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Proposal of procedure for maintenance management in plastics processing factories of Cuba

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Abstract

The work is focused on the study and analysis of the management of maintenance in the industry in general and in particular the transformation of polymeric materials in Cuba, focusing attention on the analysis of the deficiencies that occur in maintenance operations and in the inexistence of a procedure to execute it. The objective was to develop a procedure for the management of maintenance in the industry of transformation of plastic materials in our country. The results include the preparation of the procedure consisting of eight stages that must be progressively developed according to the current scenario of the organization, emphasizing the management and sustained optimization over time of processes associated with planning, programming, execution and maintenance control, aligned with the strategic objectives of the company and taking into account health and safety at work as well as the standards established for environmental protection.

Keywords

Procedure; maintenance management; plastics processing factories.

1. Introduction

The decade of the 80's of the last century, marks the beginning of the upswing and development of plastic materials in our country. Since its inception, production has been characterized by rapid growth, replacing metal, wood and ceramics, among others, thanks to its excellent properties and the low costs involved in its transformation (Pérez Rodríguez, 2005). The plastic industry in Cuba, although it does not have a development that places it in a top place in Latin America and the Caribbean, is not exempt of last generation machinery, exhibiting results that can be considered acceptable for our environment.

The increase of the demand in our country of objects, pieces and plastic components, originates the growing need to create companies for the transformation of polymeric materials. This is how plastics transformation factories such as Cajimaya, in Holguín Province and Cienfuegos, which extrude polyethylene (PE) hosepipes and polyvinyl chloride (PVC) pipelines that are widely used by agriculture and by the Company of Telecommunications (ETECSA by its acronym in Spanish) as well as factories for plastic pipelines up to 900 mm in diameter in Holguín, La Habana and Ciego de Ávila. The growing development of these processes requires the implementation of actions that contribute to maintenance management as a first-rate task in this industry. The present work is focused on the study and analysis of maintenance management in the industry in general and in particular the transformation of plastic in Cuba. The present work focuses on the study and analysis of maintenance management in the industry in general and, in particular, the transformation of plastic in Cuba.

The function of maintenance in the companies is one of the impacting elements in their results, due to the direct influence of the management of the same on the downtimes for the production area, the timely delivery and with quality to the clients and the costs associated to the works and inventories of spare parts (Pérez Rodríguez, 2005). As of February 2013, a chronogram was drawn up in our country that included the development of a process to diagnose the technical state of the facilities and maintenance management, implemented in 91 selected companies of 8 organizations. The main problems identified, according to the study

carried out by the Ministry of Industries to propose what would be the "Maintenance Policy in Cuba" (Acosta Palmer, 2013), are related to the following aspects:
• There are no procedures to carry out maintenance operations that make it possible to establish safety and health measures at work and environmental protection.
• The maintenance policy has a general focus and does not reflect its mission in each of the processes.
• Poor maintenance management.
• The analysis carried out regarding maintenance is insufficient.
• The general cost control system considers the maintenance within other cost centers and does not analyze the economic status of the maintenance areas.
• Resource planning is deficient and tends to be elaborated basically by experience and not by the needs of the maintenance plan.
• The use value of work orders is limited, in particular to control the deadline for compliance with services, so no historical analysis is performed based on the availability of the same.
• The conception to prepare the preventive maintenance plan has a schematic foundation, lacking in diagnosis, unrelated to the planning of resources and without integrated programming.
• There are no standards that guide, methodologically, the work of maintenance management.
• Poor culture at work with the procedures and standards available.
• Quality technicians do not control maintenance work.
• There is no computer-assisted maintenance system.
• Links with universities and research centers are not used to update knowledge and be aware of modern technologies
• Lack of resources
• Poor technical condition of the equipment
• Poor training and professional training system as they do not contain specific actions depending on the needs of the management and execution of maintenance
The result of the diagnosis made in 2013 by Acosta Palmer, H. determined that maintenance in Cuban industry lacks a policy to guarantee the technical status of industrial facilities; only 15.5% of the deficiencies correspond to the lack of resources and 84.5% to planning, organization, maintenance management, training and administration. What has been corroborated in the visits made what we have corroborated in the visits made to the company Plastics Business Unit Base (BUB) Plastics Cajimaya (BUB-PC) and to other Holguin territory. That is why the work focuses on the study and analysis of maintenance management in the industry in general and in particular the transformation of polymeric materials in Cuba, with the objective of developing a procedure for maintenance management in this type of factory.

