A Conceptual Model for Production Leveling (Heijunka) Implementation in Batch Production Systems

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Abstract: This paper explains an implementation model for a new method for Production Leveling designed for batch production system. The main structure of this model is grounded on three constructs: traditional framework for Operations Planning, Lean Manufacturing concepts for Production Leveling and case study guidelines. By combining the first and second construct, a framework for Production Leveling has been developed for batch production systems. Then, case study guidelines were applied to define an appropriate implementation sequence that includes prioritizing criteria of products and level production plan for capacity analysis. This conceptual model was applied on a Brazilian subsidiary of a multinational company. Furthermore, results evidence performance improvement and hence were approved by both managers and Production personnel. Finally, based on research limitations, researchers and practitioners can confirm the general applicability of this method by applying it in companies that share similarities in terms of batch processing operations.

Key words: Batch Production, Heijunka, Implementation Model, Production Leveling

1 Introduction

Due intense competition, both traditional and emerging companies must improve existing methods for Operations Planning (OP). Indeed, Production Leveling improves operational efficiency in five objectives related to flexibility, speed, cost, quality and customers' service level [1], [6], [10].

Production Leveling combines two well known concepts of Lean Manufacturing: Kanban System and Heijunka. The former means pull signaling of production based on concept for supermarket replenishment to control work-in-process inventory. The latter means a smother pattern for daily production sequencing at assembling lines [8], [9], [10].

Even though such concepts are relevant on literature, one can argue about whether or not Lean Manufacturing concepts can be generally applicable [5]. Hence, three main gaps of literature review can also be used to support such statement. First of all, both conceptual models and problem solving [2] are focused on mixed model assembling lines. Secondly, it can be said that batch production is suitable to a wide variety of manufacturing processes, even in automotive supply chains [3]. Finally, regarding that Production Leveling is often described as simple models and concepts [9], [10], the control of batch processes is often referred by using a *triangle Kanban* for few product models [8], [10]. Indeed, this implies that batch production always comprises a minor part of a value stream. Based on those statements, one question arises above all others. The question is: What are the steps necessary to level out the production when batch processes represent a major part of a value stream? Thus, there was no method based on Production Leveling designed for batch production processes and its variations related to many industrial applications [1].

Based on those gaps found on literature, this paper aims to present an implementation model for Production Leveling designed for batch production systems. Additionally, this conceptual model was applied in a major qualitative research in early 2008 in a large multinational company, located on state of São Paulo, Brazil [1]. Thus, this paper is organized as follows. In section 2, a literature review of the main concepts is presented, including the structure of Production Leveling well its main activities. In section 3, research methodology is briefly explained. Section 4 presents an implementation model. This paper ends with conclusions in section 5. Furthermore, author state that this method is suitable with all manufacturing systems that share similarities within its processing operations [1]. Hence, this general applicability is briefly summarized by providing a classification of batch processing operations in Appendix A.

2 Literature Review

This section briefly presents the theoretical framework of the new method [1] which main structure was developed based on a previous literature review. This study was designed by combining the traditional framework for Operations Planning (OP) [9], [12] for make-to-stock positioning strategy and basic concepts of Lean Manufacturing [8], [10], [13].

2.1 Theoretical Framework for Production Leveling

The traditional approach for OP comprises three levels of decisions related to a planning horizon ahead of time: *Strategic* (long term), *Tactical* (medium term) and *Operational* (short term). Regarding that Lean Manufacturing practices differ from classical approach for OP in both Tactical and Operational Level [12], this method has developed by replacing classical activities of OP by Lean Manufacturing ones in such levels [1] as depicted in Fig. 1 as follows:

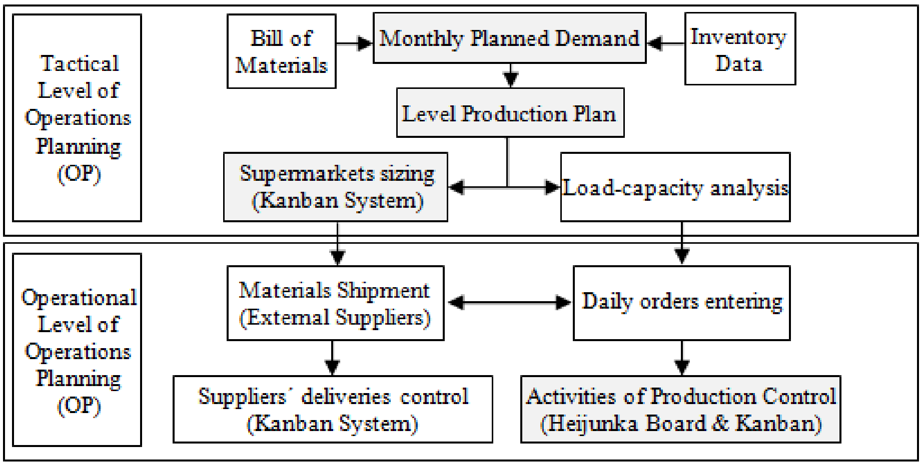

Fig. 1. Theoretical framework of Production Leveling and its main activities

Those activities highlighted at light gray boxes are shortly described as follows.

2.1.1 Tactical Level

The *Monthly Planned Demand* includes a decision based on inventory data, bill of materials and customers´ orders data. Hence, materials planners must define a planned volume (demand) for every product model for the following month. One of the key features of Production Leveling comprises the prioritization of product models due product variety. It usually suggests a make-to-stock production for both high and medium volume (‘A’ and ‘B’ items) whereas a make-to-order production for low volume (‘C’ items) [10]. Based on that decision, a *Level Production Plan* must be developed to generate a leveled production pattern [7]. It features information about production models, production batch size, set up time and a planning time horizon that can be fixed as six or more days [1], [7]. The ‘required capacity’, named as *production pitch* or *pitch*, is also calculated for every product model and comprises a total elapsed time necessary to produce an entire single batch for one given product model. Thus, it comprises an analysis of both required and available capacity of process. Finally, *Supermarket sizing* is a materials planning activity to quantify inventory storage points using the Kanban System.

2.1.2 Operational Level

Activities of Production Control feature shop-floor routines such as loading, sequencing, scheduling, dispatching and control. In a Lean Manufacturing environment, visual controls provide useful information about normal condition. These tools includes Kanban Board or Electronic Kanban as well Heijunka Board and Production Rate Control Board [1] for daily control of production completion.

3 Research Methodology

Based on objectives of this paper, the implementation model was grounded on guidelines for case studies [4]. Hence it was divided into two phases. The first one, named *Previous State*, comprises the scenario before implementation of the proposed method. Secondly, *Future State* means the condition after this implementation. Those activities are presented in the following section.

4 Implementation Model

A case study can be applied to either single or multiple cases [4]. Indeed, it is worth highlighting that this implementation model is expected to be suitable to both single and multiple cases. In this paper, researched company should be generically named Company 'A'. The two phases, named *Previous State* and *Future State*, are also presented as follows.

4.1 *Previous State* Analysis

The analysis must include one industrial facility at a time on which studied value chain must be shortly described in terms of manufacturing processes and materials flow layout. Fig. 2 depicts the main activities of *Previous State* analysis:

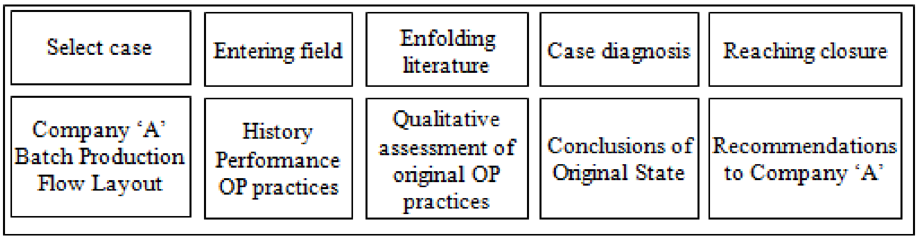

Fig. 2. First phase of the proposed methodology for *Previous State* analysis

If company and its processes features evidence that proposed method is suitable to *Previous State* scenario, then data must be collected in field including company history as well value stream performance and existing OP practices. After doing that, a qualitative assessment of such practices must be performed by comparing them with theoretical elements that composes Production Leveling. This activity comprises both principles and policies grounded on both Heijunka and Kanban Systems objectives and key features [1]. Hence, due paper limitation, a case study of this qualitative evaluation is going to be presented in details on a future research paper. After that assessment, researcher must conclude about *Previous State* and recommendations must be listed aiming to reach closure on the first phase.

