American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-11, pp-89-97
www.ajer.org
Research Paper Open Access

Chronoanalysis System: Application in the Production Process of a Pilates Equipment Factory and Their Benefits

Ioneide Pereira Martins[1], Natália Santana Carvalho[1], Rodrigo Pereira Vieira[1], André Luís Lemos Carvalho[2], Daisy Silva Araújo Campos[1], Manuela Fias Salomão[1]

[1]Centro Universitário Regional do Brasil - UNIRB
[2]Instituto Federal de Educação, Ciência e Tecnologia da Bahia - IFBA
Corresponding Author: Ioneide Pereira Martins

ABSTRACT :*Technological growth and increased competitiveness make companies look for methods and techniques that reduce cost and production time, so that productivity increases. Chronoanalysis is a tool that assists in the analysis of time and stages of the production process. This study aimed to analyze the application of chronoanalysis in the production process of a factory in the segment of pilates equipment, and also highlight the benefits that this technique can bring. Thus, it was possible to conclude that the chronoanalysis system is essential and provides the process detailing as well as the elimination of bottlenecks found in the production.*

KEYWORDS *Competitiveness, time, productivity, chronoanalysis.*

Date of Submission: 02-11-2019 Date of acceptance: 20-11-2019

I. INTRODUCTION

The advancement of globalization, competitiveness and the robustness of technological systems provide companies with a constant pursuit of increasing productivity, product quality, meeting deadlines and optimizing production processes. However, for the success of a corporation, there must also be engaged teams, good leadership and encouragement to implement innovation in most sectors (DI SERIO; VASCONCELLOS, 2008).

In addition, there are other factors that may influence the achievement of these goals, including lack of knowledge of: raw materials used in production, process steps, waste and bottlenecks (any situation that delays the manufacture of a product). These factors directly imply the company's inefficiency, results and uncertainties, besides causing effects contrary to the proposed goals and objectives, as well as its permanence in the competitive market (FURLANETTO, 2004; HYYTINEN; PAJARINEN; ROUVINEN, 2015).

Thus, to gain market space and grow economically, corporations before formulating and executing their strategies must adopt some techniques, such as: monitoring, making adjustments, gathering dispersed knowledge within the organization, reducing their cycle time. These techniques, in addition to improving productivity, will also contribute to waste elimination or reuse, cost reduction, efficient processes and increased profits (REZENDE, 2003; SILVA, 2010).

Given the techniques described above, cycle time is essential because it is characterized by the real time to complete the process. However, the one that determines the pace of production is the Takt time, as it consists of the quantity of products made during a period. Thus, to meet the need for demand is necessary to know how to synchronize the two, so it will not lead to delays in lead time (time elapsed from the request of the product / service until the final delivery of it) (TUBINO, 2007; CORRÊA; GIANESE; CAON, 2013). However, doing something that seems simple in practice can be the opposite, because depending on the bottlenecks found in the production line, in a matter of seconds Takt time changes the whole pace of the process as well as all the elaborate planning.

Therefore, an alternative to measure both times and determine the standard time, is the study of times and methods by the chronoanalysis system, which allows the detailing of the process, detecting the delays and waste as well as the gathering of dispersed knowledge within the operating environment.

This paper is an analysis of the application of the chronoanalysis system developed in a pilates equipment factory, to highlight the points of improvement in the operational line as well as to emphasize the importance of this tool today.

II. THEORETICAL FRAMEWORK

The chronoanalysis system originated from the study of times and methods to determine the standard time of production, parameters related to productivity and quality. In addition, this system can also be applied to simulate the calculation of industrial cost and cost/minute of the production (JUNIOR VIEIRA; BOMFIM; DUARTE, 2015).

According to Barnes (1977) and Maynard (1970) the forerunner of this methodology was Frederick Taylor, which described the need for subdivision, description and measurement of operations using a timer to establish standard time and then productive capacity.

However, this feature also allows you to evaluate the performance of the workforce in accomplishing tasks, as well as capturing important information aimed at continuous improvement. When measuring these operations, the tolerances found should be included, such as: personal needs, rest, load, environmental risks and others (TARDIN, et al., 2013).

