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Article

Simulation and Planning Project Logistics Operations: A Case Study of Transportation Operation of Autoclave from Petkim Port to Gördes Building Site

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Abstract: Project logistics is one of the specific logistics operations. Compared to other logistics operations, it needs more efficient planning and engineering applications in each operational process. On the other hand, each project logistics operation can be defined as tailor-made operations, since it has no similarity with other operations. Consequently, each project logistics operation should be planned and carried out according to its own conditions and parameters. This study focuses on the simulation of project logistics operations under the light of computerized applications from start to finish of the logistics operation. In this study, transportation operations of 600 tons of autoclave from the Petkim port to the Gördes building site were selected as a case study.

Keywords: project logistics; transportation; simulation, autoclave

1. Introduction

Globalization is one of the most important periods of human history and has led to change in everything in the world. The globalization process may be defined as the process of change for all the world and has led to the change of concepts such as environment, urban management, business life, transportation, and particularly people's lives. It has shaped the world in based on three main factors. Transportation can be defined as the primary factor affecting the daily life in the globalization process. In this process, it has gained more importance compared to the past as a result of the increase in transportation facilities as well as accessibility. Improvements in the fields of communication and information are the second driving force of globalization. The third factor of this process is technologic improvements. Two key concepts have become more important thanks to these factors. They can be defined as mobilization and speed. Traditionally, movements of the workforce and capital can be defined as mobilization. Nowadays the scope of this concept has expanded and, as a result of the increased competition pressure movements of gigantic production facilities over long distances have also been included within this concept. Speed is one of the most important concepts for the globalization process and has become a more important factor affecting the daily lives of people. To conduct speedier operations may bring the opportunity of reducing operational costs for companies and increasing their flexibility. Accelerating all processes of the supply chain can lead to the reduction of total costs of logistics and it can provide an improvement in flexibility and agility to companies and supply chains. To increase the capacities of logistics functions carried out in supply chain and to complete the functions such as assembly and installation before delivery points may be the easiest ways of optimal logistics operation. Depending on this kind of needs, all the construction process, between start to finish, related to bridges, infrastructural elements, energy facilities are not carried out in the building site since carrying out these processes at the same location may take a long time. For these reasons, project logistics and overweight/oversized transportation have become more important compared to the past. Therefore, project logistics is an important factor affecting people living in the rapidly industrializing world.

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2. Results

This study focused on project logistics operations and tried to find the best solution to solve operational problems. abnormal transportation operation planning is one of the most important problems for operators. more importantly, selection of lifting equipment and determining the vehicle-trailer combination is extremely difficult for logistics operators. this study suggests using simulation methods in order to organize and plan for oversized/overweight transportation. These kinds of simulation software can provide opportunities to solve optimization problems that relating to heavy transportation and can show alternative ways to reach the optimal solution.

it is possible to find best solutions such as determining the best route, selecting the optimal vehicle-trailer combination. in addition to that, some restrictions and limitations that related to heavy transportation can be detected by these kinds of software and can be shown the solution ways to logistics operators. thanks to these kinds of software, we can determine center of gravity of cargo and trailer and can load an abnormal cargo optimally and more securely.

3. Discussion

optimal abnormal transport planning can be made by simulation software. this study tried to show technologic instruments can be used even in abnormal transport operations that defined as tailor-made operations. This study can be contributed the literature that related to logistics and operation management.

4. Materials and Methods

Findings of this study depend on field works. all data that related to the case study were collected before the beginning of this operation. they were used as a data in this study by a selected simulation software.

5. Literature Review

The literature related project logistics and oversized/overweight cargo transportation is very limited. The main topics usually studied are the selection of the rational route according to heavy weight cargo, risk management, damage effect of road pavement, route optimization, trailer design for oversized cargo. In general, these studies focus on impacts of abnormal transportation. According to Palsaitis and Petreska (2012), the most important factor affecting the quality of the transportation of heavy goods is safety and security. Risk evaluation and management is one of the key issues relating to the planning of overweight/oversized cargo transportation. Usually international transportation and decision-making requires analysis of the problem both on the national and international scale and only then the most rational decision (transportation route) can be made with the view of effective risk lowering, i.e. seeking the last possible reconstruction costs [1]. Li et al (2014), draw attention to the relationship between vehicle types and effects of overweight cargoes. They argue that, overweight goods are a kind of special goods and must be loaded on the heavy duty freight cars when transported by railway. However, this sort of car is not taken into consideration when the track structure is designed. In order to have knowledge regarding the action of heavy duty freight cars on the track structure and correctly organize the transportation of overweight goods, the strength of track should be studied with the action of the heavy duty freight cars according to the basic theory of static mechanical calculation [2]. According to Tjan and Fung (2015), Total number of standard axle loads is a parameter used for the design of a new pavement structure, or showing its remaining life in service pavement structures. During the life of the pavement, various traffic loadings will pass on the design lane. The passage of those vehicles on the design lane will deteriorate the pavement structure. The design of the lanes of the pavement structure should not fail before the total number of vehicles reach its designed number of standard axle loads. There are various types of vehicles, total vehicle loads, axle types, and axle loads that will pass on the pavement. Damaging effect of those axles on the pavement structure will be different from one to the other [3]. Ray (2014) argues that, a transport system has to be adequately adjusted to industrial needs and should

