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Study of the economic and technic viability on the manufacturing process of a heatshield

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TREBALL DE FI D'ESTUDIS

1 Abstract

Alustamp is a +35-year company of Cataluña with an extensive experience in metal stamping within the automotive industry. Nowadays the company has expanded to cover the requirements from customers, and it has plants in Terrassa, China, Slovakia, and Mexico.

Alustamp has over 750 employees worldwide, it has a global turnover of ~80 M€.

In Alustamp I'm part of the HQ team in Terrassa, working in the Commercial department as project manager, I'm the main contact between the customer and the different plants of the group, and I'm in charge of the KPI report and tracking of the project's milestones.

The project started 6 years ago its production in Alustamp in Spain, as the volume was low, it was designed to fit in 2 manual presses with a total of 5 operations, 2 in the first press and 3 in the second press. The process was never stable, always having significant quantities of scrap requiring actions in the tools constantly.

For this reason, the aim of this project is the study and the implementation of the movement of a manual process to an automatic process because of an increase in requirements and also the modification of the part from flat material to embossed, to reduce the actual issues.

In the study, there are 3 selected scenarios among the rest, as the most feasible, they are analyzed and compared in detail.

The **first scenario** will be the impact of keeping the part in a manual process. It will be analyzed the feasibility of modifying the actual tools, the time to implement the modification, the time and cost of the safety stock, and finally the capacity of the current press to keep manufacturing the part with higher requirements.

The **second scenario** will be the movement of the process from manual to automatic keeping the same tools and adapting them to an automatic press; this will also take into account the time to implement the modification, the time, and the cost of the safety stock.

The **third scenario** and last study will consider the construction of new tools for an automatic process, timing, and cost impact.

After the analysis done, it was detected that the best scenario is the second one, as it has the same piece price and press capacity as the scenario 3, and slightly better in investment, turnover and timing compared to scenario 1.

The Scenario 1 is really good for timing and investment, but these 2 criteria are not the most relevant ones, remarking that the low capacity of the manual press may endanger the deliveries of this and other projects.

Finally, the next step for this project is that it will be presented to Alustamp management in April 2022, if approved any of the scenarios, it will be proposed to customer to acquire the approval and if approved will be launch in early summer 2022.

2 Abstract (Spanish)

Alustamp es una compañía con más de 35 años de Cataluña con una amplia experiencia en la estampación mecánica dentro del sector automotriz. Hoy en día la compañía se ha expandido para cubrir los requerimientos de sus clientes y tiene plantas en Terrassa, China, Eslovaquia y México. Alustamp tiene más de 750 empleado alrededor del mundo y tiene una facturación global de más de 80 M€.

En Alustamp soy parte del equipo de HQ en Terrassa, trabajando en el departamento comercial como gestor de proyectos, soy el principal contacto entre el cliente y las diferentes plantas que tenemos y estoy a cargo del reporte de KPI de los milestones del proyecto.

El proyecto empezó hace 6 años su producción en Alustamp en España, dado que el volumen era bajo, fue diseñado para producir en 2 prensas manuales con un total de 5 operaciones, 2 en la primera prensa y 3 en la segunda prensa. El proceso nunca fue estable, siempre tuvo grandes cantidades de scrap, por lo cual requería acciones del equipo de utillajes constantemente. Por esta razón, el objetivo de este proyecto es el estudio y la implementación del movimiento de un proceso manual a un proceso automático, dado que el proyecto ha recibido un incremento en las necesidades y también la modificación de la pieza de material liso a material gofrado, para mitigar los problemas actuales.

En este estudio se han seleccionado 3 escenarios entre varios, los más factibles, estos serán analizados a detalle por separado y en conjunto.

El **primer escenario** será el impacto de mantener la pieza en una prensa manual. Se analizará la factibilidad de modificar los utillajes actuales, el tiempo para implementar la modificación, el tiempo y coste del stock de seguridad y finalmente la capacidad de la prensa actual para seguir fabricando la pieza con el incremento de necesidades.

El **segundo escenario** será el movimiento del proceso de manual a automático manteniendo los mismos utillajes y adaptándolos a una prensa automática; este escenario también tomará en cuenta el tiempo en implementar la modificación, y el coste y tiempo necesario para realizar el stock de seguridad.

El **tercer escenario** y último estudio considerará la construcción de nuevos utillajes para un proceso automático, el plazo y el coste.

Una vez el análisis fue realizado, se ha detectado que el mejor escenario es el segundo, dado que tiene el mismo precio pieza y capacidad de prensa que el tercer escenario y es ligeramente superior en inversión, turnover y plazo comparado con el escenario 1.

El escenario 1 es muy bueno en plazo e inversión, pero estos 2 criterios no son los más relevantes, es importante remarcar también la baja capacidad con la que cuenta la prensa manual, la cual pondrá en peligro la entrega de piezas de este y otros proyectos.

Finalmente, los siguientes pasos a seguir en el proyecto son presentar a la gerencia de Alustamp en abril de 2022, si es aprobado cualquiera de los escenarios, se presentará a cliente para obtener su aprobación y en caso positivo se lanzará el proyecto a inicio de verano 2022.

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3 Aim

The aim of this project is the study and the implementation of the transference of a manual process to an automatic process because of an increase in requirements and also the analysis of the part or process to reduce the current issues.

4 Scope

As the project is increasing the volume of requirements, the current issues will be increasing proportionally to the volume, for this reason is important to take action on time to avoid increasing the issues to the plant.

One part of the project is the analysis of keeping the project in a manual press or moving to an automatic press, this will create together with the next part different scenarios, but there is nothing else to be done to solve the capacity issue.

The second part of the project consist in improving or solving the current issues of the heatshield, these current issues have different approaches that will be explained below with a brief analysis of why or why not will be considered for this study.

- Change of material, this may solve some or all of the current issues but involves a deep analysis, prohibitive cost as it demands the modification of the tools or even new tools and also the approval of the customer, which will have to validate if this new material would cover the current requirements or improve them.
- Embossing of current material, this is a fast and short implementation that may work as well as the change of material, the embossing improves the behavior by adding more material while keeping the same thickness, the adjustment in the tool will be minimum and customer must be consulted but as the material does not change it will not affect the requirements.
- Tool adjustments, the project is quite old, and several adjustments have been done, polishing, move of stoppers, coating of the tool, they reduced the scrap and issues, but the current status is the best it was able to achieve with tool fine tuning, this will not be analyzed as there are no further actions that can be done.
- Blank size increase, this is a double edge solution that has been tried in the past, while this solves the short part issue (explain in the work), it worsens the other issues, for this reason and also that it involves increasing the scrap and cost of the part, it will not be considered to this analysis.

Finally taking into account the above explanation, it was chosen for this project to only focus in the next 3 feasible scenarios:

The **first scenario** will be the impact of keeping the part in a manual process and all the on cost this will have. It will be analyzed the feasibility of modifying the actual tools, the time to implement the modification, the time and cost of the safety stock, and finally the capacity of the current press to keep manufacturing the part with higher requirements.

The **second scenario** will be the movement of the process from manual to automatic keeping the same tools and adapting them to an automatic press; this will also take into account the time to implement the modification, the time and the cost of the safety stock.

The **third scenario** and last study will consider the construction of new tools for an automatic process, timing, and cost impact.

For all the scenarios it will be analyzed the scrap of the part (in order to improve it as much as possible with the modification).

At the end of the studies, they will be compared considering the cost of the change, the timing, the cost of the new part and the capacity of the press.

5 Specifications

- The heatshield must be feasible for cold stamping.
- The heatshield must be of aluminum 1050 embossed and beaded all around.
- In this project, all the values will be slightly modified because of data protection for Alustamp but keeping the balance between the options.
- The process must be capable to produce 250 000 parts per year +/- 15%.
- The tools must be able to produce at least 10 years.
- The new heatshield must have the same or better modal response.

6 Justification

On of the most advanced metal processing method is the cold stamping, which is mainly used in the sheet metal processing, for this reason sometimes is also called sheet metal stamping, it is a method that consists in putting pressure over the sheets at room temperature, to deform them to be adapted into the stamping mold, this is done because of the plastic deformation of the metals. As a result, you get the sheet with the form and size of the mold.[1]

In Alustamp we use cold stamping as our material is normally almost pure aluminum (99%) between the ranges of 0,4-0,8 mm thickness, which does not require high strength for the deformation, it is below 1000 MPa that is the maximum strength for cold stamping, if the strength required is greater than this, it is necessary to apply temperature in the process and then use hot stamping.[2]

[1] *Theories Methods and Numerical Technology of Sheet Metal Cold and Hot Stamping*
[2] *Theories Methods and Numerical Technology of Sheet Metal Cold and Hot Stamping*

Even Cold stamping is appropriate in the line of work of Alustamp, it has its downsides, cold stamping produces high strength and thinning in the material, these 2 factors worsen the formability, which will make it easier for the material to spring back to its previous shape[3], which does not happen in the warm stamping, as the material is heated, and it is not necessary high strength. In Alustamp particular case, as it works with Aluminum and low thicknesses this spring back almost never happens, but it is always controlled as it is a known risk.

"Robotic companies sell 5 times more than the traditional ones, generate 4 times more added value and export 7 times more"[4] it is a fact that the industrialization of the companies improves their growth in the majority of the cases, but this "improvement" has its pros and cos, I will detail below the most important remarks that should be done regarding the industrialization of companies.

- "The automatization of industry sets on risk at least 14% of the actual Jobs and up to the 21,7% in Spain, the adaptation is going to be difficult"[5] , the industrialization is risking the economics of numerous families around the world, the machines are taking the place of the people, making everything better, without breaks and with repeatability. The same machines that humanity is creating are putting in risk the jobs of millions of people, this will have to impulse a new system, organization, or distribution of wealth, but for the moment nothing is written on stone.
- "Spain is the European second place in the automatization of business, 70,4% of the Spanish business have automatized some of their main tasks"[6] Even with all this industrialization in Spain, the numbers of Spain economy are different for the ones presented at the start of this section, after the analysis of 5.551 business along 25 years, it has been seen that the productivity is only 1,4 times higher compared to businesses without automatization, and the labor cost has not increased significantly, the study reports the payrolls have increased only 1,2 times[7]. This only shows that it is not only necessary to incorporate the technology in the industry, but we also must know how to use it and obtain the maximum profit of the technology, by itself it is proved that improves the numbers, but with knowledge and integration, it can raise the productivity from 1,4 times to 4 times.
- Focusing on Spain, it has a bigger issue, one of Spain's economy pillars is production, and since it is a first world country it means higher costs of labor, making mandatory to Spain to automatize as soon as possible it's plants, to keep being competitive in the global market, compared with countries that manufacture the same but with less labor cost. With the COVID situation this has just gotten worse, the Spanish economy fell in the first and second trimester of 2020 5,2% and 17,8% respectively[8].

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[3] He, B., Hu, P. & Ying, L., 2016. Hot Stamping Advanced Manufacturing Technology of Lightweight Car Body. Beijing: Springer & Science Press Beijing.

4 https://aecconsultoras.com/noticias-sectoriales/explotar-los-beneficios-de-la-automatizacion-la-asignatura-pendiente-de-la-industria-espanola/

5 https://retina.elpais.com/retina/2019/05/24/tendencias/1558680372_855666.html

[6] https://cuadernosdeseguridad.com/2019/10/espana-automatizacion-digitalizacion/

[7] https://aecconsultoras.com/noticias-sectoriales/explotar-los-beneficios-de-la-automatizacion-la-asignatura-pendiente-de-la-industria-espanola/

[8] https://www.infoplc.net/noticias/item/108989-presente-futuro-automatizacion-robotica-espana

In the actuality Alustamp has a current heatshield that delivers 150 000 parts every year. The heatshield is done of aluminum 1050 flat, is beaded all around and it is done in a manual press; It has 3 cushions that are assembled by an auxiliary machine.

