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RESEARCH ARTICLE

ANALYSIS OF THE SUBSEQUENT PROCEDURES TO THE ROTOMOLDING OF A COMPANY OF THE PLASTIC SEGMENT OF THE SOUTH REGION OF SANTA CATARINA

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ABSTRACT

This article aims to measure the most efficient physical arrangement for the products produced in the process by the company to the rotomoulding machine according to the demand and the capacity of the process. From the study of physical arrangement types and their characteristics, proposals were made to allocate work centers using the load distance procedure to optimize the movement of materials and people involved in the production stages. As the process restriction is in the first moment in the commercialization of the products and later in the capacity of the machine, it was from simulations of combinations of production between the items processed by the company that delimited the condition of feeding of the processes subsequent to the production. This study became relevant in view of the need to dimension the capacity of the machine based on contractual demand, through the teams involved in the activities performed during the manufacturing harmonized to the set of products produced. These two points addressed in the theoretical framework contributed to the size of the most efficient physical arrangement for the process.

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INTRODUCTION

Plan properly a layout allows the company to provide the best conditions to transform and use the resources available to achieve a better result in the productive process. On this view, the focus of this study is to develop a proposal for a physical arrangement and flow balancing that increases the efficiency of the activities developed in the field of plastic articles following the finish production in rotomolding machine. The proposal of the physical arrangement of a process is directly related to the analysis of the times and methods of work. As the company examined acquired the equipment and is in the process of adaptation, is necessary to delimit the string that offers better operating efficiency to the process. To this end, the analysis of the physical arrangement of workplaces and the methods adopted is necessary since, from the determination of an efficient process, has the possibility of reducing the operating cost and consequently of increased competitiveness.

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From the proposed boundaries are determined the operating sequence, the leadtime for processing, the unproductive times identified and the restrictions imposed by the own process to produce an physical arrangement that meets the goals of efficiency and effectiveness of the organization.

Theoretical framework

Physical arrangement and flow

The physical arrangement comprises the way are placed all installations, machinery, equipment and operators involved in the production, that is, matches the way occupied by physical resources arranged within a facility. (SLACK; CHAMBERS; JOHNSTON, 2002; CHEW and CHEW, 2012). For to Krajewski and Krajevski (2004), the way in which it is conducted the decision-making process about the physical arrangement reflects decisions on competitive priorities of the organization. In this sense, are set aspects of the process, the ability, the people, the equipment and the space required. Gaither and Frazier (2002) point out that the physical arrangement planning linked to strategies fetched in operations

should be aligned to factors that will make the company competitive, low-cost, fast delivery and on time, high quality products and services and product flexibility and volume. Moreira (2004) States that the primary concern of all planning a layout is to make more easy and smooth movement of the work through the system, both for the flow of people, as to the materials. In this sense, the decisions, according to Slack, Chambers and Johnston (2002) characterize the way resources are transformed, the flow of materials and information flows to the customer, that this disposition changes impact the stream influencing directly on productive efficiency and corporate costs. Laugeni and Malik (2005) state that the first determination for physical arrangement corresponds to the amount that will be produced, when it is possible to calculate the number of machines, stock area among other spaces for better use. Slack, Chambers and Johnston (2002) point out that an organization must take possession of decisions about the layout in the early stages before installation and operation of the company, to avoid an incorrect physical arrangement with effects of flow pattern productive with long and confused, intermediate materials stocks to the process, inflexible operations, unpredictable flows and consequently high costs.
In addition to the need to meet a demand previously determined there are other reasons to drive a change physical arrangement. Moreira (2004) and Ab, Peinado and Graeml (2007) highlight some of them: the inefficiency of operations, high rates of accidents, product changes, need to expose more of the products/services to customers, changes in production volume or flow of customers, productivity problems, such as low quality level and demand for a new product.

Slack, Chambers and Johnston (2002) point out in this regard that the study and modification of physical arrangement can also offer more security to avoid accidents; a conduit in extension of the flow of information and materials to meet the objectives of the company, comfort for labour; ease in coordinating and managerial supervision, as well as access to resources. Aguiar, Peinado (2007) Harvard Business Review and claim that the physical arrangement is presented in the literature of the area into five types: physical positional arrangement or fixed position; physical arrangement per product or per line; physical process or functional arrangement; physical arrangement cellular or group Technology and physical hybrid arrangement. Moreira (2014), States that it is possible to find the physical positional arrangement on a production system for projects in which the product tends to stand around being directed and centered people, tools and materials needed. As Gaither and Frazier (2002) this layout is suitable for very bulky, large, heavy or fragile as shipbuilding, aircraft, bridges, railways, among others.

