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TOYOTA PRODUCTION SYSTEM - ONE EXAMPLE TO SHIPBUILDING INDUSTRY

Delmo Alves de Moura
Federal University of ABC, Brazil
E-mail: delmo.moura@ufabc.edu.br

Rui Carlos Botter
University of São Paulo, Brazil
E-mail: rcbotter@usp.br

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ABSTRACT

The objective is analysing the shipbuilding industry and their competitiveness to develop and apply Toyota Production System. The methodology consisted in the qualitative type research by means of personal interviews, with entrepreneurs, presidents, directors and managers of the maritime industry. The contribution of that work was several Toyota Production System technicians can and should be applied at shipyards to improve their vessel manufacturing and assembling systems. The shipbuilding system can use the techniques used in the Toyota Production System as an example for its production process. Production should be lean, minimize defects, stop production and reduce or eliminate inventories. Lean production is regarded by many as simply an enhancement of mass production methods, whereas agility implies breaking out of the mass production mould and producing much more highly customized products - where the customer wants them in any quantity. In a product line context, it amounts to striving for economies of scope, rather than economies of scale ideally serving ever smaller niche markets, even quantities of one, without the high cost traditionally associated with customization. A lean company may be thought of as a very productive and cost efficient producer of goods or services.

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Keywords: Toyota Production System, Lean production, Agility, Shipbuilding

1. INTRODUCTION

1.1. Toyota Production System (TPS)

The main objective of that work is analyses the shipbuilding industry and their competitiveness to develop and apply Toyota Production System. The Shipbuilding has some stages of production that may have affinity with the Toyota Production System and thereby improve the competitiveness of the domestic industry. Various production techniques may be relevant to improve waste of time and products in the production stages of vessels.

Some overseas yards already work applying the Toyota Production System in their industrial facilities. This greatly reduced the time wasted on project development, vessel production time, improved the integration of people who work directly and indirectly in the production of ships and, above all, improved the competitiveness of the shipyards.

Know the tools related to the Toyota Production System, know how to apply them in several stages, from product development to final production. As well as integrating it with its supply chain, is an important competitive differential to remain in the shipbuilding market.

Producing to eliminate inventory, waste, defects and meet the market need is a strategic differential of the Toyota Production System. Building an integrated logistics chain among its suppliers is another essential factor in the success of the system.

Since the conception of the assembly line and the following development of the Toyota Production System (TPS), efficiency has been a central objective of manufacturing. Lean manufacturing focuses on the systematic elimination of wastes from an organization's operations through a set of synergistic work practices to produce products and services at the rate of demand.

Lean manufacturing represents a multifaceted concept that may be grouped together as distinct bundles of organizational practices. A list of bundles of lean practices includes JIT, total quality management, total preventative maintenance, and human resource management, pull, flow, low setup, controlled processes,

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productive maintenance and involved employees. Lean manufacturing is as a set of practices focused on reduction of wastes and non-value added activities from a firm's manufacturing operations (YANG, et al. 2011; BROWN; SCHMITT; SCHONBERGER, 2015; HASLE, et al. 2012; KUULA; PUTKIRANTA; TOIVANEN, 2012, BENNET; KLUNG, 2012; CHAVEZ, et al., 2013; HENDRY; HUANG; STEVENSON, 2013; BONNEY; JABER, 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN, RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; VENTO, et al., 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

The base of the Toyota Production System (TPS) is to eliminate waste in the system. Therefore work philosophy and a few techniques / tools were inserted in the day to day organization to achieve such goal.

The seven types of waste recommended that should be eliminated in TPS are:

- Overproduction; Transport, which adds no value to the product; Process, transactions that should not exist; Waiting time, intermediate stock which generates queue in the process; Stock, throughout the production process, supply chain and finished products; Driving, which adds no value to the product; Defects, which burden the productive process generating rework; wasted of time; manpower; hours of equipment etc.

