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STUDY AND DEVELOPMENT OF A MANUFACTURING PROCESS OF WINDSHIELD WIPERS

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ABSTRACT: *The development of a production line that aims to reconcile productivity with quality has major importance in a globalized market, to guarantee the competitiveness of a company. Due to the rapid development of technologies, it is necessary that a manufacturing process accompany these changes, so that the production time is as small as possible, while maintaining the efficiency and effectiveness of the process, in order to meet the needs of the customers. This article aims to show the development of a process of manufacturing windshield wipers, obtained through bibliographical references, emphasizing that it must follow the requirements of quality and safety standards.*
Keywords: *Windshield wipers. Quality. Safety. Production Process.*

1. INTRODUCTION

The auto market is growing fast, so the auto parts industry needs to follow the same path. The windshield wiper is a key piece for driver safety and its manufacturing process must follow strict quality inspection procedures to ensure that the final product meets both the customer's specifications and safety and quality standards. It is known that the development of a product, as well as its manufacturing plant, requires investments not only in the technological part of the process, but also in the specialization of labor, and implantation of tools capable of tracking every step of the process, In order to guarantee the quality of the final product. This is essential if, in a globalized world, the market is increasingly specialized and competitive.

The objective of this study was the research of the development of a windshield wiper manufacturing plant, mapped from the entry of raw material in the process to the inspection and quality assurance of the product, using control tools to maintain efficiency and The effectiveness of the process.

Through bibliographic references it was possible to understand each step of the cleaner manufacturing process, and to contribute with suggestions of an action plan to improve it.

2. THEORETICAL REFERENCE

In this section the main concepts of this study are presented, to better clarify the methods used. They are: processes, quality tools and techniques and history of windshield wiper.

2.1. Processes

Processes can be understood as the set of all activities that are executed in a sequenced way, with the purpose of resulting in a good or service. According to Harrington (1991), process is any activity that takes an input, adds value to it, and provides output for a specific customer.

The practice of process management aims at continuous improvement of performance by raising the quality levels of its processes (DI SORDI, 2008). Thus, companies must be able to change according to need or opportunity, thus being able to promote improvements in the process, not only productive but organizational, aiming at generating profit, saving time, labor, fixed and variable expenses, among other factors.

2.2. Quality Tools And Techniques

With the emergence of the Quality Management System, which is focused on the quality of production and services of a particular company, it was necessary to create techniques and tools that analyze the facts and assist those involved in a decision making process.

The use of such tools aims to reach or increase the degree of efficiency and effectiveness of a particular activity or process. And these techniques are necessary to please the customer, since in the Quality Management there is the concern, not only with the quantity of production, but also with the quality of the same. Another objective of the use of these techniques is to increase the capacity of the fulfillment of the objectives outlined in the initial plan. Of the techniques of quality management we can mention:

- Planning: identification of the standards of a project;
- Quality Assurance: guarantee quality standards;
- Quality Control: related to supervision.

To aid in the use of these techniques, the use of quality tools is done, followed by those used in the study in question:

- Flowchart: use graphical support to list all activities of the process, presenting a logical sequence of everything that is carried out in the process steps. It is considered one of the inputs to the control plane;
- 5W2H: used to help plan actions by developing a framework to answer the following questions: What? When? Why? Where? Who? How? How much?
- FMEA: Failure Mode and Effects Analysis is a tool that assists in the design of systems, products, processes or services. It is used to define, identify, and eliminate potential failures, problems, or errors of the unit of analysis. It is also considered input to the control plan;
- Control Plan used in the monitoring of resources for the development of process and product quality control.

2.3. History Of Windshield Wiper

Initially, in 1903, the windshield wiper was designed by Mary Anderson (UNITED STATES PATENT AND TRADE MARK OFFICE Website) as a device that consisted of a manually operated metal lever from inside the vehicle. An oscillating arm was actuated by this lever, articulating a rubber blade that effected the cleaning, thus improving the visibility of the driver. However, he demanded that the driver drive with only one hand, and as fatigue increased, it also made steering more difficult.

Later, in 1922, William M. Folberth patented the automatic windshield wiper mechanism, which was driven by a vacuum pump. This system was used as standard until the 1960s. But this system had a deficiency in its speed of operation, which was altered with the speed of the vehicle. To eliminate this failure, manufacturers have developed the drive cleaners through electric motors, which is basically the system used nowadays.

