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Shifting from conveyor lines to work cell-based systems: the case of a consumer electric products manufacturer in Brazil

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Abstract: The division of process in short-cycle tasks performed along belt conveyors became a widely sought organizational pattern in manufacturing operations following the emergence of mass production. Later on, when manufacturers had to face the challenge to fulfill more diversified demands, the derivation of "mixed-model assembly lines" extended the potential utilization of belt conveyors. However, more recently, a number of organizations are abandoning their utilization and switching to the adoption of work-cell based assembly systems. This article investigates such shift in operations strategy from an international perspective. Firstly, it discusses the experience of electric and electronics industries in Japan, where this trend became a major trend in the late 1990s. To support the understanding of its underpinning rationality, a conceptual review on the advantages and disadvantages of belt conveyor assembly lines is included. Next, it presents an in-depth longitudinal case study of a consumer electric products manufacturer in Brazil that embarked on a program to migrate from the utilization of conveyor lines to the work-cell based assembly system in one of its plants. The implementation of a pilot work-cell in a kick-off project is analyzed and the prospects of the ongoing efforts to deploy similar maneuver in other facilities is presented.

Keywords: belt conveyor, assembly line, work-cell, line balancing

INTRODUCTION

The conveyor line production system is one of the most representative epitomes of the Fordist mass production paradigm. The classical approach of optimizing production line design and operation by dividing a whole process in short cycle tasks, applying line balancing, and laying out the required resources sequentially along belt conveyor lines, by means of which parts and products are automatically transported, for long has been justified due to advantages such as;

- economies of scale achieved in volume production,
- ease of production control,
- shorter throughput times, and
- possibility to employ low-skilled workers.

Although the exploitation of conveyor line system has leveraged industrial growth, it exhibits weaknesses and deficiencies which bring problems to its adherents. However, historically, decision makers in manufacturing firms have relieved these drawbacks considering its compensating advantages.

The significant transformations that have reshaped market, technology, labor and enterprise organization patterns since the emergence of the Fordist paradigm in the early 20th century motivated the development of alternative systems more suitable to the new business and competition circumstances. The evolutionary emergence of mixed-model production lines, transfer-lines, and flexible assembly lines (Hill, 1993), contributed to expand the range of cost efficient applications of conveyor line system and thus prevented the obsolescence of this approach.

However, leading manufacturers are now revisiting the traditional standpoint of leaving out the inherent disadvantages of the conveyor line system. In this context, it is worthy noting the striking trend of abandoning conveyor lines currently observed in some industries in Japan (Isa & Tsuru, 2002; Miyake, 2006).

The purpose of this article is twofold. Firstly, it aims to bring to light the trend of replacing the utilization of belt conveyor lines by an alternative production system based on work-cells that emerged in some manufacturing industries in that country and discuss its grounds and motivations. The other objective is to present an in-depth study of a manufacturing plant in Brazil where the organization of the production process is undergoing an outstanding revamping movement in which an approach similar to the one taken by the above mentioned Japanese manufacturers is being deployed. From the theoretical point of view, this empirical study is motivated by the issue of testing greater generalizability of this shift in production organization mode, for attaining improved operational performance, in a quite different setting like the Brazilian industry.

In the next sections, the backgrounds of this trend are outlined and the shortcomings and disadvantages of the belt conveyor-based assembly systems which motivated the emergence of an alternative production system in Japan are discussed. Next, an in-depth longitudinal case study of a manufacturing plant in Brazil that has embarked on a similar change process is presented. Finally, the main aspects related to the experience undertaken at this unit of analysis, its prospects, and the conclusions of the case research are discussed.

THE EMERGENCE OF THE CELL PRODUCTION SYSTEM IN JAPAN

As consumption patterns become increasingly sophisticated and manufacturers strive to improve their competitiveness offering quality products at competitive costs, broadening product mix, and keeping it attractive by launching systematically new products, markets have become more turbulent. The volatility of market demands has impelled leading manufacturers to search the development of alternative production systems that might enable them operate more responsively (Katayama & Bennett, 1996).

The initiatives towards reorganization of production system in progress in Japan, especially, in the electric and electronics industries, provide evidences of this movement. In these industries, high/medium volume products usually have been produced in mixed-model production lines (Hill, 1991) equipped with Advanced Manufacturing Technologies (AMTs) that relieve reliance on labor.

However, following the burst of the so-called "bubble" economy in Japan by 1991, it was observed a reversal in the trend toward large-scale automation (Tsuru, 2001; Isa & Tsuru, 2002). This was motivated not only by the economic stagnation which seriously curbed capital investments, but also because a significant part of investments in automation resources became controversial for falling short in providing bold contributions to productivity improvement.

In this context, industry observers ascertained that by mid-1990s an alternative approach to design and organize production system was arising in some industries in Japan relying on more human-centered systems resembling the "craft work" of traditional workshops (Williams, 1994; Shinohara, 1995).

Isa & Tsuru (2002) studied this strategic turnaround in which the approach of dividing work into short cycle tasks performed along belt conveyor has been replaced by workplace innovations that enable the accomplishment of both high labor efficiency and enhanced flexibility. This organization change includes measures like the (a) assignment of more challenging and meaningful functions to workforce by multi-tasking, purposeful learning and skills development, involvement in continuous process improvement, and greater autonomy; (b) implementation of workstations designed to foster high performance work, and (c) reliance on low-cost automation (LCA) resources. The pattern of production system that emerged from this turnaround has been called "cell production system".