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correspond to the changing requirements of cargo transportation. The application of a systematic approach to the processes of transporting oversize/heavyweight cargoes (OHC) can lead to reduction of the logistics costs and may lead to more rapidly economic growth for a country. It also provides an opportunity to effectively carry the OHC to multiple economically active points located on the curtain territory. The selection of the OHC transportation routes requires the development of an 'instrument' for an objective evaluation of the OHC transportation route segments or the entire route with the application of a universal evaluation points system [4]. Other studies focus on the damage effect of road pavement such as Cebon (1992) [5] and Salama et al (2006) [6].

6 Project Logistics and Oversized Cargo Transportation

Project logistics can be defined as the all logistics functions such as transportation, warehousing, and other logistics activities for non-standard cargo. Depending on this definition, dimensions and weights of the non-standard cargo are above the limits determined by authorities. For this reason, all the processes of the project logistics and the oversized cargo transportation may change depending on the cargo specifications. Therefore, each project logistics operation may be defined as tailor-made operations and should not be similar to another operation. Planning, organizing and carrying out of these processes should be conducted on the basis of each logistics operation.

On the other hand, project logistics is one of the specific logistical activities and it can be defined as a stakeholder of the almost all the industries. Project logistics and oversized transportation activities may provide strategic advantages for all industries and companies. These industries may improve their capacities and performance and are dependent on the project logistics services in terms of productivity and efficiency. Their industrial activities are not possible without the project logistics services.

In developing countries, the number of the infrastructure, energy, and building projects increase in line with the development level. Specialized vehicles, trailers, cranes, and equipment are required to carry out logistics activities for gigantic objects. These objects can have different specifications. They may be defined as cranes, hoists, bulldozers, excavators, loaders, road rollers, specialized dumper trucks and components of steel structures, bridge spans, and large power equipment [7]. These materials can be transported between sender and receiver in general. At the same time, different transportation modes such as roadway and maritime railway can be used in same transport operation by operators. In contrast, road transportation is definitely used for each project logistics operations for door-to-door operations is not possible in other transportation modes except for road transportation.

In project logistics operations, the most important point is determining all steps of the logistics processes in detail. Specifying the vehicles, trailers, and cranes to be used is necessary at the beginning. In addition to that, all operational processes should be planned at the micro level. A number of risks and threats may occur in these processes and have different risk levels in each operational processes. To manage these risks, all logistical processes should be under control. If any process is ignored by the transport operators, risks related to the project logistics operation may high. If a decision taken by the operators is wrong, the risks become extremely high. In the case of any changes in the conditions pertaining to oversized cargo such dimensions or weights, all structural features and characteristics of the logistics operation may change. The changes in logistics applications such as routes, vehicle types, trailer specifications as well as applications and rules on loading or unloading operations are possible within the framework of the changing conditions. Accordingly, the level of risks may vary depending on these changeable situations. The requirements of the project logistics have already exceeded the level that can be met by the human factor. Nowadays, to carry out an excellent project logistics operation is not possible without technological elements. In recent years, logistics operators have started to use technologic elements in all operational processes for more successful and safe operations. Consequently, improving technology may help to control risk factors beyond the logistics operations. This study focuses on the impacts of technology on the performance level of the project logistics operation.

