Operating modes in manufacturing cells – an Action Research study

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Abstract

This paper describes the operating modes adopted in manufacturing cells of an assembly controller's heat boilers firm and its influence on the productivity. The paper also presents the difficulties that cells faces when it is formed free of care in selecting and recruiting adequate and motivated people to form the team for operating the cells. These careless and other factors discussed here causes lower productivity. One of the appointed advantages of the cells is the possibility of varying the number of operators when the demand varies. In spite of this, this advantage could be a disadvantage if the persons recruited are not prepared or motivated. This action research industrial study shows that the cells must be part of a strategy of the company not an easy solution that someone thinks that "may be it works here". When the cells are adopted inside this spirit its difficult to achieve all the benefits of the cells transforming these, many times, in failures.

Keywords**:** Manufacturing cells, Operating modes, Rabbit Chase, Working Balance.

1. Introduction

A manufacturing cell has been identified as a system dedicated to the manufacture of a family of identical parts. The manufacture based on a setting of such cells is usually referred to as Cellular Manufacturing. A more comprehensive definition of a manufacturing cell points to a manufacturing system that groups and organizes the manufacturing resources, such as people, machines, tools, buffers, and handling devices, for the manufacture of a part family and/or the assembly of a family of products with identical or similar manufacturing requirements. Cellular manufacturing aims at economies of scale through economies of scope, i.e. through increased variety of products manufactured in the same system. This approach of identical or similar processing of similar objects is known as Group Technology (GT) [1]. It is for this reason that manufacturing systems based on cells are frequently associated with GT.

This paper is about the operating modes of the operators in the cells that assemblies heat controllers and its influence on the productivity. Others factors are also affecting negatively the productivity.

The methodology used for this study was the Action Research because the investigator was involved in the production environment being part of the team during a six months period as a cell leader.

In this paper, in section 2, the benefits of Cellular Manufacturing are presented. The methodology followed in the work described in this paper is put forward in section 3. The section 4 describes the work developed: presents the product firm and the production cells, the critical analysis and the proposals suggested. The final section presents some concluding remarks.

2. Benefits of Cellular Manufacturing System

Cellular Manufacturing System (CMS) can have a beneficial impact on manufacturing operations of an enterprise, largely published in the bibliography, namely, Wemmerlöv and Hyer [2], Nyman [3], Singh and Rajamani [4], Suresh and Kay [5], Kamrani and Logendran [6], Irani [7], Wemmerlöv and Johnson [8][9], Shayan and Sobhanallahi [10] and Hyer and Wemmerlöv [11].

To the operational level, the improvements are in the lead times, the resources utilization (machines and people), in the products and processes quality and the required space. As the parts are completely or almost completely manufactured inside the cell the travel distance diminish and, consequently, the transport time. This permits the production of minor lots due to the machines proximity. Grouping the parts with similar processes for production in the same cell simplifies the workflows and reduces the machines set-up time and the associated costs. This contributes also for the economic production of minor lots and, consequently, the WIP and the space required are reduced. The reduction of these times, set-up and transport, and the non interference of other different products in the cell reduce the throughput time, and, consequently, the lead time of good quality products because it is easier controlling the occurrence of defects.

Other benefits can be achieved that are related with the people that work in the cells. Normally, a cell is constituted by a team that in a coordinated manner share the tasks processing in the different workstations. Working teams, which are closely related with cell operating modes, can take several configurations, such as semi-autonomous workgroups, self-directed or self-managing work teams and lean teams [12], [13], [14], [15] and [16]. The teams can acquire or be formed to be self-management teams, where all team members participate in the local decision making traditionally of responsibility exclusive of supervisors or managers [17]. Self-management is defined as autonomous decision making inside the cell related with the tasks to be performed and how to organize the processes to achieve this [18]. Some of the advantages of self-management teams are to give empower and responsibility to the team, reduce the need of managers intervention and encourage the cooperation and creativity [19].