It is worthy distinguishing it from the preceding and more well-known concept of cellular manufacturing system (also known as cellular layout or group layout) as both can be easily confounded (Miyake, 2006). The latter is a plant organization approach which advocates the laying out of production resources in such a way to form manufacturing cells self-contained with all necessary machines and tools to produce a given set of similar products (Hill, 1991; Luggen, 1991; IJMTM, 2001). This contrasts from the traditional process (or functional) layout paradigm which considers the arrangement of process areas by grouping resources with similar capabilities. For Luggen, the cellular organization essentially aims the tradeoff of inter-departments material handling for intra-department material handling.

Cellular manufacturing system and cell production system represent two resembling but distinct production system design concepts. While the former is primarily driven by the objective of reducing materials flow complexity in typically capital-intensive systems to produce a more stable variety of items, the latter is an approach to boost plant responsiveness and cost efficiency to cope with more volatile demands relying on more labor-intensive systems. However, both of them share the idea of organizing resources in production cells driven by the rationale of creating smaller "plants-within-a-plant" which yield shorter throughput times and lower work-in-process (WIP) levels (Miyake, 2006).

THE LIMITS OF THE CONVEYOR LINE PRODUCTION SYSTEM

In a seminal field study on the trend of shifting from conveyor line system to cell production system, Shinohara (1995) investigated initiatives taken in the electronics industry by firms like NEC-Nagano, Yamagata Casio, Olympus, Pioneer and Santronics. More recently, Asao et al. (2004) investigated similar conversion cases in plants dedicated to assembly of printers, digital cameras, digital video cameras, and module parts for digital electric equipment. These authors investigated how managers of the investigated plants perceived the use of conveyor lines nowadays and reported a growing concern with their intrinsic weaknesses, which has impelled the awareness that the advantages of this production system may not pay off its adoption any more.

Quoting the perspective of a Japanese management institute, Shinohara (1995) remarked that conveyor lines present a series of detrimental aspects for productivity which may be represented by the following seven waste categories:

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1. under-utilization of workforce due to the fact that line cycle time is bounded by the slowest worker
2. waste of time in reaching work-piece on conveyor and returning it onto conveyor after task completion
3. waste of inventory due to the holding of work-in-process (WIP) between successive stations
4. waste due to defective parts and rework
5. waste of resource capacity during product model changeover
6. waste due to difficulty in promoting mutual support among workers
7. waste of waiting time by workers operating partially automated short cycle process that does not allow handling of multiple machines.

Besides these, Asao et al. (2004) pointed out additional categories of losses as follow: i. line balancing loss, ii. double checks, and iii. extra space. These authors complemented that production in conveyor lines reveals other types of problems such as;

- reliance on large investments in facilities,
- reliance on indirect and support personnel who generate no added value,
- underutilization of the workers' intellectual capacity, and
- the evident rigidity of this production system that makes product model changes, introduction of new products, and process changeovers costly and time-consuming, and moreover, layout reconfiguration extremely difficult.

Also, the very nature of the process division and organization along belt conveyors brings other disadvantages as:

- the line only runs in case all stations are available and ready to operate, and
- it entails the adoption of prevalently one-sided physical motions.

Considering the conveyor line system from a broader perspective, Asano (1997) remarks that larger lines are especially more fragile in coping with production volume decline. Given the demands to justify the huge investments they required, the implantation of conveyor lines leads to the concern of accomplishing the highest capacity utilization rates at the expense of large and costly inventories of work-in-process and finished goods.

In earlier times, the disadvantages of the conveyor line system used to be overlooked since it provided a reasonable operational solution in view of the competition patterns that prevailed. However, manufacturing managers in Japan have revealed an increasing discomfort with these weaknesses which evince the limitation of the conveyor line system in enabling the organization respond to the dramatic changes that are reconfiguring the business and market environment.

Moreover, since the late 1980s, Japanese manufacturing firms have demonstrated great concern with the declining attractiveness of the work in conventional assembly lines and rising turnover in this type of job positions. Even in plants of Toyota Motor, where the celebrated lean production system was conceived, this issue has called for keen attention of management, motivating the review and improvement of work conditions in final assembly lines (Fujimoto, 1999).

The criticism against the conveyor line system thus can be summarized in the following fundamental limitations:

- The losses that are inherent to processes performed along conveyor lines, though not formally measured by managers, are in fact of much greater magnitude than usually supposed, and increase with the line length.
- Conveyor lines can provide the most efficient process solution when dedicated to a specific product or product family. On the other hand, this implicates in a structural rigidity that makes terribly cumbersome to cope with product model changes, product mix variation, and lot size reduction.
- The highly repetitive minute tasks and difficulty to promote group interactions that distinguish manned conveyor lines impose a monotonous and alienating work environment to the workforce.

RESEARCH METHOD

The development of this work was based on case study method. According to Yin (1994, p.13), a case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". Among the different case study design alternatives, the single-case study design was adopted. A single case study is appropriate where it represents a critical case or meets all criteria for testing a theory, or where it is a revelatory case (Yin, 1994). A single case allows the investigation of the phenomenon in depth to provide rich description and understanding.

