ANALYSIS OF AN INTEGRATED MANUFACTURING SYSTEM IN THE AUTOMOTIVE PAINT DEPARTMENT OF THE DACIA FACTORY IN MIOVENI

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Rezumat. *În departamentul de vopsire există o gamă largă de procese datorită complexității acestei operații, pornind de la procesele automatizate de tratare a suprafeței tablei, depunerea electrostatică a stratului de cataforeză prin imersie în baia de vopsea, pregătirea prin șlefuire a stratului de cataforeză. , aplicarea masticului de etanșare și antigravitație atât manual cât și robotizat, pregătirea și aplicarea robotizată a straturilor dure, pregătirea și șlefuirea înainte de aplicarea straturilor de bază și a lacului în procese manuale și robotizate, uscarea diferitelor straturi aplicate prin trecerea lor prin cuptoare. uscarea, si nu in ultimul rând, șlefuirea eventualelor defecte minore și pregătirea caroseriei finite pentru livrarea la compartimentul de Asamblare Generală. Prin urmare, având o gamă diversificată de procese în cadrul Departamentului de Vopsire, sunt prezentate și exemplificate toate caracteristicile întâlnite în cadrul acestui sistem de producție.*

Abstract. *In the Painting department, there is a wide range of processes due to the complexity required for this job, starting from the automated processes of sheet surface treatment, electrostatic deposition of the cataphoresis layer by immersion in the product bath, preparation by sanding the cataphoresis layer, application of sealing and anti-gravity mastic both manually and robotically, preparation and robotic application of hard layers, preparation and sanding before the application of base layers and varnish in manual and robotic processes, drying of the various applied layers by passing them through ovens drying, and last but not the least, sanding possible minor defects and preparing the finished body for delivery to the General Assembly department. Therefore, having a diverse range of processes within the Dyeing Department, we were able to present and exemplify all the features encountered within a manufacturing system.*

Keywords: Production, Industrial flow, Automation, Dyeing Department

1. Introduction: the manufacturing system

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Manufacturing system means all the material and non-material components that compete to make a product and that are grouped in time and space in a well-determined way. (Fig. 1)

