Standardization of Packaging Materials for Various Products and Cost Optimization in Packaging

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ABOUT YATSAN

YATSAN was founded **in 1974** as a manufacturer of **bed products** and has **60.000 m^2** production plant **in Torbalı.**

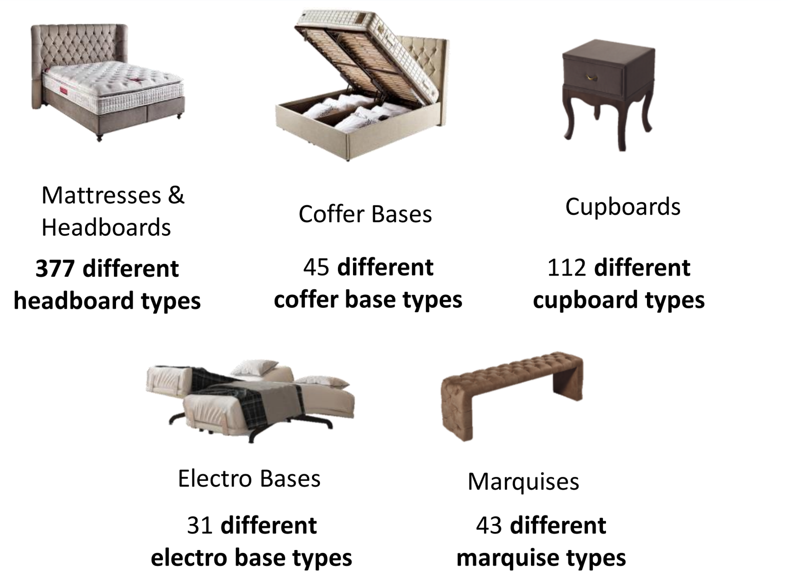
There are **213 white collars** and **480 blue collars** in the company.

The **production capacity** of the company is *700 mattresses per day.*

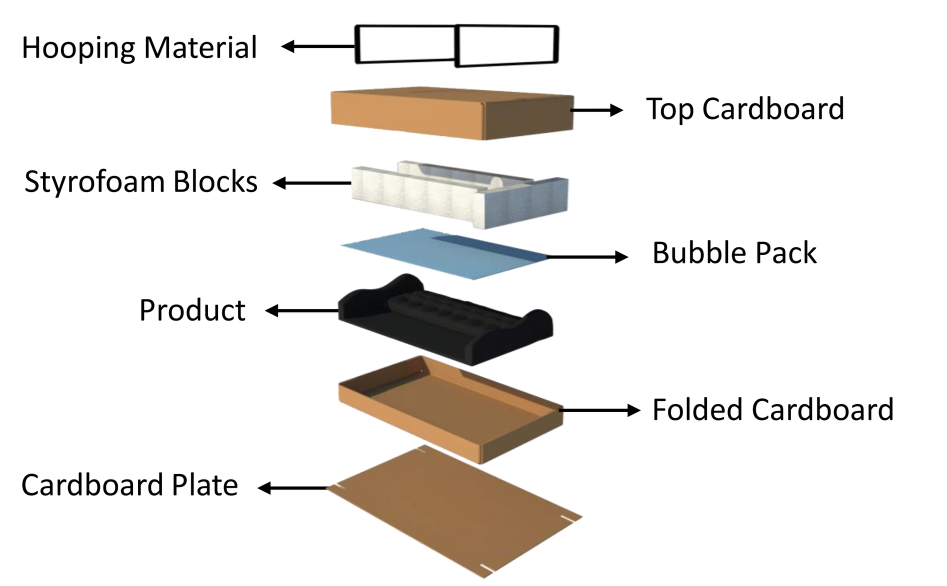
The company has **100 stores in 23 provinces** and **serves in 500 sales points in 52 different** countries.

The company has **40% market share** in mattresses.