Thus, this method is a versatile tool that applies to production planning and control, as it can also assist in controlling production capacity, layout and continuous improvement. However, to perform it, seven steps must be followed: record the information of the operation; record the operator's productive time; subdivide operations; set the cycle time; observe the rhythm of the operator; determine the tolerances and finally get the default time (CAETANO, et al., 2016).

Cury and Saraiva (2018) add that the study of times and methods provides a detailed analysis of the operation or task performed by the operator. In addition to calculating production capacity, increasing efficiency, it also measures activities that add value and eliminates those that bring bottlenecks and waste. In addition, it uses standardized movements in each operation with monitoring assignment of time Takt time, cycle time, lead time.

This procedure occurs to determine the default time for each operation as well as the total process. After this standardization, the employee starts to work better and without overload, because delineating the quantity of products in a certain period makes it easier to elaborate the production planning and control (CABRAL et al., 2018).

Peinado and Graeml (2007) discuss that this technique is linked to method engineering, work design and ergonomics. Method engineering is linked to work efficiency and optimization, i.e., making adjustments to machines, handling, material handling and others. The project work is related to the activities that influence the technology used, people's relationships and the methods employed in production. Ergonomics consists of a study of man with the environment, equipment, professional occupation, which allows applying the knowledge of anatomy and psychology in the solution of problems arising from this relationship.

Chronoanalysis System

The chronoanalysis system or also known as time study is a methodology that determines the best and efficient way to perform a task. For its performance, a chronometer is used to measure the standard times. In addition, this reference will provide: determination of the company's productive capacity, preparation of production planning and control, determination of the value of direct labor in the final product, balancing of production and assembly lines as well as estimation of cost of a new product (PEINADO; GRAEML, 2007).

Moreover, this tool is used to identify process delay factors and to solve them. It employs the concept of lean manufacturing as: the 5S (utilization, cleaning, organization, standardization and discipline); PDCA (plan, do, check and act); total preventive maintenance - TPM. Thus, it is possible to establish continuous improvement actions in the operating environment (PESSOTTI; CHAGAS; BOA MORTE, 2015).

Cury and Saraiva (2018) complement that this method allows: the optimization of production and processes; flexibility; cost reduction; better mapping of the production line; Fast delivery of products to customers.

Peinado and Graeml (2007) report that the equipment needed for this study consists of a stopwatch, clipboard, observation sheet and the chronoanalyst himself. Thus, to determine the standard production time, one must consider: the speed at which the employee works, tolerance factor, number of parts to be produced during the measurement.

Cabral et al. (2018) mentions that it is from this monitoring that it is possible to define and classify the movements used to perform the tasks, and determine which are the priority and unnecessary elements within the operational area.

III. CASE STUDY

This study is characterized by a descriptive analytical research, which aims to detail the inspected phenomenon. Thus, the case study is divided into five stages. In the first stage, he described the role of chronoanalysis in the production processes. In stages two and three reported the points of improvement observed during this application in the sectors: metallurgical and carpentry. The last stage refers to the improvements implemented in both sectors already mentioned.

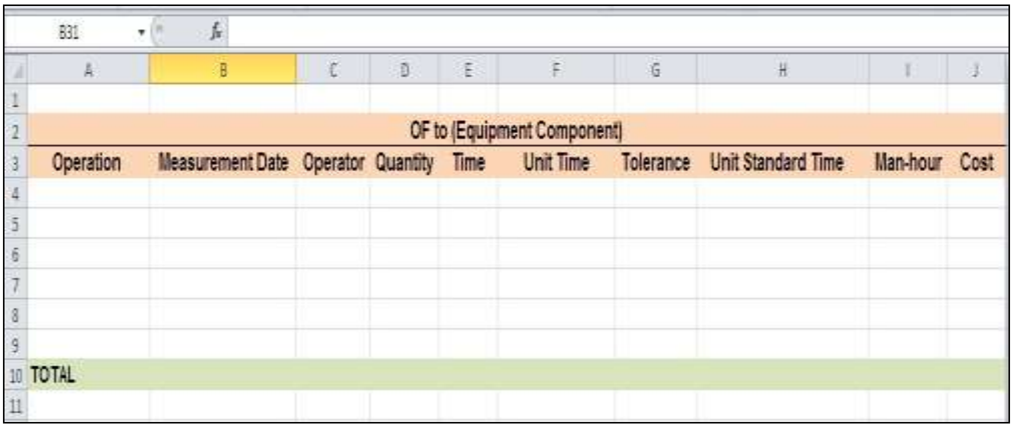
Stage 1: Applying chronoanalysis to the Pilates Equipment Company