1.2. Agile Manufacturing

Agility can be summarized as the use of well known developed technologies and manufacturing methods. Among them there are Lean Manufacturing, CIM, TQM, MRP II, BPR, Employee Empowerment and OPT. In other words agility is the ability to grow business in competitive markets of continuous and unexpected changes, with rapid response aimed at the consumer/customer valuing the product and service (YANG, et al. 2010; CHAVEZ, et al., 2013; HENDRY; HUANG, STEVENSON, 2013; BONNEY; JABER, 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN,

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2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

- CIM (Computer Integrating Manufacturing); TQM (Total Quality Management); MRP II (Manufacturing Resources Planning II); BPR (Business Process Reengineering); OPT (Optimized Production Technology).

Agile can be describe as ability of an organization to detect changes (which can be opportunities or threats or a combination of both) in its business environment and hence providing focused and rapid responses to its customers and stakeholders by reconfiguring its resources, processes and strategies (LEITE, BRAZ, 2016)

An effective integration of response ability and knowledge management in order to rapidly, efficiently and accurately adapt to any unexpected (or unpredictable) change in both proactive and reactive business/ customer needs and opportunities without compromising with the cost or the quality of the product/ process (GANGULY, et al., 2009; DRAKE; LEE; HUSSAIN, 2013; VENTO, et al., 2016).

Ability of a firm to dynamically modify and/ or reconfigure individual business processes to accommodate required and potential needs of the firm. Ability of a firm to redesign their existing processes rapidly and create new processes in a timely fashion in order to be able to take advantage and thrive of the unpredictable and highly dynamic market conditions.

The ability of a firm to excel simultaneously on operations capabilities of quality, delivery, flexibility and cost in a coordinated fashion' (VENTO, et al., 2016).

The Lean Manufacturing system aims to reduce the lead time for obtaining the components /parts, subsets etc. related to the supply chain, to reduce time of production /processing, to run the process/operation without faults (do it right at the first time) and to eliminate or minimize stocks with high control over the operations, on time deliveries, increased productivity with efficiency in operations (HASLE, et al. 2012; KUULA; PUTKIRANTA; TOIVANEN, 2012; ZU; KAYNAK, 2012; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; EL-KHALIL, 2015; BR KUMAR;

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SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017; MOHAMMADDUST, et al., 2017).

Research conducted by Iaccoca Institute, Lehigh University, in USA resulted in a report about agility manufacturing. New criterion are:

- Constant changes; Fast response; Improved quality; Social responsibility

Thus, an agile manufacturing company must have a broad view of new needs in the business environment, skill and ability to deal with turbulence and gain competitive advantage in its businesses (LEITE; BRAZ, 2016).

The four main categories to be an organization in a rapidly changing environment are: In Fast Response (ability to identify changes and promote rapid responses of reactive and proactive manner) and sensitivity to anticipate market changes; Immediate reaction to changes and insert them into the system and Absorbing changes.

In Competence (a set of abilities that produces higher productivity, efficiency and effectiveness in operations and processes to the tasks to achieve the goals set by company):

- Have strategic vision; Appropriate technologies or enough technological ability; Quality of products and services; Efficiency in costs; High rate of introduction of new products; People are trained, certified and involved with the process; Efficiency and effectiveness in lean operations; Internal and external cooperation and Integration (KUULA; PUTKIRANTA; TOIVANEN, 2012; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; VENTO, et al., 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

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In flexibility (ability to process different products and achieve different goals with the same manufacturing plant):

- Flexibility in the volume of products; Flexibility in product models; Organizational flexibility and Flexible people.