2. Background and current state of maintenance management of Cuba

2.1 Conceptual analysis of maintenance management

In the literature consulted, the word maintenance refers to that activity from which it is possible to maintain a product, a machine, a team, among others, so that it works in the correct way or, failing that, the one that allows practice repairing some of them in case they demand it, so they can recover their traditional operation.
Below we analyze different terms used by some of the specialists in the subject:
Kamenitzer (1985) related the maintenance with the cleaning and lubrication of the equipment while Encinas Beltrán (1994) defines it as the activity that allows the machines not only to work, but to do it efficiently, reliably and with quality. Tavares de Carvalho (1994) links it with the task of increasing the availability of equipment. On the other hand, Dounce Villanueva (1998) refers that maintenance is one of the two main branches into which conservation is divided and is responsible for taking care of the service provided by physical resources and Sotuyo Blanco (2000) argues that it is a business function by means of whose activities of control, repair and revision, allows to guarantee the regular operation and the good state of conservation of the facilities (Borroto Pentón, 2005).
According to Sánchez & Molina (1991), the main goal of maintenance policies is to reduce downtime at the lowest possible cost. The best known are: maintenance policy for breakdown, preventive maintenance policy and predictive maintenance policy. On the other hand, Crespo Marquéz and Sánchez Ruiz (1995) state that maintenance is integrated by a whole range of partial policies, which can be: maintenance policy exclusively corrective, total periodic maintenance, periodic preventive maintenance as a function of operating time without failures and preventive maintenance based on the results of a previous inspection.
The maintenance activity, regardless of the entity in which it is developed, must achieve the reduction of unforeseen breakdowns and the repair time of the fixed assets, must seek the extension of the useful life of the components, with the corresponding saving of resources and energy and thereby reduce the cost of maintaining the facilities, resulting in the continuous improvement of the quality and efficiency of the services (Borroto Pentón, 2005).
According to Cuartas Pérez (2008), it is the set of activities that must be carried out on facilities and equipment, in order to correct or prevent failures, seeking that they continue to provide the service for which they were designed.
In the Venezuelan standard COVENIN 3049-93 of 2001, the word maintenance is defined as the set of actions that allow to conserve or restore a productive system to a specific state, so that it can fulfill a given service. Fernández Arena (2009) states that it is the work understood to care for and restore up to an economic level, each and every one of the existing means of production. De la Paz Martínez (2014) defines maintenance as the integration of technical, organizational and economic actions aimed at

conserving or restoring the good state of assets, based on the observance and reduction of its wear and tear and in order to extend its economic life, with greater availability and reliability, to meet its functions with quality and efficiency, conserving the environment and safety during its life cycle.

Based on the studies conducted on the subject, the author agrees with De la Paz Martínez (2014) as the concept provided contains essential elements such as safety and health at work of people and protection of the environment.

2.2 Industrial maintenance in Cuba.

In Cuba, before 1959 and with the exception of certain industries, there was no maintenance culture and it was not until 1961, when respect for this activity began to be promoted after the introduction of the Planned Preventive Maintenance (PPM) (Sánchez Sánchez & Grau Avalos, 2009).

When analyzing the activities carried out in function of the development of the maintenance in our country, it can be assured that there has been a gradual advance, nevertheless, it should be noted that it is far from achieving that the companies acquire a fortified culture and with solid foundations to Maintenance Management (Velázquez Pérez, 2014). Table 1 shows a brief historical review of industrial maintenance in Cuba.

Table 1. Brief historical review of industrial maintenance in Cuba

Year	Author or institution	Contribution to maintenance
1975	Automotive Technical Service Center	Published the maintenance and repair manual for industrial equipment. The purpose of this manual was to guide the application of planned preventive maintenance in plants and workshops, mainly in the mechanical industry
1976	Automotive Technical Service Center	Promulgated Law No. 1323, Organization Law of the Central State Administration, which established, in Article 81, subsection ch, "... the elaboration of Maintenance and Exploitation Standards for Machines- tool of the country. "
1981	II Congress of the Communist Party of Cuba	It was established as a guideline: "Execute a systematic maintenance policy and general repairs that allow guaranteeing or restoring the potential capacities of the units ..." Most of the companies assumed the PPM (Chaviano Duarte, 2015) .
1986	III Congress of the Communist Party of Cuba	It was established as guidelines for the five-year period (1986-1990): "Reduce the negative influence exerted in the use of installed capacities (...) breakage of technological equipment and reduction of the performance of basic funds due to insufficient maintenance or inadequate operation. "
1987	Cuban Standard (NC 92-44: 86)	Establishes the fundamental terms and definitions and most commonly used in the maintenance and repair of industrial items.
1987	Objectives of the economic policy from the III Congress	It notes: "The policy of maintenance and periodic reparation of the equipment, buildings and facilities should be prioritized, due to its decisive influence in the saving of resources for investments, as well as in the operation uninterrupted of the productive process and in the reduction of the norms of consumption of energy and materials. "
1991	Resolution on economic development	After the Fourth Congress of the Party, when and due to the collapse of the socialist camp and the lack of parts and components, maintenance becomes more important
1996	Proposal made by De la Paz Martínez	From the Cuban version of the Alternative Maintenance System (AMS), introduced in the Cuban mechanical industry by Portuondo Pichardo (1989), this is developed under the name of Alternative Maintenance System, maintaining its acronyms (AMS).
1999	Sánchez Sánchez	Makes a contribution to the Maintenance Management System in companies producing raw sugar, with the aim of improving the management of physical assets in the Ministry of the Sugar Industry (MINAZ by its acronym in Spanish).
2001	Aguilera Martínez	He made a contribution from the perspective of the planning of Human Resources in the AMS
2005	Borroto Pentón	Develops and implements a procedure for carrying out the maintenance audit in the Ministry of Public Health, specifically in hospitals in the province of Villa Clara (SAMHOS).
2009	Alfonso Llanes	He proposed a procedure to manage the outsourcing process of maintenance in companies of the Ministry of the Food Industry (MINAL by its acronym in Spanish)
2009	Fernández Arenas	Designed and applied a procedure for the evaluation and control of Maintenance Management in Matanzas Hotels, through a General Indicator
2010	Torres Rodríguez	Developed a Maintenance Management or Technical Services approach in the Ministry of Tourism (MINTUR by its acronym in Spanish) applied to the Sun and Beach Hotels that considers the "environmental dimension".
2013	Acosta Palmer	With the objective of implementing guidelines 117 and 220 of the VI Congress of the PCC, aimed at prioritizing industrial maintenance, it was decided to elaborate the policy for which the Ministry of Industry (MINDUS by its acronym in Spanish) was designated; To this end, a temporary work group was set up consisting of representatives of the organizations that have

