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EXHAUST MANUFACTURING PROCESSES

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Abstract

Actually a large part of the population has at least one car, this has been showing that more and more vehicles are becoming more present in society. Keeping in mind that the car is composed of several parts, the purpose of this article is to talk about an important component of the car in environmente and sound, the exhaust. The exhaust can be divided into several components, such as: intake manifold, catalytic converter, intermediate muffler, rear muffler and front tube. Increasingly, there is a growing demand to reduce the emission of pollutants into atmospheric air, so carmakers are always striving to develop exhaust gases that can filter out most of the harmful gases emitted by vehicles in harmless gases that are less lethal to the environment. This article covers each of the processes of exhaust components that are diverse, such as: Tube cutting, calendering, welding and folding. In addition to the processes, it is also presenting the quality of the process: Process flowchart, FMEA (Failure Mode Effect Analysis) of each process and the control plan, which together with the production layout.

Keywords: *Environment, Processes, Production*

1. INTRODUCTION

A vehicle exhaust or exhaust system is a conductor that enables the automobile to direct the combustion result gases out of the engine environment and influence engine development. Generally produced with stainless materials due to the strong corrosion caused by the gases, in addition to filtering materials. Its application is best known in automobiles, but it is used in any explode engine, in generators, boats, trains etc.

The exhaust directly influences the performance and power of the engine, since it is the one that is responsible for the release of the gases. If the gases have difficulty coming out, the engine will perform poorly, but if the outlets are too loose, the engine will make unnecessary stress.

For the proper functioning of any motor vehicle it is necessary to have a gas system capable of efficiently disposing of these vehicles. Of an exhaust assembly, basically three functions are intended: (1) to channel exhaust from the engine to the outside; (2) reduce engine noise and (3) reduce emissions of polluting gases into the atmosphere.

1.1 Major Components

The main components that make up an exhaust system are:

Intake Collector - captures the gases from the fuel burn by the engine.
Front tube or motor tube - is connected to the intake manifold, initiating the conduction of the gases to the catalyst.
Catalytic - which has been compulsory since 1992, is responsible for transforming harmful gases into non-polluting elements. It consists of a ceramic or metallic hive impregnated with noble metals

(palladium, platinum and rhodium), wrapped in a shock absorbing blanket to protect against impact, and encapsulated in stainless steel housing. Chevrolet vehicles are in compliance with the Air Pollution Control Program for Motor Vehicles - PROCONVE.

Intermediate Quiet - reduces noise (high-frequency sound waves), improves engine performance, and therefore helps fuel economy.

Rear silencer - completes the functions of the intermediate muffler, reducing low frequency sound waves

Figure 1 - Vehicle exhaust system

The main functions of an exhaust are:

- Efficient release of gases resulting from combustion
- Reduction of combustion noise
- Lifetime of the engine
- Control and fuel economy
- Reduction of emission of pollutants

1.2 Type of production

The production process of a product can be divided into two categories: Push production, which occurs in anticipation of customer orders and pulled production, which is triggered in response to customers' requests (CHOPRA AND MEINDL, 2003). The exhaust production process follows the pulled production model, initiated by the request made by the automaker.

To manufacture products it is necessary to have the right amount of materials. In addition, these materials must be purchased at the lowest possible cost, of a higher quality and must be available at the time the production is started. (BERTAGLIA, 2009, p.168).

2. EXHAUST SYSTEM

2.1 Components

The exhaust system is the part responsible to treating the toxic gases released by the engine, in addition to reducing vehicle noise. Although not the most remembered when buying a car, it is very important both for the proper functioning of the vehicle and for the preservation of the environment. The system consists of three main parts, connected by the exhaust pipes, arranged between the engine and the vehicle's tailpipe. Below is a description of the exhaust components.

2.1.1 Engine Tube

After the introduction of the catalytic converter in the exhaust system, this part is now produced in stainless steel so that it does not release fragments that can clog the catalyst. By working at high temperature it is difficult to wear, since it does not house the water from the gases expelled by the engine. Because it is of more elaborate material and work in high temperatures, it does not retain water or oxidizing material, possessing a long useful life.

Figure 2 - Engine Tube

Source: Google images

2.1.2 Catalyst

The catalytic converter is designed to work in tune with the automotive fuel system, which in good working order is capable of converting about 98% of polluting and harmful gases.

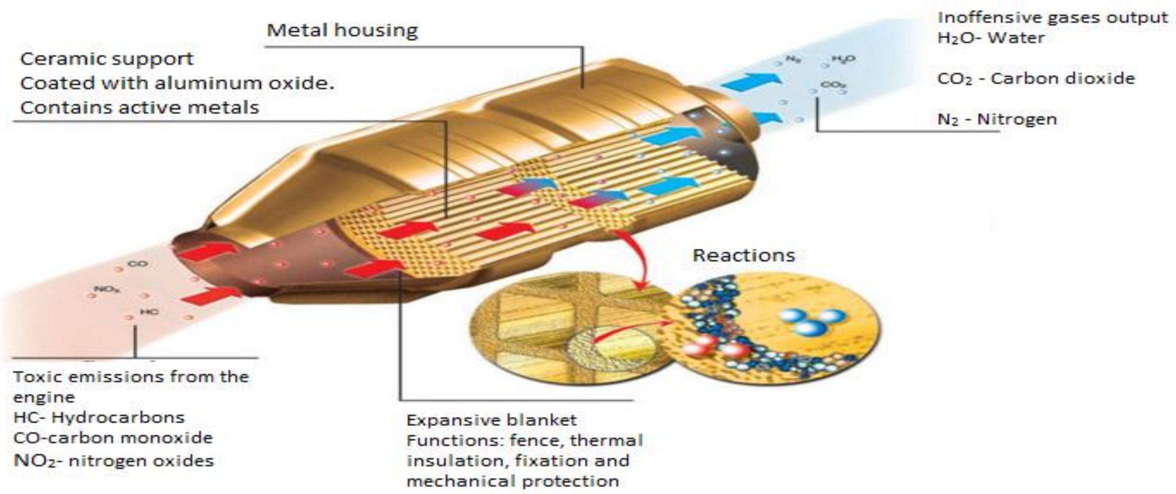
The catalyst is a component of the vehicle exhaust system, formed by a ceramic or metal core. It acts by transforming highly toxic gases such as carbon monoxide (CO), non-combustion hydrocarbons (HC) and oxides of nitrogen (NOx) into non-toxic gases such as carbon dioxide (CO2), nitrogen gas (N2) and Water vapor (H2O).