4.2 *Future State* Analysis

Based on proposed approach [1], the second phase model begins with a training seminar, and a *Pilot Project Planning* structured on a *PDCA cycle* followed by a *Pilot Project Execution*. After that, performance indicators must be gathered and analyzed before and after the implementation. Furthermore, researcher must assess whether or not implemented practices adhere to Production Leveling principles and policies [1]. If so, based on facts and data, proposed method will be validated regarding research limitations. After that, the case study ends with conclusions and final recommendations. Those decisions are summarized in Fig. 3 as follows.

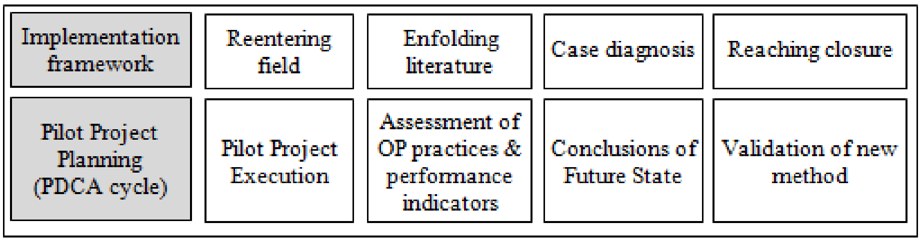

Fig. 3. Second phase of the proposed methodology for *Future State* analysis

4.2.1 Implementation Framework

Based on proposed model [1], the implementation framework highlighted on light gray box in Fig. 3 includes a *Pilot Project Planning* that starts with a *Level Production Plan*. Hence, such activity is described in Fig. 4 as follows:

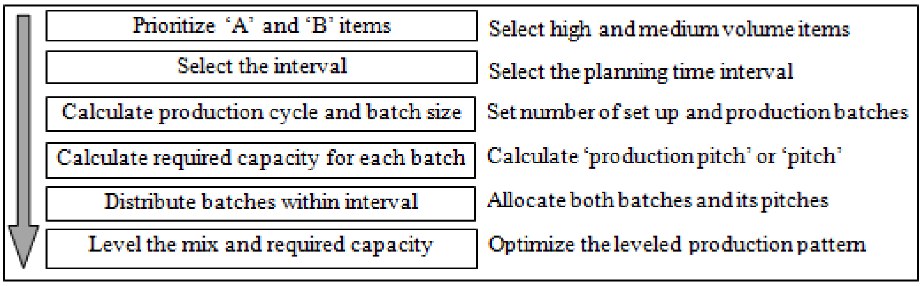

Fig. 4. Activities of the Level Production Plan designing

Fig. 4 shows the proposed method that includes the criterion for classification of products based on monthly demand, namely *ABC analysis*. After selecting prioritized items, researcher must to design a Level Production Plan for each machine that comprises the studied value stream. This plan can be alternatively designed by leveling the required capacity using the following information [1]: Set up or Changeover time, production batch size and production rate at the studied machine.

Additionally, process stability and its related constraints must be listed for further analysis. The first decision is a calculation of production cycle within interval related to the theoretical number of monthly set up operations. Second decision comprises the required capacity (*production pitch* or *pitch*) for each product model related total processing time elapsed from setting up machine till processing an entire production batch. Finally, this plan comprises visual information as depicted on Fig. 5 [1].

Product Model	1	Pitch	2	Pitch	3	Pitch	4	Pitch	5	Pitch
A	250	213	250	213	250	213	250	213	250	213
B	220	190	220	190	220	190	220	190	220	190
C	210	183	210	183	210	183	210	183	210	183
D	256	217			256	217			256	217
E			250	213			250	213		
F	150	138			150	138			150	138
G			240	205						
H							180	160		
I	180	160							180	160
J					140	130				
Daily Required Capacity (min)		1,168		1,143		1,168		1,143		1,168
Total Available Time (min)		1,214		1,214		1,214		1,214		1,214
Daily Remaining Time (min)		46		71		46		71		46
Utilization of Capacity (%)		96%		94%		96%		94%		96%

Fig. 5. A Level Production Plan for one single machine featuring five days planning interval.

