Internal logistics management: Brazilian warehouse best practices based on lean methodology

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Abstract: In Brazil, a developing country, companies must continuously improve and specialise. Thus, in order to mitigate threats from competitors, logistics warehouse management has become a contributing factor for organisation success and part of strategy. In this sense, the more space and optimising inventory operation, the better material flow from production line up to service level, deploying profitable and productive results. Therefore, technical improvements in internal operations are critical for the studied organisation survival. In this study, we intend to demonstrate how best practices and tools based on lean manufacturing methodology are able to increase efficiency by reducing costs and waste in a company of oil and gas industry. This qualitative research integrated in a field research comprises company's warehouses visitation, non-invasion observation and employees' interviews. The result of this paper proposes solutions with low costs, mitigating waste performance to outline a production enhancement.

Keywords: supply chain; lean manufacturing; internal logistics.

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1 Introduction

In order to attend customer expectations companies target excellence in an increasingly competitive environment (Lam et al., 2015; Olhager and Prajogo, 2012). This is crucial in warehouse decision making and production integration, mixing products to manufacturing established goals. Henceforth, organisations envision internal operations integration, leaving aside individualistic vision towards coordinated work (Ben-Daya et al., 2013; Brodetskiy, 2015).

Besides integration, another important topic in this increasing competitive process is identifying business losses, evaluating throughout value chain mapping. This management tool aims to elucidate productive process losses according to enterprise goals, analysing its improvement plan. By its simple approach and methodology, the value chain mapping deploys activities with aggregated value during production (Brown et al., 2014).

Grosse and Glock (2015) and Zammori et al. (2014) highlight internal logistics and warehouse management are able to increase efficiency and reduce costs, identifying assertiveness and contributing to operations savings. Although many automated systems are available for picking, approximately 80% of companies have manual picking activities. This is due to cognitive and motor advantages in decision making manual picking compared to automatic systems.

Supply chain management (SCM) process visibility goes beyond the increased availability of information flow, as this should be relevant. In this sense, it is necessary to identify which process are affected by the lack of its visibility and thereafter strengthen information flow (Caridi et al., 2014).

Another key factor in SCM is human capital training, mainly those from warehouse. Due to repetition, these people learning imply tasks assimilation. Thus, training must provide a great number of familiar situations to improve its man labour (Grosse and Glock, 2015).

Given this context, it is necessary to characterise major industrial environment in which internal logistics is often underestimated. According to some professionals, this is due to fact SCM does not generate added value. Thus, barriers to change in areas such as warehouse, material picking, internal storage and handling are often left aside to perform other activities.

Within this context, this paper aims to analyse internal logistics process in a Brazilian oil and gas company. This paper is an empirical study which integrates academic and professional contributions. From academic perspective it is used lean manufacturing techniques in a supply chain context. From business viewpoint, oil and gas supply chain managers presents practical guidelines and empirical results of lean techniques.

Based on the aforementioned literature, this study aims to reflect upon lean techniques in oil and gas company through internal logistics operation: from receiving materials goods inputs to production line delivery and manufacture.

In order to achieve this goal visits in loco and interviews were conducted for data collection and better understanding of real problems. This paper is divided in six sections: and this one is the introduction. The second section reviews lean manufacturing techniques literature and important aspects in operations and logistics management. Third section presents research methods. The fourth section describes the current scenario. After analysis, fifth section discusses logistic best practices. The last section highlights final considerations.

2 Literature review of quality management in logistics

The heart of lean manufacturing approach consists in preserving value with less work by the identification and elimination of ‘waste’ in developing standardised, reliable processes (Baril et al., 2016). In this context, lean is a multi-dimensional concept with wide variety applications. In order to understand which aspects of lean are in literature, this current paper section begins reviewing lean manufacturing concepts and techniques. Then, operational aspects such as: production flexibility, indicators, material handling and picking are discussed.

According to Kupiainen et al. (2015), reviewing the academic literature is fundamental for three main reasons aggregating and synthesising existing knowledge, identifying changes in research related to time and providing academic foundation to start a new point of analysis investigation.