The focused case involves the experience of a major consumer electric products manufacturer established in Brazil whose name is omitted in respect of the confidentiality requested by the firm, and thus is refereed to as CEPM-Br. This firm decided in 2005 to tackle a project for exploring the concept of replacing the organization of assembly process around belt conveyors by a system based on work-cells. Given the pioneering nature of such organization innovation initiative it can be considered a revelatory experience, being one of the earliest examinations of the phenomenon involved outside the context of the manufacturing industries in Japan and Japanese manufacturing corporations for academic purposes. For this reason, besides providing a description of an actual experiment and mapping its key variables, this case study intends to contribute in the inductive construction of the theories behind the observed experience.

Two authors of this article were actually engaged in the aimed change process as participants of the CEPM-Br team that conducted this project. This not only facilitated direct observations and access to primary sources of data but made possible a close follow up of this real-world situation for grasping an in-depth view of its evolution and building a reliable understanding of its issues and underlying rationale. This study was developed over a period of approximately one year, from June 2005 to May 2006 in two stages. In the first stage, one of the authors – a student of a major undergraduate production engineering course – participated in the project since the very beginning as part of a internship program undertaken in the plant taken as unit of analysis. This made possible the grasping of the initial situation, the accompanying of the change process evolution, and thereby the realization of a detailed description of the case. In the second stage, when the change process had already advanced substantially, the other author – a senior manager in the focused plant – who had a critical role as a major change agent contributed in the ex-post assessment of the case and its outcomes.

The analysis of the case was also supported by other three informants; a corporate senior manager who supported this change process, and by two staff members employed at the unit of analysis who participated in the change process as *kaizen* support analysts and, therefore, had an in-depth understanding of operational aspects of the case. These contacts were realized in earlier stages of the change process and later on when it was firmly on course.

Additional information could be directly gathered from memoranda of three on-site visits made by the main researcher of this work and other primary sources like internal reports and presentations, documentary video, and spreadsheet data. These data gathering means provided multiple sources of information and views to enrich the description of the case and ensure the consistency of its analysis.

THE CASE OF A CONSUMER ELECTRIC PRODUCTS MANUFACTURER IN BRAZIL (CEPM-BR)

Backgrounds of the CEPM-Br case

CEPM-Br was a firm of national capital, which was incorporated by a leading global manufacturer of consumer electric products in the 1990s. Despite this overtaking CEPM-Br's products are still traded with its original brands in domestic markets and local management has been given great autonomy to deploy the operations strategy. Nowadays, it produces a large variety of electric products for home in four manufacturing sites.

Yet in the mid-1990s, other global competitors have aggressively entered in the Brazilian market of consumer electric products seizing significant market shares.

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This has awakened the concerns of CEPM-Br's management to strengthen the overall competitiveness of its operations. The case here presented is about the turnaround undertaken in one of its plants aiming the reconfiguration of the production system so as to increase its performance in terms of productivity, quality, flexibility and responsiveness. This plant is located in a site with 50,000 m^2 of built area, employing about 1,500 people and is dedicated to the production of a specific type of product.

The operations of this plant are based on a hybrid production system combining push and pull techniques. While the production program in the final assembly process is defined in make-to-stock (MTS) mode, the supply of the required parts are either pushed by previous stages or pulled from supermarkets where internally stamped and coated parts are stocked.

When this turnaround was initiated, the final assembly process was organized around 3 long assembly lines equipped with belt conveyor ranging from 25 to 35 meters. Each line had capacity to assemble several product models. When completed, the assembled products are quite heavy (31-55 kg) and large with its external dimensions ranging from 495 to 920 mm. As these products are quite sizeable, belt conveyors were utilized to support the product body during the execution of manual assemblies and to move it along the main assembly process.

The capacity of each line had been established to vary from 50 to 150 units per hour depending on the product complexity. An implication of this was that the production cycle time varied from 24 to 72 seconds imposing short cycle tasks to a workforce that ranged from 75 to 85 operators. Approximately 62% of them were assigned to main assembly and the remaining to connected sub-lines which fed subassemblies. Because of the large number of workstations comprised by the lines, product changeover was time consuming and this motivated production planners to produce large batches. A total of 130 product models were assembled and finished goods inventories were very high.

Driven by the need to increase productivity, the management of the plant undertook efforts to streamline processes based on the lean production approach. A series of process improvement actions were then carried out by systematically identifying losses, and applying lean concepts and techniques. Thus the design of methods, workstation layout, workbench, and auxiliary devices were reviewed, and work load was rebalanced, bringing significant gains as follow: i) Line efficiency could be raised significantly and this enabled the shutdown of one of the four belt conveyors operated in the unit of analysis in early 2005; ii) the remaining three belt conveyors were shortened about 35% in length, iii) workforce reduced nearly 9%, and iv) occupied floor space reduced 55%.

These gains could be effectively sustained, however as the performance of the rationalized assembly lines gradually rose, opportunities for further significant improvements became unlikely. Furthermore, despite the gains, the improved assembly lines still featured some evident deficiencies as follow:

- short cycle times
- short distance between successive operators
- poor line balancing efficiency