The company under study has been active in the pilates equipment production segment since 1991 and has approximately 53 employees. Among these, three are focused on the development of the chronoanalysis system in the production process. The case study carried out in this company includes two sectors: metallurgy and carpentry with the sub-sector sandpaper/router.

Material and methods

As mentioned in the theoretical framework, the performance of the chronoanalysis occurs through the use of some materials such as clipboard, paper, pencil, eraser and stopwatch. In the production process of the company, the manufacturing orders (OF´s) are made available - and when the operator starts manufacturing the item, the process / production area chronoanalyst also starts the respective standard time timing notes for each operation performed as well as identifies and notes the possible delay and waste factors.

After making these notes, the chronoanalyst enters the data collected in two different chronoanalysis worksheets, one for the metallurgical sector and one for the woodworking sector, which also encompasses the sub-sector sandpaper/router. The spreadsheet model for entering the collected data can be viewed according to Fig. 1:



	A	B	C	D	E	F	G	H	I	J
1										
2	OF to (Equipment Component)									
3	Operation	Measurement Date	Operator	Quantity	Time	Unit Time	Tolerance	Unit Standard Time	Man-hour	Cost
4										
5										
6										
7										
8										
9										
10	TOTAL									
11										

Fig.1. Blank spreadsheet template for data entry
Source: Authors, 2019

The spreadsheet model presented above corresponds to the control of data collected by the chronoanalysis system. On a clipboard, record the name of the equipment and which component is being manufactured, then the stopwatch is started according to the operation being performed. As the operations are performed, the time of each of them, the date of measurement, the name of the operator and the quantity produced in this time interval, i.e., the sample part, are noted. After collection, this data is entered into a spreadsheet called a report as a means of tracking the standard time of operations. The described stage can be observed as a fictitious example in Fig. 2 below:

13	OF to Combo Chair									
14	Operation	Measurement Date	Operator	Quantity	Time	Unit Time	Tolerance	Unit Standard Time	Man-hour	Cost
15	Setup Cut	01/nov	Henrique	20	00:02:00	00:00:06	0%	00:00:06	R$ 20,80	R$ 0,03
16	Cut	01/nov	Henrique	10	00:15:20	00:01:32	15%	00:01:46	R$ 20,80	R$ 0,61
17	Post-cutting cleaning	01/nov	Henrique	10	00:01:20	00:00:08	8%	00:00:09	R$ 20,80	R$ 0,05
18	Setup Drill	03/nov	Breno	20	00:06:45	00:00:20	0%	00:00:20	R$ 15,20	R$ 0,08
19	Drill	03/nov	Breno	15	00:07:15	00:00:29	15%	00:00:33	R$ 15,20	R$ 0,14
20	Post-drilling cleaning	03/nov	Breno	15	00:03:10	00:00:13	8%	00:00:14	R$ 15,20	R$ 0,06
21	Setup Weld	07/nov	Henrique	20	00:10:50	00:00:33	0%	00:00:33	R$ 20,80	R$ 0,19
22	Weld	07/nov	Henrique	20	01:20:30	00:04:02	15%	00:04:38	R$ 20,80	R$ 1,61
23	Pos-weld straightening	07/nov	Henrique	20	00:40:25	00:02:01	15%	00:02:19	R$ 20,80	R$ 0,80
24	Setup Polishing	07/nov	Lucas	20	00:04:50	00:00:14	0%	00:00:14	R$ 23,30	R$ 0,09
25	Final Polishing	07/nov	Lucas	15	01:38:46	00:06:35	20%	00:07:54	R$ 23,30	R$ 3,07
26	TOTAL							00:18:46		R$ 6,74

Fig.2. Fictitious example of chronoanalysis operations and measurements
Source: Authors, 2019.