2.1 Lean manufacturing

Globalisation and market competition became fundamental to industrial site enhancement in various segments to achieve excellence and competitiveness. These improvements seek to raise product quality, reduce production lead-time and cost, as well as increase flexibility (Khanchanapong et al., 2014; Martínez-Jurado and Moyano-Fuentes, 2014).

In this context, Bortolotti et al. (2015) and Manzouri and Rahman (2013) confirms that lean management arises as an effective alternative to better assist entire operating performance. Based upon lean philosophy and techniques, five principles are considered: value, value chain, flow, pull production and perfection, for eliminating waste in production process.

Arunagiri and Gnanavelbabu (2014) reported evaluation of approximately 30 quality management tools related to lean manufacturing. It concluded that only five of them were extremely effective taking into account the evaluated companies’ sample. Amongst the most effective quality management tools are: 5S (*seiri, seiton, seiso, seiketsu, shitsuke*), overall equipment efficiency (OEE), 8 practical problem solving (8PPS), Pareto analysis and losses elimination.

From literature cross-study Gorane and Kant (2014) associate supply chain practices (SCP) with quality management metrics. The successful implementation of SCP can only be verified if the organisation performance is measured. In Table 1, Gorane and Kant (2014) define some SCP and its quality management metrics:

Table 1 Classification of SCP

SCP	*Metrics*
Manufacturing practices	JIT and lean manufacturing, postponement, agile manufacturing, mass customisation, strategic planning
Quality practices	TQM, Six Sigma, continuous improvement, benchmarking and performance measurement, supplier evaluation and rating
Relational practices	Supplier and customer relationship, information sharing
Practices related to organisation culture	Agreed vision and goals, top management commitment and support, employee motivation, employee training, employee involvement

Source: Gorane and Kant (2014)

Table 1 Classification of SCP (continued)

SCP	*Metrics*
Green SCP	Environmental management system (EMS), green manufacturing, green purchasing, reverse logistics
Technological practices	Information technology, RFID, technology for agile manufacturing
Inventory management practices	VMI, outsourcing, RFID, JIT, postponement, agile manufacturing
Logistics practices	3PL, 4PL, transportation and distribution management, geography proximity
Purchasing practices	e-procurement, JIT purchasing

Source: Gorane and Kant (2014)

Jabbour et al. (2013) relate some of these quality management translated into lean techniques: multifunction process; continuous improvement; 5S (*seiri, seiton, seiso, seiketsu, shitsuke*) which means 'sort', 'straighten', 'shine', 'standardise', and 'sustain'; total production maintenance; Kanban; just-in-time; production batch reduction; improvement cycle (kaizen) and supplier relationship.

Table 2 Lean techniques and its definition

Lean manufacturing	*Definition*
Multifunction process	Skills and personnel development, encouraging autonomy to prevent failures
Continuous improvement	Relentless pursuit of quality, cost, delivery
5S	Visual management approach, aiming to mitigate clutter and inefficiency
Total production maintenance	Keep machinery with satisfactory service levels, reducing downtime due to breakage or malfunction
Kanban	Visual pulled production system elaborated with coloured cards
Just-in-time	Continuous pulled production, no time/product/men-hour waste
Batch reduction	Reduction of production batch sizes, contributing to just-in-time and reducing work in process
Kaizen	Labour workers and managers on possible improvements evaluation
Suppliers relationship	Supplier communication creating partnerships to seek better information management

Source: Jabbour et al. (2013)

The use of less known techniques like Gemba also occurs in industrial and enterprise environments. This technique consists in going to the place where product 'gains value', in order to understand how process operates in practice, identifying losses or possible improvement points (Vaz and Simão, 2014).

Netland et al. (2015) points Gemba should be implemented in all production environments, whether industrial or not. They allow top management to be close to production, making it possible to observe the whole process and talk personally to labour workers facilitating possible improvements and process adjustments. This practice allows information flow between operating staff and top management through suggestions and solutions in production environment (Holtskog, 2013).