Forming good teams is essential to obtain benefits. This is why some authors look for this problem as an integrated problem of operators and machine selection and allocation to cells, when establishing manufacturing cells [20], [21], [22] and [23]. Additionally, Bidanda et al. [24] in their survey emphasize that important issues to be treated in cells include operators allocation strategies, skills identification, training, communication, reward/compensation systems,

definition of operators roles, teamwork and conflict management.
The number of operators and the affected tasks to them can be variable, according to the necessary cell output and the operators' skills. The workstation ergonomics, the standing work to facilitate the mobility and the motivation resulting from the tasks enlargement and rotation are considerable. The operators fatigue is recognized minor due to the operators' mobility that adopts a dynamic standing posture [25]. This dynamic standing posture promotes the adoption of different cell operating modes, i.e., internal organization and distribution of the operators by the workstations related with how people work and flow within a cell. Cell operating modes explore strategies such as teamwork and time-sharing resources [26], rabbit chase, TSS and working balance [27], bucket-brigades [28], [29] and [30] or batton-touch [31]. The bucket brigades (BB) is a novel, powerful and flexible cell operating mode for operators work within a cell. The BB mode resembles the work organization and behavior of bees and ants [32], [33] and [29]. The TSS mode is considered by the authors of the BB mode as one of its possible implementations. These operating modes had similarities and dissimilarities, summarized in Alves [34], more or less adequate to different production environments. Almost all of these operating modes are implemented in the well known and popular U shaped physical layout configuration [35] and [36]. These operating modes contribute to an activity much less monotonous that the one in repetitive environment.
But the full benefits of such product-oriented approach to production can only be realized when overall production is considered. This means that, efficient production of parts or assembly of products alone is not enough to ensure effective advantages for a company as a whole. It is also necessary considering the parts production coordination for effectively and efficiently making complete products and quick respond to the customer orders of end items. Several authors propose systems and management approaches focusing on the coordinated manufacturing of parts and components and their assembly towards efficient production and delivery of product customer orders. This manufacturing approach can generally be referred as Product Oriented Manufacturing (POM). Examples of POM systems are what Black [37] refers as Linked-Cell Manufacturing System and also the Quick Response Manufacturing system referred by Suri [26]. Several authors, including Burbidge [38], Süer et al. [39] and Süer [40] also emphasize the importance of systems integration and synchronized work in cellular manufacturing. Thus, to effectively respond to the market demand challenges of today, CMS must evolve to Product Oriented Manufacturing System (POMS), frequently reconfigured for fitting and efficiently respond to product demand changes [41] and [42].

3. The Action Research Methodology

As a final project of Industrial and Management Engineer Master Thesis, the first author of this paper was integrated in a firm for managing the cells of heat boilers controllers. The main objective was to improve the cells productivity. The firm believes that cells productivity was lower because the operators weren't motivated to raise the output levels. So, it was necessary to integrate in the cells one impartial person that could observe, analyze and participate in the cells life inspiring trust to the operators. This work was developed through observation, analysis and participation in the daily events in three final assembly cells of the firm, adopting what has been, normally, called an action research methodology.

"Action research...aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process." ([43] in O'Brien [44])
This methodology comes from a methodologies family that uses the action (or alteration) and the research (the understanding) simultaneously. Initially, it is executed a cyclic or a spiral process that switch between action and critical analysis and, after that, occur a data and methods understanding that continually would be improved [45].
O'Brien [44] presented the Figure 1, that he adapts from Susman [46], to describe the cyclical nature of the action research process. This process includes five steps: diagnosing, action planning, taking action, evaluating and specifying learning.

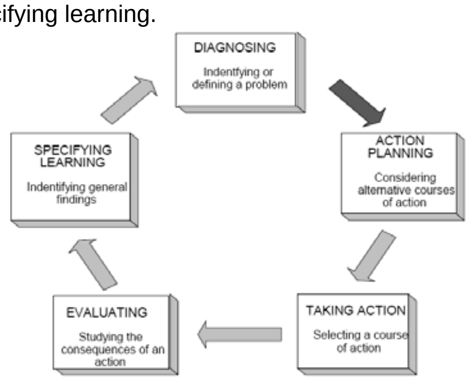

Fig. 1 Detailed Action Research Model (adopted from [44]).

In the first step it is essential to identify the problem and collect data to search the solution or solutions. The second step is the planning of the actions to develop. Then, one of these solution is chosen, the third step, and is followed by an evaluation of the results obtained, the fourth step. Finally, the fifth consists in verifying if the problem was solved or not. In this case the process begins until the solution for the problem is found.
The problem was identified by the firm as being the lower productivity of the cells that it was aware of the need to improve this. The firm also believes that the causes for this are the motivation and organization of cells operators. Thus, the work developed was to respond to the following research questions:

- Why the productivity in the cells is inferior to the expected by the firm?
- How the operating mode influences the operators' motivation?
- How the cells productivity can be raised?

4. The developed work

The work was developed following the methodology presented above. The problem was identified being necessary to diagnosis the situation and collect the data. The relevant data to the problem is described next, followed by the critical analysis. Further, were presented the proposals presentation and some were implemented. The results were discussed. The proposals weren't implement yet originates other research cycle.

