



APPLICATION OF THEROTECHNOLOGY IN ELECTRONIC EMBROIDERY MACHINE (CASE STUDY EMBROIDERY MACHINES AND LASER)

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ABSTRACT

In this article is discussed the application of a technique called terotecnologia, seeking the combination of management economics management with technology, highlighting the importance of life-cycle cost of the equipment. The main objective of terotecnologia is the search for alternative techniques, reliability studies and technical evaluations for-economic life cycles of equipment becoming less expensive. The terotecnologia has demonstrated the importance of involving users, such as operators and maintenance technicians in the design phase of the project to facilitate the maintainability of equipment. This work is intended for students in automation, professional technicians and professionals working with industrial machinery. I hope, therefore, contribute to the spread of this new concept that shows a new way of working resulting in numerous benefits for companies in the industry.

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INTRODUCTION

In this article we will discuss the application of a technique developed in the 70s by the British known as terotechnology, which seeks the combination of management of economy with technology management, highlighting the importance of equipment life cycle cost. The main objective of therotechnology is the search for technical alternatives, reliability studies and technical-economic evaluations to obtain equipment life cycles less and less costly. The therotechnology has demonstrated the importance of the involvement of users, such as operators and maintenance technicians, in the design phase of the project to facilitate the maintenance of equipment. Throughout its evolution, the maintenance has lost its corrective character and assumed more and more a preventive position.

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This evolution is in line with the current economic trend of globalization and cannibalization of professions, which leaves little room for a productive system stigmatized by frequent failures. Today, the tendency is to take into account the reliability and ease of maintenance of the system, service or equipment in designing it, since production systems are increasingly complex and interdependent. This trend is borne out by the increasing use of a new maintenance management philosophy, which can increase equipment life and reduce spare parts, workloads on scheduled maintenance and maintenance costs. So in 1970, Britain's Ministry of Technology created the concept of therotechnology, related to the ease of maintenance of machines, equipment and systems. The therotechnology consisted of the participation of the final operators in the design phase of the systems, services or equipment projects, so that one could think of the ease of its maintenance (Bruno Michel Sant Anna Irani, 2011).

Maintenance

If in the recent past it was a good idea to accept that the maintenance mission was to establish the original conditions of

equipment and systems, that is no longer enough, and the mission was to ensure the equipment availability to achieve a production program with reliability, safety and low cost, which defines that the maintenance mission in any production unit is to maintain and improve equipment availability at the lowest cost. Maintenance is a set of actions to detect, prevent or correct failures or defects, functional or potential failures, in order to maintain the operational and safety conditions of items, systems or assets (Pinto *et al.*, 2007). As firms grow, the need for increased profitability, industrial competition, the struggle for survival forces increased productivity and profitability. It is necessary for the various levels of the company to have people with the knowledge to organize, predict, plan, prioritize, gather necessary resources at the right time and in the right quality, and measure the various costs resulting from the various factors and decide for the best. In maintenance there are a series of challenges and early decisions, along with knowledge of proper techniques so that it is possible to mitigate the consequences of the inevitable: equipment wear and failure (Branco Filho, 2008).

Concepts of maintenance

The way in which the intervention in equipment or systems is made characterizes the various types of maintenance that exist. Often this variety causes some confusion in the characterization of maintenance types. Therefore, it is important to characterize the various types of maintenance, provided that, regardless of denominations, they all fit into one of the following types: **Corrective Maintenance:** all maintenance work performed on machines that are in fault, to remedy this failure and / or defect. If corrective maintenance is to be done immediately, because serious consequences may arise, then it may be called emergency corrective maintenance. **Preventive Maintenance:** is the performance performed in order to reduce or avoid the failure or break in performance, obeying a previously prepared plan, based on defined intervals of time. **Predictive maintenance:** it is the performance performed based on modifications of condition or performance parameters, whose monitoring obeys a systematic (Branco Filho, 1996).

The company

Acting for more than 25 years in the market, is the largest manufacturing industry of embroidery machines and laser cutting machines from Brazil, based in Criciúma, Santa Catarina. Has a structure of 3,200 m² of constructed area and qualified professionals who are dedicated to research and technological developments to better meet the needs of the market. Focused on developing technological solutions, has as a differential service and expert technical support throughout the national territory, as well as the ease of handling of their products. Their equipment meet the threads of the sectors: textiles, footwear, handicrafts, decorations, gifts and visual communication, toys, stickers, among others. On embroidery machines line its main models are the Multi needles that differ by the number of heads, which can be one, two, four or six, serving since, called household customers, even large companies that have large-scale production, seen in Figure 1. It also has color graphics Panel, electronic sensors of upper and lower lines and memory protection lack of energy that allows continue the embroidery from the stopping point. A unique feature of the bid for a technician to install the machine, technical training and equipment and operating

software, in addition to customer service and technical support, with spare parts for prompt delivery (<http://www.futurize.ind.br/paginas/empresa>).