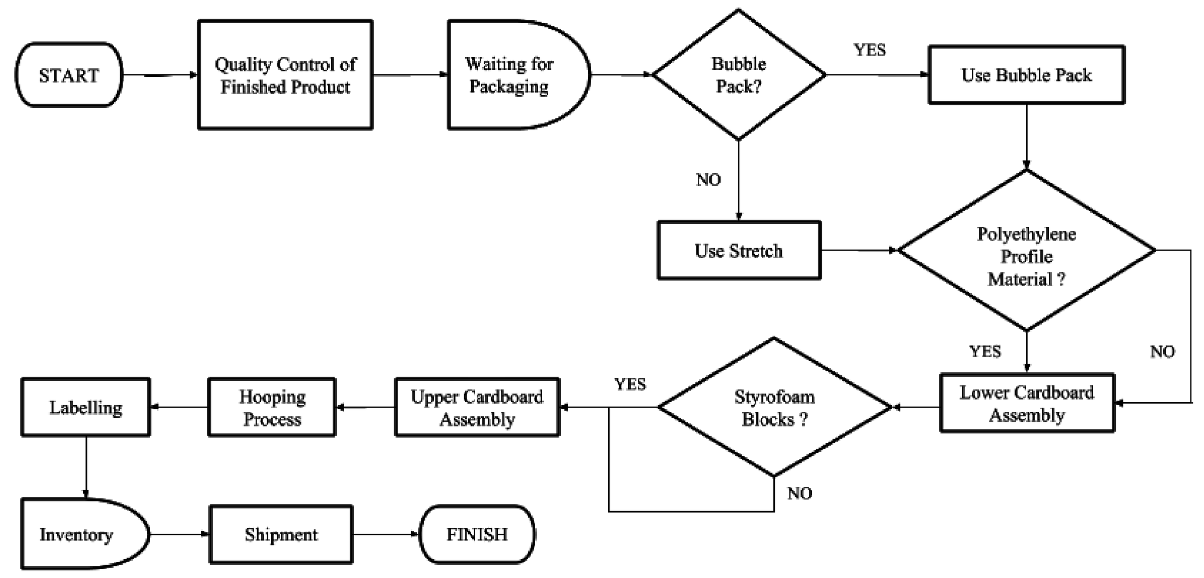
PRODUCTS OF THE COMPANY



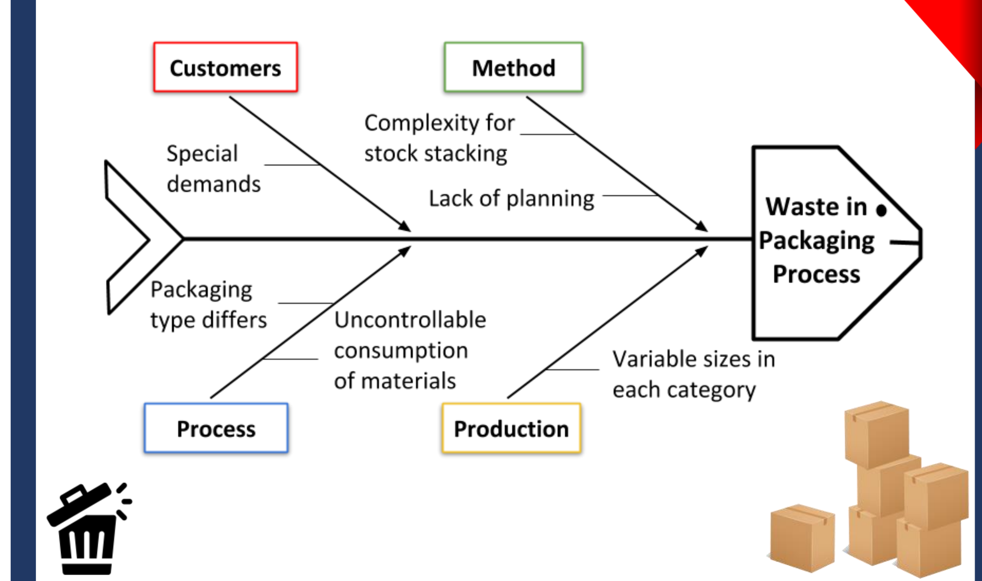
PACKAGING MATERIALS



PACKAGING PROCESS



SYMPTOMS



PROBLEM DEFINITION

- Since Yatsan cares importance to the special demands of their customers, the company produces variable sizes of products.
- The absence of a standard packaging system in the company causes **an excess** or **lack of cardboard stocks.**
- Employees choose the appropriate cardboard sizes for products **based on their own experience.**
- It causes **difficulty in stock tracking** of cardboards.
- The current packaging system **wastes packaging materials** in significant amounts.

LITERATURE REVIEW

Author	Year	Problem	Objective Function	Method
Wilson, R.C.	1965	A Packaging Problem	Minimize the fixed cost of having box sizes in the system and the total operating cost of boxes in the system	Integer Programming & Heuristic Solution Procedure
