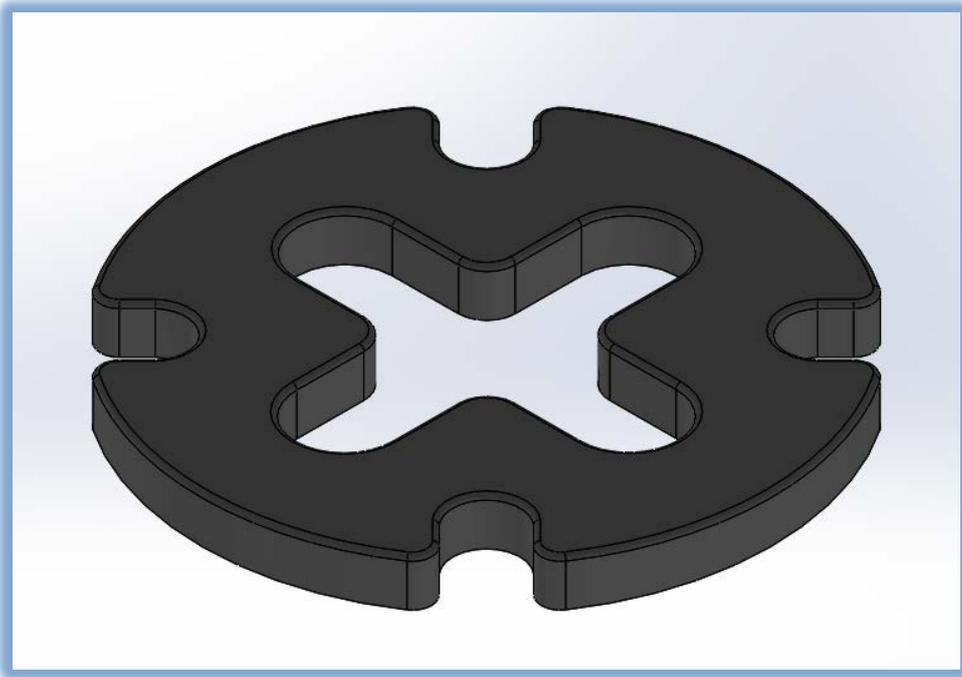


Industrialization of a Fine Blanking part.



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1. Objective:

1.1 Project definition.

The objective of the project is to define an industrial production process of fine blanking part, since we receive the quotation order of a part, till to deliver finished part to the customer.

In this case we have received a drawing of finished seat structure component, defined annual production in 320.000 units per year. In the drawing are defined the part specification as, dimensions, tolerances, surface finishing, raw materials, and heat treatments, in order to achieve mechanical properties on finished parts.

For the purpose of to define and design the industrial process, we will have to analyze the drawing, performing a feasibility study to know technically and economically if the part production is feasible with our tools and with our technical resources and in our facilities. After that we shall design a fine blanking tool, following production phases, like deburring process and heat treatment process.

1.2 Project Scope.

The project scope is to define what fine blanking technology is, and how it works.

Prepare a technical feasibility study before quote the part to our customer in order to know if we are capable to produce the parts in an industrial way with our production lines and in our facilities.

Design and draw a fine blanking tool which will be able to produce the requested part. Design and define a deburring process, choose the facilities and machines to do that. Define Heat treatment process to achieve mechanical properties, defined in the drawing, on the part. Design a control plan for whole process, using APQP (advanced product quality planning), where will be defined, production control plan.

2. Theoretical information and definitions.

2.1. Fine blanking definition.

Fine blanking technology is variant of stamping process, the main characteristics of it could be defined with two words, flow and shear. Fine blanking allows, blank out and clean cut metal parts, without any tear-off and scars. The cut surfaces – showing only very small dimensional tolerances – can be used without any secondary operations.

The process also, allows us to do following operations in composite progressive dies:

Bending

Off-set bending

Coining

Forming

Limiting parameters, like webs and holes diameters, can even be lower than with common blanking technology. Secondary operations like drilling, milling, or grinding can be omitted, achieving cost reductions.

Parts with thickness from 0.5 to 20 mm, made of steel, cooper and aluminum alloys are nowadays economically fine blanked.

The following factors influence the process:

Fine blanked part shape

Part material

Fine blanking tool

Fine blanking press

Lubricants

2.1.1 Graphical differences between fine blanking and conventional stamping.

The sketch below shows that, in the fine blanking tool there is a guide plate where the force of pressure could be controlled due it is connected with guides directly in contract with the press. During the blanking process the ejector follows the punch keeping the part compressed and therefore assuring its flatness, also in the fine blanking tool there is no a conic output in the die tool.

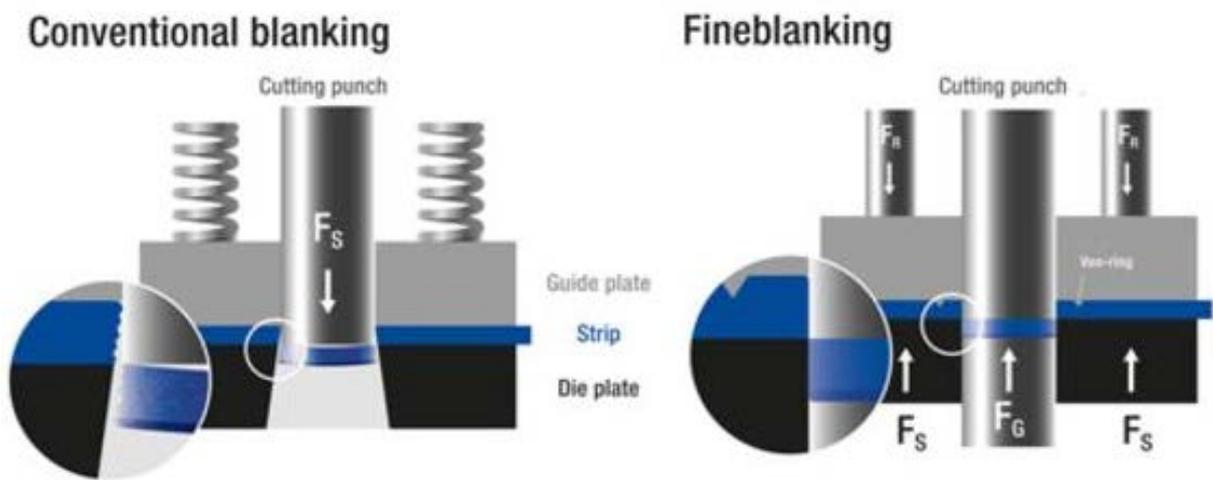


Fig. 1 [TDM16] (Sketch showing components and process differences between both tech's).

2.1.2 Technical differences between produced parts using fine blanking and conventional stamping.

Within the next table we can see the main technical differences between both technologies. This information can help us to decide which kind of technology we should choose to produce a part in industrial terms.

Fine blanking:	Conventional blanking
High flatness requirements achievable	Lack of flatness in the part
High perpendicularity between blanked face and surface of the part	Lack of perpendicularity
High control of the roughness on the blanked surface	There is no control of the roughness on the blanked surface
Is it possible to avoid any tear off over blanked surface	Tears off over 2/3 of blanked surface
High precision in blanked dimensions (till 0.005 mm)	Lower precision in blanked dimensions 0.1
Tolerances around 1% of thickness	Tolerances achievable around 8 % of thickness
Scrap and blanked part are ejected at the same time and the same way by the rear of the press.	Scrap and blanked part are evacuated through die plate and let fall down in a tray.

Fig. 2 [TEC14] (Differences between both technologies).

2.2.2 Graphic example of differences in finishing of blanked surfaces fine blanked parts and conventional stamping.

The picture below, shows the difference, over the cut surface, between fine blanking technology and conventional stamping. In the picture is appreciable the different finishing between kind of technologies. In our case, and tacking in account the drawing requirements we will need a lower Ra finished surface, for this reason we will choose fine blanking technology.

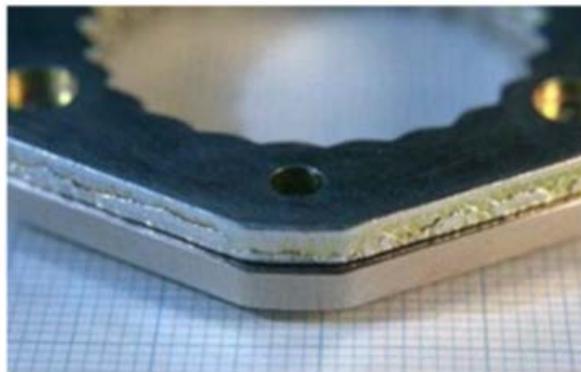


Fig. 3 [TEC14] (Upper part, conventional stamping, lower part fine blanking).

2.2.3 Tool Behavior and raw material during fine blanking process:

Simulation is a good tool to calculate peak tensions and elastic deforming on tool elements. But mostly it is used flow calculations in cold forming operations (coning, bending and drawing).

In the next picture we can see where could appear the efforts, both of tool elements and raw material. The color gradient shows *Von mises stresses* in each component which is involved during cutting process:

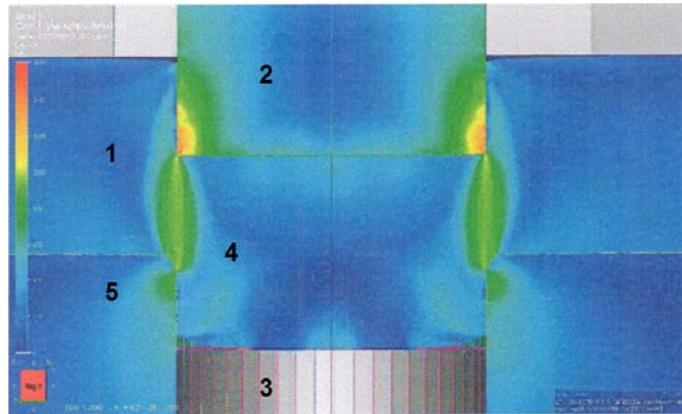


Fig. 4 [VMS16] (Von mises stresses during fin blanking)

Parts involved in the process (see picture):

- 1- Raw material
- 2- Punch
- 3- Die plate
- 4- Ejector

From the image, and following the color rules, we can extract that the critical area during blanking process is the cutting edge of punch, which is an active component during process.

2.2.4 Steel fibers behavior after fine blanking.

The next micrography of a section, belong to a carbon steel (C45) part, shows how the steel fibers suffer a plastic deformation after cutting process. We can observe that due the raw material efforts and plastic deformation, as soon as we see closer to the cutting line, the strain vector increases and therefore the fiber radius deformation, are bigger.