As data is entered, it is calculated using formulas: unit time, unit standard time, hourly cost of operation, and unit cost of the production process. These formulas are elaborated in Excel and the conditional function IF and IFNOT is used, because through the conditional test, it is possible to make a logical comparison of a given value and the desired value, that is, if the test done is true or false. Thus, these formulas can be described below according to their given parameter.

Unit time calculation

The unit time calculation is programmed to extract the production time for one unit of the manufactured part, i.e., it is the timed time divided by the quantity counted in this interval. Thus, the following formula is used for this calculation.

Unit time = IF (excel time cell = “”; “”; Time/Quantity)

This system allows that if the excel time cell contains no value, the space of the excel unit time cell remains empty (“”) otherwise the value for this cell will be obtained by dividing time by quantity.

Unit standard time calculation

The unit standard time calculation consists of the time the process is performed, that is, the normal process time included in the operator's ergonomic tolerances. In view of this, this calculation is made with the following formula below:

Unit standard time = (Unit time) * (Tolerance) + Unit time)

Unit standard time consists of the actual process time. However, the calculation of this time occurs with the multiplication of unit time by tolerance. But, in this system the unit time is multiplied by the tolerance and added again with the unit time because in the determination of the operation times always takes acyclic activities, among them the setup and sequencing (DINIZ; CALIFE, 2015).

For these reasons, it is recommended that these activities be timed separately, as the tolerance of these activities is 0%. The determination of the final work tolerances results from the sum of the fixed percentages of the variable and invariable tolerances analyzed during the process operations.

However, to perform this calculation it is necessary to delimit the different physical efforts corresponding to each operation, among which the most influential are: personal needs; fatigue; standing; posture; environmental factors such as: heat, cold, noise and vibration as well as the use of muscle strength. Once the design is done, these operations are listed and added to the sum of these efforts, which will result in the determination of the final tolerance in percent.

Therefore, the greater the physical effort made by the employee during the operation, the greater will be his final tolerance. However, in setup operations this tolerance is considered zero because it corresponds to the processing time of the machine and therefore the effort is negligible.

Man-hour calculation

At first the man-hour calculation or also called hourly cost occurs through a request from the warehouse sector to the human resources department. The latter calculates the operator's salary to define the man-hour cost, after performing this procedure the human resources sends this data to the warehouse and this in turn makes it available to the production sector.

Subsequently, this information is added to the time analysis worksheet in the tab called data, where there is the respective employee name as well as the man-hour cost provided by the human resources department. However, there is a need for the IF and IFNOT conditional formula because operations are performed according to the operator, so this formula can be understood as follows:

Man-hour = IF (OPERATOR NAME = ""; ""; IF (OPERATOR NAME= "Name"; DATE!$ MAN-HOUR COST $)

The man-hour cost provided by human resources does not change when entered in the spreadsheet, this data only serves to identify the operating cost developed by the worker. For this reason, the formula of this system is characterized for entering this data according to the operator name, however if the operator cell is empty ("") the value will not be entered, otherwise the value for this cell will match the operator name.

Unit cost of the production process

The calculation of the unit cost of production is the cost of each operation, but this depends on the values of the standard unit time and the man-hour cost, because this time is considered the real of the process and has its respective monetary value in relation to the hand. Thus, the formula for this calculation can be represented below:

Unit cost = IF (Time = ""; ""; (HOUR (Unit standard time) + MINUTE (Unit standard time) / 60 + SECOND (Unit standard time) / 3600 * (Man-hour cost)

This system allows that if the time cell contains no value, the space of the cell remains empty (""), otherwise the final result will be obtained by the time unit transformations, i.e., hour, minute and second multiplied at man-hour cost. Thus, the unit cost of each operation is obtained.

Thus, with the unit cost of each operation, the total cost OF´s of given equipment can be obtained, in which this parameter allows to compare the cost of the produced equipment with its current selling price. The delineation of this allows a better dimension of the true value of equipment rather than making an estimate of it.

