The evolution of Brazilian FPSO material handling systems

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Practitioner Summary:
The purpose of this article is to show the evolution of Brazilian FPSO material handling systems, through material handling team work analysis and the understanding of designers practices. This study provides evidence of how the concepts concerning the design of these systems has changed over time and how better solutions have been implemented for improving the efficiency, safety and work conditions in the design of the oil platforms.

The study has been based on the work undertaken aboard a Brazilian oil platform, following the ergonomic work analysis principles, based on observations in the field and verbalizations obtained from workers during and after the execution of an activity. This analysis was critical for understanding the main determinants factors of working conditions. These factors has oriented a short analysis on two older Brazilian oil platforms, for identifying the main characteristics of the material handling work.

Lastly, meetings were held with material handling system designers in order to understand how the new projects are being developed, based on real case of a Brazilian platform project under development. Also, the opportunity was availed for deepen the knowledge of how the units of different generation were conceived and to understand de logics involved in each project development.

The analysis carried out allowed us to identify the main cargo unloading and loading data, and to indicate the main design factors of offshore material handling systems, such as the laydown area, the chemicals deck, the main material flows at the processing plant and the integration between material handling sub-systems. Based on these factors, four different Brazilian material handling systems have been analyzed, in order to understand the design tendencies and evolution of these systems over time.

The analysis of 3 generations of Brazilian platforms has shown that the main design factors have changed significantly over time, and there have been big efforts to improve the integration between them. The low level of integration between the disciplines during the design process and the difficulties faced by the material handling system designers to access the work onboard operational platforms is seen as the key for improving the design of these systems.

The analysis of all the platforms together enabled to conclude that the three generations showed different project concepts. On the one hand, the designers knowledge and documents detail are growing but, on the other hand, the enterprise politics of cost has, on the 3rd generation, reduced the resources available for developing the system and shared the procurement process on smaller pieces, increasing the difficulty to integrate de different parts.

The meeting with project designers indicated that the way to overcome the obstacles to an effective evolution of these systems depends on (1) a better integration between the disciplines responsible for the design of material handling systems, and (2) a greater proximity between project designers and operational activity, since most of project designers do not have access to the activities undertaken in the field.

Keywords: cargo handling, material handling systems, offshore platforms design

1. Introduction

The material handling systems in Brazilian FPSO platforms have undergone great transformations over the years, ever since the first platform in FPSO format was launched in Brazil in 1997. Amongst the main reasons for these changes was the advance of technology and knowledge concerning these systems, also due to the environment in which these platforms are operating – above all in the decisions taken in the concept phase.
These changes on project concepts also generate changes in the work aboard these units. The cargo handling activity at offshore platforms is critical from the working conditions point of view, given the high physical effort undertaken and the high accident rate. The literature that studies the cargo handling work, however, does not transcend the relation between man and the handled object. For this reason, the analysis does not include the systematic dimension of activity, and therefore, ignore the influence of variables defined since the first steps of the project design on the work undertaken.

In this work, the development of a systematic analysis of cargo handling team activity, allowed to outline an evolutionary framework of the work undertaken by the team in different systems. The analysis of this framework allows to highlight the difference between these systems and the way the modus operandi change in each of them.

Amongst the main conclusions, we highlight the importance of project decisions and policies related to the type of work which will be undertaken in the future, the difficulty which the Brazilian project designers encountered having little operational field access and the difficulties of integrating the individual parts that make up these projects of the system due to the fact that there is no specific supporting discipline for the area of material handling.

2. The Research Study Undertaken

The study started from the analysis of the real work of a platform P-C and focused on the identification of the determining factors of working conditions that are inherent to design of these systems. Four visits aboard occurred and the main activities of the cargo handling team were accompanied, including interviews with different members of the team – and with members of other teams, when considered necessary – plus collecting information and relevant documents for deepening the knowledge related to the activities of this team and the functioning of the platform material handling system.