Customer is now going to use this project to adapt to the new models and an increase of volume up to 200 000, as the new platform will be used in more vehicles.

For this project we will define different scenarios and bring the best proposal for Alustamp and the customer, considering the feasibility and costs.

7 Background

Alustamp is a +35-year company of Cataluña with an extensive experience in metal stamping within the automotive industry. Nowadays the company has expanded to cover the requirements from customers, and it has plants in Terrassa, China, Slovakia and Mexico.

Alustamp has over 750 employees worldwide, it has a global turnover of ~80 M€.

In Alustamp I'm part of the HQ team in Terrassa, working in the Commercial department as project manager, I'm the main contact between the customer and the different plants from Alustamp, and I'm in charge of the KPI report and tracking of the project's milestones.

The project started 6 years ago its production in Alustamp in Spain, as the volume was low, it was designed to fit in 2 manual presses with a total of 5 operations, 2 in the first press and 3 in the second press. Most of the projects in Alustamp are embossed to allow the flow of the material and avoid cracks in the parts, but this project by internal mistake was done in smooth material.

Even it is said that the embossing reduces the tensile strength and the total elongation decreases[9], this is partial true, because this is true if we consider the same amount of material. For example, if we take a flat 50x50 cm aluminum foil, and we emboss it, it will reduce its size to maybe 45x45 cm (It is mentioned maybe, as the embossing can be done in multiple ways and heights). If at this point, we pretend to get the same shape with both blanks, it is clear that the material embossed will be more propense to crack or even falling short of material. But when we say that we will use now embossed material instead of flat for this project, we mean the same size of foil after the embossed process, this means that in the same 50x50 cm we will have more material, as it is embossed, allowing it to flow even more compared to the flat material.

The fine-tuning was long, and the process was never stable, always having vast quantities of scrap (Table 1. Scrap and downtime evolution) and requiring actions in the tools constantly.

[9] Lizuka, T., 2012. *Research Gate.*

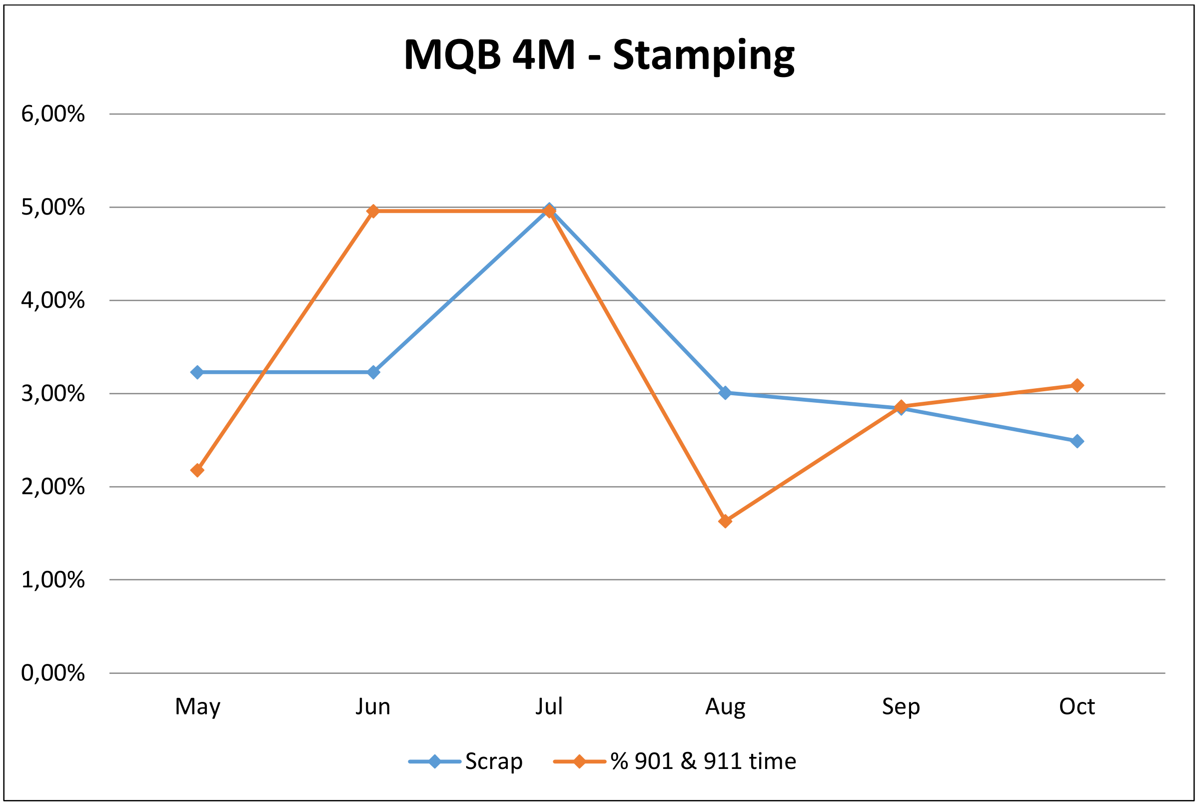

Table 1. Scrap and downtime evolution

8 Current situation

The process consists of 5 operations as explained before, each step will be explained below and afterward will be explained the current issue at the plant:

- OP20 Deep Drawing: In this step we give the general geometry of the part, except possible negative areas, or areas that may be critical for the stamping, in the Figure 1. Deep Drawing it can be appreciated the blank as a big brown rectangle and the tool that gives the shape to the part in blue.

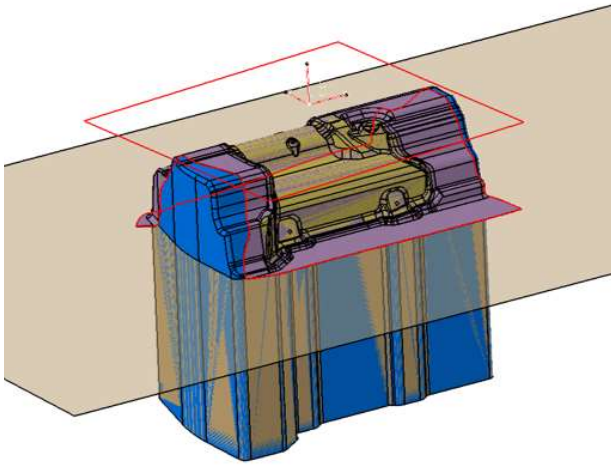

Figure 1. Deep Drawing

- OP30 Cutting: In this operation we cut the material that is scrap/not used in the part, in the Figure 2. Cutting we can appreciate the green area as scrap that is out of the contour of the part.

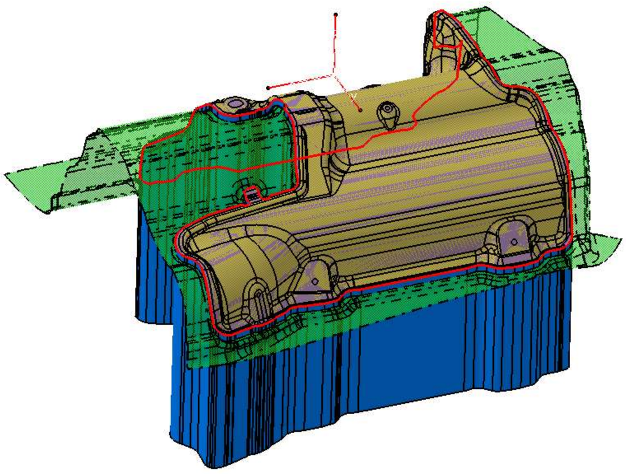

Figure 2. Cutting

- OP40 Bending up: This operation and the next one is only requested by some customers; we do a bending all around the part to avoid any possible injury of the customer operators while manipulating the part (as the part is aluminum of really low thickness it is really easy to cut yourself with it). In this first step, as seen in the Figure 3. Bending up, we only do the forming up of all the contour of the part (red area in the picture), we leave all the border with a 90º angle that will be closed in the next operation step.

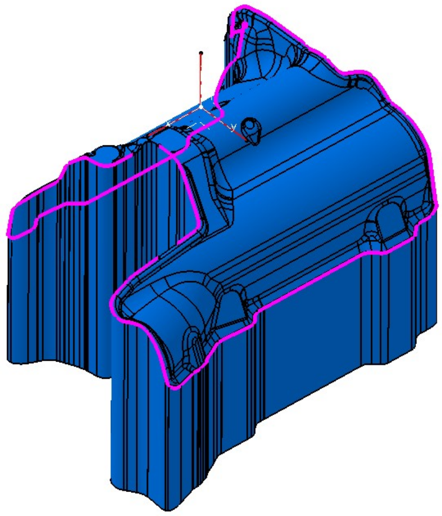

Figure 3. Bending up

- OP50 Folding: In this operation we close the bending/hemming all around the part, to avoid the sharp edges.

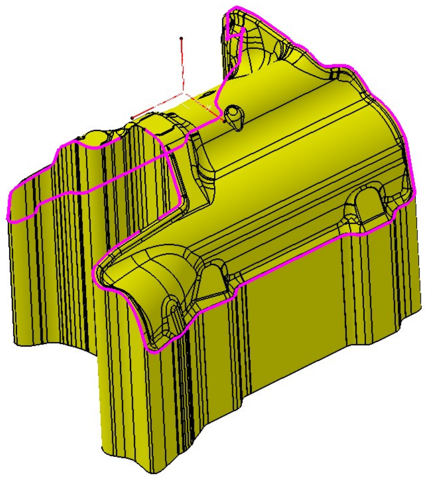

Figure 4. Folding

- OP60 Forming + Punching + Marking: In this last operation we do several things that will be explained below.
    - Forming: If we look at the bottom left side of the Figure 5. Forming + Punching + Marking, we can see that the border of the part has an angle, to achieve this angle we need to form it after the cutting and bending, for this reason we require this extra operation to do it. (It cannot be done in combination with other operations as all of the previous operation are also acting in this area, and we cannot do both at the same time).
    - Punching: By internal normative we always do the punching of the holes in the last operation, as we have really restrictive tolerances for the holes. If we do the holes in a previous operation the deformation caused by the next operation/s will increase the deviation of the position and size, with respect to the original one. We can also detect that there are different kind of punching, the basic one is vertical, that it is done in the same direction of the movement of the press, and the second one in with CAM, that it happens when the hole has an important angle, then we do the punching with a CAM (It's a mechanism that when activated by the closure of the press deforms or punches the part in a direction different than the press axis).
    - Marking: This is done in the last step by a similar reason as the punching, the marking does not have tolerances, but if it is done in a previous step, there is a possibility that the deformation of the part causes the marking to be not legible to be read.

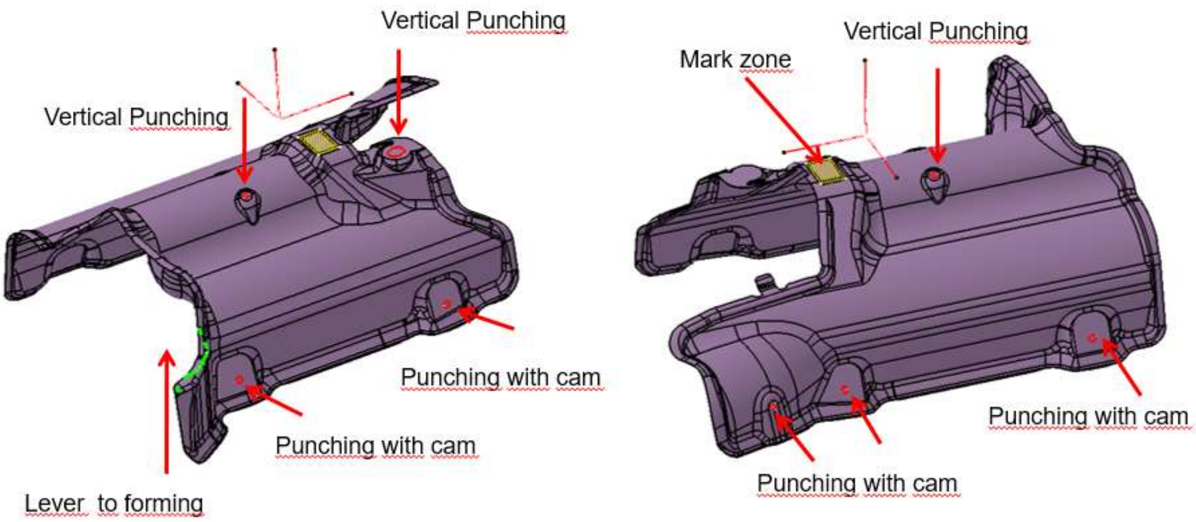

Figure 5. Forming + Punching + Marking

The current scrap of the project is in five different areas and defects:

- Missing material: This happens when the blank is not in the correct position, there are several causes for this, but the root of them is the movement of the blank before the stamping.