Stage 2: Points of improvement observed during the application of chronoanalysis in the metallurgical sector

During the measurements, several points of improvement were observed and pointed out. In addition, the operator could also participate and give their opinion with their suggestions. Thus, these observations were collected and recorded in the report tab of the metallurgy sector time analysis spreadsheet to have control. Thus, some of these observations can be described below:

Quick steel drill insulation

During the process it was found that 4 mm and 6.5 mm high-speed drills often broke and required constant replacement. Thus, in conversation with the operator it was found that tungsten drills of a specific brand are the best in durability, i.e., it provides an increase in productivity.

Thus, as an improvement action, it was requested to change the fast steel drills to the tungsten drills mentioned above, but this procedure would only be finalized after viewing the cost-benefit of the item quotation.

Performance operation delay factors in the after post-weld process.

Em acompanhamento da operação Solda, identificou-se como fator de atraso a operação de desempeno pós – solda. O tempo para este desempeno torna-se maior que o esperado porque o material se deforma com o calor no processo de soldagem.

In the follow - up of the welding operation, the post-weld performance operation was identified as a delay factor. The time for this performance becomes longer than expected because the material deforms with heat in the welding process.

Buying suggestion 2 to 3 mm Carbon Steel Cutting Disc

Throughout the measurement process, the operators suggested to us the purchase of the 2 to 3 mm Carbon Steel Cutting Disc as a proposal to improve the cutting step of the bars composed by this material. The cutting process of this is done with the cutting disc for stainless steel, which quickly wears off.

Thus, you must make a quote to make the acquisition, then formalize the registration, and thus make this item available in production.

Suggestion of placing the drawings of the parts to be manufactured in the printed OF´s

During the drilling operation, it is observed that in the manufacture of occasional parts, the operator was hampered in the execution. Thus, as a recommendation for improvement, the employee suggested the inclusion of part drawings in the OF's containing the specifications of the hole diameter to avoid drilling errors.

Thus, you can choose to make the drawings and make them available in the catalog folders as a reference. To accomplish this, it is necessary to hire an extra designer for these demands.

Purchase requisition a 15 mm drill reamer

During the chronoanalysis measurements, the employee requested the purchase of a 15 mm drill reamer. However, before performing the quotation stage, the buyer should: investigate whether the reamer is characterized as straight or conical; inquire if the requested 15 mm refers to the diameter of the reamer or drill and probe the final application of this drill in the manufacturing process. And after delimiting the complete item information, you can send the purchase request to the supplier for purchase.

Stage 3: Points of improvement observed during the application of chronoanalysis in the carpentry sector

The improvement actions reported in this sector also resulted from the same process performed in the metallurgy sector. Thus, these actions can be listed as follows:

Identification of lack of consumable item in the sub-sector sandpaper/router

During the chronoanalysis process in the carpentry sector, it was found the lack of a consumable item in the sub-sector sandpaper/router. Thus, it was suggested as improvement the elaboration of the calculations regarding the minimum and maximum stocks.

Process stop due to missing one more compressed air hose point

During the measurements a process stoppage was identified due to the lack of one more compressed air hose point, which helps in the development of simultaneous activities. Thus, it is proposed as an improvement action the inclusion of another hose point in the process.

Unproductive Time for downtime in the process of removing wood from the pipe

Following the wood thickness reduction operation, it was identified as unproductive time the stop in the process to remove wood waste from the pipe. In a joint investigation with the members of the production, it was found that the reduction in pipe reduction was inadequate and this caused the clogging, which generated constant stops in production. Thus, after discussion, as a proposal for improvement, it was decided to change the piping.

Insulation of the sandpaper 80 red color

During the measurements made on the sandpaper/routers, the operators signaled that the red sandpaper 80 is rapidly deteriorating in the process and this causes constant replenishment in production. Thus, it is suggested to replace this sandpaper with yellow sandpaper 80, since in production the sandpaper 120 yellow colors is used, and this is efficient and durable.