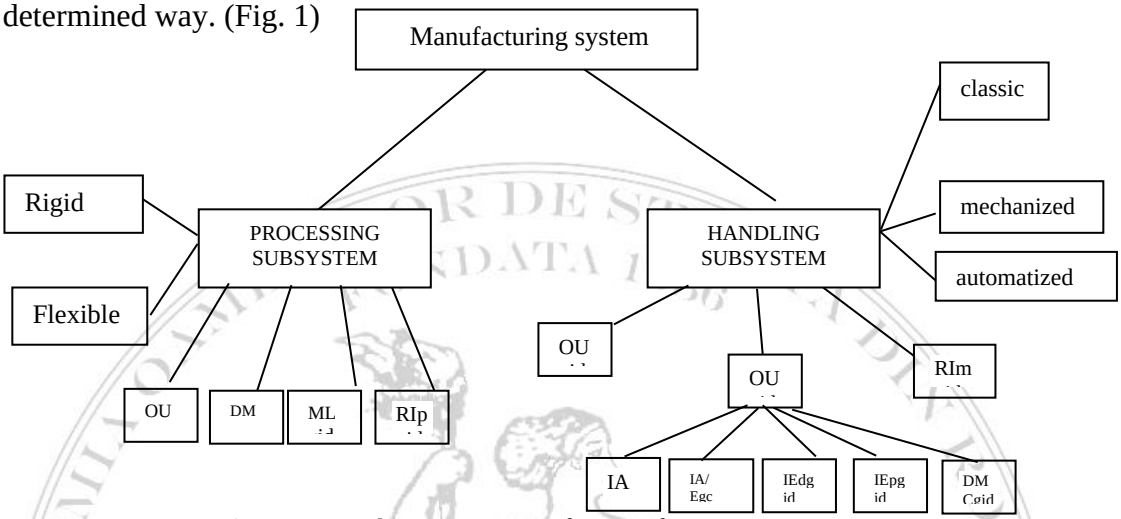
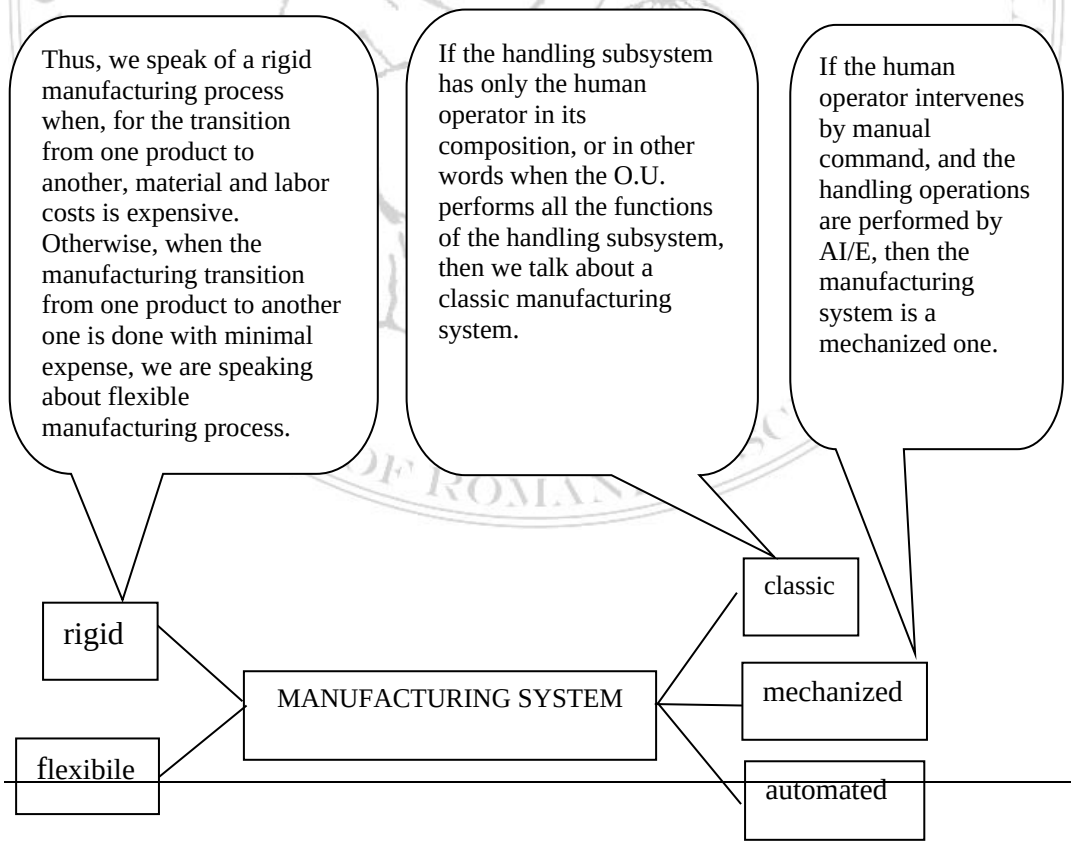


Fig.1 Structural representation of a manufacturing system.

Manufacturing process means all the activities that compete with manufacturing. (Fig. 2)



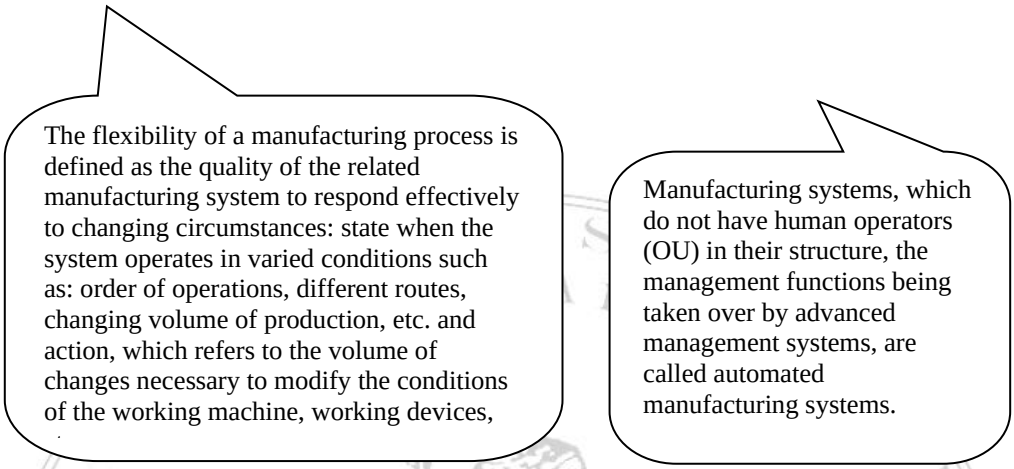


Fig. 2 Manufacturing system activities

Into the manufacturing process, two types of operations appear:

- processing operations (Fig. 3)
- handling operations (Fig. 4)

The processing subsystem.