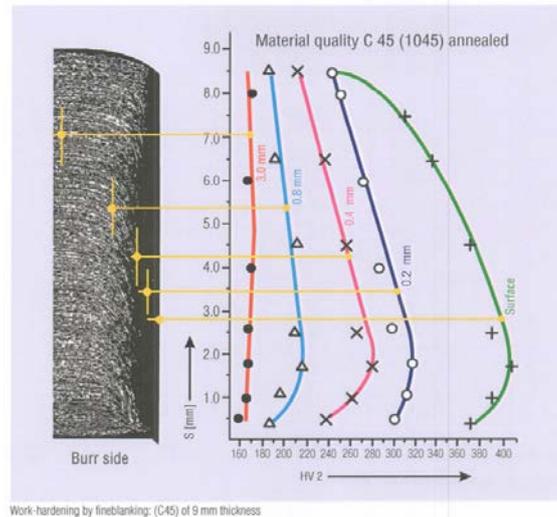


Fig. 5 [FTR03] (Plastic deformation over steel fibers).

As explained in previous paragraph fine blanking is a flow and shear process. Crystals of the structure get first fully cold formed and afterwards cut. Fine blanking therefore requires different characteristics of the material to be cut than conventional blanking process. The illustration above shows how extensive the flow process influences the work hardening of fine blanked part. In practice word hardening g is very common.

In fine blanking process can be performed a complete cut (total thickness) or semi-cut and nipples (not complete thickness):

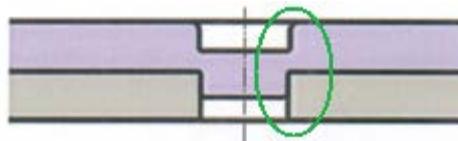


Fig. 6 [FTR03] (Nipple sketch)

In a nipple deformation the punch does not go completely through the raw material the punch penetration length is lower than the raw material thickness, with that we achieve a deformation of the material avoiding completely cut. Using the fine blanking technologies and fine blanking materials compositions and mechanical characteristics, is achievable nipple height, till 80% of raw material thickness, without breakage. This kind of process are used in the industry to avoid added phases to the part for example, assemblies or welding, therefore the part could be cheaper than parts produced by other stamping solutions.

In the fig.7, we can see how the fibers are deformed after nipple deformation, without complete breakage of them and complete cutting.

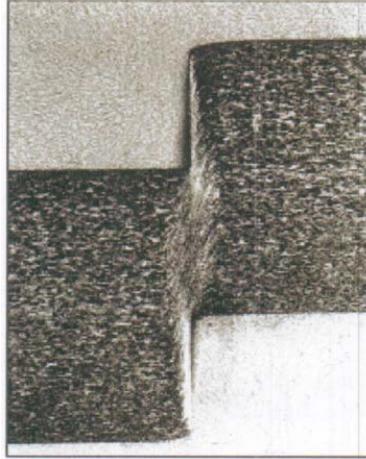


Fig. 7 [FTA12] (Fiber section)

2.2. Concepts and definitions:

2.2.1 Parameters of fine blanked surface:

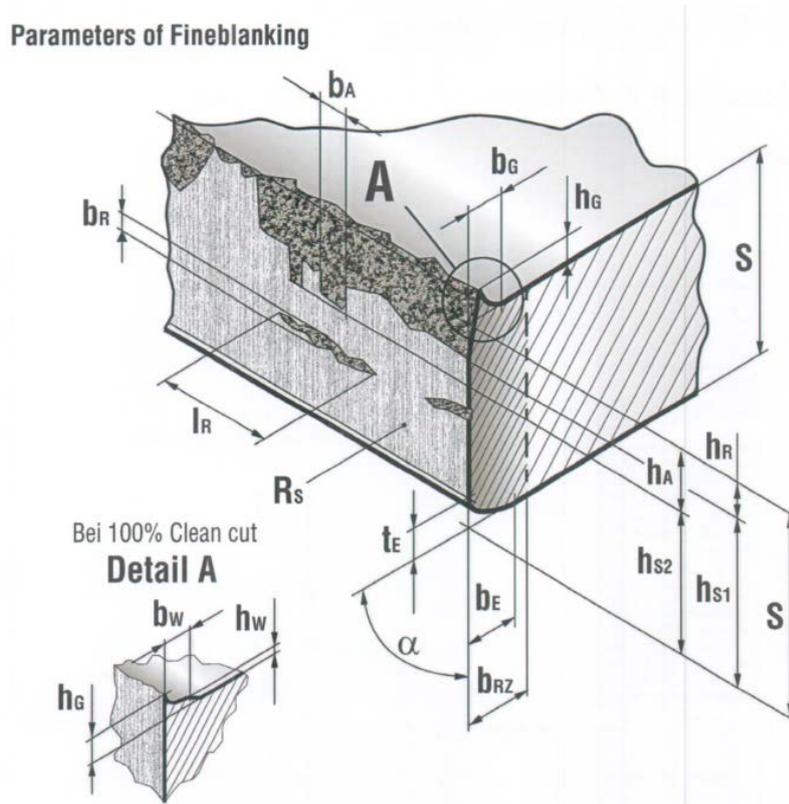


Fig. 8 [FTR03] (Fine blanking cutting section parameters).

* This illustration is no to scale. It is valid for inside and outside surfaces of a fine blanked part.

Listed all parameters, by name, identification in the scheme and its magnitude:

Material thickness	S [mm]	Burr width	bG [mm]
Die-roll width	bE [mm]	Burr height	hG [mm]
Die-roll depth	tE [mm]	Angle of cut surface	a [°]
Tear-off	hR [%]	Surface roughness	RS [Ra]
Clean cut ratio	hS1 [%]	Hardness increase at border area	bRZ [mm]
Clean cut ratio	hS2 [%]	Bulge width	bW [mm]
Scar length	lR [mm]	Bulge height	hW [mm]
Tear-off height (shell-like shaped)	hA [mm]	Scar height	br R [Nr.1-4]
Tear-off width (shell-like shaped)	bA [mm]		

2.2.2 Definition of main parameters:

2.2.2.1 Burr:

A burr is a raised edge or small piece of material remaining attached to a work piece after a modification process. In fine blanking process, the burrs always appear, only in one side, this is the side in contact with die plate (if only one cutting direction is used in the designed tool).

The burr size depends on the:

Blanking material

Tensile strength

Condition of the cutting edge

Cutting clearance clean cut ratio of the surface

The burr height increases with increasing dullness of the punch cutting edge. Here we can see the increment of the burrs, in the same blanked part, using the same punch, raw material thickness, mechanical characteristics and chemical composition:

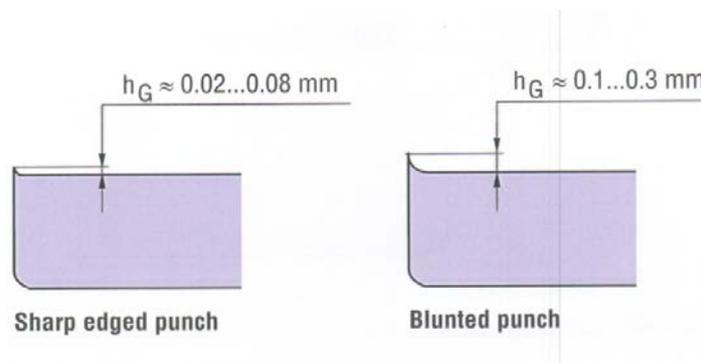


Fig. 9 [FTR03] (Differences between sharp punch and blunted punch).

As we can extract from Fig. 9, is very important to avoid increases of the burr the correct machining and maintenance of the active components of the tool. Otherwise we will have big burrs, and therefore difficulties during deburring stage.

It is important to know the burr height in order to determine whether and how a burr must be removed. There are several possibilities to deburr the part:

Sand belt grinding.

Brushing.

Barrel grinding

Shot peening

Example of burr after fine blanking process:



Fig. 10 [MTP16] (Burr after blanking “tooth shape”).

Fig. 10, shows which kind of burr appear in the burr side after fine blanking part. We can observe the behavior of the burr depending of the shape to be cut, over the little radius (tooth shape) the burr is bigger than the big radius (between tooth shape). This is an effect created by the stress concentration applied over the raw material.

Burr in a 16MnCr5 part, thickness 5mm:

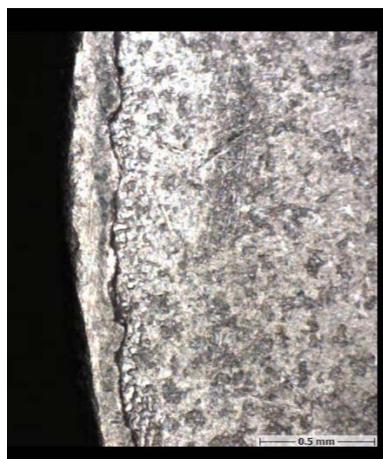


Fig. 11 [MTP16] (Shown burr in a micrography increased x20).

In the micrography is shown a burr over 16MnCr5 part, 5 mm thickness, incorrectly deburred, the burr has been not eliminated completely and it has bent over itself.

When the burr does not remove and remains on the part, it could provoke, mostly functional incidences in further stages of the part.

2.2.2.2. Die roll:

The die roll is an unavoidable characteristic of a fine blanking part, because as explained the process of fine blanking is composed by a fluency of the raw material and shear process (following plastic deformation characteristics).

Die roll size depends on the part geometry, thickness and corner radius size and angles. The width b_E is usually about the five times larger than the depth, t_E . (See fig. 8)

Quality of material, tensile strength, as well as the tool state, influences strongly to the die roll size. Another quality criterion, is the perpendicularity of cut surface. Fine blanked parts always show some deviation from the right angle, in contrary to conventional stamping. It means that the outer form dimension of a part is a bit smaller on the die roll side than the burr side. As for inner forms it is exactly opposite.

How to predict die roll during feasibility study?

Using the next chart, we can calculate approximately the die roll which will appear in the fine blanked part depending the inner shape, outer shape and raw material thickness:

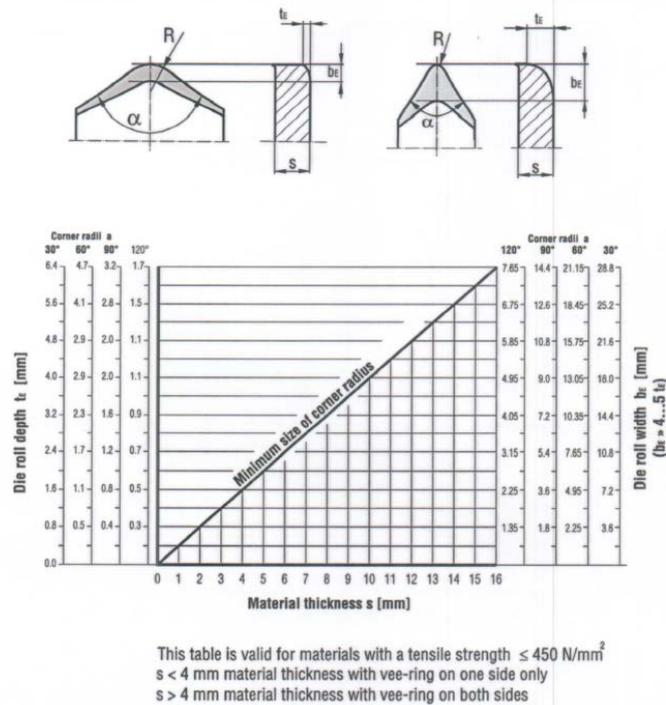


Fig. 12 [FTR03] (Radius predictive chart).