Once identified the main characteristics of the P-C materials handling system, we made a visit aboard two FPSO platforms which make up part of the first generation Brazilian FPSO platforms (P-A and P-B). In order to undertake the research study in these units, interviews were made, including guided visits and accompaniment of cargo handling activities for two days – approximately 24 hours of work shift – in each one of these platforms. The analysis were focused on the understanding of the material handling system, based on the factors inherent in the design project foreseen in the work undertaken on P-C. Table 1 shows the main information concerning the operating platforms visited.

Table 1. General information of the platforms visited.

<table>
<thead>
<tr>
<th>Data</th>
<th>P-A</th>
<th>P-B</th>
<th>P-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>StartedProduction</td>
<td>1997</td>
<td>1998</td>
<td>2004</td>
</tr>
<tr>
<td>Production(barrel/day)</td>
<td>38,000</td>
<td>14,800</td>
<td>100,000</td>
</tr>
<tr>
<td>People on board</td>
<td>210</td>
<td>172</td>
<td>198</td>
</tr>
</tbody>
</table>

Having researched the three operating platforms of the two different generations, we began a study on a platform in a phase of conception of a more recent generation of Brazilian platforms (P-D). In this stage of the study, we held meetings with design projectors and made analysis of design diagrams and project documentation. We also had the objective of understanding the platform material handling system, based on factors inherent to the project identified in the P-C study.

A comparative analysis between these platforms of 3 distinct generations enabled us to observe big changes in the design projects of these systems. In the next item, we will demonstrate the main results of this work.

3. The identification of the determining factors of working conditions

The analysis of the real work undertaken in P-C – details of this process can be viewed in ABRAÇADO (2013) and ABRAÇADO & DUARTE (2014) – enabled us to identify the main determining factors of working conditions inherent to the design of offshore materials handling system, which were divided in three main
parts: the design project of individual areas, the design project of material flows and access, and the design project of material handling equipment.

The design project of areas has to do with the dimensioning of the laydown areas, the chemical products area, the provisions reception area, the processing plant, its modules, the set up arrangement of equipment, the areas of maintenance and unloading of equipment, among others. The concept of the areas has an influence on the whole design project of the platform with interconnected discussions involving a number of project disciplines.

The design project of accesses and flows will give the processing vision of the materials contemplated for use in the project, above all in the processing plant where the handling activities show greater complexity. It is this factor that establishes the route taken by the different pieces of equipment right from their origin to their final destination. This factor should take into consideration the sizes and intervals of the routes, the main flows, the interfaces (entry and exit of modules, hatches, doorways, lifts, vertical handling spaces, among others). We verified that the materials flow is concentrated on the laydown area, which functions as a centre of interfacing, between the processing plant, workshops, chemical products deck, the provisions reception area, the storage area, among others.

The design project of equipment is responsible for establishing the most adequate means of material handling in order to best move equipment and cargo around using these flow processes. It is they that will permit the removal and handling of materials from one place to another using established flow processes. The design project of the equipment involved is not restricted to the pieces of equipment themselves, but also includes the necessary structure for their operation. A hoist needs an installation point to be able to operate, for example. A trolley rail cart requires a rail track. We verified 3 types of main equipment: the offshore cranes, which are the most complex and important pieces of handling equipment on the platform, the piece of equipment for longitudinal handling, and the pieces of equipment for vertical handling.

These three essential factors interact intensely towards the formation of a material handling system. If these factors are not thought through in an integrated way, the system will probably show wasted spaces, which are incompatible between routes and devices, difficulties of access, important equipment not contemplated by handling systems, among other omissions.

4. The evolution of material handling systems

In this part of our study we will discuss in detail the material handling system of 3 generations of platforms, the differences in their concepts and the positive and negative points of each project. Lastly, we will demonstrate the evolutive framework of material handling systems of Brazilian platforms.

4.1 The 1st generation systems: the case of P-A and P-B

Platform P-A was the first FPSO used in the Campos Basin. It has a simple handling plan focused on individual areas and a relatively big distance between the superstructure and processing plant, demanding a significant displacement of workers between the locations. This type of problem was more acute on platform P-B, where there is, furthermore, a football pitch, separating the two areas.