Processing operations are those components of the manufacturing process in which the object of work changes its shape, state of aggregation, structure or surface quality.

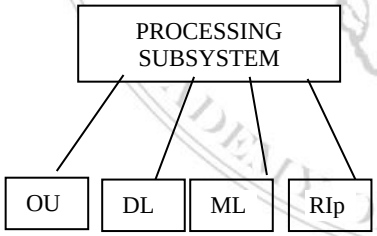


Fig. 3 Processing subsystem

OU - the human operator

DL - working devices

ML - working machines

R.I.p – the industrial processing robots

OU
Human operator
Manual operation with the people's help.

DL
Working device

Assembly device

OU

The human operators in the processing system are the people who carry out the processing, grinding and application of various layers of paint, varnish, etc. on the body.
In the painting department, there are operations carried out with human operators, for the sanding of defects on the layers of cataphoresis, finishing and painted bodywork, for manual aplication of mastic, paint and varnish.

DL

The working devices are the devices needed to carry out the assembly operations of the various parts of the body.
In the painting department, work devices are used only in the preparation area for assembling the fuel hatch on the body.
To be more eloquent, in the above example we have a picture of a right front door assembly device.

ML
Working machine

Grinding machine

R.I.p
Industrial processing robot

Painting robot

ML

The work machines are the machines with which human operators carry out their activity within the manufacturing process.
In a painting department, the most used work machines are the grinding and polishing machines used to eliminate possible defects after the application and drying of each applied layer (cataphoresis, finish, base, varnish).

R.I.p

The industrial processing robots are the robots that, after performing the established operations, help to change the characteristics of the part or, in the case of our example, the entire body.
Within the Paint Shop there are industrial processing robots for mastic application, primer, base and varnish application operations.

The handling subsystem.

The handling operations are those components of the manufacturing process through which the work object changes its situation (position and orientation in space).

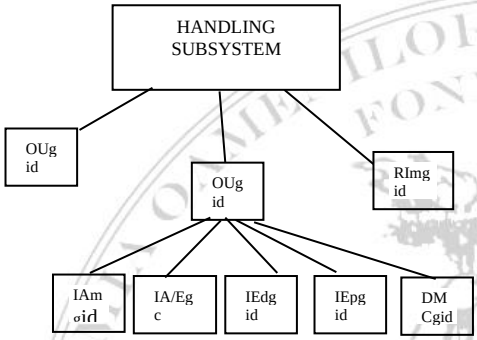
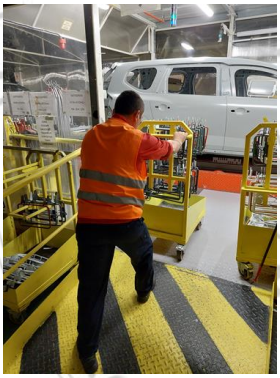


Fig. 4 Handling subsystem

The handling subsystem performs the handling operations specific to the manufacturing process and consists of:

- human operator **(O.U.)**
- industrial handling robots **(R.I.m)**
- supply and exhaust installations (**I.A/E.**), which in turn can be: installations bringing raw materials (**I.A.m**)
- tools and devices bringing and evacuating installations (**I.A/Esc**)
- waste disposal facilities (**I.E.d**)
- measurement and control devices (**D.M.C.**).



OU

A human operator in a handling system is a person who works in the manufacturing process, but who does not contribute to changing the product's characteristics, but only performs manipulation and movement operations of certain parts, machines, etc.
In the painting department from Mioveni, there are only two positions where human operators are used for manipulation, to carry out the operations of supplying devices and cycling parts.

R.I.m

The industrial manipulation robots are robots that only perform operations of handling parts or machines, not bringing any change to the manufactured part, but only helping other installations or robots in carrying out their operations.
In the painting department, we meet this type of robots on the paint application lines in the engine compartment areas. They carry out the operation of lifting, maintaining and lowering the front hoods, to allow the painting robots to have access to the areas where they carry out their activity.