Moreira (2014) States that these products have unique characteristics, a low degree of standardization and some degree of immobility. Thephysical process or functional rranjo it is designed to have a stream with a variety of product designs and processing steps required by products. The scripts are different not getting a linear sequence of operations for all products or projects. (GAITHER and FRAZIER, 2002). Moreira (2014) sets which is characteristic of this arrangement are work centers according to the function to be performed on the product or the machines that perform the same function are grouped together in a single Department functional leaving a system flexible to change in the project. According to Chi and Chi (2012) due to the existence of different routes resulting in cross-flow, long traversed paths and product drives, the time of crossing of the streams is high and there is a poorer efficiency. Therefore, the major challenge of this arrangement is to reconcile the relative position and the area used in each sector so that they can bring the sectors so that they have a more intense stream itself, to minimize unnecessary movements and a better use of areas available. The physical arrangement per product or per line corresponds to the continuous production systems, being used when a linear sequence of operations in the manufacture with balanced work center. (MOREIRA, 2014). Chi and Chi (2012) highlight that this physical arrangement the string used in the process is based on positioning the features so that they add value to the product. This activity is suitable when there is the production of a few types of products with high volume and a similar operational flow. For Ab, Peinado and Graeml (2007) for product arrangement corresponds to position the machinery and labor or work centers according to the sequence of Assembly.

In an arrangement by an assembly line product units spend a step to another within a preset rate so that there is always someone adding value (CORRÊA; CORRÊA, 2012). The physical arrangement cellular or group technology similar resources are grouped so that they can render a group of items with similar characteristics during the processing steps. (CHEW and CHEW, 2012). To Krajewski and Krajevski (2004) complements the definition stating that the first step encompasses in parts group with similar characteristics in family, after this decision, allocate the resources in sequence in a cell as the household operations grouped. D'agostini (2013) concludes that the purpose of this arrangement is to produce different product families with similar operational scripts in the same processing sequences. According to Gaither and Frazier (2002) this layout presents the characteristics of an arrangement by product and process. And decision by choosing cellular arrangement would be: changes to simplified machines; accessories and related training costs are reduced, smaller crossing time; less stock of products in the process. The physical arrangement mixed or hybrid features when used in a combination of various types of layouts. For example: a restaurant, have the positional arrangement, understanding the tables; the kitchen presents the arrangement per process; the meal and prepared in a buffet, featuring an arrangement in line. (SLACK, CHAMBERS and JOHNSTON, 2002; GAITHER and FRAZIER, 2002). Table I presents the advantages and disadvantages in the use of each of the physical arrangement types defined:

One of the important aspects in order to achieve goals of efficiency in the delimitation of the physical arrangement of an industrial organization is the deepening of the study of time and methods assigned to each analyzed, discussed in the following topic.

Times and methods

Slack, Chambers and Johnston (2002) and Aquilano, Chase and Jacobs (2006) punctuate the study of the working method comprises the following approaches:

- Select the work to be studied;
- Register the relevant activities of the current method through the flowchart, or buildings for graphics, man-machine drives operations and activities;

Table I. Advantages and disadvantages of the types of Physical Arrangements

	Advantages	Disadvantages
Positional	Very high flexibility of *mix* and product; Product or client is not moved or disturbed; High variety of tasks for the workforce.	Unit costs too high; Space programming or activities can be complex; It can mean a lot of movement of equipment and manpower.
Process	High flexibility of *mix* and product; Relatively robust in the event of interruption of steps; Supervision of equipment and installation relatively easy.	Low resource utilization; Can have high stock in process or customer queues; Complex flow can be difficult to control.
Cell phone	Can you give a good balance between cost and flexibility of operations with relatively high variety; Fast crossing; Teamwork can result in better motivation.	Can be expensive to reconfigure the current physical arrangement; May require additional capacity; Can reduce levels of resource utilization.
Product	Low unit cost for high volumes; The opportunity for specialization of equipment; Convenient handling and materials.	May have low *mix* flexibility; Not very robust against interruptions; Work can be repetitive.

