Novel cryogenic coupling for loading LPG bullet truck

Goutam Kumar Bose¹ and Tapas Kumar Mandal²

¹Mechanical Engineering Department, Haldia Institute of Technology, Haldia, Purba Medinipur, West Bengal, India. Pin 721657.
²Department of Process, Indian Oil Petronas Pvt. Ltd. Haldia, Purba Medinipur, West Bengal, India. Pin 721657.

E-mail: gkbose@yahoo.com, mandalt72@yahoo.com

Abstract This research work has been carried out in the Indian Oil Petronas private limited company’s plant located at Haldia, West Bengal, India. The study is related to the LPG Bullet Truck Loading. Due to higher customers (Cooking gas) demand it was necessary to improve the productivity of the gantry by about 10% to face the increasing demand. The time of LPG Bullet Truck fitting with loading arm needed improvement. This work is related to develop the bullet trucks loading capacity of the terminal to face the increasing demand. After successfully implementing the improved cryogenic coupling for loading the bullet truck the productivity improvement took place. The LPG bullet truck loading is increased average from 315 bullet trucks per day to 357 bullet trucks per day or LPG loading 5512.5 MT per day to 6247.5 MT per day i.e. equivalent to increase bullet trucks loading by 13 %. This will eventually save cost.

Keywords: Bullet truck, Cryogenic coupling, Productivity improvement, Cost saving

1. Introduction

There are various bottling plants both private unit and PSU unit which can undertake to supply the extra demand of LPG day to day, but one should their existing resources to maximize the profit. Considering all possible ways and safety, in order to improve the production, the time of bullet trucks fitting with loading arm has to be reduced using modern temporary fixing method which can minimize the fixing time.

A real multi-compartment container loading problem arises in the liquefied material distribution under several practical constraints [1]. The problem for a logistics company is that it has to serve its customers by first putting the products on pallets and then loading the pallets into trucks [2]. The multi container loading problem of a company can be developed and solved through integer linear models [3]. A two-stage packing problem can be solved for a daily distribution process of a trading company [4]. Therefore a container loading problem can be dealt with frequently with the help of operations research [5]. A tree search algorithm for the three-dimensional container loading problem (3D-CLP) can be developed. The 3D-CLP is the problem of loading a subset of a given set of rectangular boxes into a rectangular container so that the packing volume is maximized [6]. The existing approaches to container loading problems are each applicable only to a narrow part of the spectrum of situations encountered in practice and that there are many
scenarios for which there are no adequate methodologies [7]. There are some characteristics of major accidents in the petrochemical sector included in the major accident reporting system (MARS). Through the statistical analysis focused on the main categorization fields of the MARS short reports and additionally a refinement of the immediate causes of major accidents with focus on the organizational factors can be attempted through the details provided in the full reports [8]. A specific analysis of the accidents occurred in the 21st century can be performed by comparing them with the total set of accidents. Finally, a set of specific recommendations can be inferred from the results provided [9]. Several researchers have contributed their work related to the container loading problem, accidents related to the petroleum industry and routing problems of container vehicles. Attanasio et. al. (2007) has studied about the variants of the Three-dimensional Loading Capacitated Vehicle Routing Problem (3L-CVRP) a MILP model is proposed for the periodic 3L-CVRP. Pedruzzi et.al. (2016) has conducted a logistical study using a mathematical model based on the Three-dimensional Bin Packing Problem to optimize the arrangement of boxes inside the vehicles, leading to a better use of the vehicle’s volumetric capacity to transport food. Haessler and Talbot (1990), presents a complex computer-based heuristic procedure for sizing customer orders and developing three dimensional load diagrams for rail and truck shipment of low density products. Chen et al. (1995) for the problem of loading a single container with variable height and proposed a solution for 3D-BPP based on Genetic Algorithms. Oueidat et.al. (2015) has aimed is to assess whether the prescribed safety program covers all of the system's phases; namely operations and audits. Moura and Oliveira (2009) present a framework to integrate these two problems using two different resolutions methods the Vehicle Routing Problem with Time Windows and the Container Loading Problem. Sanjeeb et.al. (2010) has studied the separation problem for single-constraint sets and show that it can be solved in polynomial time when the resulting inequality is required to be sufficiently different from the associated MIR inequalities.