I.A.m

Installations bringing materials and raw materials, are the installations with which the workstations are transported and supplied. In the attached figure is an AGV that transports materials and shutters from the storage area to their assembly station.

I.A/Esc

Installations bringing and removing tools and devices, are similar to I.A.m with the only difference that they do not transport raw materials or materials and carry out the transport of tools or working devices.
In the painting department, we have a single installation for transporting the front end and rear hood support devices necessary for the flow in the Mastic workshop area.

I.E.d

The waste disposal facilities are the facilities that transport the waste resulting from the operations of the manufacturing system to the waste storage areas.
In the attached image we have the installations for separating paint residues from the water used for the vapor collection curtains in the paint application cabins.

D.M.C.

Measuring and control devices are the devices used to verify and control the conformity of paint layers.

Production flow of the Dyeing department

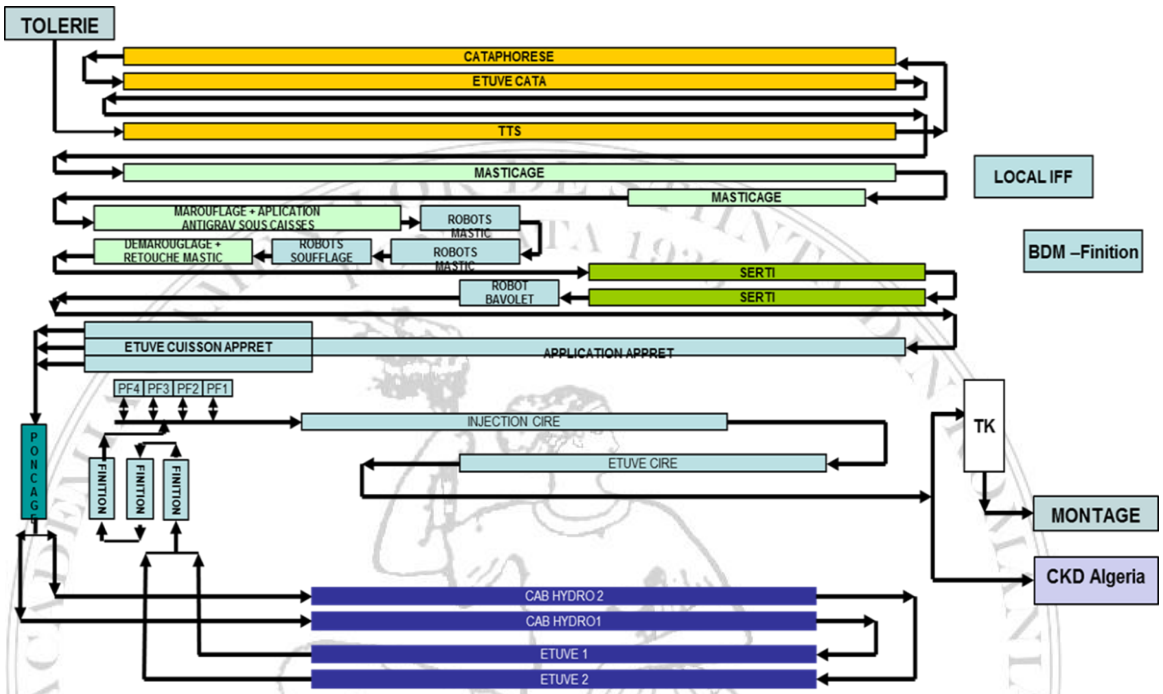


Fig. 5 The representative Scheme of the Dyeing Flow

In the Figure 5, is presented the manufacturing flow diagram of the Painting Department of the Dacia Mioveni factory.

The manufacturing flow, or the route of a car body from the entrance to the painting Department to the entrance to the assembly Department, goes through the following manufacturing processes, divided into three large manufacturing areas, during 6 manufacturing hours.

The three main areas in the painting department are: the TTS-Cataforeza area, the Mastication Area and the ABV Area (application of primer, base and varnish).

The first manufacturing area is the TTS-Cataphoresis area, which includes the degreasing and surface treatment tunnel (TTS) of the bodies composed of 10 stages of body immersion and intermediate stages of body washing by high-pressure spraying between them. All 10 stages of body surface preparation contain

various corrosive products and surface treatment, to properly prepare the surface for the application of the cataphoresis layer. The basins contain heated industrial water, degreasing and fluffing substances, phosphating bath, washing with used and clean demineralized water.