4.1 Description and characterization of the Industrial Setting

The industrial setting of this study belongs to a well consolidated firm. Until three years ago, the firm only assembled one kind of product. Then, it decided to assembly another product, heating boilers controllers, to supply another firm from the same group. The heating boiler controller is a device for the electronic control of boilers. The firm has 68 models of heating boilers controllers. The main heating boiler controllers' component is an electronic card. This electronic card characterizes the heating boiler controllers' model. Almost all models have different electronic cards. The models that have equals electronic cards had other differences, or in the types of components (buttons, display,…) or in the number of components. A model could have a total of 30 different components, manually inserted or with screw machines.
The production system for assembling this product is composed of two manual assembly lines and three manual assembly final cells (Figure 2).

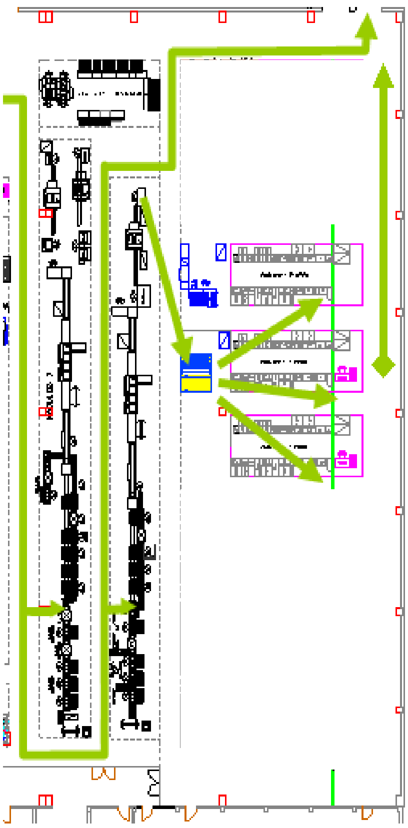

Fig. 2 Layout of heat boiler controllers assembly lines and cells.

The arrow indicates the work flow from the assembly lines to the assembly final cells. The two lines assembly a subassembly that is the input to the three assembly cells. The manual assembly lines output is the assembly final cells input like the concept of connected cells described in Süer et al. [39] and Süer [40].
The three cells are replicated cells, having the equivalent equipment, to face a high demand. This means that any model could be assembling in any cell. In spite of this, one of the cells is more oriented to a high demand model in order to minimize the set-up time of two different equipments in the cell that requires a software programme. This model had fewer operations, so is required a higher output for this cell.

The cells output is 1340 units in an eight hours shift (457 minutes). Two of the cells have an output of 440 units and the third one has 460 units (the more oriented). The takt time for the two cells is 62,3 seconds and for the third one is 59,6 seconds. The cells productivity is 90% but the objective is 100%.
The figure 3 shows the layout for one of the cells. It also shows the operators and his movements. Each cell has four female operators. They have the necessary skills to operate all the tasks in the cell, i.e., the teams are multifunctional, but with different performances. When one of the operators need to absence, the others replace this absence without affecting the normal functional of the cells, i.e., they explore one of the advantages of the cells already referred in this paper.

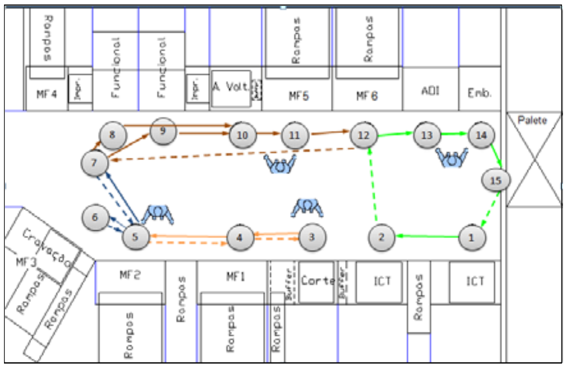

Fig 3 Layout of a heating boiler controller assembly cell.

The operating modes adopted in the cells are the working balance or the rabbit chase. The figure 3 shows the operators in the working balance mode and the standard work sheets are in the figures 4, 5, 6 and 7. They are dynamic standing in each zone: the first operator works on the workstations 3 and 4 (Operator 1, Figure 4), the second operator works in 5, 6 and 7 (Operator 2, Figure 5), the third works on the 8, 9, 10, 11 (Operator 3, Figure 6) and the fourth works on the workstations 12, 13, 14, 15, 1 and 2 (Operator 4, Figure 7). They stay in these zones for two hours because they are four operators during a period of eight hours. After that they switch the zones. This demands that they rotate for all tasks in the cell and knowing all the operations.