This study has been carried out in the Indian Oil Petronas Private Limited company’s plant located at Haldia, West Bengal, India. The current work is related to loading of LPG Bullet trucks. The average capacity of the bullet truck is about 17.5 MT. There are 16 bays in the plant and the plant runs in three shifts in seven days. The LPG Bullet Truck is loaded for different LPG Bottling plant in eastern India as per requirement of PSU (IOC & BPC) and other Private customer’s demand. There are two cryogenic storage tank one for Propane and another for Butane. Beside this there are different size mounted bullet storage tank out of which three bullets capacity 1900 MT, two bullets capacity 600 MT and another two bullets capacity 150 MT. These bullets tanks are approved by concerned authority (PESO) and are tested as per norms.

On the basis of secondary data on an average 320 X 26 bullet trucks each capacity is 17.5 MT per month have been loaded in the last six months from August 2018 to January 2019. The heat exchanger capacity is 375 MT LPG / hour. But the gantry loading capacity is low i.e. 318 to 320 bullet truck per day. Now due to different government schemes and increasing population of the country, the demand is ever increasing. This resulted in loading extra 20000 MT LPG per month to cater the customer demand. In other words the present LPG loading capacity of the gantry should be increased from 145600 MT LPG to 165600 MT LPG per month. Hence the number of LPG bullet tank loading is increased from 320 bullet trucks per day to 384 bullet trucks per day or LPG loading 5617 MT per day to 6825 MT per day i.e. equivalent to increase bullet trucks loading by 22%. Here production is improved by about 1208 MT per day which will reduce production cost and also fulfill the increasing customer demand. It will also increase revenue of
the plant by about Rs.21 lakh per month (for material handling charge only). For that extra production extra consumable will be used but per unit production (bullet truck loading) use of consumable per bullet truck will be reduced. That will be given details in saving from consumable head.

The plant has only 16 bays in the bullet truck loading gantry. These 16 bays are working with 85% efficiency but total production is less than the demand. Therefore, our scope is limited to the improvement in the process related to the different step involved in the bullet truck loading. In this current research the design of the bullet trucks loading line flange is to be modified and loading arm flange connect and disconnect before loading the LPG and after completion the loading of LPG in order to accommodate more bullet trucks. At first the trial on two bays has been carried out. After inspecting and checking and time study of all parameters of bullet trucks before loading, during loading and after loading, it is found that a huge time is saved when dry cryogenic coupling for LPG bullet truck loading is applied. This new attachment increases the speed of the LPG bullet truck loading. The additional loading bay will be a costly affair and it is beyond scope of this study. However, it revisits existing process parameters for improving effectiveness is considered in this project. The different steps performed before the bullet truck loading are reconsidered to maintain efficient time management accordingly some modifications in the parameters such as few steps are modified. Necessary trial and errors of the same have been conducted to make final decision.

1.1 The problem on hand

It has been said that the bullet trucks are loaded at gantry through 16 bays in the plant. There is also decantation provision of leakage or disputed bullet trucks in 2 bays out of 16 bays but normally loading operation continue at 16 bays for three shifts per day. After proper checking of bullet trucks, it enters in gantry for loading LPG/Propane/Butane as per requirement of the customer. But the bullet trucks loading line flange has to mesh with the loading arm flange of the bay at gantry. There are eight nut and bolts to be fixed manually for proper fitment. This resulted in loss of time in loading bay. Therefore, in order to eradicate this time loss in loading bays, design modifications are needed to increase production for achieve customer demand. This will help the company in planning for increasing the manufacturing capacity to fulfill the rising demand from the customers.