Cataphoresis is composed of four main baths for immersion in the product and stages of washing with UFN liquid (obtained by ultrafiltration of the liquid from the cataphoresis bath), the four baths are combined into one bath of 300 cubic meters of cataphoresis in which the process of its deposition on body is made by electrostatic deposition by immersion in the product bath and three washing baths after this with liquid obtained from ultrafiltration of the product in the cataphoresis bath.

The first big process ends with the passage of the car body for 45 minutes through a drying oven that has about 160 linear meters and a maximum temperature reached on the part of about 190°C.

TTS Zone Flow - Cataphoresis (Fig. 6)

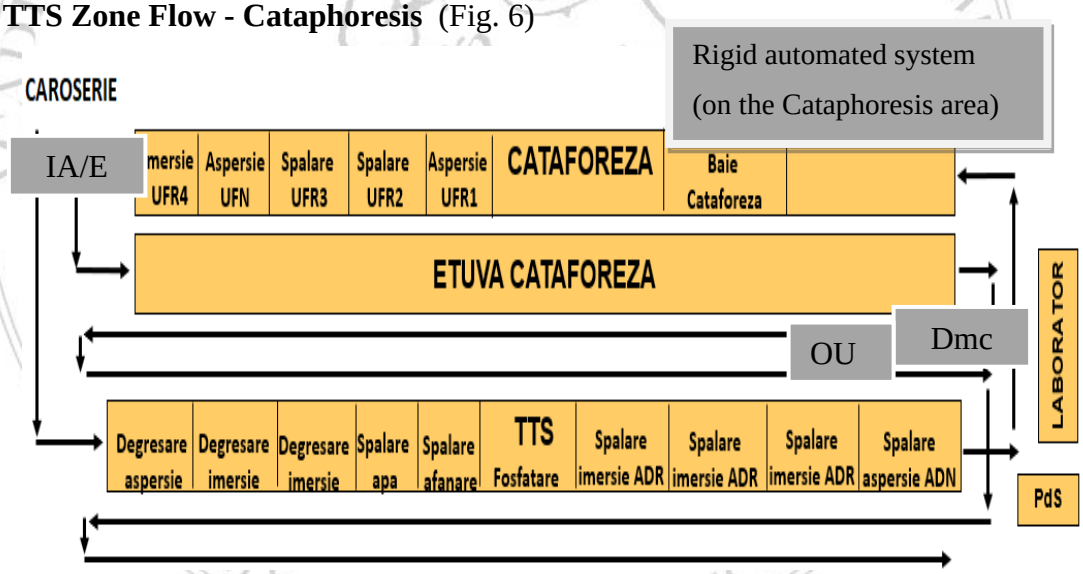
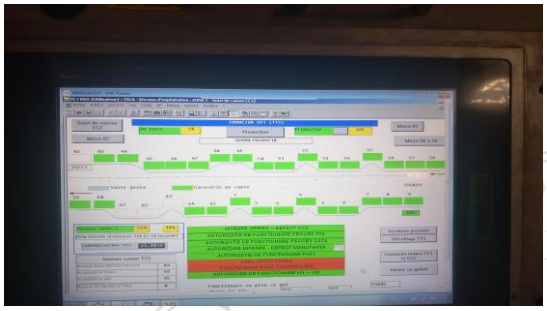
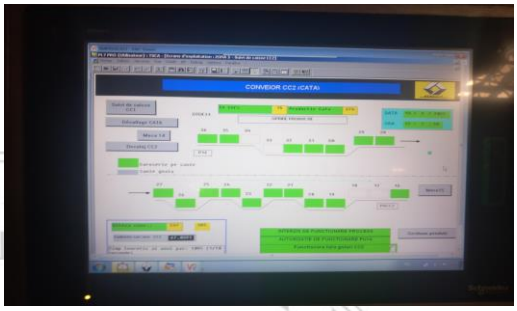


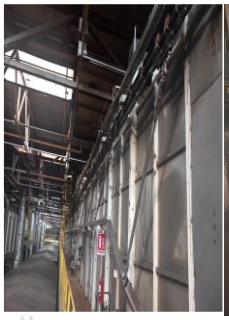
Fig.6 TTS zone Flow cataphoresis



Display body traceability tracking to ensure conformity of process parameters on the TTS area



Display tracking of bodywork traceability to ensure compliance with process parameters in the Cataforeza area



Transfer of the bodywork inside the bathroom areas TTS degreasing and cataphoresis application with the help of transport pendulums

Car body transport outside the bathroom areas with the help of roller tables

Automatic transfer throughout the TTS Cataphoresis area, by suspending the bodywork on pendulums transfer bathrooms (TTS Cataphoresis area), transfer tables between the TTS line and Cataphoresis and Cataphoresis and Etuva, conveyor in the cataphoresis oven.