The catalytic converter of an automobile consists of a mixture of catalysts 5 noble metals (such as platinum, palladium and rhodium) connected to a porous, hive-type ceramic support, through which the exhaust gases pass (ATKINS, 1999).

The shape of the hive is intended to provide a large contact surface so that the gases can react faster, it is estimated that the total surface of the hive of a converter is equivalent to the area of four soccer fields (FONSECA, 2007).

Catalysts that promote the combustion of CO and hydrocarbons are, in general, transition metal oxides and noble metals, such as platinum. The same materials can be used to reduce NOx in N2 and O2 (BROWN, 2007).

Figure 3 – Catalyst



Source: http://motorsa.com.br/como-funciona-o-catalisador/

Basically, for vehicles with Otto cycle engines (alcohol, gnv and / or gasoline) there are two types of catalysts:

Oxidation catalysts: metals such as palladium (Pd) and platinum (Pt) in very small amounts (to keep the catalyst with a low price) convert hydrocarbons from unburned gasoline and carbon monoxide to carbon dioxide and water.
Reduction catalysts: metals such as palladium (Pd) and rhodium (Rh), also in very small amounts, convert nitrogen oxide into nitrogen and oxygen. Nitrogen oxide contributes to the photochemical mist, also known as Smog.

2.1.3 Intermediate silencer

Its function is to eliminate the high frequency noise of the motor caused by the combustion of the gases in the engine. Perfect intermediaries prevent gas from entering the interior of the vehicle, Maintains the compression ratio of the engine, reduces consumption. Watch out! Exhaust / dampers - with specification of inch (diameter) lower than factory specifications, loses performance, strangles engine and decreases engine life.

Figure 4 - Intermediate silencer

Source: Google Images

2.1.4 Rear silencer

Its function is to eliminate the low frequency noise of the motor caused by the combustion of the gases in the engine.

Figure 5 - Rear silencer

Source: Google Images

2.1.5 Tips

The tips are just that final part of the exhaust. Basically they have the aesthetic function and allow the personalization of the vehicle with quality and beauty.

Figure 6 – Tip

Source: Google Images

2.1.6 Exhaust pipes

They are generally made of AISI 304, 321 or 316 / 316L austenitic stainless steel (on request) and externally coated with AISI 304 stainless steel wire braid.

They can be used in temperatures from - -319° F to + 1112 ° F, having excellent corrosion resistance.

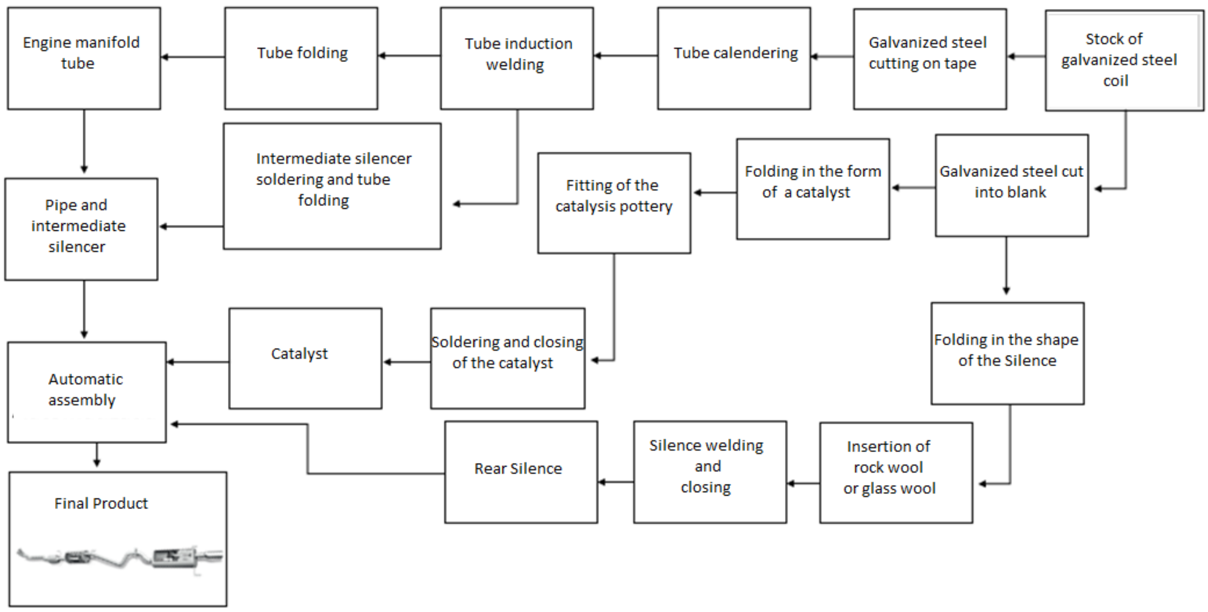
Figure 7 - Exhaust pipes

Source: Google Image

3. MANUFACTURING PROCESS

Figure 8 illustrates the macro flowchart of the exhaust production process. The process begins with the entry of galvanized steel coils. The steel coil is cut into tape for the production of everything and blank for the production of the silencer and the catalyst. At the end of the process is the automated assembly and welding of all the components that constitute the exhaust.