In Quickness (ability to deal with tasks and operations in a shorter time). Short time to insert new products in the market; Fast delivery of products and services and Fast transaction time

Agile manufacturing encompasses both the concepts of lean and flexible. Also that lean manufacturing is primarily concerned with minimization (if not elimination) of waste through an efficient production process (GANGULY, et al. 2009; HASLE, et al. 2012; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

Agile manufacturing means that the production process must be able to respond quickly to changes in information from the market This requires lead time compression in terms of flow of information and material, and the ability, at short notice, to change to a wide variety of products Therefore, the ability to rapidly reconfigure a the production process is essential. In lean manufacturing the ability to change products quickly is also key as any time wasted in changing over to a new product is muda and therefore should be eliminated (CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

To summarize these two characteristics agile manufacturing calls for a high level of rapid reconfiguration and will eliminate as much waste as possible but does

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not emphasize the elimination of all waste as a prerequisite. Lean manufacturing states that all non value adding activities, or muda, must be eliminated (CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; WICKRAMASINGHE; WICKRAMASINGHE, 2016; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

Agile manufacturing further requires an all encompassing view, whereas lean production is typically associated only with the factory floor. Agility further embodies such concepts as rapid formation of multi company alliances or virtual companies to introduce new products to the market. An agile company is primarily characterised as a very fast and efficient learning organisation if it was not first productive and cost efficient (CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

In agile manufacturing, the main features shall be (LEITE; BRAZ, 2016; VENTO et al., 2016):

- High quality products and highly customized; Products and services with high added value; Mobilization of key competences; Commitment to social and environmental matters; Responding to change and uncertainty and Intern Integration and between companies.

2. THE ENABLERS OF AGILE MANUFACTURING

The enablers of Agile Manufacturing are the strategies, systems, technologies, methodologies and tools that allow the company to become agile. For better understanding, these enablers are classified based on its focus. This classification groups the enablers of Agile Manufacturing, according to the focus on four categories (LEITE; BRAZ, 2016):

- Strategies: Virtual enterprise / virtual manufacturing

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Virtual enterprise is a temporary aggregation of smaller units and its core competencies and associated resources, which gather together to explore business opportunities and act like a single large company. However, as one company is not often able to respond quickly to market needs, the virtual company works for its agility. The subject of virtual enterprises within an agile context is considered vital and indispensable for Agile Manufacturing (LEITE; BRAZ, 2016).

Integration of supply chain; Management based on key competences; Simultaneous Engineering; Management based on uncertainty and change; Knowledge based management; Technologies: Hardware - Tools & Equipment (ZU; KAYNAK, 2012; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017).

To Leite, Braz (2016), Agile Manufacturing requires the rapid shift in product assembly. This is only possible with an adequate structure for the hardware (robots, feeders of flexible parts, module assembly, automated visual inspection, computer guided vehicles etc. Information Technology: computers and software

The technology and information systems used in Agile Manufacturing can be divided according to the purposes intended, in: Technology and systems dedicated to agile project: CAD, CAM, the computer aided planning process - CAPP (FENG, et al., 2015; LEITE; BRAZ, 2016).

Technologies and systems for the agile production: FMS, CIM. Technologies and systems of communication and integration inside and among enterprises MRP, ERP, EDI and electronic commerce.

- CAD (Computer Aided Design); CAM (Computer Aided Manufacturing); FMS (Flexible Manufacturing System); MRP (Material Requirement Planning); ERP (Enterprise Resource Planning); EDI (Electronic Data Interchange).

Several techniques and systems are addressed in the literature that support the agile systems design: CAD/CAM, rapid prototyping and QFD are some examples. Regarding the project support systems for Agile Manufacturing, some jobs are worth highlighting:

- QFD (Quality Function Deployment); Planning and Control Systems; Integration of management systems and database; People; Continuous improvement; Commitment of senior management and empowerment; People

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multi qualified, flexible and knowledgeable; Teamwork and participation and Training and continuing education.

The main human factors to be considered for an agile manufacturing environment are: continuous improvement, top management commitment and empowerment, use of flexible multienabled people, teamwork and participation, training and continuing education (LEITE; BRAZ, 2016).

3. SOME IMPORTANT POINTS TO BECOME LEAN AND/OR AGILE

3.1. TQM - Total Quality Management

TQM is something more solid which involves an integrated and shared chain with strategic goals of high performance and quality, aiming at highly competitive markets with sustainable industrial processes and international reference. However, quality program like ISO 9000 does not necessarily guarantee the best quality practices and can not be considered an integrated process throughout the production chain, but it is a first step to check quality (YANG, et al. 2010; HENDRY; HUANG; STEVENSON, 2013; LEITE; BRAZ, 2016; VENTO, et al., 2016; MOHAMMADDUST, et al., 2017).