To use correctly that chart we have to know three variables of the surface or shape that we want to analyze, these are, radius, angle and thickness. Using these three values we have to draw three lines to the chart and find the crossing point of them, then we will have if this shape is feasible or not with three input parameters. If the crossing point appears under the “minimum size of corner radius” line, the shape is not feasible.

We will use it, during the feasibility study of our part.

2.2.2.3 Tear off:

Tear off is a fracture or breakage of material and only appears over the blanked surface, from any point of section (blanked area) and till the end of raw material. When the blanking efforts in the raw material are higher than forces which keep united the steel grains, the material breaks by the union line of grains, provoking a leak of uniformity over the blanked surface.

Examples and grades of tears off:

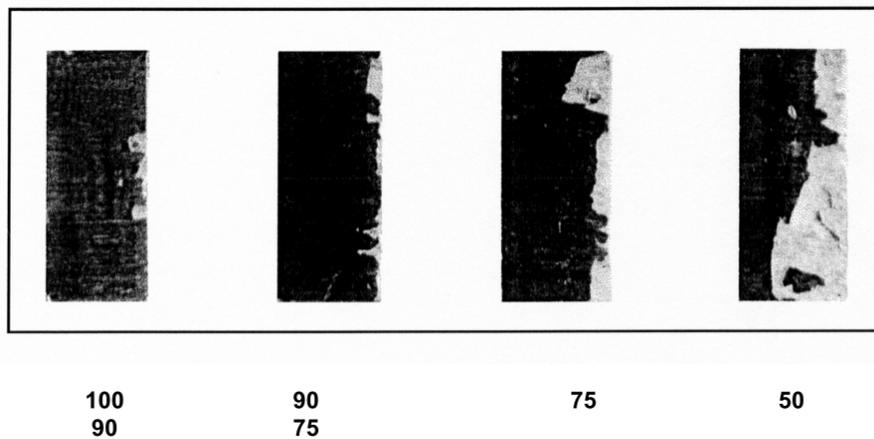


Fig. 13 [VDI94] (Gradient of tear off over blanked surface).

Example of tear off technical definition (drawing):

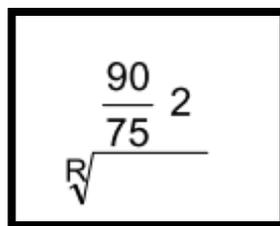


Fig. 14 [VDI94] (Drawing definition for tear off).

The fig. 14 shows how we can find in the drawing the tear of requirement, the important numbers are "90 and 75" which can change as defined in Fig. 13. E.g. This picture means exactly that, is requested minimum 90% clean surface, being allowed peaks at 25% of tear off. Then number "2" in the drawing defines the scar level, which phenomenon will be explained within the next paragraph.

2.2.2.4 Scars:

The cracks are, located fissures in the blanking surface. These are defined by number (1-4) to the right of fine blanking specs. The appearance of the cracks could be provoked for several inputs in the process, but the main ones are the raw material grain size, edges of the punches and tolerances between active components of the tool.

Examples and grades of Scars:

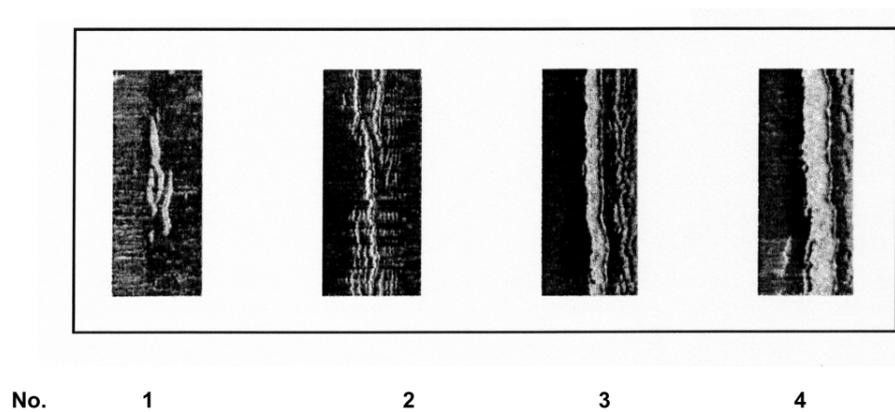


Fig. 15 [VDI94] (Gradient of scars over blanked surface).

See Fig. 14 to know how is defined scar in the drawing.

2.2.2.5 Grain size:

When a metal or alloy is processed, the atoms within each growing grain are lined up in a specific pattern, depending on the crystal structure of sample. With growth, each grain will eventually impact others and form an interface where the atomic orientations differ. It has been established that the mechanical properties of the sample improve as the grain size decreases. Therefore, alloy composition and processing must be carefully controlled to obtain the desired grain size. For fine blanking process has to be taken in account at the moment to define raw material requirements, that the minimum size of grain size should be 6 (inversely proportional value, is not the measurement of the grain size if not the number of grains in a defined area, following G index, acc. E112-10 (ISO 643)).

Example of grain sizes:

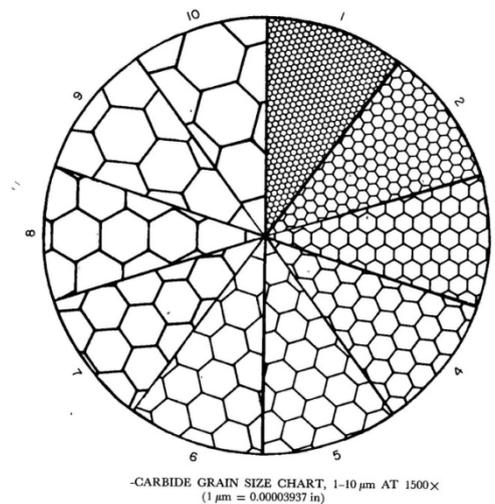


Fig. 16 [DOL16] (Carbide grain size chart).

The Fig. 15 shows the difference in relative terms of grain size, from grade 1 to 10.

3. Part analysis:

3.1 Documentation and information received from the customer.

3.1.1 Technical definition (Drawing delivered by the customer):

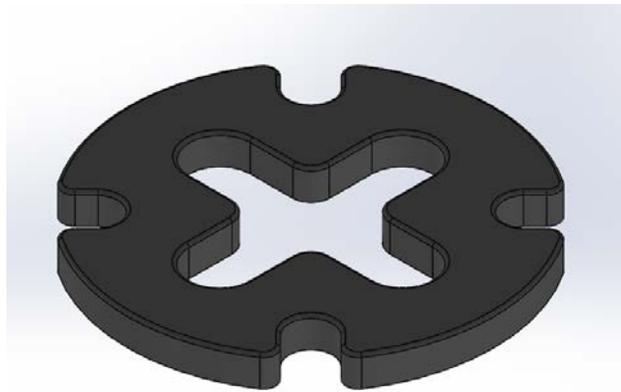


Fig. 17 [MTP16] (Isometric part view).

Fig. 17 show the part that our customer is requesting for. This picture is not to scale but give us an idea which kind of part we will have to study. The complete drawing is shown within paragraph 4 “feasibility study” on Fig. 21.

3.1.2 Sales characteristics of the project:

-Target price:

Our customer has informed us that the price target is 49 € /1000 parts

- Quantity of parts to be delivered, per year:

2.000.000 per year

- Amortization of the project design:

2 years

LTA's 3X5

3.2 Information regarding the functionality of the part:

3.2.1 Part location and function:

For all producers is very important to know what the location and function of the part is, in order to understand and focus the own production process, which will be the solicitations over the parts, assembly needs, and so on... As our customer has informed us, the part will be assembled on driver seat mechanism, which will allow to the car driver adjusting the inclination of the back rest. Our part will be located in the driver seat, defined in the next picture:

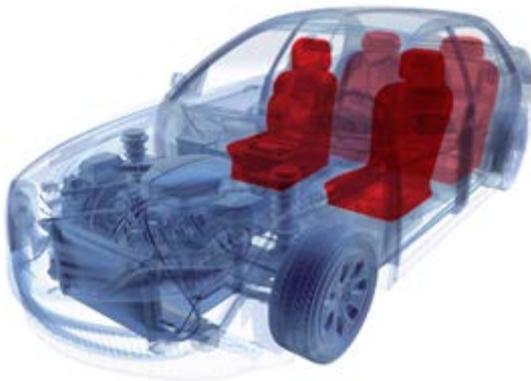


Fig. 18 [FEP16] (Car structure).



Fig. 19 [FAU16] (Seat metallic structure).

Tacking in account this information, and as defined in the drawing, this part is a “security and regulation” part **S/R**. It means that this indication has to be taken in account during whole production process, because the manufacturer has legal liability if direct or indirectly the final consumer is injured due a wrong function of the part. The logo which defines in the drawing this part regulation is, as follows:



Fig. 20 [MTP16]

This kind of symbology is framed in the automotive norms, instead standard norms as VDI, AFNOR, DIN...

3.2.2 Part description:

As we have seen in the previous paragraph the part will be assembled in a turning axe which will allow to the user to regulate the backrest inclination. The durability tests, has been calculated for a minimum of 11.000 cycles, before appear gaps in the mechanism. This quantity of cycles has been calculated according following information:

Two persons share car with different seating positions. Person A uses the car at the morning, person B alt the evening, 6 days per week.

The car is used 312 days per year (52 weeks)

Car life average in Europe is 9 years and the worst case in east Europe is 11 years. (Data belong to year 2014, and extracted from "<http://www.20minutos.es/noticia/1975264/0/vida-media-vehiculos/coches-asciende-14-anos/crisis/>").

$$2 \times 312 \times 14,5 \times 1.2 = 10.857 \text{ cycles}$$

** 1.2 is the reliability coefficient.*

Fig. 21 [MTP] (Calculation of cycles during part useful life).

Due the location of the part inside the mechanism and the solicitations over the part assembled in the seat, the part should to present tenacity on the core and high hardness on its surface. On that area, the part will suffer wear and the core of part will suffer torsion stresses, for this reason is defined in the drawing as a raw material, 16MnCr5 with a heat treatment, after fine blanking process. Through it, we will achieve on the part, hardened surface at 700-780 Hv and hardness gradient to the core with a depth: 550 Hv 0.3.

