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Organizational Principles Oriented to Maximize Innovative Ideas of Blue-Collar Employees in Manufacturing

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Abstract

This paper is focused on the blue-collar workforce, or more simply operators, as the central aspect of the manufacturing processes to produce manufacturing environments that can decrease routine-based operations. As a result, manufacturing operations can become again an attractive area to consider for creative organizations. The framework, comprising an organised culture of setting challenges, organisation of their resolution and up-skilling to enable competences, is based on a theoretical analysis of the work conditions for operators using a technical, sociological and psychological approach and evaluating different barriers for innovation.

We illustrate this analysis using a case study in a small assembly company (SME) in which a new organizational structure was simulated to maximize intrinsic motivation and the working environment in the blue-collar workforce.

Keywords: intrinsic motivation, creativity, autopoietic groups.

1 Introduction

Although intrinsic motivation and creativity have been analysed in manufacturing systems, studies about manufacturing techniques have identified different barriers for motivation and creativity. For example, the Total Quality Management model (TQM) uses quality standardization methods through Statistical Process Control Tools (SPC), with the commitment of the team and a high involvement of managers to achieve the best quality standards. TQM is used widely in the work environment of the blue-collar workforce to minimize defects during the process, but an excessive standardization of methodology to minimize errors can affect significantly the intrinsic motivation of the workforce, ergo creativity and innovation (Prajogo & Sohal, 2001). Another technique that is used in manufacturing processes towards re-engineering is Quality Circles (QC). Within an innovative cultural approach, QC has given excellent results in the Nippon culture. In Western culture, QC helps to process improvement, but at the same time it is likely that affects the innovative process (Hall, 1996). The same issues with innovation can be caused by Lean Sigma, the variation technique that has created excellent results to minimize variations during the manufacturing process (Johnstone, Pairaudeau, & Pettersson, 2011).

An issue for operators is the extensive repetitive work of the manufacturing methodology due to quality assurance created by standardization methods, such as TQM, QC and Lean Sigma.

The automation of the repetitive processes could be a solution with, for example, the possibility of technology doing the repetitive work. At the same time, barriers to innovation and creativity will not decrease for blue-collars if their work only requires a work-station to observe how the machines work, or if they are in the middle of several processes in order to pass raw material from one side to another and performing maintenance activities. In this scenario, only the Research and Development (R&D), Project and new departments will execute innovation activities. As a consequence, it is probable that the manufacturing industry will have similar systems, but with a significant problem with innovation aspects. New theories to transform the whole manufacturing process towards innovation should emerge in order to address the issues described.

2 Production systems based on Taylor's approach and their transformation to dynamic work systems.

Taylorism has modelled the organizational structures of organizations worldwide by creating specialist workers for every task, aiming towards boosting productivity and work efficiency, also minimizing the level of job complexity and increasing repeatability (Crowley, et al., 2015). Subsequently, the lean production concepts have become adopting core concepts of the Toyota production system (TPS) due to its productivity results. However, lean manufacturing still has roots in Taylorism and its effects (often called "Neo-Taylorism" in sociological studies as a consequence). Cellular manufacturing theories have emerged, offering an alternative to Taylorism with multi skilled and semi-autonomous groups with an improved socio-technical approach (Koukoulaki, 2014).

Cellular manufacturing theories are the result of production methodologies to enhance the complexity of the operations, thus production cells increase mental skills to perform the tasks and challenge within the daily work. Both are psychological factors to promote intrinsic motivation. However, the creation of groups also increases barriers in the hierarchical structure and ambiguity with the external environment, thus there are impediments for creativity. Therefore, both methods require a different approach to obtain a creativity based structure in an autopoietic model, one that is able to sustain itself. To define a new method, it is analysed a hypothetical system which is oriented to creativity through discoveries, in which every sequence of finding, association and generation develops a generative system of creativeness (figure 1). This system is independent and capable to manifest a continuous process of discoveries, making it into an autopoietic system to produce ideas.