Fig. 5 depicts a Level Production Plan with five days of planning interval. First left column has selected product models in machine whereas every day has production batches (columns labeled as numbers) and its related required capacity in minutes (columns labeled as ´Pitch´). After ending this activity, the next one comprises Kanban System designing regarding value stream features such as product variety, standard packages for product model, as depicted in Fig. 6.

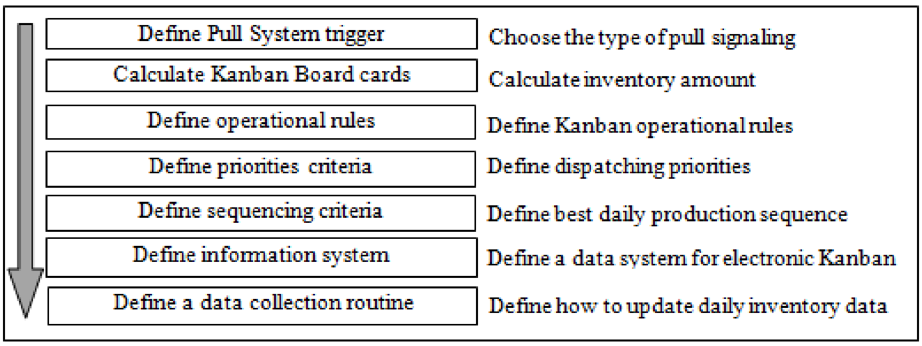

Fig. 6. Information flow applied to design a Kanban System

Finally, operational rules must be set to define how Production personnel must execute daily level scheduling and its five activities of production control by using visual controls such as Kanban Board and set of cards, Heijunka Board and Hourly Production Rate control. In some cases, due product variety, an electronic Kanban could be best suitable to control a Pull System. Finally, operational rules and its information flow are both depicted in Fig. 7.

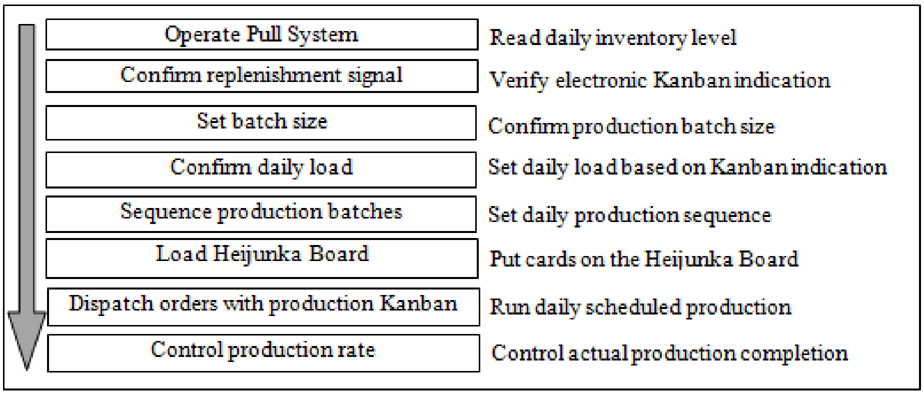

Fig. 7. Operational rules for Activities of Production Control

5 Conclusions

This paper presented an implementation model grounded on Production Leveling designed to batch production. The methodological approach was designed by using a guideline for case study and comprises an *Previous State* and *Future State*. Both phases include an analysis of OP practices. The major contribution of this paper is to present a new and simple method Production Leveling that was empirically tested in early 2008 that helped to achieve satisfactory results. This method is grounded on Lean Manufacturing concepts with major changes at *Tactical* and *Operational* levels. By defining an alternate method for Level Production Plan, future papers will show results of an implementation and qualitative assessment of proposed method. To conclude, based on research limitations, researchers and practitioners can apply these concepts aiming to test its general applicability in different scenarios of batch production with product variety in make-to-stock positioning strategy.

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Appendix A: Classification of Batch Processing Operations

Proposed method can be generally applicable in batch process system whenever it shares the same kind of processing operations described as follows:

- Disjunctive type I – It converts a single piece of material into several parts, such as press stamping like processes by cutting up hot rolled steel coils to generate multiple purpose parts by varying materials, geometry and so forth.
- Disjunctive type II – It comprises some types of metallurgical processes that convert powder and pellets into a batch of parts such as extrusion and plastic injection molding.