4.2 Raw material:

The raw material is clearly defined in the drawing. Defined raw material is 16MnCr5 (Wr. 1.7131), is a commonly used, raw material quality in fine blanking technology. In the most cases has to be case hardened to achieve the mechanical characteristics to be valid for the using application.

4.2.1 Raw material description:

This steel grade is a low alloy chromium, manganese case hardening steel. Carburized 16MnCr5 gives a hard case with a strong core whilst retaining a degree of toughness. It is suited for applications which require a combination of toughness and wear resistance and is commonly supplied in round bar or flat coil.

4.2.1.1 Applications:

This carburizing steel grade is suitable for shafts, gears, pinions, collets, pins and camshafts and is commonly used in the engineering and automotive industries.

4.2.1.2 Chemical composition (16MnCr5):

C	Si	Mn	P	S	Cr
0.14 - 0.19	max 0.4	1 - 1.3	max 0.025	max 0.035	0.8 - 1.1

Fig. 23 [STS13] (16MnCr5 main elements of and proportions defined in %).

4.2.1.3 Mechanical characteristics:

Name	Standard	Tensile strength	Yield strength	Elongation at
16MnCr5	EN 10132-2	≤ 550	≤ 425	≥ 21

Fig. 24 [STS13] (16MnCr5 main mechanical characteristics).

4.3 Dimensional and shape (tolerances):

First of all, we have to analyze the shape of the part Vs the thickness of it, in order to classify the difficulty that we will find to produce the part, using fine blanking technology. Using the following chart, we can define it:

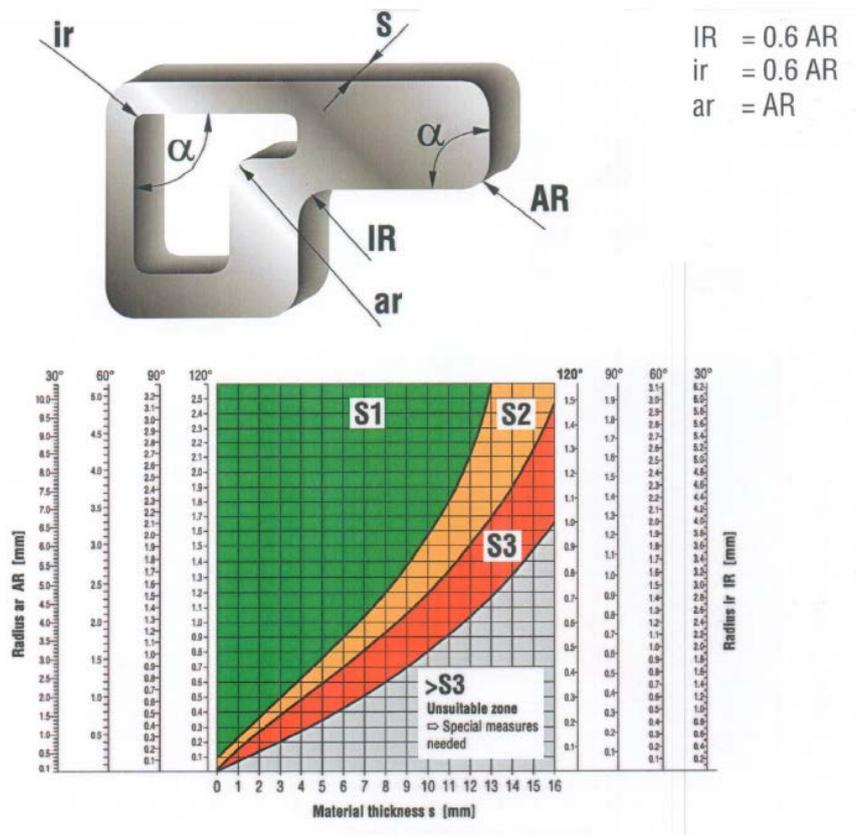


Fig. 25 [FTR03] (Part difficulty definition chart).

To use correctly that chart we have to know three variables of the surface or shape that we want to analyze, these are, radius, angle and thickness. Using these three values we have to draw three lines to the chart and find the crossing point of them, then we will have the information to classify the difficulty of the part. In the chart we have identified 4 areas, S1, S2, S3, and >S3. If the crossing point appears in grey area, >S3, the part is not feasible by fine blanking technology.

Taking in account the outer radius and the inner shape of the part, we can define this part as **S1 (low production difficulty)**.

In this case all tolerances can be achieved by fine blanking technology due the lowest tolerance identified in the drawing is “error form” over itself, 0.05 bilateral, this tolerance can be found in the outer shape of the part, where is functional surface of the part. The other tolerances are bigger and due it less restrictive, therefore achievable.

4.4 Surface finishing (coatings):

Many times, fine blanked parts have to be coated with several kind of coatings, electrolytic, lubricating coats, corrosion protection, etc.... In this case is not defined any coating in the drawing, for this reason this section **does not apply** for this feasibility study.

4.5 Mechanical characteristics (finished part):

In the drawing we can identify final mechanical characteristics for the part to be achieved. Tacking in account that the raw material has different mechanical properties, the requirements of finished part defined in the drawing, have to be achieved performing a heat treatment process over there, in this case the specs to be achieved are:

Surface hardness: 700-780 Hv

Hardness depth: 550 Hv 0.3

4.6 Requirements of blanked surfaces and maximum die roll:

Defined in the drawing, fine blanking is 90/75, it means that the blanked surface has to be guaranteed over the blanking area at least 90%.

In the drawing we can to find a requirement regarding minimum functional thickness (another way to define die roll). As functional thickness defined we find 3.6 mm, due this information, we have to take in account that if the total thickness is 5 mm (nominal thickness), and the tear off is maximum 10%, the die roll never can be higher than 1 mm. In function of following chart we can assure “theoretically” that the die roll maximum 1 mm can be assured, in theory, over all shapes of the drawn part.

4.7 Edges and corner radius (burr side):

In the drawing is defined also, the finishing edges on the part, we can identify the requirement with this symbol:

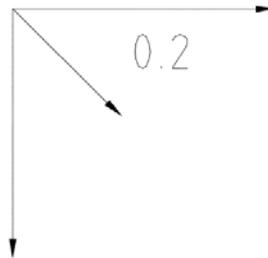


Fig. 26 [MTP16] (Drawing symbology to define edges).

This symbol means that, all the edges has to be round at least, 0.2 mm. We will must to take care with this requirement at the moment to define the production process, because in fine blanking technology, only can be achieved radius in the die roll side, in the opposite side we can only achieve burrs (protruding material), or at least 90° edge. Fig. 27 represents the edge in the die roll side and burr side, after rounding process.

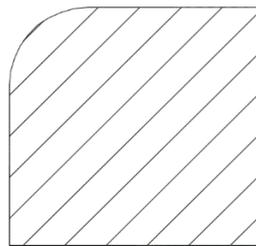


Fig. 27 [MTP16] (Radius section sketch).

5. Tool component description:

5.1 Die plate:

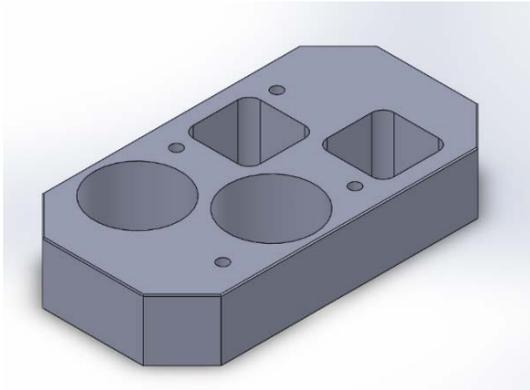


Fig. 28 [MTP16] (Upper side)

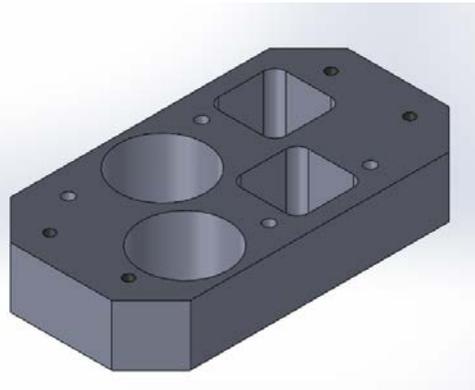


Fig. 29 [MTP16] (Bottom side)

Is together with the punches, the active element of the tool, and which suffer direct efforts during blanking process. Those elements give us the possibility to give form to steel, cutting it with desired shape. In our tool the die plate is composed by 3 different elements. Die tool and 4 postiches, two for every stage. With this design we want to achieve that the element which will suffer wear be smaller and easy to be replaced, due it we get cheaper and faster element maintenance. By counterpart the construction cost (initial investment) will be higher because will be more machining working hours.

Regarding elements raw materials, we can use finest materials for active elements instead, increasing live of those elements, and poor material for die plate, which will not suffer wear, all by the whole price.

Postiches and die plate are fixed using adjustment tolerances (f7 – H8) between them and nailed postiches in the die plate nests.

5.1.1 Construction process:

Selected raw material (F-112), the gross block is grinded by one face to achieve enough flatness in one side. At this moment all the holes have to be machined using a CNC drilling.

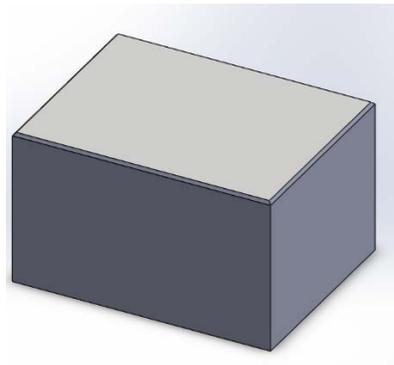


Fig. 30 [MTP16] (Block after one side grinded (flat)).

After that, using a CNC milling 5 axes, the block is machined with a high advance speed of the milling machine to create the whole outer perimeter including chamfers.

The next step is, to create 4 nests for postiches, it has to be done in two different stages, one for coarsely material creating square holes and the other one, is for finishing, giving to the holes very low tolerance deviations and surface roughness.

During the same machining stage, the fixing holes and the screws are machined in the plate. 4 holes M8 X 45.

At the end the plate is heat treated applying quenching and tempering in a void furnace, to avoid calamines after the process. Applying the heat treatment, we will achieve a hardening around 53-56 HRC.

At the end of the process (always after heat treatment), an adjustment works should be done, to assure that any deformation, appeared during heat treatment process, has affected the component functionality.