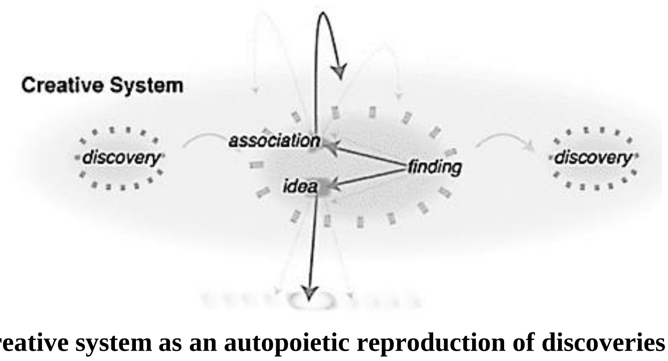

Figure 1. Creative system as an autopoietic reproduction of discoveries (Iba , 2011).

The autopoietic system must have the capability to produce all necessary resources to work independently, and thus it has to be capable to select from outside of the boundary elements for combining and transform them, emerging in a new element. Subsequently, the constitution of the systems depends on every internal element of the system; hence all the characteristics, which affects the apparatus must be part of it in order to preserve the system (figure 2). The uncertainty is given by the inherent boundaries that the system has, and for this reason the information within the structure must flow in a dynamic way and should be easy to obtain, so the link within other autopoietic systems of the organization can be defined clearly.

Every characteristic of lean manufacturing should be an intrinsic part of the autopoietic system to accomplish this concept. Following this principle, cell methodology should include every element which constitutes part of the manufacturing system, thus the apparatus must be capable to receive feedstock, maintain its internal processes and create the final product.

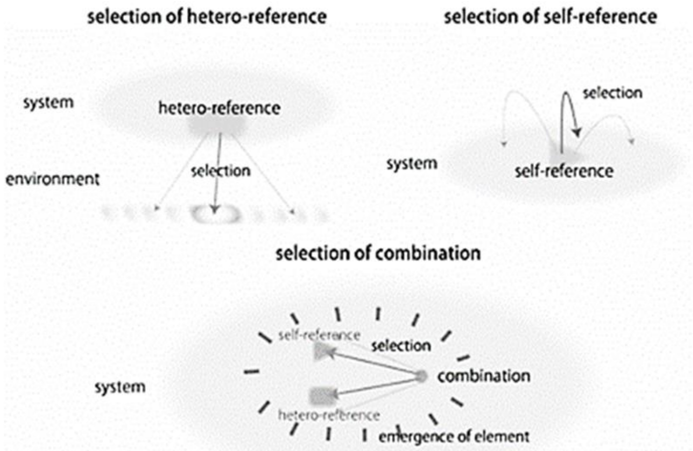

Figure 2. Three selections for element constitution (Iba , 2011).

Another important aspect of the autopoietic theory is the sociological approach, which covers how individuals are part of groups with the apparent perception of independence and freedom only within the boundaries of the system. The result is a collective consciousness in each group of the organization. Nonetheless, intrinsic barriers within the systems affect the holistic idea of individuals, thus the creative system is also affected. Hence homogenization of the workforce is imperative in order to obtain the creative system (Iba , 2011).

Using one of the methodologies of lean called cross training, combined with autopoietic principles in a group of manufacturing cells, it is possible to create multi-skilled workers capable to work in every department of each group during specific amount of time, eliminating the idea of a person being part of only to one department of the system, decreasing role conflict and dealing with ambiguity. Hence, the organization within the autopoietic system will be a dynamic environment, with individuals working in every area of the system during a certain amount of time, under the direction of leaders on specific tasks to preserve the system. With this structure, the manufacturing system can eliminate the influence of Taylorism, which is focused on specialization.

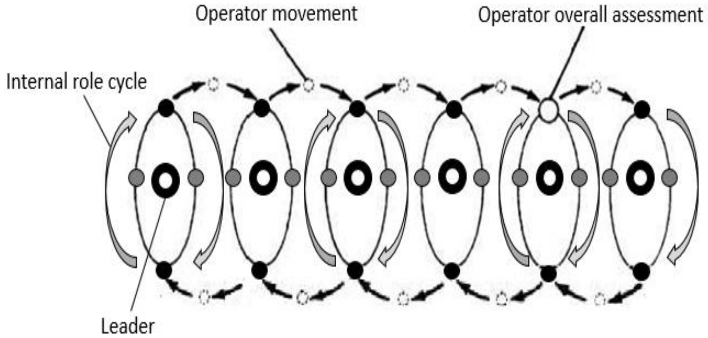

Figure 3 Dynamic Manufacturing environment within an autopoietic system.