TQM has the emphasis on continuous improvement of industrial processes, always seeking the feedback system, in order to improve the process and eliminate potential causes of problems. Thus, TQM integrates the suppliers from the development phase of the project, in the quest for continuous improvement with a focus on flawless process, reducing the development time, with operational reliability in the process, and products with no defects according to the specifications of the customer or market, free of processing errors or rework, with a balanced industrial operations, with high productivity and reduced operating costs (YANG, et al. 2010; KUULA; PUTKIRANTA; TOIVANEN, 2012; HENDRY; HUANG; STEVENSON, 2013; EL-KHALIL, 2015; NARAYANAMURTHY; GURUMURTHY, 2016).

3.2. Core Competency

Core competencies are factors that involve collective learning and the way that those values are disseminated in an organization, and how those competences are managed in order to enhance the integration among the agents who seek for competitive advantage of an organization to face competitors.

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The core competence of an organization may allow the opening of new markets or be a positive factor to try to keep customers, being an advantage over the competitors when decisions of purchase are made, as well as being an outstanding brand when compared to others. Core competence can make a competitor to have difficulty imitating it.

3.3. Innovation

Innovation is a key factor in competitive advantage for an organization. Then, fine tune with the needs of markets is a key factor to promote the competitive edge of companies. Factors such as financial sustainability, ways of relating to their supply chain and customers, reliability and recognized quality of products and service are key points that shall be taken into consideration when making strategic decision for a company to become globally competitive (ZU; KAYNAK, 2012, OTA; HAZAMA; SAMSON, 2013; FOX, 2013; PÉRY; AGERON; NEUBERT, 2013; OKE, 2013; DEKKERS; KÜHNLE, 2012; SÄFSTEN, et al., 2014; BRUNCH; BELLGRAN, 2014; KAFETZOPOULOS; PSOMAS, 2015; THEYEL; HOFMANN, 2015; WALLIN; PARIDA; ISAKSSON, 2015; VENTO, et al., 2016; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017).

Innovation means that industries can gain competitive advantages in their segments. Thus, it is essential that companies make investment as a way to stand out from competitors and gain recognition (OTA; HAZAMA; SAMSON, 2013; FOX, 2013; OKE, 2013; DEKKERS; KÜHNLE, 2012; SÄFSTEN, et al., 2014; BRUNCH; BELLGRAN, 2014; KAFETZOPOULOS; PSOMAS, 2015; THEYEL; HOFMANN, 2015; WALLIN; PARIDA; ISAKSSON, 2015).

Innovation will require pro-active strategies for anticipating technological and market changes which directly or indirectly affect companies when facing their main competitors. Thus, this process should also be inserted in the supply chain of a client, otherwise it would have difficulties in gaining competitive advantage over the competitor. It is also essential to integrate innovative business strategy of a company and its partners (ZU; KAYNAK, 2012; OTA; HAZAMA; SAMSON, 2013; FOX, 2013; PÉRY; AGERON; NEUBERT, 2013; OKE, 2013; DEKKERS; KÜHNLE, 2012; SÄFSTEN, et al., 2014; BRUNCH; BELLGRAN, 2014; KAFETZOPOULOS;

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PSOMAS, 2015; THEYEL; HOFMANN, 2015; WALLIN; PARIDA; ISAKSSON, 2015; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017).

3.4. Advantage in Manufacturing

The competitive advantage in manufacturing shows that the company stands out from its competitors to meet market needs. That means making right is related to the goal of quality performance, making fast relates to Speed, making in time relates to reliability, customization relates to flexibility and making with low cost is related to the objective costs.

The manufacturing strategy, according to, can not be isolated from corporate strategy and should affect and be affected by other areas of business such as Marketing, Finance, Purchasing, Research and Development, Human Resources etc.. The authors comment that the manufacturing objectives are expressed in terms of some dimensions of performance used to measure manufacturing strategy, characterized by: cost, quality, flexibility and delivery.