5. 2 Postiches:

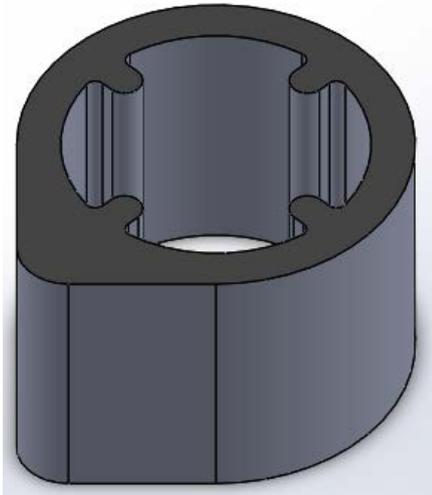


Fig. 31 [MTP16] (Postiche outer shape)

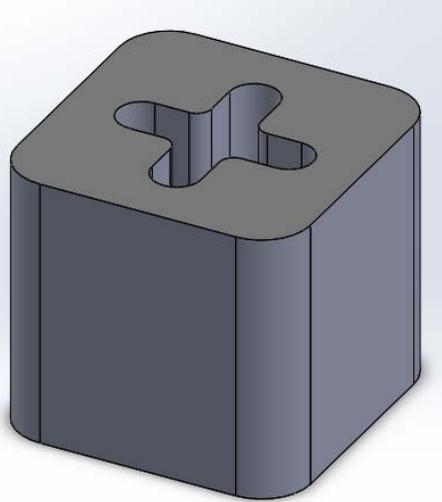


Fig.32 [MTP16] (Postiche inner shape)

The postiches are the elements which will suffer the wear, saving the die plate of it. Using this kind of design, we can reduce the maintenance costs, and we can improve the maintaining and repairing time. Also we can have stock of replacement components with a low cost, because the production of a postiche is cheaper to than a complete die plate.

For these elements we have chosen as **raw material K490 (Böhler)**. For more information regarding K490, see annexes [ABO11]

5.2.1 Construction process:

The gross block is grinded by one face to achieve enough flatness in one side. The block is machined around its outer shape, till it is offset 1 mm from the final dimensions. After that one hole of 5 mm has to be done, in order to use after heat treatment in EDM process.

The next step consists in apply a heat treatment over the semi elaborated component, in this case we have decided to apply “Quenching and tempering” to achieve hardness in the core as 60-64 HRC.

5.2.1.1 Parameters recommended for Heat treatment by raw material supplier.

Quenching:

- 1030 a 1080 °C/ oil, N2
- After heating: 20 – 30 minutes
- Cooling in oil bath.

Tempering:

- Warm slowly till tempering temperature just after quenching
- Time to be in the oven, 1 hour for every 20 mm of thickness of machining part, minimum 2 hours.
- Cool in air (not force and temperature).
- Raw material producer recommends perform 3 tempering at the same temperature.
- Achievable hardness: 58 – 64 HRC

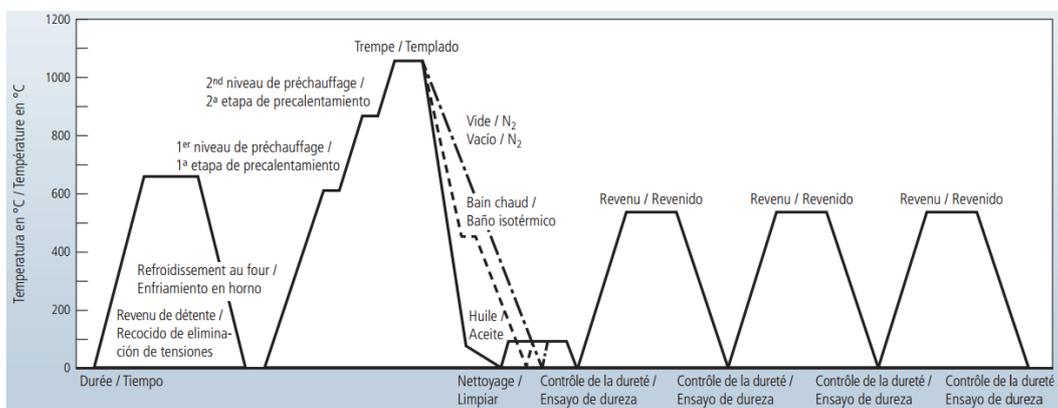


Fig. 33 [ABO11] (Recommended heat treatment to be done over the raw material)

5.2.1.2 Machining outer shape (fine finishing).

After heat treatment we have to remember, that we have oversized the element 1 mm, during first machining, for this reason, at this moment we have to perform a second machining preparing the machining tool for finishing parameters, in order to assure the dimensions with their own tolerances and surface finishing.

5.2.1.3 EDM (wire).

The next step, is to cut the inner form of the postiche, in this case we should to use EDM machine by cooper wire.



Fig. 34 [MTP16] (Picture taken in real EDM machine during punches cutting process).

5.2.1.4 Coating.

The final phase to apply a coating over the postiche to achieve high mechanical properties and protect the element form the wear.

Selected coating ALCRONA:

Coating properties	
Coating material	AlCrN-based
Micro hardness* (HV 0.05)	3.200
Friction coefficient between steels (dry)	0,35
Maximum working temperature (°C)	1.100
Color	Bright grey

Fig. 35 [OBA 16] (ALCRONA technical characteristics).



Fig. 36 [OBA 16] (ALCRONA aspect).

The Fig. 36 shows a drilling tool after performed ALCRONA coating over the active surface (cutting surface). Covered area presents a dark aspect which is a singular characteristic of ALCRONA.

At the end of the process (always after heat treatment), an adjustment works should be done, to assure that any deformation, appeared during heat treatment process, has affected the component functionality.

5.3 Ejectors (Inner shape):

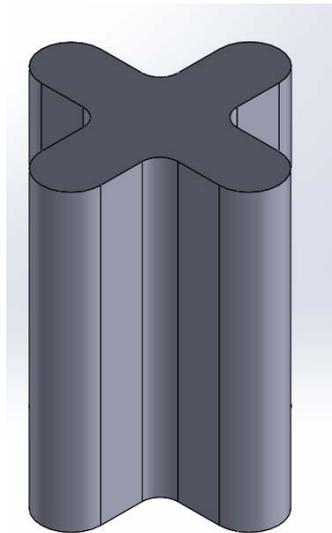


Fig. 37 [MTP16] (Upper side).

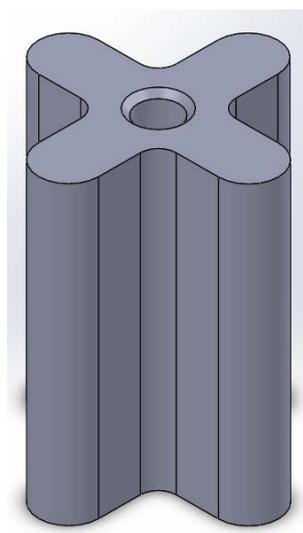


Fig. 38 [MTP16] (bottom side).

This tool component is which receive the counter force during the blanking process, and the responsible for taking out the scrap from the die plate (postiches). This component has not very high solicitations over its edges and therefore is not needed high wear resistance, for this reason in this case we have chosen raw material **Uddeholm Sverker 21**, which corresponds to (1.2379 / KA 11), hardened to achieve 55-58 HRC, but we have not included any coating or surface treatment. (See producer data within Annexes).

5.3.1 Construction process:

The construction process designed for this component will be, to grind the gross block of steel firstly by one face to achieve enough flatness, and after that to grind the opposite face also, to achieve two parallel faces. The next one, is drill one through hole to be able the copper wire through by the steel block and start EDM stage, the process with which we will able to cut the outer shape of the component. The tolerances capability of this process, fixing the correct parameters before to start, is around 1 μm , and the achievable Ra values for the surface finishing are until 0.04 μm .

The next stage of the process is to perform a blind hole centered in the bottom face, which will be used to create the fixing screw.

In this moment the component is heat treated applying quenching and tempering, in a void furnace, to avoid calamines and decarburization on the surface, appearance during the process.

5.3.1.1 Heat treatment recommended parameters by the raw material supplier:

Hardening:

- PRE- heating temperature: 650–750°C.
- Austenitizing temperature: 990–1050°C

Temperatura °C	Tiempo de mantenimiento* minutos	Dureza antes del revenido HRC
990	60	aprox. 63 HRC
1010	45	aprox. 64 HRC
1030	30	aprox. 65 HRC

Fig. 39 [SVK12] (HT parameters recommended by supplier).

* Time to keep the temperature, just after achieved Austenitizing temperature.

In order to achieve final hardness (after tempering) 55-58 HRC, we have defined 1020 °C as austenitizing temperature.

Tempering:

To achieve the hardness defined by us (55-58 HRC), we have to choose the tempering temperature, in this case, and following the chart, given by the supplier, the tempering temperature should to be around 350 °C. The supplier indicates, to perform the tempering operation twice, with a minimum tempering time, 2 hours.

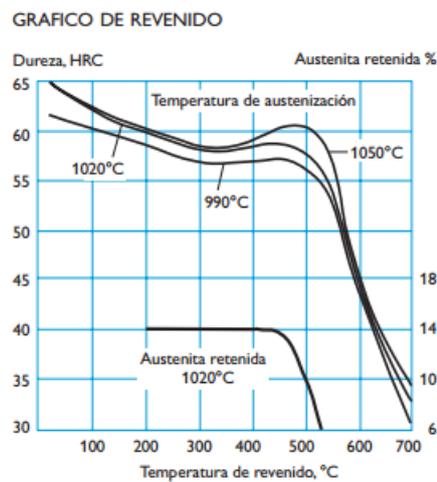


Fig. 40 [SVK12] (Tempering chart).

After heat treatment, using a cooper electrode (EDM process), the screw is created inside the hole.

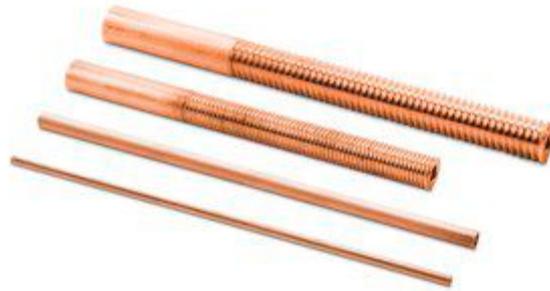


Fig. 41 [DIY16] (Screws electrodes).

This kind of process is applied to avoid machining over heat treated parts. The electrodes are machined and the raw material is copper, they are a little bit smaller than the final shape (screw). The electrode is placed inside the previous drilled hole, and be moved (orbiting perpendicularly to axe hole) touching the hole walls, then those surfaces are degrading creating the tooth screw .

At the end of the process (always after heat treatment), an adjustment works should be done, to assure that any deformation, appeared during heat treatment process, has affected the component functionality.