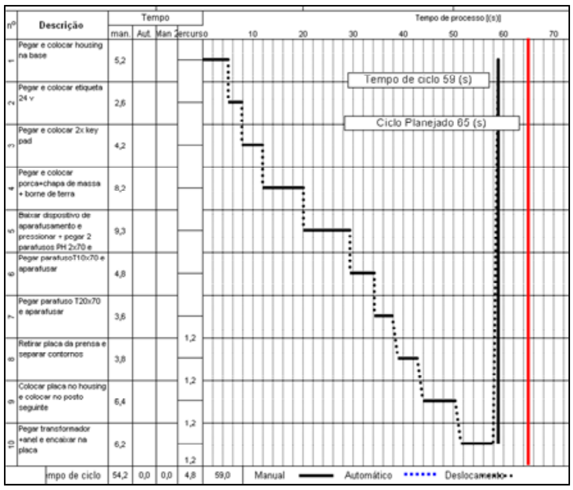

Fig. 4 Standard work sheet for the cell operator 1.

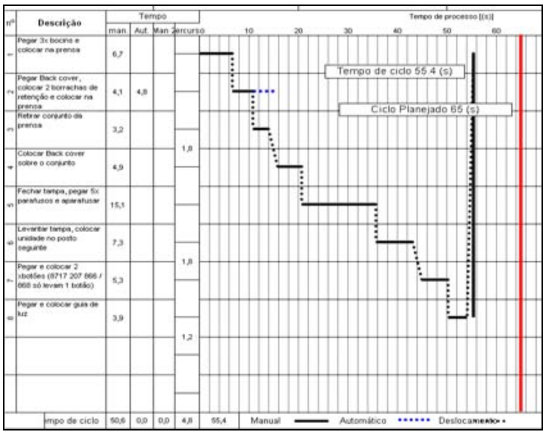

Fig. 5 Standard work sheet for the cell operator 2.

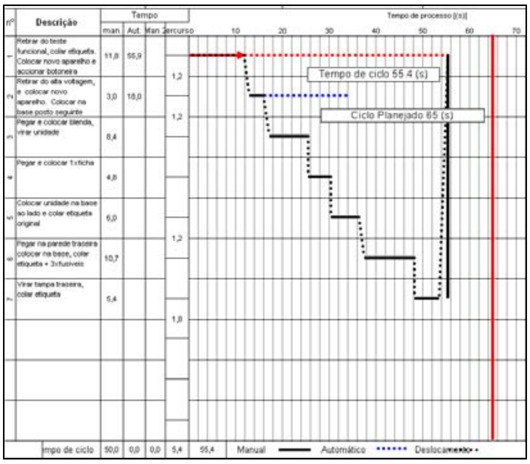

Fig. 6 Standard work sheet for the cell operator 3.

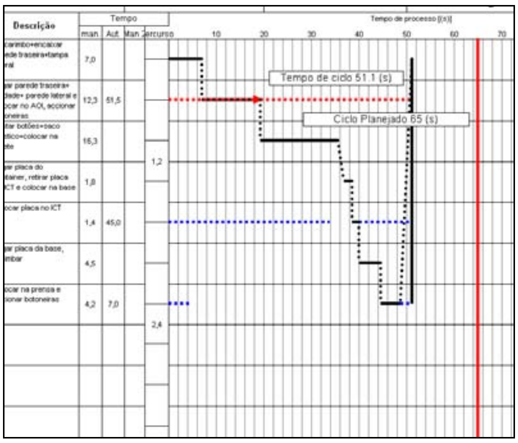

Fig. 7 Standard work sheet for the cell operator 4.

In the rabbit chase mode, the operator begins with the product in the workstation 1 and travel to the end (workstation 15) with the product.

Adopting one or other mode depends of various factors like the team motivation, one learning operator, the number of operators available for the cell or the existence of a physical incapacity in one operator. The operating mode in the beginning of the day is selected by the team and is only altered if something happens like a medical attendance or training that impossibility all the operators of being in the cells. This selection is decided by the team but, in spite of this, it is far away from the concept presented above - the self-management team - because this is the only decision they can make. The advantages inherent to a self-management team weren't achieved.

4.2. Critical analysis

This section identifies the cells problems grouped in the three classes: the selection system for the cells; the cells internal organization and ergonomic aspects.

The team performance is different from cell to cell. This may be due to various factors: the frequent entrance and exit of different operators to and from cells, recruited in the firm or outside the firm, different rhythms for each cell and the inexistence of a system selection for cells.

