Implementation of Rail Loading and Gold Bullion, Silver Ounces and Supplies for the Mining of Precious Materials and Gems

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ABSTRACT
The following article describes the logistics analysis on one of the commonly detected problems in trains, associated with BINPACKING, as it is, the wagon's load, by transporting precious materials extracted from the mines in the state of Chihuahua, as they are: gold ingots, silver ounces and precious gemstones, it has also analyzed the supplies transportation for subterranean mining in the state, which results complicated when optimizing space for good arrangement, to be able to take advantage of the total cargo capacity and the time this process takes.

The main goal was utilizing an algorithm for the optimization of the cargo and the materials arrangement to transport them from the city of Chihuahua to Los Mochis, Sinaloa. The freight train line to utilize is FERROMEX, one of the most representative in the country. It's important to consider the client's requirements and the wagon's capacity to assure the supplying of this materials effectively. We utilized data that allowed doing simulations in the MATLAB software by VRP (Vehicle Routing Problem) to optimize the routes they will follow for the materials and supplies transportation to afterwards realize the load in the FERROMEX's train wagons.

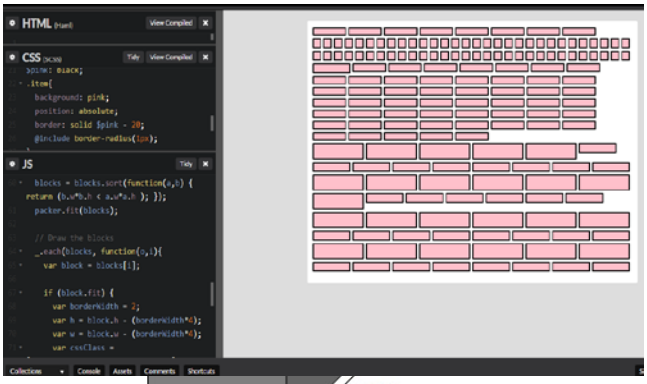
Keywords
Trains; BINPACKING; cargo; MATLAB; VRP.

1. INTRODUCTION
Mineral commercialization allows us to define the supply and demand of mining products in a plane of time, in function of the calculus of the type and quantity of mineral products the different industry actors will produce and consume in the future, satisfying the client's, actionists', provider's and society's needs to contribute to the country's development. The freight train is considered as the best option to transport minerals given their main advantages attributed to low cost, low energy consumption and it avoids traffic, above all. For instance, logistics has more importance for the organizations because consumers demand greater quality, the growth level and economic stability depends on an excellent merchandise distribution.

In the present investigation it is presented an option for train transportation of the enterprise FERROMEX, of materials extracted from different mines in the state of Chihuahua specially: Santa Bárbara, El Oro and Parral joined to the mining machinery utilized in subterranean mines; applying VRP for the transport routes optimization, by the MATLAB software.

2. PROBLEM DESCRIPTION
In Mexico there are many markets and corridors of loading large-volume where the rail transport services of load are bear the "heavy burden" of land transport. Thus contribute to promote national economic development by giving the producers, importers and exporters access to transport services of great capacity for a likely cost lower than for roadway transport. The prospects generated in terms of development make the performance of the industry of rail transport of loads a matter of public interest in Mexico, as in many other countries. The rail service was a fundamental element in the process of industrialization of Mexico. The expansion and deregulation of other means of transport generated to decline in its activity. Faced with the need to compete in the global market with efficient transport and economic, in the mid-nineties Mexico concessions rail services to companies in the private sector. This same situation is lived in other countries, mainly in Europe and Latin America. The granting of the rail service had as an objective to create more infrastructure, modernize the structure internal trade, count with efficient transport and economic, encourage competitiveness in the economy and provide benefits in terms of mobility. To realize the concessions had to modify the Constitutional Article 28, by changing to the railways the recognition of strategic area by the priority area for national development, and consequently created the Regulatory Law of rail service. It should be noted that this measure, which is necessary for the momentum of the railways as a means of transport intervener of economic development, had not had the necessary support in the law which has no measures to ensure in its entirety

the objectives [4]. According to the Global Competitiveness Report 2013-2014 of the World Economic Forum, the quality of the railway infrastructure in Mexico occupies the position 60 with



a rating of 2.8 of a maximum of 7 points and below possible, the average of 3.2 points of a set of 121 countries. The extension, penetration and capillarity of the network has caused that industries that transport their products or source of raw materials used the trucking of load, despite which they could have recourse to the intense use of the railway should it be of greater efficiency and lower risk to the characteristics of the transported [4]. Currently, the railway serves