Ilıcak, I.	2003	Bi-objective Bin-Packaging Problems	Minimize the total number of bins used and the total overdeviation	MIP
Wu et al.	2015	3D Variable Size Bin-Packing Problem	Maximize the volume of the items packed	Three-stage Heuristic Algorithm
Haouari, M., & Serairi, M.	2009	Variable-sized Bin-Packing Problem	Minimize the total cost of the selected bins	A Set Covering-based Heuristic
S.M. Lee	1973	Goal programming for decision analysis of multiple objectives	Decision analysis of multiple objectives	Goal Programming

PERFORMANCE MEASURES

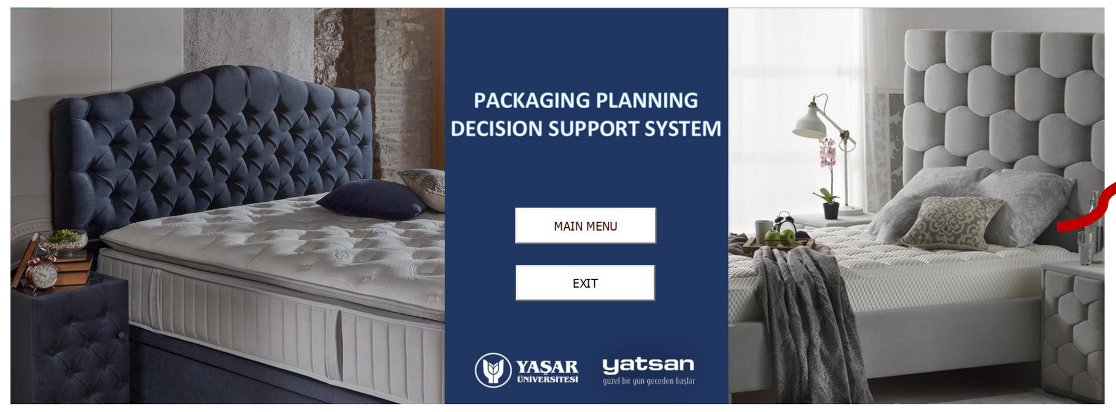
REDUCTION IN
- Total cardboard waste
- Total cardboard variety
- Total packaging cost

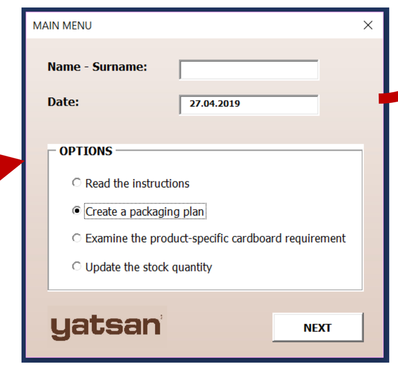
AIM OF THE PROJECT

- **Standardizing the packaging** by creating common packaging sizes in each product group
- **Decreasing waste** in the packaging system
- **Cost reduction** in the packaging system
- **Reducing the inventory** of cardboards by decreasing the number of different package sizes