It is well know that the cells had the flexibility to adapt to a different number of operators but it is expected that the new operators in the cell has the necessary skills to execute the operations quickly and precisely without causing defects to the heat controller. This requires a learning time that is not promoted to the new operators in the cell. An interested and motivated operator needs two weeks of formation to acquire a skills level equivalent to hers team colleagues and some experience to acquire the work rhythm of the cell. The operators are rapidly recruited, by recruitment firms, and easily dispensed because they don't have a work contract. It is also necessary that the team keep consolidated and the successive operators entrances and exits causes instability and, consequently, lower productivity and lower quality of the product. So, the external recruitment of operators perturbs the normal working of the cell.

Sometimes the operators came from others sections of the firm but this also brings difficulties. Normally, these operators are "pushed" for the cells by convenience of the firm, because or they are feed a baby or they belong to a syndicate and needs to absence more times than the others. These operators don't adapt to the cell life and after a brief period they left the cell, perturbing its normal working. These situations cause a motivation decrease, and, therefore, lower productivity.

The higher turnover of the operators in the cell makes hard to achieve a homogeneous team with team spirit. A homogeneous team with work modes and team spirit achieved a synchronous rhythm, a continuous production flow and better results. The new operator entrance without experience and without interest, create some conflicts. Because, the lower yield of the new operator affect the yield of team.

Sometimes, a good team may be formed that function well, but this has to happen always not by a chance. So, to make this happen it is necessary a selection system to select operators for cells. The creation of good teams reduces the problems and conflicts.

The cells process is always adjusting according the needs of operators. This frequent improvement of the processes and of cell organization conduces to reduced WIP and reduced buffers or unnecessary movements. As a result, it was observed that one of the equipment in the cells causes discomfort to the operators. The operation implies a great effort to the operators in positioning the model because they had to handle with one hand the model which weights one kilo and with the other hand she takes the model from the equipment to put the next, already in her hand.

It was also observed frequently defects and rejections in the models caused by the lack of maintenance to the equipments in the cells. This influence the cells output because one defect is sufficient to stop the production flow and, consequentially, the good quality models are less than the needed. Following a philosophy adapted from Lean Manufacturing [47] and [48], the firm did not maintain models stock to allow continue with the process. Sometimes, the defect wasn't a defect but a wrong rejection. This situation occurs many times during one work day, reflecting this on the output cells because one reject, wrong or not, correspond to a minus one unit in the final. This demonstrates the need to program maintenance to the equipments in order to reduce the rejection. Additionally, the operators weren't prepared to set-up the equipment or devices. For example, when the cell needs a change of a model, the operators had to call the maintenance operators. So, it is verified that the operators didn't practice an autonomous maintenance, being that a pillar of the methodology Total Productive Maintenance – TPM and an indispensable tool in the Lean Manufacturing.

A situation that can be also improved is related with the models change. There is a need of models changing many times during the day in the two of the cells become worse when these changes involve the components changes. In the extreme case, the QuickChangeOver - QCO [49] was 10 minutes which means 10 units less in the final output. So, it is important to reduce the QCO time.

Other problems had to do with ergonomic aspects. The tables, where they assembly the models, were too high because they were established according the standards of Deutsch population (the firm belongs to a group Deutsch) and the standard for Portuguese population is minor. This causes some discomfort to the operators; they hadn't the ergonomic conditions more adequate involving more effort and fatigue. These reflect in their productivity and need improvement.

4.3. Presentation of proposals

The proposals were presented in the order that the problems were described in the previous section.

4.3.1. Selection system of operators

The first proposal was to formulate a selection system for the operators to the cells in order to select operators motivated and with skills necessary to work in and execute, quickly and efficiently, the operations in the cells. As Hyer and Wemmerlov [11] noted, the selection of qualified people to perform assigned tasks can make a substantial difference in productivity. With this in mind it was proposed a selection system that had in consideration the knowledge, skills, abilities and other characteristics – KSAOs [11, page 403]. These authors (see previous reference, page 405) point six categories of KSAO that are critical to effective cell operations:

1. Technical skills in multiple areas (multi-functionality);
2. Interpersonal skills and abilities
3. Problem-solving and decision making skills
4. Administrative and management skills
5. The ability to learn
6. The willingness to learn

Adapting these KSAO to the firm and to these particular cells, it reinforces only the skills needs, six categories were developed: physical skills (belongs to the second category) and social skills (belongs to the second category), global knowledge of the production process (belongs to the fourth category), technical skills in multiple areas and the ability to learn and willingness to learn. Of course, these six categories did frame the previous six categories referred but with more or less emphasis according to the cells need.