		an impact on this activity and which began to carry out the diagnosis in 91 entities selected according to the Acosta Palmer procedure.
2014	Velázquez Pérez	It takes an important step forward in the development of Maintenance Management through the application of the AMS in the Graphic Enterprise of Villa Clara, because it proposes a procedure that includes a set of tools for the selection of maintenance to be applied in each equipment or group of equipment installed.

Adapted from: De la Paz Martínez (2014)

As can be seen, the development of maintenance in Cuba gained momentum from the 21st century, with the implementation of a series of procedures to apply the AMS, mostly in the industry. However, none of these has been applied in the plastics industry, which corroborates the novelty of this work.

2.3 The Plastic Materials industry in Cuba.

The plastic industry in Cuba, although it does not have a development that places it in a top place in Latin America and the Caribbean, is not exempt of last generation machinery, exhibiting results that can be considered acceptable for our environment. At the time of the Council of Mutual Economic Assistance (CAME), most of the manufactured products of plastics were received from the socialist area. Only two companies transformed, on an industrial scale, the thermoplastic materials: Havana Plastics and the Plastics Workshops of the National Domestic Products Production Industry (INPUD by its acronym in Spanish) in Villa Clara. There were other small companies that, with machines of small power and in many cases built in the same entities (craft machines), carried out the production of parts and components through the processes of injection and extrusion (Pérez Rodríguez, 2005). The increase of the demand in our country of objects, pieces and plastic components, originates the growing need to create companies for the transformation of these materials. This is how plastics transformation companies such as Cajimaya, in Holguin Province and Cienfuegos, which extrude polyethylene (PE) hoses and polyvinyl chloride (PVC) pipes that are widely used by agriculture and by the Company of Telecommunications (ETECSA). In Granma Province is the Transformation Company of Manzanillo, which supplies plastic teaching materials for the teaching process in the Ministry of Education (MINED by its acronym in Spanish) and in the Commodity Recovery Company of Granma. transformed for the production of mixed plastic from recycled plastic raw materials. In Santiago de Cuba is the company dedicated to the manufacture of rubber soles for footwear (Pérez Rodríguez & Salvador Moya et al., 2013).

Just to mention some companies that have emerged in recent years dedicated to various productions, are those made of composite materials obtained from unsaturated polyester with fiberglass as the shipyards of Gibara, Manzanillo and Cienfuegos, as well as factories for the transformation of thermoplastics such as the HOLPLAST, HIDROPLAST and CIEGOPLAST pipe mills, located in the provinces of Holguín, La Habana and Ciego de Ávila, respectively. These companies are characterized by having high productive capacities with modern technologies, some completely automated (Pérez Rodríguez, 2005).

The growing development of these processes requires the implementation of actions that contribute to maintenance management as a first-rate task in this industry. This is characterized by a continuous process of 24 hours and the initial heating of the machines consumes too much electrical energy. Currently in Cuba in the processing factories of plastic materials the application of Planned Preventive Maintenance has been generalized because for many years it has been considered the most progressive and, given its planned and preventive nature, the one that could best harmonize the maintenance activities with the Factory productivity. However, in a study conducted in 2016 by Pérez Pérez it was concluded that there are several drawbacks in the application of this type of maintenance for this industry, such as: it is impractical to apply it in modern and complex equipment, it is difficult application in chain production lines, provides a similar treatment to all equipment, regardless of the role that corresponds to them in the production process, or its peculiarities and unnecessary changes are made so that higher costs are incurred. The main problem we face is the existence of a maintenance system (PPM) that does not respond to current operating conditions in this type of factory causing the emergence of breakdowns in the equipment of the production process. Through the diagnosis and management of maintenance to the companies HOLPLAST and Cajimaya, it was concluded that the maintenance system that best suits this type of industry is the Alternate maintenance system (AMS) because it has the following advantages: : it must guarantee a job with a minimum number of failures until the moment in which it is foreseen that a repair should be carried out and decrease the possibilities of causing imbalances and errors by avoiding the assembly and disarming with a regularity that is not always necessary.