STANDARD

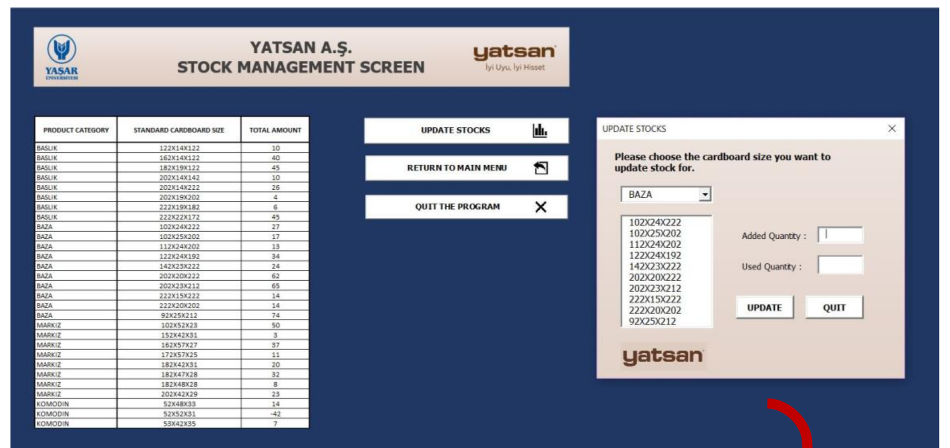
DECISION SUPPORT SYSTEM

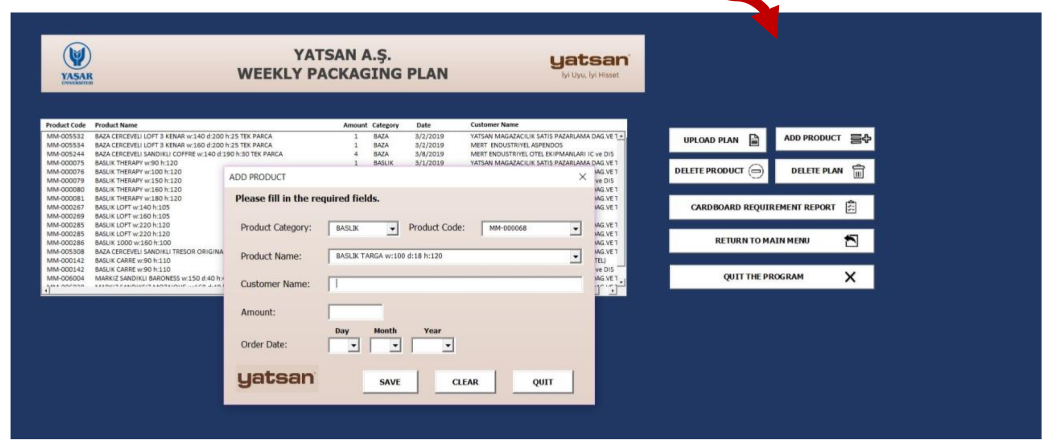




STEP 1:
When the user selects one of the 4 options in the main menu user form, the user is directed to the corresponding screen.

STEP 2:
If the second option is selected, the user will be directed to the Packaging Plan screen. The user can make changes to the plan on this screen.