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7 Steps of the Project Logistics Operation

Since project logistics is different from standard logistics operations, planning their processes should be more detailed and can be completed in the following four steps from beginning to end: data collecting and analysis; design and planning; implementation and finalization. In the first stage, all the data related to the cargo are collected in detail. Not only dimensions and weight but also other specifications have significant importance for transport operators. All the factors affecting the structural features of the logistics operation are taken into consideration by the operation planners. Customer demands and expectations as well as cargo specifications are also extremely important. However, their importance is low compared to the specifications of the heavy cargo and does not have the highest priority. In general, transport operators and planners demand detailed information about loads, as well as their images and technical drawings. In this process, all solution ways are determined and an alternative pool is created. The priorities are the technical and the legal limitations in planning an optimal transport operation.

Technical limits are related to the operational capacity of logistics firms. In some cases, when technical specifications of the loads are considered, the capacity of the firm may not be sufficient. In such a condition, logistics operators may have recourse to external sources to carry out their logistics operations. If the cargo dimensions or weight are up to limits, this kind of solution is not possible. Therefore, logistics planners should take into consideration the technical capacity and cargo specifications together. If the technical capacity is not sufficient, turning down the customer demands is possible.

On the other hand, even if the technical capacity is sufficient, to carry out the project logistics operations may not be possible as a result of the limitations determined by the legal instruments. Although the logistics planners take into consideration all the alternatives about the logistics operation, running the operation may be impossible. A similar condition may arise due to the lack of technical capacity. In addition to that, even the logistics operations can be carried out, some legal limitations can lead to inefficiency. As a result of this, as the transit time becomes longer, logistics costs may increase dramatically.

When international transportation is included in logistics operations, operation planning processes may be more complex. At first, the number of constraints may increase, depending on the number of countries on the route. Legal instruments and limitations of the project logistics operations may vary in each country. These limitations may be caused by natural or unnatural conditions. For example, bridges, overpasses, underpasses and physical conditions of roads can become a constraint for vehicles that carry oversized cargo. On the other hand, legal procedures and applications related to the use of roads may vary and may be defined as procedures about escort vehicles, restrictions on driving times and prohibitions on road use. They may reflect concerns of the countries about road safety in general. According to the risk level, logistics planners trying to determine the best solution to reduce these risks and planners strive to achieve the highest benefits and efficiency in optimal conditions.

The second step is the design and planning stage. In this process, planning of the logistics operations is carried out with computerized applications such as simulations. All decisions on route selections, choosing the vehicle and trailer type, using hoists can be taken with the use of simulation programs and software. The most important decision is selecting the vehicle, trailers, and equipment in accordance with the cargo specifications. The simulation software called Faremax version 3.1 can provide effective solutions in this selection processes. This software can help us to choose the optimal trailer types in accordance with cargo dimensions and weights. First of all, specifications of the oversized cargo are determined on the software. Mass, length, height, center of gravity of the abnormal load should be described in this system. After that, payload per axle can be calculated in this software. This software can show the optimal trailer type among all the defined trailer types. On the other hand, if logistics planners are not satisfied with the solutions provided by the software, they can intervene in the system. At the same time, routes and transport modes which will be used in the logistics operation are determined at this stage with the load specifications, the technical and the legal constraints taken into account. Logistics planners can select the optimal transportation mode or

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modes in accordance with all limitations. In terms of cost minimization and benefit maximization, the logistics operations can be divided into many parts by planners and each part of the logistics operation can be carried out with the use of a different transport mode. In general, logistics operations using different transport modes such as road, maritime and railway transportation can be observed in the project logistics operations within the framework of the intermodal transportation. On the other hand, the load weight should be evenly distributed on the vehicle. The axle load has to be determined in accordance with regulations and can vary in each country. If the vehicle will pass throughout many countries, the axle load should be calculated in terms of the minimum value for the axle load applied in any country. In addition to that, in accordance with the permits given by authorities, the daily driving times may vary. While some authorities can give permit for driving in the night, this implementation is not available in some countries. Prohibitions and restrictions applied by authorities may be valid for some highways in a country. In such cases, these roads should be excluded from the alternatives. For example, the use of the main highway known as O-32 for oversized cargo transportation is prohibited by road authorities and cannot be determined as a route for heavy freight transportation. Logistics planners should take into consideration all details of the project logistics operation and should not overlook any detail. Especially, all restrictions and limitations applied by road authorities in different countries should be taken into account simultaneously. In addition to that, in order to carry out the project logistics operations safely and efficiently, field works related to the operation have an utmost importance. Therefore, all examination and inspection processes are completed by planners on the highway before the actual transport operation. All conditions related to bridges, underpasses, overpasses, and other road elements are examined by logistics operators. The bottlenecks which cause difficulties are specified by them. They can prepare the operation plan in the light of these observations and inspections.