Value stream mapping (VSM) is the primary step for evaluation and deployment of any other technique linked to loss reduction. Its main purpose is to provide data and meaningful information so that one knows what are the tasks which directly contribute to add value to final product and those, which do not. So, it seeks to eliminate activities that do not add value focusing on increase value to the process (Sundar et al., 2014; Alsyouf et al., 2011; Mohanraj et al., 2011).

Despite aforementioned benefits, Tillema and Van der Steen (2015) remember lean program implementation is not always successful. In most cases, program failure is due to lack of support of high-management, as well as barriers related to organisational culture, among other factors. This implies that project may be unfinished. For instance, failure in improving performance can bring worse results than previous implementation (Martínez-Jurado et al., 2014).

Moreover, Netland et al. (2015) believe to ensure lean program successful implementation, especially in manufactory, it is necessary to develop a teamwork focused on development, improvement and reexamination on performance to ensure implementation success.

Thus, as major lean features it can be highlighted the correct use of available resources by minimising losses and the ability to remove non-value added activities from manufacturing process. Finally, enabling maximisation of customer value by increasing productivity, quality, reducing lead time and costs (Wahab et al., 2013; Saleeshya et al., 2015).

2.2 Production flexibility and indicators

Market uncertainty has become a major concern of organisations. Thus, production flexibility grows into a competitive strategy. The need to meet a greater amount of customer profiles with increasingly customised products and greater demands, making product lifetime is then, reduced, resulting from a higher degree of production flexibility (Choe et al., 2015; Kurien and Qureshi, 2015).

Therefore, production flexibility proposes a practical solution to face uncertainty. This practice is known as manufacturer ability to cooperate in the pursuit of meeting customers' needs and desires. Based on this idea, Choe et al. (2015) classified production flexibility into 11 types spread over three levels (components, systems, and value), demonstrated and specified in Table 3:

Table 3 Flexibility types

Type		*Areas*
I	Components	Machinery, material handling and operational flexibility
II	Systems	Work processes, products, routing, volume and expansion strategies
III	Aggregated value	Programs and systems, production and market flexibility

Source: Choe et al. (2015)

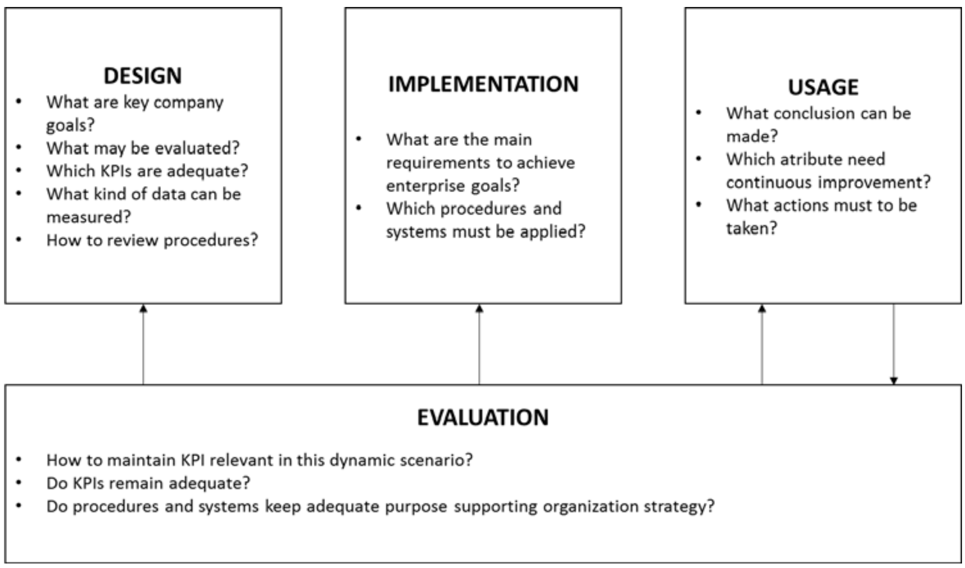
One way to control production flexibility is through means evaluation or metrics (KPIs – key performance indicators), which can be understood as the way of quantifying efficiency and effectiveness. The purpose of establishing these metrics is based on improvement in which hit into a new goal.