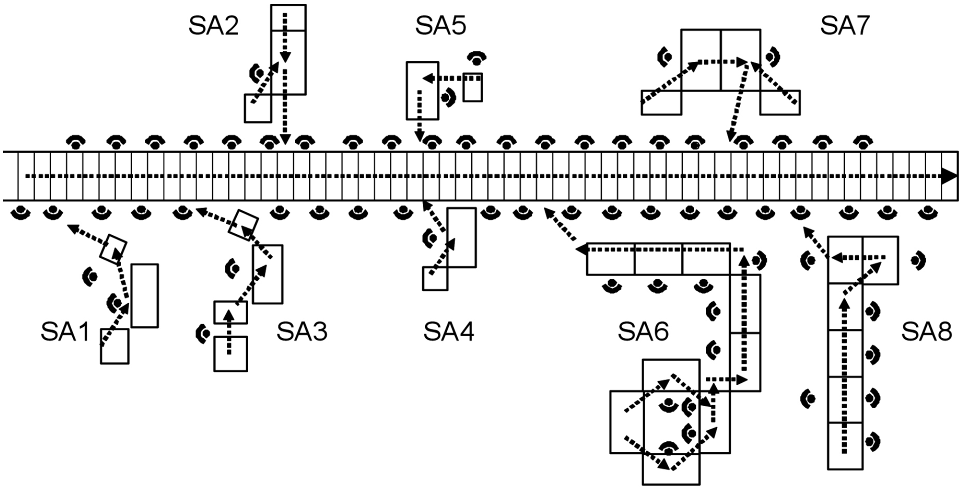

Figure 1 - Layout of the belt conveyor assembly line.

Figure 1 exhibits the layout of one of the lines in which 42 operators were employed in the main assembly process and 26 operators were employed in subassembly (SA) processes. Figure 2 indicates that in a certain line, for a cycle time of 22 seconds, the line balancing losses were of 29% and 22%, respectively, in the main assembly and subassembly.

The management then realized that to overcome these deficiencies, a production system innovation should be seriously considered given the limitations to obtain further significant improvements maintaining the utilization of the conveyor line system.

This motivated managers to consider the challenging proposal of abandoning traditional paradigms, by replacing large conveyor lines by more compact and agile assembly systems organized in work-cells.

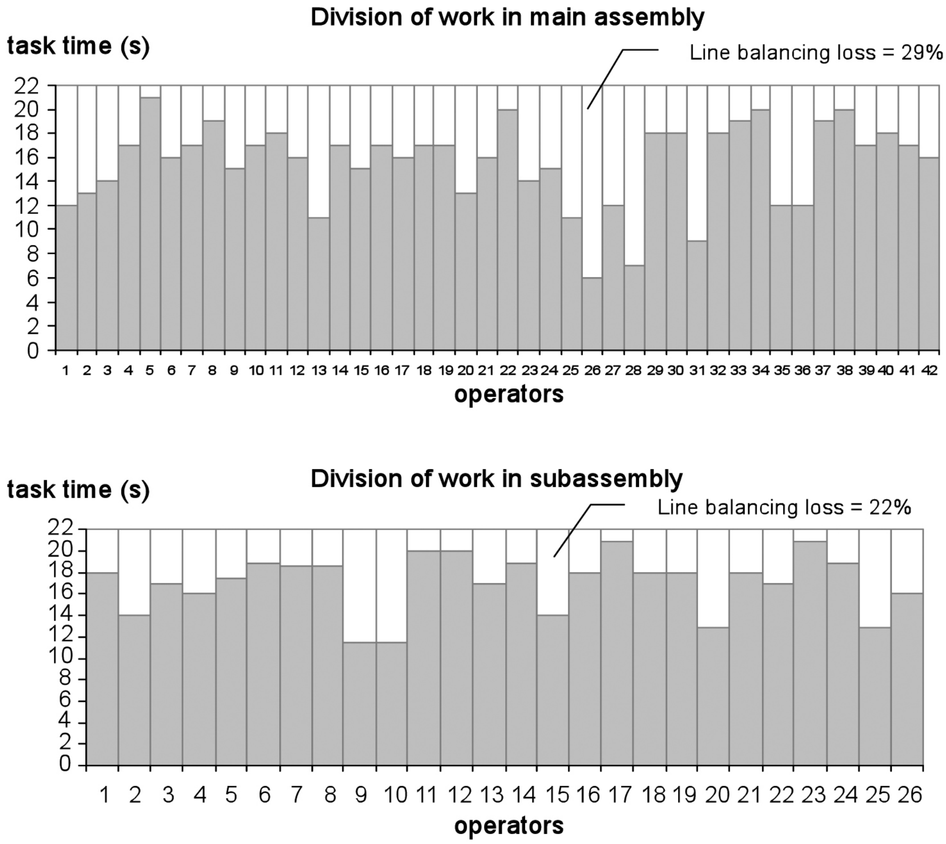

Figure 2 - Division of work in conveyor line process.

The production system change project in the final assembly process

To test the feasibility of this shift, a pilot work-cell was initially designed for the final assembly of a product model whose demand was relatively low as the risks should be minimized and few people could be transferred from the operating lines to experiment the alternative process of production. The implementation of the pilot work-cell involved a team coordinated by the production manager, assembly line coordinators, production engineering experts, and *kaizen* support staff.

The design of this work-cell started by disassembling step by step a unit of the product that would be assembled. Each separated part, was laid out on the floor in the reverse sequence of the assembly process and the set of all individual parts were arranged in such a way to define a U-shaped line.

The design of the pilot work-cell followed some guidelines. Firstly, it was defined that the product would not be moved by conveyors. Thus, a low cart was built in-house

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so that the product could be laid on it and completed as it is conveyed smoothly through successive workstations positioned along a U-line where a subset of parts would be assembled.

