05	107.74	226.66	131.22	72.43	50.70
28.35	44.05	85.49	100.66	132.21	272.72	177.29	128.37	115.96
36.86	59.72	105.07	121.27	156.68	318.79	223.36	184.30	181.22
45.38	75.38	124.64	141.88	181.16	364.86	269.42	240.24	246.48
53.89	91.04	144.22	162.49	205.63	410.92	315.49	296.18	311.74
62.40	106.70	163.80	183.09	230.10	456.99	361.55	352.11	377.00
70.91	122.37	183.38	203.70	254.57	503.05	407.62	408.05	442.26
79.42	138.03	202.96	224.31	279.05	549.12	453.68	463.99	507.52
33.37	53.29	97.03	112.81	146.64	299.89	204.45	161.35	154.44
25.06	38.00	77.92	92.70	122.75	254.92	159.49	106.75	90.74
55.99	94.91	149.06	167.58	211.67	422.30	326.87	309.99	327.86
61.31	104.71	161.30	180.47	226.98	451.12	355.68	344.98	368.68
66.64	114.50	173.55	193.36	242.29	479.93	384.49	379.97	409.50
71.96	124.30	185.80	206.25	257.60	508.74	413.31	414.96	450.32
127.17	225.89	312.78	339.92	416.33	807.53	712.09	777.77	873.60
122.26	216.84	301.47	328.01	402.19	780.92	685.48	745.46	835.90
117.00	207.17	289.38	315.28	387.08	752.47	657.04	710.91	795.60
111.91	197.81	277.68	302.97	372.45	724.94	629.51	677.49	756.60
107.20	189.13	266.84	291.56	358.90	699.43	604.00	646.51	720.46
102.18	179.90	255.29	279.40	344.47	672.27	576.83	613.53	681.98
97.33	170.98	244.14	267.66	330.53	646.02	550.59	581.66	644.80
92.18	161.49	232.28	255.18	315.71	618.13	522.69	547.78	605.28
87.26	152.44	220.97	243.28	301.57	591.52	496.08	515.47	567.58
86.04	150.20	218.17	240.32	298.06	584.91	489.47	507.45	558.22
89.73	157.00	226.67	249.27	308.69	604.91	509.48	531.74	586.56
94.31	165.42	237.20	260.36	321.85	629.69	534.25	561.82	621.66
99.47	174.91	249.05	272.84	336.67	657.59	562.15	595.70	661.18
104.35	183.89	260.29	284.66	350.71	684.01	588.58	627.79	698.62
109.64	193.63	272.45	297.47	365.92	712.64	617.21	662.55	739.18
114.12	201.86	282.75	308.31	378.79	736.87	641.44	691.97	773.50
118.97	210.79	293.90	320.05	392.73	763.12	667.68	723.84	810.68
123.71	219.52	304.82	331.54	406.38	788.81	693.37	755.04	847.08
129.14	229.51	317.30	344.68	421.98	818.17	722.74	790.70	888.68
133.96	238.37	328.38	356.34	435.83	844.24	748.80	822.34	925.60
138.64	246.98	339.14	367.67	449.28	869.56	774.13	853.10	961.48
143.96	256.78	351.39	380.56	464.59	898.38	802.94	888.09	1002.30
149.12	266.26	363.25	393.04	479.41	926.27	830.84	921.96	1041.82
153.86	275.00	374.17	404.53	493.06	951.97	856.53	953.16	1078.22
158.48	283.48	384.77	415.70	506.32	976.93	881.49	983.47	1113.58
163.49	292.72	396.32	427.85	520.75	1004.09	908.65	1016.45	1152.06
168.24	301.45	407.24	439.35	534.40	1029.78	934.35	1047.65	1188.46
173.40	310.94	419.09	451.83	549.22	1057.68	962.24	1081.53	1227.98
178.15	319.68	430.01	463.32	562.87	1083.37	987.94	1112.73	1264.38
184.42	331.22	444.44	478.51	580.91	1117.33	1021.89	1153.95	1312.48
188.49	338.71	453.80	488.36	592.61	1139.35	1043.92	1180.70	1343.68

```
;
enddata

min=@sum(arco(i,j): costo(i,j)*x(i,j));

@for(producto(i):@sum(ubicacion(j):x(i,j))=1);
@for(ubicacion(j):@sum(producto(i):x(i,j))<=1);
@for(arco (i,j):@bin(x));

end

X( P1, U2)         1.000000          28.39000
X( P2, U38)        1.000000          38.00000
X( P3, U11)        1.000000          104.7100
X( P4, U37)        1.000000          102.1800
X( P5, U29)        1.000000          150.2000
X( P6, U1)         1.000000          94.31000
X( P7, U10)        1.000000          123.7100
X( P8, U28)        1.000000          158.4800
```

```
X( P9, U19)          1.000000              178.1500
```

Current location of the 9 components with the most frequency			
Material	Frequency	Current location	Distance per Frequency
5C6805588R	92	1E-04	94
5C0121251L	50	1C-30	371.77
5C0121251M	40	1C-05	276.98
5C0820411K	38	1C-27	428.67
5QM121251A	32	1C-24	455.03
5C6805588Q	17	1H-01	180.59
5QM816411	17	1C-07	502.87
5GM807109A	14	1C-22	888.08
5C0145803E	12	1C-17	810.68
		Total	4008.7

Location proposed by the model for the 9 components			
Material	Frequency	Current location	Distance per Frequency
5C6805588R	92	1K-02	28.35
5C0121251L	50	1C-24	331.22
5C0121251M	40	1C-11	149.06
5C0820411K	38	1C-23	393.04
5QM121251A	32	1C-18	365.92
5C6805588Q	17	K-01	226.66
5QM816411	17	1H-02	159.49
5GM807109A	14	1C-14	1081.53
5C0145803E	12	1C-05	888.68
		Total	3623.935496

The proposed model optimizes 10% of the routes of the locations towards the picking area considering the 9 products that have the highest frequency of consumption in the production line.

6. Conclusions

In this study, we investigated a Storage Location Allocation Problem (SLAP), the problem is defined with a linear programming formulation to find the optimal allocation of items at a minimum operating cost. The instance to be solved is a real problem of a supplier company level 1 of the automotive industry, in addition to working with a production system Just In Sequence. When applying the model in the picking area, savings of approximately XXX percent of daily trips from the locations to the buffer (picking) were obtained. The resolution of the model took less than a minute, despite being a combinatorial problem. This shows that the model can be applied in the company to make operational decisions of storage, due to the low computational time that demands to solve the more complex situation that it has.

Finally, the nobility of the model and the operations of the company allow to carry out another study considering 1) the costs of transport from the place of arrival of the orders to the warehouse, to the storage locations of each order, 2) costs associated with distances Between the units of the same order that are stored in different locations, 3) the storage capacity of each location, and 4) the time of transfer of the components of the locations to the picking area or production line.

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