5.4 Ejector (Outer shape):

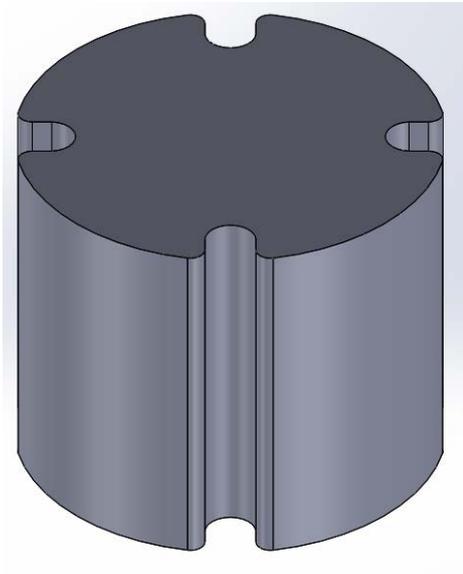


Fig. 42 [MTP16] (Upper side).

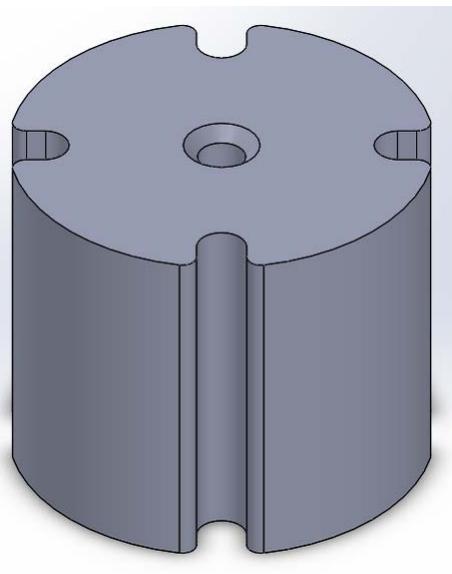


Fig. 43 [MTP16] (bottom side).

This component needs similar mechanical requirements than other ejector (outer shape), for this reason the chosen raw material and final mechanical properties are the same. The production process in this case, is the same as well, grinding, machining, EDM by wire for cut the outer shape, through hole for fixing screw, heat treatment, screwed by EDM, and final adjustment.

5.5 Punch inner form:

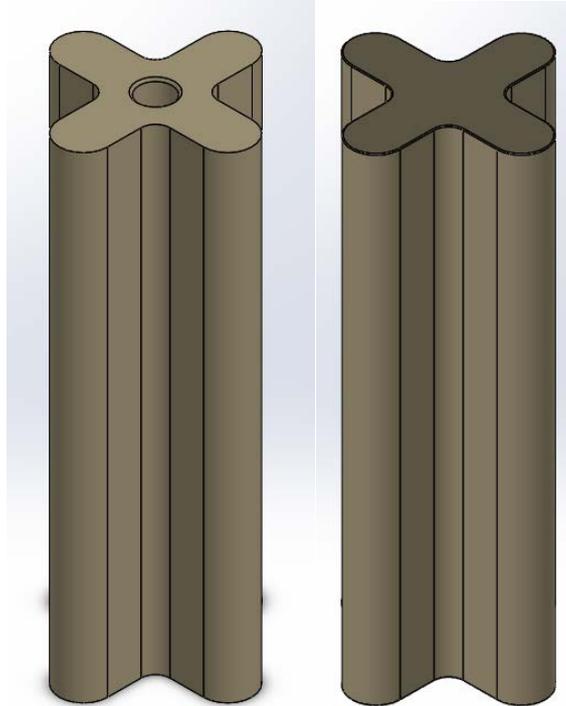


Fig. 44 [MTP] (Upper side). Fig. 45 [MTP] (Bottom side).

The punches together with the die plate are the active elements of the tool, for this reason if we want to find a good relation between durability and component costs, we must to define high wear resistance material, or add a coating over the punch to extend the useful life of the punches.

The inner punch is the element which will cut the inner shape of the part, the fine blanking requirements for this shape are 90/75, and it means that the cutting edge of the punch has to have a radius, 0.05-0.1, to avoid breakage of material during blanking process. With this radius we achieve a fluency material during the cutting process and therefore a good surface finishing, without cracks or tears off.

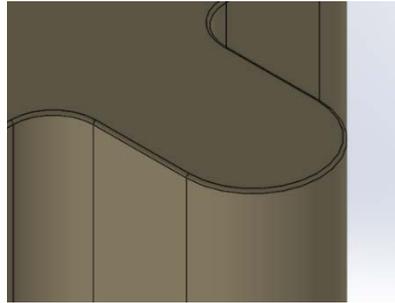


Fig. 46 [MTP] (Radius 0.1 detail).

In this case we have defined as a raw material for the inner form punches, **ASP2005 (UE HS 2-3-4), belong to supplier, ERASTEEL**. (See more information regarding raw material within Annexes).

5.5.1 Construction process:

The construction process designed for this component will be, to grind the gross block of steel firstly by one face to achieve enough flatness, and after that to grind the opposite face also, to achieve two parallel faces. The next one, is drill one through hole to be able the copper wire through by the steel block and start EDM stage, the process with which we will be able to cut the outer shape of the component. The tolerances capability of this process, fixing the correct parameters before to start, is around $1\ \mu\text{m}$, and the achievable Ra values for the surface finishing is until $0.04\ \mu\text{m}$.

The next stage of the process is to perform a blind hole centered in the bottom face, which will be used to create the fixing screw, also a chamfer to help to center the EDM electrode.

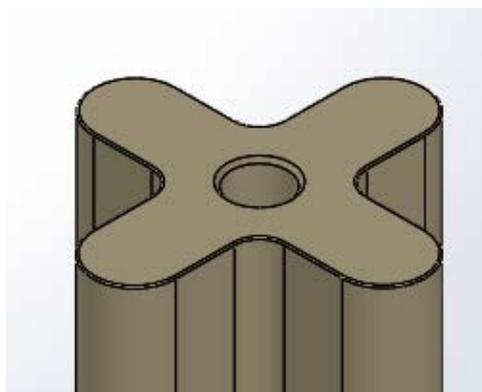


Fig. 47 [MTP] (Detail of blind hole).

At this moment the component is heat treated applying quenching and tempering, in a void furnace, to avoid calamines and decarburization on the surface, appearance during the process.

5.5.1.1 Heat treatment recommended parameters by the raw material supplier:

Hardening:

- PRE-heating temperature: Two steps

First step: 450 - 500 °C

Second step: 850-900 °C

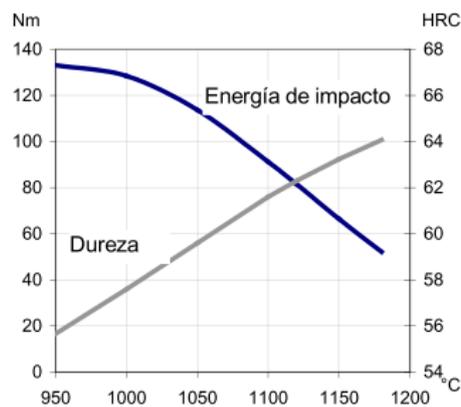


Fig. 48 [ERS10] (Austenitizing temperature chart).

In our case we want to achieve hardness up to 60 HRC, so we have to define as austenitizing temperature 1160°C. At the end of heat treatment, the parts should be cooled in oil bath at 40-50 °C.

Tempering:

- Tempering in three phases: war till 560°C during minimum one hour. Cool till TA (25°C), between every stage.

5.5.1.2 EDM (electrode):

After heat treatment, using a cooper electrode (EDM process), the screw is created inside the hole.

At the end of the construction process (always after heat treatment), an adjustment works should be done, to assure that any deformation, appeared during heat treatment process, has affected the component functionality.

5.5.1.3 Coating:

To achieve high durability of the punch and give it high hardness properties, we have defined a coating at the end of the process which we will achieve 80 HRC. In this case we has chosen TiN, as a coating for the punches.

TiN definition:

Titanium nitride is an extremely hard ceramic material frequently used components coated onto titanium alloys, steel, and aluminum carbides to improve the surface properties of the substrate.



Fig. 49 [OBA 16] (TiN coating aspect)

The coating layer thickness is 6-9 μm , it has to be taken in previous constructional phases drawing.

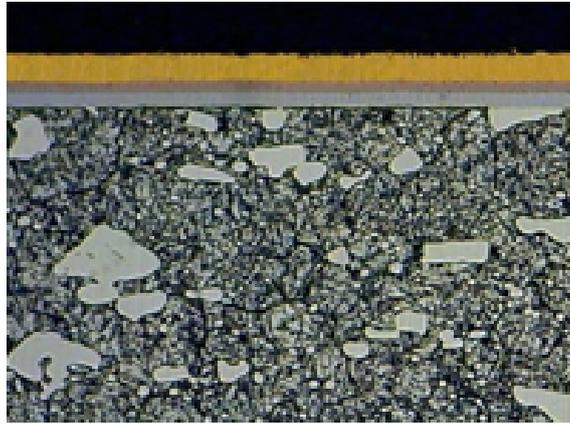


Fig. 50 [OCO] (Layer section aspect, at microscope).

The Fig. 50 shows how the different layers of coating are placed over the steel surface. In the picture we can identify three layers, golden layer, red layer and grey layer. The golden layer is the ceramic (TiN) material and the hardest component of the coating.

5.6 Punch outer shape:

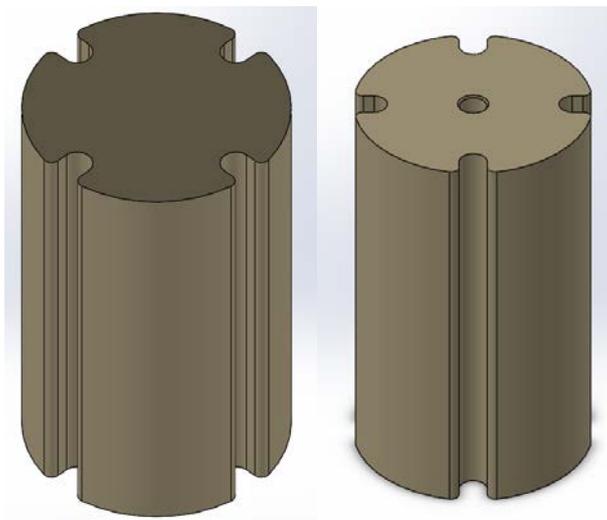


Fig. 51 [MTP] (Upper side).

Fig. 52 [MTP] (Bottom side).

This component needs similar mechanical requirements than other punch (inner shape), for this reason the chosen raw material and final mechanical properties are the same. The production process in this case, is the same as well, grinding, machining, EDM by wire for cut the outer shape, blind hole for fixing screw, heat treatment, screwed by EDM, and final adjustment.