Source: Slack, Chambers and Johnston (2002, p. 214)

Table II . Advantages and disadvantages of the rotomolding process

Advantages	Disadvantages
Freedom of design pieces-geometries, thicknesses, cutter, etc.	Limited production only for low volumes.
Machinery and tooling of low cost when compared to the blow molding, injection or thermoforming.	Little variety of raw materials available due to long cycle times.
Low-level tensions in the cast.	Expensive materials when necessary of micronization.
Little industrial waste generation.	Need of to support the long processing times.
Excellent process for producing parts with metal inserts.	Lower dimensional accuracy when compared to blow molding, injection or thermoforming.

Source: Mello (2010, p. 33)

- Examine critically the way in which it is developed the method, by means of questions that seek to improve the method, in order to detect existing weaknesses;
- Develop a new method, based on previous reviews, eliminating whole parts of the activity; combining elements; change the string to improve work efficiency or simplify the activity by reducing the contents of work;
- Install a new method with the new working practices;
- Monitor, after deployment, the effectiveness of the method, seeking continuous improvement of the process.

Santos et al. (2015) sets out that the most common method to measure human performance in carrying out the activities in an operation is through the timing of each activity performed to obtain their times. Aquilano, Chase and Jacobs (2006) state that after collecting a certain number of times of each element, it is the average of the time. In possession of each element, sum to result in a time that will match the performance of the operator. Laugeni and Malik (2005) stand out so that time result present greater reliability, we should consider that a person is exposed during your journey to oscillations, as stops for personal needs, fatigue, among others interruptions in your productivity, and to this end, we should add a time between 10 min and 25 min (5%) of the time about a day's work for 8 hours. Laugeni and Malik (2005) characterize the importance of own measures of time standards for the company, because it can set standards to promote better programming with an effective use of resources; conduct further study of balancing production, through comparisons of values and scripts formed, as well as analyze the production planning; determine the costs of products and determination of budgets.

Rotomolding process

The rotational molding is a process that consists of the plastic transformation under the influence of low pressure and high temperature to produce hollow solid parts. This process develops pieces large and small, with simple and complex geometries. (TOMASI, 2013; MELLO, 2010). Morita (2012) exemplifies that water tanks, fuel tanks, toys, playgrounds, decoration items, mannequins, parts, among other techniques are developed for this technique.

According to Mello (2010) the rotomolding process consists of 4 steps:

a) Mould loading with the polymeric material to be processed with the weight of the piece;
b) After closed the lid of the mold, the same is directed to an oven where the heating process, to perform the fusion of materials and the adhesion of the polymer on the surface of the mould;
c) After a period in heating, the cooling step, to which the material loses heat and solidifying, characteristic of the process, the steps (b) and (c) are performed with the biaxial rotation movement of the mould by spreading the material for cavity;
d) The piece ready is removed from the mold, finalizing the process.

This process compared to other thermoplastic processing processes, enables advantages related to ease of replacement of colours and materials; the molds are inexpensive; possibility of forming multilayer parts; different pieces can be molded at the same time together; subsequent operations the moldings are not necessary in most cases, depending on the design of the pieces. (PISANU, 2008). The last two disadvantages presented, are justified by Mello (2010) and Tomasi (2013) when defining the rotomolding process presents cycles with sequence of heated and cooled the mold during each cycle of rotational molding, offering greater cycles on need greater time and oven temperature enabling the thermal degradation of plastic material or a high degree of crystallinity during cooling, affecting the quality of the product, dramatically reducing your endurance mechanics. Another side effect of long cycles would be an increase in the cost of production.