Technological capability is one of the attributes that can differentiate a company from its competitors. They report that firms that possess technological expertise recognized by the market have an asset difficult to be imitated contributes to the improvement of products, increasing their value and creating a gap in the market among companies that have it and those that still try to achieve. The development of technological capability must be inserted in the strategy defined by the company.

4. SOME EXPERINCES

South Korea approached the boundaries of technology, activities related to Research and Development (R&D) has become more intense. There was a need for targeted search for relevant information, more interaction between the project team and other departments of the organization like production and marketing, and even with other companies, such as the suppliers, customers, local research institutions, and universities.

One of the policies implemented in Korea was the import of technology and its dissemination to all Korean companies in that segment, aiming to have the largest possible number of Korean companies with knowledge of the new world leading technologies. Then, Korean companies noticed the need to develop their own

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technologies, assimilate, adapt and improve the imported technology. For this, there was a need for investment and integration with the areas of research and development (R&D) with the intention of having their own technologies. Therefore, with increasing industrialization, there were government policies focused on increasing research and development.

The policy aimed at import substitution was critical in creating the demand for foreign technology transfer. The import substitution through protectionism contributed greatly to the transfer of technology from other countries, leveraging various industries and introducing more sophisticated products

Add to that the export issue, which became the top priority of the Korean government to achieve goals of economic growth. Thus, the government selected strategic industries, both for import substitution and for export promotion.

As a segment changed his condition from not developed to an exporter, the Korean government decreased significantly its protectionism. The Korean government defined exports target montlhy, and companies were required to achieve that goals being monitored constantly by the Minister of Trade and Industry, directors of the biggest financial institutions, leaders of business associations and representatives of leading exporting companies.

As South Korea was one of the countries that entered the shipbuilding sector much later than its biggest competitors at the time, she had the advantage of the projects best suited their yards, compared to existing in the Asia and Europe. Apart from this, some were designed with huge capacity, exceeding enormously the total capacity of countries considered high power production for the season. The ability of a single Korean shipyard has already surpassed the total production of a country. In addition to these items, there was the fact that the Korean manpower work more hours per week, compared with European countries, and this has increased the competitiveness of Korean shipbuilding segment of the world.

South Korea has created policies towards the shipbuilding segment that gave sustainability to the sector by promoting the development of technology centers, universities, companies of marine parts, service companies, industrial parks, schools, technical and labor specialized work, and has focused primarily on the external market. Export was a challenge that has afforded it the policies for the

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shipbuilding sector and enormous efforts have been made by various actors directly or indirectly related to the country to reach their goals and become globally competitive in that segment .

Both South Korea and Japan have specialized in the production of bulk carriers and tankers focused on mass production, benefiting their production lines because the yards have reduced or eliminated the flexibility offered to the clients, the ship owners, benefiting economies of scale and reducing production costs. Low or no flexibility, high quality, low cost, reduced cycle time for development and production with some innovation / technology were some of the strategies used by Korean shipyards (OTA; HAZAMA; SAMSON, 2013; FOX, 2013; PÉRY; AGERON; NEUBERT, 2013; OKE, 2013; DEKKERS; KÜHNLE, 2012; SÄFSTE, et al., 2014; BRUNCH; BELLGRAN, 2014; KAFETZOPOULOS; PSOMAS, 2015; THEYEL; HOFMANN, 2015; WALLIN; PARIDA; ISAKSSON, 2015).

This has seen a huge gain with the learning curve, obtaining a competitive advantage against global competitors. The strategy of South Korea was producing ships different from those produced in Japan, with simpler and cheaper products. Another peculiarity was the planning for the financing focused on exports. There was heavy subsidies in the Korean shipbuilding sector, for insertion of its vessels in various world markets, as well as having strong export policy aimed at solidifying entire structure to make South Korea a country among the most renowned world shipbuilding market.