Figure 3 shows the concept of a dynamic manufacturing environment within an autopoietic system. Every operator is part of the internal role cycle within every department, such as production, maintenance and materials. After a certain period of time, operators change their responsibilities onto other departments until they return to the initial phase. An overall assessment of his work can be realized in one of the stages of the dynamic environment. Also leaders can be part of the dynamic cycle. This innovative methodology creates dynamic processes and agile cultures, with an intrinsic consciousness of the system towards boosting innovativeness, key factors for the modern production.

Current concepts of manufacturing processes, such as Product Family Architecture (PFA), Reconfigurable Manufacturing Systems (RMS) and delaying differentiation can be applied in an autopoietic system configuration as this does not affect the technical process due to his specific approach to the operators, regardless of the technical system. Core principles of RMS and PFA are part of the theory in cellular manufacturing systems. Consequently, these methodologies can be used in the autopoietic structure using the lean concepts of the organization to create a correct boundaries of the manufacturing process; hence the cellular manufacturing configuration will be one structure within the autopoietic system (figure 4).

According to the example presented in figure 4, there are several groups of machines distributed in cells and controlled by one or two operators. Every operator is capable to perform basic tasks, such as controlling machines during the process and material handling, but also more complex tasks, such as production control, maintenance or the role of the leader of the group within the autopoietic system. As a consequence of the dynamic environment, the lean tool On Job Training (OJT) is required to facilitate the rotation of personnel in every assignation within the system and to ensure the training. The system needs to contain every process to maintain its existence; hence the inputs of the system will only be the raw material and the production volume, and the output is the final product. As a consequence, every cell within the system should create a sub-component of the product and every component should be controlled and evaluated in the same cell. This pattern will be repeated on the assembly and control line. As the autopoietic model is based on changes in the hierarchical structure towards obtaining innovative work environments, after the analysis of their concepts it is possible to conclude that current manufacturing models cited, such as Project management theories, QRM, Agile Methodology, Mass Customization, TQM, Lean manufacturing, TOC, PFA, RMS, OMS and Six Sigma can be applied within this theory.

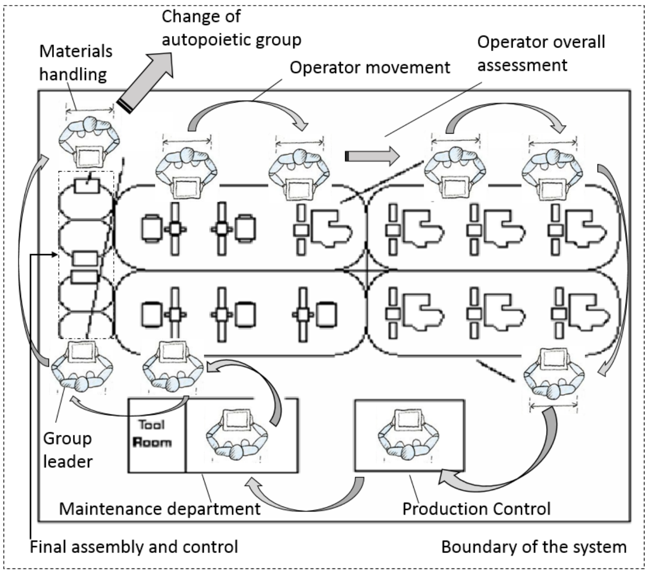

Figure 4 Dynamic Manufacturing environment applied to Cell manufacturing

3 Case Study

3.1 Description of industrial environment

The analysis of the manufacturing process was conducted based on the hierarchical structure of a small assembly company (SME) that produced four types of products: radios and speakers for the automotive sector, cell phones and televisions. The name and technical data of the company has been removed to provide confidentiality. The company produces the parts in several plants in China and conducts the assembly process in Ecuador. The assembly process was certified during the case study under international standards, such as ISO/TS 16949. One hundred and six operators have worked in this company under this scheme. In addition, there were four independent lines per product. Due to the dynamic market of the products produced in this company, more flexibility was required in their processes to reduce the time for introducing new products.

The theoretical implementation of the autopoietic structure was planned in twelve meetings between the management team and the researchers during one year. One real-life simulation using the autopoietic model was performed with the operators of the cell-phone assembly line during one day of work. The results presented in this section are the results of the work obtained during management meetings to discuss the implementation plan of the autopoietic model and the simulation.