Figure 8 - Macro Flowchart of Production



Source: Developed by the own authors

3. LAY-OUT PRODUCTION LINE

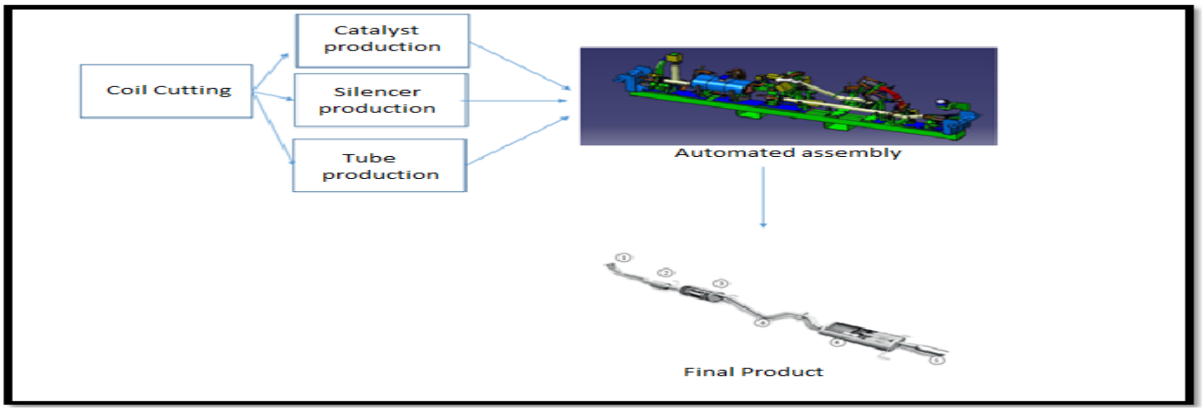
The organization of a production operation is defined by a production layout. The layout of a productive operation defines a physical location of the transformation resources, and may vary according to a characteristic of the product (SLACK et al, 2008). For a determination of the production layout are information about product characteristics, quantities, sequences of operations, equipment space and handling, as well as information on stocks, expedition and transportation (RIBEIRO et al., 2016). For Fonseca et al. (2016) a general plan physical arrangement is responsible for productivity problems or low quality level in production.

Exhaust production follows an in-line production layout, where the material moves in the workstations. On the first station is made with the cutting of the steel reels in various sizes, according to the production requirement of each product.

As the cut sheets proceed to the tube production stations, the production of the catalyst cover and the silencer. At the end of the production of the items that make up the vehicle exhaust system, these items are assembled automatically without a defined template, the final product or exhaust system being complete. Figure 9 illustrates the exhaust production layout. After a cut of the coils, the material goes to three workstations and a production of the tube, silencer and catalyst.

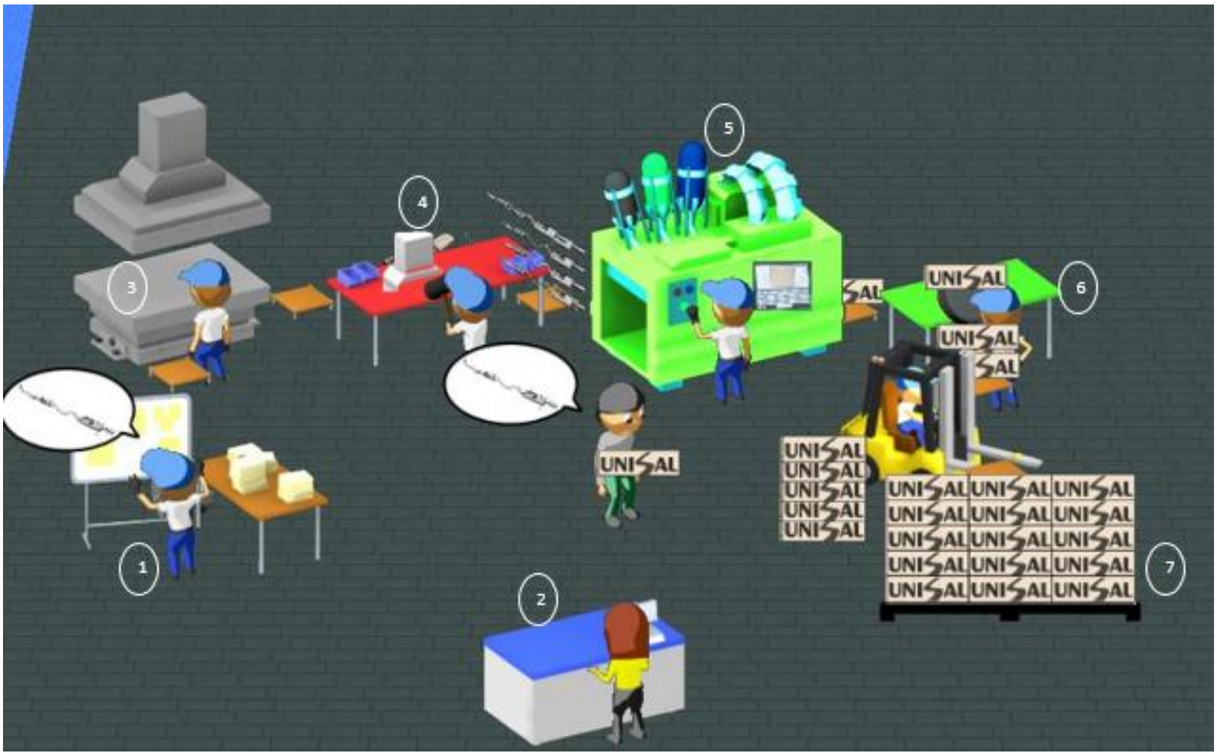
The fourth station performs an automated assembly and welding of the exhaust components. Figure 10 shows in an illustrative manner of the exhaust production. Station 1 corresponds to the planning and control of production and station 2 the supervision of production. In season 3 the steel coils are cut which are transformed into products at the station. 4. In the station 5. the automated assembly of the exhaust components occurs and in station 6 the final product inspection takes place. The station 7 corresponds to the stock of the final product.