5.7 Guide plate :

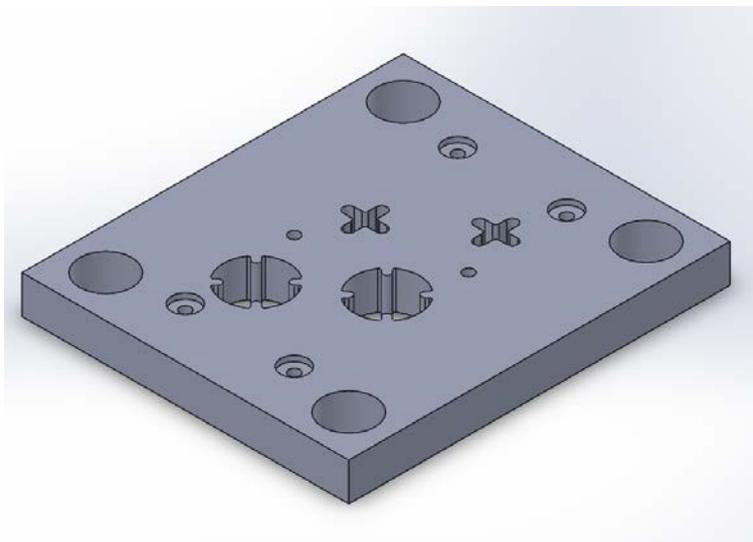


Fig. 53 [MTP16] (Upper side).

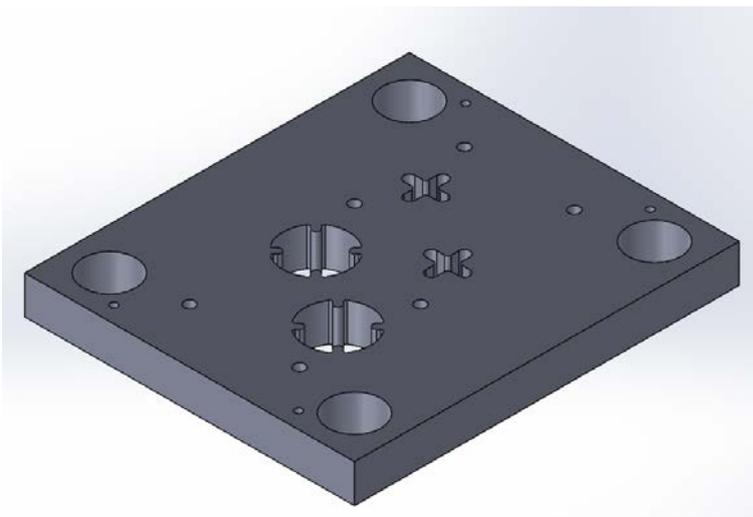


Fig.54 [MTP16] (Bottom side).

The guide plate function is to guide the punches, and keep the raw material blocked between guide plate and die plate during fine blanking process. The hardness requirements are not so high because is not active component, during blanking process.

For this component we have decided to purchase a semi finished plate, in a tool component local supplier named INMACISA, following the purchasing data:

Standard/ norm: (Number model, 52, see table in annexes).

Supplier: INMACISA (Spain tool components supplier).

Raw material: F114 / F112 / F ST-52

Hardness: Not defined.

* For more details see annexes.

5.8 Raw material guide.

This component keeps the raw material centered inside the tool, from the entrance till the way out. This is a passive security component on the tool, cause for guarantee the correct steps of raw material and correct alignment of the strip, we have added to the tool two step punches. So implementing this component to the tool we will reduce main raw material step incidences during the process.

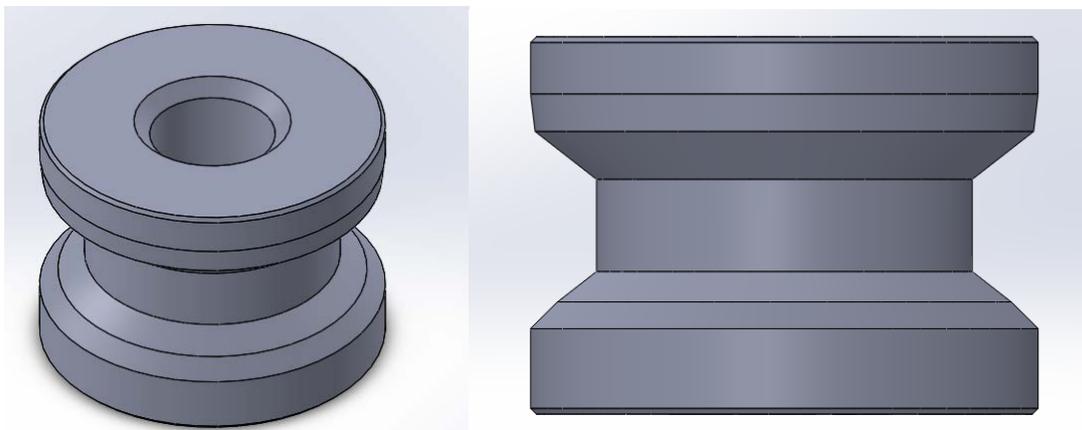


Fig. 55 [MTP16] (Raw material guide).

5.9 Normalized components

To use normalized components allows us to reduce tool costs, and give us a lower lead time to change a broken component because we can have elements in stock in our facilities by a low warehouse costs.

Regarding the maintenance topics, to use normalized components, give us a very short component replacement time due it is possible to foresee element changes before stop the tool due a breakage or mechanical incidence.

Following are described the normalized elements used to produce the tool:

5.9.1 Columns

The columns are the components which keep centered upper die cast, bottom die cast and guide plate, by means of bearings. In this case we have chosen standard component as well from local supplier INMACISA.



Fig. 56 [MTP16] (Guide column).

Purchasing data:

Standard/ norm: w/o specific norm.

Supplier: INMACISA (Spain tool components supplier)

Raw material: 1.7264

Hardness: 60-62 HRC

Functional surface finishing: 

5.9.2 Bearing:

These elements together with the columns, are the responsible to keep centered, upper die cast, bottom die cast and guide plate, and keep lubricated the functional surfaces of the columns. In this case we have chosen standard component as well. Those caps, are constructed with graphite (black dots) filling bronze ring, to avoid excessive frictions, and therefore warmings. This kind of element is more expensive but the durability is higher than cost increases, for this reason we have chosen it.

5.9.2.1 Bearings (Guide plate):



Fig. 57[ELD16] (Bearing picture).

Purchasing data:

Standard/ norm: CDA932

Supplier: ELDRACHLER (Spain tool guiding components supplier)

Raw material: Strong cast bronze bored metal with special solid lubricants embedded (graphite).

Hardness: Not defined.

Functional surface finishing:



5.9.2.2 Bearing (Bottom die-casting Guide plate):



Fig. 58 [MTP16] (SLD Bearing simulation).

Purchasing data:

Standard/ norm: (diameters 48 -38 / Length 74)

Supplier: INMACISA (Spain tool components supplier)

Raw material: 1.7264, Strong cast bronze bored metal.

Hardness: 60-62 HRC.

Functional surface finishing:



5.9.2.3 Bearing (Upper die-casting plate):

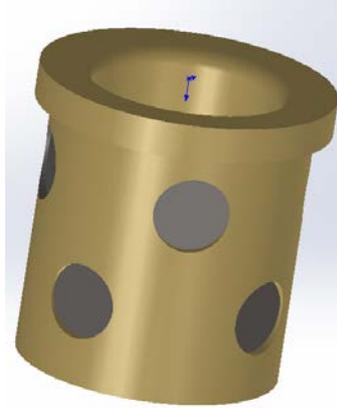


Fig. 59 [TRP16] (STP bearing simulation).

Purchasing data:

Standard/ norm: (Diameters 48 -38 / Length 74)

Supplier: INMACISA (Spain tool components supplier)

Raw material: CDA932, Strong cast bronze bored metal with special solid lubricants embedded (graphite).

Hardness: Not defined.

Functional surface finishing:



5.9.3 Fasteners:

All the screws that we have used to design the tool belong, in different Metric and length, to Din 912. We can purchase these screws in any industrial hardware store, indicating, DIN, Metric, and length.



Fig. 60 [UGA16] (DIN 912 screw example).

5.9.4 Die cast upper

This component is which gives rigidity to the upper block. In this case we have chosen standard component as well.

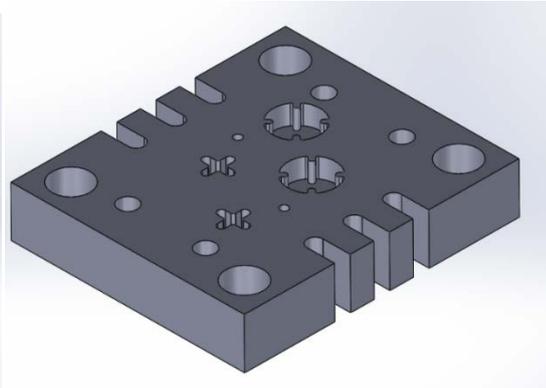
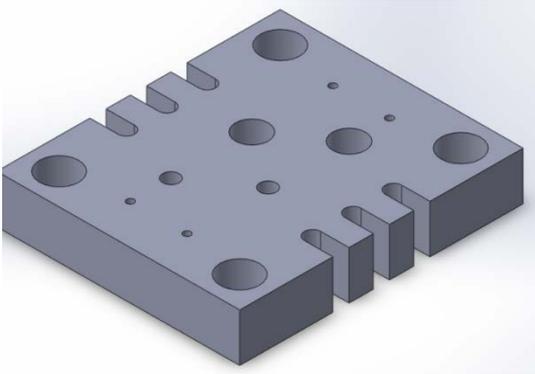


Fig. 61 [MTP16] (Die cast upper, upper die).

Fig. 62 [MTP16] (Die cast upper, lower side).

Purchasing data:

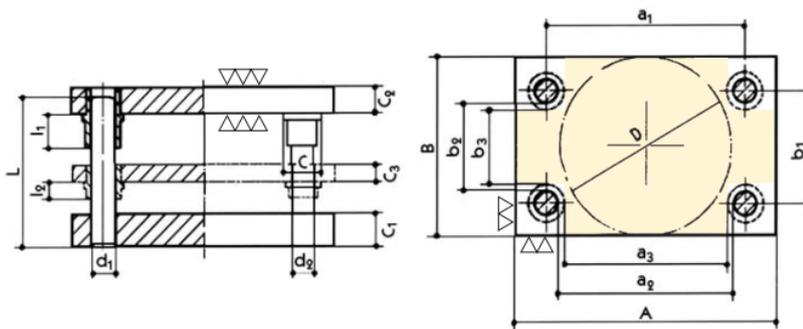


Fig. 63 [INM16] (INMACISA catalogue sketch).

Standard/ norm: (Number model, 51, see table in annexes).

Supplier: INMACISA (Spain tool components supplier).

Raw material: F114 / F112 / F ST-52

Hardness: Not defined.

All the machining operations, as holes and punches nests, will be machined before heat treatment.

5.9.5 Die cast bottom:

This component is which gives rigidity to the lower block. In this case we have chosen standard component as well.