Figure 6. Missing Material

- Cracks: This happens when the material reaches its maximum stretch, causing it to open in the most critical area.

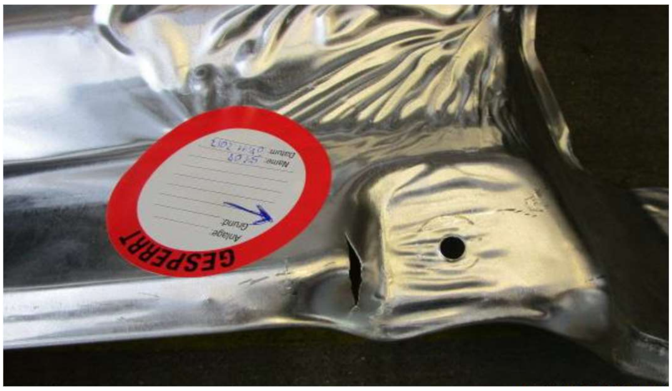

Figure 7. Cracks

- Overlapping through hole: This is a defect for our customer, there is a normative the does not allow us to have overlapping through the holes or near them, because if causes issues when they want to assemble the part in the vehicle.

Figure 8. Overlapping through hole

- Open overlapping: This happens when the deformation of the material causes it to double into itself and it is pressed to the material thickness causing a crack in the overlapping by the stress. Even if sometimes this opening is not visible, they are not accepted by customers, as they may expand with the vibrations of the vehicle while driving.

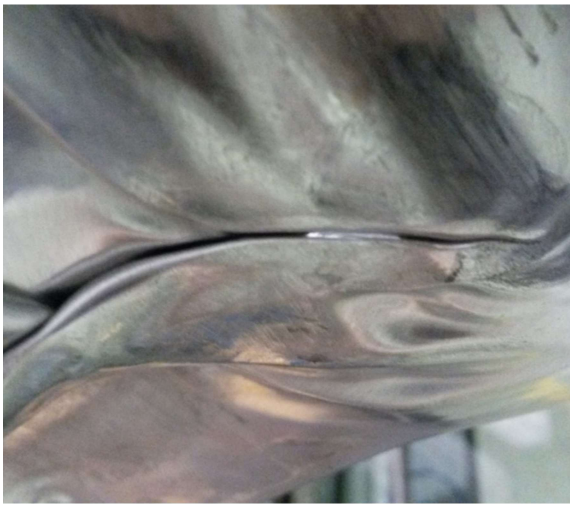

Figure 9. Open Overlapping

- Overlapping through hemming: This has the same explanation as the previous point, but it does not break, the issue is that as it is in the border of the part most of the times it is sharp, being a potential harm to operators.

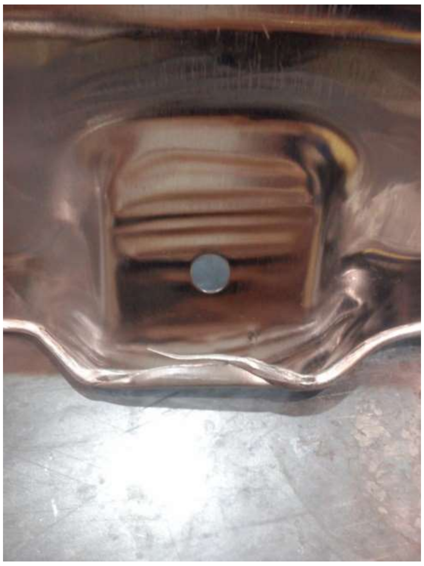

Figure 10. Overlapping through hemming

In Alustamp all of this are common damages in the parts but is not common to have altogether in the same part.

Even most of these issues are common in the sector and should be detected before, when doing the stamping simulations with the CAD data[10], that was not the case for this part. In the software analysis you can avoid the most critical and massive defects, but not the small ones, this is just as a remark, as this part was simulated before the manufacturing of the dies and the defects were solves or moved to not critical area before its construction.

9 Root cause and solution analysis

Each of the different defects has diverse ways to be solved, most with try and failure methods done in the tooling department, they consist in polishing the tools in the critical areas to reduce the friction or sharp areas, the issue with this project is that one solution works for an issue but worsen the other.

Several points of the process were reworked through the years, maintenance, and work with the tools, but when one problem is solved, it appears another one. By internal mistake, this part was originally quoted in a flat material, which may be the main issue.

[10] StampingSimulation, 2019. *Stampingsimulation.* [Online]

Alustamp has developed the embossed material to avoid most of the common defects in the parts, this may solve most of the issue, brief explanation to show how I will solve each of them below.

- Missing material: With the embossed material it is easier to deform the blank while doing the stamping, which will avoid extreme movements of the blank, which is the root cause of this defect.
- Cracks: As we have the embossed material we have more material, then the material has more possibility to stretch without breaking.
- Overlapping through hole: It is easier to control the overlapping with an embossed material that has more repeatability than the flat one, as the material has less movement, and it is easier to deform. As remark, the overlapping will always occur in the stamping, the only thing that we can do is move them to an area which is not critical.
- Open overlapping and overlapping through hemming: This point will not be solved automatically by changing to embossed material but will be easier to control and avoid pressing this area in the stamping (If we don't press and overlapping it will not open, and then will be acceptable for customer).

The volume increased with the time in this project, and together with it also the issues and time spent on adjusting the tools, the critical point was in the last quarter of 2020 when the volume increase to 200 000, that made the project critical.

With this current situation it is required a change, I propose to change the material to embossed, I did a trial using the same thickness of material, but in this case embossed (Difference in Figure 11. Comparative proposal vs actual), showing a significant improvement in the scrap, from 10 parts produced 0 parts were rejected.

Figure 11. Comparative proposal vs actual

Together with the proposal, it was required to do a feasibility analysis and also an economic analysis in order to make change attractive to customer, because only changing from smooth to embossed has an increase of price, as the material is compressed with the embossment it causes to have more material in the same surface. But as now we have more material and it can flow better, we can also reduce the size of the blank as explained in the feasibility analysis section.

7 Development

In this section I will analyze the differences between the different scenarios, in first instance we will analyze the technical feasibility to make the different modifications, afterwards we will be analyzing the different costs that will impact each of the solutions and finally I will also analyze the different timings for the implementation of the solutions.

7.1 Feasibility comparative

In this section I will analyze the feasibility to change from flat to embossed material, which is common between the three scenarios

Before showing any proposal to customer it is necessary to demonstrate that the change will not have an affectation to customer system, this means that the new part must be the same or better than the previous one. As for this part we are only "build to print supplier", we are no responsible of the design and we do not have all the environment and specs information. For this reason, the only test we can provide customer is a modal simulation that shows the response of the part in a static response. The table below shows all the scenarios analyzed compared to the actual one. It was analyzed to reduce thickness of the part, as to make attractive the change we have to present customer with a piece price reduction, as now the part is embossed it will be more rigid, being able to reduce the thickness of the part, but later, after checking the simulations it can be seen that this is not correct in all the cases.

A modal simulation is a tool that supplies us the limits of the response of a system, it is used to determine the different dynamic characteristics of the system, for example natural frequencies, damping ratios and mode shapes[11]. A modal analysis is used for the study of the dynamic properties in the frequency domain. It is an amply method used in the automotive sector to analyzed the affectation of the ongoing car vibrations in each of its parts, normally it is done in 3 steps, first the supplier or the OEM does a modal simulation to see the most critical areas affected, when approved, the part or set of parts is submitted to vibration forces using a shaker test, and finally after all previous are successful, all the parts attached to the vehicle are

[11] Bin Zahid, Fahad, 2020, A review if operational modal analysis techniques for in-service modal identification. 7th of July 2020. Volume 42. Issue 8

submitted to a real test, where the car is used in extreme environments, dirt, mountain, snow, etc.

Even the modal simulation is done by a software tool we must understand how It work and how to interpret the results. A modal simulation is part of the Dynamics, and in particular linear dynamic, by linear we understand that the stiffness (K) and the damping (C) are constant along time.

In the modal simulation we resolve the natural frequencies (Formula below in the Figure 12. Natural frequency Formula) and modes of vibration of the structure during free vibration. It is important to remark that the modal simulation does not depend of the loads in the system and that helps us analyze the weakest areas of the heatshield.

$$F_n = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

Figure 12. Natural frequency Formula

The minimum frequency target to achieve depends of the vibration frequency of each area of the vehicle, in our case, the target is 50 Hz, but if our part was in the engine area, the target would be 230 Hz, as in this area the environment is submitted to higher frequencies.

The targets of the modal analyses are from the frequency of the environment, that is below 50 or 230 Hz, then the target is to have a natural frequency of the heatshield higher than this, because if both frequencies are the same or similar, the amplitude increases significantly, which will lead to irreparable damage (example of similar frequencies can be seen in the Figure 13. Sum of amplitudes example, where the amplitude of 2 different waves/objects its added leading to an immense and dangerous amplitude) and the increase in the amplitude in , that's why it's really important for our products to know and control the natural frequency.

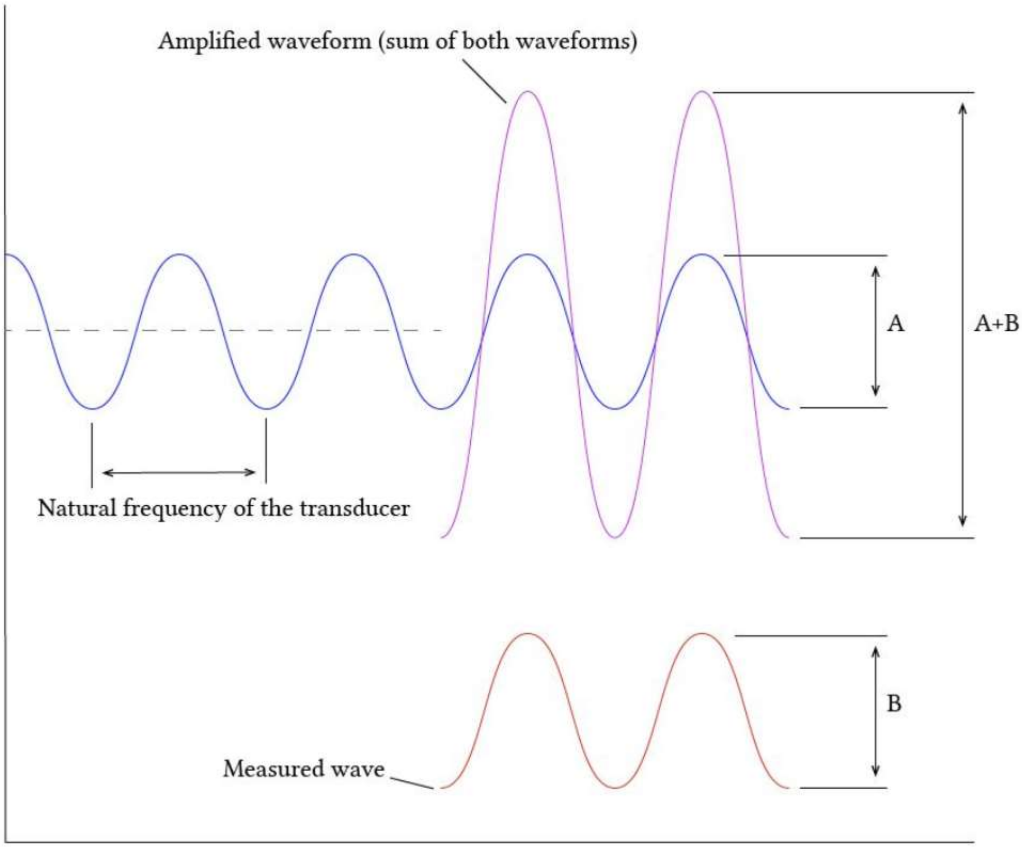

Figure 13. Sum of amplitudes example[12]

In order to make a modal analysis is only necessary the CAD data and knowledge of the fixation points in it, the material, and the thickness of it, in the case of the heatshields it's easy, as almost always all the holes in the heatshields are for fixing. The material is important as it will give us the information of the stiffness K (Composed by density, young module and coefficient poison).

