EUROPEAN ACADEMIC RESEARCH
Vol. VII, Issue 6/ September2019

ISSN 2286-4822
www.euacademic.org

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Implantation of a hybrid production system in an agricultural and automotive wheel manufacturer: Action Research

JOVANI JR. DE OLIVEIRA NASCIMENTO
Faculdades Integradas Einstein de Limeira-SP
MARCELO ROCHA
Faculdades Integradas Einstein de Limeira-SP
VANESSA MORAES ROCHA DE MUNNO
Faculdades Integradas Einstein de Limeira-SP
BIANCO GALLAZZI DA SILVA LEITE
Faculdades Integradas Einstein de Limeira-SP
IVAN CORRER
Faculdades Integradas Einstein de Limeira-SP

Abstract

Currently due to the high competitiveness of the market, companies are looking for methods that enable process improvement, thus reducing waste and production costs. In this sense, companies are investing in the implantation of hybrid production systems, aiming at the integration of different production systems, such as pull and push production systems, using the main attributes of each system in function of the characteristics of each process, always aiming higher productivity. The research company is a manufacturer of metal wheels and has a pushed production environment, however its order backlog varies from small to large production batches, which directly interferes with the increase in delay backlog index. Therefore, the present article aims to implant a hybrid production system, aiming to reduce the amount of overdue requests. The methodology used in the development of this article was action research. The implantation of the hybrid production system resulted in an average reduction in the delay of *orders from 36% to 4%, this increasing the availability of machines and tools and reducing production costs.*

Keywords: Pull System, Push System, Hybrid System, Action Research

1. INTRODUCTION

In the current scenario of competitiveness, organizations are seeking strategies to establish themselves in the market and, to achieve this goal, investments in innovation, quality and punctuality in product delivery are increasing (FERNANDES and GODINHO FILHO, 2016).

To achieve these goals and remain competitive, organizations need to apply methods that aim to improve processes, producing only what is necessary and in the required quantity, thus reducing waste and, consequently, production costs. Thus, organizations need production systems that adapt to the new reality, making them more competitive and improving their processes (SENTHIIL & MIRUDHUNEKA, 2014).

Among the most used production systems, we can highlight the push system, in which production planning begins after the definition of demand forecast and has the characteristic of large batch production (GSTETTNER; KUHN, 1996), and also the pull production system, which has the principle of reducing waste by containing the use of in-process material and avoiding excessive stock, producing only the necessary, as demand (SHIMOKAWA; FUJIMOTO, 2011).

According to Kendall (2007), the pushed system has some shortcomings, including the need to maintain a high inventory of finished products, at the risk of products becoming obsolete, the need to maintain suppliers capable of delivering large quantities of raw material, as well as ample response time in case of changes in demand forecasting, thus causing overproduction or lack of products. For Fernandes and Godinho Filho (2016), the pull system has an ease of application in organizations with low product variety, and in companies with contrary characteristics, the system has great difficulty of adaptation and response.

According to Ming-Wei & Shi-Lian (1992), the need to solve production management problems has resulted in the development and implementation of hybrid production systems. Ohno (1997), corroborates that in certain organizations, the system to be used should not be distinguished between pulled system and pushed system, since each has positive and negative points, but rather deploy both systems hybrid.

The researched company has a pushed production , however its order varies from large to small production batches and, as a problem, a high rate of late delivery orders to customers has been identified. In this context, the present article aims to implant a hybrid production system in a wheel manufacturer, aiming to reduce the amount of backlogs.

2. LITERATURE REVIEW

2.1. Production Systems

According to Fernandes and Godinho Filho (2016), production systems have an extremely important function in companies, their responsibility is to meet customer demand quickly and efficiently, so a system needs to achieve its objectives, effectively and efficiently the least possible waste of resources.

Production systems can be characterized as a set of integrated activities, involved in the production of goods or services (MOREIRA, 2008), and may be subject to internal and external changes, which generate needs for greater integration between activities (FERNANDES and GODINHO FILHO, 2016).

The main systems used in the manufacturing process are the pull and push production systems, however, their combined use has been one of the main management decisions (LOPES; PASQUALINI; SIEDENBERG, 2010).

2.2. Pushed Production System

The pushed production system consists of manufacturing a quantity of products, defined by available stocks and forecasted demand. The periods required for production are established from standardized information, entered at specific times for each operation of the manufacturing process, since the product is manufactured sequentially (OHNO, 1997). It is fundamental in the pushed production system the use of Material Requirements Planning (MRP) (STEVENSON; HENDRY; KINGSMAN, 2005).