Figure 9 - Production Layout



Source: Developed by the own authors

Figure 10 - Illustrated production layout



Source: Developed by the own authors

4. CONTROL PLAN

It is possible to verify that the American automakers Chrysler, Ford and General Motors have developed the Advanced Product Quality Planning Guide, which has the Control Plan as one of its main tools for communication and control of parts and processes.

According to IQA (1994), the control plan was designed to reduce the complexity of product quality planning for customers and suppliers, as well as improving the communication of product quality planning requirements to its subcontractors, and was used as A form to describe systems for controlling parts and processes in three phases of planning:

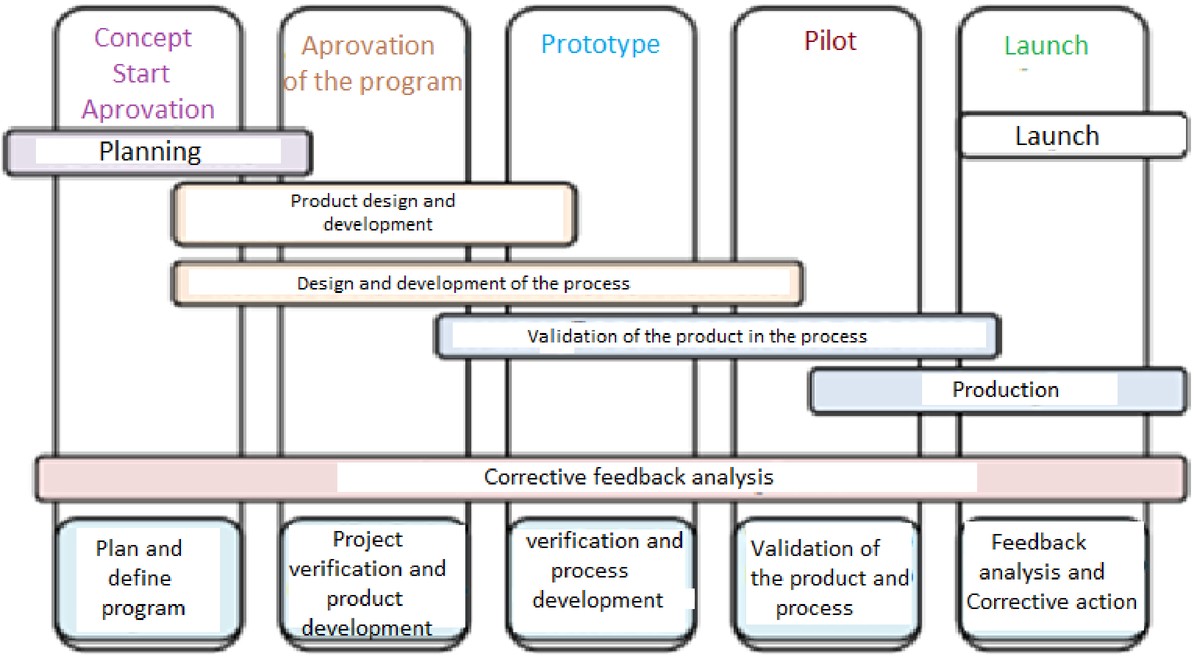
• Prototype: A description of the dimensional measurements, material and performance tests that will occur during prototype construction;

• Pre-launch: A description of dimensional measurements, material and performance tests that will occur after the prototype and prior to serial production;

• Production: A complete documentation of the process or product characteristics, process controls, tests and measurement systems that will occur during series production.

According to the PMBOK guide (PMI, 2008), advanced product quality planning also follows a cycle: Planning, Realization, Analysis, Action. Within this focus stands out the schedule of product quality planning, illustrated in Figure 12 , Where the phases in which the control plane is inserted are insert.

Figure 12 - Control Plane Phases



Source: IQA (1994)

Inputs to the Control Plan are considered:
• Process flow chart;
• Failure Mode and Effect Analysis - FMEA;
• Special features;
• Lessons learned from similar pieces;
• Knowledge of the team in relation to the process;
• Critical analysis of the project;

• Optimization methods.

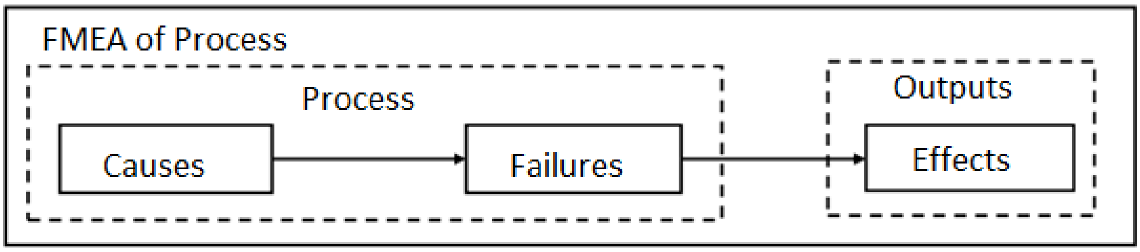
5. FMEA OF THE PROCESS

Failure Mode and Effect analysis (FMEA) is widely used by companies to conduct an analysis of their processes. Technical specification ISO / TS16949: 2002 determines the use of FMEA for all suppliers of a car's production chain, with the aim of reducing failure modes. The FMEA is an important tool for quality management of a productive process, being an analysis of effects and Failure Mode and Effect Analysis (FMEA). The FMEA tool allows to identify the causes and effects of each failure mode of a machine or production system (MENEGHINI; ZAIONS, 2016). Also, according to Meneghini and Zaions (2016), any event that can take a physical item to functional failure is a failure mode and its description must contain sufficient detail to enable selection of an appropriate maintenance strategy.