Once done the simulation, we get 2 results, the deformity, which can be seen in the image, that shows the weakest areas of the heatshield, and also the Eigenvalue, that helps us understand how the equilibria points behave, and as we are in linear dynamic systems, this will determine the trajectory of the system given any initial conditions.

[12] Yartsev, A., 2017. *Deranged Physiology.* [Online]

In Alustamp this is done by a software that does everything automatically with the information mentioned in the previous paragraphs, In the Figure 14. Heatshield Fixation for simulation it is appreciated the fixation areas of this heatshield that we are analyzing.

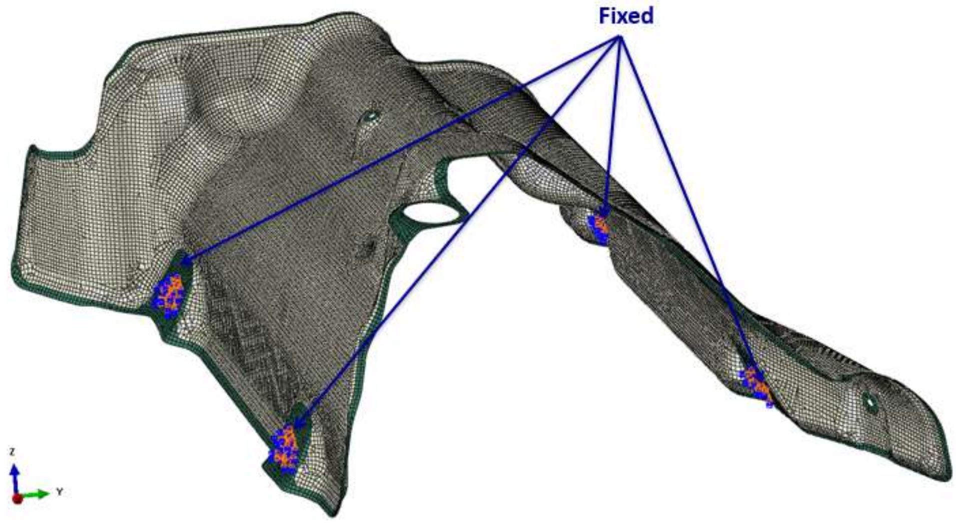

Figure 14. Heatshield Fixation for simulation

After the definition of the material, the thickness and the fixations, it is necessary to set the "quality" of the analysis, the number of nodes in which the heatshield will be split, the more nodes the more precise but the longer it will take for the program to finish, this is normally done with a "try and failure method", you run the project with a set amount of nodes, and if required a deeper analysis in a particular area you increase the amount of nodes.

The simulation was run for different thickness but with negative results to improve the thickness, in this work we only show the 2 relevant scenarios, the original with a smooth material and the new one with an embossed material.

In the Figure 15. Modal Simulation Smooth it can be checked the current status of the project, which we will use to compare to the new one.

**Modal simulation result
0,5 mm Thickness
Smooth**

Mode	Frequency [Hz]
1	44.2
2	62.00
3	75,7
4	107.1
5	119.7

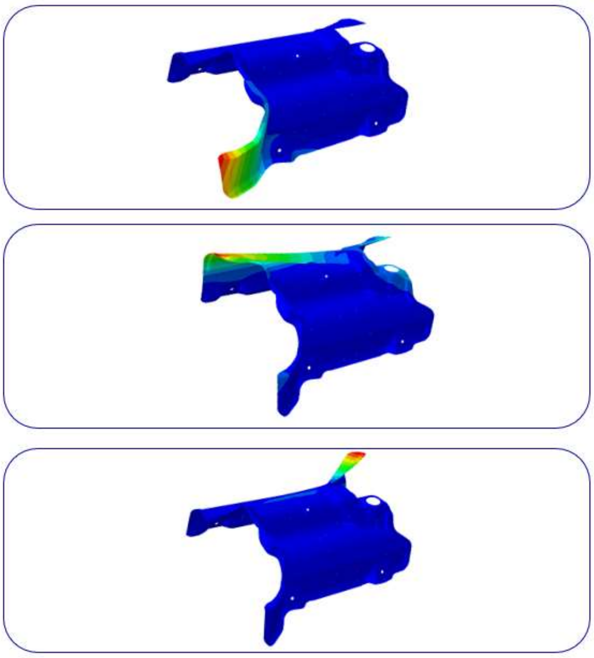

Figure 15. Modal Simulation Smooth

In the Figure 16. Modal Simulation Embossed we can check the improvement just from changing the material from smooth to Embossed, as explained before this was also done to analyze a possible reduction in the thickness, but the result was lower than the original and discarded.

Modal simulation result
0,5 mm Thickness
Embossed to 2,5 mm

Mode	Frequency [Hz]
1	51.97
2	72.02
3	85.00
4	128.00
5	140.83

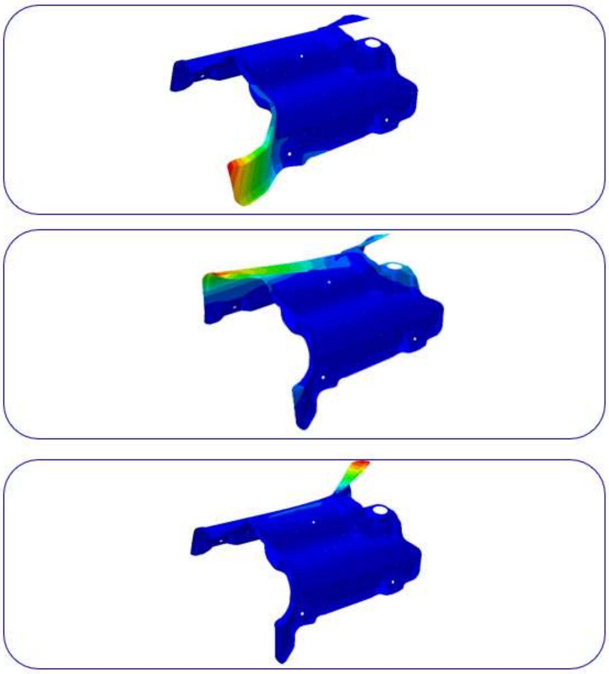

Figure 16. Modal Simulation Embossed

In terms of feasibility the 3 scenarios are feasible, as shown with the above information of the modal analysis, nevertheless it's necessary the customer approval, as they have the responsibility of the design, and they have more tools and specifications that we are not aware off. Also, for any kind of test required by Customer we have available prototypes for them to test right away.

7.2 Economic

For the economic comparison between the different options, it is necessary to analyze several points, for this reason this section will be divided in different subtasks.

7.2.1 Part Analysis

In this section of the Economic Analysis, I will study only the affectation cost that the impacts the part directly, for this reason in first place I will analyze the differences between each part and then the cost analysis of this differences.

7.2.1.1 CAD data analysis

Before starting the economic analysis of the part it's necessary to obtain some data form the CAD of the part or from the part itself, we need the size of the blank.

The blank currently used in smooth is 0,6x700x760, and it was used the same with the embossed trials, but now in the scrap of the part we can see that improvement is possible. In the length (760 that is the direction of embossment), we can see in Figure 17. Length analysis first image and Figure 18. Length analysis second image, that a lot of improvement can be done. As it is always necessary to leave some space to hold the blank, we are going to leave 15 mm for each side, that later on with further trials can be reduced even more; Then, we can reduce until 740 mm.

Figure 17. Length analysis first image

Figure 18. Length analysis second image

Then from the wide of the blank, we have the Figure 19. Width analysis first image and Figure 20. Width analysis second image, where we can see that we also have room for improvement. We can reduce to 690 mm.

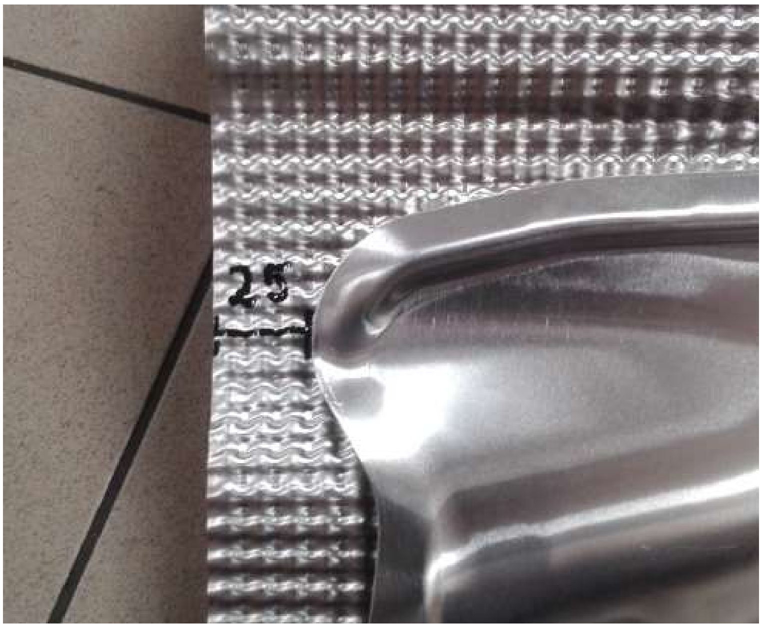

Figure 19. Width analysis first image

Figure 20. Width analysis second image

To corroborate the above data we will also analyze the blank size the traditional way, using a CAD data visualizer to draw lines in the part and measure them, which can be done with the software used in Alustamp, Work Xplore, this program also calculate automatically the area of the part, this is shown in Figure 21. Blank size analysis.