According to Corrêa (1997), MRP is a production scheduling system, based on the product structure, considering that its objective is to control and evaluate the need for inputs for the production of a given item, as well as the time they will be handed out.

For Gstettner and Kuhn (1996), the MRP system assists in the planning and execution of manufacturing orders according to the quantity determined in demand forecasts, which allows better management of materials and production processes.

Lemos (1999) and Slack; Johnston; Chambers, (2009), consider some disadvantages in the use of the pushed production system, such as difficulty in changing the master production plan once demand forecast deviations, causing high safety stock, difficulties in establishing production batches, setup , idleness, queues and intermediate stocks.

Thus, MRP is a tool used to perform production planning and control, focusing on material needs based on original demand, resulting from the master production plan, as well as obtaining alternatives to inventory management practices (BOHNEN; God, 2012).

2.3. Pulled Production System

According to Ohno (1997) and Tubino (2000), the pulled production system is started from the information generated in the subsequent processes, producing only what was required. According to Liker and Meier (2007), the pulled production system can be understood as a flow between processes, in which the material transforms as it advances between the stages of the production process.

The pulled production system is based on the logical management of production, considering the actual customer demand, thus avoiding excessive production and materials in process (DENNIS, 2008).

Material movement between processes is initiated only when requested by internal or external customer orders (SHIMOKAWA; FUJIMOTO, 2011). Such request is made through the kanban system.

The kanban system is based on the control of material flow with “cards”, which defines the quantity (batch) and the ideal time devoted to production (LAGE JUNIOR and GODINHO FILHO, 2010).

Production using the kanban system reduces the waiting time of the products to be processed, the idleness of the machines and intermediate stocks in processes, increasing the productivity of the production system (ALVES, 1996, TUBINO; LEMOS, 1999, CARVALHO, 2013).

According to Vollmann et al. (2006) the kanban system has some disadvantages to be analyzed, among them, the need for precise planning, in case of errors in the quantity to be produced, or else, at the moment of starting production, it will be a larger than necessary stock is generated. Another factor to consider is the fact that it does not perform well when there is a variety of products or relatively unstable demand, leading to high inventories, increased stocking value, decreased quantity produced and idleness.

2.4. Hybrid Production System

According to Powell et al. (2013), the hybrid production system allows the use of two or more production systems. Second Rentes; Nazarene; Silva, (2005), a factory unit is programmed by a hybrid system when it has more than one production planning system model.

Adopting only one type of production planning system may not deliver the expected results. In this case, to remain competitive with their competitors, many companies use hybrid production systems (OLHAGER and WIKNER, 2000, MEMARI; RAHIM; AHMAD, 2014).

According to Geraghty and Heavey (2005) and Jeganathan & Mani (2012) the most well-known hybrid systems are those that contemplate the pull production system (use of the MRP system) and the push production system (use of the kanban system) and encourage questions about best practices of each system, as well as integrating both structures.
According to Spearman; Woodruff; Hopp, (1990) and Corrêa and Gianesi (1996) the kanban system has robust control over work in process (WIP), however, it needs to maintain a minimum stock to be “pulled” at each stage of the process. thus generating a larger WIP than necessary. However, when the kanban system is integrated into a hybrid system the WIP tends to be smaller compared to the whole system application.

Smalley (2005), fosters the difficulty of MRP in controlling a complete system, because the productive environment is dynamic, while its forecasts are static and its updates are not completely reliable.

Goddard (1991), already identified that, with the implementation of hybrid systems, it was possible to merge the strengths and weaknesses of the systems ensuring a better use of the joints of their characteristics.

3. METHODOLOGY

This research has a quantitative approach, of explanatory character and applied nature, since the place of the research served as basis for data collection, action analysis and verification of the presented results.

The research developed is classified as action research, because there is contact and interference in a participatory way of researchers and, according to Gil (2010), action research has situational characteristics, in which it seeks to diagnose a particular problem, in a given situation, aiming for practical results.

Mello et al. (2012) consider action research as the practice-oriented production of knowledge, modifying the reality of study. Westbrook (1995), Coughlan and Coghlan (2002) and Thiollent (2007) define the steps for conducting action research as: exploratory phase; formulation of the problem; hypothesis construction; holding of seminar; sample selection; data collect; data analysis; preparation of action plan; implementation and evaluation of results.