Source: Authors (2017)

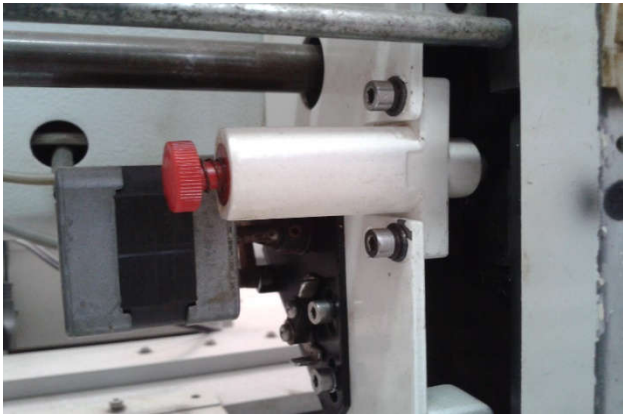
Figure 1. MB 904 embroidery machine

Problem

One of the problems is high occurrence of company assists within the warranty period, which causes a high cost to the company that assumes the offset expenses, lodging and meals of the technicians. Unlike other segments after the product sale profit from the assists, in the case of Futurize isn't it interesting that these maintenance occurring even after the guarantee because, besides having a reduced external technical framework for meet the whole national territory, because the company has machines sold in all States of Brazil, the vast majority of customers are homemade, or small businesses. So today the maintenance are not the focus of the company's profit, since it is charged only the client required to cover the cost of technical shift to the location. To minimize the problems of maintenance, by the factors mentioned above, was made an analysis upon the history of calls made during the period of two years. Analyzing this information we saw who were served 27 warranty maintenance, called and these costs were approximately R\$54,000.00. It was diagnosed that the highest incidence of maintenance, warranty, occurred on the solenoid *drive*, *encoder* disk and the exchanger.

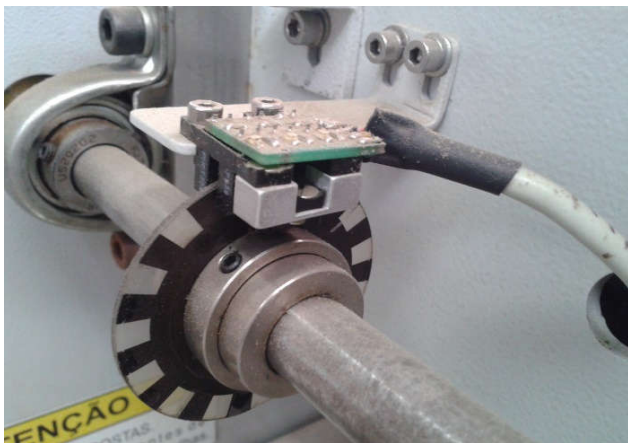
Maintenance parts

The drive solenoid is a bent propeller-shaped or can be defined as a set of turns of same axle spaced evenly. By applying an electric current in this thread it will generate a magnetic field around and inside the solenoid, by operating a small piston that moves the drive stop the side causing the same release the needle bar pin, as shown in Figure 2. Depending on the type of embroidery stitch the solenoid is triggered, on average, once every two seconds, which on a routine about 10 hours of work a day causes the premature wear of the part due to various maneuvers carried out. Already the *encoder* is a type of position transducer, able to convert linear or angular movements into electrical signals, which can be transformed into binary information so that they can be processed by a computer with the aim of set them in variables of type distance, position, etc., as shown in Figure 3. In this case the *encoder* is used to know the position of the axis of the machine by determining how the stopping point, the angle to the cutting knife entry etc. How this *encoder* is a type of plastic zebrado size, have a lot of problems, because it scratches easily, and even dust causes failure in your reading.