Thus, as an improvement action, the chronoanalyst chose to request clarification from the supplier about the influence that the color of the sandpaper has on the process and whether they are specific to certain types of wood.

In response, the supplier informed that the color does not interfere with the process as all the sandpaper contains the same properties. Therefore, it was decided to follow the recommendation of the operator about the replacement of the sandpaper, and request the quotation of the item to perform these tests.

Bottleneck in the exchange of sandpaper 80 in the electric orbital

Following the coarse sandpaper operation in the sub-sector sandpaper/router, it was identified that the operator takes a long time to bond the sandpaper 80 to the electric orbital. This delay occurs because the operator travels to the upholstery sector to pick up the glue and then waits for the time to glue.

In process analysis, this procedure should in fact continue to be performed, but excessive operator movement can be reduced by providing a bottle of this glue in the subsector along with the necessary protective equipment.

Stage 4: Improvements applied to the metallurgical sector
Inventory control monitoring in the metallurgical sector

Inventories consist of accumulations of material resources used in transformation processes. These accumulations allow the process operations not to be interrupted and not cause stop in another sequential operation (CORRÊA; GIANESI; CAON, 2013).

As noted, it was noticed that in the metallurgy sector there are two cabinets, one of them referring to consumption items for production. These items are other inputs that in addition to assisting in the manufacture of equipment provide the transformation of raw materials and ensure the final finishing of the part that makes up the equipment.

In the consumer cabinet there are divisions on the shelves and in each division there is an identification tag with the respective item code to be stored as well as the minimum and maximum stock specifications. Inventory control is tracked in this sector during replacement or delivery periods, which are performed weekly on a specific day.

The operator orders items weekly on a specified day by means of a requisition. This is filled according to the inspection and counting of the items arranged in the closet, if these items are near or below the minimum stock, the operator must add the respective items in the requisition form and deliver to the warehouse.

The warehouse organizes the requested items for replacement and makes the deliveries. However, even if these materials are replenished, some of these materials are missing due to unforeseen circumstances by the supplier or lack of availability of the material. Thus, in order to avoid downtime in the production process, the inventory of this sector is monitored, which ensures that these missing items are flagged and placed as a priority for purchase.

Stage 5: Improvements applied in the carpentry sector
Calculation of minimum and maximum stocks of consumption items in the carpentry sector and the sub-sector sandpaper/router

As mentioned in the improvement points of step three, one of the problems found refers to the lack of the sandpaper 80 consumable item in the sub-sector sandpaper/router. Thus, it was suggested as an improvement proposal the calculation of minimum and maximum stocks of consumable items to enable the control of production inventory and ensure that the process occurs without interruptions.

The minimum stock or also called safety stock is the minimum quantity of materials to be stored. Their main objective is to act as shock absorbers in the moments of failure so that the production process is not affected (BORBA et al., 2015).

The maximum stock is characterized by the maximum quantity of certain profitable materials. This has as its main objective, to meet the fluctuations of demand in a short period of time as well as preventing their excessive purchase (ROMITO et al., 2011).

In order to remedy the problem, a survey of the items used in both sectors should be carried out with the help of the leading operators of the carpentry sector and the sub-sector sandpaper/router to perform the calculations.

Thus, we checked the production cabinets that could be used and adapted. Thus, the following result was obtained: the adaptation of the existing cabinet in the cabinetmaking sector and the reuse of the existing cabinet in the sub-sector sandpaper/router.

Subsequently, in order to perform the calculations of minimum and maximum stocks, two spreadsheets were created corresponding to each sector. In this way, the corresponding model can be seen in Fig. 3 below:

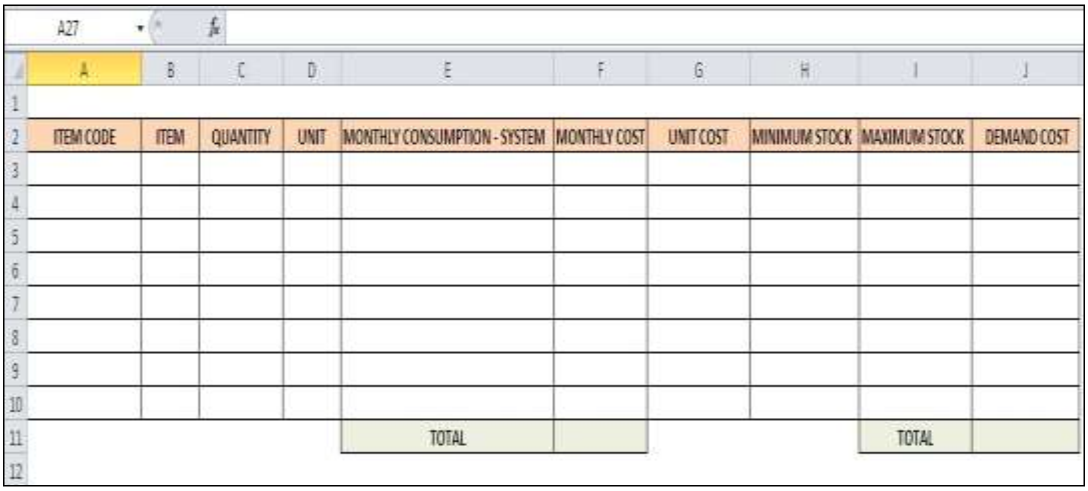


Fig. 3. Spreadsheet model used for stock calculations
Source: Authors, 2019.

The model in the figure above refers to the stock calculation procedure. At first, the item column included the technical description of the items collected with the help of the operators, as well as the insertion of their respective codes registered in the efinnance system. Then, add the quantity of these items based on the weekly replenishment period, i.e., the minimum demand quantity (minimum inventory) that the operator consumes within one week. However, some of these are durable and have a longer time to replenish, whether monthly, semi-annually or annually.

For this reason, you must change this quantity of these items to weekly values and enter these values in the minimum stock column. Then, use the formula below to calculate the maximum stock.

Maximum stock = minimum stock + (Safety stock * lead time)

The lead time is the total time for the demand to arrive, that is, from the purchase order to its arrival. In the pilates equipment company under review, demand is characterized as independent (demand that does not depend on demand for another item) and replenished bi-weekly due to the purchase order (OCS), so the replacement period of the overall maximum stock, which is controlled by the storeroom equals two weeks.

That way, this OCS process resembles the specific day when the industry-leading operator makes the requisition form for the items required to complete the maximum stock and delivery to the warehouse, which in turn releases the material for replacement on the day following what was requested. Thus, the production lead time is one day.

In view of this, the calculation of the maximum stock is made by multiplying the safety stock by the lead time of one, which corresponds to one day. Thus, the maximum stock will be twice the minimum stock. After the operation is done, the maximum quantity is multiplied by the unit cost of the item in order to obtain the cost of the demand related to the sector.

However, durable consumer items were not registered in the system and for this reason make it difficult to study the sector cost based on demand. These items should be submitted for quotation, but due to specifications, you may find it difficult to search if the contacted suppliers do not work with these materials. Thus, as a solution to this difficulty it is decided to request a quote from the manufacturer through a representative.

In addition, by calculating the cost of the sector's demand, it can be identified that the total cost of the sector's demand will be higher than the monthly cost, because of the specifications of the durable items.

IV. CONCLUSION

This paper presents a case study on the analyzes made by the chronoanalysis system in a pilates equipment factory, which allowed the identification of improvement points in the production processes of the metallurgy and joinery sectors.

Given this, we noticed the degree of importance of performance in time analysis in an operational line to capture improvements, cost reduction, waste elimination as well as the definition of productive capacity. During the measurements and observations made, critical situations could be noted, such as: the unproductive time for stopping the process to remove wood from the pipe, lack of the consumption item in the sub-sector sandpaper/router, excessive movement in the exchange of sandpaper 80 electric orbital and bottleneck in the performance operation in the post-welding process. These factors slow down the process and compromise all subsequent operations.