Analysis of physical arrangement using the procedure load distance

Moreira (2014) States that a critical factor found in physical arrangements for process consists in the great movement of people and materials that are being adapted to each product streams, influenced by the position of the machines and equipment. And to assign a better arrangement in the models are created possibilities to find the best available work centers through the distance. To Krajewski and Krajewski (2004) States that this process is to identify the points and compare them to quantitative factors, by distance, cost or both, in order to evaluate the centres based in the vicinity with the goal to minimize the weighted weights system totals. This procedure is part of an initial model based on the information on the number of existing departments which will be distributed in total space; the individual needs of space for each Department; the load of materials moved and the number of voyages between the departments; and if down on transportation costs are different, becomes an important criterion in choosing the best layout. (MOREIRA, 2014). To Krajewski and Krajewski (2004) complement each other that to set the system load distance simply multiply the measurements of distances covered by charges that follow by the centers. To a lesser extent found comprises the best choice.

Methodological procedures

Deer and Bervian (1983) state that research is the activity aimed at the solution of problems through the use of scientific methods, starting with a question or problem and searching for an answer or solution. In this respect, the initial approach of this study is characterized by a bibliographical research on the characteristics of the types of physical arrangement and the rotomolding process to give support to field research. The field study was characterized by a exploratory descriptive research with quantitative approach, aimed at studying and analyzing the processes subsequent to rotational molding of a plastic company in the southern region of Santa Catarina. In this way, from the collection of the times of the tasks and the delimitation of the operational sequence of each of the products processed in the company, we used the procedure from charge to establish the appropriate physical arrangement to meet the forecast of demand. The entire study was based on information collected in the company itself.

Presentation and data analysis

The rotomolding process offers the possibility of producing at the same time various products according to the demand. Before this advantage it is necessary to take the opportunity that the machine offers to produce all products simultaneously. This minimizes the fixed costs of each product, due to the fact the machine consuming each cycle rendered the same amount of gas and energy. According to this principle, it is necessary to balance the production of rotomolding machine in order to get the most efficient use of your productive capacity. As the products after production need machining and finishing, transformation becomes relevant set a production model to be aware of the time that will be used for the transformation. Desired by the company guidelines include meet the required volume for each product in the month and have a stock of parts that correspond to the contractual volume of demand for each piece, condition required by the client. On this monthly volume sued, the company must be prepared to deliver smaller batches every week of each piece, as shown in table III.

Table III - Contractual monthly Demand

Product	Demand/month
1 piece	300
2 piece	200
3 piece	300
4 piece	100
5 piece	200
6 piece	220
7 piece	220
8 piece	200

Source: Drawn by the authors (2017)

Rotomolding machine has this group of 8 pieces to be processed in 9 molds, two for the part 1. Parts 2, 3 and 7 have a mold each having the condition of forming two pieces at the same time, in a series produced for one of these pieces, generates 2 pieces. The conditions found during production are restricted to a product, part 7, possessing different characteristics from other parts produced what makes be produced along the 1.2 and 4 parts, however there is a possibility to be done along with the 3.5 parts, 6 and 8. To produce, the machine can be configured in two ways according to the similarities of the pieces, which will only be produced if there are parts not stocked. In the same cycle is possible if processing between one and seven models simultaneously, recalling that two of them can be doubled by the fact there are two molds. Given this, it is necessary to be developed the removal of a template that has no similarity with the 7 piece to be placed in the machine, requiring the exchange of tool. This difficulty in the process occurs through the technical characteristics that influence in the process. To be found the best balance of the machine model, based on the increased demand required between the products, which also the greater number of cycles required to reach the stock, in this condition, the part 1 and 3 (300 pieces). As the part 1 does not have conditions to be produced along with the 7 piece, makes the same restriction found among the pieces. Machine cycles were organised in two possible ways:

Alternative 1: When made the play, 2 parts 1, 3, 4, 5, 6 and 8 can be produced along with the part 1.
Alternative 2: When made 7 piece can be produced along with 3 parts, 5.6 and 8.

In these settings, each cycle produces the missing parts to complete the stock, and as the inventory level determined cease to be produced. The capacity utilisation of the machine corresponds to a total of 100% when produced in an ideal condition with 9 molds together in a cycle. The available productive journey starts the 5:00 the beginning of the first cycle of rotational molding and finishing your production the 18:18 in the afternoon. This period of production consists of cycles lasting 31 minutes over a 3 time the 12 minutes that lead operators to manually machine parts ejector, time depends on the number of parts that the machine producing. To this end, it is necessary to carry out two operations in rotomolding machine production, heating and cooling of the oven. Before starting production, it is necessary to make the heating of the oven, it takes around 6 minutes, and at the end of the production, cooling it takes 20 to 30 minutes. Are considered in the simulation 5 days a week and 4 weeks in a month. To enable a better analysis of which configuration you deploy, were collected the values for the main costs involved in the process, as shown in table IV:

Table IV. Productive Data

Cost of energy	7.20	R$/ciclo
MP cost 1	9.05	R$/kg
Cost 2 MP	9.13	R$/kg
Cost of Gas	3.6	R$/kg
Gas consumption	8.5	kg/cycle

Source: Drawn by the authors (2017)

Based on these conditions were outlined the following simulations:

Simulation 1

On the demand of each piece, it has been estimated the amount required to be produced for a day in the period of 20 days. As the demands for some odd values parts (parts 3 and 7), and these parts have molds that produce a couple of pieces, were planned two programming scenarios with daily goals to be produced on alternate days, according to table V:

Table V. Simulation 1

Product	Alternating Daily Schedule		Total	
	Goal day 1	Goal day 2	Week	Month
1 piece	16	14	76	300
2 piece	10	10	50	200
3 piece	16	14	76	300
4 piece	5	5	25	100
5 piece	10	10	50	200
6 piece	11	11	55	220
7 piece	10	12	54	220
8 piece	10	10	50	200
Cycles	13	13	65	260
Capacity utilisation	39%	38%	38%	38%

Source: Drawn by the authors (2017)

Simulation 2

This simulation aims to make use of the whole workday to take advantage of the maximum use of the capacity of the machine in relation to the time available. For this purpose, were arranged in a cycle all parts can be produced together until reaching the demand required by the month. In this purpose, it is possible in addition to take advantage of the maximum capacity of the machine, it is possible to have the largest number of parts produced in a day. However this condition allows the 7 piece is produced only when there is opportunity to be made with pieces of similar features, i.e. was stipulated a daily production target after you have stored the pieces with smaller volume production promotes the condition to produce the play 7 as shown in table VI:

Table VI. Simulation 2

Product	Monthly Production Target	Total			
		1st Week	2nd Week	3rd Week	4th Week
1 piece	300	180	120	0	0
2 piece	200	180	20	0	0
3 piece	300	180	120	0	0
4 piece	100	90	10	0	0
5 piece	200	90	98	12	0
6 piece	220	90	98	32	0
7 piece	220	0	76	144	0
8 piece	200	90	98	12	0
Cycles	260	90	98	72	0
Capacity utilisation	40%	89%	55%	16%	0%

Source: Drawn by the authors (2017)

The production starts with the manufacture of all parts throughout the first week, except the part 7. From the second week, obtained the required amount to some parts (parts 1, 2, 3 and 4) and they are no longer produced, begins with the production of 7 with 5.6 and 8 parts until the demand for each. This simulation model covers a period of 13 working days of production, which promotes an anticipation of the volume produced and a machine stop during the month. It is seen that when it seeks to produce with a bigger set pieces the capacity utilisation is more satisfying, in relation to the second goal, to produce with the lowest number of pieces. Also, in this condition, the company will have available the 7 piece only in the second week of production, risk position, if there is a spike in demand with low or no inventory of the parts produced, making it impossible for the company to answer the customer with the desired volume.

Simulation 3

This simulation is intended to meet the maximum capacity of the machine, the entire period available for production and obtain all the parts in the same week, based on the conditions of the second simulation, alternating daily settings. As production shifts, on the first day will produce a scenario given a demand, as well as on the second day, based on the second scenario, repeating alternately during each working day produced until the demand, as table VII:

Table VII . Simulation 3

Product	Productive Goal Monthly	Productive scenario on alternate days		Total/week		
		1	2	SEM. 1	SEM. 2	No. 3
1 piece	300	36		108	72	120
2 piece	200	36		108	72	20
3 piece	300	36		108	72	120
4 piece	100	18		54	36	10
5 piece	200	18	21	96	99	5
6 piece	220	18	21	96	99	25
7 piece	220		42	84	126	10
8 piece	200	18	21	96	99	5
Cycles	260	18	21	96	99	65
Capacity utilisation	44%	89%	44%	71%	62%	43%

Source: Drawn by the authors (2017)

On the objectives for this simulation, is determined to obtain all kinds of parts during the first week and in the following. This model allows the company to have on hand all products every two days of production according to demand and accumulating a stock each week, giving customer flexibility.