3.2 Characteristics of the autopoietic model.

To define the main characteristics that the autopoietic model has for creating a flexible environment which enables operators to be intrinsically motivated, creative and focused on innovation, it was necessary to create a blend between mechanistic tasks, which are necessary in manufacturing due to its intrinsic requirement of repetition with other tasks that produce cognitive stimulation. In regard to the management of knowledge, the optimal solution was the minimization of internal barriers within an organization in which everyone must have access to the information avoiding barriers to creativity, in line with the theoretical framework of this paper. However, this was one of the most difficult tasks to change in the mind-set of the current structure.

An important aspect analysed was the possibility of using current manufacturing methodologies in combination with the autopoietic model to create a flexible working process, thus cell manufacturing methodologies and lean practices were defined by the production team as compatible with the autopoietic system concepts. The main reason was that the radical change should be conducted in management methods of the human resource, instead of technical methodologies to enhance innovativeness, but the challenge was the control of the operators. Nonetheless, radical changes, such as the high rotation of personnel within every team in the autopoietic group, were supported by lean techniques, such as OJT. Hence, current manufacturing processes were necessary as part of the theoretical model to maintain the process without special causes of variation, but with controlled risks. As a result of the analysis, characteristics of the system were defined, such as boundaries of the autopoietic model, sociological requirements within this system and technical methodology to maintain the efficiency of the process but avoiding rigid structures, as well as the main aspects under the sociological approach. Hence, these elements were considered in the design and implementation of an autopoietic group.

The skills that operators must have for being capable to work in the autopoietic model were defined through a literature review of creativity and innovation concepts (Figure 5).

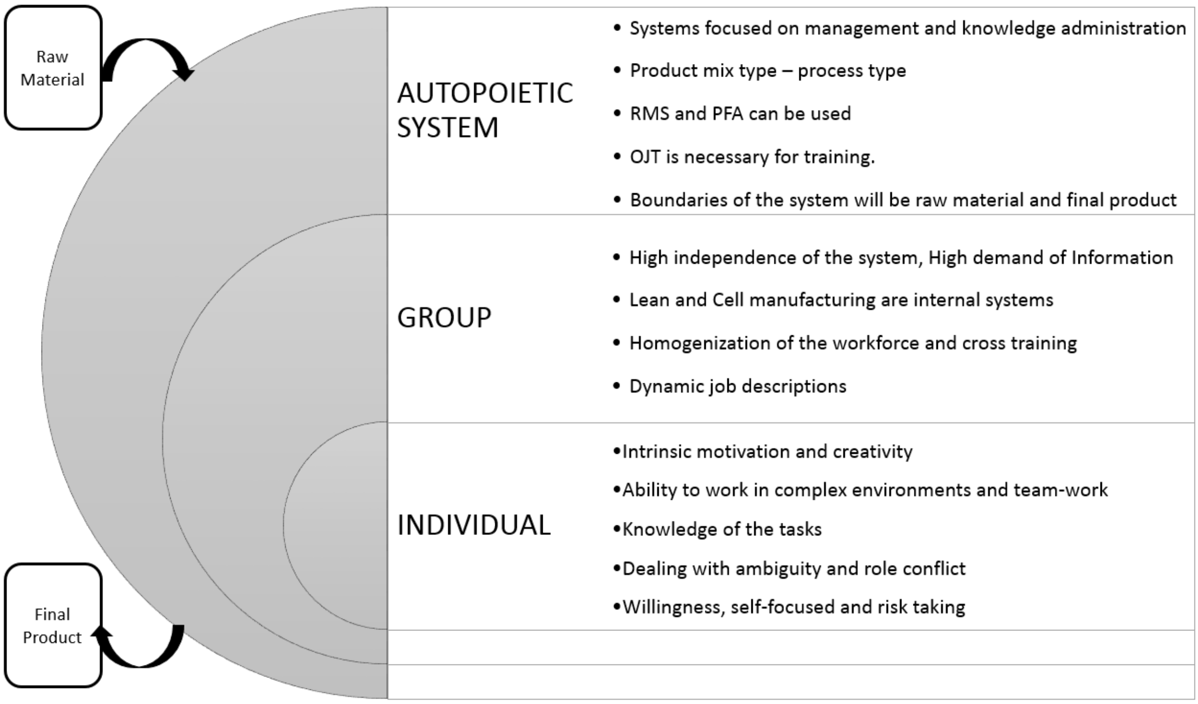

Figure 5 Characteristics of the autopoietic system for manufacturing.