Windshield wiper blades have evolved over the years, mainly to obtain the distribution of rubber pressure on the windshield by the force applied by the arm in the center of the windshield. Following are the types of reeds that have existed and are on the market today:

- Flat blade: rubber blade fixed to a metal rod which was applied to the flat surface windshield without bending;
- Blades with four points of support: stainless steel plate where the rubber blade was inserted, being pressed by two articulators, and these were pressed by an arc. This project was developed for windscreens with curvatures;
- Aeramic Blade: the main arches had a triangular cross-section in order to allow them to function even under high wind pressure due the high speeds;
- Speed Blade: had as its main objective to reduce the wind resistance under the blade, and keep it in contact with the windshield at high speeds. It had torsion springs to keep pressure on the entire surface of the windshield, just like the previous project;
- Conventional Blade: with the increased windshield length, the blades also had to have their length increased. It was intended to ensure uniform distribution of pressure along the length. Thus, it used the same design of the blade with four points, but with longer lengths;
- New flat blade: the main objective of this blade was the improvement of design, reduction of noise at high speeds, and quality of cleaning. The main feature of this model is the curvature of the metal support of the rubber or silicone blade that provides this pressure distribution.

3. METHODOLOGY

The fundamental goal of science is to prove the truth of the facts. The difference of the scientific knowledge for the other forms of knowledge is its characteristic of verifiability. It is necessary to determine the method that made it possible to arrive at this knowledge, to consider it scientific. Thus, the method is understood as the way to reach a purpose, being the scientific method the set of procedures both intellectual and technical used to achieve knowledge (GIL, 2008).

3.1. Research

Gil (2008, page 26) defines research as a "formal and systematic project of developing the scientific method". The research aims to discover answers to problems using scientific procedures.

3.1.1. Types Of Research

The types of research can be classified according to objectives and technical procedures (GIL, 2008).

According to objectives, can be mentioned:

- Exploratory research;
- Descriptive research;
- Explanatory research.

According to technical procedures, are divided into:

- Bibliographic research;
- Documentary research;
- Experimental research;
- Data survey;
- Field study;
- Case study;
- Research and action.

The research method used for the study in question was the method of bibliographical research, which is developed with already elaborated material, consisting mainly of books and scientific articles (GIL, 2008).

4. MANUFACTURING PROCESS OF WINDSHIELD WIPERS

O processo de fabricação do limpador consiste, basicamente, na entrada das matérias-primas (*input*), os processamentos das mesmas, agregando, assim, valor a elas, controle de processo ou inspeção, acabamento e montagem, garantia da qualidade do produto final (*output*) e por fim, encaminhamento para o cliente.

4.1. Raw Materials Used In The Process

The raw materials used into the manucturing process of windshield wiper blade are:

- Coil or sheet steel;

Figure 1. Coil or sheet steel

- Colorless silicone;

Figure 2. Colorless Silicone

– Black powder paint

Figure 3. Black poder paint

4.2. Equipments Used In The Manufacturing Process

The equipment used in the production and finishes of the windshield wiper blade are listed below:

– Forklift trucks;

Figure 4. Forklift truck

– Hydraulic press;

Figure 5. Hydraulic press

– Crane;

Figure 6. Crane

– Paint booth (running machine, spray gun and booth);

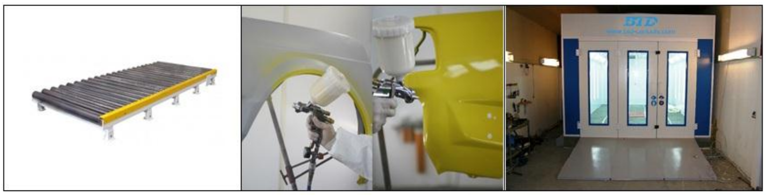

Figure 7. Paint booth

– Screwdriver;

Figure 8. Screwdriver

– Compressed air system;

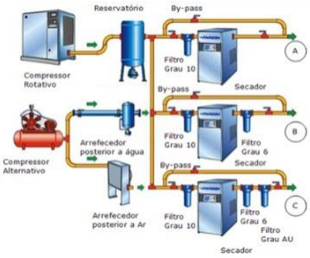

Figure 9. Compressed air system

– Welding system;

Figure 10. Welding system

– Sandpaper;

Figure 11. Sandpaper

– Packing materials;

Figure 12. Packing Materials

– Inspection equipment (gauges, calipers, model parts).