Source: Authors (2017)

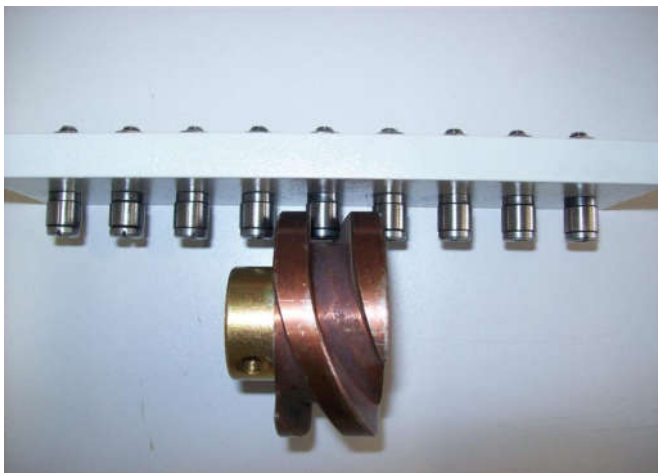
Figure 2. Drive solenoid



Source: Authors (2017)

Figure 3. The Disk encoder and electronics

Multi-needle machines of 4 and 6 heads exist only with a needle exchanger, because they are connected by a pole. Then, when the machine comes to a stop, with the thread take-up lever aligned, it fires the stepper motor to make the exchange. The exchanger consists of a helical cam with a tear in the middle, nine pins that pass through the center of the cam, and a PIN for each needle, and a pot that, coupled to the shaft of the stepper motor, switches your resistance, stating the program, in which the machine needle is physically.



Source: Authors (2017)

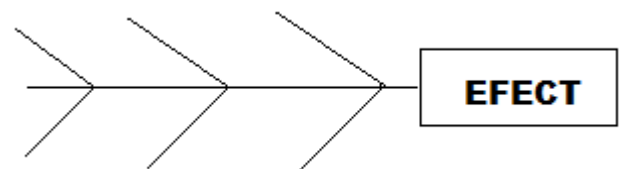
Figure 4. Old needle exchanger

Because it is only one cam to pass the nine pins in the middle, there is the problem of locking the head in time to make the switch. This problem occurs because of a change in

the reading of the pot that, by cam RIP being too narrow, requires a precise adjustment. In view of the number of maintenance that needs to be performed to futurize within the time of guarantee of the machine in the light of the problems with these pieces, the theme of this question, is what can be done to improve the functioning of the same. Taking into account the constant problems within the warranty period of the machines and the high cost to the same resolution, the objective of this work is to make a survey of the history of problems in the parts described in order to propose changes aimed at improvement and durability of mechanical and electronic parts. Once this is done, consider whether there will be reduction of expenses with the securities that generate a loss for the company.

I saw the problem, changes and results in operating process

The diagnosis of location of the high occurrence of maintenance service and technical assistance was carried out based on empirical observation of the technicians of the company's own team. Based on acquired data after analysis of the history of assists and made the data verification, it was found by the team, from the maintenance carried out, the predominance of the problems related to the three pieces pointed out: drive, solenoid, encoder disk and needle exchanger suffering premature wear during the warranty period. What at first was spontaneously and as a simple verbal record unattached, soon came to deserve more detailed attention gaining perspective of search solution. Taking into account the concept of terotechnology, which shows the importance of the participation of the technical maintenance and even the operators themselves in project design, anyway the same know much equipment for live the day-to-day life of the machine, and knowledge for visiting trade shows industry technology, as well as access to the same equipment function from other manufacturers. Based on Ishikawa tool, better known as fishbone, seen in Figure 5, which allows structured hierarchically the potential causes of a given problem or an opportunity for improvement, as well as its effect on the quality of products, associated with brainstorming, which in addition to a technique of dynamic group is an activity designed to explore the creative potential of an individual or a group, placing it at the service of predetermined goals, over the dates were adding information and building collectively the outline of a future solution as exchange of parts, adjustments and numerous other ideas were setting a path.

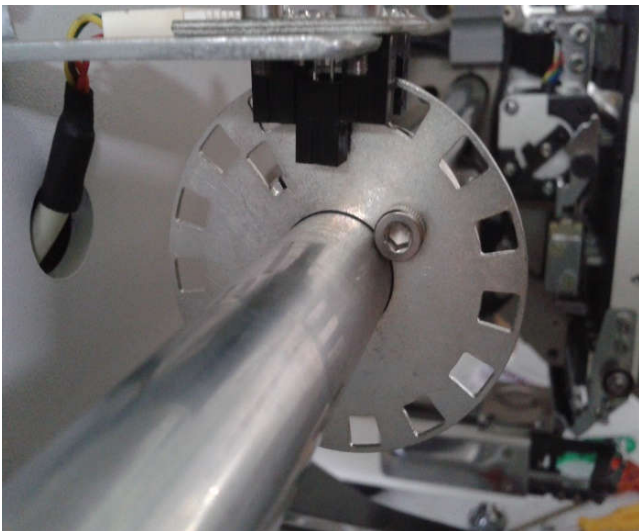


Source: Authors (2017)