The big distance observed between the superstructure and the processing plants of P-A and P-B platforms is not necessarily a gain. Although in theory, some distance is desirable in order to keep the superstructure safe, the distance is so great that it creates negative effects (ex: weariness, loss of time in moving around, among others). Apart from the latter, these platforms do not use this distance as an effective and secure work area. In both platforms, the cargos are positioned in improvised areas on the main deck, which becomes a risk as much for the workers, as for the structures, apart from obstructing the routeways, reducing the accessibility in some areas to the main deck.

The modules of the processing plant have few levels in these two platforms – a fact that can be explained by the low production capacity, the few by-pass mechanisms, which reduce the quantity of equipment in the plant, and the relatively large size of these ships - , which reduces the handling difficulties quite considerably, but in both cases the presence of fixed handling devices is uncommon, as well as the presence of structures that enable the installation of manual devices. Thus, any equipment out of the reach of cranes, which does not permit manual handling, will demand the use of scaffolding for the installation of manual hoists, increasing the cost and the execution time of these manoeuvres.
In both the platforms, the cranes which access the cargo area communicate the bow crane through a trolley-car - a trolley on rails whose track extends from the stern to the bow -, but the crane positioned close to the processing plant remains isolated, incapable of carrying out an interface with another piece of equipment and give continuity to handling activities. On P-B, there is the attenuating factor that this crane also accesses the main deck, which also serves as an improvised laydown area, permitting the removal of pieces of equipment from it. On P-A, the removal of equipment from the plant with a crane demands a support vessel, which remains positioned near the side of the platform to receive pieces of equipment.

In spite of the platforms being of the same generation, P-B shows a similar evolution to P-A. Although the platform had spent resources with expensive handling devices and of little use – such as the lift of the laydown area, which was never used due to the greater facility of undertaking the same manoeuvres with a crane -, there are improvements in the integration between the main deck and the processing plant. If in P-A the access was made through ladders, in the case of P-B this access is made through ramps, permitting access without the use of the crane. These ramps are located as much on the port side as on the starboard side. P-A also has less flat routeways. The escape routes contain ladders in several stretches and there is great difficulty in circumventing deck piping to go from one side of the ship to the other, a matter which is attenuated in P-B. The lack of an integrated plan of material handling for the whole platform is nitched on these two platforms, with materials flow poorly defined and a lack of handling devices. In general, the system functions as a result of its cranes, of the trolley-car and of basic manual trolley-cars, although in P-B they are more varied. When lifting is necessary, out of reach of the crane, scaffolding is mounted for the installation of manually operated hoists.

### 4.2 The 2nd generation systems: the case of P-C

Platform P-C showed significant changes in its design project concept when compared with the first generation platforms. The distance between the superstructure and the processing plant was drastically reduced, since the topside of the platform was initiated immediately in front of the superstructure, in this way making the platform significantly more compact. The production modules, however, are further away from the superstructure due to the presence of a large laydown area, which is followed by utilities modules, maintaining the superstructure in a relatively secure area.

The set up arrangement of the P-C is only possible due to the policies of usage of cranes on this platform. The platform has 3 cranes, in that two of them are located near the main laydown area and another at the bow, but whose objective is not to service the processing plant, but has the purpose of carrying out the loading and unloading of cargos, provisions and chemical products, apart from having access to the utilities module and the bow systems. The processing plant has high capacity fixed handling devices that permit compensating the absence of a crane in the modules where there are more requirements.

Another fundamental characteristic of the P-C system is the valorization of the cargo areas. Its main laydown area, in the stern, has an area of approximately 840m2, which is considered very relevant, and a smaller auxiliary area in the bow. The platform’s chemical products deck also has an area of approximately 840m2, being considered one of the best among all company platforms. In order to guarantee these characteristics, however, the modules are placed quite close to each other and the platform becomes significantly edified – one part of the modules reaches up to 4 levels.

The richness of the cargo areas, releases the use of the main laydown area for a big quantity of functions. Apart from receiving cargos, the laydown area separates the superstructure from the processing plant and functions as an interface centre within the platform, in that all the other material handling passes through this location. It is an open area, with cargos received by the platform and, thus, is considered a secure area as regards risks of explosion, oil leaks, fire, among others. Thus, it is very beneficial to the security of the superstructure that this area is apart from the processing plant.