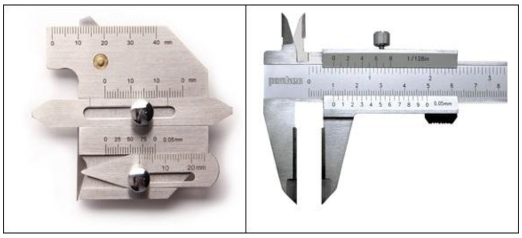

Figure 13. Gauge and caliper

4.3. Quality Tools Used in the Present Study

The study was based on the bibliographical research, not only on the manufacturing process itself, but also on the use of quality tools that aid in the planning of the project, as well as in the understanding of the process, and its traceability, in order to help in the continuous improvement of the object of study.

4.3.1. 5W2H Tool

As explained earlier, 5W2H is a quality tool that is used for action planning, where the questions are answered:

– What?: what should be done;
– Who?: who will do;
– When?: when will it be done;
– Where?: where will it be done;
– Why?: why should it be done;
– How?: how should it be done;
– How much?: how much will it cost to be done.

The tool was used for the planning of every study, being followed step by step, so that all project could occur in the stipulated time**.**.

Planejamento 5W2H

OBJETIVO Limpador de Para-Brisa

GRUPO 17 Bruno Batista 140386, Fábio Felpe 140445,Igor 140056, João 141031, Lais Valentim 150268, Maria Alice 140078

LIDER João Gabriel 141031

O Que (WHAT)	Quem (WHO)	Quando (WHEN)		Onde (WHERE)	Como (HOW)	Porque (WHY)	Quanto (HOW	% Complet	Hoje	Situação
		Inicio	Fim							
Escolha do projeto	Todos	08/ago	08/ago	sala de aula	Consenso	Ponto de partida	-	100,0%	100,0%	
Planejamento 5W2H	Todos	15/ago	15/ago	sala de aula	Excel	Controle do Projeto	-	100,0%	100,0%	
Pesquisa de Materiais	Fábio	15/ago	29/ago	biblioteca/ casa	Livros, Internet	Levantamento de dados	-	100,0%	100,0%	
Fluxograma do Processo	Bruno	15/ago	29/ago	biblioteca/ casa	Pacote Office	Controle de Produção	-	100,0%	100,0%	
Plano de Controle	Maria Alice	29/ago	12/set	biblioteca/ casa	Internet	Segurança de Produção	-	100,0%	100,0%	
FMEA de Processo	Lais	29/ago	12/set	biblioteca/ casa	Livros, Internet	Levantamento de Possíveis Falhas	-	100,0%	100,0%	
Lay-out esq. Da Linha de Prod	João,Igor	12/set	26/set	biblioteca/ casa	Livros, Internet	Esquematização da Prod.	-	100,0%	100,0%	
Equipamentos utiliz. Na Prod.	João,Igor	12/set	26/set	biblioteca/ casa	Livros, Internet	Levantamento da Prod.	-	100,0%	100,0%	
Relatório Artigo Científico	Lais, Maria Alice.	07/nov	18/nov	biblioteca/ casa	Word / Excel	Controle e Conclusão do Projeto	-	0,0%	81,8%	
Preparação da apresentação	Todos	18/nov	20/nov	biblioteca/ casa	Power Point / Word	Formatação do Projeto	-	0,0%	0,0%	
Ajustes Técnicos	Fábio, João.	18/nov	20/nov	biblioteca/ casa	Power Point / Word	Formatação do Projeto	-	0,0%	0,0%	
Apresentação	Todos	21/nov	21/nov	sala de aula	Apresentação do Projeto	Divulgação do Projeto	-	0,0%	0,0%	

Figure 14. 5W2H Planning.

The planning follows the order of project choice, followed by the execution of the project itself. After that, there is the research of the materials used in the production, construction of the flowchart of the manufacturing process, as well as the elaboration of a control plan and the FMEA for the same. A schematic layout of the production line is also built to complement the design, and then a survey is made of the equipment that is used in this manufacturing line. The other items follow the preparation of a report, preparation of the presentation, final adjustments, and finally the presentation of the study in question.

4.3.2. Flowchart of the Process

Flowchart is a graphical support tool used to list all the steps of the process in order to simplify its operation. It must present a logical sequence of manufacturing methodology.

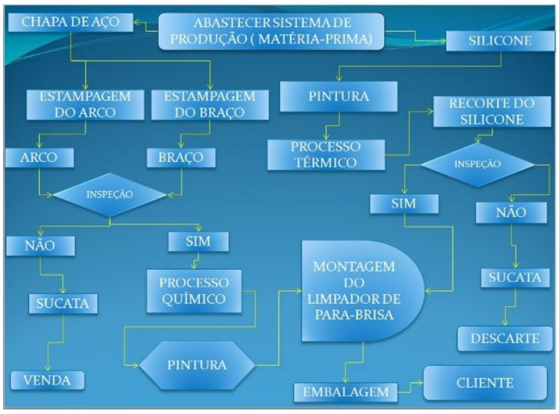

Figure 15. Flowchart of manufacturing process of windshield wiper.