Simulation 4

This simulation aims to achieve maximum daily use of the machine producing all parts every day at maximum capacity and in the daily time available as table VIII:

Table VIII. Simulation 4

Product	Daily Goal	Total	
		Weekly	Month
1 piece	24	120	300
2 piece	16	80	200
3 piece	24	120	300
4 piece	8	40	100
5 piece	16	80	200
6 piece	18	90	220
7 piece	16	80	220
8 piece	16	80	200
Cycles	20	100	260
Capacity utilisation	61%	61%	38%

Source: Drawn by the authors (2017)

On the values, there is the possibility of having all the pieces every day in view of the demand and obtain a stock in the first few weeks due to the maximum use of the capacity of the machine. Before this maximum use you have in the first few weeks, the pieces with lower demands are complementary and not more produced, reducing the capacity of the machine in the final weeks of the month and consequences on monthly production capacity machine. This simulation shows a condition due to get all the pieces all day and to an earlier in the production as a result of the maximum allowable use by the machine. As this simulation aims to meet the demand, the capacity remains low for the machine is idle in the last days of the month.

Analysis of simulations based on costs

Before the simulation, you can assume the main costs of values found, as table IX:

Table IX. General Summary of Simulations

	1	2	3	4
Total cycles	260	260	260	260
Production Capacity (%)	38.33%	39.93%	44.09%	38.36%
Days Produced	20	14	14	13
Cost of gas (R$)	8. 286.33	8. 286.33	8. 286.33	8. 286.33
MP 1 cost (R$)	12,353.25	12,353.25	12,353.25	12,353.25
Cost 2 MP (R$)	12,220.51	12,220.51	12,220.51	12,220.51
Energy (R$)	2,113.35	2,041.31	2,041.31	2,029.30
Total cost (R$)	34. 733.28	34. 733.28	34. 733.28	34. 733.28

Source: Drawn by the authors (2017)

You can verify that this simulation allowed the same total number of cycles required for the production, which demonstrates that this production pegged 1 and 7 parts that determine the number of cycles needed, independent of the particular arrangement to produce. On the day produced, the more you enjoy the time available and greater productive capacity used, fewer days will be needed to process the products.

As at the moment the company does not follow a production model, which is justified to be acquiring knowledge in this new segment, it is essential to adopt a production model, which offers a better use of the time available, the productive capacity and introduce a stability in the costs involved. The simulations developed show that regardless of format produced in a fixed demand according to the contract, it is possible to produce all products within approximate cycles regardless of the way produced, in sight of it, the factors that will generate impact on the cost involved in the rotomolding process corresponds to the heating and cooling of the oven, the longer this process is carried out during the month, the greater the expense involved in the production. According to the simulations, it is possible to assess that regardless of the setting developed there is a great deal of idleness in the productive capacity of the machine, giving the company the opportunity to occupy these spaces an increase in new products to increase your revenue and demand. When assessing the number of cycles obtained in each simulation, we see the importance of organizing the production of the machine since the greater the number of cycles, the higher production cost, however, the greater the number of processor products at the same time, will be retrieved from an apportionment of the costs for such products in order to minimize unit costs, the ability to process more products in the same condition and opportunity. The simulation which obtained the best result was the simulation 4. This meets the requirements of using the daily time available to produce, have all products every day with a safety margin of weekly stock, and a lower cost per be if using the best productive capacity.

Analysis of the physical arrangement following rotational molding

From the simulations performed to meet demand and choosing the best combination of parts processing procedure was used for distance analysis define the physical arrangement of subsequent operations to the process of rotational molding.