Figure 5 shows the key aspects that the operators, group and the system should possess to create the autopoietic model. The theoretical model has considered the mix between mechanistic and cognitive-enhancing tasks under intrinsic aspects of its configuration. Moreover, teamwork was ruled by the system requirement of increased independence. As a consequence, rotation of personnel under every manufacturing cell had required systematic revision, control of the results and opportune feedback, due to the possibility of different levels of performance in every combination of operators.

3.3 Transformation of the blue-collar hierarchical structure to the autopoietic model.

The first step was analysis between the characteristics of the autopoietic system for manufacturing that were established in the previous section with the hierarchical structure of the manufacturing department in the SME. An initial issue encountered was the lack of capability to produce all the necessary resources to work independently, which is one of the main characteristics of the autopoietic system, thus it was necessary to include in the theoretical structure other areas that were part of other departments on this company, such as Product Engineering, Production Planning and the Storage Department, to create a self-sufficient manufacturing structure. It is important to point out that material handling was under responsibility of the Storage Department and also it was a necessary element to consider in the creation of the autopoietic structure. Senior positions remained under the hierarchical structure, with the change focused in quality, maintenance, storehouse and production technicians, quality and team leaders.

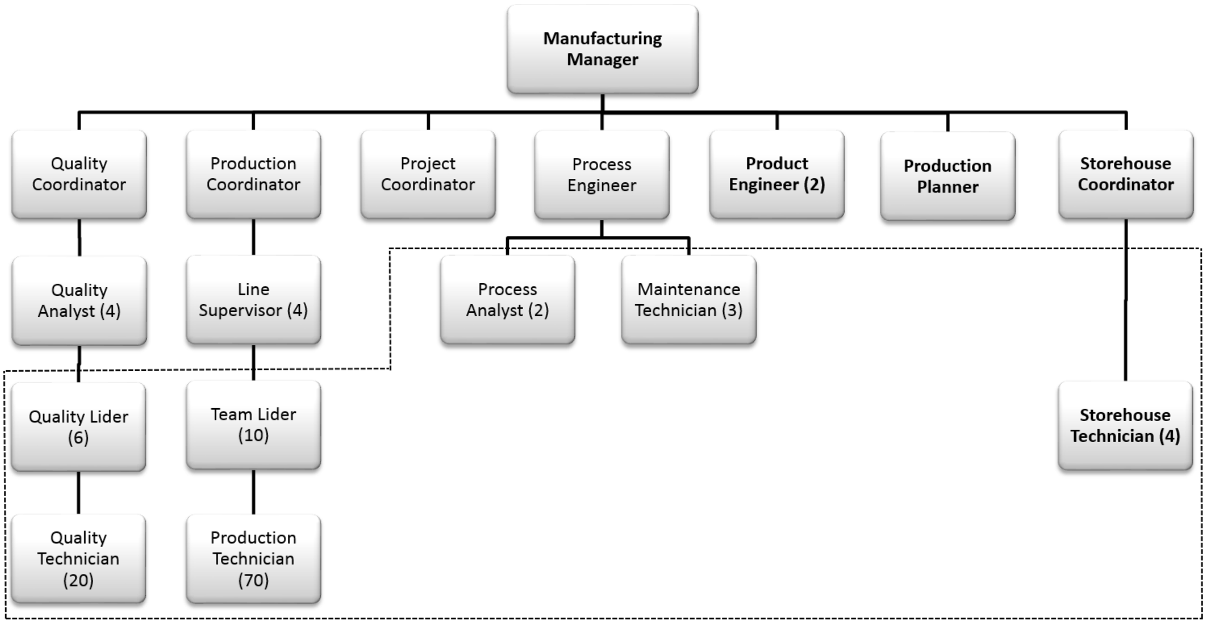

Figure 6 Organizational structure of the manufacturing department of the company analysed, with the additional departments required.

The findings of the proposed structure considered the analysis and results through psychological, sociological and technical aspects to create a manufacturing structure that enables intrinsic motivation and creativity under the mechanistic work performed by the operators. Key concepts were the rotation of personnel within a flexible structure considering efficiency and quality aspects, the definition of boundaries of the autopoietic system, the application of lean concepts and cellular manufacturing ideas oriented to obtain the autopoietic system that possesses an innovative culture as an alternative to Taylorism methodologies. The resultant autopoietic structure for the company analysed is indicated in Figure 7. The change of a clustered-base structure to a dynamic and autopoietic group structure was a radical step to follow in the mind-set of the organization concerned, with dynamic blue-collar and analysts rotating in each manufacturing level and intradepartmental borders ceasing to exist through the rotation of the operators and holistic goals for the group.