Next, with regard to work organization, it was defined that in the main assembly, operators would be assigned to perform complete processes. As an implication of this, instead of being placed in a specific workstation, these operators would rotate cyclically the U-shaped cell in a row following the subsequent operator in the so-called "rabbit chase" mode, completing one product per cycle (Suzaki, 1987). The adoption of U-shaped cell layout was fitting for minimizing the distance between the position where the cart carrying a finished product ahould be left at the main assembly exit, and the entry point from where the operator should start the next assembly cycle.

Also, to minimize the length of the main assembly route in the U-shaped cell, the preparations of subassemblies were positioned outside to take place in connected workstations. These guidelines contributed to make the work-cell more compact.

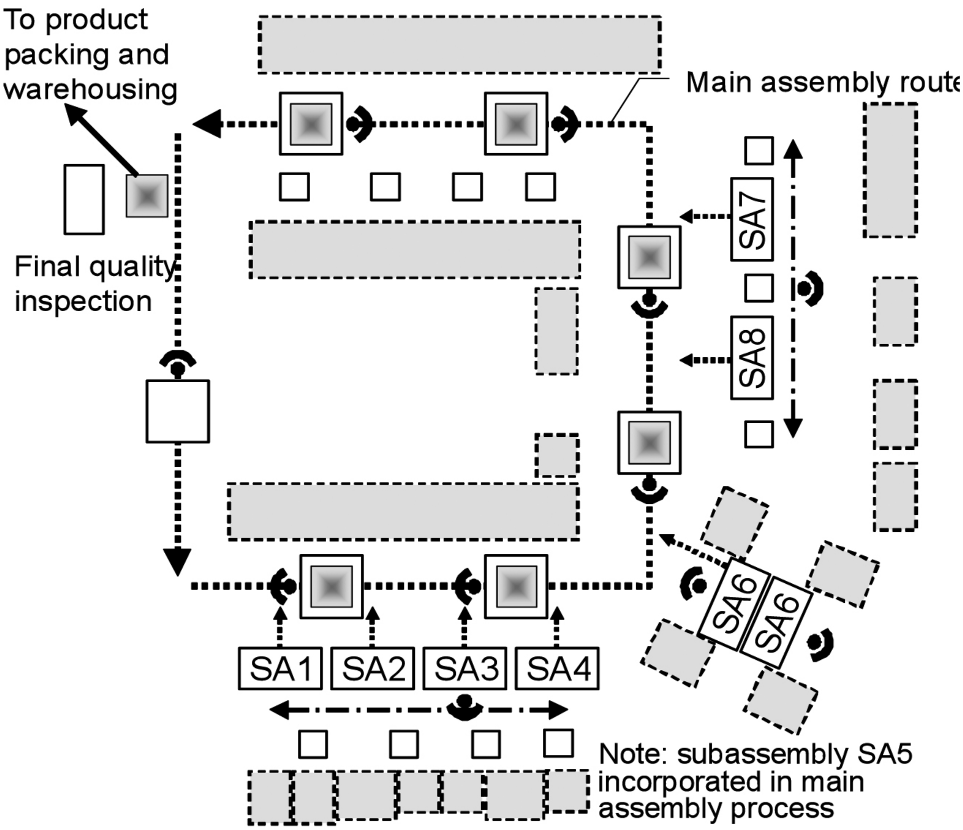

Figure 3 - Layout of the pilot work-cell.

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Experienced operators were then observed performing the assembly tasks in the work-cell and motion times were measured by the *kaizen* staff. Considering this separation and applying a cell balancing method, the total 80 motion elements required were initially grouped to be performed by a team of just 11 operators in a cycle time of 144 seconds; 7 in main assembly and 4 to subassemblies as shown in Figure 3. As indicated in Figure 4, this allocation reduced line balancing losses in the main assembly and subassembly processes to 5% and 9%, respectively.

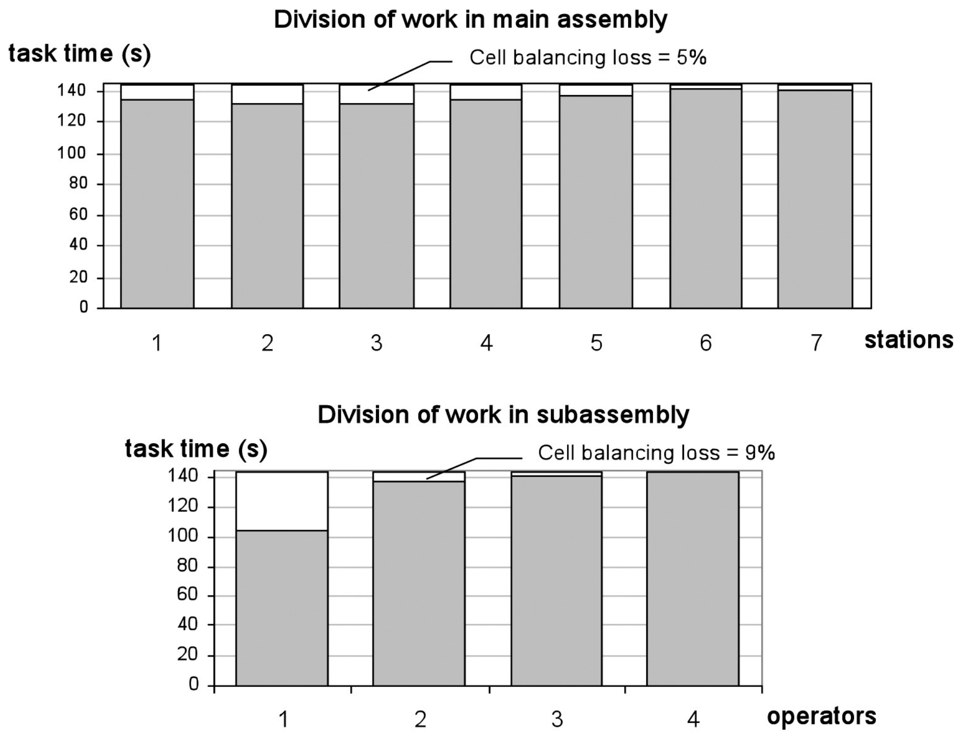

Figure 4 - Division of work in the pilot work-cell.