The other thing required from the CAD is the blank size to be used, for this we require to imagine the development of part in flat, for this we do some lines (Figure 21. Blank size analysis) in the CAD and come to the next results: Width (Green Lines) = 575+75+5+5+30 = 690, Length (Red Lines) = 595+95+40+5+5 = 740. (We played with the extra considered in both sides to match the physical trial done by the plant, which is more realistic than a CAD analysis)

Note: The extra considered in the above calculation is 5 mm in each direction for the beaded all around and the extra 10 or 20 per side is for the appropriate cutting, for every process in Alustamp *we require some scrap to be able to hold the blank while stamping.*

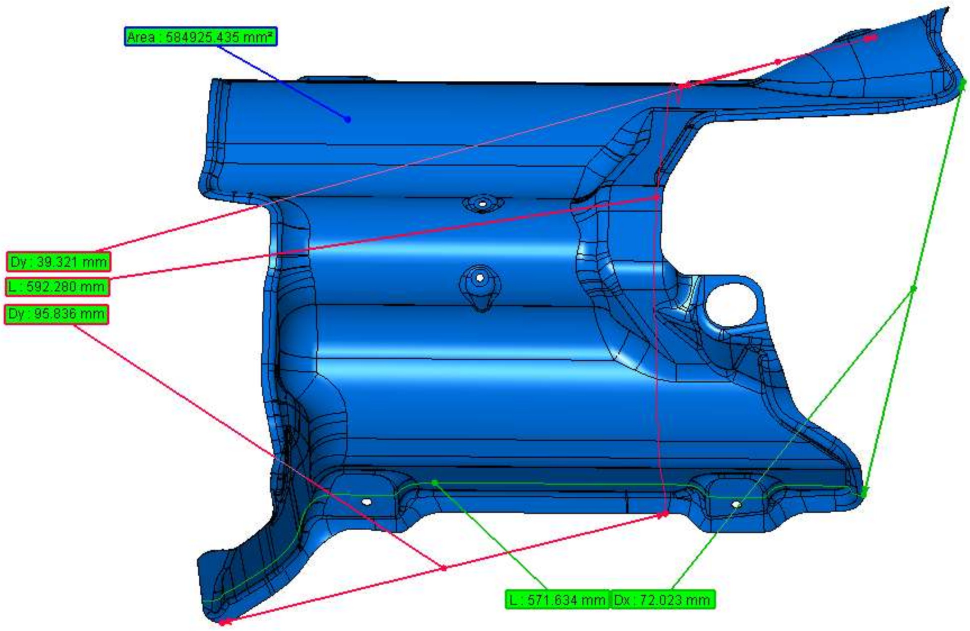

Figure 21. Blank size analysis

7.2.1.2 Part cost analysis

For this step is easier to work with an excel file, that it is attached in the Annex A, below I explain the briefly each of the analysis done in the excel file.

The first analysis done in the excel file is the material, the next information is already known:

- Material
- Material Density
- Thickness
- Blank size (From CAD data analysis)
- Area of the blank
- Part surface (From CAD data analysis)
- Material cost
- Scrap price (this is the price that Alustamp will sell the scrap generated in the process)

The above information is synthetized in the table shown in the Table 2. Material Data, and used in common for all the analyses.

Material Data			
Material	Aluminum 1050		
Density (kg/mm3)	2,7E-06		
Thickness (mm)	0,6		
Blank size(mm)	690	x	740
Area(mm2)	510.600		
Part Surface (mm2)	292.463		
Material cost (€/kg)	€ 2,70		
Scrap price (€/kg)	€ 1,57		
Embossement Contraction	5,6%		

Table 2. Material Data

With all the above information we will obtain the weight of the part and the blank, which we will use to know the scrap weight by difference. Afterwards we will calculate the total material cost, that it is obtained by the RAW material cost minus the scrap price.

After calculating the material cost is necessary to calculate the process cost. For this we have the next data from the current process and estimation of the future process based on similar parts:

- # Presses
- # Operators (Also considering operators that move the material and finished parts)
- Parts produced per hour.
- Press Machinery rate per hour (cost)
- Labor cost per hour

This data is also synthetized in the table in the Table 3. Production Data Manual Press, and used in common for actual and scenario 1, and the in the Table 4. Production Data Automatic Press for scenarios 2 and 3.

Production Data	
Presses required	2
Operators required per press	2
Transport operators required per press	0,33
Parts per hour produced	200
Press machinery rate (€/hr)	€ 22,72
Labor cost (€/hr)	€ 26,73

Table 3. Production Data Manual Press

Production Data		
Presses required	1	
Operators required per press	2	
Transport operators required per press	0,5	
Parts per hour produced	660	
Press machinery rate (€/hr)	€	76,14
Labor cost (€/hr)	€	26,73

Table 4. Production Data Automatic Press

With all this data then it's required to analyze the production cost per part, for this reason we multiply to machines/operators used times the cost of each, and later we divide the result with the parts produced in an hour.

Finally, only for the actual process and the First Scenario is important to remark that part has a rejection that must be analyzed in the study, for this we need to take into account to factors, check all the parts is necessary 1 extra operator and also the scrap percentage taken from Table 1. Scrap and downtime evolution, these 2 values are shown in the Table 5. Additional Data for economic analysis. Take into account that the rejected parts are transformed into scrap that is sold later.

100% check of parts (1 operator)	€	0,13
Scrap/Rejection Analysis (5%)	€	0,09

Table 5. Additional Data for economic analysis

The sum of the material and process cost is the total part cost, this total cost is the one we will consider for the comparisons between the different options.

7.2.1.3 First Scenario

Considering this scenario is keeping the part in a manual process, we can see the material analysis in the Table 6. Material Analysis first scenario and the process analysis and final cost in the Table 7. Production Analysis first scenario.

Material Analysis	
Gross weight (kg)	0,873
Part weight (kg)	0,500
Scrap (Kg)	0,373
RAW Material cost (€)	€ 2,36
Scrap revenue (€)	€ 0,59
Total Material cost (€)	€ 1,77

Table 6. Material Analysis first scenario

Production Analysis	
Press cost (€)	€ 0,11
Personal cost (€)	€ 0,31
Total Process cost (€)	€ 0,43
Total Production cost (€)	€ 0,85
Total Manufacturing cost	€ 2,62

Table 7. Production Analysis first scenario

As seen from the tables the final cost of the part is 2,62 € which is lower than the actual cost of the part, with the improvement of the material from flat to embossed the scrap is reduced to 0, for this reason we don't have any extra cost, this improvement compensate the increase on cost of the material caused by the embossment contraction (even that the blank size is smaller, with the contraction of material we have more material than before)

7.2.1.4 Second Scenario

Considering this scenario is modifying the actual tools to work on an automatic press, we can see the material analysis in the Table 8. Material Analysis second scenario and the process analysis and final cost in the Table 9. Production Analysis second scenario.

Material Analysis	
Gross weight (kg)	0,873
Part weight (kg)	0,500
Scrap (Kg)	0,373
RAW Material cost (€)	€ 2,36
Scrap revenue (€)	€ 0,59
Total Material cost (€)	€ 1,77

Table 8. Material Analysis second scenario

Production Analysis	
Press cost (€)	€ 0,12
Personal cost (€)	€ 0,10
Total Process cost (€)	€ 0,22
Total Production cost (€)	€ 0,22
Total Manufacturing cost	€ 1,99

Table 9. Production Analysis second scenario

As seen from the tables the final cost of the part is 1,99 € which is much lower than the actual cost of the part and lower than scenario 1, we don't have any extra cost because of the material change as explained in the scenario 1, and in this scenario, we have an improved process, producing more parts per hour with less operators.

7.2.1.5 Third Scenario

Considering this scenario is keeping the part in a manual process, we can see the material analysis in the Table 10. Material Analysis third scenario and the process analysis and final cost in the Table 11. Production Analysis third scenario.

Material Analysis	
Gross weight (kg)	0,873
Part weight (kg)	0,500
Scrap (Kg)	0,373
RAW Material cost (€)	€ 2,36
Scrap revenue (€)	€ 0,59
Total Material cost (€)	€ 1,77

Table 10. Material Analysis third scenario

Production Analysis	
Press cost (€)	€ 0,12
Personal cost (€)	€ 0,10
Total Process cost (€)	€ 0,22
Total Production cost (€)	€ 0,22
Total Manufacturing cost	€ 1,99

Table 11. Production Analysis third scenario

As both scenarios (2 & 3) have the same process, the part price is the same, the analysis done in scenario 2 is the same for scenario 3. The difference in these scenarios will be analyzed later with the tooling cost and the timing.

7.2.2 Tools

In this section we will review the different cost impact that each of the scenarios present, this impact is quite representative as it affects Alustamp in short term, in contrast to the revenue from the part price that will be received in the long term.

7.2.2.1 Analysis

For the cost impact regarding we will consider the cost of the modification of the tools or the new tooling, for this step I got the support from Tool purchasing department, they have the experience and knowledge to quote, they are in charge of knowing the current status of the market as well as the required modifications to be done in a tooling. For this they only require the CAD data from the actual version and the proposal, which was commented in a previous section, the material, and the volume the tools will be manufacturing.

Even that it is not a tooling, in this section we will also include the safety stock costs, this is for 2 main reasons:

- The safety stock is strongly connected with the tooling, depending on the quantity of weeks required to modify the tooling this will require a bigger or shorter safety stock, as Alustamp must keep delivering parts to the customer while the tools are in modification and while doing the modification the tools cannot produce.
- This cost must be paid on short term, making it the same type of cost as the tooling, which require immediate inversion.

For this analysis we will take into account the next considerations:

- The cost of the modification or new tools supplied by the purchasing department.
- The cost of the shipping supplied by the logistics department based on the size and weight of the tools.
- Tool design costs are included in the tooling price.

And the next considerations were not taken into account:

- The profit of Alustamp.
- Any possible financial cost.
- The management cost of each department.
- The duty and taxes from moving the tools.

7.2.2.2 Safety Stock

The safety stock as explained in the previous point is essential to take the decision, not only increases the total lead time for the implementation of some scenarios but also increases substantially the total cost.

For the analysis of the safety stock, we will take into account the next considerations:

- Safety stock transport from the plant to the warehouse
- Warehouse rent cost.
- Safety stock transport from the warehouse to the plant.
- Temporal packaging of the parts, as the series packaging is a GIBO gitterbox that goes in return from customer it cannot be used, we consider in the quote card box packaging of an equivalent size, which is 1200 mm x 1000 mm x 800 mm.

And the next considerations were not taken into account:

- The profit of Alustamp.
- Any possible financial cost.
- The management cost of each department.

The safety stock analysis was estimated with the support of logistics department, as they have the cost and values for each part.

We start with the following data:

- Packaging box size.
- Parts per box: 130 parts.
- Box cost: 9,49 € per box.
- Yearly volume of the project: 200.000 parts per year.
- Weeks required for the modification (supplied by tool purchasing department):
    - First Scenario: 6 weeks.
    - Second Scenario: 11 weeks.
    - Thirds Scenario: Not required, new tools.
- Truck capacity: 47 boxes per truck.
- Transport cost: 60 € per route.
- Warehouse fee per box: 1€.
- Warehouse cost: 10€ for each box each month.

Detailed analysis explanation below, further information in detail in the ANEX 2.

The firs think to determine is the number of parts we have to produce in order to cover the deliveries while the modification of the tools is being done, in automation we know that we consider a year has 48 week, then the safety stock we must do for scenarios 1 and 2 is shown in the Table 12. Safety Stock Scenario 1 and Table 13. Safety Stock Scenario 2 respectively.

Safety Stock Volume		
Yearly Volume	200.000	Parts
Weeks for safety stock	6	Weeks
Part for Safety Stock	25.000	Parts

Table 12. Safety Stock Scenario 1

Safety Stock Volume		
Yearly Volume	200.000	Parts
Weeks for safety stock	11	Weeks
Part for Safety Stock	45.833	Parts

Table 13. Safety Stock Scenario 2

Having the number of parts requires is easy to know the quantity of boxes we require, that we will later us to know the total packaging cost for the safety stock, these numbers are shown in the Table 14. Scenario 1 Box quantity and Table 15. Scenario 2 Box quantity respectively.

Packaging		
Total boxes = Parts / Box quantity	193	Boxes

Table 14. Scenario 1 Box quantity

Packaging		
Total boxes = Parts / Box quantity	353	Boxes

Table 15. Scenario 2 Box quantity

After knowing the packaging cost, the next important cost to take into account is the warehouse cost, this study is more complex as we need to know the quantity of week required by the plant production to manufacture the safety stock, this number was requested to the process engineer, which takes into account the capacity of the press to estimate an approximate number of weeks. Once we have the weeks required to manufacture the safety stock and the weeks for modification, we are ready to build the safety stock table, in which we will detail the number of boxes we will have each week in the warehouse that we require to know the total storage cost, this tables can be seen in the Table 16. Warehouse Cost Scenario 1 and Table 17. Warehouse Cost Scenario 2 , for scenarios 1 and 2, respectively. We will later use this table to also analyze the transport costs.