The third step is the implementation stage. At this stage, selected loading equipment is sent to the loading port. All staff and equipment appointed to the operation are prepared for the activity t carried out in the field of loading. The loading operation is completed by taking into account the technical details and engineering calculations. Immediately after this, final controlling is performed and loaded vehicle can be moved by operators. Within the framework of taken measures relating to safety and security, all processes should be monitored by planners and operators during the logistics operation. If there is a deviation from the prepared operation plan, they should intervene in the logistics process immediately.

In the fourth phase, known as the finalization stage, the results of the completed operation are evaluated by the operators. If there is any deviation, they can make an observation to find the reason for it.

8 A Case Study of Autoclave Transportation from Petkim Port to Gördes Building Site

The nickel ore becomes pure nickel within sulphuric acid under high pressure and heating conditions. The using of tanks in this process are defined as the autoclave. Within the frame of this project, many logistics activities are observed in the scope of this logistics operation. First, the autoclave which weighs 600 tons were transferred from the ship to the road vehicle and was transported from the Petkim Port to the Gördes building site in the second stage. In the final stage, the autoclave was put onto the stand created in the building site. In the first stage of the project logistics operation, set of data relating to the autoclave was collected. It weighs 600 tons, and its length is 34 meters, width is 7.05 meters, and height is 7.15 meters. It will be transported from the Petkim Port to the Gördes building site. Approximately, the distance of the route is 180 kilometers. At the same time, technical drawings of this material have been requested by the logistics planners.

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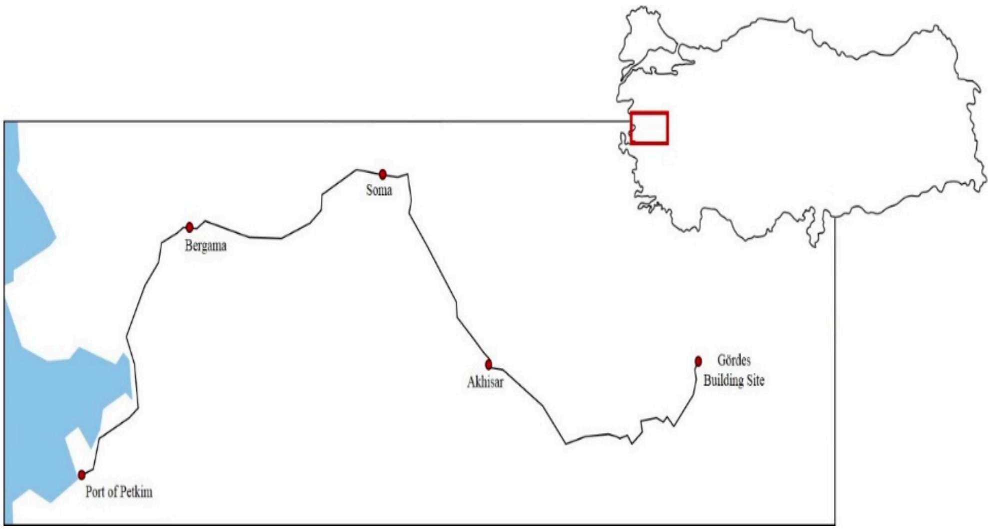

Figure 1. Selected Route between the Port of Petkim to the Gördes Building Site

There is a need to determine the two important parameters of the number of axle and the traction force of the selected vehicles. As well as the number of the axle of the selected trailer, the traction force of the used trucks and the self-propelled modular transporters (SPMT) were determined within the framework of the technical and legal constraints. The axle load limit is determined as 11 tons per axle in accordance with the road regulations and should not be exceeded. Therefore, if the total weight is divided by the limitation value of per axle, the number of the axle can be calculated as 66. An equation relating to the axle load calculation can be shown as below;

$$n_{ax} = \frac{w_l}{u_{lv}} \tag{1}$$

$$l_{al} \le \frac{w_l}{n_{ax}} \tag{2}$$

While n_{ax} represents the number of axles, w_l is the sum of the weights of the transported materials and trailer, u_{lv} is the limitation value per axle, while l_{al} is the limit value per axle. When Eq. (1) is applied to reach the number of the axles, the result shown below can be obtained as:

$$n_{ax} \ge \frac{w_l}{u_{lv}} \Rightarrow \frac{716,2}{11} = 62,27$$

The number of axles (n_{ax}) is calculated as 62,27 tons. Since other trailer types cannot respond to the needs related to the distribution of weight excluded modular trailers, the logistics planners decided to use modular trailers in this operation. This kind of trailers can consist of many parts. In total, the modular trailer configuration consists of three sets and there are 22 axles in each set. Consequently, the oversized cargo has been loaded on the modular trailer which has 66 axles.