2. Cause and effect relationships

First cause and effect analysis is undertaken to determine the factors responsible for lower performance of Bullet Truck Loading process as shown in table 1. The aim behind this is to improve productivity of the process.

| Cause | Effect |
|-------|--------|
| 1. Less number of bays runs in the gantry. | 1. Lower number of bullet truck loaded. |
| 2. Design of the fastener nut-bolt number decrease. | 2. Increase chances of leakage. |
| 3. Jump step of loading procedure. | 3. Increase risk of failure. |
| 4. The system design change. | 4. Has to change maximum equipment. |
| 5. Present capacity of the pumps and equipment change. | 5. Has to change maximum pipeline. |
| 6. Fastener design change. | 6. Effective in time saving. |
It is evident from the above table is that the effect is lower number of bullet truck can be loaded with the present set up and design. Therefore it is necessary to improve present setup in terms of quick coupling, pump setting and other relevant changes in order to improve productivity. This problem is critical because all steps of loading has to be maintained properly with respect of safety and also has to increase the productivity to face the increasing demand. Therefore introducing improved technology/equipment will help improving production and utilizing available resources.

The data for the research study have been collected from the production department. The production was in shift A, B and C in total 316 to 320 bullet trucks before implementation of the project. Now the demand has increased about 12%, this initiates the project. In the historical perspective we have furnished production for the period of 10 months. In a month the company works for 26 days average. This project intends to fulfill the shortfall in the demand by improving capacity of the bullet truck loading by 13%.

3. LPG bullet truck loading

The LPG Bullet Truck Loading process is very similar to other liquid filling in trucks. But the difference is that it is more dangerous than diesel, kerosene or any edible oil because any leakage or release of it become more dangerous to human for gas inhalation causing nausea, breathlessness, headache and other pulmonary obstructive problems. Further LPG is highly inflammable; in open air immediately it starts to evaporate. In tank/vessel heating will cause pressurizing and chance of explosion. So excess filling/loading is prohibited, and before loading all safety parameter are checked step wise. The stepwise Standard Operating Procedure (SOP) for LPG bullet trucks loading is shown in table 2.

| SL No | Job Description | Action By | Time |
|-------|----------------|-----------|------|
| 1     | Calling bullet trucks by their registration number through announcing system. | Security | NA   |
| 2     | Checking of documents /TREM Card prior to entry at Terminal. | Security | 4 min|
| 3     | Prior to entry Check for availability of 2 numbers 9/10 Kg DCP type fire extinguishers, Approved type spark arrestor welded on exhaust and 300 Amp master cut-off switch available. | Security | 3 min|
| 4     | Prior to entry, check for availability of prohibited items like mobile phone set, matches box, bidi/cigarettes, torch, camera etc. | Security | 2 min|
| 5     | Prior to entry, check that self-starter is in good working condition and no naked electrical wire exists/visible in the bullet truck. | Security | 3 min|
| 6     | Allow entry of the bullet trucks after recording. | Security | 2 min|
| 7     | Weighing of empty bullet trucks at weigh-bridge and record maintained. | Officer at Weigh-Bridge | 3 min|
| 8     | Marshalling and guiding of the empty bullet truck for parking behind the selected loading bay of the Gantry. | Security | 4 min|
| 9     | Opening of blind flange of the loading nozzle of the bullet trucks. | Driver of TT | 5 min|
| 10    | Inspection of condition of flange and its raised face portion for any unevenness, pitting, corrosion etc. | IPPL’s Officer at Gantry | 2 min|
| 11    | Allowing entry of the bullet truck at loading gantry after exit of previous bullet trucks. | IPPL’s Officer at Gantry | 1 min|
Positioning of the bullet truck at loading bay, switching off engine, Master cut-off switch to be isolated, chock blocks to be positioned on wheels and earthing clip to be connected at designated point of the bullet trucks.