The improvements applied in the carpentry and metallurgy sectors brought efficiency and effectiveness to the production processes. Thus, it is possible to conclude that the chronoanalysis system is important, because through it we can: detail the process, identify abnormalities, identify improvements, change layout´s, improve tasks without compromising and overload the operator. In addition, by determining the standard time one can calculate the production capacity and manage new demands so as not to compromise the efficiency of the process.

REFERENCES

[1]. BORBA, R.C.J. et al. Aplicação do Sistema Máximo – Mínimo no Controle de Estoque de uma Empresa do Segmento Termoplástico. In: XXXV ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., Fortaleza, (2015).

[2]. CABRAL, V.G. et al. Cronoanálise em uma confeitaria: aplicação e interpretação de resultados. In: XXXVIII ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., Maceió, (2018).

[3]. CAETANO, S.C.E.M. et al. Análise do Impacto da Utilização da Cronoanálise do Planejamento e Controle da Produção: um estudo de caso em uma usina siderúrgica. In: XXXVI ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., João Pessoa, (2016).

[4]. CORRÊA,L.H.;GIANESE,N.G.I.;CAON,M. Planejamento, Programação e Controle da Produção. 5. ed. São Paulo: Atlas, (2013).

[5]. CURY, A.H.P.; SARAIVA, J. Time and motion study applied to a production line of organic lenses in Manaus Industrial Hub.v.25.n.4. pp.901-915, (2018).

[6]. DI SERIO, C.L.; VASCONCELLOS, A.M. Estratégia e Competitividade Empresarial: inovação e criação de valor. Saraiva S/A Livreiros e Editores, (2008).

[7]. DINIZ, S.O.N.; CALIFE, S.F.N. Cronoanálise e Balanceamento de Linha de Montagem: estudo de caso em uma montadora de veículos. In: XXXV ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., Fortaleza, (2015).

[8]. FURLANETTO, A.; GORINI NETO, D. Planejamento, Programação e Controle da Produção. Monografia - Universidade do Extremo Sul Catarinense, Criciúma, (2004).

[9]. HYYTINEN, A.; PAJARINEN, M.; ROUVINEN, P. Does innovativeness reduce startup survival rates?. Journal of Business Venturing. pp. 1-18, (2014).

[10]. JUNIOR VIEIRA, R.J.; BOMFIM, B.W.; DUARTE, S.A.J. Os benefícios da Implantação da Cronoanálise. In: XXXV ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., Fortaleza, (2015).

[11]. PEINADO, J.; GRAEML, R. A. Administração da produção. 1ª ed. Curitiba: Unicesp, (2007).

[12]. PESSOTTI,Q.R.;CHAGAS,S.T.;BOA MORTE,A.J. Aplicação da Cronoanálise e de Ferramentas da Qualidade como meio para aumento da Produtividade em uma Empresa do Ramo Moveleiro. In: XXXV ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. Anais eletrônicos..., Fortaleza, (2015).

[13]. REZENDE,C.F.J. Balanced Scorecard e a Gestão do Capital Intelectual: alcançando a performance balanceada na economia do conhecimento. 2. Reimpressão. Rio de Janeiro: Elsevier, (2003).

[14]. ROMITO, R.P. et al. Gestão de Estoques: um estudo em empresa de comércio varejista. In: VIII SIMPÓSIO DE EXCELÊNCIA EM GESTÃO E TECNOLOGIA. Anais eletrônicos... (2011).

[15]. SILVA, M. T. Gestão de operações: a engenharia de produção a serviço da modernização da empresa. 3. ed. São Paulo: Blucher, (2010).

[16]. TARDIN, M. G. et al. Aplicação de conceitos de engenharia de métodos em uma panificadora: um estudo de caso na panificadora Monza. In: XXXI Encontro Nacional de Engenharia de Produção - ENEGEP, 8 a 11 out. Anais... Salvador/BA, pp. 1-19, (2013).

[17]. TUBINO, D. Planejamento e Controle da Produção: teoria e prática. 2.ed.São Paulo: Atlas, (2007).

Ioneide Pereira Martins" Chronoanalysis System: Application in the Production Process of a Pilates Equipment Factory and Their Benefits" American Journal of Engineering Research (AJER), vol. 8, no. 11, 2019, pp 89-97