Precious Material Issue	Profundity	Width	Height	Weight (Kg)
Gold ingot	250 mm	70 mm	35 mm	12.5
Lead wall	350 mm	110 mm	60 mm	26
Silver Bar	300 mm	80 mm	50 mm	12.6
Box containing gems	50 mm	50 mm	50 mm	7.87

to large industrial customers, while medium and small producers have not benefited. Eliminated entire routes arguing the low profitability; it has conditioned the service to complete wagons, and the passenger service decreased in 80%. In reality, the process generated two monopolies that, without competition, not contributed to national development. This structure of the industry of rail service promotes an environment of competition and make indispensable interconnection between lines [4].

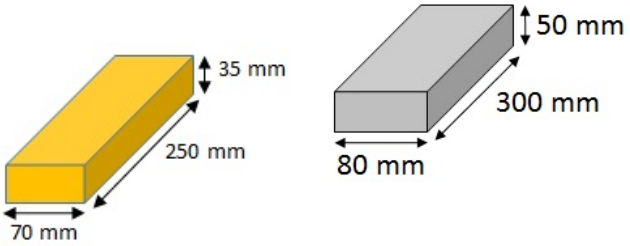


Figure 1. Representation of elements to transport in Train.

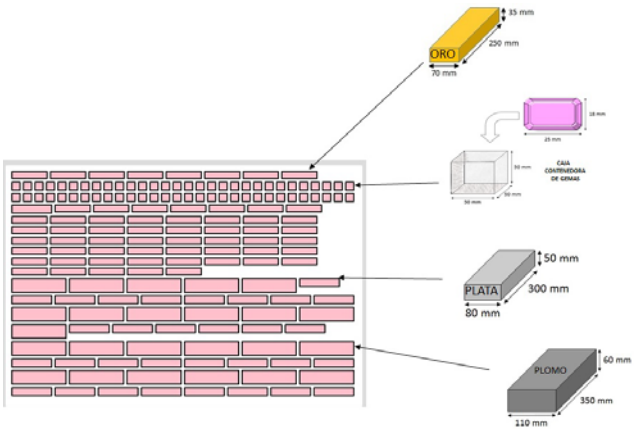
Table 1. Dimensions of each element in the model to represent

We propose the use of an Intelligent Emulator which can calculate the correct distribution of material as in Figure 2.

Figure 2. Use of Bin Packing Emulator to represent the correct ordination in the wagon.

3. PROBLEMATICAL REPRESENTATION OF KNOWLEDGE

Ternium is a steel producer company leader in the Latin American market. Account with integrated processes for the manufacture of steel and derivatives, with the highest technology. Is the largest manufacturer of finished steel products in Latin America. Caters to customers from a variety of industries such as automotive, construction, metalworking, white line, packaging, energy and transport. Ternium and its subsidiaries have 16 production centers in Argentina, Colombia, United States, Guatemala and Mexico [8]. It also integrates the control group of Usiminas jointly with Nippon Steel & Sumitomo Metal Corporation (NSSMC) and housing of employees of Usiminas. With a solid position, provides high complexity steels to major markets in the region. Ternium develops through strong steels productive integration. Its plants cover the entire process of manufacture, from the mining of iron ore to the manufacture of high value added products, and promotes the development of the companies of the metal mechanic sector. The production capacity of Ternium is 10.8 million tonnes of finished steel per year [8]. The rolls of hot-rolled steel are inputs for the manufacture of intermediate and capital goods, for example: automotive parts, profiles, structures, pressure vessels and piping, among others. Additionally, the own steel industry uses the hot foil as an input to produce foil cold rolled over [5]. For that reason the company Ternium uses the system of rail transport on the basis of the city of the city of Monterrey to the city of Puebla for the relocation of its products.