The physical characteristics mean the endurance capacity of the operator. The work in cells demands an effort of doing the assembly operations and the transport always with a model in the hands. As already said, the model weights one kilo and demands a high agility with the hands and dynamic standing, movement along the cell. If some operator had a limitation with standing work or with weight work, she couldn't be selected for the cells. In the past this occurred and the operator didn't stay one week in the cells. To avoid this is critical to analyse the medical conditions of the operators. Additionally, the ergonomic conditions weren't the most adequate for the operators with lower high because of the assembly tables, as already mentioned. If these were kept it would be better to select taller operators.

The social skills mean that it is important select people with higher sense of responsibility, cooperation and communication skills. The cells work demands the ability to work with others, being these skills a critical factor.

The global knowledge of the process and the product quality means knowing the philosophy of the firm, principles and tools used like the 5S tool [50]. The firm had a skills matrix presenting the skills that each operator is qualified to do and the training already received. So, when selecting the operators for the cells consulting this matrix is mandatory. When recruiting one operator outside the firm it is necessary to obtain these information in other way (interviews, references and biographical data,…), see reference [11] for other techniques and bibliographic references, and with the HR specialist help. Detecting the need for training in recruiting people to the cells, it is important to point the need of a rigorous and specific formation related with the work in the cells like team spirit need, motivation, cooperate and share responsibility, among others. This means more formation time.

The technical skills mean ability to perform the variety of technical operations in the cell. In the operating mode rabbit chase this is a pre-requisite. The process didn't demand a technical specific formation. During the learning process the operator reveals her skill for performing the operations, being the base for this the time cycle. A bad performing didn't necessarily mean that the operator isn't inadequate because she could be influenced by other factors like the ability or the willingness to learn. These characteristics play an important role, affecting all the characteristics referred above. It must be selected operators that were motivated to acquire new skills and willing to learn new procedures, i.e., constantly open to learn. But this is not enough, being necessary also ability to learn in order to progress in her knowledge. In the selection process, special care must be taken to these two variables because they are, many times, responsible for the lower productivity. They are directly related with the operators' motivation and performance.

The operators' selection becomes a visible and easy process showing in a matrix the operators skills, referred above. In the Table 1 is presented such matrix.

Table 1: Matrix skills

	Operator name											
Skills	Maria			Rosa			Marta			Ana		
Technical	1	2	**3**	1	**2**	3	**1**	2	3	1	2	**3**
Social	**1**	2	3	1	2	**3**	**1**	2	3	1	2	**3**
Physical	1	2	**3**	1	**2**	3	**1**	2	3	1	**2**	3
Process knowledge	1	2	**3**	1	**2**	3	1	**2**	3	1	2	**3**
Willingness to learn	**1**	2	3	**1**	2	3	1	**2**	3	1	2	**3**
Ability to learn	**1**	2	3	**1**	2	3	1	**2**	3	1	**2**	3
Total	3	0	3	2	3	1	3	3	0	0	2	**4**

Legend: 1-Not satisfying; 2- Satisfying; 3- Satisfying greatly

In this table, the shaded number means the operator has the skill level, for example, Maria has a 3 level in the technical skill (the maximum). The selected operator in this case is

Ana because has a four in the total of the level 3, meaning she has maximum level (3) in four skills. Using this matrix to select people for the cells, will reduce the frequently entrance and exit of the operators, and as a result, create more stability to the team, and, thus, higher productivity. In spite of this, the final decision is making by the cell supervisor that could use this matrix to base his choice.
The selection system is not yet implemented, so, it is advanced two other proposals that had to do with the operators already affected to the cells. This consists in forming different teams. In the first proposal it was formed three teams with equivalent skills, grouping operators with higher and minor productivity. The second proposal was to form two good teams, selecting operators with higher productivity and to form one team with minor productivity operators. In this second proposal was inherent the fact that were better win in two cells and lost in one rather than lost in the three cells because of the perturbation caused by the less productive operators. These two proposals were implemented and the results related with the daily production levels were quite astonish (Table 2).

Table 2: Daily production obtained from the two proposals

	Daily production (models)	
	Proposal 1	Proposal 2
Cell 1	420	440
Cell 2	350	400
Cell 3	350	380
Total	1120	1220

It is notorious that the second proposal achieve better results that the first proposal for the two good teams and also for the team not so good. It seems that the performance of other teams make this third team work harder to obtain better results and didn't distant too much from the objectives of other two. It looks that this stimulates the competitive spirit. Of course those other indicators were necessary to validate this conclusion, making sure that the production increase was caused only by the teams' formation.