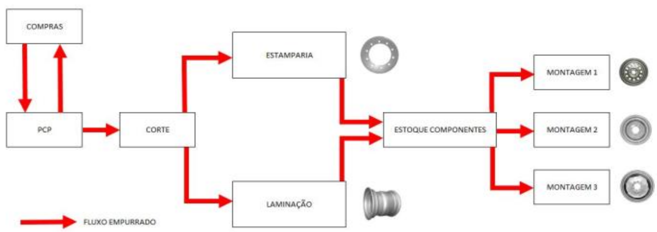
3.1. Action Research

This study had as its place of study a small metallurgical company manufacturer of metal wheels, located in the interior of the State.

The manufacturing process of a wheel consists of the production of two components: rim (lamination process) and disc (stamping process), which are subsequently joined by means of the assembly and welding process.

The productive physical arrangement used (Figure 1) is based on pushed production flow, in which the MRP system assists in the production scheduling and the PCP requests the raw material from the purchasing sector. With the available raw material, begins the cutting process that supplies the stamping and lamination sectors, in which the components discs and rims are manufactured respectively. With the components processed, the assembly and welding process of the components begins.

Figure 1 - Pushed wheel production flow



Source: Authors

The market in which the company operates is divided between agricultural and automotive products, which represent 68.45% and 31.55% of sales, respectively.

In recent years, the company studied has begun to have problems with delays in the delivery of its products, due to changing orders from its customers, who began to buy many increasingly smaller and diversified products. This change in demand interfered with the delivery time of its products by 36% of its order book, due to the delayed delivery of raw materials, small production batches and increased setups.

Based on the problems presented, it was hypothesized to implant a hybrid production system, integrating the kanban system with the MRP system to produce its components. This system initially would be implant to regulate the productive flow of the components and reduce their lack at the time of the assembly of the wheels to finalize the orders.

The main advantage to be obtained with the implantation of this production system would be the possibility of increasing the availability of machines to produce lower volume items, in order to supply the demand of the main customers, who mix orders of larger lots with smaller lots, which impacts on longer preparation times and consequently on delivery delays.

Therefore, based on the scenario presented, a planning was carried out to implantation a hybrid production system, which was developed from August / 2018 to April / 2019.

Initially, a seminar was held with employees from the engineering, production planning, control (PCP), commercial, and an external consultant, in which a brainstorming was performed to define the company sectors in which the kanban system would be implanted and which would continue to use the MRP system.

From the initial study, it was determined that the disc component was the process with the longest production cycle time within the final product manufacturing, thus, the stamping sector for the system implementation was defined, considering that the machines of this sector had the shortest time available for production of other products. The stamping process of the discs consists of the following operations: pulling disc, fixing hole, center holes and hub drilling (Figure 2).

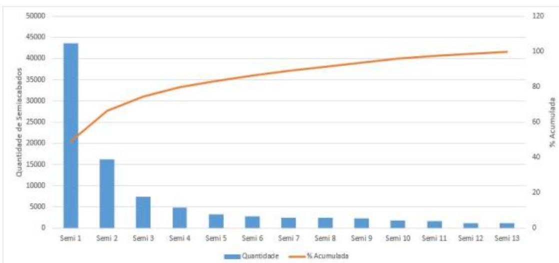
Figure 2 - Disc Stamping Process Operations

Source: authors

Based on the team's decision to implant the kanban system in the stamping sector, the initial application in the agricultural segment products was defined, with a view to representing 74.55% of the company's annual revenues.

With the sector and product segment defined, the team began to collect and analyze the manufacturing data of the discs, and through this analysis, it was possible to group them in semi-finished families, using the ABC curve concept (Figure 3). What differentiates the discs from finished to semi-finished is the fixing hole and hub, while families are determined by the disc stamp.

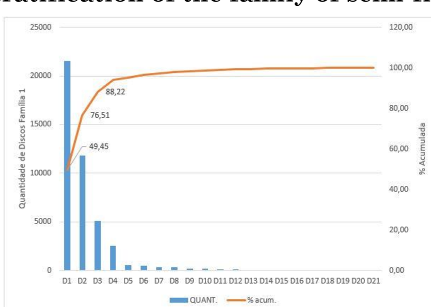
Figure 3 - Semi-finished disc families



Source: Authors

Within each family of semi-finished disc, data were stratified based on the ABC curve concepts to identify which of the components had the highest representativeness. Figure 4 presents the stratified data of the semi-finished family 1, in which it can be observed that the items, D1, D2 and D3 represent 88.22% of the production of this family.