2.4 Analysis of maintenance management models

The industrial maintenance, in the factories of transformation of plastics, is presented as a set of techniques aimed at maintaining the technology throughout its life cycle, getting to use the equipment with the highest technical availability and at the lowest cost, guaranteeing a effective technical assistance through adequate training and skills management (Pérez Pérez, 2016). Currently, a change has to take place in its management, beginning with understanding that the planned preventive maintenance system (PPM) established and almost generalized in Cuban companies, presents major problems that make it difficult to execute and highly expensive. the maintenance activity is inefficient, faced with an increasingly demanding market and increasingly competitive environments.

Several authors have addressed the issue of maintenance management: Pintelon and Van Wassehnye (1990), Pintelon and Gelders (1992), Vanneste and Wassenhove (1995), Riis, et al. . (1997), Duffuaa et al. (2000), Hassanain et al. (2001), Tsang (2002),

Waeyenbergh and Pintelon (2002), Murthy, et al. (2002), Cholasuke, et al. (2004), Abydayyeh, et al. (2005), Campbell (20055) Borroto Pentón (2005), Pramod, et al. (2006), Prasad, et al. (2006), Kelly (2006), Soderholm, et al. (2007), Tam, et al. (2007), Crespo (2007), Wireman (2008) Fernández Arenas (2009) and Velazquez Pérez (2014); Pérez Pérez (2016), Labañino Fernández (2015), Hernández Paneque (2016), Hidalgo Batista (2018) based on the analysis of what these authors propose, the main characteristics that the model must have for an efficient management of the maintenance in factories of transformation of plastic materials. For the selection of the models, the following requirements were established:

1. It must be of global management and not be focused on a single phase of management or a maintenance tool
2. That was not computer.
3. That a new model proposal be presented, not a revision or application of the existing ones.
4. That the model had, preferably, a graphic representation.

Each of the proposals of the 23 selected models has its qualities and limitations, so it is useful to know and analyze them in order to take the best of each one and, subsequently, apply it with the considerations that the practice merits. For a better analysis of them, a comparative table was drawn up to determine the main characteristics that maintenance management models should have; After carrying out the analysis, the following conclusions were reached:

1. Only 56% of the analyzed models present a focus on processes and are linked to the strategic objectives of the organization.
2. Very few present a clear definition of responsibilities and adequate communication.
3. 70% do not analyze the life cycle.
4. Only 65% of the models have a focus on continuous improvement.
5. Of the 23 selected models, only 9 have a methodology for them.

3. RESULTS AND DISCUSSION

3.1 Procedure for maintenance management in plastic processing factories of Cuba.

The analysis made it possible to visualize important aspects that are linked to the chronological evolution of the contributions of the different authors. Maintenance management encompasses compliance with a set of strategic functions that must be strictly complied with: planning, organization, execution and control.

The proposed procedure has been structured in 8 stages (Figure 1) and is based on those designed by De la Paz Martínez (1996), López Campo and Crespo Márquez (2008), Viveros, Stegmaier, Kristjanpolle, Barbera and Crespo (2012) and Velázquez Pérez (2014) as well as the experience of the author and the criteria of specialists of the University of Holguín and of factories of transformation of plastics.

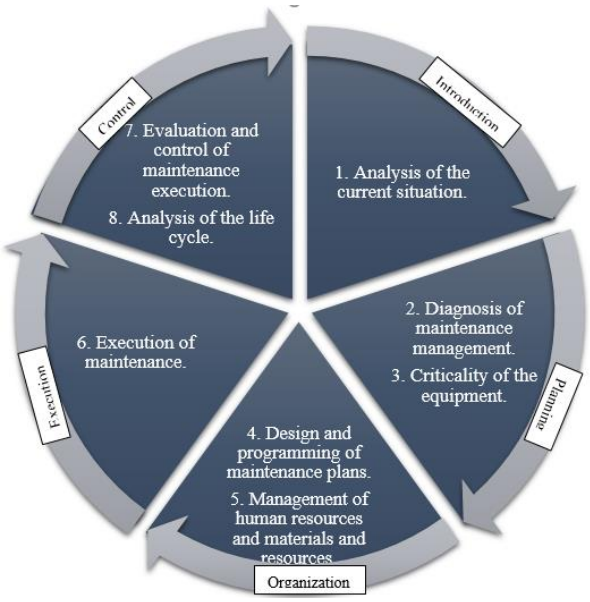

Figure 1. Procedure for maintenance management in plastics processing factories

The purpose of the procedure is from the social point of view to elevate the culture by the maintenance management and the conception of the sustainable development and its meaning in the business field that transcends the balance of objective solutions for the increase of the productivity, without limiting the potential to meet the needs of future generations. In the economic order, the implementation of the procedure will allow to achieve a rational use of the material and financial resources as well as the analysis of the cost of the life cycle of the assets of the company that will make it possible to know all the costs associated to them in order to make decisions on the acquisition of new equipment (replacement or new acquisition) and develop accurate predictions.