Table X. Distances between workstations

Distance between workstations	The proposal (m)	Proposal B (metres)	Proposal C (m)	Proposal D (metres)
1-2	19.47	16.47	14.8	14.8
2-3	1.5	1.5	1.5	1.5
2-4	11.4	12.9	11.4	11.4
2-5	11.4	12.9	11.4	11.4
3-6	11.4	12.9	11.4	11.4
4-5	2	3.5	2	2
5-6	15.37	15.37	15.37	5
6-7	11.45	11.45	11.45	2.5
6-8	12.95	12.95	12.95	4
6-9	6	6	6	8
6-12	1.35	1.35	1.35	1.35
7-8	1.5	1.5	1.5	1.5
8-9	1.5	1.5	1.5	1.5
8-10	1.7	1.7	1.7	1.7
8-11	2	2	2	2
8-13	1.35	1.35	1.35	1.35
9-11	1	1	1	1
9-14	3	3	3	3
11-14	2	2	2	2
11-16	1	1	1	1
12-14	1.35	1.35	1.35	1.35
13-15	1.35	1.35	1.35	1.35
14-16	2	2	2	2
15-16	2	2	2	2
16-17	20	20	20	15

Source: Drawn by the authors (2017)

Table XI -Operating Sequence

Product	Operational Sequence	Demand for PCs/month
1 piece	1-2-4-5-6-8-10-8-13-15-16-17	300
2 piece	1-2-3-6-9-14-16-17	200
3 piece	1-2-3-6-8-9-11-14-16-17	300
4 piece	1-2-5-6-12-14-16-17	100
5 piece	1-2-3-6-8-9-11-14-16-17	200
6 piece	1-2-4-5-6-7-8-11-16-17	220
7 piece	1-2-5-6-8-9-8-11-14-16-17	220
8 piece	1-2-4-5-6-7-8-11-16-17	200

Source: Drawn by the authors (2017)

Table XII. Distance traveled by products

Product	Distance (meters)				Distance travelled per product (m)			
	Proposal	Proposal B	Proposal C	Proposal D	1 layout	2 layout	Layout 3	Layout 4
1 piece	89.29	80.23	77.06	52.74	26787	24069	23118	15822
2 piece	63.37	61.87	58.7	55.7	12674	12374	11740	11140
3 piece	71.82	70.32	67.15	53.2	21546	21096	20145	15960
4 piece	70.94	69.44	66.27	50.9	7094	6944	6627	5090
5 piece	71.82	70.32	67.15	53.2	14364	14064	13430	10640
6 piece	84.19	84.19	79.52	55.2	18522	18522	17494	12144
7 piece	88.19	86.69	83.52	59.2	19402	19072	18374	13024
8 piece	84.19	84.19	79.52	55.2	16838	16838	15904	11040
	Total per layout (m)				137227	132979	126833	94860

Source: Drawn by the authors (2017)

To do so, were considered the operational sequences for each of the products and the distance between the jobs for, from the combination chosen to minimize the transport of parts between stations. The table X presents the distance between workstations in the physical arrangement proposals developed:

The following (table XI) is the operational sequence of each of the products processed after the rotational molding and the quantity processed by month:

Based on the obtained distances between the centres of work and operational sequence of each product, was given the total covered by the products in four proposals for the new physical arrangement, arriving the following values as presented in table XII:

On the results, the proposal D obtained a better route, resulting in a layout with a distance for all products at the end of the month of 95 km, this value has become significant in the face of attempts to reduce the transport from the distance between the posts and the streams that crossed with other products, as well as the shortest distance possible between operations.

Conclusion

This case study was the initial support for the purpose of determining the physical arrangement more suited to manufactured products, eliminate the unnecessary distances and routes to the production process, as well as the machine size of rotational molding to manufacture the required volume within the restrictions found in the process, establishing the lowest value of cycles and days needed to be produced, as well as possible to suggest improvements to the process. Based on the ability of balancing machine was possible if have notion of the opportunity that the company study to get fill and use the idle capacity of the machine in the production of new items. It was possible to evaluate that, get the workplace in order to facilitate the flow of products becomes a fundamental procedure. Therefore, for such a result, the information available and times of operations, the methods developed during the activities and in particular the contractual demand will promote more consistent result to make the flow of products reduced, more aligned over the work centers, and in a shorter time. These results contribute to the company, that when does not apply a flow analysis of products in your layout, you may have costs that go unnoticed that, while not singled out, damage the company's financial welcomes, before transport or unnecessary or lengthy operations that raise the times of the processed products and stocks funded. Determine the flow of products after produced became the main point to determine and evaluate from the quantity produced physical spaces that would be needed to assign the operations, or even intermediate stocks between each centre of work.

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