The FMEA allows a systematic and standardized evaluation of possible failures, their consequences and guiding the adoption of corrective and / or preventive measures, besides being used as a problem solving technique (CARDOSO et al., 2016). Through the FMEA, the potential modes of failure in process are identified and considered in decision making, allowing the reduction of these and also the reduction of the likelihood that they will occur (SOUZA et al., 2016). The FMEA should be applied to perform the risk assessment, understanding what the impacts on the client will be if a certain function of the process fails (AGUIAR; MELLO, 2008).

For Aguiar and Mello (2008) the Process FMEA can be represented as a sequence of three events defined as Causes, Failures and Effects, as shown in figure 13.

Figure 13 - FMEA of Process



Source: (AGUIAR; MELLO, 2008)

Based on the data researched on the production process of a vehicle exhaust system, the FMEA was developed. In this stage, the FMEA form was completed from the operations carried out in the production process, as detailed in the flowcharts previously presented.

The FMEA form considers the process function (Requirements), which describes a certain stage of the process. In the potential failure mode, we list the variables that can generate future potential failures and the impact of this failure in the process is described in the Potential Failure Effect item. Severity represents the severity of a potential failure effect, that is, a scale ranging from 1 to 10 must be assigned to classify how dangerous (severe) a failure is determined. The main causes or mechanisms that generate or may generate a potential failure are described in the Cause (s) column and Potential Failure Mechanism (s). The occurrence column serves to classify how many times this failure occurs within the production process. As also in severity the occurrence has a fixed table with the occurrence values for errors on a scale of 1 to 10.

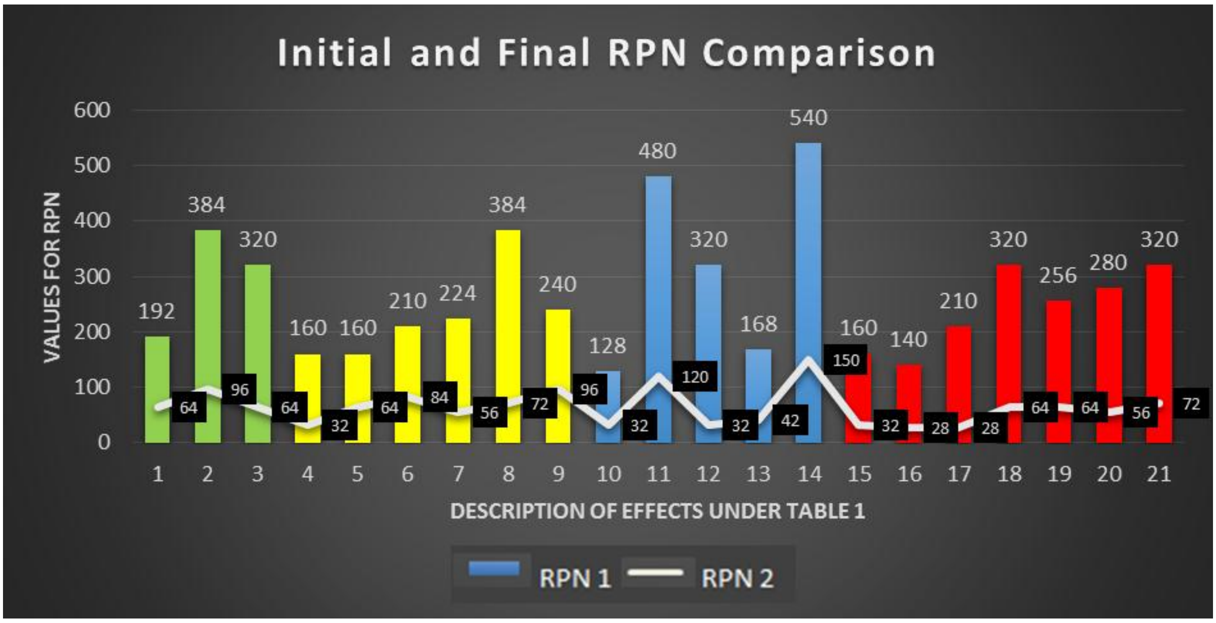
The FMEA form in the Prevent Current Controls column of the process describes the control that is currently applied to prevent any failure from occurring. RPN is the acronym for priority number of risk, calculated by multiplying factors of severity, occurrence and detection. Once the RPN of a particular failure has been calculated, a control plan is then entered for processes with a very high risk priority. The Recommended actions column lists actions to reduce the occurrence or improve the detection of a particular failure. Finally we have the consequences of implementing the actions (Result of actions), which in turn will bring new values for occurrence and detection. Table 1 describes the effects of potential failures in the production process.