It has an important contribution to the care and conservation of the environment because it is based on protecting the environment and guaranteeing safety and health at work, taking into account measures to prevent the deposition of waste and emission of polluting gases into the environment, environmental training of workers, the purchase of organic products and the organization of environmental plans for the production of cleaner and high quality products

3.2 The stages of the procedure are the following:

Stage 1: Analysis of the current situation. Its objective is to create the starting point to efficiently carry out maintenance management and thus guarantee the fluidity and quality of the subsequent phases. In this stage, the work group is created, the maintenance staff is involved and the maintenance area is characterized according to: name and model of the equipment; code and serial number; year of manufacture, function (s); technical status; years of exploitation and most frequent breakdowns.

Stage 2: Diagnosis of maintenance management. This stage is of great importance because it aims to identify the main deficiencies in the maintenance area for the plastics industry. For this it is necessary to divide Maintenance Management into Areas of Action (general organization, human resources, economic control, planning, organization and control and maintenance engineering) not only to be able to evaluate the level of work, but to facilitate its study and introduction of the process of continuous improvement in each of its aspects, because from a general view it is very difficult to face given its complexity and breadth. Each element is evaluated from the answers obtained in the interviews, the observations made in the visits to the facilities, the documents reviewed and other verification mechanisms used, which will make up the general assessment classified into 5 levels: level 5 (excellence), level 4 (competence), level 3 (comprehension) level 2 (awareness) and level 1 (innocence). Finally, the maintenance strategy that must be followed in the company is defined.

Stage 3: Criticist of the equipment. It is vitally important to disaggregate the physical assets of the organization based on its criticality, that is, its greater or lesser impact on the global production system. Through an idea storm the elements to be taken into account according to this type of industry were defined. First, the work team selected in the first stage meets and the classification of the equipment is analyzed to determine, according to the characteristics of the installed technological equipment, the classification in groups I, II and III.

The equipment that will be included in group I will meet the following requirements:
• Technological impossibility to be replaced.
• High operational precision.
• High degree of automation.
• High complexity.
• They are used above 80% of their capacity.
• They work in continuous production, two shifts or more.
• Great influence on operational and human safety.
• High price.
• New or with exploitation time of less than five years.
• Serious impact on the quality of the product.
• May cause moderate impacts to the environment.
• Your stop completely affects the production.
• Many stops due to failures.
• High criticality indicator.

The equipment that will be included in group II, will meet the following requirements:
• They exist in sufficient quantity to guarantee their replacement without affecting the productive process.
• They are mechanically driven or have a lower degree of automation.
• They have moderate complexity.
• They work up to 80% of their capacity.
• Moderate impact on product quality.
• They can cause low impacts to the environment.
• Your stop affects, partially, the production.
• Occasional stops.
• Moderate criticality indicator.

The equipment that will be included in group III will meet the following requirements:
• They exist in large quantity.
• They are technically simple.
• They are employed in auxiliary services.
• They have very low cost.

- They are used below 50% of their capacity.
- They do not affect the quality of the product.
- They do not cause impacts to the environment.
- Your stop does not affect production.
- Uncommon stops.
- Low criticality indicator.

As can be seen, these criteria are evaluated in the three levels for each classification group, with greater involvement in group I and lower in group III and are present in each of them, that the environmental criterion responds to the assessment that is carried out in the ISO 14004: 2015 "Environmental management systems - general guidelines on principles, systems and support techniques". It should be noted that the fact of determining the appropriate subsystem according to the group of the corresponding classification does not imply that it is adopted, since the conditions that allow it must also be met.

Stage 4: Design and programming of maintenance plans.
To carry out the design of the maintenance system, the information contained in the following sources must be taken into account:
- Equipment manufacturer's manual.
- Generic lists of failure modes.
- Technical background records.
- The people who maintain and operate the equipment.

After gathering the necessary information, the following steps must be followed to define the maintenance system:
1. Apply the Failure and Effect Mode Analysis (FMEA) to the different equipment that make up the installation.
2. Classify the faults according to their occurrence.
3. Analyze the faults using the logical decision making process analysis diagram.
4. Assign the maintenance policies to be followed and prepare the instructions.

For this last step, it must also be taken into account that according to the group in which the equipment is classified, the maintenance policy will be matched as follows: the equipment included in group I will be given predictive maintenance; those who classify in group II will undergo preventive maintenance and finally corrective maintenance will be made to those who are in group III.
Once the type of maintenance to be carried out is defined, a detailed schedule of all the maintenance activities must be carried out, considering the production needs in the time scale and the opportunity cost for the company during the execution of the tasks. The scheduling of maintenance activities should optimize the allocation of both human and material resources, as well as minimize the impact on production. The maintenance schedule should be made short (<1 year), medium (1-5 years) and long term (> 5 years). For the optimization of maintenance plans should use the RCS technique (Reliability-Centered Spare Parts) because nowadays, the warehouses of spare parts maintain a great variety of pieces in stock, from economic consumables to critical spare parts that cost thousands of dollars . The RCS - Reliability-Centered Parts - is a systematic and structured process that establishes rational criteria for the definition of replacement strategies. These criteria are based on the evaluation of the consequences of the shortage and the analysis throughout the life cycle of the asset, analyzing the costs associated with the spare part during that period of time.