Based on this information, decision-making process is facilitated providing relevant data about past performance. It then enables better standards for further evaluation, proving how results directly relate to decisions. In this sense, they prevent conflicting metrics, reinforcing business strategy, while remaining compatible with organisational culture, providing data to benchmarking (Gutierrez et al., 2015; Shah and Sharma, 2014).

On the other hand, Lima et al. (2013) and Gutierrez et al. (2015) suggest that metrics should be drawn from business strategy, in order to consider its customers and other stakeholders (competitors, shareholders, partners, etc.). A model based on four stages is presented:

1 design
2 implementation
3 usage/review
4 evaluation.

Figure 1 Stages relationship



Source: Gutierrez et al. (2015)

The 'design' stage identifies key points to be analysed, metrics development and results analysis platform. In stage 'implementation', the focus is to collect, analyse and disseminate data. Regular metrics are reported to the assessed sector. During stage 'usage', a number of changes and revisions are made so as to make metrics more adherent to the process performed. Figure 1 shows the relationship of these key points.

Another contributing factor to production flexibility and KPIs evaluation is related to lean techniques such as value stream mapping which allows organisation to eliminate steps, processes and activities that do not influence final product preparation (Yang et al., 2015).

2.3 Material handling and picking flexibility

The main role of material handling is providing components or transportation within workstations, so this is one basic element, perhaps the most important of production flexibility. In this sense, the stockman is fundamental in material handling because so far, even counting on modern machinery, there is still reliance on human labour (Choe et al., 2015).

Hence, some man-labour advantages compared to machine, such as human flexibility of perceiving patterns, improvising procedures when problems are yet unforeseen, acting as deductive power to avoid exceeding deadlines, as well as judging priority to be executed during bottlenecks occurrence. The operator ability to perform other cognitive activities such as supervision is also worth noting.

Choe et al. (2015) also take into account the fact operators rely on their interpretation capacity to undertake the tasks. On the other hand, it means one mistake could negatively influence material handling. Thus, there is a need to provide adequately information to ensure successful application.

Consequently, another strategic activity for flexibility is material separation in a warehouse – described as a process in which the separation stockman receives a list of materials. This list refers to specification, coding and quantity of items that need to be separated. From this point, the storekeeper (or stockman) starts material separation. Thereafter he separates all items, checking them one more time and then packing to shipment (Gross and Glock, 2015).

Whereas this separation activity, most time is spent on locating material to be separated. Henceforth, warehouse must be mapped, so separation list reduces maximum storekeeper movement in search of materials (Chackelson et al., 2013).

The author also points there are four main problems related to this planning: physical arrangement of the warehouse (*layout*), scripting (*routing*), batch separation (or *lot separation*) and storage characteristics. Table 4 correlates these problems and definitions.

According to Rahman et al. (2013) and Danese (2013), one of the companies' main goals in recent years is related to reduction of man labour and stock. In other words, while inventory warehouse does not achieve excellence, low-cost strategy will not be reached. In this context, lean manufacturing application becomes relevant, especially through kanban, technique based on a visible cards indicating, warning or relating the occurrence of something.

According to Resta et al. (2015), lean tools effectiveness apply to both factories and warehouses. Kanban mainly by its visual characteristic helps organise and rearrange pieces in storage areas. Therefore, lean manufacturing and its tools applicability are feasible for production improvement (Holtskog, 2013).

Table 4 Warehouse main planning issues

Problem	*Definition*
Warehouse layout	Determining warehouse physical configuration, including setting the amount of corridors, streets and their dimensions. The storage system can escape parallel corridors patterns for models V-shaped, U and fishbone.
Routing	Sequence in which the stockman must perform the separation material, so that the operator travel time between one material and another is kept to a minimum.
Separation of lot/batch	Corresponds to capacity of planning aggregating separation chips similar to the storekeeper so he does not have the need to return to the same point after separating a list and working with lists similar routes.
Storage characteristics	Determines how product should enter and be stored in the warehouse. It may be defined according to the characteristic of the process performed. If there is random use of materials storage process can follow the same pattern without compromising operation. Another definition is the local specification for materials used when there are large volume: similar characteristics remain in the same area.