4.3.2. Internal reorganization of cells

The difficulty problem felt by the operators in the equipment described in the critical analysis section was solved by a change in the equipment. This implied a positioning change of the model in the equipment. So, the operator didn't have to action the buttons, she had to position only the model in the equipment. The change in the equipment reduced the discomfort and, at the same time, the operation time was reduced.
The operating mode to adopt for the team work in the cells depends of how homogeneous the team functions. The operating mode in the beginning of the day is selected by the team and is only altered if something happens like a medical consulting or training that impossibility all the operators of being in the cells.
This selection is decided by the team but in order to achieve the advantages inherent to a self-management team, the team must be empowered to take other decisions. These decisions could be assuming an active role in selecting the team members or forming the cells team of each cell. They know when is better assume one operating mode rather than the other. For example, when the cells work only with three operators they assume the rabbit chase because in the working balance, each member of the team works in a larger zone and each feel more fatigue (Figure 8). The work load wasn't leveled by all operators.

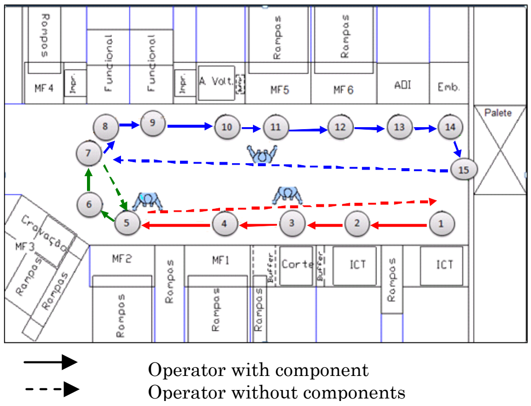

Fig. 8 Working balance operating mode with three operators.

In the rabbit chase (Figure 9) all operators have to do all operations (the most difficult and the easier ones). They feel they are in equal circumstances. This in line with the study of Black and Chen [27] that found out that the rabbit chase mode in apparel cells is an operating mode better for a team with three or less operators.
This is also a better mode to the operators that couldn't support the pressure of being two hours (period time that they stay doing the same operation in the working balance) doing the same thing.

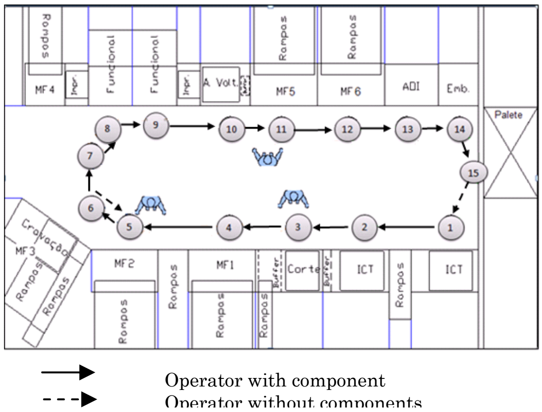

Fig. 9 Rabbit chase operating mode with three operators.

They also verified that the work in the rabbit chase mode, the team must be multifunctional and with similar rhythm. The existence of a slower operator will affect the work rhythm of the team and, consequently, the team productivity. In this case, is more adequate to adopt the working balance mode because the operator stay fixed for a two hours period and she will improve her rhythm due to the repetition of operations, without affecting the team performance.
In the rabbit chase mode the operators were always with the model (Figure 10). The empty movements are much less than in working balance mode.

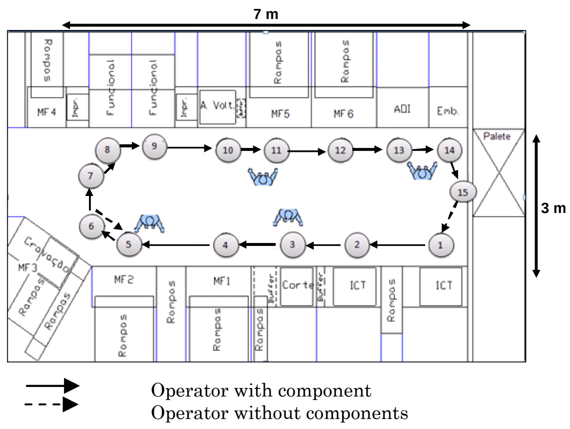

Fig. 10 Rabbit chase operating mode with four operators.

In the working balance mode the operator transports the model part of her movement and is with hands empty the other part. The figure 11 shows that empty movements corresponds to a total of 15 meters against 2,5 meters of the rabbit chase mode (Figure 10). So, the operators perform an operation without value to the model and had to be minimized. The rabbit chase mode brings more added value than the working balance mode.
It seems that the operators didn't know other operating modes of working in the cells. So, to the plan formation already proposed it is important add an operating mode module, giving to the operators more choices to select.