Stage 5: Management of human and material resources. It is done as shown in figure 2.

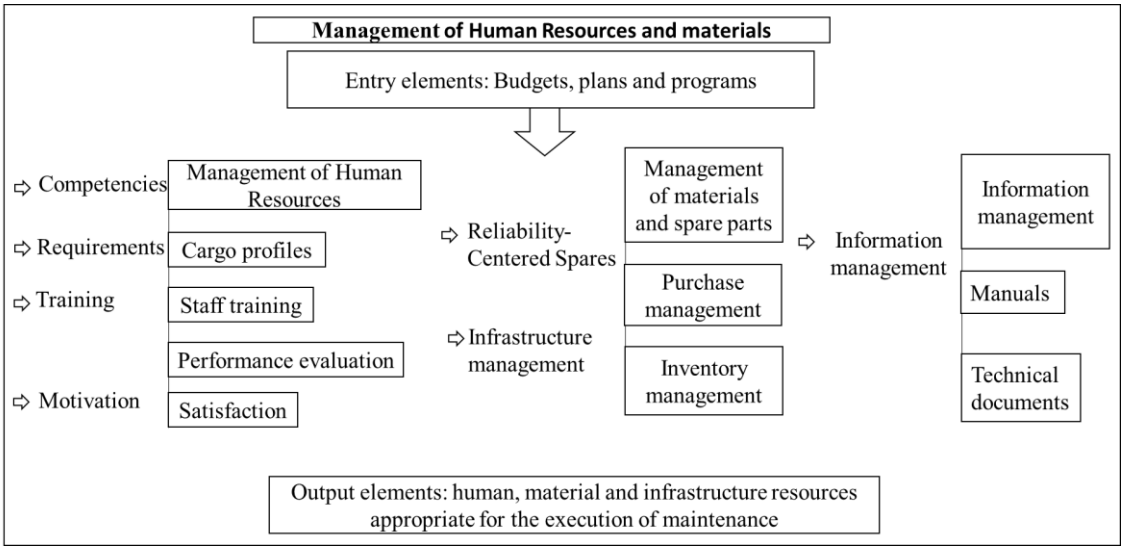

Figure 2. Entry and exit elements of stage 5 management of human resources and materials.

Stage 6: Execution of maintenance. In this stage, the planned maintenance for the company's equipment is developed according to the group to which it belongs. This can be done with your own means or through the hiring of third parties (De la Paz Martínez, 2016). For this, the safety and health of the workers must be guaranteed, minimizing the potential risks.

Stage 7: Evaluation and control of maintenance execution. The execution of the maintenance activities (once designed, planned and programmed as described in previous sections) must be evaluated and the deviations controlled to achieve, continuously, the objectives of the company; To this end, it is proposed as techniques to use the OVAR method (objectives, action and responsible variables) and the balanced scorecard (BSC).
Stage 8: Analysis of the life cycle. The main objective of this stage is to quantify the totality of the expenses (direct or indirect, fixed or variable) paid throughout its useful life, this includes the costs generated in the different stages of its life such as: research and development, acquisition, construction, operation and disincorporation. This information is very useful to technically support decisions (based on an economic analysis) of equipment purchase, optimization and re-designs, programming of maintenance and re-empowerment or replacement of an asset (Lopez Cruz and Crespo Marquez, 2008).

3.3 Practical application in the company of Plastics Business Unit of Base (BUB) Cajimaya

The BUB-PC "Arcadio Leyte Vidal", belongs to the Industrial Company of Irrigation, with registered office in Road of Felton Km 2 ½, Cajimaya, Municipality Mayarí; It was created on April 2, 1997 by the Minister of Economy and Planning and is subordinated to the GEM Business Group of the Ministry of the Iron and Steel Industry.
Its mission is the production and wholesale marketing of parts, articles and accessories obtained from the transformation of thermoplastic materials to the domestic market for domestic use and in applications to agriculture, construction, industry, telecommunications, tourism, as well as the technical services associated with these. The entity has a general address with five functional addresses; It is an installation for the extrusion of polyethylene pipes (PE high, HDPE and low density, LDPE) and polyvinyl chloride (PVC), for sanitary, electrical, irrigation and hydraulic systems as well as plastic accessories by injection and articles of rubber. It has a production hall consisting of an extrusion, injection, rubber workshop and a quality laboratory. They have a machining workshop and five warehouses: raw materials, the parts and supplies center, lubricants, finished production under roof and one for finished production in the open. It also has a socio-administrative building where the areas of regulation and control are concentrated.