Figure 4 - Stratification of the family of semi-finished disc 1

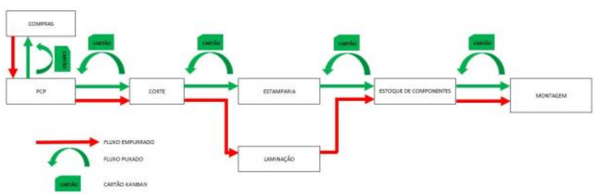


Source: Authors

Based on these criteria, it was proposed that items representing 80% to 90% of the quantity produced in each semi-finished family would have a special treatment in the manufacturing process (mixed kanban) in order to increase the availability of the machines.

After evaluation by the team and based on the collected data, the process of implementation of the hybrid production system began, integrating the MRP system with the kanban system (Figure 5).

Figure 5 - Deployed Hybrid Production Flow



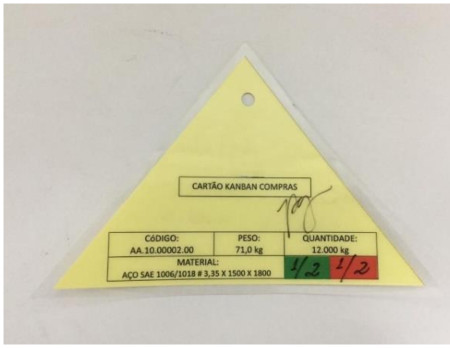
Source: Authors

The MRP system was dedicated to the lamination sector and the stamping sector to have the kanban system, since the assembly sector became the final customer of the component stock, ie this sector was responsible for start production of a new production batch by releasing kanban cards.

To conduct and integrate this new production system, the operators were trained and advised on how to proceed with the arrival of the production cards, and also assigned an employee to be responsible for monitoring and monitoring throughout the production flow which items were missing and could affect the assembly.

For ordering raw materials, a card of different color and shape was created to assist in the identification process and determine which cards belong to the purchasing sector (Figure 6).

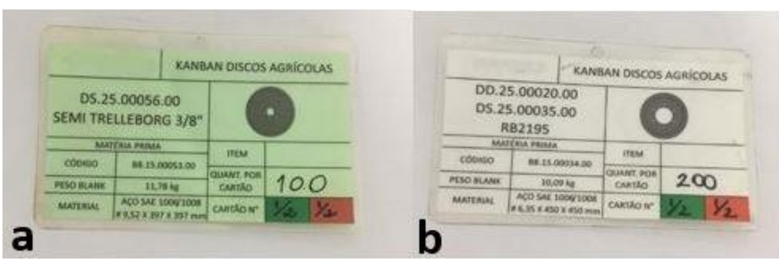
Figure 6 - Shopping kanban card



Source: Authors

The kanban system deployed in the stamping sector was a mixed kanban system integrating families of semi-finished discs (green cards) with finished discs (white cards), as shown in Figure 7.

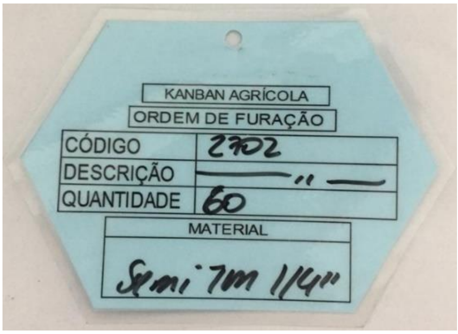
Figure 7 - Kanban Cards: Semi-Finished Components (a) and Finished Components (b)



Source: Authors

As shown in Figure 4, the alternative of the mixed kanban system was considered to increase machine availability, as within a family of semi-finished discs there are some that have a significantly high representativeness in relation to the total family, thus these items would be stored as finished components for assembly, while the semi-finished discs return to the stamping process to be finalized together with a special kanban card (Figure 8).

Figure 8 - Kanban card for drilling semi-finished products



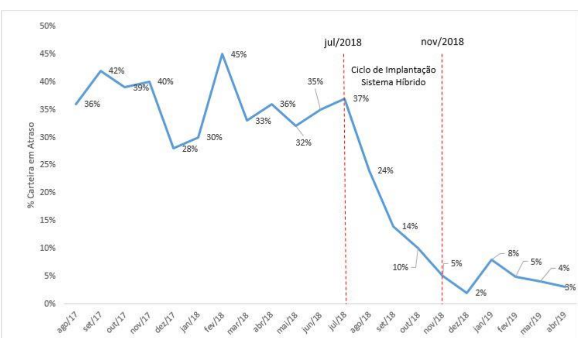
Source: Authors

This special kanban card is used for low-demand semi-finished products, which will only be manufactured upon customer request (pull system). The quantity to be produced of these items will be equal to the required demand.