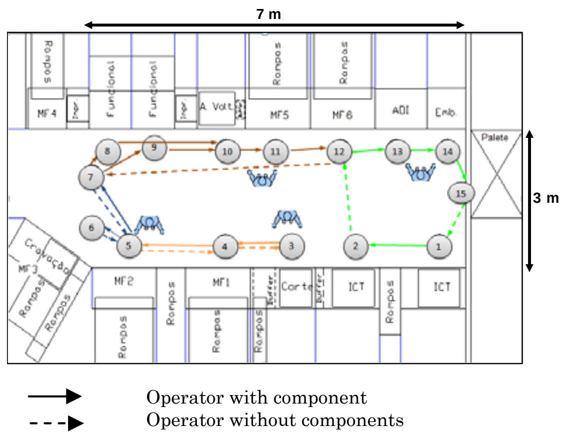

Fig. 11 Working balance operating mode with four operators.

Another proposal was implement a turnover system that rotates the teams for the three cells. This means establish a week for a team in each cell. In the end of the week the team goes to another cell. This possibilities that all the cells acquire the skills level equivalent, becoming these cells totally replicated cells. Of course, this mean implement the selection system proposed in order to achieve homogeneous teams.
It was suggested an elaboration plan for the equipments maintenance by the responsible department in order to reduce the breakdown number and also the improper rejections number. It is suggested also an equipment autonomous maintenance formation plan for the operators in the cells. This plan must contain modules related with the equipments function like the software program change of some test equipment (it was suggested one such plan but it is not presented here). This proposal will reduce the losses inherent to the equipment functions.

In order to optimise the process, by reducing the change times, was proposed the levelling [51] for the three cells that had in consideration the models change. This levelling implies a models sequence definition that minimizes the changes in the components and in the equipment set-up. This implementation will reduce the changeover time and increase the output achieving a higher productivity and a greater capacity to accomplish the levelling defined.

4.3.3. Ergonomical reorganization

It was suggested to put adjustable working tables or a platform to lift the operators for solving the need of higher assembly tables. The platform height must be defined based on the Portuguese population ergonomic study [52]. Adjusting and improving the operators work conditions, it is one more factor that could conduces to better results.

5. CONCLUDING REMARKS

The methodology selected for this study permitted the clear understanding of the situation and the cells problems, promoting learning by doing, i.e., the researcher had the opportunity to experiment the cell life operating the machines and feeling the product being assembled. However, the involvement in the cells life was so intense that sometimes it was difficult to the researcher didn't involve emotionally and had time for the writing report.
One general finding of this work was that the teams in these cells were formed without any attention to the importance that the people had in the behaviour and performance of the cells. This finding emphasizes the work done by many authors already referred in this paper of diffusing the importance of the team in cells life and performance.
Analysing the multifunctional teams was verified some problems related with the selection system operators inexistence, the cells internal disorganization and the ergonomic unfitting conditions. These problems were the answer to the first research question. These problems cause the inferior cells productivity. So, were presented some proposals: a selection system plan through the elaboration of a skills matrix; the internal organization of the cells and the reduction of ergonomic conditions.
The first proposal could help forming teams motivated and prepared to work in the cells. This wasn't yet implemented by the firm at the end of the work done there but it will be considered for because the firm implements the turnover system, rotating the teams among the cells and will note the need of having a homogeneous team.
In the cell internal organization was reduced the difficulties in handling one equipment simultaneously with the reduction of its operation time. It was elaborated a maintenance plan to execute by the operators in order to eliminate the wait time for the maintenance team when occur a need of component change or a equipment set-up. Relating to the operating modes adopted it is essential that the operators exactly defines the situations when to adopt different operating modes. This could be in the instructors' sheet of each cell, showing how to work in each mode. The team must be empowered to take decisions wherever implies the team formation and work, improving this self-esteem and motivation. Knowing other operating modes could be also beneficial for the team work. The improvement of cell organization along with the ergonomic conditions would raise the cells productivity.
Some proposals need a new research cycle and implementation to clearly demonstrate to the firm the need of looking to the cells as a competitive strategy. It seems, being

in the firm, that none strategy behinds the implementation of the cells nor the POM system that the cells belongs. One important underlying strategy to POMS design and redesign is system dedication to specific products or to families of similar products, ensuring synchronized production of components and assemblies. It seems that it weren't explored as one.

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