Table 1 - Description of Relevant Items Regarding the Effects of the Process FMEA shown in the Chart

Potential(s) Failure(s) effect(s)- Items	Description
1	Cut is inaccurate and damages plate
2	Cut of the plate will be out of specification
3	Variation in product thickness
4	Solidification cracks that damage the product
5	Crack Crater
6	Porosity
7	Lack of fusion
8	Bite
9	Lack of penetration
10	Appearance of bubbles in the product
11	Appearance of rips and holes in the product
12	Variation in product thickness
13	Formation of surface defects
14	Presence of lumps in the piece
15	Scrap Product
16	Waste of raw material
17	Rework in the product
18	Scrap Product
19	Scrap Product
20	Waste of raw material
21	Waste of labor

Source: Developed by the own authors

Graph 1 - Comparison between RPN`s



Source: Developed by the own authors

Table 2 - Complementary Legend for Process FMEA Presented Graphically

Legend	Description
	FMEA Cutting
	FMEA Welding
	FMEA Calendering
	FMEA Folding

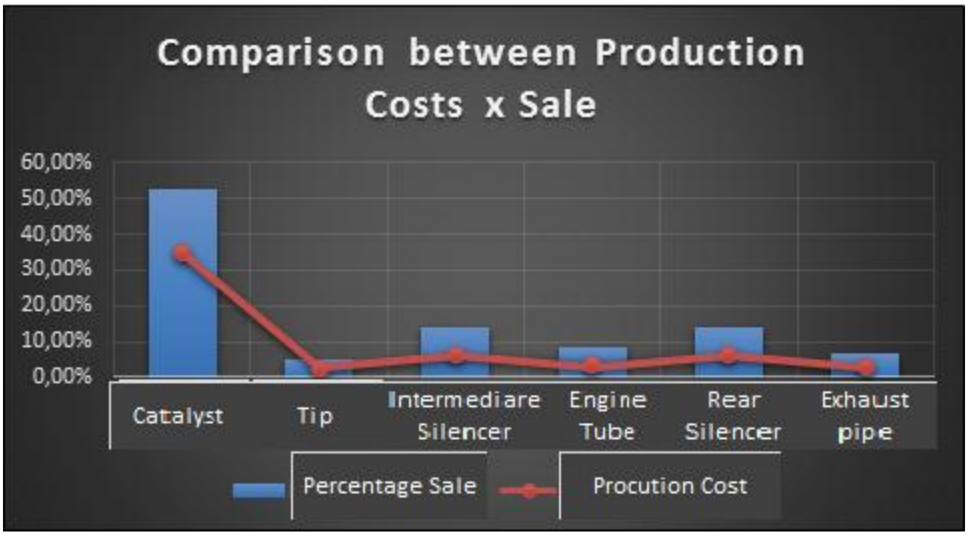
Source: Developed by the own authors

6. CONCLUSION

Through the product "exhaust" that was studied with intensity can observe several characteristics in relation to the same that had not yet been observed by the members of the group, after all, it is very rare for anyone to verify the need to open an exhaust to identify manufacturing processes.

Moreover, based on Graphic 2 below it can be observed that the product in question when efficiently produced in its manufacturing process tends to make profit the company that produces this line of automotive products.

Graph 2 - Simulation of Product Profitability



Source: Developed by the own authors

Calculating based on the information evidenced by the authors of quotations in different stores, it was identified through the whole study on the benefits of its gain in question of production and a form of evidenced a percentage representative in relation to the cost And its average selling price. As a result, it obtained an average of 50% of the proceeds from the sale of exhausts.

Thus, based on this project built through the theoretical study together with the practice, identify a point of view on the theme and a relevance to the work in relation to the same time to the production processes, which have full application of the content Of the discipline taught.

Generally speaking the work group reach the goal sought and achieved the goals presumed by the teacher. In addition, put a theory in practice lived group work, ethics and honesty in the midst of society, which are also core values for the university attended by the group.

REFERENCES

AGUIAR, D.; MELLO, C. H. P. **FMEA DE PROCESSO: UMA PROPOSTA DE APLICAÇÃO BASEADA NOS CONCEITOS DA ISO 9001:2000.** Enegep. **Anais**...2008

ATKINS, P; JONES, L. **Princípios de Química: Questionando a vida moderna e o meio ambiente**. Porto Alegre: Artmed, 1999.

BERTAGLIA, Paulo R. **Logística e gerenciamento da cadeia de abastecimento.** 2ª Ed. Rev. e ampliada. São Paulo: Saraiva 2009.

BROWN, Theodore L. **Química, a ciência central.** São Paulo: Pearson Prentice Hall, 2007

CARDOSO, B. et al. **ANÁLISE DA GESTÃO DE MANUTENÇÃO EM UMA UNIVERSIDADE PÚBLICA NO INTERIOR DO ESTADO DO PARÁ.** Enegep. **Anais**...2016

CHOPRA, Sunil. MEINDL, Peter. **Gerenciamento da cadeia de distribuição:** Estratégia, Planejamento e Operação. 1ªed. São Paulo: Pearson, 2003.

FONSECA, D. C. et al. ANÁLISE DE ARRANJO FÍSICO EM UMA EMPRESA DE

REFINAMENTO DO SAL. **Enegep**, 2016.

FONSECA, Martha Reis. **Físico-Química: textos e atividades complementares**. São Paulo: FTD, 2007

IQA - Instituto de Qualidade Automotiva (Ford, Chrysler, General Motors). **Planejamento Avançado da Qualidade do Produto e Plano de Controle.** 1º Ed. 1994.