	Customer requirement of boxes per week (Total boxes diveded by 6 weeks)	32	Boxes
	Production per week (Total parts divided by 12 weeks)	17	Boxes
	Storage cost :	10,00	€/ Month / Box
Week	Boxes per week in warehouse	Cost per week (7 x Cost x Box)	
1	17	39,67 €	
2	34	79,33 €	
3	51	119,00 €	
4	68	158,67 €	
5	85	198,33 €	
6	102	238,00 €	
7	119	277,67 €	
8	136	317,33 €	
9	153	357,00 €	
10	170	396,67 €	
11	187	436,33 €	
12	193	450,33 €	Safety stock finished
13	161	375,67 €	
14	129	301,00 €	
15	97	226,33 €	
16	65	151,67 €	
17	33	77,00 €	Last delivery
18	-	- €	
19	0	- €	
20	0	- €	
	Total Warehouse cost :	4.200,00 €	

Table 16. Warehouse Cost Scenario 1

	Customer requirement of boxes per week (Total boxes diveded by 11 weeks)	32	Boxes
	Production per week (Total parts divided by 18 weeks)	20	Boxes
	Storage cost :	10,00	€/ Month / Box
Week	Boxes per week in warehouse	Cost per week (7 x Cost x Box)	
1	20	46,67 €	
2	40	93,33 €	
3	60	140,00 €	
4	80	186,67 €	
5	100	233,33 €	
6	120	280,00 €	
7	140	326,67 €	
8	160	373,33 €	
9	180	420,00 €	
10	200	466,67 €	
11	220	513,33 €	
12	240	560,00 €	
13	260	606,67 €	
14	280	653,33 €	
15	300	700,00 €	
16	320	746,67 €	
17	340	793,33 €	
18	353	823,67 €	Safety stock finished
19	321	749,00 €	
20	289	674,33 €	
21	257	599,67 €	
22	225	525,00 €	
23	193	450,33 €	
24	161	375,67 €	
25	129	301,00 €	
26	97	226,33 €	
27	65	151,67 €	
28	33	77,00 €	Last delivery
29	-	- €	
	Total Warehouse cost :	12.093,67 €	

Table 17. Warehouse Cost Scenario 2

To analyze the data, we already have some information from the previous exercises, first of all, we know that we can fit 47 boxes per truck and the cost for each transport one way is 60 euro. This information was gotten from the logistics department. Also, together with this information, from each scenario we know the number of trucks we will require from the warehouse analysis. We can find all this information summarized in the Table 18. Transport Cost Scenario 1 and the Table 19. Transport Cost Scenario 2, from scenarios 1 and 2, respectively.

Transport :	
Boxes per truck	47
Transport cost	60
Trucks Required from Plant to Warehouse	12
Trucks Required from Plant to Warehouse	6

Table 18. Transport Cost Scenario 1

Transport :	
Boxes per truck	47
Transport cost	60
Trucks Required from Plant to Warehouse	18
Trucks Required from Plant to Warehouse	11

Table 19. Transport Cost Scenario 2

The analysis of the final cost and the conclusions will be shown in the next sections, where we will analyze each scenario separately and then do a general comparative between them.

7.2.2.3 First Scenario

This scenario we remember is keeping the process in a manual press and just do the modification to the new material, it is normal that the safety stock is the cheaper from the other scenario, as it requires the minimum amount of time for modification thus the minimum time and cost for safety stock, cost wisely speaking this is the best scenario, but we will have to analyze this data together with the piece price and the timing.

In the Table 20. Total Safety Stock Cost Scenario 1 we can see the final result from the safety stock analysis for this scenario, adding up the packaging, the transport, and the warehouse costs.

In the Table 21. Total Modification Cost Scenario 1, we find the final summary of all the short-term costs, all the tool medication costs were supplied by purchasing department and we are adding up the safety stock cost.

		Boxes * Cost	
	Total Packaing cost	**1831,57 €**	
		Trucks x Cost	
From plant to warehouse		720,00 €	
From warehouse to ESTAMP		360,00 €	
	Total Transport cost	**1080,00 €**	
Warehouse fee per box (1 €)		193,00 €	
Total Warehouse cost		4200,00 €	
	Total Warehouse cost	**4393,00 €**	
TOTAL SAFETY STOCK COST		**7304,57 €**	

Table 20. Total Safety Stock Cost Scenario 1

Tools Cost		
Modification of Stamping	€	15.000
Modification of Cutting	€	12.000
Modification of Bending 90	€	8.000
Modification of Bending 180	€	8.000
Modification of Forming + Punching	€	6.000
Modification of Checking Fixture	€	2.000
Total Safety Stock Cost	€	7.305
Total Modification Cost	€	58.305

Table 21. Total Modification Cost Scenario 1

7.2.2.4 Second Scenario

This scenario is an in-between solution, modify the tools to have the advantages of an automatic press but with the actual tools, we will analyze in general at the end of this document, this will have some advantages and some disadvantages, the modification cost is between the first and the third scenario even with the huge safety stock required and major modification of the tools.

In the Table 22. Total Safety Stock Cost Scenario 2 we can see the final result from the safety stock analysis for this scenario, adding up the packaging, the transport, and the warehouse costs.

In the Table 23. Total Modification Cost Scenario 2, we find the final summary of all the short-term costs, all the tool medication costs were supplied by purchasing department and we are adding up the safety stock cost.

		Boxes * Cost	
	Total Packaging cost	**3349,97 €**	
		Trucks x Cost	
From plant to warehouse		1080,00 €	
From warehouse to ESTAMP		660,00 €	
	Total Transport cost	**1740,00 €**	
Warehouse fee per box (1 €)		353,00 €	
Total Warehouse cost		12093,67 €	
	Total Warehouse cost	**12446,67 €**	
TOTAL SAFETY STOCK COST		**17536,64 €**	

Table 22. Total Safety Stock Cost Scenario 2

Tools Cost		
Modification of Stamping	€	25.000
Modification of Cutting	€	23.000
Modification of Bending 90	€	15.000
Modification of Bending 180	€	15.000
Modification of Forming + Punching	€	13.000
Modification of Checking Fixture	€	2.000
Total Safety Stock Cost	€	17.537
Total Modification Cost	€	110.537

Table 23. Total Modification Cost Scenario 2

7.2.2.5 Third Scenario

As expected, this scenario has the higher cost from all of them, these tools are completely new that require casting, machinery, milling and a lot of trials and human work, finally but not least they also require transport, as to get competitive prices the tools are produced in China.

It is important to add a remark, that in all of the short-term cost analysis done in this section I'm not considering the fine tuning to be done in the production plant, but if we would consider it, this scenario would have a slightly higher cost, as it requires more trials, the tools are completely new and require more tuning.

Tools Cost	
Stamping	€ 35.000
Cutting	€ 30.000
Bending 90	€ 27.000
Bending 180	€ 27.000
Formint + Punching	€ 28.000
Checking Fixture	€ 7.000
Tools transport	€ 5.000
Total Modification Cost	€ 159.000

Table 24. Total Modification Cost Scenario 3

7.2.3 Total Economic Comparative

In this part I will do the first big comparative between the different scenarios, it's really important to take into account that we are only measuring the cost side in front of our customer, as we are not analyzing the business margin and the profit. In a real scenario this 2 values will be key factors in the decision of the best scenario and the final proposal.

First of all, in the Table 25. Final Cost Comparative we can see the economic summary of all the scenarios, it is important to remark that it was added a third column that is the turnover, this is obtained from multiplying the part cost times the yearly volume of the project.

	Part	Tooling Cost	Annual Turnover
Actual	2,79 €		558.516 €
Scenario 1	2,62 €	58.305 €	524.512 €
Scenario 2	1,99 €	110.537 €	397.833 €
Scenario 3	1,99 €	159.000 €	397.833 €

Table 25. Final Cost Comparative

From this table enough may not be clear the best solution in a cost-manner, but if we do further numbers along the years easily can see the best option, in the next graph Figure 22. Cost Yearly Analysis, we can see the evolution in the cost for our customer along the first 3 years, it is clear that in a long term the best solutions are the ones with low part price, but in the graph, it is not clear the break point, for this reason we will see the evolution month per month in the first 2 years.

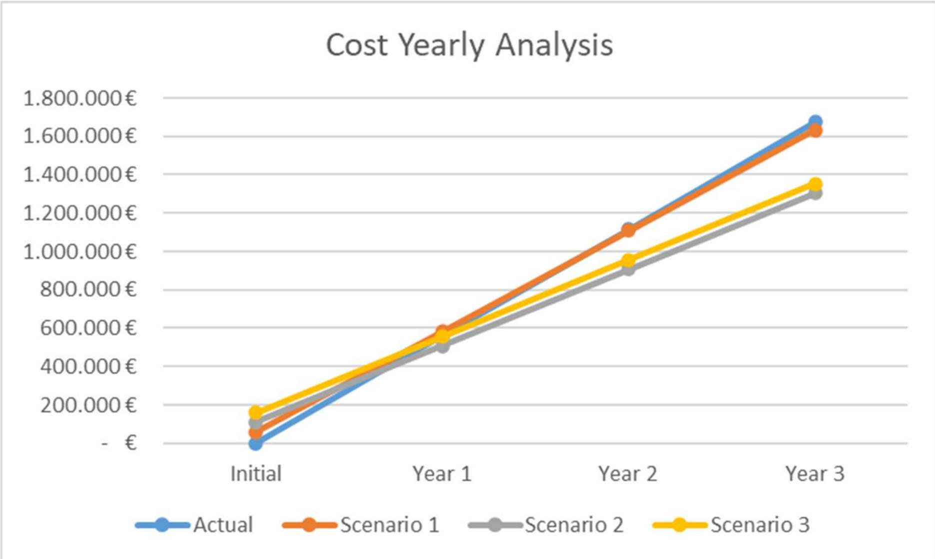

Figure 22. Cost Yearly Analysis

In the Figure 23. Cost Monthly Analysis we can appreciate with more detail the break points of each scenario and we can arrive to the next summary:

- Between the Month 1 and Month 4 the best scenario would be the 1, as it represents the less tooling cost but keeping a high cost on the part.
- In the Month 5 we have the breakpoint in which the best scenario is the 2, from here until the end the best scenario is this one, as it has the same piece price as the scenario 3, but with a lower tool cost.
- Is important to remark that on Month 9 we have the breakpoint between scenarios 1 and 3.

- In the Month 20 is the breakpoint between the actual part and the scenario 1.