For the transport of coated steel rolls (1.22 MT), you need a platform with the specifications (Table 1) for the accommodation of the rolls of steel and specific mineral as is shown in Figure 3.

Figure 3. Specification of each issue in the railway transport

4. METHODOLOGY

To optimize the arrangement of the rolls coated in wagons for your transportation, is a clear problem of distribution of objects in wagons (bin packing). Classic problem of combinatorial optimization NP-hard, in which there is a sequence of n objects L= {a1, a2…….an} with a given size 0 < S(a1)≤C and a limited number of containers ,each of capacity C. The objective is to determine the number of containers in which all objects can be distributed, the expression expresses this problem, given [10]: N= number of objects to distribute, in where C= Capacity of the platform I=sequence of n objects to1 S1 (A1)= size of each object ai Find a minimum partition of L minimum , L= B1 or B2 u. U BM Such that in each set bj the sum of the size of each object s(ai) In Bj , does not exceed c. To make the arrangement of the rolls of steel is used a genetic algorithm that will be run on the Matlab software to generate the solution of a better optimization of the spaces in the platform. Table 2 shows the pseudocode to use [10].

Table 2. Genetic Algorithm hybrid of grouping for BPP:

1 Start

2 Initialize parameters: max_gen, L2, gen1, gen2

3 Generate initial population with PI_D-A

4 while generation < max_gen and best solution > L2

5 Select individuals to cross in proportion to their aptitude.

6 Apply Crossing_BFD and generate new individuals.

7 Substitute the worst individuals for the new individuals.

8 Apply Mutation_RV to the worst individuals.

9 If generation > gen1

10 Clone the best individuals of the population

11 Apply Mutation_RpP to the cloned individuals

12 Substitute the worst individuals for the cloned individuals

13 End if

14 Apply Delete_by_Substitution to the repeated individuals

15 If generation > gen2

16 Select the best individuals to cross

17 Apply Crossing_RpP to generate new_individuals

18 Substitute the worst individuals for the new_individuals

19 End if

20 Register the best_solution

21 End while

22 End procedure

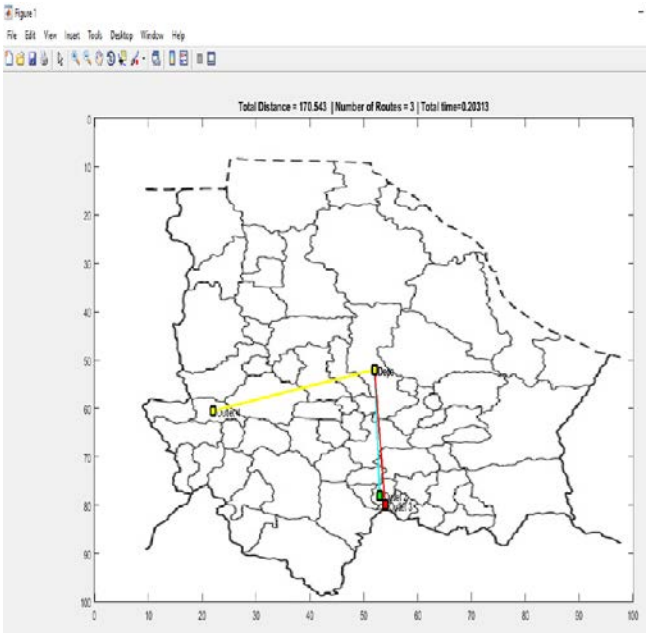


Figure 4. Representation of VRP with the optimal routes to Railway system.

To do this although there are a number of definitions of products made of steel or other metals that can be presented in the form of rolls of better known as steel coils, and defined in the UNE- EN 10.079:1992'[3].