$$l_{al} \ge \frac{716,2}{66} \Rightarrow 10,85 \text{ tons} < 11 \text{ tons}$$

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When the tractive force of SPMT is calculated at the levels of maximum and minimum, many parameters and factors are taken into consideration such as speeds, road curves, gradients, physical conditions of the roads and climate conditions. The tractive force of trucks can be calculated as below;

$$v_{kN} = a.\left(\frac{x^2}{l^2}\right).C \tag{3}$$

While v_{kN} represents the needed tractive force, x is the length of the loading area in meters, l is the theoretical drawbar length in meters. a is an equivalent vertical acceleration in hitch point in m/s2. Value of a may vary related to the suspension types. If selected vehicles have air suspension, a is equal to 1.8 m/s2, otherwise, a value is considered to be 2.4 m/s2. When Eq. (3) is applied to reach the number of axles, the result can be obtained as shown below. [8].

$$v_{kN} = 1.8.\left(\frac{34^2}{1.5^2}\right).716 = 554.88 \text{ kN}$$

This value of needed tractive was calculated at minimum level. If other conditions are considered, to increase the needed tractive force can be possible. As a result of this, logistics planners determine the tractive force according to the most difficult climatic and physical conditions.

After determining the needed tractive force and axle load in the light of the obtained data, road surveys are performed by planners. The critical points which may cause difficulties for the operation are determined and are identified in this process. In the framework of this project, 335 critical points have been identified. Geographic Identification System (GIS) is used for the analysis of the road conditions. Finally, average gradients of this route have been determined as 12%.

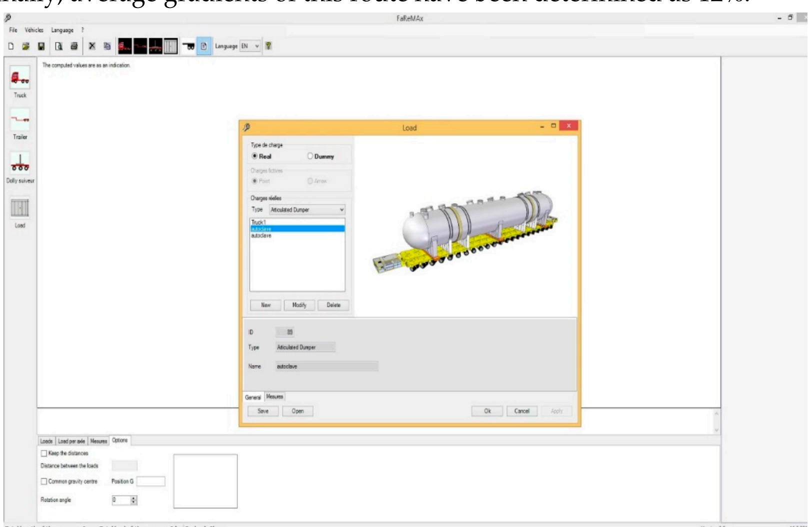

Figure 2. Simulation Optimal Trailer Specifications in Faremax Software

After the first step, logistics planners have started the second stage. In this stage, logistics planners and operators have taken a decision about using trailer type and trucks. When the trailer type is selected, some factors are considered about them. Initially, manoeuvrability is one of the most important factors in carrying out an efficient logistics operation in terms of minimizing the logistics costs. It may allow the use of the least amount of resource more safely and optimal logistics operations may be possible in this way. Secondly, the number of the axle should be optimal to prevent the damage to the road surface. Its chassis height should be low and low chassis can allow an easier

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loading and unloading operation. On the other hand, if the total height of the loaded vehicle is low, the number of critical points such as bridges, underpasses, overpasses and tunnels can be reduced.

Only with the consideration of these requirements, modular trailers can respond to all the above mentioned needs. Therefore, modular trailers have been chosen by planners. On the other hand, self-propelled modular transporters (SPMT) have been selected because they are compatible with modular trailer. Secondly, solutions related to critical points were determined by operators. The by-pass operations related to bridges were performed to ensure the safety passage over the bridges. The number of removed electricity and telephone lines is 280. Two overpasses have been removed. Road widening work has been done 20 times, while 16 traffic lights and 6 traffic signs were removed. Preparation process was completed in 18 months. At the end of the process, all staff and equipment were ready for the actual operation. In addition to that, all permits related to transport operation are taken from the road authorities before the actual operation.