Loading arm to be connected using IPPL’s supplied spiral wound metal gaskets and studs & nuts.

Check tightness of loading arm with the flange of loading nozzle of the bullet trucks followed by leak test by crack opening the delivery valve of loading arm.

Setting the quantity of product to be loaded in BCU and open the loading arm valve slowly to start loading of the bullet trucks.

Monitoring of loading operation of the bullet trucks and the driver of the tank truck must be present near the valve box of the bullet trucks for immediate access in case of emergency.

Close the loading arm valve, 3” loading line valve and bullet truck’s loading nozzle after completion of loading and recover the liquid from the said pipe section by opening the ½” vent valve.

Disconnect the loading arm and place the same on its position. Keep the gasket and Stud-nuts at designated place.

Disconnect the earthing clip and keep the same at designated place. Remove chock blocks.

Inspect the loading bay and verify & record the quantity loaded for information to Weigh-bridge.

Allow the bullet trucks to move out for weighment.

Weighment of loaded bullet trucks and issue weighment slip.

Submission of weighment slip to S&D.

Preparation of Challan / invoice.

Allow exit of the bullet trucks after verification and recording of the challan / invoice.

| Step | Task Description | Time (min) |
|------|------------------|------------|
| 12   | Positioning of the bullet truck at loading bay, switching off engine, Master cut-off switch to be isolated, chock blocks to be positioned on wheels and earthing clip to be connected at designated point of the bullet trucks. | 3 |
| 13   | Loading arm to be connected using IPPL’s supplied spiral wound metal gaskets and studs & nuts. | 8 |
| 14   | Check tightness of loading arm with the flange of loading nozzle of the bullet trucks followed by leak test by crack opening the delivery valve of loading arm. | 1 |
| 15   | Setting the quantity of product to be loaded in BCU and open the loading arm valve slowly to start loading of the bullet trucks | 1 |
| 16   | Monitoring of loading operation of the bullet trucks and the driver of the tank truck must be present near the valve box of the bullet trucks for immediate access in case of emergency. | 40 |
| 17   | Close the loading arm valve, 3” loading line valve and bullet truck’s loading nozzle after completion of loading and recover the liquid from the said pipe section by opening the ½” vent valve. | 3 |
| 18   | Disconnect the loading arm and place the same on its position. Keep the gasket and Stud-nuts at designated place. | 8 |
| 19   | Disconnect the earthing clip and keep the same at designated place. Remove chock blocks. | 1 |
| 20   | Inspect the loading bay and verify & record the quantity loaded for information to Weigh-bridge. | 1 |
| 21   | Allow the bullet trucks to move out for weighment. | NA |
| 22   | Weighment of loaded bullet trucks and issue weighment slip. | NA |
| 23   | Submission of weighment slip to S&D. | NA |
| 24   | Preparation of Challan / invoice. | NA |
| 25   | Allow exit of the bullet trucks after verification and recording of the challan / invoice. | NA |

In the SOP, it is observed that a bullet truck occupies a bay from step No.11 to step No.20 and during which it takes 67 minutes. If we consider idle time 5%, as a result in a shift in 16 bays bullet truck can be loaded = 16 x 8 x 60 / (67 x 1.05) = 109 number. From the above steps No.11 to No. 20 time span is more vital because in this period the bullet trucks occupy the loading bay. It is observed that only if we can cut down time taken from step no. 11 to step No. 20 by 13 minutes then production may increase by 13 %. This time cut down or time reduction of bay occupying during loading is our main target to solution the problem or to increase productivity. It is observed that in SOP step No.13 & step No.18 refers to the time of connecting and disconnecting of loading arm to bullet trucks flange. In loading bay if we use quick coupling & decoupling (QCDC) part instead of flange joint then it may reduce time & as a result productivity will be improved. Beside this we will go through all the possible of study to check how to reduce time span in occupying the loading bay and we will implement the best ways to this project. Thus, the problem is to improve the productivity of the LPG bullet truck loading at bay in the gantry.
4. Dry cryogenic coupling