Once taking the best form of accommodation will take the times, the possibility to optimize the times of loading and unloading. To do this use the orthogonal arrangements are designs proposed by Taguchi which, as its name indicates, have the property of orthogonality, same that also possess the factorial designs classics. These arrangements are fractionated factorial designs complete, or mixed, depending on the number of factors to consider in a particular case [6]. For the calculation of the time will be the orthogonal method, better known as Taguchi method. The analytic tool used are usually factorial designs fractionated, however when the number of factors is increased, possible interactions increase, as well as the complications to identify what are the specific conditions to experience. An Orthogonal arrangement can be compared with a fractional factorial replication, so that preserves the concept of orthogonality and contrasts. A fractional factorial experiment is also a settlement orthogonal. Taguchi developed a

series of specific arrangements called [12]: La (b)C

factor	Description	Level 1	Level 2
A	Machine	A	B
B	Weight of steel roll	4 T	24 T
C	Turn	1	2
D	Distance traveled	200	700
E	Operator	1	2

(2)

Where: a = Represents the number of tests or experimental conditions to be taken. This is the number of lines or lines in the settlement. b = Represents the different levels to which they will take every factor. c = Is the number of independent effects that you can analyze, this is the number of columns. To perform a better optimization in the times will be through the use of hypothetical data due to the lack of actual data in the time calculation of loading and unloading of the rolls or steel coils.

Table 3. Number of factors and descriptions of each issue.

5. DESIGN OF EXPERIMENTS

As mentioned, through the usage of MATLAB run the genetic algorithm in order to accommodate the rolls of steel in the best way possible by minimizing the spaces in the railway platform. In table 5 the measures to use of the rolls. To run once every type of roll in software, with the selected instances to observe its behavior.

Table 4. Steel roll specifications

Types of rolls	Length (m)	Width (m)
1	1.5	1,2
2	2	1.9

To perform the experiment was implemented a genetic algorithm, with a capacity of population of 500 and 5000 generations. In Figure 4 shows part of the algorithm to use to insert the selected instances of the rolls.

Using the orthogonal design of Taguchi aims to obtain the most significant factors with respect to the time of loading and unloading. For the experiment were used 3 controllable factors which are the types of machine to uses either crane of clamps and crane hook type c, weight of the steel coils, work shifts and 2 non-controllable factors, is the distance travelled and the operators involved in the load. In this way should be carried out 8 runs with the goal of finding the shortest possible time of all the bullfights.

Table 5. The load factors

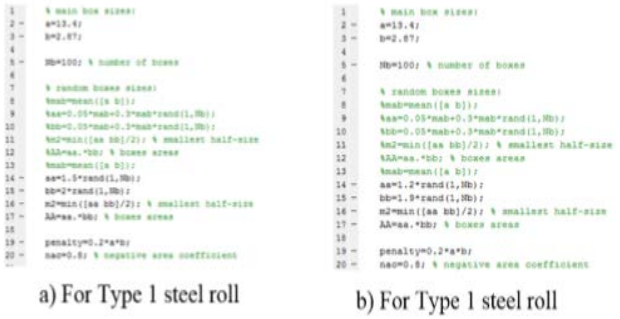


Figure 5. Code in Matlab.

6. ANALYSIS AND DISCUSSION OF RESULTS

As mentioned in the literature, tests were carried out in the Matlab software to display the possible accommodations in the platform, for your transportation. In the event, through the modification and the use of a genetic algorithm, it was decided to find a possible solution to the problem of Bin Packing for this two types are used two instances to the rolls of steel. In the bullfight 1 (Figure 6 A) instances used were of 1.9 m long and 1.2 wide. The second bullfights (Figure 6 B) is 2 m long by 1.5 m wide. Both with a population of 100.

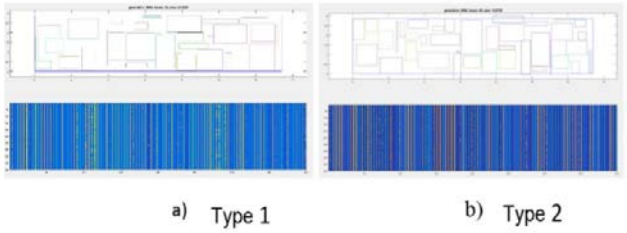


Figure 6. Implementation of the algorithm in Matlab.

As mentioned in the previous figure, in the first run is obtained 40 boxes, that by multiplying the weight in tons exceeds the permitted weight. In the second run is visualized 30 boxes generated by the use of the algorithm. When performing the bullfights Minitab for the design of the experiment were gets some graphs called noise signal. These tables identify the most significant value that you want to find. In that case to the problem, the most significant values are the shifts and the machines (cranes) specified in figure 7. Through the use of the orthogonal design was analyzed the estimation of the contribution of the individual factors that influence the load - download the rolls of steel.