Source: Chackelson et al. (2013)

3 Methodology

This section describes the method used for data collection and analysis. The purpose is to assess trends and identify what is important in lean practices applied to warehouse management. Adopting similar methodological strategy than Pernstål et al. (2013), this research limited references in which title, keywords and abstract are in accordance with this study.

In order to assess the problem studied, Holtskog (2013) depicts the case study as one of the best methods for real problems investigation. Considering its complex phenomena and wide application in business, this technique is useful for its ability to offer real, feasible and simple solutions in short-term.

Case study must fully commit to information confidence and security. Aiming to better understand the industrial environment, researchers visit warehouses to understand the problem. Data was collected by a questionnaire based on previous literature discussed in section two. The chosen respondents include staff employee from tactical and operational hierarchical level. The questionnaire proposes to check employees awareness about warehouse problems. The short questionnaire was composed with four closed questions, two binary (yes or no) and two multiple choices.

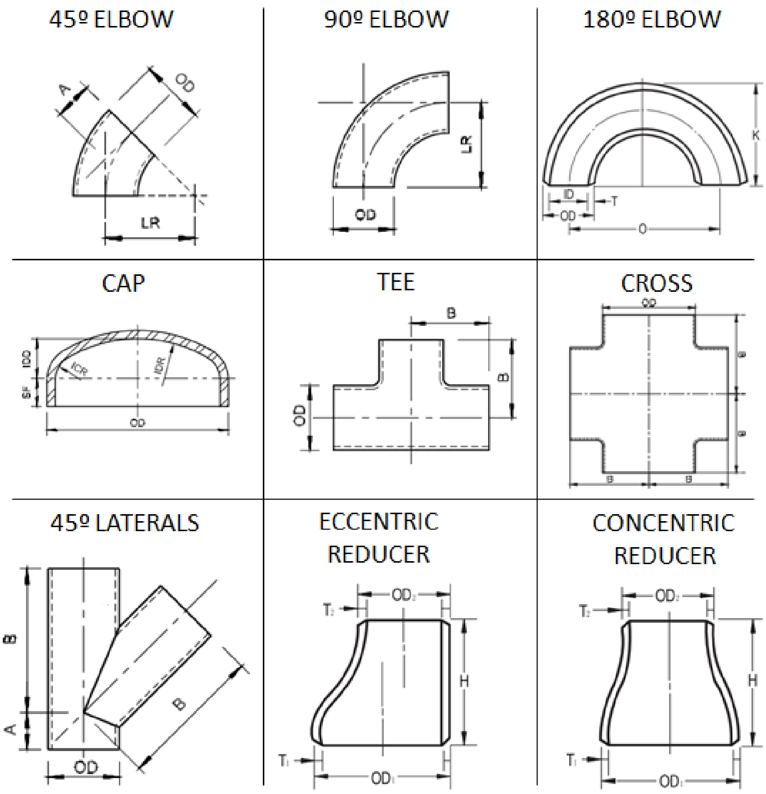
Considering this context, Quality management terms such as: *Gemba tools*, *visual manufacturing kanban* and *muda* were selected as these best adhered to the identified problems.

4 Logistics quality management case study

The company studied is a Brazilian organisation upstream on a supply chain responsible for providing spools for oil exploitation, refining, and other industrial operations. The study location was in southeastern Brazil. This company had primarily engaged in manufacturing industrial solutions for large projects and industrial equipment for refineries, petrochemical, floating production storage and offloading (FPSO), pipelines, among others. In addition to solutions for industrial pipes, the company also has extensive experience in manufacturing steel welded pipes, pressure vessels and special equipment in its portfolio.

Due to the large scope of its operations, this study will be limited to the manufacturing industrial pipes segment in southeastern Brazil, focusing on its flow of materials and information. For a better understanding, application warehouse materials are also limited to pipes connections as shown by Figure 2.

Figure 2 Steel connections



Source: Adapted by SENAI, Companhia Siderúrgica de Tubarão (1996)

The industrial pipeline site has two warehouses – the internal distribution is organised according to each material diameter area. Thus, materials with diameters up to 4 inches are stored in warehouse racks 1 (containing eight shelves and three workbenches for these materials storage), while materials greater than 4 inches diameter are stored in the warehouse 2 (it contains three shelves, three workbenches and free area to pallets and plunder accommodation).