Japan has established itself in the strategy of cost leadership, according to the model of Porter. With strong participation of several companies related to the sector, with special dedication to factors related to quality control, well trained manpower able to perform their tasks with the highest quality in the production process, the emphasis for having a classification society qualified and a standardization policy which would help boost the business of shipbuilding. But soon the focus of Japanese policies shifted to Research and Development, with strong predominance of the critical success factor Innovation.

It is critical that a business analyzes the trade-offs from the manufacturing area, in order that the settings defined in the strategic production can meet the corporate strategies and allow the company to become competitive in highly

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competitive global markets. Analyzing possible decisions and their alternatives is essential to guide the likely direction to be followed by an organization to promote their competitive advantages in the market.

Japan has guaranteed a minimum production at its shipyards, which contributed to promoting the development of the sector. This program was called Keikaku Zosen. Furthermore, there was a massive investment in automation, to reduce the cost of manpower, and this factor contributed greatly to developing the critical success factor Technology and, thus, Japan is recognized with this competitive advantage ahead the international market of shipbuilding.

Japan has innovated in the production of ships and consequently has increased productivity, but also innovated in the design of vessels. Invested in robotics and in managerial and administrative techniques for controlling the flow of materials and their respective quality.

Another very important factor in the Japanese shipbuilding system was the integration existing in the supply chain among shipyards and their suppliers of ship parts, and there was integration between shipyards and ship owners too, and also between competing shipyards. There was bigger cooperation for product development and technology that would benefit everyone, with government incentives, helping the growth of the local maritime sector. There was the implementation of national policy for promotion of scientific and technological activities involving laboratories, universities, research institutes etc. (ZU; KAYNAK, 2012; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017).

Thus, the Japanese were able to get competitive prices globally and even below the market average in the construction of their ships, besides offering special financing conditions for international ship owners to build their ships in shipyards in Japan. For this it was necessary plans, incentive mechanisms and instruments of industrial policy that would involve not only shipbuilding but the chain that was directly or indirectly related to the Japanese shipbuilding industry. For instance: chemical, steel and metallurgic industries, electrical machinery and transport equipment and heavy chemical industry. There was the essential participation of the Ministry of International Trade and Industry to create such industrial policies that ensure sustained growth of the segment.

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5. METHODOLOGICAL PROCEDURES

The methodology consisted in the qualitative type research. It was carried through by means of personal interviews, with entrepreneurs, presidents, directors and managers of the maritime industry. The criterion used for election of the companies in the qualitative research was based on the importance of the company inside its segment. Therefore, the questionnaire was applied exclusively in the 31 visited shipyards in Brazil and and abroad. However, other data had been collected personally in the other actors of the national maritime industry.

In the State of Rio de Janeiro there is a concentration of shipyards focused on the segments of the ship construction, repair and offshore platform construction. When it is analyzed the integration factor among the shipyards of these segments in the State of Rio de Janeiro, the research has pointed out that is almost inexistent the exchange of experience, know-how, technology or knowledge among the companies.

Few are the suppliers that participate on the development phase of products from the shipyards and when this occurs, it is generally in the offshore platform segment where there is the PROMINP programme and the leadership of Petrobras, that contributes for the small integration among the companies of this specific segment (offshore platform construction). The integration with the other actors of these segments, such as universities, research and development centres, government, etc. is isolated and without industrial policies that contribute for the development of the maritime segments.

When the segment is analyzed, it is evident that there is not a cluster; therefore the shipyards are installed in several places in the country, with enormous distances among them and also with their supply chains. There is not any kind of integration among them, not even integration with universities, research and development centres, government, and the other actors from the nautical segment.

The methodological procedures adopted was based on the opinion of experts. This type of research design can be used to answer questions about relationships, including those of cause and. Thus, the questioning of the participants happened through questionnaires.

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Regarding the questionnaire, the survey method involves structured questions that the respondents answered and which was carried out to describe the current stage of shipyards. The questionnaire was sent to people working in the shipbuilding industry, product development experts, production managers, production supervisors, and production specialists. Thus, composing the research sample.