MENEGHINI, C.; ZAIONS, D. **A MANUTENÇÃO CENTRADA EM CONFIABILIDADE APLICADA A UM SISTEMA DE EMBALAGEM DE ALIMENTÍCIA**Anais Enegep. **Anais**...2016

PMI, PMBOK ® Guide - **A Guide to the Project Management Body of Knowledge – Project Management Institute** – 2008**.**

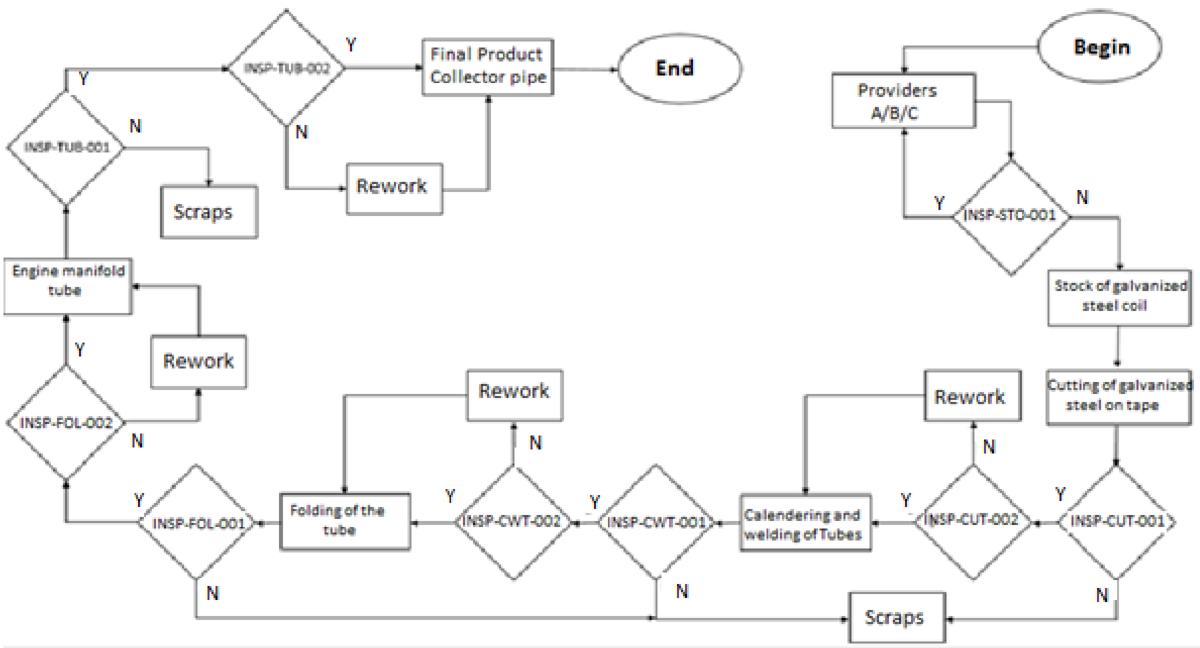
RIBEIRO, J. et al. **ANÁLISE DA ALTERAÇÃO DE ARRANJO FÍSICO NA PERSPECTIVA DOS SETE DESPERDÍCIOS: UM ESTUDO DE CASO EM UMA MONTADORA DE IMPLEMENTOS AGRÍCOLAS**Enegep. **Anais**...2016

SLACK, Nigel. CHAMBERS, Stuart. JOHNSTON, Robert. BETTS, Alan. **Gerenciamento de Operações e de Processos:** Princípios e pratica de impacto estratégico. Bookman, 2008.