Figure 5. Ishikawa diagram (cause and effect chart)

One of the three pieces whose premature wear motivated this work is the encoder, Figure 6. The encoder disc is the part that allows the reading of the angle of rotation of the shaft of the Federal judiciary by the electronics. Through this reading are defined specific roles in the realization of the final work as a stop angle, cutting knife drive, solenoid activation of drive, among others. The malfunction of this piece brings about the stoppage of the machine. As a component related to electronic

reading, therefore, hypersensitive, the slightest change in the disk, like dust, stains or scratch, for example, they caused reading distortion and hindered the operation of the machine. The e-reader performs the decoding of the signal by means of a transmitter and a receiver for binary system against signal interruption and what is accomplished by the disk in your zebra surface: white (transparent) allows the meeting and the black determines the interruption. Any stains or dust in the white part determined reading the black causing the interruption of the signal; as well as any scratch on black part determined reading of white, inverting the signs and paralyzing the machine. The solution to the problem if given by the exchange of the plastic disc zebra size by a metallic disc leaked. In this reading is facilitated, because where was white allowing contact between transmitter and receiver, is now leaked without risk of dust buildup, stain or any physical element that distort the reading. The part before, that interrupted the contact, now fulfils this function in the same way without risk of change for scratches.



Source: Authors (2017)

Figure 6. Encoder disk new model

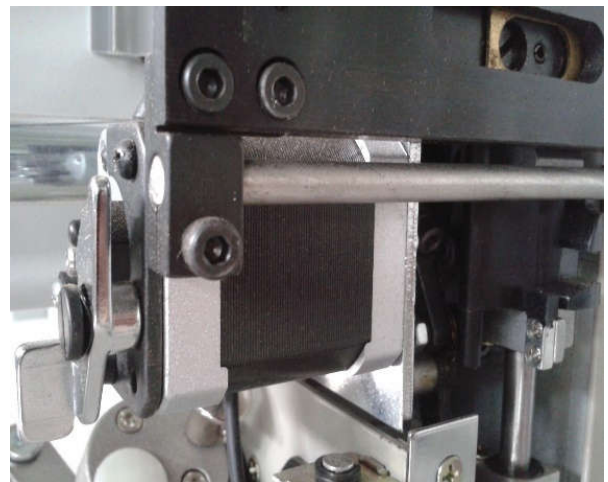
Another piece that has been modified, due to the problems already mentioned, was the Needle exchanger, Figure 7. To solve the problem of the cam, which easily desregulava, caused by the variation of the pot and the parade out of the position of the thread take-up lever, once again the team of technical assistance, in conjunction with the project team, searched for a solution based on technical knowledge acquired by experience. Previously the elicoidal cam had a problem into the PIN. Its opening had to, every back, fit perfectly in the needle PIN. After the cam fit the PIN, even gave another half back, arriving at your stop, called cam neutral. The slightest variation led to the locking of the machine, because the cam didn't fit the PIN. The old system could: a cam to nine pins. The idea that if you had to solve the problem of locking was to do the inverse: a cam system with nine dead spots for only one pin. The working principle of the play remains the same: engaged in the tip of the shaft of the stepper motor that, when turning, changes the resistance of the potentiometer, informing the program in which the machine needle. The change occurred in the operation of the exchanger, does not require the fitting of each cam back on pins. Now, the cam was designed for cylindrical shape, longer helical, with only a PIN that always remains docked inside the cam cutting. Thus, the problem of fitting has been resolved.