The research is classified as a qualitative and descriptive case. Descriptive research has as its primary objective the description of the characteristics of a given population or phenomenon or, thus, the establishment of relations between variables. It is defined as an intermediate study between exploratory and explanatory research, that is, it is not as preliminary as the first nor as profound as the second. In this context, describing means identifying, reporting, comparing, other aspects (PANDEY; PANDEY, 2015; KOTHARI, 2004; KUMAR, 2011).

The research of an applied nature seeks to produce knowledge for an application and is directed to solve a specific problem and that can be easy to apply. Exploratory research is aimed at studying problems in order to discover new practices, process or product improvements, and data collection that can be used to develop new models (PANDEY; PANDEY, 2015; KOTHARI, 2004; KUMAR, 2011).

6. SHIPYARD can WORK TOWARDS LEAN SHIPBUILDING OR AGILE MANUFACTURING

In order to work with the production system similar to an automobile assembly plant, a shipyard must acquire most of the parts and components in the form of subsets, available on the market aiming to reducing domestic costs of production.

A key factor in production management is related to the flow of information on the sites, focusing on planning and control of the production process. To make this analogy is relevant to the lean production system with special attention to the Just-In-Time, the resource planning and project management organization (CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; LEITE; BRAZ, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

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As the shipbuilding is characterized within the system of production by large projects is essential to focus on managing each activity in order to reduce operating costs, waste and carrying out each task in the correct period without generating stocks.

Integrated information systems are critical to achieving the state of the art in various functions of a shipyard. Production features such as cutting boards with numerical control, or the use of automated processes on dedicated production lines, and also functions of planning and control only affect the state of the art if there are available information systems product, process and resources available and fully integrated.

Concentrating similar production processes identifying families of products that can be manufactured in the same cost centers, using the productive capacity of resources, machinery, equipment, people, in order to generate a continuous flow of operations, without generating intermediate stocks throughout the process production is a prerequisite for entering into the Lean Manufacturing system (KUULA; PUTKIRANTA; TOIVANEN, 2012; SILVEIRA; SNIDER; BALAKRISHNAN, 2013; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

The focus is not to generate batch processing (batch processing), but uniformly according to the needs of each production center, optimizing resources and minimizing or eliminating driving steps, intermediate stock during the production process. The gain of manufacturing family of products is higher when compared with manufacturing by specialized centers in functions.

Thus, it is sometimes necessary to duplicate a production center in the layout of a shipyard. It does not mean to double the area that existed initially for this batch operation, but rearrange physically to fill the needs for a continuous production flow. It is often necessary smaller areas and resources with the dismemberment of manufacturing centers that were concentrated.

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Eliminating intermediate stocks in the process can provide an enormous gain in physical space for the shipyards. Lean flow allows cost savings in operations and improve efficiency and effectiveness of production, allowing to balance tasks and optimize the use of productive resources (SILVEIRA; SNIDER; BALAKRISHNAN, 2013; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

Reducing or eliminating stock will resulted in the reduction of its costs, involving the supply chain, materials and processes in the physical area, which serve to support the lean production system. Another relevant factor is the cost of unnecessary drives that are eliminated with the inclusion of a lean production flow (ZU; KAYNAK, 2012; SILVEIRA; SNIDER; BALAKRISHNAN, 2013; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017; MOHAMMADDUST, et al., 2017).

The problems that arise in the production system will be easier identified and mapped. So, an action plan may be strategically placed to eliminate or minimize them aiming to not to interrupt production. With the elimination of batch production and the insertion of a lean flow, reducing inventory, an essential factor that will be easily noticed is the quality of manufactured products, as problems related to quality will be easily detected and require quick, efficient and effective solution (VRIES, 2013; HASLE, et al. 2012; SILVEIRA; SNIDER; BALAKRISHNAN, 2013; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; VENTO, et

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al., 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

The large batch production does not allow us to understand the problems of quality detected. When they are detected they will have caused more problems along the entire supply chain, manufacturing, increasing costs by increasing waste of resources, time, machine, manwork etc.