Stage 1: Analysis of the current situation.
At this stage, the working group was created, composed of workers from the factory under study and professors from the University of Holguin. In addition, the commitment, preparation and active participation of all the personnel involved was achieved, from the top management to the maintenance staff.
Analysis of technology and its degree of obsolescence.
The technology has a low level of development compared to the HOLPLAST, CIEGOPLAST and HIDROPLAST factories, which have automated control systems; Italian BANDERA technology extrusion machines, for example, have 23 years of operation and although they have temperature control and spindle speed, they do not have automated process control. Through informal interviews with technicians and qualified personnel of the company and through direct observation, the lack of spare parts for plastic processing machines in general and in particular for extrusion machines was verified. Recently two of the machines had to be sold to the Various Local Industries Company (VLIC) of Holguín for the lack of accessories for their repair. There was a poor command of maintenance management and through the documentary review it was possible to observe the lack of technical data sheets and fault control sheets.
Another aspect to be noted is that there are difficulties related to the availability of the transportation means of the entity, which have a high degree of aging and lack of spare parts for the maintenance of the same. As regards occupational safety and health, the signaling in the work areas of the risks to which the personnel working in this entity is exposed is deficient. On the other hand, there is a marked deficit and obsolescence of computer resources in some administrative areas, which conspires against the quality and speed of work; neither do they have an internal communication network for data transfer. Another problem is that the process map is not included as a support process for maintenance management. The foregoing supports the need to design a model with its main support tools for efficient maintenance management in the BUB-PC.
Organization of maintenance in the BUB-PC
The Business Group (GEM for its acronym in Spanish) has a technical direction where the main maintenance specialist is, who is responsible for preparing the General Procedure for carrying out this work in each Business Unit of Base among which is find the BUB-PC. The Investment and Maintenance specialist in each BUB is responsible for complying and demanding what is established in the general procedure.
The BUB-PC has three maintenance brigades subordinated to the head of maintenance, which support the efficient development of the production process in case of difficulties with the installed technological equipment and are responsible for carrying out the tasks that are endorsed in the plan of maintenance. The maintenance that is applied is the planned preventive (PPM), widespread in almost all Cuban companies without a prior study of the characteristics and needs of each company, which represents a problem

because it is difficult to execute and is highly expensive, bringing with it that the maintenance activity is inefficient, faced with an increasingly demanding market and increasingly competitive environments.

The aim of the maintenance area in the BUB-PC is to guarantee the prolongation of the useful life of the equipment and the facilities through the correct planning and execution of the maintenance and repair system. Currently this activity is carried out with the application of the general procedure developed by the main specialist and a standard that designates the responsibilities that must be assumed for the execution of this task. However, both documents lack the information necessary for the correct performance of this process, leaving ambiguous the explanation of some of the steps to follow which leads to inefficiencies and complaints from workers. For the above reasons, it is necessary to design a maintenance management model with its main support tools, which is adapted to the characteristics of the plastics companies in general and in particular to the BUB-PC, to ensure that this work execute with quality and efficiency, which is the objective of this work.

Stage 2: Diagnosis of maintenance management.
The result of the diagnosis is shown in table 2.

Table 2. Diagnosis to the management of the Quality of the BUB-PC

No.	Category of Maintenance Management	Goal	Maintenance Rating	%
1.	General Maintenance Organization	15	8,85	59,00
2.	Human Resources	10	8,05	80,50
3.	Economic Control	15	12,53	83,53
4.	Planning, programming and control	15	11,48	76,53
5.	Maintenance Engineering	20	14,30	71,50
6.	Outsourcing	10	10,00	100,00
7.	Security Management	15	11,40	76,00
	Total	100	76,61	**Regular**

The BUB-PC is in level 3 (Comprehension): The organization and the individuals are developing improvement plans for the systems, they are being applied gradually.

Analysis of results by area:

1. **The general maintenance organization of the company**
   - The charge template in the general organization of the maintenance area is not complete.
   - There is a deficit in the material resources necessary to carry out the maintenance work, as the execution of maintenance periods due to insufficient availability of spare parts is not guaranteed.
   - Regarding the reports and reports there is the main deficiency is not analyzed for further solution.
2. **Evaluation of human resources in the company:**
   - The training of technicians and operators is not systematic.
   - It should be noted that there have been several courses to overcome the middle management, some of which have been carried out within the company.
   - As a disincentive, the reward given by the results of maintenance work is not enough.
3. **Economic Control Area shows that:**
   - As for the Economic Indicators, there is no continuous monitoring of the results in such a way that the workers know the current status of each one of these.
   - However, an aspect that is not measured in this area is the correct use of the budget, so it is valid to point out that in 2015 of a plan of 722.9 thousands of Cuban pesos, a total of 176.15 was executed thousands of Cuban pesos, for 28.61%. Being left without using a total of 546.75. Whatever denotes a poor management of the financial resource.
4. **Planning, Programming and Control Area**
   - Work against breakdown, breaching the planned maintenance program.
   - Periodic inspections of the technological and firefighting equipment are not carried out.
   - The availability of the installed capacity in the tooling workshop is not exploited to the maximum.
5. **Preventive Maintenance Area has deficiencies in:**
   - The control of the preventive maintenance inspections due to the lack of equipment to perform the inspection and control of the equipment (example MICROLOG to measure vibrations).
   - The maintenance plan is not complied with, work is carried out against breakdown.
   - The quality of the work performed for the same reason explained above is not controlled.
   - Environmental management is in a regular state, with deficiencies in actions and measures on the environment.
6. **Security Management Area, shows that:**
   - Safety regulations for hazardous work are not met 100%.