As a result of the simulation, blue-collars were able to perceive the system more holistically, which derived in an increment in their suggestions using the standardized system for improvements of the company. Prior the exercise, the rate of suggestions per employee in the cell phone assembly line was around 13% and after the simulation, it was incremented to 82%. There were no changes in the reward scheme for suggestions under the analysis. As a result, the increase in job complexity, challenge and role conflict, and the minimization of organizational barriers, the operators were intrinsically motivated to propose new ideas.

A detailed analysis of suggestions made by the operators and feedback given by team leaders indicated a positive endorsement of the autopoietic manufacturing system as implemented in this case study. Roles and responsibilities of workers were not limited to a specific task, instead they were required to work in different roles inside of their department under their specific level of job complexity, minimizing mechanistic tasks, increasing job complexity, fomenting teamwork with every person in the organization, minimizing ambiguity and increasing competivity between workers. All of these aspects were factors that promote intrinsic motivation and creativity. Additionally, the autopoietic group was capable for controling its own operational expenses, the acquisition of materials required for manufacturing and defining of improvement methods to reduce costs.

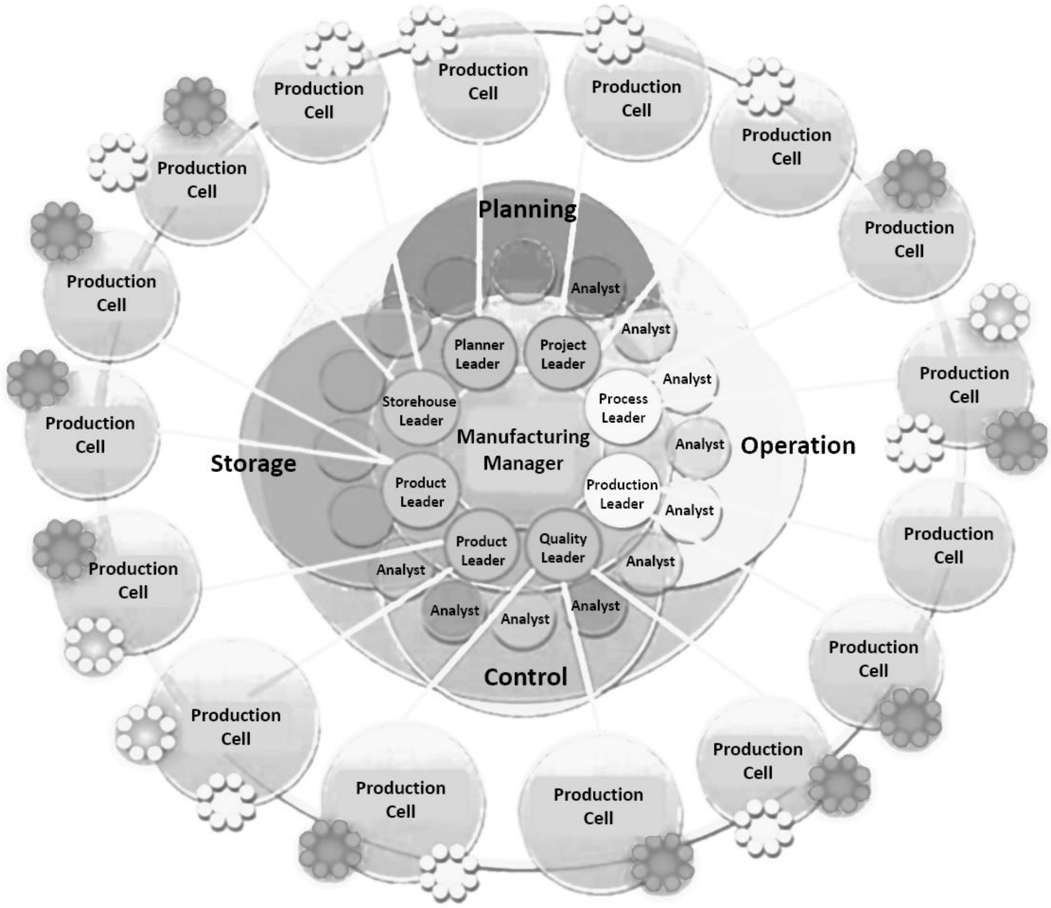

Figure 7 Autopoietic model developed for the manufacturing company analysed.