Although P-C has high capacity handling devices capable of undertaking the handling between the different levels of modules, the handling between the high capacity fixed devices and the installation/disassembly point of the equipment is not always a trivial task. The platform does not have any monorails – or other facilities for the installation of portable handling devices – in sufficient quantity, which permits the undertaking of handlings from the second floor to the top floor of the modules with any ease. In the light of this fragility, very often the handlings are delayed due to the mounting of scaffolding which permit the installation of hoists.
In P-C, the two aft cranes do not have direct communication with bow crane, but the platform counts with two high capacity trolleys (18 t e 5 t) capable of circulating along the central plant routeway and undertake the communication indirectly. In the modules, where their use is more frequent, there are interface points where the trolleys enter to pick up the pieces of equipment handled by fixed handling devices. The platform with trolleys permits furthermore, the handling of containers and large pieces of plant equipment.

The interface between the main deck and the processing plant is an important definition for the good functioning of the vessel’s materials handling system, since it is on this deck that the workshops are located, the storehouse, among other important areas. In P-C, this interface is carried out by means of a cargo lift located in the aft starboard side, with sufficient capacity to support the weight of the main devices of horizontal handling of the platform plus a further 5 t. This facility permits access to the main deck with no need for device substitution, including locations such as storehouses, workshops, access to the utilities room, fire pumps, and mooring system, among others.

4.3 The 3rd generation systems: The P-D case

The P-D platform is being conceived in a very distinct form from the platforms studied previously. Regarding the set up arrangement and organizing of the modules of the plant; the difference is very significant, since the superstructure is followed immediately by generating modules, which in thesis are less secure than the laydown area, which is located immediately after, competing for space with the utilities module.

Because of its concept of two cranes and policy of undertaking handling at the plant, whenever possible, P-D has less flexibility of positioning of the plant modules, since the modules in greater demand will have to be close to the cranes. The latter signifies, if previously the modules in great demand had independent handling systems, today these modules are dependent on cranes and need to be located within their field of action. The cranes are supplemented with structures for the installation of handling devices such as portable hoists and davits. Another factor that generates reduction in the flexibility of the positioning of modules on P-D is the insertion of an H2S removal module, which occupies a space that in P-C does not need to be taken up. This module will be necessary due to the characteristics of the oil produced, which has a high concentration of H2S.

The platform has a sole laydown area accessed by means of the aft crane. The cargo area of this platform is approximately 30% of the total area added together all the laydown area of P-C. Furthermore it is does not have a chemical products deck. The drums and cylinders are located in a space in a part of the laydown area of the cargo deck with no access by cranes, and the containers are positioned in the piperack structure. The inexistence of a deck for chemical products, eliminating the need for the creation of a grey area for the cranes in the modules in this location where these containers will be located, as occurs in the case of P-C. Furthermore differently from P-C, where all the chemical products are connected to their lines on the chemical products deck itself, in P-D the drums and cylinders are handled right up to the module of destination. Even so, it is necessary to circulate with these products right through the plant.

In the P-D plant, the laydown area assumes the function of a partial centre of interface. It is possible to go from the plant to the superstructure without passing through the laydown area, for example. In the same way that it is possible pick up equipment from the processing plant with the crane and move it to another point, without passing through that area.

The significant reduction of the laydown area, however, is not the consequence of the reduction of the size of the processing plant, since P-D is one of the biggest of the company. In P-D, the space which was sacrificed on the laydown area and on the chemical products deck was used to fulfill two demands: (1) the separation of the modules and (2) the horizontalization of the plant.

In P-C the modules are quite close to each other, whereas in P-D there is separation between them with the objective of separating the components of risk and avoiding the spreading of fires. That is, the materials handling system lost space in the deck area, but the platform gained in security. The P-D platform has the tendency furthermore to gain in terms of ventilation and better circulation of people and cargos – which represents an important gain for the material handling system.