	Machine	Weight of steel roll	Turn	Distance travelled ofthe crane	Operator	Y(Loading time)
1	1	1	1	1	1	3.07
2	1	1	1	2	2	2.56
3	1	2	2	1	1	4.35
4	1	2	2	2	2	3.35
5	2	1	2	1	2	5.01
6	2	1	2	2	1	4.17
7	2	2	1	1	2	3.26
8	2	2	1	2	1	4.37

Análisis de Taguchi: y (tiempo dec vs. Maquina, Pso del roll, Turno, ...

Tabla de respuesta para relaciones de señal a ruido
Más grande es mejor

Nivel	Maquina	Peso del rollo	Turno	Distancia Recorrida por la grúa	Operadores
1	10.29	11.08	10.25	11.69	11.93
2	12.37	11.59	12.42	10.97	10.73
Delta	2.07	0.51	2.17	0.72	1.20
Clasificar	2	5	1	4	3

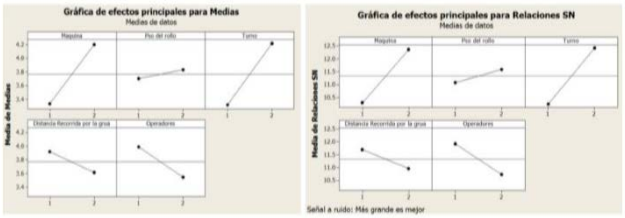


Figure 7. Graphs of stockings and relationships of noise.

Making a connection with the figure 6 of the graphics, you can confirm which are the most significant factors for the load delos steel coils, mentioned above. The following table and displays the Taguchi analysis performed in the Minitab.

Table 6. Taguchi analysis generated in Minitab.

According to the results obtained for the time of accommodation in the transport must be performed to accommodate the time of unloading in the following design. On the basis of the results obtained in the experiment, the bullfights, it was found that the average is 4.0625, this means that you have to improve in the management of the use of the cranes. Other factors that affect is the turn as well as the use of cranes, an implementation in order to resolve this problem is the use of cranes. As can be seen to hold this type of materials is necessary to use mooring direct and indirect. The mooring indirect secure ground, it gives resistance to lateral and longitudinal movement of the rolls. While the direct ties anchored the rolls of steel. To perform this process, it is necessary to count with the mooring straps, cables or chains, taking into account the voltage of these materials.

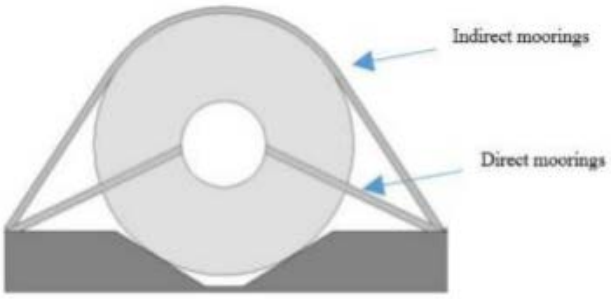


Figure 8. Types of mooring

7. CONCLUSIONS AND RECOMMENDATIONS

After performing the bullfights, it was noted that the software we generated a greater number of boxes, due to the fact that only took the measures of the rolls, but taking another variable to improve this process would be the weight, what is needed to make further modifications to the genetic algorithm. Through the use of the orthogonal design was analyzed the estimation of the contribution of the individual factors that influence the loading - Unloading the rolls of steel. These times could be improved with the use of more cranes but this would result in higher costs to the company due to the shift and more operators, as well as earn the best condition for a process, so that the characteristics in a good quality can be sustained. For future work with respect to the design of experiments you can find more factors and make a greater amount of runs with the aim of improving this procedure. Also can implementing a VRP to perform the possible stops that could be along the route that goes from City of Monterrey to the city of Puebla. For transport requires the use of non-slip elements between the rolls of steel and the support, since it is considered to be essential in the transport of these products. The steel coils of mooring and subject will be duly approved and be ruled out in the event of breakage, wear or deformation of the same. As mentioned it is essential to make use of the standards set by the government agencies for its better transportation.

8. ACKNOWLEDGEMENTS

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