During the simulation of the autopoietical model, leaders of every group were able to work with different set-ups of workers, based on goals and objectives of the organizations rather than specific ideas of a pre-defined group. While it is probable that quality and process techniques such as lean, TQM and so on, were not capable to foment creativity and also have inherent barriers in its concepts to intrinsic motivation, the result of this introductory research has presented that it is possible to decrease the negative results of mechanistic work through application of the autopoietic model.

It was mentioned during the simulation that the autopoietic model contains risk of affecting quality and efficiency of manufacturing operations, nonetheless, as it was mentioned in a previous section, it was concluded that organizations must take controlled risks to succeed in the design of creative environments.

4. Conclusions and notes for future research.

The creativity process in groups and organizations is an area of study that faces several challenges, as the natural process of human creativity is still fairly unknown field (Iba , 2011). Although several research works have determined the key factors to enhance creativeness and have defined connection between intrinsic motivation and creativity to promote innovativeness (Amabil, et al., 1996; Coelho, et al., 2011; Auernhammer & Hall, 2013; Paramitha & Indarti, 2014), the manufacturing industry concepts to produce efficiently that are widely used globally have presented significant problems to enhance innovativeness into its workforce, because some of its intrinsic methodologies are contraries to the intrinsic motivation and creativity theories (Hall, 1996; Prajogo & Sohal, 2001; Menzela, et al., 2007; Layer, et al., 2009; Johnstone, et al., 2011).

Despite the fact that “talent driven innovation” has being considered as top priority among drivers of global manufacturing competitiveness (Chryssolouris, Mavrikios , & Mourtzis , 2013), the alternatives proposed for the state of the art have been focused mostly on designing external alternatives to facilitate the creative process (Menzela, et al., 2007; Auernhammer & Hall , 2013). However intrinsic motivation, one of the principal requirements of the innovation process, is not driven by external rewards or features. On the other hand, studies conducted with a sociological approach have considered lean manufacturing and cellular manufacturing techniques as neo–Tayloristic systems with negative connotations to human creative process (Pruijt, 2003). This study has evaluated technical and management systems, psychological and sociological aspects of the state of the art aiming towards proposing a theoretical model for manufacturing that can be capable of minimizing barriers to creativity and maximizing intrinsic motivation of blue collars. It was re-afirmed during the study that operators are the main source of knowledge about the process, but at the same time they are under strict and rigid systems, which block their creativity, as it was studied by Walter (2012).

After the analysis of the literature and the evaluation of technical, psychological and sociological aspects, it was determined that enhancing innovation should be focused on organizational structures, rather than alterations within technical methodologies. For this reason this study has looked also into sociological models that can be considered as alternatives to replace a clustered-based entities in current organizational structures, because rigid systems and monotonous tasks can affect enormously the process of creativity. As a result, a new theory of dynamic and autopoietic groups for manufacturing has emerged. This model has proposed an alternative to cluster entity structures and can be compatible with current manufacturing proccesses, using exploratory and exploitative innovation concepts and lean techniques, such as OJT, to eliminate special causes of variation, despite of its dynamic configuration.

The study proposes an organizational model for the core area of the manufacturing processes, which can be analysed in conjunction with new structures for manufacturing to design creative manufacturing environments that can be applied to decrease routine-based operations. However, it has inherent limitations. It is necessary to conduct additional studies in higher positions, such as the leadership level, analyst and supervisors to the new, reduced hierarchical structure, in order to determine solutions towards promoting creativity under the dynamic and autopoietic model. Also, experimental analysis should be conducted in future studies to find quantitative results of the theoretical model in different manufacturing sectors through long-term analysis. Theoretical studies for other organizational levels are necessary as well to create an entire autopoietic structure, focused on creativity and innovation for organizations. Finally, this model require studies in medium and large companies towards evaluating the application of autopoietic characteristics for developing new structures for the new era of manufacturing, such as Industry 4.0. Future studies can consider the application of the autopoietic model in other sectors, such as services and health as well.

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