The horizontalization of the plant also generates a series of gains for platform P-D, the main one being the greater accessibility of the cranes to the processing plant. A verticalized plant will give access to the cranes only to high floors. A module with just two levels, on the other hand, can offer quite satisfactory access if an access area for critical equipment is considered for the first floor. The use of the cranes
handlings in the plant permits a significant reduction of cost with acquisition, maintenance and certification of fixed devices.

In P-D, the typical situations of handling in areas which are not accessed by cranes, portable devices become the main device in use, for example, manual hoists, davits and mountable cranes. P-D platform counts with indepth studies and abundant structures for these types of portable devices. All the modules have handling plans for their main pieces of equipment and structures ready to receive hoists, davits and other devices which permit the handling processes until an interface point. The idea of material flow right from its origin until its final destination is more present than in platforms of previous generations.

In relation to cranes, there was a reduction from 3 to 2 units in P-D. This alteration occurred after the implementation of new project policies, with a view to cost reductions. The big question is whether, at the same time as the responsibility of the cranes in the equation of the plant handling increased, their quantity was reduced. The gain of importance of the cranes is not conducive with the policy adopted for new projects; since in this thesis, the significant total quantitative reduction of devices in the new projects already represents a considerable cost reduction.

Another project concept measure which significantly prejudices the general set up arrangement of P-D is the fact that the positioning of the two cranes did not receive the participation of the project designers of the arrangement of the plant, who in turn have to redouble their efforts to adequately organize the modules into their respective positions. This decision, for this platform, was taken by the hull project designer. Thus, there is a lack of adjustment logic between the necessities of the plant and the positioning of the cranes. In this platform, all the set up arrangement was planned in function of the cranes predetermined positioning.

This situation complicates the preparation of the general arrangement of the plant, since it eliminates a series of possibilities which the change in the location of the cranes can generate. Among negative comments, made by the project designers regarding the positioning of the P-D cranes, which call attention are: (1) in this platform the cranes do not intercommunicate and (2) the cranes do not substitute any operational absence of each other.

Since the cranes were positioned in the extremities of the plant, there is no crossover in the operational radius of the cranes, and this is very bad for the general arrangement concept, since it prejudices the handling activities throughout the plant. The only device which is capable of undertaking handling of heavy equipment is the 5 t trolley, but as it was designed to move in the escape routes, this device will have difficulties in handling large size pieces of equipment or containers (many of which will surpass its capacity). The trolley has also a much lower cargo capacity compared to the weight of the heaviest pieces of plant equipment and chemical product containers, for example. The P-D does not have a high capacity trolley such as the 18 t one that P-C possesses, due mainly to the reduction of resources made available in the preparation of the system of new projects. Thus, the interface between the cranes becomes to a certain extent comprised, creating a grey area in which the handling activities will be carried out with more difficulty. The alternative for the handling of heavier equipment is the use of skates, which are small trolleys which support heavy equipment, but the handling and manoeuvring of these heavier pieces of equipment using this method is physically tiring.

It is also important to mention that the cranes do not substitute each other. That is, if the aft crane is not working, the bow crane does not have a cargo area to receive containers, for example. The same applies for heavy equipment inside the modules. The communication of the cranes becomes even more relevant in this situation, since even if there is no common cargo area, accessed by both cranes, the cargos could be allocated to an intermediary point and afterwards be collected by the other crane.

The principle access to the main deck – which is also the provisions unloading area – is undertaken from a small laydown area located in the aft-starboard, at the level of the main deck. This small deck is accessed by the aft crane and has the function of receiving materials which will be sent to their final destination. Among these final locations, one can cite the warehouse, the workshops, and the provisions storehouse.