SOUZA, G. et al. **APLICAÇÃO DOS METODOS DFMA E FMEA EM UM LAPTOP INFANTIL**Enegep. **Anais**...2016

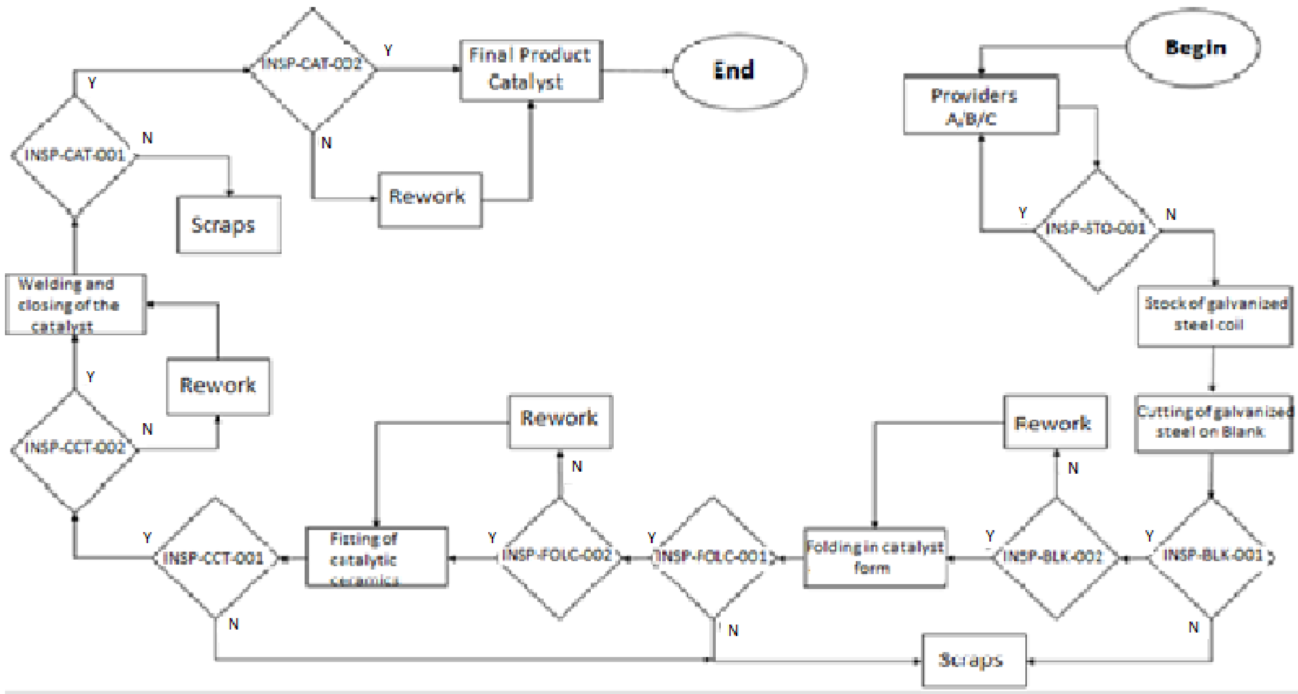
ANNEXES

Exhaust Pipe Production Flowchart



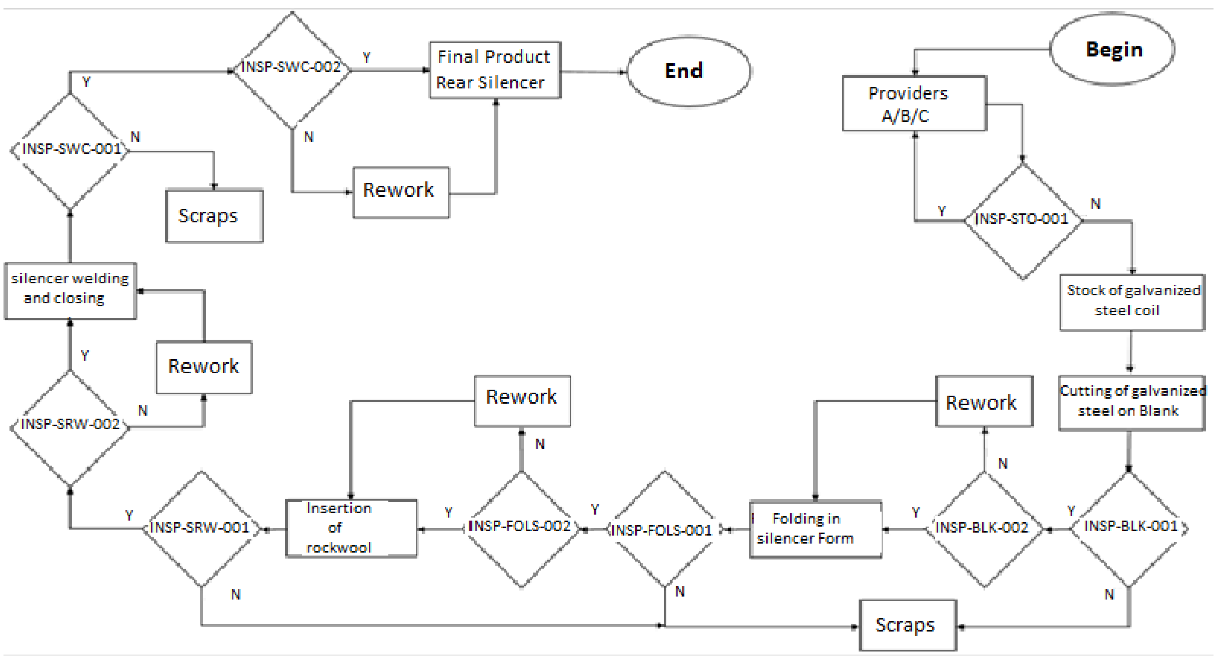
Source: Developed by the own authors

Catalyst production flowchart



Source: Developed by the own authors

Silencer production flowchart



Source: Developed by the own authors

Assembly and Welding of the Flange in the Tube and the Tube in the Catalyst

Op	Description	Criterion	Control Means	Frequency
1	Flange Mounting and Welding on the Tube and the Catalyst	Solder free of splashes, pores, carpings, bites and cracks	Visual	100% Record 1 every 10
		Check Flange Alignment	Caliber	100% Record 1 every 10
		Check for a hole in the flange tube Sensor O_2	Visual	100% Record 1 every 10
		Check for hook clip	Visual	100% Record 1 every 10
		Verify the presence of the bracket (2x)	Visual	100% Record 1 every 10

Source: Developed by the own authors

Intermediate Silencer Mounting and Welding with the Catalyst

Op	Description	Criterion	Control Means	Frequency
2	Mounting and Welding Intermediate Silent with the Catalyst	Solder free of splashes, pores, carpings, bites and cracks	Visual	100% Record 1 every 10
		Dimension of 300 ± 5mm (Catalyst and Silencer)	Measure tape	First and last piece of the lot. 100% Record 1 every 10
		Check the clamp	Visual	100% Record 1 every 10
		Alignment and leveling between silencer and catalytic converter	Inspection table and Set-square	100% Record 1 every 10

Source: Developed by the own authors

Mounting and Welding Back Silencer with Intermediate Silencer

Op	Description	Criterion	Control Means	Frequency
3	**Silencer rear mounting and welding with the intermediate silencer**	Solder free of splashes, pores, carpings, bites and cracks	Visual	100% Record 1 every 10
		Dimension of 650 mm ± 7 mm (Inter and Rear Silence)	Measure Tape	First and last piece of the lot. 100% Record 1 every 10
		Alignment and flatness between silencers Inter. and Rear	Ruler and set-square	First and last piece of the lot. 100% Record 1 every 10

Source: Developed by the own authors

Mounting and Welding Back Silencer with Tip

Op	Description	Criterion	Control Means	Frequency
4	Mounting and Welding Back Silencer with Tip	Solder free of splashes, pores, carpings, bites and cracks	Visual	100% Record 1 every 10
		Dimension of 450 mm ± 7 mm (Inter and Rear silencer)	Measure tape	First and last piece of the lot. 100% Record 1 every 10
		Check the clamp	Visual	100% Record 1 every 10
		Check for hook clasp	Visual	100% Record 1 every 10

Source: Developed by the own authors