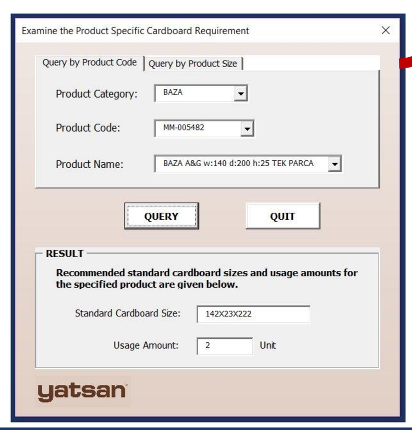




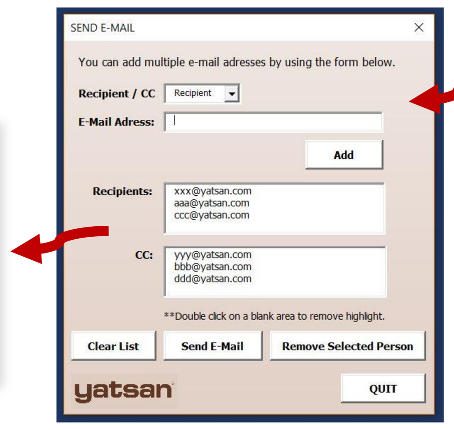
STEP 5:
This user form allows the user to query the cardboard requirement of a product by using the product code and product name or by simply entering the product size.

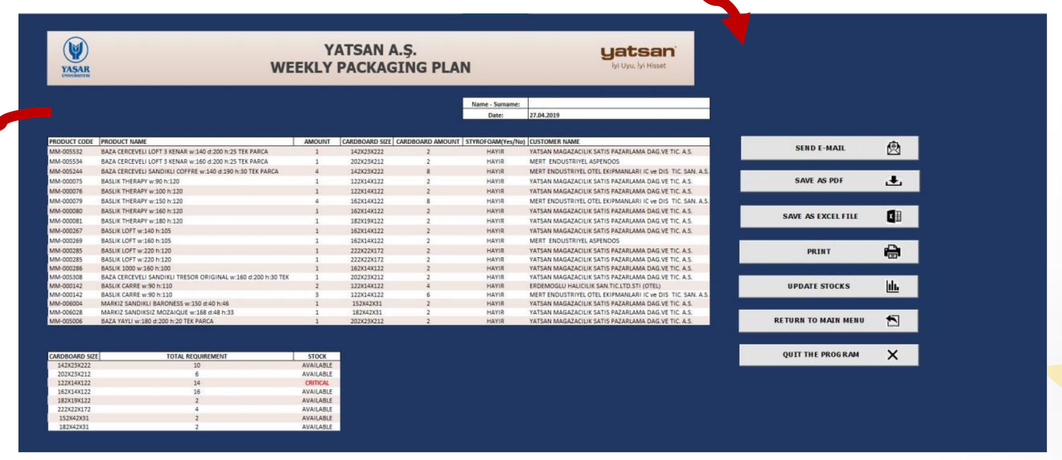
STEP 6:
On this interface the user selects the cardboard size which he wants to update the stock quantity.

STEP 3:
The standard cardboard sizes are assigned to the products in the packaging plan, Styrofoam usage status is indicated, the total cardboard requirements are calculated and finally, inventory control is made for each cardboard size to be used according to the plan.