The elimination of the platform cargo lift has as main consequence the increase of the handling cycles. Whereas in P-C, a piece of equipment could be moved from a module to a workshop, for example, without changing the handling device, in P-D it is necessary to carry out at least 3 cycles for the same situation: handling using a trolley until the laydown area; handling using a crane to another trolley to the main deck; and handling using a further trolley till the workshop. Apart from the latter, in situations that demand different manoeuvres, when there is a lift, it is possible to place a large quantity of cargo in it and descend the whole quantity at a single time. With the cranes, these handlings can only be completed in several cycles.
5. Discussion

In this paper, we have shown how the analysis of activity enables to support a systematic study, not only of local work conditions, but to establish, from the determinant factors of working conditions, a diagnosis of the evolution of conditions working on different systems. This analysis was based on the understanding of the work in three distinct platform generations and verbalizations with designers.

The study of the 4 platforms allowed us to build an evolutive framework of Brazilian FPSOs material handling systems, divided in 3 generations, according to Table 2.

The analysis of all platforms together enabled us to conclude that the three generations has shown totally different project concepts, based on the amount of knowledge that the company had of this type of installation, project and cost policies at each time, and that all these elements have directly influenced the modus operandi of the team.

Table 2. The evolution of Brazilian FPSOs material handling systems.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>1st Generation</th>
<th>2nd Generation</th>
<th>3rd Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laydown areas</td>
<td>Cargos spread out on the main deck.</td>
<td>Wide area, above the demand.</td>
<td>Compact area.</td>
</tr>
<tr>
<td>Spacing between modules</td>
<td>Low.</td>
<td>Low.</td>
<td>High.</td>
</tr>
<tr>
<td>Cranes location</td>
<td>Three, spreadout on the deck. One of them in the plant.</td>
<td>Three. All near the laydown areas, with no access to plant modules.</td>
<td>Two, in the plant, with access to laydown areas and plant modules.</td>
</tr>
<tr>
<td>Communication between cranes</td>
<td>Nonexistent.</td>
<td>Indirect, by high capacity trolleys.</td>
<td>Indirect for 5 t cargos, by trolley.</td>
</tr>
<tr>
<td>Operational basis</td>
<td>Cranes; manual trolleys. Lack of lifting structures.</td>
<td>Fixed devices and high capacity trolleys.</td>
<td>Cranes, mó equipment, monorails and trolley.</td>
</tr>
<tr>
<td>Main difficulties</td>
<td>Handling until reaching the cranes with portable devices and poorly designed flows (big effort).</td>
<td>Handling between the location of installation and main devices (big effort required for some modules).</td>
<td>Detailed plan; resources for the main pieces of equipment; predominance of manual equipment (big effort required).</td>
</tr>
<tr>
<td>Resources</td>
<td>Sparse devices.</td>
<td>Increase of resources, cost of procurement, maintenance and certification.</td>
<td>Reduction of project, maintenance and certification costs</td>
</tr>
</tbody>
</table>

The first generation platforms have a fragile handling plan, with little integration between the areas, a concept of materials flow, which is quite restricted and only a small amount of handling resources. The handling time has the custom of being long and the use of scaffolding and improvised methods is common in these locations. One clearly perceives that the design of material flows and accesses, and types of equipment were not considered in a holistic way. They are the first stage, where many problems were identified. These first generation platforms were the initiating point for the second generation projects.

In the second and third generations the concepts of areas, design of material flows and accesses, and types of equipment are present, in a more integrated form, even though the characteristics of these projects are quite distinct. In the second generation, however, the integration is much more visible at a level of general set up arrangement, than in the internal systems of the modules. Although the systems function well from the moment in which the material reaches the devices of the main modules, which makes interface with
plant’s central route, this facility is not verified in the handlings between the locations of installation/disassembly of the existing equipment. The consequence of this is the need for mounting of scaffolding and the use of improvised methods, which increase the execution time and physical effort of execution. In P-D, being the newest generation the plans are highly detailed, right from origin until the final destination, with flows being well designed.

One notices nevertheless that the elimination of a series of facilities in P-D, such as a crane, the lifts, and the high capacity trolleys, have made the work more strenuous and the execution times longer. This difference is the result of project cost reduction policies, which resulted, apart from the elimination of important resources, in the division of the project in two parts: hull and processing plant. This division placed the positioning of the cranes under the responsibility of the hull project designer, reducing the possibility of the project designers of the plant concatenate the necessities of the arrangement set up and handling with access to the cranes. These factors make the cranes less effective in their handling activities.