Source: Authors (2017)

Figure 7. New model needle exchanger

The third piece that suffered modification to the better performance of the machine was to Drive solenoid, Figure 8. His problem was the rapid wear suffered because of the excessive number of daily maneuvers. The solenoid used previously was composed of a set of turns of same axle evenly spaced, that when he received an electric current generated an electric field around the turns, engaging so the piston, which moved the drive off to the side, making him drop the needle spike at the time of stopping machine. As mentioned earlier, due to various daily drives, solenoid suffered overheating, to interfere in your proper functioning and, almost always, burned the piece. To work around this problem, the team has proposed a radical change in the drive system drive. What was once a Spire and a ceramic coated piston, demonstrating a weakness in work overloads, was replaced by a stepper motor, which makes the same function to trigger the drive to drop the needle spike. However, the way it's performed this function, is different from the previous, aiming precisely to minimize the problems. In this new mode, the stepper motor has an arm attached to the shaft and your at the end of that arm a bearing, the engine fire that arm goes forward and rolling contact drive pushes him aside, doing so with that release the needle spike. In addition to solving the problem mentioned above about the old solenoid, decreasing considerably the noise of the machine, otherwise the drive beat directly to the piston, now the beat is cushioned by the bearing makes the drive run by He. This whole process between the detection and the identification of problems, the search for solutions, changes and verification and testing of first results were between 2015 and 2016. From 2017 all machines sold already obeyed the new Assembly process.



Source: Authors (2017)

Figure 8. The Exchanger drive motor solenoid

Results regarding the maintenance in warranty period

Beginning in 2017, in January, more specifically, when it initiated the sale and delivery of the modified machines, expectations as to the results, that is, the changes in the rates of occurrence of maintenance, was great. After all, it was a considerable amount of time invested by a diverse group of professionals in the search for solutions. But in October, the results were less than the joy and satisfaction of those who started the whole process: the maintenance technicians, the most affected by the problem, the more interested in your solution and, obviously, the most committed to the success of the endeavor. The results can be displayed in simple numbers, but without doubt, are very significant. In 2017, were held 15 maintenance in warranty time. In 2016, 12 maintenance. In 2017, until October, with the modified machines, the company answered only 02 (two) occurrences of this type of care. Jumps to the eye, so the gain that resulted from the work of adaptation and change promoted by the team.

Conclusion

In General, the improvements made in a company, are management, or technological processes, tend to meet and benefit everyone. This is much more notable when the improvements arising from layers of employees who are not at the top of the chart and the company hierarchies. As we have seen, the objective of this research was to report and recognize the importance of Terotecnologia in General forwards detection and troubleshooting, in the case of the productive process, specifically in the production of machinery, equipment and components. Terotecnologia is a new concept of integration of various types of specialties from all levels of the company in order to improve and facilitate the process of maintainability with increased service life of equipment with a lower maintenance cost.

This should cause, spontaneous or systematically, the formation of a multi-disciplinary team where, in principle, break the paradigms of the hierarchy. The word is important because the nature of own methodology terotecnológica, the solution always comes from the sum, the integration of knowledge of each and every one. You can see that this is a systemic methodology as it is interdependent, where all are related in the same degree of importance. More than the parties, the titles, the specialties or hierarchical degree, what matters is the set.

For a while, breaks the paradigm of specialties and the operator, assembler or maintenance technician, for example, can become intellectual mentor, the creator of a new process or change. The whole process of terotecnologia can spontaneously or already inside a company's management philosophy. But will always have to depend on the political will of the leaders and managers. In our case, the company welcomed promptly spontaneous initiatives Futurize of maintenance technicians who sought solutions to problems of premature wear of parts.

At first pressured by the occurrence of maintenance after the installation, they knew the cause was located at a point before your work. This was the starting point for the clarification of the problem, the search solution and the final clarification. This spontaneity of the sector technical assistance, manifested in dialogue with professionals from various sectors, came to drawing the first experience terotecnológica of the company. The results obtained are very expressive and no doubt will be reflected in gains in several areas that make up the company. We will not only reduce travel expenses and maintenance. That financial gain is already significant if we consider the average value cited previously. But becomes almost negligible when you consider what can come of this greater durability of the machine and reduce the maintenance: the very quality of the machine becomes an important element of marketing, and eventually grow the power of sale, the company's credibility and strengthen your brand. It can be concluded without a shadow of a doubt the efficiency and effectiveness of terotecnologia about the gains and overall benefits of it arising. In our case, in addition to solve a problem, we incorporate spontaneously the concept of preventive maintenance, where before there was only the corrective maintenance. It is important to stress that the adoption of terotecnologia by companies, given the size of its results, must involve, for functional and ethical issues at the opening of the General data, including financial, arising from changes and innovations that arise from this new process. Note that in the whole process of terotecnologia is a complex dynamics, systemic and direct benefits to all parties in various aspects. The company wins the resulting improvements and gain employees as they develop skills (mostly intellectuals and inventive) before not farmed. Apparently, the terotecnologia opens its doors not only to new technological paradigms but also management, and even social processes.

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