Dry Cryogenic Coupling consist of a “tank” unit which is a type of a non-return valve and a “hose” unit with a valve driven by an internal cam curve to open both valves at the same time. Operation is a single action using a straight forward turning motion to connect the couplings and using open flow path. An initial push and turn action on the hose unit provides engagement with the tank unit thus locking and sealing the two units together. Further through rotation the internal valves are opened, thereby allowing full flow with a minimum of pressure drop. A selective system allows the system to be used to a wide range of cryogenic liquefied gases without any risk of failure owing to “human” error. Dry Cryogenic Coupling is made with stainless steel material having different diameter as shown in figure 2. There is provision to place ERC fitting upstream it to avoid accident.

Fig.- 2: Dry Cryogenic Coupling.

The Cryogenic Coupling material can bear a wide range of temperature for that no problem arise in ambient temperature, loading or temperature of gases like Propane, Butane or LPG (range from -42° C to +10° C). The figure 3 shows the LPG loading arm.
Fig.- 3: LPG Loading arm

5. Analysis
In this analysis on the truck loading for productivity improvement 4W and 1H is carried out as explained in the table 3. It is followed by Cause and Effect diagram as portrayed in the figure 4 below.

| Where | What | Who | When | How |
|-------|------|-----|------|-----|
| In the truck loading gantry. | Fitment mechanism changed. | Plant head. | In the month of August, 2019 started. | Under close observation change one by one. |
| At IndianOil Petronas Pvt.Ltd., Haldia. West Bengal, India. | Use dry cryogenic coupling instead of flange joint. That is more quick, reliable, and cost saving. | Operators. Team members. Maintence department members. | In the month of August, 2019 completed. Initially face few problems. Now all are normal and stream line. | Observe advantage & disadvantage. Some training has been given to all gantry operator for smooth and easy handling. |

Table-3: 4W-1H analysis
6. Production before and after project

The production quantity before and after implementation of the project based on the number of LPG Bullet truck loading will depict the improvement. Here 12 months production data before and 3 months production data after implementation of the project is considered and it is portrayed in figure 5. However, magnitude of the improvement is calculated on the basis of average production.
Before implementation the company used to load average 8193 bullet truck per month which has increased to about 9292. Thus there is about 1099 bullet trucks more loading in a month, which is 13% of the previous production. This production may face the aggregate demand of the clients.

Consumption of various resources for the period of 12 months from April 2018 to March 2019 is calculated and is shown in table 4.

| Resources/ bullet truck | Before | After | Difference | Production Rate | Unit | Amount |
|-------------------------|--------|-------|------------|-----------------|------|--------|
| Electricity             | 150.13 | 149.8 | 0.33       | 357 x 26        | Rs/ Kwh | 24504   |
| Steam.                  | 406.9  | 405.8 | 1.1        | 357x 26         | Rs/ Kg  | 51051   |
| DM water                | 427.2  | 424.3 | 2.9        | 357 x 26        | Rs / KL | 4306.05 |
| Industrial Water        | 543.8  | 539.0 | 4.8        | 357 x 26        | Rs / KL | 4455.05 |
| Gasket Pc.              | 0.125  | 0.1   | 0.025      | 357 x 26        | Rs/ Pc. | 5801.15 |

Total Amount saved per month from resources considering 26 working day and average 357 bullet truck loading per day. 90117

7. Cost of the project
The estimated the cost of project implementation includes manpower, material and administrative cost at 15%. The total cost of the project implementation is Rs.55.73 Lakh. This is one time cost. It includes manpower cost of about Rs. 54934/- for decision making, training and implementation cost. The material cost is about Rs. 55.17 Lakh. The major amount required for purchase of Dry Cryogenic Coupling and its attachments. The total cost of Rs. 56 Lakh is considered for the calculation of economic feasibility.