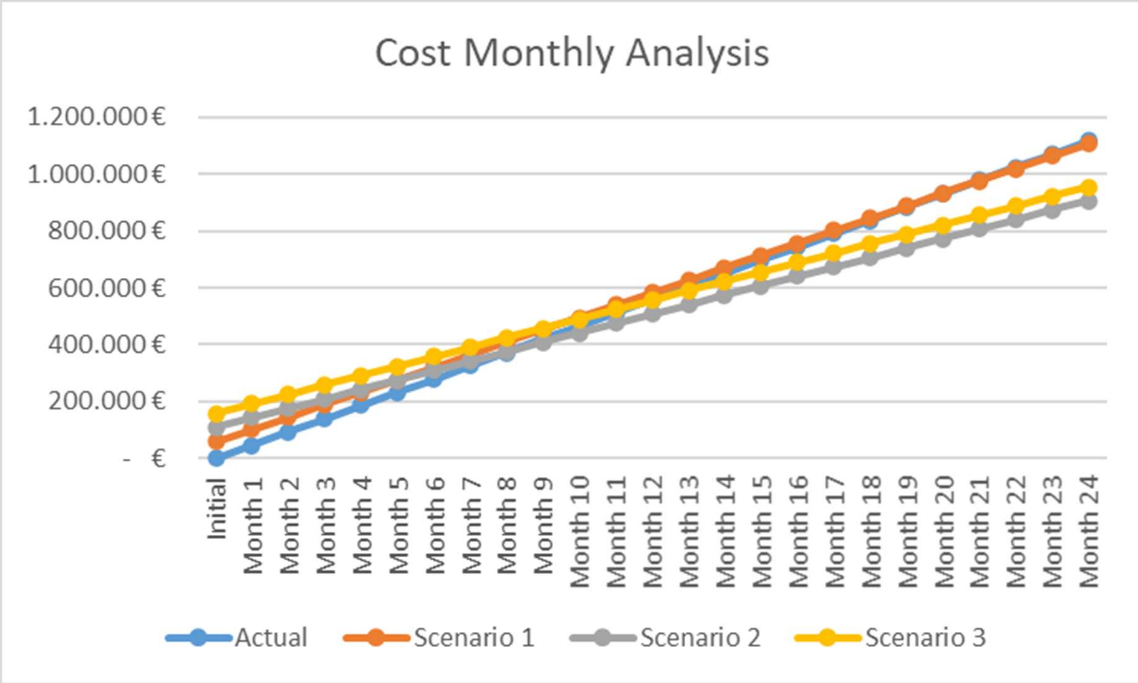

Figure 23. Cost Monthly Analysis

If this would be an internal modification, Alustamp approves the improvement of processes if the return of the investment is below 1 year, in this case we conclude that the best scenario only taking into consideration the cost is the Scenario 3 and then the Scenario 2 (Both of them recover the investment in less than a year). It is required to compare these results with the rest of the analysis done in the document and then do weighing to determine the best option to our customer, even if they take the final decision is important to present the analysis to them, as our main principle in Alustamp is customer orientation.

7.3 Timing

It is not only important to measure the economic impact in the project, as one critical point to make the decision is to know the timing to implement all the modifications. In this section I will analyze how I proceed with this analysis, and all the considerations taken into account.

7.3.1 Analysis

For the analysis we are considering only the next points, which are the critical path for the accomplishment of the project:

- The timing starts once customer approves design and sends a purchase order as agreement of payment.
- Material for safety stock reception.
- Safety stock Production (This is the timing required to build a stock of parts to be able to modify the tools, as while the tools are being modified, we still must deliver parts to our customer)
- Project Design, this is not part of the critical path as can be done in parallel to the safety stock production, this milestone represents the time we require to design the tools of the modification.
- Tool modification, this milestone is the time that the toolmaker requires to modify the tools, this is done external to the plant.
- Production trials is the time necessary to fine tune the tooling in our plant and prepare everything for a series production.
- Internal Run and Rate is an internal modification where we do a checklist and production under series conditions, to guarantee everything is ready for serial production.
- Parts inspection/Quality control/transport to customer is the time necessary to take some sample of the series conditions production, analyze them, and send the parts together with the reports to the customer for approval.
- Parts available at Customer, is the milestone that we can give customer of when we would be able to start production in series, just pending by their side the approval of the parts delivered.
- To compare easier between all the scenario we will consider that all start the same week (W1), we avoid using specific dates are it is still not clear the kickoff date, and also this way we can see clearly the total weeks required for each scenario.
- Import remark taking into account the last point is that as we are not defining a specific kickoff date, and for this reason we cannot know the holidays that may affect the timing, the timing may be longer pending on the kickoff date agreed.

7.3.1.1 Scenario 1

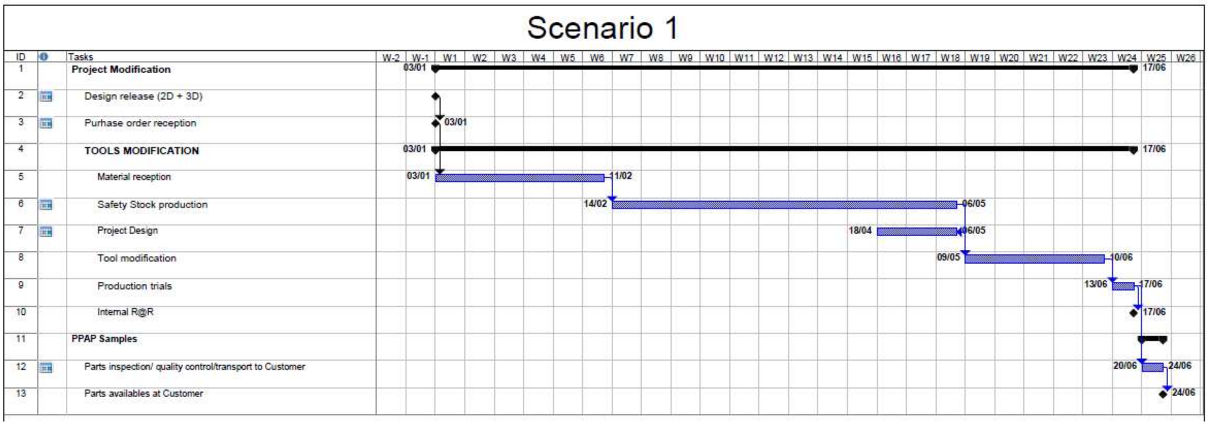

Figure 24. Timing Scenario 1

This scenario requires the modification of the tools, as the tools cannot be used while doing the modification, we must build a safety stock to keep delivering parts to our customer while doing the modification. This safety stock requires 2 steps:

- The purchase of the raw material to do the safety stock, as it is additional material not considered for normal production.
- The production itself of the safety stock, which requires a lot of weeks as this production is not considered in the normal timing.

After safety stock is done, it is required a minimum number of weeks to do the modifications of the tools, trials, and production, as the modification is not that big.

7.3.1.2 Scenario 2

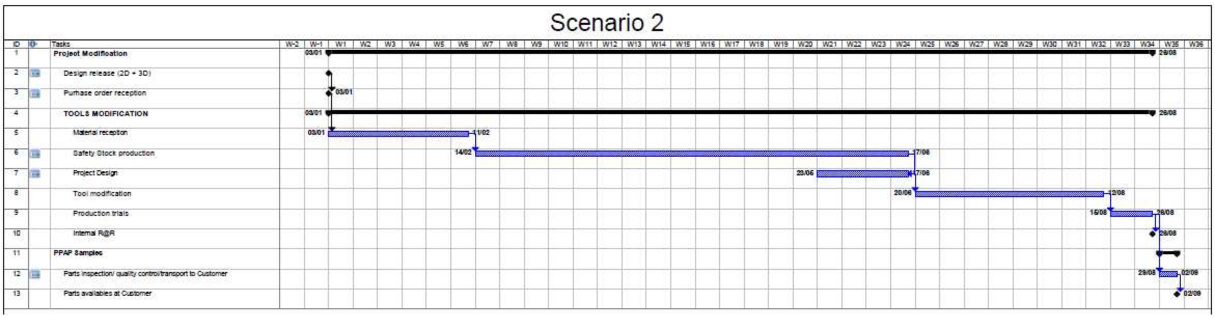

Figure 25. Timing Scenario 2

This second scenario is similar to the first one, the distribution is the same, but it has the next modifications:

- The modification time is longer as the tools require a big modification to be able to fit in an automatic press.
- As the modification time is longer, the safety stock required is also longer, for this reason the plant requires more weeks in order to produce it; just as a remark the material reception time is the same, as the time is standard for all quantities, an as it is really big the safety stock required, there will be several material deliveries along the production, to avoid the material causing capacity issues in the warehouse.

7.3.1.3 Scenario 3

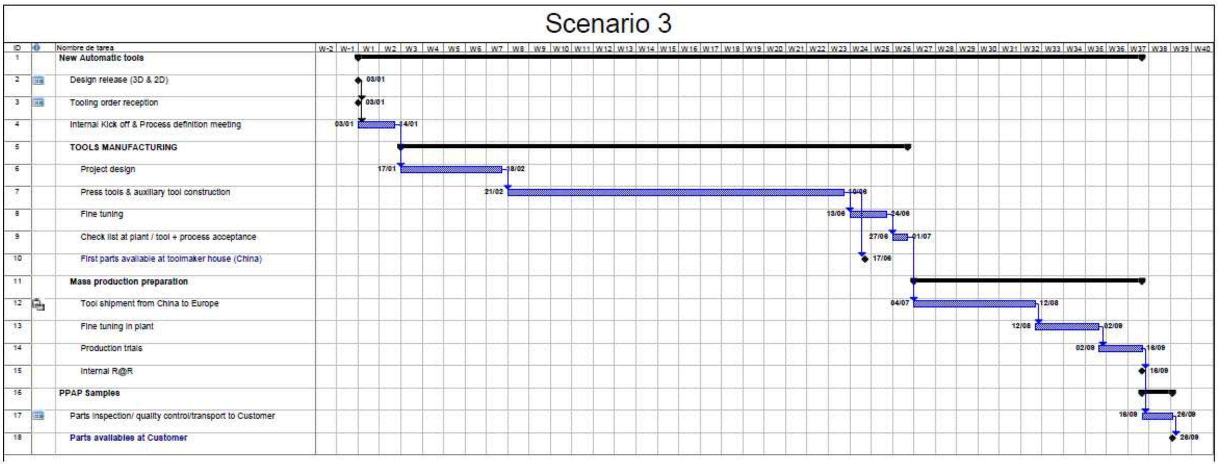

Figure 26. Timing Scenario 3

This timing represents the standard tool production of Alustamp, as this scenario does not require the old tools, we can use them to keep producing parts while building the new ones, avoiding the necessity of a safety stock.

Below I will explain each of the steps of this timing:

- Process definition meeting: Same step as the other scenarios, internal meeting to agree on the process and timing.
- Process design: In the previous scenarios this can be done in parallel to the safety stock, but in this one this is not possible and requires its timing, in the step the technical office designers design the tools that will be build.
- Tool construction: This step can be deeper slitted, but it is not the main topic of this thesis, in this point it is englobed the casting, machining, trials and fine tuning of the tools, between other steps.
- Fine tuning: Production of first parts and small adjustments.

- Checklist: A person from Alustamp goes to the production time to review a production and validate the tools.
- Shipment: Normally done by ship and it takes around 6 weeks.
- Fine tuning at plant: First round of trials in the plant, where we use the hydraulic press to control the production and be able to analyze each step of the stamping process with enough detail.
- Production trail: Second round of trials in the plant, that it is done in the production press that will be used, normally we do around 50-100 parts, in order to advance to possible issues and prepare everything for a long production.
- Internal Run and Rate: Final trial, the objective of this step is to do a long production and take the decision if the process is ready to be transferred to the plant and ready for the serial production of the project.
- PPAP: Essential step in all the scenarios, is where we prepare all the documentation requested by our customer, and we send it to them for approval, together with 5 parts from production and their respective dimensional.

7.3.2 Comparative

Only taking into account the lead time of each of the scenarios, the best one by far is the first scenario, as only requires 25 weeks in order to do the modification and start delivering, and the scenarios 2 and 3 require 35 and 38, respectively. This will require further analyses with the other aspects of this project, as the timing has a straight relation with the cost, mainly from the safety stock required.

7.4 Tool Capacity

In this section I will analyze the capacity of the Manual and Automatic presses, at the start of the project the capacity was not an issue as the project had low volume, but this has increased until today, which may affect the capacity of the press and may turn an optional modification to a mandatory one.

Capacity study requires a deep study in the capacity of the processes, their quality, their productivity, and their availability. I will summarize as much as possible in this thesis the analysis and only detail the relevant topic for the process. Also, most of the data is already given, as it is from other current projects in Alustamp.