4. ANALYSIS OF RESULTS

Figure 9 shows the result of the backlog reduction due to the implantation of the hybrid system in the studied company.

Figure 9 - Portfolio overdue August / 2017 to April / 2019



Source: Authors

As can be seen before the implantation of the hybrid production system (July 2018), the average backlog rate was 36%. After implantation started (July 2018) and completed (November 2018), an average order delivery delay rate of 4% was obtained. The backlog reduction was possible due to improvements in the stamping sector, the identification of the products that had the largest representation and the division of the components into semi-finished families.

The use of the mixed kanban system increased the availability of machines to produce lower demand items, without affecting the higher volume items and, thus, a better flow in the production flow.

It is noteworthy that in January / 2019 and February / 2019, the company experienced instability due to the delay in the delivery of raw materials to suppliers and, to solve this fact, it was decided that it would be necessary to increase the frequency of purchases of raw material.

5. CONCLUSION

The present work aimed to present a proposal to implantation a hybrid production system, integrating pushed production system with pulled production system, aiming at reducing the order delivery delay in a wheel manufacturer.

Through research, a mixed kanban system was developed within the stamping sector, generating the integration of finished components with semi-finished ones. With the implantation, the average backlog of order backlog was reduced from 36% to 4%.

In addition to reducing the average backlog of order backlog, other benefits were achieved such as: reduced costs with reduced overtime; increased availability of machines and tools for preventive maintenance, among others.

Future work suggests new research related to the application of hybrid production systems in industries of other segments.

Thanks
To the engineer Vito José Carone (in memorian).

REFERENCES

1. ALVES, J. M. **O sistema just in time reduz os custos do processo produtivo.** Congresso Internacional de Custos. UNICAMP, 1996.
2. BOHNEN, F., DEUSE, J. **Leveling of low volume and high mix production based on a Group Technology Approach.** CIRP Journal of Manufacturing Science and Technology, v. 4, p. 247-251, 2012.
3. CARVALHO, P. P. S. **Implementação de sistema Kanban adaptado para redução de estoques de matéria-prima:** um estudo de caso. Dissertação (Mestrado em Engenharia Industrial). Programa de Pós-Graduação em Engenharia Industrial. Universidade Federal da Bahia. Salvador, 2013.
4. CORRÊA, H. L. **Planejamento, programação e controle da produção:** MRP II/ERP: conceitos, uso e implantação. São Paulo: Gianesi Corrêa & Associados: Atlas, 1997.
5. CORRÊA, H. L., GIANESI, I. G. N. **JIT, MRP II e OPT:** um enfoque estratégico. São Paulo: Atlas, 1996.
6. COUGHLAN, P., COGHLAN, D. **Action research for operations management.** International Journal of Operations & Production Management, v. 22, n. 2, p. 220-240, 2002.
7. DENNIS, P. **Produção Lean Simplificada.** Porto Alegre, Bookman, 2008.
8. FERNANDES, F. C. F., GODINHO FILHO, M. **Planejamento e controle da produção:** dos fundamentos ao essencial. São Paulo: Atlas, 2016.

9. GSTETTNER, S., KUHN, H. **Analysis of production control systems Kanban and CONWIP.** International Journal of Production Research. v.34, p. 3253-3273, 1996.
10. GERAGHTY, J., HEAVEY, C. **A review and comparison of hybrid and pull-type production control strategies.** OR Spectrum, v. 27, n. 2, p. 435-457, 2005.
11. GIL, A. C. **Como elaborar projetos de pesquisa.** São Paulo: Atlas, 5ª Ed., 2010.
12. GODDARD, W. E. **JIT/TQC + MRP II = Sinergy.** Modern Materials Handling, v. 46, p. 35, 1991.
13. JEGANATHAN, K., MANI, M**. Improving the material and information flow from subassembly shop to multiple final assembly lines.** Master of Science Thesis. Department of Technology Management and Economics. Chalmers University of Technology. Sweden, 2012.
14. KENDALL, G.I. **Visão Viável:** transformando o faturamento em lucro líquido. Porto Alegre: Bookman, 2007.
15. LAGE JUNIOR, M., GODINHO FILHO, M**. Variations of the *Kanban* system**: literature review and classification. International Journal of Production Economics, v. 125, p. 13-21, 2010.
16. LEMOS, A. C. D. **Aplicação de uma metodologia de ajuste do Sistema Kanban em um caso real utilizando a simulação computacional.** Dissertação de mestrado, Universidade Federal de Santa Catarina, 1999.
17. LIKER, J. K., MEIER, D. **O Modelo Toyota:** Manual de Aplicação. Porto Alegre: Bookman, p 432, 2007.
18. LOPES, A. O, PASQUALINI, F., SIEDENBERG, D. **Gestão da Produção.** Ijuí: Unijuí, p. 69, 2010.