The concept change between P-C and P-D is based, above all on the changes of the project policies and from the experience obtained from one project to another. In P-C, the project designers valued the cargo areas, but worked with modules closer together, more edified and with independent handling systems. In P-D, priority was given to the separation between the modules and horizontalization of the plant, with broadening of the use of plant cranes.

The main change caused by the new project concept was the significant reduction in the quantity of fixed devices. The P-C plant was planned with a large quantity of fixed hoists spread out among its modules. On the other hand, the new generation of platforms have a smaller quantity of fixed devices, placed only in critical locations. The high cost of acquisition, certification and maintenance of these devices, added to the low availability and low usage, created this concept change. The cranes, which are more robust and high reaching pieces of equipment, will be the main handling devices in the P-D plant and will be assisted by portable devices which could be installed for specific uses and then stored afterwards to avoid excessive effects of weathering.

This type of initiative would assure a functional project with relevant reduction in the cost of procurement of devices, certification and maintenance in the period of operation, but increases the manual efforts necessary to undertake the handlings in the plant, in areas where there is no access using a crane. The functioning condition of a plant in this particular way is through the maximization of the reach of cranes to the plant's type of equipment and this only occurs by means of horizontalization of the processing plant. The edification of the modules, thus, would affect P-D more than P-C, since the first depends more on the cranes than the second.

On the other hand, the concept of P-C is significantly more expensive than P-D, as much in terms of project as in operational terms, due to the high cost of maintenance and certification of the fixed devices. The component of cost reduction in P-D, however, is so strong that apart from the elimination of the fixed devices, it has resulted in the removal of facilities with high usage index, such one of the cranes, the cargo lift and the superstructure lift. The elimination of these facilities generates losses for the entire system project of P-D, since the difficulties to undertake certain handlings will be greater and will demand more time and physical effort of the team in the undertaking of tasks. In spite of the indications suggested in this study, however, it would be precipitated to state that there would be reduction in operational efficiency of the unit due to these difficulties, since the platform is still in its conceptual phase.

Thus, one can affirm that P-C and P-D are projects conceptually distinct, right from origin. The large scale usage of fixed handling devices or the use of cranes for the undertaking of plant handlings deeply affect the prioritization of relevant factors in the project, amongst them the necessity of the plant horizontalization.

If the policies driving the project indicate cost reduction with equipment, there is an ever increasing concern from the project designer teams with material handling systems. The latter has generated more detailed and complete project design documents, which significantly reduce the chances of there being blind spots and relevant flows not contemplated. In P-D specific plans were prepared for the main pieces of equipment of each module, right from its removal to its interface in the module. Despite indicating 3 generations of material handling systems in this period (1997-2013), it does not signify that all platforms in the period follow identical directives, since the projects are always changing. This research study does show, however, that the concept of all 3 generation projects studied follow quite distinct directives. Whereas in the first generation the vision of the material handling system is quite incipient, in the second it already seems to be mature on the macro level, with a costly concept, but nonetheless functional. In the third generation, a
new solution arose for these systems, which permitted significant project cost reduction and more robust solutions, but which demanded greater efforts from the workers in the activities of manual handling.

The meeting with project designers indicated that an effective evolution of these systems depends on a greater proximity between project design work and actual operational activity. Since at present, many project designers do not have access to the activities undertaken in the field, for this reason, there is a lack of clarity regarding the real demands of the workers. Reality is conjured up in the mind of a project designer through an “exercise of the imagination”, since he/she tries to predict what would happen, without having had access to what effectively happens during work activities.

Another complicating factor for design projecting of these systems, according to the project designers, relates to the decentralization of the design project of these systems. In the Brazilian projects, the cargo handling is fragmented into several disciplines, above all the set up arrangement – with specialization in project design of areas, material flows and accesses – and another for mechanics – plus a specialization in project design of handling equipment. There is an ever stronger movement of interaction between these disciplines, but this is a process that merits improvement.

Acknowledgements

For my family, friends, teachers and co-workers.

References