The third step is the implementation stage which can be defined as the actual operation process. This process began with the loading operation. The autoclave was transferred from the ship to the modular trailer by two cranes that have the lifting capacity of 750 tons. There were six bends with a 90-degree angle exiting from the port of Petkim. Planners tried to find optimal pass conditions. They made recommendations for the improvement of the physical conditions of the road. These recommendations were largely implemented by practitioners. In this process, two bypass bridges were installed and traffic signs were removed.

Figure 3. Installation of the By-Pass Bridge and Removing the Traffic Signs and Overpass

Measurements were made using Geographic Information Systems (GIS) for all the road sections including ridgeways. Depending on the physical values of the road sections, three-dimensional manoeuvre simulations in Auto-CAD were used for the study. In accordance with these simulations, road expansion works were completed.

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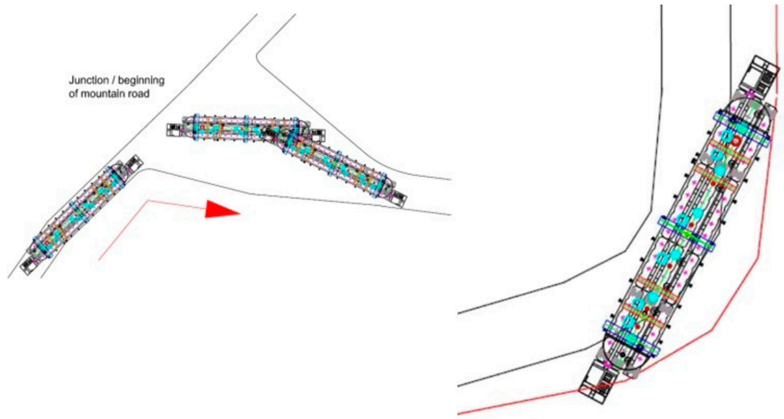

Figure 4. Three-dimensional Maneuver Simulation in Auto-CAD Software

Actual transport operation was completed in 64 days. Vehicles could be moved only in the daylight and all the staff walked for 180 kilometres during the operation. At the same time, in order to prevent the damage on the road pavements in high-temperature conditions, cooling process through irrigation was carried out.

Beginning of the final stage was the entrance of the autoclave to the Gördes building site. Assembly process was simulated in the Auto-CAD software. The autoclave was lifted out the modular trailer by crane and was put on the temporary platform. Immediately after, to provide the movement of the autoclave on the horizontal axis, the configuration of the modular trailer and SPMT were changed. The autoclave was re-loaded on the modular trailer after the configuration change. In this process, numerous technical analysis and engineering were performed before the re-loading operation. In the final stage, autoclave was moved on the horizontal axis and was put on the permanent platform. In the same way, assembly operation was simulated in the Auto-CAD software. The project logistics operation was completed with the assembly process.

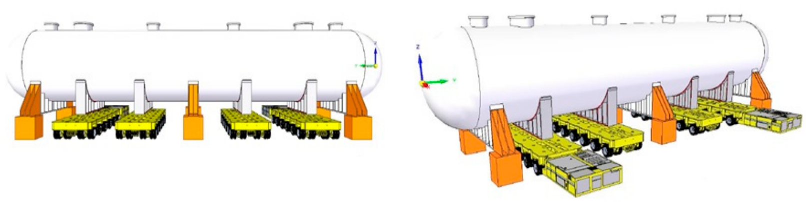

Figure 5. Three-dimensional Configuration Change Simulation in the Auto-CAD Software

Conclusion

The project logistics operations are one of the most specific processes and have very complex logistics applications. On the other hand, some significant relationships can be observed between engineering and logistics. Each project logistics process depends on engineering and technical applications and has no tolerance for operational errors. A small error may cause the logistics operation to fail. Therefore, all the staff and logistics planners should have sensitivity and try to find more effective and optimal ways to solve any problems relating to the logistics process. The performance of the project logistics operations depends on effective planning and systematic approaches. Computerized systems and software may be the best way to solve human failures and can help to create systematic and planned logistics operations. As a result, the most important factor is zero mistake in the project logistics operations. Minimized errors may lead to very serious risks coming real.

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