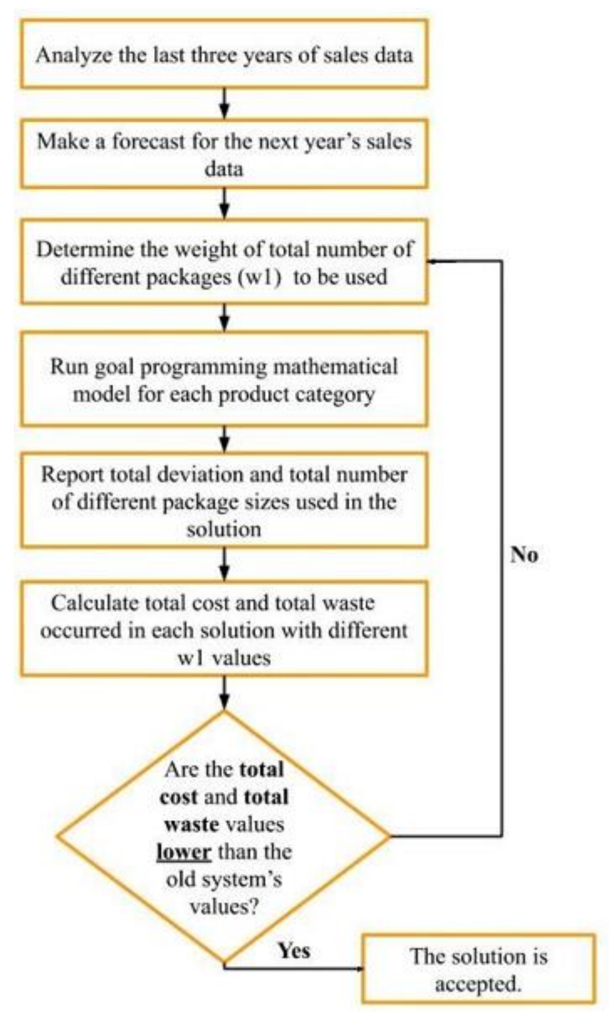


STEP 4:
Cardboard Requirement Report can be sent to the desired people by e-mail by using this form.





SOLUTION METHODOLOGY



FORMULATION OF THE MATHEMATICAL MODEL

Sets & Indices :

i: Products in different size, $i \in N$

j: Packages in different size, $j \in M$

d: Dimension index, $d = 1,2,3$,

1 refers to width, 2 refers to depth, 3 refers to height

Parameters :

z_{id} = size of d^{th} dimension of product i

a_{jd} = size of d^{th} dimension of package j

f_i = forecasted demand of product i

w_1 = the weight of total number of different packages used

w_2 = the weight of total deviation of the package sizes from product sizes

Decision Variables:

$$x_{ij} = \begin{cases} 1, & \text{if product i is assigned to package j} \\ 0, & \text{otherwise} \end{cases}$$

$$y_j = \begin{cases} 1, & \text{if package j is selected} \\ 0, & \text{otherwise} \end{cases}$$

Objective Function :

$$\text{Min} \quad \mathbf{w_1} \cdot \sum_{j=1}^{M} y_j + \mathbf{w_2} \cdot \sum_{i=1}^{N} \sum_{j=1}^{M} f_i \cdot x_{ij} \cdot ((a_{j1} - z_{i1}) + (a_{j2} - z_{i2}) + (a_{j3} - z_{i3})) \qquad (1)$$

Constraints:

$$\sum_{j=1}^{m} x_{ij} = 1 \qquad \forall i \in N \qquad (2)$$

Each product is assigned to exactly one package

$$x_{ij} \leq y_j \qquad \forall i \in N, j \in M \qquad (3)$$

If a product is assigned to a package, then the package should be used.

$$a_{j1} - z_{i1} \geq -M(1 - x_{ij}) \qquad \forall i \in N, j \in M \qquad (4)$$

$$a_{j2} - z_{i2} \geq -M(1 - x_{ij}) \qquad \forall i \in N, j \in M \qquad (5)$$

$$a_{j3} - z_{i3} \geq -M(1 - x_{ij}) \qquad \forall i \in N, j \in M \qquad (6)$$

Constraints to prevent assignment of the product to a smaller package size

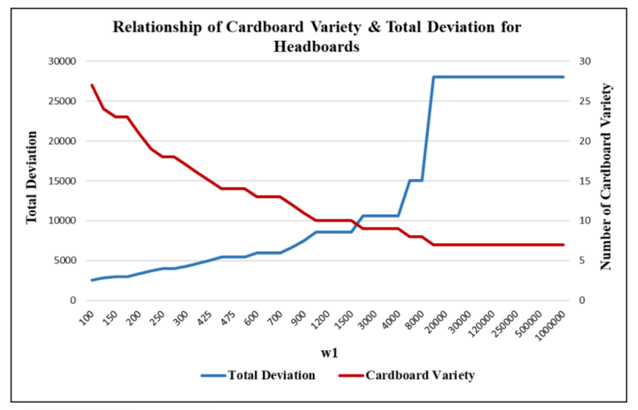
$$\sum_{j=1}^{N} x_{ij} \geq y_j \qquad j \in M \qquad (7)$$