A pilot work-cell based on this configuration was built and in August 2005 its trial run started with a few operators since the belt conveyor line that would be replaced was still running hindering the removal of more workers. This testing stage was critical for the following issues:

- Job enlargement: Operators used to perform fragmented tasks within short cycle times in conveyor lines should be trained to undertake a broad scope process in the main assembly process that required 955 seconds.
- Parts replenishment logistics: An area called "refrigerator", where parts pulled from "supermarkets" in original large racks could be stored, was installed outside

the work-cell, otherwise more space would be needed in the cell. To make each workstation as compact as possible and at the same time increase the amount of parts to be assembled by each operation, small bins were arranged to facilitate parts feeding at points of use. Typically, the stocks kept at points of use are sized to fulfill between 30 and 60 minute of production needs. An operator called *mizusumashi* (Miyake, 2006) was assigned to cyclically transfer parts in small quantities from the "refrigerator" to these bins as illustrated in Figure 5.

- Process improvement: Initially, the man-hour productivity was lower in the pilot work-cell. To make it comparable to the productivity in conveyor line system, the *kaizen* staff worked intensively close to operators to rationalize the work in each workstation (in main assembly and subassembly), by developing fixtures that facilitate task execution and quality assurance, improving ergonomics, identifying equipment requirements (e.g. electric screwdrivers, riveting tools), and revising process sequence. The participation of the operators was critical to analyze the process and implement these improvements effectively.

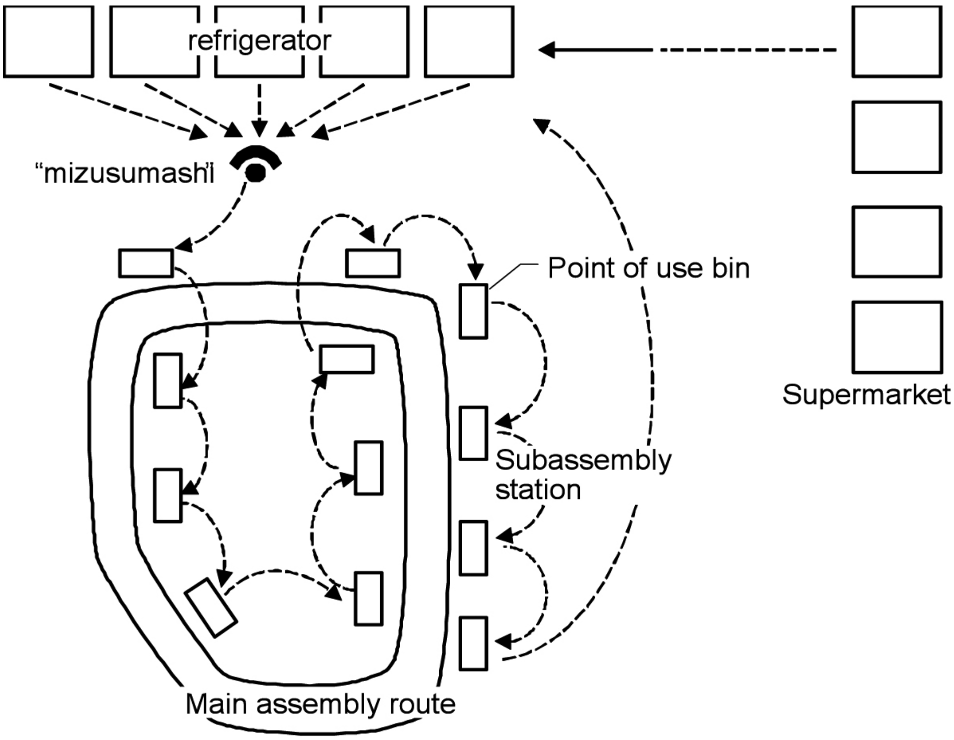

Figure 5 - Replenishment of point of use bins.

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When the pilot work-cell was properly configured it was transferred to a definitive location by September 2005. This could be carried out swiftly in about 6 hours, so that in the following day it was already operational. The low investments required by the pilot work-cell besides the ease and rapidness of building, adjusting, transferring and reinstalling it in comparison to the cumbersome efforts that conveyor line systems would require were quite impressive from the managerial viewpoint.

The work team was then complemented in the pilot cell and they achieved promising performance levels in terms of productivity and quality. These results convinced the managers to roll out the strategic project of changing the production system in assembly process. A plan was then devised to replace the 3 conveyor lines by a set of 8 work-cells in the assembly process as shown in Figure 6.