- Deficient lighting and ventilation in the production service workshop and productive workshops.
- The means of protection and hygiene are missing, as well as the area against fire.

Stage 3: Criticity of the equipment.
The classification was made taking as reference the procedure developed by De la Paz Martínez (1996) and others proposed by Velázquez Pérez (2014)
Based on these criteria, the teams were classified as follows:
Group I: With Predictive Maintenance (as well as CHILLER twin-screw and cold air compressors, centrifugal cooling pumps).
Group II: With Planned Preventive Maintenance (injection and extrusion machines, lathes, milling machines, flat saws, presses and piston compressors).
Group III: With corrective maintenance (circular saw and centrifugal pump).

Stage 4: Design and programming of maintenance plans.
In this stage, the working group defined that the policy to be followed is proactive, since it seeks to improve performance, in addition to maintaining the availability of assets. Use monitoring and diagnostics to determine both the operating condition and the performance of the equipment. Maintenance is performed on equipment that is in good condition if the improvement of performance can save or produce benefits and is adapted to the AMS.
It is necessary to clarify that for the equipment that was selected for the predictive maintenance, the maintenance specialist is working on the preparation of the inspection guides for each team or group of equipment, where the frequency of the inspections, the degree of industriousness, will be recorded. what is required for each intervention and the duration of the maintenance operations, how to provide the necessary resources for the next repair and all the documents proposed in this system.
For the planned preventive maintenance, the operations to be carried out in the cycle were taken into account, which have been divided into 4 categories according to the PPM: Review (R), Small Repair (S), Medium Repair (M), General Repair (G). The duration of the repair cycles and the content of the repairs is recorded in the Company's Manual.
In the subsystem of corrective maintenance, once the fault is reported, the maintenance specialist communicates to the workers of the same crew and prepares the breakdown report. This can be detected by the mechanics or the equipment operator. The brigade leader proceeds to issue the work order that will be attended in the minimum possible time and concluded the work is signed the work order by the operator and the workshop manager to give their agreement with the work done and keep it in the technical team folder for updating the history of the team who will facilitate the accounting record of the information.

Failure Mode and Effect Analysis (FMEA) (tables 3,4,5,6 and 7)
Example Equipment: Extruder
Table 3. Equipment: Extruder

Functional fault	**Failure mode**	**Equipment part affected**	**Causes of failure**	**Fault effect**	**Recommended maintenance activity**
Does not extrude the pipeline	Transmission system failure	Main engine	Filter mats are dirty	Total production stop	Clean filter mats
			Injury damage to the bearings		Clean the engine and repair
			The start is blocked by the command system		Verify existence of failure warning in the command system

Table 4. Classification of failures

Functional failures	**Part of the affected equipment**	**Cause of failure**	**Classification of faults**	
			According to frequency	**According to detection**
Does not perform pipe extrusion	Main engine	Filter mats are dirty	Cyclical	Easy detection
		Injury damage to the bearings	Cyclical	Difficult detection
		The boot is blocked by the Random command system	Aleatoria	Random

Table 5. Classification of failures

Failure	**Can it be detected?**		**Affectations**		**Can it be prevented?**		**Planned tasks**		**Wait for failure**
	Yes	**No**	**Environment**	**Operational**	**Yes**	**No**	**Condition**	**Cyclical**	
The filter mats are dirty	x			x	x			x	
Incipient damage to the bearings		x		x	x		x		
The boot is blocked by the command system	x			x		x			x

Table 6. Maintenance tasks

Tipo de tarea	Cantidad
On condition	21
Cyclical	32
Wait for failure	30

Table 7. Selection of the new maintenance system

Fallo	Maintenance systems		
	Corrective Maintenance	Preventive Maintenance	Predictive Maintenance
The filter mats are dirty		X	
Incipient damage to the bearings			X
The boot is blocked by the command system	X		

4. CONCLUSIONS

1. The basic functions of maintenance management were identified: plan, organize and control and their operation, as indispensable requisites to achieve the optimum in this process.
2. A procedure for the management of maintenance structured in 8 stages is proposed, which allows to guide the execution of this process in the plastics companies in general.
3. The purpose of the proposed procedure is not only to maintain the machines but also the installations of: lighting, computer networks, electric power systems, compressed air, water, air conditioning, internal streets, floors, warehouses, etc. It must also coordinate with human resources a plan for the continuous training of personnel
4. The partial application of the methodology allowed to verify its feasibility for the increase of efficiency in the companies of transformation of plastic materials in Cuba, demonstrating its logical consistency, flexibility, transcendence, perspective and relevance in the research framework.

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