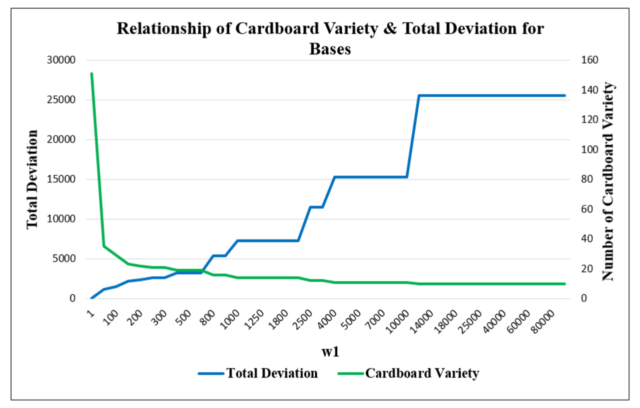
If there is no product size assigned to a package size, then the package size is not selected.

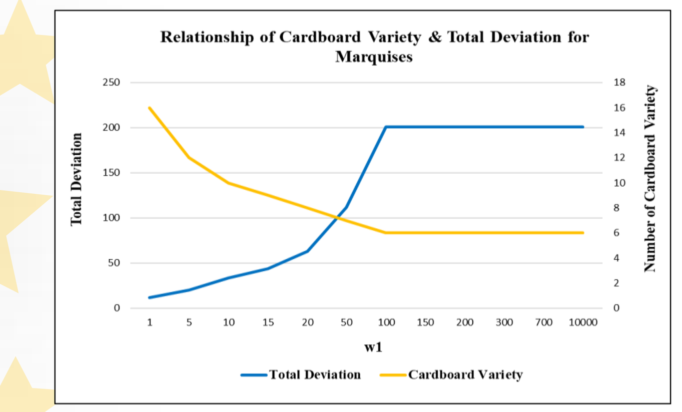
$$x_{ij}, y_j \in \{0, 1\} \qquad \forall i \in N, j \in M \qquad (8)$$

Domain of variables

VALIDATION, COMPARISON AND IMPROVEMENTS







In each product category, w_1 values which give better results in the total amount of waste and the total number of packages used have been accepted as the optimal solution.

Total Packaging Cost & Total Waste Comparisons

Category	w1	Number of Cardboard Variety	Total Waste Level of Old Packaging System (cm^2)	Total Waste Level of New Packaging System (cm^2)	Percentage Improvement (%)
Bases	12000	10	13078412,75	9657168	26
Headboards	1100	8	5627897,75	4113180	27
Marquises	20	8	120188	67826	44
Cupboards	Noneffective	3	-	-	-

Category	w1	Number of Cardboard Variety	Total Cost of Old Packaging System (TL)	Total Cost of New Packaging System (TL)	Percentage Improvement (%)
Bases	12000	10	19295,84	18435,54	4,46
Headboards	1100	8	6875,12	6143,82	10,64
Marquises	20	8	296,74	145,6	50,93
Cupboards	Noneffective	3	-	-	-

Category	Total Number of Different Product Sizes
Bases	504
Headboards	1385
Marquises	72
Cupboards	4

Standard Package Sizes

Product Category

Bases		Headboards		Marquises		Cupboards
102X24X222	202X20X222	122X14X122	202X14X222	102X52X23	182X42X31	52X48X33
102X25X202	202X23X212	162X14X122	202X19X202	152X42X31	182X47X28	52X52X31
112X24X202	222X15X222	182X19X122	222X19X182	162X57X27	182X48X28	53X42X35
122X24X192	222X20X202	202X14X142	222X22X172	172X57X25	202X42X29	
142X23X222	92X25X212					

Improvement in Headboard Category
10,64 %
27 %

Improvement in Base Category
4,46 %
26 %

Improvement in Marquise Category
50,93 %
44 %

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