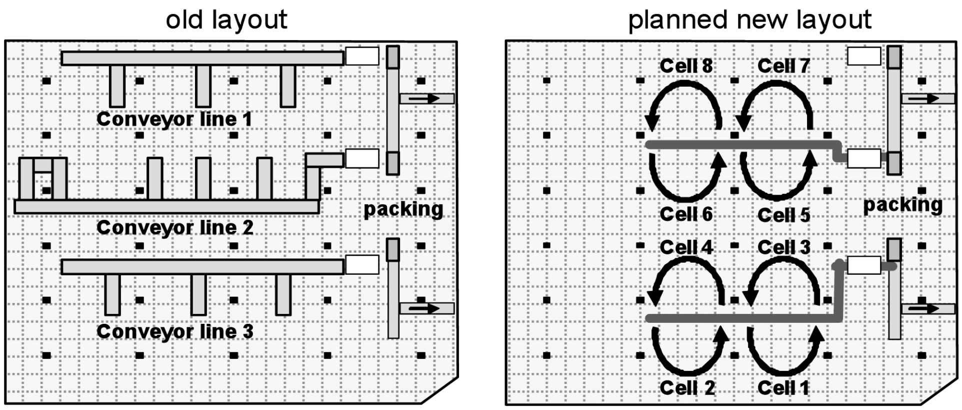

Figure 6 - Old and new layout for the assembly process.

The decision of this change process was also corroborated by encouraging impacts on workforce. Monitoring the operators' willingness to work in a context of enlarged jobs, it was observed that capable operators could not only undertake a much broader scope process in final assembly but also contribute to reduce nonconformities since this implied testing their own work. Moreover, the U-shaped layout promoted constant sharing of knowledge and practical experience among the team members facilitating the development of group competences. Soon each operator grasped a systemic view of the entire process and incorporated a keen sense of responsibility.

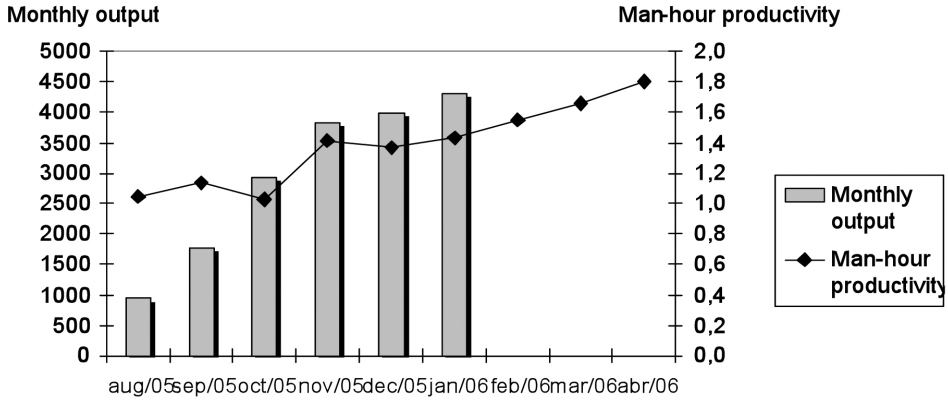

Figure 7 - Man-hour productivity in pilot work-cell.

Operational performance of the work-cell system

As additional operators were included in the work team the output of the pilot work-cell increased. Figure 7 indicates that during the production ramp-up, man-hour productivity has clearly raised as the learning process and *kaizen* activities advanced. It is worthy mentioning that in this period the number of product models assembled was also increased.

The migration to the planned new layout advanced as additional assembly work-cells were built. Figure 8 indicates the chronology of each cell building and implementation process. By the end of 2005, a total of 4 work-cells had been implemented. The other 4 work-cells were implemented in the first quarter of 2006. The change process advanced gradually and in its course, the involved change agents developed and refined a proper planning and implementation method for the type of assembly work-cells they conceived. The intense learning attained by tackling the problems and challenges faced during the installation, try out and production ramp up of the initial cells enabled the organization to improve and shorten the preparation of the following work-cells.

Figure 8 also indicates when each belt conveyor lines were eventually shut down. The three conveyor lines were dismantled and removed from the plant in stages and thereby the new work-cells were gradually installed in the released spaces.

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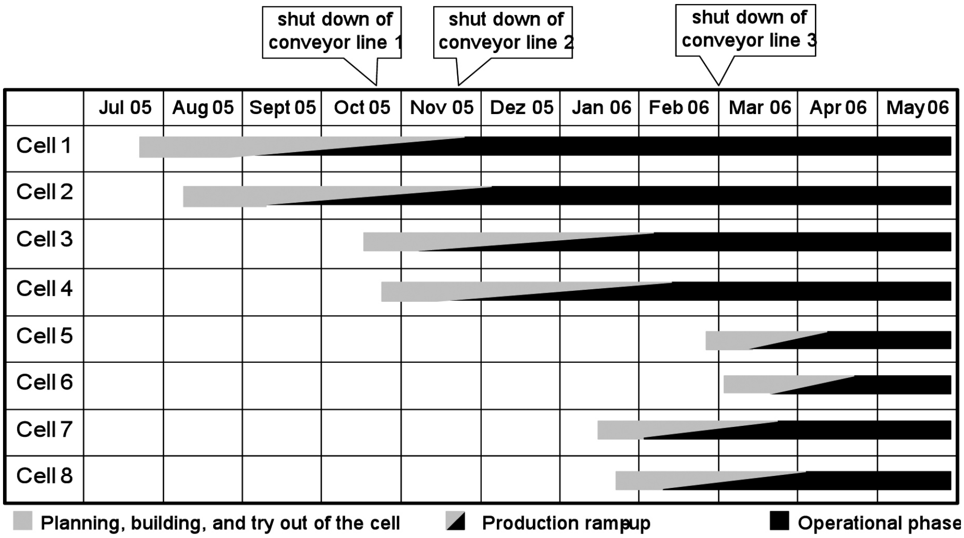

Figure 8 – Chronology of the cells implementation process.