The rates of the consumables are same before and after implementation to show true result of this project. Thus, on above mentioned five consumables Rs. 90117 per month is saved if on an average 9292 bullet trucks per month are loaded.
Table-5: Total manpower requirement

| SL.No. | Nature of Job  | No. of Employees | SL.No. | Nature of Job  | No. of Employees |
|--------|----------------|-----------------|--------|----------------|-----------------|
| 1      | Control room officer | 2               | 1      | Control room officer | 2               |
| 2      | W.B. officer       | 1               | 2      | W.B. officer       | 1               |
| 3      | Gantry officer     | 2               | 3      | Gantry officer     | 2               |
| 4      | Gantry operator    | 2               | 4      | Gantry operator    | 2               |

8. Economic justification

As per agreement, Indian Oil Pertonas Pvt. Ltd. receives a terminaling charge from PSU customer and few private customers as handling charge over per MT of LPG handling. To implementation of this project the number of the manpower before and after are same. Output of the truck loading before was 8193 trucks per month (average) which has increased to 9292 per month (average). Thus, the labour productivity before was \( \frac{8193}{4368} = 1.9 \) bullet trucks per man hour. The labour productivity after is \( \frac{9292}{4368} = 2.1 \) bullet trucks per man-hour. Thus, the labour efficiency has increased from 1.9 to 2.1 bullet trucks per man hour or by 10.5%.

Thus saving from manpower is as follows:

- Cost of man power saving:
  - 6 Operator average @ 18000 = 108000
  - 15 Officer average @ 45000 = 675000
  - Total cost of manpower Rs. = 783000 for 8193 truck loading per month (average).

Therefore manpower cost for one truck loading before the project

\[ \frac{783000}{8193} = \text{Rs. 95.56/- or Rs. 96/- per bullet truck.} \]

Therefore manpower cost for one truck loading after the project

\[ \frac{783000}{9292} = \text{Rs. 84.26/- or Rs.84/- per bullet truck.} \]

Therefore manpower saving = \( (96 - 84) \times 9292 = \text{Rs. 111504/-} \)

The saving from lesser consumption of Resources (5 Nos.) = Rs. 90117 per month. A bullet truck average capacity about 17.5 MT

Beside this extra terminaling charge which is collecting from our customer \((9292 – 8193) \times 17.5 \times 105 = \text{Rs. 2019412/- per month (if average bullet truck loading is considered before the project 8193 and after the project Rs.9292/- per month, terminaling charge Rs.105 per MT.).} \)

The net saving is Rs.111504 + Rs. 90117+ Rs. 2019412= Rs. 22,21,033/- month.

9. Conclusion

This research study is a capacity improvement program based on customer demand. The demand is increasing day by day depending upon government policy and increasing population. Accordingly, the modification is required to fulfill the demand through improved productivity of
bullet truck loading. In order to achieve this loading arm fitting procedure with bullet truck loading flange is changed. Before implementation of the project the system was capable to load average about 8193 bullet trucks per month which was not sufficient to cater the demand of the clients. Therefore cause and effect, why-why analysis is conducted to find out the causes behind lower productivity. Simply improving efficiency of the truck loading increase the expected level of production, which is about 13% of the previous production. The manpower productivity has increased from 1.9 to 2.1 tank trucks per man-hour. By comparing the data before and after implementation of the project it is observed that five key resources are reduced per unit production due to improvement in the productivity. The saving from Electricity, Steam, Demineralized water, Industrial water, and Gasket is about Rs.90117 per month. For additional loading of tank truck (production) about Rs.2019412/- extra income is done by the organization as terminaling charge and saving from manpower is Rs.11504. Overall the saving from this project is Rs. 2221033/- per month. The reduction in consumable is also important from the economic as well as environment viewpoint. Industrial water and Dematerialized water consumption per bullet truck reduced. Electricity consumption is also reduced by 0.2 %. Thus it is also a part of social obligations.