The productivity of a company is an important indicator of competitiveness. When production problems are eliminated or reduced to a minimum acceptable, will automatically increase the productivity of the organization by avoiding rework or loss of semi-processed or finished product. In constructions that operate under a system of large projects with high operational costs, by operations, parts, products, subsets etc. is essential to have quality assured on the manufacture and also on its supply chain, because production stoppages due to defects can make the final product too much expensive and drive up costs, reducing productivity and competitiveness of a shipyard (EL-KHALIL, 2015; VENTO, et al., 2016; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017).

Rework, unnecessary movements, activities that do not add value to the product are factors that minimize the productivity of a company and increase the lead time for implementing the final product, making it uncompetitive compared to its main competitors (EL-KHALIL, 2015).

Assured quality of parts, components, assemblies, subassemblies etc. is the backbone of a lean process to eliminate waste and activities that add no value to the final product. Get output with high productivity will require that this concept is widespread in every stage of the production process. The industrial layout should be efficient and provide operational efficiency by eliminating most unnecessary transport and reducing the operation time in the shipyard (SILVEIRA; SNIDER; BALAKRISHNAN, 2013; CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; EL-KHALIL, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; VENTO, et al., 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

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The implementation of the system 5S's housekeeping is also essential in the whole production system. This type of technical corroborates to increase productivity, to eliminate unnecessary handling or transport, to reduce manufacturing time, to eliminate defects and to improve productivity and strengthen lean production (CHAVEZ, et al., 2013; DIBIA; DHAKAL; ONUH, 2014; THANKI; THAKKAR, 2014; PANWAR; JAIN; RATHORE, 2015; MARODIN; SAURIN, 2015; EL-KHALIL, 2015; BR KUMAR; SHARMA; AGARWAL, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; MOHAMMADDUST, et al., 2017).

Lean production also extends to the supply chain of the shipyards. Receiving materials in time to be processed is important to minimize or eliminate the stocks in the production process. Receiving the products with assured quality from the supply chain will require that quality control is performed inside the supplier’s plant so that the manufacturing system does not stop at the shipyard (CHAVEZ, et al., 2013; BONNEY; JABER, 2013; DIBIA; DHAKAL; ONUH, 2014; PANWAR; JAIN; RATHORE, 2015; BALL, 2015; PAKDIL; LEONARD, 2015; MUND; PIETERSE; CAMERON, 2015; CHAY, et al., 2015; HU, et al., 2015; BIRKIE, 2016; VENTO, et al., 2016; ALI; DEIF, 2016; NARAYANAMURTHY; GURUMURTHY, 2016; CHEN; SU; RO, 2017; KAMALAHMADI; PARAST, 2017; MOHAMMADDUST, et al., 2017).

7. CONCLUSIONS

Some overseas shipbuilding yards are already more apt to apply the concepts and techniques of the Toyota Production system, given the need to survive in a competitive market with Asian shipyards such as Chinese, Korean and Japanese.

The shipyards installed in Brazil do not yet have these characteristics and have not yet implemented a Toyota Production System. However, there is a way to implement a system similar to that used in the automobile industry and thereby improve the competitiveness of the shipyards.

Several Toyota production system technicians can and should be deployed at shipyards to improve their vessel manufacturing and assembling systems. Even long and medium term production, having a supply chain committed to the production phases of the vessels is essential for business success.

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The shipyards must work to minimize or eliminate waste in project and production phases. The integration with the supply chain is essential to develop families of interim products.

The production must fabricated using standard work processes in the same way each time using the same equipment.

To implement agile manufacturing, product design and planning must become very closely integrated with manufacturing, and all bottlenecks in product flow and the flow of engineering information must be minimized. The tight integration between design functions, planning and manufacturing requires precise and sufficiently complete information on all aspects of product, production processes and operations are available.

Thus, it is expected that future systems design and planning are closely aligned with the manufacturing technology, and future manufacturing systems will require more complete and more accurate when compared to the information available at this time.

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