With regard to production ramp-up time of assembly work-cells, it was noticed that the organization could manage to reduce it significantly from about 3 months taken in the earlier work-cells to just one month in the latter ones. This was greatly supported by the organizational expertise developed for work-cell design; assembly method planning and improvement; and on-the-job training of operators.

Based on data gathered in the subject migration project, Table 1 compares some attributes and performance indicators of the production in a conveyor line and in a work-cell, indicating the advantages of the latter one in supporting the shortening of production lead time, reducing resources requirements, and fostering manufacturing agility.

Quality assurance, has also benefited from this change as in the new work-cells a single operator handles the main assembly process of a product. This enhanced traceability of root causes of nonconformities, promoted self-testing and self-control, and stimulated cooperation among team members.

Table 1 - Comparative data.

	Conveyor line	**Work-cell**
Man-hour productivity [a, b]	100	129
Setup time (minutes) [b]	9	5
Throughput time (minutes) [b]	30	15
Job span (# of workers in main assembly)	42	1
Work in process (# of products)	33	11
Defective rate [a]	100	30
Required floor-space [a, c]	100	75
Relocation time [d]	at least 2 months	1 day
Investment [a]	100	17

Notes: [a] Index number relative to line
[b] average figures
[c] includes area to store parts and components at points of use
[d] time span until starting production try out after transfer and reinstallation

The greater flexibility brought by the new production system was complemented by comprehensive improvement actions taken in the parts supply processes bringing significant reductions in the inventories held at the plant taken as unit of analysis as exhibited by Table 2. As the new system makes possible the final assembly of products in smaller batches in more frequent orders, relatively larger gains could be attained in the inventories of internally fabricated items for which more immediate rationalization measures could be taken.

Table 2 – Impacts on inventories.

	Conveyor line	**Work-cell**
Lot size of outsourced parts [b]	15 days	2 days
Lot size of internally fabricated parts [b]	1,200	320
Internally stamped parts [a, b]	100	14
Internally enameled parts	100	2
Finished goods inventory [a]	100	90

Notes: [a] Index number relative to line
[b] average figures

CONCLUSION

The new assembly system enables small lot production and brought about sound conditions for the plant to operate much more responsively. As a matter of fact, the new production system makes possible the simultaneous production of a larger number of products: up to 8 different products against 3 in the previous system.

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The implementation of the pilot cell and the overall production system change project that followed have evinced wastes and problems inherent to the conveyor line system. Furthermore, these experiences have demonstrated that work-cell based assembly system can be a key driver to accomplishing the CEPM-Br's strategic objective of enhancing operational excellence and reinforcing its competitiveness.

In the period considered by this case, the Brazil's currency has experienced a strong appreciation of about 10.5% against US dollar hitting seriously the export capacity of the manufacturers in this country. Even so, the efficiency gains that the adoption of the new production system brought about enabled to sustain the price competitiveness of the CEPM-Br's export-oriented products and prevented the transfer of its production to lower countries.

As for the "migration to work-cells approach" in itself undertaken in this case, given the significant gains and operational advantages observed in this initiative, its inherent potential, and the substantial competence developed by the involved project team, CEPM-Br's top management has already set plans to disseminate it in other manufacturing sites operated in Brazil involving the final assembly of other types of products. At the corporate level, CEPM is considering the application of this approach in manufacturing units located in other regions of the world as well. This further suggests the potential transferability of the work-cell based system.

Despite the potential of its broad scope application, it is important to remark that the adoption of this system should not be considered as a panacea. In fact, CEPM-Br managers acknowledge that depending on circumstances, the utilization of belt conveyor should be kept as its replacement by a work-cell based system may not be justified. This would be the case of production lines dedicated to a single standard product (or a narrow product family featuring minimum variation) where very specific processes required substantial capital investments in fabrication and assembly technologies, since, at least from the criterion of investment return, the shift to the cellular assembly approach would not justify.

With the bolstering of the operational capabilities in the assembly process, CEPM-Br management has now established the objectives to reintroduce low volume product models that had been removed from catalogue and launch new products with customizable elements. These plans were previously considered unfeasible given the rigidity of the conveyor lines used.

Considering the issue of broader diffusion of a production organization approach that resembles the cell production system developed by Japanese manufacturers, this case supports the transferability and feasibility of effective implementation of similar concepts and solutions in the setting of a consumer electric products industry in Brazil. However, while in Japan, the need to nurture more meaningful work environment and the pressure to agilely cope with introduction of new products induced by the trend of product life cycle shrinking are underlined among the primary motivations to adopt cell production system, in the case of CEPM-Br has prevailed the concerns to build a more cost efficient system that enables production in smaller lots and to improve quality of conformance.

Nevertheless, although lack of labor is not a constraint in Brazil, CEPM-Br managers believe that working conditions should be resolutely improved to sustain the work-cells. As a matter of fact, improvements are being devised so that female workers can also be employed in the main assembly process, a more ergonomic cart is under development, and the wage system was revised to compensate workers according to the skills and knowledge required in the new production system.

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Biography

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