For further increase the production we need to change system parameter and the setting of equipment according to the pumps& pipeline capacity and also synchronizing all of them. This may further increase the production of the truck loading. Thus, there is scope for improvement till 9984 bullet truck per month. The system efficiency can be improved in such way in future if required. Thus, there is scope for improvement in the present system.

Acknowledgement
The authors are thankful to the management of the Indian Oil Petronas Private Limited Haldia, West Bengal, India. Also special thanks to the department of process for their cooperation and help.

References
[1] Ranck, R. J., Yanasse, H. H., Morabito, R. and Junqueira L. (2019) A hybrid approach for a multi compartment container loading problem, Expert Systems with Applications, 137, 471- 492.

[2] Alonso M. T., Alvarez-Valdes R, Parreño F. and Tamarit J. M. (2016) Algorithms for Pallet Building and Truck Loading in an Interdepot Transportation Problem, Mathematical Problems in Engineering, 8, 1 – 11.

[3] Alonso, M.T., Alvarez-Valdes, R., Iori, M., Parreño, F. & Tamarit, J.M. (2017) Mathematical models for multicontainer loading problems, Omega, Elsevier, 66, 106-117.

[4] Moura, A. and Bortfeldt, A. (2017) A two – stage packing problem procedure, International Transactions in Operational Research, 24, 43–58.

[5] Bortfeldt, A. and Wäscher, G. (2013) Constraints in container loading – A state-of-the-art review, European Journal of Operational Research, Elsevier, 229(1), 1-20.
[6] Fanslau, T., Bortfeldt, A., 2010 A tree search algorithm for solving the container loading problem, INFORMS Journal on Computing, 22, 222–235.

[7] Bischoff, E. E. and Ratcliff, M. S. W., (1995) Issues in the development of approaches to container loading, Omega, Elsevier, 23(4), 377-390.

[8] Nivolianitou, Z. Konstandinidou and M. Michalis, C. (2006) Statistical analysis of major accidents in petrochemical industry notified to the major accident reporting system (MARS), Journal of Hazardous Materials, 137 (1) , 1-7.

[9] Hemmatian, B., Abdolhamidzadeh, B., Darbra, R., and Casal, J. (2014) The significance of domino effect in chemical accidents, Journal of Loss Prevention in the Process Industries, 29, 30-38.

[10] Attanasio, A., Fuduli, A., Ghiani, G., & Triki, C. (2007) Integrated shipment dispatching and packing problems: a case study, Journal of Mathematical Modelling and Algorithms, 6(1), 77-85.

[11] Pedruzzi S., Paulo L., Nunes A., Rosa R. and Arpini B. P. (2016 ) A mathematical model to optimize the volumetric capacity of trucks utilized in the transport of food products, Gestão & Produção, 23 (2), 350 – 364.

[12] Haessler R. W. and Talbot F. B. (1990 ) Load planning for shipments of low density products, European Journal of Operational Research, 44 2, 289–299.

[13] Chen, C. S., Lee, S. M., and Shen, Q. S. (1995) An analytical model for the container loading problem, European Journal of Operational Research, 80(1), 68-76.

[14] Oueidat, D., Guarnieri, F., Garbolino, E., Rigaud E., (2015) Evaluating the Safety Operations Procedures of an LPG Storage and Distribution Plant with STAMP, Procedia Engineering, 128, 83-92.

[15]. Moura, A. and Oliveira, J. F., (2009) An integrated approach to the vehicle routing and container loading problems, Operations Research Spectrum, 31, 4, 775–800.

[16]. Sanjeeb D., Marcos G., Oktay G., (2010) Two-Step MIR Inequalities for Mixed Integer Programs, INFORMS Journal on Computing, 22(2), 236–249.