19. MELLO, C. H. P., TURRIONI, J. B., XAVIER, A. F., CAMPOS, D. F. **Pesquisa-ação na engenharia de produção:** proposta de estruturação para sua condução. Produção, São Paulo, v. 22, n. 1, p. 1-13, 2012.
20. MEMARI, A., RAHIM, A. R. B. A., AHMAD, R. B. **Production planning and inventory control in automotive supply chain networks**. International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems, p. 430-439, 2014.
21. MING-WEI, J., SHI-LIAN, L. **A hybrid system of manufacturing resource planning and just-in-time manufacturing.** Computers in Industry, v.19, p. 151-155, 1992.
22. MOREIRA, D. **Administração da Produção e Operações.** Saraiva, 1ª ed., 2008.
23. OHNO, T. **O Sistema Toyota de Produção:** Além da Produção em Larga Escala. Porto Alegre, Bookman, 1997.
24. OLHAGER, J., WIKNER, J. **Production planning and control tools.** Journal Production Planning & Control, p. 210-222, 2000.
25. POWELL, D., ALFNES, E., STRANDHAGEN, J. O., DREYER, H. **The concurrent application of lean production and ERP:** Towards an ERP-based on lean implementation process. Computers in Industry, v. 64, p. 324-335, 2013.
26. RENTES, A. F., NAZARENO, R. R., SILVA, A. L. **Aplicações de produção enxuta em uma empresa do setor agroindustrial.** Gestão avançada da manufatura. Jaboticabal: Novos Talentos, v. 2, p. 171-182, 2005.
27. SENTHIL, P. V., MIRUDHUNEKA, V. S. **Simulation Study of Hybrid Push/Pull System.** International

Journal of Emerging Technology & Research, v. 1, p. 1053-1060, 2014.

28. SHIMOKAWA, K., FUJIMOTO, T. **O Nascimento do Lean:** Conversas com Taiichi Ohno, Eiji Toyoda e outras pessoas que deram forma ao modelo Toyota de gestão. Porto Alegre: Bookman, p. 296, 2011.
29. SLACK, N., JOHNSTON, R., CHAMBERS, S. **Administração da Produção.** São Paulo: Atlas, 3ª Ed., 2009.
30. SMALLEY, A. **Criando o sistema puxado nivelado:** um guia para aperfeiçoamento de sistemas lean de produção, voltado para profissionais de planejamento, operações, controle e engenharia. Brookline: Lean Enterprise Institute, 2005.
31. SPEARMAN, M. L., WOODRUFF, D. L., HOPP, W. J. **CONWIP:** a pull alternative to kanban. International Journal of Production Research, v. 28, p. 879-894, 1990.
32. STEVENSON, M., HENDRY, L. C., KINGSMAN, B. G. **A review of production planning and control:** the applicability of key concepts to the make-to-order industry. International Journal of Production Research, v. 43, p. 869-898, 2005.
33. THIOLLENT, M. **Metodologia da pesquisa-açã**o. São Paulo: Cortez, 15ª Ed., 2007.
34. TUBINO, D. F., LEMOS, A. C. D. **Aplicação de uma metodologia de ajuste do sistema Kanban em um caso real utilizando simulação computacional.** Encontro Nacional de Engenharia de Produção, XIX ENEGEP, 1999.
35. TUBINO, D. F. **Manual de planejamento e controle da produção.** São Paulo: Atlas, 2000.
36. VOLLMANN, T. E., BERRY, W. L., WHYBARK, D. C., JACOBS, F. R. **Sistemas de Planejamento & Controle da Produção para o gerenciamento da**

cadeia de suprimentos. Porto Alegre: Bookman, 5ª Ed., 2006.

37. WESTBROOK, R. **Action research:** a new paradigm for research in production and operations management. International Journal of Operations & Production Management, v. 15, n. 12, p. 6-20, 1995.