The process steps follow the sequence below:

a) Supply of raw material - steel: the steel sheet is taken to the process of stamping the arc and the wiper arm;
b) Inspection: After stamping, the bow and arm go through an inspection process to verify they are within the quality standards. If not, they are discarded as scrap, and sold. If so, they are released to the next stage of the process;
c) Chemical process: after release by inspection, the arm and bow are subjected to chemical treatments, to improve resistance against the elements, such as rain, wind, snow, etc;
d) Painting: is the next step to the chemical treatment. Being done that, it is separated for assembly;
e) Supply of raw material - silicone: the silicone starch is taken to the painting process with black powder paint;
f) Thermal process: soon after, the silicone is subjected to a thermal process, for homogenization and mass transformation for the next step;
g) Silicone Trim: In this step, the silicone mass enters a press, where it is cut into the pallet mounting mold;
h) Inspection: after trimming, the parts are inspected to ensure they are within the standards to follow. If not, they are discarded as scrap. If yes, they are released to the assembly stage;
i) Assembly of the wiper: here the bow, arm and silicone are joined and the cleaners, already considered as final product, are assembled;
j) Packing: After assembly, the cleaners are packed and shipped to the customer.

A production layout was constructed as a complement to the manufacturing process, in order to understand the arrangement of the equipment used and the sequenced production steps.

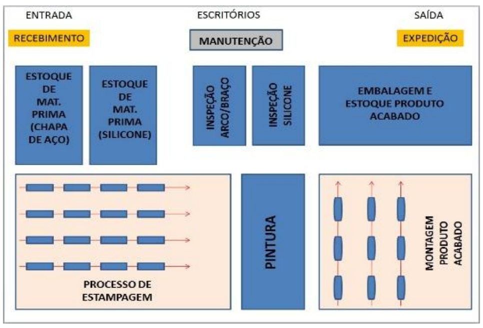

Figure 16. Layout

4.3.3. Control Plan

The control plan, as previously conceptualized, is used in the monitoring of resources for the development of process and product quality control.

With the help of flowchart and the elaboration of a FMEA, it is possible to elaborate a control plan to seek the continuous improvement of the process.

Operação	Variáveis	Meios de controle	Frequência
Estampagem	Dimensão: atendimento às dimensões de projeto	Análise dimensional em laboratório de metrologia	Tomada de amostra durante processo
	Dimensão: diâmetro dos furos dos pinos	Gabarito passa-não passa (peças pequenas) - operador/supervisor	1x a cada 100 peças ou a cada 10min de produção
		Análise dimensional em laboratório de metrologia	Conforme tabela da amostragem de lote (varia com tamanho do lote)
	Dimensão: comprimento e curvatura	Análise dimensional em laboratório de metrologia	Conforme tabela de amostragem de lote (varia com tamanho do lote)
	Dimensão: espessura	Análise dimensional em laboratório de metrologia	Conforme tabela de amostragem de lote (varia com tamanho do lote)
			Controle da qualidade da matéria-prima / certificado de qualidades
	Rebarba (conforme especificação de projeto)	Visual - operador	1x a cada 100 peças ou a cada 10min de produção
		Ensaio e medição em laboratório de metrologia	Conforme tabela de amostragem de lote (varia com tamanho do lote)
Inspeção de Qualidade	Falha devido à falta de validação dos equipamentos ou instrumentos do setor operacional	Rotina de validação dos equipamentos e instrumentos operacionais	1x por dia ou por turno
	Falha devido à falta de verificação dos equipamentos ou instrumentos de laboratório	Assegurar calibração rotineira de equipamentos e instrumentos e validação com padrões primários	1x por dia
	Falta de certificação de instrumentos e equipamentos	Assegurar calibração rotineira e certificação de equipamentos e instrumentos por laboratórios credenciados - padrões primários e secundários	Depende do equipamento/instrumento; a cada 1 ano ou 06 meses
	Falha operacional ou manuseio de equipamentos ou instrumentos	Treinamento operacional; treinamento e qualificação dos profissionais da qualidade	Variável: operacional a cada 06 meses, qualidade a cada 2 anos
Processo de Pintura	Falha na espessura da camada de tinta	Assegurar regulagens e parâmetros operacionais na etapa de pintura - operacional/supervisão	1x por lote de peças ou sempre que houver qualquer intervenção nas máquinas de pintura e seus equipamentos
		Medição da espessura de tinta em laboratório de metrologia	Conforme tabela de amostragem de lote (varia com tamanho do lote)
	Formação de bolhas ou presença de inclusões	Assegurar desengorduramento das peças metálicas antes da pintura por imersão - operacional	Constantemente
		Assegurar que a câmara de pintura e seus equipamentos estejam hermeticamente isolados das outras fontes de inclusões, ventos e particulados - projeto e operacional	Constantemente
		Avaliação visual - operacional	Constantemente
		Avaliação visual - controle de qualidade	Conforme tabela de amostragem de lote (varia com tamanho do lote)