As main segment feature is noted the lack of standard products, because all of them are manufactured according to pipe design (i.e. labour force is performed by project) differing from each other mostly in diameter, form, direction, angle, derivation, among other specifications. Moreover, in most cases, client defines which projects will be concluded, making it difficult for medium-term production planning. Consequently it generates routine material payment for production sector.

4.1 Case study problem description

For better understanding, a field research was planned in order to check sectors involved and storage areas. These visits considered non-invasive data analysis guided by lean Gemba methodology (concept which means 'going where things happen') with the purpose of finding out how activities are performed and how value is generated.

It can be inferred, from Gemba approach, several points restricting service level and simple improvement points began to be executed. Thus, identifying whether this vision during visitation was similar to employees was a challenge. In sum, a short survey form was elaborated which can be seen in Figure 3.

Figure 3 Gemba interview form

INTERVIEW FORM

Title

GEMBA METHOD STOCKMAN PERCEPTION

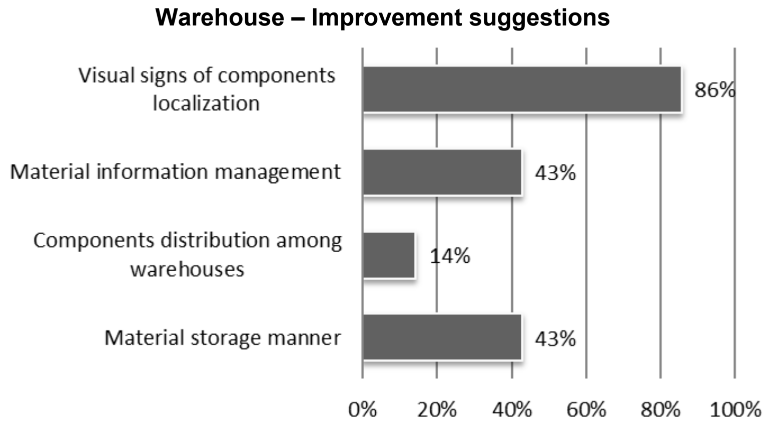
Role:

Question	*Answer*
By analysing warehouse today is there any improvement to be made?	☐ Yes ☐ No
If previous positive answer, this is due to:	☐ Material storage manner ☐ Components distribution among warehouses ☐ Material information management ☐ Visual signs of components localisation
What are the most influential warehouse problems?	☐ Lack of material forecasting ☐ Qualitative inspection delay ☐ Lack of material distribution flow ☐ Short time run to picking ☐ No material locator control ☐ Inability to generate real inventory report
Do the warehouse improvements represent additional costs?	☐ Yes ☐ No

Thus, the survey was applied to employees who works directly in warehouse activities. Questions containing issues such as: improvement analysis and best practices (*material storage manner, components distribution among warehouses, material information management, visual signs of components localisation*), as well as identification of main challenges in warehousing (*lack of material forecasting, qualitative inspection delay, lack of material distribution flux, short time run to picking, no material locator control, inability to generate real inventory report*).

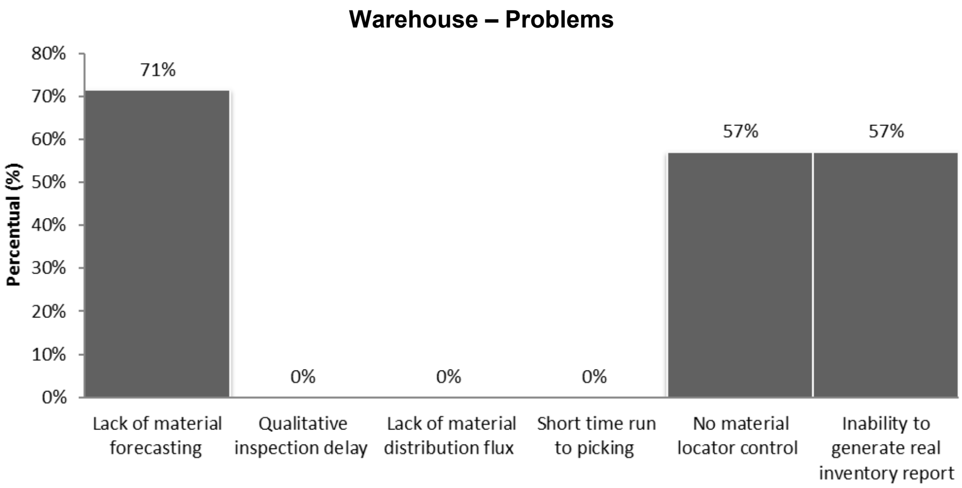
The survey was answered by seven employees: three tactical level (supervision, coordination, managing) and four operational level. They exposed their opinion about warehousing, as well as presenting their improvement and major problems viewpoints. Having completed the questionnaire, it was possible to group answers stratifying answers, as well as tracing main points as Figure 4 shows:

Figure 4 Possible improvement warehouse topics



Therefore, in the team's view, it should be developed methods and techniques considering as criteria decreasing importance, improving visual signalling location of components, allowing better information management. In the second part of interview, other issues were identified during Gemba course in production area and results are shown in Figure 5.

Figure 5 Problems related by warehouse team



Based on Figure 5 results, the main problems identified to process were: lack of materials arrival predictability, lack of material localisation control, impossibility of establishing actual inventory reports. Finally, employees' views were collected to understand their vision on investment need to improve warehouses. This survey result is display in Figure 6.

Figure 6 Improvement costs related to warehouse management

Then, visiting warehouses, the primary perception and interview provided the necessary information to evaluate and propose improvements to process. Therefore, warehouse studied raised its service level by reducing waste using lean approach.

Finally, the following improvement proposal covers items such as changing layout, ideal setting position for warehouse components, pallets organisation in storage areas, among others. All proposals aim to raise the speed materials separation (picking), which directly contributes to faster material availability in production line.

5 Improvement proposal

Assessing the improvements main points after collecting data, several simple changes were identified, which, if implemented, will bring immediate positive results. Therefore, improvements deployed lean manufacturing method. Table 5 reflects 'best practices' checked for warehouse operations based on this study survey.

Table 5 Warehouse basic improvement action plan

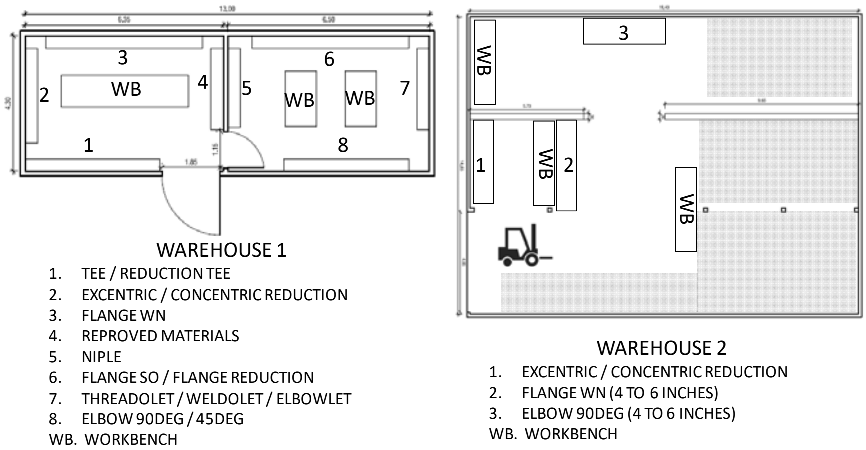
Action plan				
What?	*How?*	*Who?/ Where?*	*Why?*	*How much?*
Warehouse manual verticalisation	By the same material on pallets looting	Stockman Warehouse 2	Warehouse space better usage	US$ 0.00
Add the same material on the same pallet	Manually moving pieces to the same pallet	Stockman Warehouse 2	Visual identification where material is sought	US$ 0,00

Table 5 Warehouse basic improvement action plan (continued)