Car body washing with high-pressure spray nozzles to remove possible impurities

Car body washing with high-pressure spray nozzles to remove possible impurities (spray washing after each stage/bath).

Electrostatic cataphoresis layer deposition process by immersing the car body in the product bath.

Automated flexible system (on the TTS area)

In the TTS area, the system is automated and flexible, in this area of the paint shop the diversity mix of the bodywork does not matter for carrying out the surface treatment process of the bodywork.

Rigid automated system (on the Cataphoresis area)

On the Cataphoresis line, the system is automated, rigid, because in order to be able to maintain the process parameters imposed for the area of the cataphoresis bath, the mix of introduced bodies cannot be random, but is well established in order not to compromise the quality of the car body.

The second large area of the Painting Department is the Mastic Workshop area, which includes grinding operations for the preparation of the bodies after application and drying of the cataphoresis layer, mastic application operations in both manual and robotic processes, and operations for mounting pellets and shutters to achieve the tightness of the car bodies on the areas of technological holes for piloting and assembly of the bodies.

Cataphoresis leakage removal operation by sanding after drying the primer layer.
Human operation by checking the entire car body assembly and polishing any defects generated in the cataphoresis process.

The cataphoresis sanding area is provided by four people.

Mastic application operation on both interior and exterior areas in areas difficult to achieve by mastic application robots.

The estimated percentage of mastic application in the manual process is 40%.

Robotic mastic application operation both inside the bodywork and in the area under the bodywork, in the process of sprayed, extruded and anti-gravity mastic application.

The estimated percentage of robotization of the mastic workshop being 60%.

The third and last of the processes of the Painting Department is the ABV Workshop (Primer, Base, Varnish).

This workshop includes most of the activities within the department and is the workshop responsible for the conformity of the quality of the car bodies delivered to the General Assembly Department.

The activities in this workshop are:

The bodywork preparation area before applying the finishing layer, by completely wiping the bodywork with a cloth to remove any impurities on the cataphoresis layer.

The primer application area on the outer area of the car bodies, operation carried out robotically in three types of primer color and respectively two layers of application, to achieve the correct application of the base (color) on the car body.

The finishing layer has the role of uniformizing or preparing the layer before applying the paint.

After the hardening application operation, the car bodies are directed to three ovens for their drying, which increase the temperature of the car body to a maximum of 140°C for 40 min.

After the drying of the finishing layers, the car bodies are directed to the preparation area by sanding and erasing defects on the finishing layer, an operation performed entirely by hand.

After preparing the car bodies, they are directed on two application lines, base and varnish, lines being positioned in parallel.

On the base and varnish application lines, the processes are both done manually (when carrying out the inside painting operations of doors and door panels) and robotically with the help of industrial robots for painting and manipulation, used to keep the hoods in an open position.

Robot manipulator for holding open the front hood and rear hood and robot for applying paint based on the interior area of the engine compartment and trunk.

Robots for applying base layers and varnish on the entire car body assembly.


Manual application operations of the base and varnish on the area of door frames and door caissons.

Installation operation of the fuel hatch on the car, done manually by riveting it.

The last process, but also the most important, is the finishing process with the Zebra C/R verification area (verification and retouching), where the 100% verification operation of the car body assembly is carried out, the retouching of any defects and their validation for promotion to the General Assembly department.

C/R line (check and retouch) body validation for delivery to the General Assembly Department

Conclusions

In a painting department, we can meet all the peculiarities and components of a production system, both flexible in certain areas and rigid, due to the complexity and importance of both aesthetics and protection of the car body made in this process.

The painting department is the area with the greatest importance, considering that here all the sheet metal treatment processes are carried out to

ensure its anti-corrosion, but also the future tightness of the car by applying layers of sealing mastic and shutters, and not least in this department, the body gets the color and shine that makes it attractive and scalable to future customers.

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