Figure 17. Control Plan

4.3.4. FMEA – Failure Mode and Effects Analysis

Failure modes and effects analysis is a technique that defines, identifies, and eliminates potential or known failures, problems or errors of the unit under analysis, before they reach the user.

When the FMEA is properly conducted, it provides ancillary information on:

- Reduction of operational risk of systems, through improvement, and;
- To prevent failures / errors reaching the user, through preventive actions.

The FMEA has the following properties:

- Identify known and potential failure modes;
- Identify causes and effects of each mode of failure;
- Prioritize failure modes according to RPN (risk priority number), which is the product of frequency of occurrence, severity and detection;
- List corrective actions.

FMEA PROCESSO DE FABRICAÇÃO LIMPADOR DE PARA-BRISA

											Resultados da Ação				
ETAPAS DO PROCESSO	Modo de Falha Potencial	Potencial Efeito da Falha	SEV	Causa Potencial da Falha	OCR	Método de Detecção	DET	RPN (SxOxD)	Ação Recomendada	Responsável/data	Ação Tomada	Sever.	Ocorr.	Detec.	RPN
Abastecimento de MP	Atraso no Fornecimento MP não conforme	Atraso na produção	8	Fornecedor não qualificado	3	Follow up com parceiros fornecedores	2	48							
Estampagem	Quebra da Ferramenta Falha na máquina Falha na operação	Atraso na produção; risco de acidente	9	Treinamento não adequado; queda de energia; falta de manutenção preventiva	5	Treinamento adequado, manutenção periódica, uso de geradores de energia.	3	135							
Inspeção de Qualidade	Falha na calibração dos eqp Falha Operacional	Entrega do produto não conforme	6	Treinamento não adequado; falta de aferição diária do equipamento; falta de aferição por empresa especializada	5	Treinamento adequado Verificação dos equipamentos usados na inspeção	2	60							
Processo Químico	Falha na esteira de transporte do produto	Processo não eficaz	5	Queda de energia; desgaste do equipamento;	3	Manutenção periódica do equipamento, utilização de geradores.	2	30							
Processo de Pintura	Falta de ar comprimido; Formação de bolhas	Parada no processo de pintura; perda de produto no processo	7	Queda de energia; Problema nos compressores; regulagem da pistola.	2	Manutenção periódica do equipamento, utilização de geradores.	2	28							
Recorte do Silicone	Falha na máquina; falha na operação	Atraso na Produção	8	Treinamento não adequado; queda de energia; falta de manutenção preventiva	5	Manutenção Preventiva, corretiva e preditiva; Treinamento adequado	3	120							
Montagem do Limpador de Para Brisa	Falha na montagem; falha operacional.	Atraso na entrega do produto	8	queda ne energia; falta de manutenção, desgaste do equipamento; falta de mão de obra qualificada	4	Treinamento adequado; manutenção preventiva, corretiva e preditiva.	2	64							

Figure 18. FMEA

5. CONCLUSION

In a globalized world, standing out in a competitive market is of the utmost importance. A manufacturing process must then be within world standards of productivity, safety and quality.

The development of new products, the specialization of labor and the aid of tools able to trace and facilitate, thus, the follow-up of all the stages of manufacture is very important so that the industry is able to compete within the market.

In carrying out the necessary research for this work, it was verified that the objective was reached, and that it added knowledge to all the authors of this study.

It is also concluded that all companies must be open to changes in their growth, and that, however difficult it may be to implement new technological resources and new control techniques, this may be able to help Insertion within a market that always seeks to please the demands of the consumer.

As a suggestion, it is also requested that an experimental research be carried out, so that the studies described in this article can be implemented and used as an auxiliary tool for organizational growth.

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