Action plan				
What?	*How?*	*Who?/ Where?*	*Why?*	*How much?*
Developing warehouse mapping *(visual manufacturing)*	Using layout map to find the desired materials	Coordinator Warehouse 1 and 2	Create quality mngt. culture (5S) in the warehouse	US$ 10
Layout change	Changing shelves and tables position	Coordinator Warehouse 2	Allow better forklift traffic (safety)	US$ 0.00
Develop sign with every type of material *(kanban)*	Using components drawings and printing	Coordinator Warehouse 1 and 2	Fix the sign to support warehouse map	US$ 25
Organising pallets increasing its diameter	Moving pallets with forklift	Stockman Warehouse 2	Make it easier to use FIFO approach (small diameter)	US$ 0.00
Manufacture wood drawer to small items	Using wood boxes to create smaller sections	Stockman Warehouse 1	Allow small items better storage	US$ 0.00
Apply material summary to stock withdraw	Changing material payment model: from project to manufacturing lot	Production planner and coordinator	Facilitate stockman picking process	US$ 0.00
Grid the warehouse	Inserting gate and missing grid to lock warehouse	Coordinator Warehouse 2	Increase storage protection (security)	US$ 1.000

Thereafter, it is possible to observe that most of proposed changes are not related to its financial investments. This is due to the fact changes for organisational goals are required, also focusing on new warehousing culture. Taking lean culture into account, team integration can be highlighted, deploying total support in developing project. In Figure 7 is showed each warehouse map and the location of its components by type.

Figure 7 Visual manufacturing warehouse layout



During warehouses visit, it was perceived the stockman difficulty to locate components. The scenario became more critical in warehouse 1 due to small size materials. Thus, the warehouse map was proposed setting each type of shelf. However, location definition alone is not enough to end the problem of mixing components on the shelves. It was recommended to create cards (*kanban*) fixing them in closets.

The warehouse 2 shaded area is bounded to pallets, taking into consideration that pallets sides are reserved for elbows allowing stacking and supporting warehouse beams. Warehouse 2 back was filled with larger connections diameters which tend to stay longer (stored time criteria) in warehouse. Thus, diameter decreases as they get closer to the warehouse entrance.

The following work station pallet storage area was purposely placed in this position to delimit the maximum point of placing pallets, allowing forklift free movement for all warehouse 2.

Thus, it is expected that items application in the action plan achieve the desired effect as warehouse management improve and fosters a better working environment.

6 Final considerations

Managing internal logistical process is an issue that has currently become critical for success in a competitive market within any industry and supply chain. This article offers a robust review in literature, complemented by an empirical study of lean techniques applied in oil and gas company warehouse.

Internal logistics can be considered as an interdisciplinary topic of interest for scholars, because not only works in SCM but also operation and manufacturing. Additionally, it has a direct relation on service level impacting on financial performance and the consumer perception of company reputation.

Academic literature review reinforces this interdisciplinary aspect and also points to the need of developing models which correlates lean techniques in a manufacturing context, especially in warehouse operations (Sundar et al., 2014). In this sense, this article offers a contribution to literature fulfil the gap between theory and practice. Furthermore, this article is also aligned with other authors as Wang et al. (2015) who demonstrate that lean practices are perceived as having positive impact on business in general.

A managerial reflection is also provided by this paper. The guidelines and questionnaire developed in sections four and five serves as quick tools to identify main problems in a warehouse operation and a complementary step to implement lean techniques. One empirical conclusion worth noting is that most proposals do not depends on a financial support, considering its importance in a world recovering from economic crisis.

Although this paper provides empirical evidence of a Brazilian oil and gas industry, one must acknowledge the extent to which these findings can be generalised across a wider range of products, countries and industries is limited. From a conceptual point of view, lean methodology in a warehouse operation is an issue that is still rare in literature and need further studies on the subject.

In addition, it remains a lack of SCM tools and models to aid companies. Future studies might check the validity and expand on our findings, moving towards the development of other guidelines and new empirical studies. One should also ratify this study was restricted to only one manufacturing company.

Therefore, as supply chain is becoming more relevant for industrial engineering, it is increasing the study of lean methodology in production engineering and SCM, such as transportation, information and distribution.

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