7.4.1 Manual Press Capacity

First of all, we need to recover some basic information from the production plant and also from the project, the information know is the following (Also presented in Table 26. Manual Press Data):

- Day/Week the plant work, in this case is 5.
- Shifts/Day the plant has, most of the year is 3 turns.
- Hours/Shift, which corresponds to 8 hours per week, the downtime and inefficiency will be explained below with the OEE and planned downtime.
- Planned downtime, this value is 30 min standard per shift, it represents the required stops in the production for workers to make a break and rest.
- Net available time, this is the weekly addition of the working time minus the planned downtime.
- Demonstrated OEE, represents an historical average from the OEE of all past projects in this press, the OEE number is a percentage that represent the real number of parts that you will get, it is a combination of 3 factors:
    - Availability, represents the percentage of time the machine is ready to manufacture parts, this time is affected by maintenance stops and unplanned issues.
    - Quality, represents the rejection of the part, this value normally oscillates between 0-1% in Alustamp aluminum parts.
    - Productivity, represents the real number of parts produced compared to the quoted/theoretical, as the press is manual this number has a big oscillation, between 95% and 120%, the number can be positive in our plant as the target is set to be easily achieved and improved, if improved the operators will win a salary bonus.
- Yearly Parts required, for this particular project, data given from before.
- Weekly Parts required, considering working 48 weeks pear year.
- Parts/hour, estimation of parts per hour this project will be able to produce.
- Sec/Parts, same number as before expressed in seconds.

Days/Week	5
Shifts/Day	3
Hours/Shift	8
Planned downtime(Min/Shift)	30
Net available time	112,5
Demostrated OEE	81%
Yearly Part requirement	200.000
Weekly Part requirement (48 weeks)	4.167
Parts/Hour	200
Sec/Part	18

Table 26. Manual Press Data

Once the previous information is obtained, we must know the requirements and chrono for each of the parts allocated in the production press that we will analyze, this information is summarized in the Table 27. Manual Press Capacity, where we also calculate the time required to produce that part, that considers the parts per week, the seconds per part and finally the historical OEE percentage explained before, with this we get a real approximation to the reality this project has; Finally taking into account the time required and the Net available time we get the % Allocation in the press analyzed.

Part	Parts per week	Sec/Part	Time required (h/week)	Tool Change (min/week)	% Allocation
1	3700	15	19,03	120	19%
2	2300	17	13,41	120	14%
3	2700	18	16,67	120	17%
4	1300	17	7,58	120	9%
5	1700	21	12,24	120	13%
This project	4166	18	25,72	120	25%
			Total Press Allocation		95%

Table 27. Manual Press Capacity

The normal saturation of a machine should be around 80-90%, if the % allocated exceeds the 90% you are in risk of having a capacity issue, the reason for this is that automotive sector volumes are not stable, they have an annual production tolerance of +/- 15%, so it can happen that some project of the same press increase the production above the nominal and cause a saturation.

7.4.2 Automatic Press Capacity

The analysis of an automatic press is the same as a manual press, but there are some remarks that must be done in order to understand better the situation and differences with the Manual press:

The Automatic press has a better chrono compared to the manual press, as it is done completely by a machine and at high speed.

The OEE of an automatic press is normally higher than the manual press, this can be explained in each of the parts that compound the OEE calculation:

Availability, this is the only part of the OEE that may be equal or even less compared to the manual press, the reason is that the stops in an automatic press require more time to be fixed, but in the other hand, they should happen with less frequency.

Quality, as there is no human factor in the process, the quality of parts is more stable and lower % compared to the manual press.

Productivity, this value that is represented as a percentage is always close the 100%, as there is no fatigue or change of rhythm in the press.

Finally, and just as a remark, the projects allocated in an automatic press are normal medium-high volume projects, as it can produce high quantity of parts per hour if it is used for a low volume project it will be more time in the setup of the press than producing parts because of short productions.

Bellow in the Table 28. Automatic Press Data, we can see the data known or calculated before the automatic press analysis.

Days/Week	5
Shifts/Day	3
Hours/Shift	8
Planned downtime(Min/Shift)	30
Net available time	112,5
Demostrated OEE	93%
Yearly Part requirement	200.000
Weekly Part requirement (48 weeks)	4.167
Parts/Hour	660
Sec/Part	5,45

Table 28. Automatic Press Data

Same as we did with the Manual press, we will proceed to analyze each of the projects in the automatic press to check it's currents saturation in case we decide to move the project under study to the automatic press, this can be seen in the Table 29. Automatic Press Capacity.

Part	Parts per week	Sec/Part	Time required (h/week)	Tool Change (min/week)	% Allocation
1	7000	5,45	11,39	120	12%
2	5600	5	8,36	120	9%
3	8100	5,45	13,19	120	13%
4	5100	6	9,14	120	10%
5	4700	5,45	7,65	120	9%
6	6300	6	11,29	120	12%
7	6400	5	9,56	120	10%
This project	4166	5,454545	6,79	120	8%
			Total Press Allocation		83%

Table 29. Automatic Press Capacity

As we can see, the Automatic press has more project of higher volume and with much better flexibility to adapt to the increase of capacity in case this project decides to be moved to this press.

8 General comparative

Until now, different approaches for the 3 scenarios were done and analyzed separately, in this section I will analyze all of them together using the support of the technic weighted value (VTP in Spanish), before proceeding to show the results I will explain the weight given to each of the sections and the reason of the chosen weight.

Part Price, even the part price is quite important, for Alustamp this improvement represent a reduction in the turnover of the part, for this reason the weight of this criteria is 30.

Investment, as this cost will be paid by Alustamp it is really important and will be weighted 50.

Timing, this is not critical, if the investment is approved, the timing of the project to be completed is not relevant for Alustamp.

Capacity, together with the investment is the most important criteria, if the press does not have capacity it will put in risk the deliveries of this project or others.

Before showing the standardized results, I present in the Table 30. Result table before standardization the values for each of the criteria, which were previously analyzed in each of the sections of this work.

Before Standardization	Alternatives			
Criteria	Scenario 1	Scenario 2	Scenario 3	Weight
Part Price	2,62 €	1,99 €	1,99 €	30
Investment (Tooling)	58.305,00 €	110.527,00 €	159.000,00 €	50
Timing (Weeks)	25	35	38	15
Capacity (Press Saturation%)	95%	83%	83%	50

Table 30. Result table before standardization

To analyze this data, I standardized the information in a scale from 1 to 10, according the VTP analysis, the result is shown in the Table 31. Result table after standardization.

After Standardization from 1 to 10	Alternatives			
Criteria	Scenario 1	Scenario 2	Scenario 3	Weight
Part Price	1	10	10	30
Investment (Tooling)	10	5,332459407	1	50
Timing (Weeks)	10	3,076923077	1	15
Capacity (Press Saturation%)	1	10	10	50

Table 31. Result table after standardization

Finally, we get the VTP results shown in the Table 32. VTP Result,

Scenario 1	Scenario 2	Scenario 3	
731	852,78	605	
0,504	0,588	0,417	VTP

Table 32. VTP Result

From the VTP analysis the best option is the Scenario 2, which is logical as it has a lower investment than scenario 3 and a short lead time, the other criteria are equal for both options, part price, timing and capacity are the same.

The Scenario 1 is really good for timing and investment, but timing is not the most relevant criteria for Alustamp, remarking that the low capacity of the manual press may endanger the deliveries of this and other projects.

The scenario 2 presents as explained along this work presents some advantages and challenges:

- It represents a major modification in the tooling affecting all the operations, this implies a long lead time and the requirement of a safety stock.
- The safety stock is an estimation based on current demands, once the project is approved by Alustamp and customer, the safety stock must be checked together with the customer and agreed, to avoid any shortage while doing the modification.
- With this modification, the tools will be moved from a manual press to an automatic press, which will free the manual presses from their current capacity issue without endangering the automatic ones.
- Even the investment is high, it will be recovered in only 10 months and a half (Pending to achieve piece price agreement with customer, as there is a process improvement, they will be willing to support the investment also)

9 Environmental impact

Alustamp and its products are environmentally friendly most ot them, the main product of the company is aluminum, which scrap is sent to a foundry in order to be reused. The automotive sector is too strict regarding environmental impact, for this reason they have several normative for this and also a document called IMDS, that allows everyone in the supply chain to track the material precedence of all the vehicle, in this document we have to fill all the material used in our product and from where it comes.

Aluminum waste from Alustamp is then sent to a recycling center, which melts again he aluminum ensuring the reuse. The wonderful thing about aluminum is that it can be used again indefinitely, the aluminum does not losses its characteristics[13], it does not matter how many times this cycle has been repeated, also it is a really common material used in a lot of applications, most common one is the cans of the soft drinks.

Apart from the aluminum this project also uses lubricant oil for its production, without it the material does not flow propriety and may crack. This oil is self-evaporating, this means that after few hours in transport or storage the oil evaporates into the atmosphere without leaving traces and without environmental impact.

This part is also regulated by VW standards that are European and globally accepted for the treatment of residues, the principal standards that apply are:

- VW01155, For IMDS material follow up, from the lowest supplier in the production chain to the last.
- VW91101, For the treatment of dangerous materials, how they should be worked with and disposed.
- VW 91101, For the environmental standard for vehicles, parts, materials, and operating fluids.

[13] Rinkesh, s.f. *Conserve Energy Future.* [Online]

10 Conclusions

The main aim of the project was to find a solution to two issues, which will be solved with the scenario two selected.

The first issue was the increase of requirements from customer, with scenario two there is no risk of capacity as we will be changing the manufacturing press, ensuring that the production of this or other parts is not endangered.

Also, with the second Scenario Alustamp and customer will find a benefit from the change of press and the improvement in the cycle time of the process, which will push to approve this proposal by both affected companies.

Se second issue was the current issues with the heatshield, with scenario two this will also be solved, as we are changing the material from flat to embossed, this has been proven that solves all of the issues and also it has been simulated that the part has a better modal analysis compared to the current one.

By this change of material, I also slightly improve the blank size of the part, but this is not reflected positively in the piece price as even if the blank size is reduced, the material increases, as it has an embossing height that increases the amount of material per mm2, which is results in the end as more material.

In general Scenario 2 was superior to the other 2 scenarios mainly because the investment is low compared to the build of new tools and also because it solves the current capacity issue with the presses. The part price is reduced making the scenario even more favorable, and finally it solves the current issues with the heatshield (this is solved with all the scenarios presented in this project).

As a summary of the work, all the three scenarios presented solved the aim of the project, but with different pros and cons. One of the main focuses of the project was to compare in different aspects the scenarios and determine the best or most fit scenario for the current situation of the project, it was pretty useful along the comparative the tools from the MUESAI subject "Project Management", also I must remark that the topics I learned in this subject motivated me to start working as project manager, that is a really interesting position in a business, is a person that it is given the mission and authority to follow up the project, it is an authority that he will have to exercise smartly to avoid making the authority a negative factor in the future, once the project is finished.[14]

[14] Brojt, D., 2005. *Project Management.* 1a ed. Buenos Aires: Granica S.A..

11 Future Projection

The project will be presented to Alustamp management in April 2022, showing the benefit of doing the investment and the return of the investment. Management will evaluate the options and decide if the project will be accepted or will risk It to keep going with the current situation.

If accepted/approved, the project will be shared with customer, as it is their product and any change in it, or its process must be evaluated and approved by them.

Its possible customer requires prototypes of the new part in order to validate the functionality, this will delay the approval maybe until July-August.

Once approved, the timing showed in the project will start running and the modification will be done.

When agreed with Alustamp management and customer, several tasks must be done before starting the project:

- Customer must simulate the new part in the complete vehicle under different simulations, thermic, static, vibration, etc.
- If necessary, customer will do physical trial, these may be done in a shaker test or in a vehicle.
- It is pending to agree with customer the new piece price and split of benefits from this modification, and also split of costs.
- New CAD data and drawing have to be realized with customer including the modifications in this work.
- It has to be coordinated with customer logistics department the safety stock production, as from Alustamp we cannot see far in the future the requirements and we must ensure lack of parts while the modification is ongoing. (The tools cannot produce any part in the middle of the modification)

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