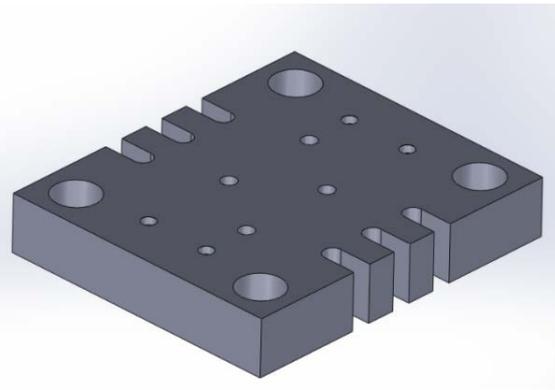
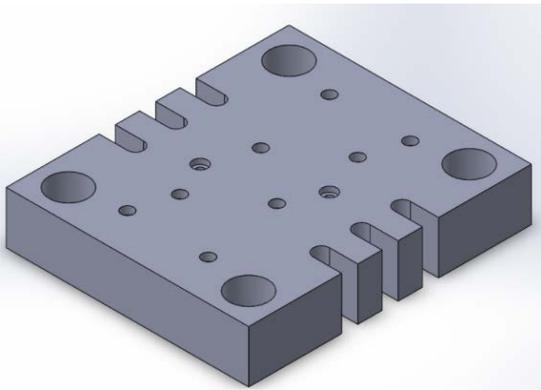


Fig. 64 [MTP16] (Die cast bottom, upper die).

Fig. 65 [MTP16] (Die cast bottom, upper die).

Purchasing data:

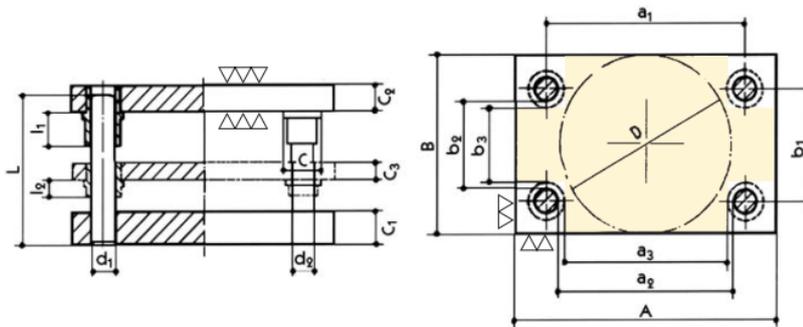


Fig. 66 [INM16] (INMACISA catalogue sketch).

Standard/ norm: (Number model, 51, see table in annexes).

Supplier: INMACISA (Spain tool components supplier).

Raw material: F114 / F112 / F ST-52

Hardness: Not defined.

All the machining operations, as holes and punches nests, will be machined before heat treatment.

5.9.6 Springs (guide plate):

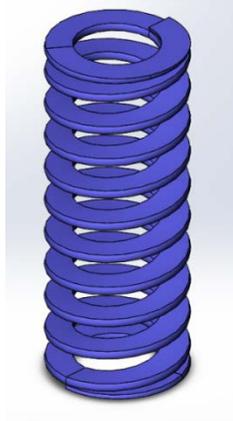


Fig. 67 [TRP16] (STP spring simulation).

The springs are the responsible to return the guide plate after blanking process, to initial position. The tolerance between the punches and guide plate are lower but does not create big frictions , therefore the force that we will need to assures the recovery of guide plate position is not extremely high for this reason we had chosen medium force springs (blue color).

To assure the correct function of the springs, we have designed a pre-charge of 5 mm, with it, the pressure of guide plate over the strip will be enough to keep it blocked during blanking stage.

5.9.7 Step control punches:

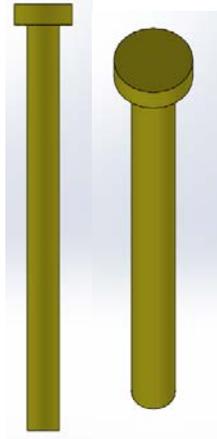


Fig. 68 [MTP16] (Step control punches).

This is the component together with the press security control sensors, which will ensure the correct step of the raw material through the tool.

In this case we have designed a progressive tool, therefore raw material step must be assured to avoid producing defective parts.

Quality information: If we would have a defective step of the raw material, it would produce an inner form in the part out of tolerance, respecting the outer shape.

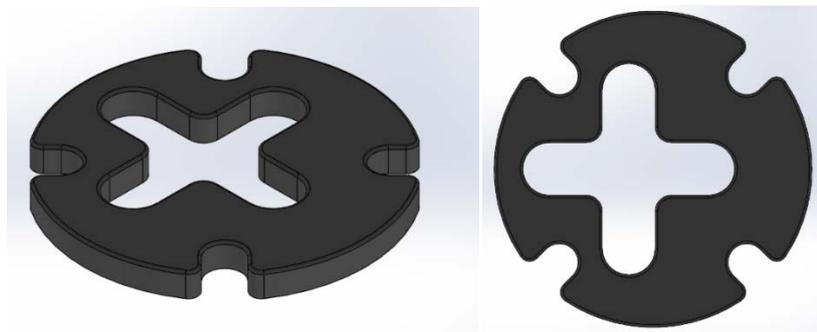


Fig. 69 [MTP16] (Isometric view kilter part)

Fig.70 [MTP16] (E.g. kilter part)

In this case we have opted to buy this standard component, to reduce costs, stocks, and reaction time, in case of component breakage.

Purchasing data:

Standard/ norm: DIN 9861

Supplier: INMACISA (Spain tool components supplier)

Raw material: HSS

Hardness active area: 2200 HV

Hardness conic head: 50±5 HRC

Coating: TIN (it gives to the punch active area high hardness and a good balance between properties)

6. Calculations.

6.1 Definition of forces which are involved in fine blanking process.

In order to get the correct dimensions of the tool elements and to determine the required press setting data, is necessary to calculate the forces involved in the fine blanking process, in advance.

At the beginning of the motion sequence, the material is clamped prior to any blanking by the Vee-ring force F_R on the outer periphery of the cutting line. In our tool this force will not be involved because we have designed the tool without vee-ring.

After that, the material is clamped against the punch within the cutting line by means of the counter force F_g .

The cutting action starts with the material being clamped. In this moment goes in to an action F_R cutting force.

After that the ejection force F_{GA} has to be calculated because the steel parts (parts and scraps) have to take out from the die plate.

6.1.1 Calculation of the cutting force.

A certain cutting force F_s has to be applied in order to cut out the part. As explained, the amount of cutting force depends on the lengths of the cutting line (perimeter external and internal perimeter), the material thickness and its tensile strength:

F_s Cutting force (N)

l Length of cutting line (mm)

s Material thickness (mm)

Rm Tensile strength (N/mm²)

0.9 Empirical factor (depending on yield strength and tensile strength)

The cutting force is calculated using following formula:

$$F_s = l \cdot s \cdot R_m \cdot 0.9 [N]$$

$$F_s = [(137.68 \cdot 2) + (233.17 \cdot 2) + (31.41 \cdot 2)] \cdot 5 \cdot 550 \cdot 0.9 [N]$$

$$F_s = 2.212.430 [N]$$

The inner form of the part is 137.68 mm length, and outer 233.17. Taking in account that we have two nests in the tool, we have to multiplying by 2, both perimeters to obtain total length, of cut part. Also is involved decontrol step punched perimeter, which are 34.41 for each (there are 2, as well).

Since practice the required cutting force depends on the factors like state of cutting edge, size of the cutting clearance, geometry the part, lubrication, surface roughness of the cutting elements, as well as the thickness tolerance of the material, the factor 0.9 is applied for the calculation because of safety reasons.

6.1.2 Calculation of the vee-ring force:

The vee force F_R is the force needed to press the vee ring into the material to favour the clamping before any cutting starts. The vee ring force, which on the quality tensile strength of the material is approximately calculated by given formula:

F_R Vee-ring force (N)

S Material thickness

f_2 * Empirical factor

L_r Vee-ring length (mm))

h Vee-ring height

R_m Tensile strength (n/mm²)

* Factor $f_2 = 4$ was deteminated by empirical tests.

$$F_R = Lr \cdot h \cdot Rm \cdot f^2 [N]$$

$$F_R = 0 \cdot 0 \cdot 550 \cdot f^2 [N]$$

$$F_R = 0 [N]$$

In this case the results are 0, because we have not implemented vee-ring in guide plate, due the tolerances of outer dimensions of our part, are not enough, very restrictive as to put a vee ring.

6.1.3 Calculation of the counter force:

The counter force F_g ; press the material within the inner cutting line against the punch while cutting takes place. A deformation of the part to be blanked is avoided by this. The counter force is calculated by the given formula:

$$F_g = A \cdot q_g [N]$$

To calculate the counterforce, we will need the areas of the part (holes surface and part surface without inner forms).

F_g Counter force (N)

A Pressure surface of the part, without inner forms (mm²)

q_g Specific counter force 20-70 N/mm²

$$A_{tp} = 2.598,892 \text{ [mm}^2\text{]}$$

$$A_{pi} = \mathbf{664,8053 \text{ [mm}^2\text{]}}$$

$$A_{po} = 2.598,892 - 664,8053 = \mathbf{1935,409 \text{ [mm}^2\text{]}}$$

$$A_h = \mathbf{78.54 \text{ [mm}^2\text{]}}$$

* Index **po** is regarding the part (outer form)

* Index **pi** is regarding the part (inner form)

* Index **h** is for the step punches.

* Index **t** is for total pressure (two cavities).

Outer shape:

$$F_{gpo} = 1934,09 \cdot 60 \text{ [N]}$$

$$\mathbf{F_{gpo} = 116.933 \text{ [N]}}$$

$$F_{gpot} = 116.933 \cdot 2 \text{ [N]}$$

$$\mathbf{F_{gpot} = 233.892 \text{ [N]}}$$

Inner shape:

$$F_{gpi} = 664.8053 \cdot 60 \text{ [N]}$$

$$\mathbf{F_{gpi} = 39.888,3 \text{ [N]}}$$

$$F_{gpit} = 39.888,3 \cdot 2 \text{ [N]}$$

$$\mathbf{F_{gpit} = 79.776 \text{ [N]}}$$

Control step holes:

$$F_{gh} = 78,54 \cdot 2 \text{ [N]}$$

$$F_{gh} = 157,08 \text{ [N]}$$

$$F_{ght} = 157,08 \cdot 2 \text{ [N]}$$

$$\mathbf{F_{ght} = 314.16 \text{ [N]}}$$

Taking in account the total counter force calculated, the press will should give is:

$$F_{gpt} = 116.933 + 79.776 + 314. [N]$$

$$F_{gpt} = 197.023 [N]$$

* **Technical hints:** The punch force must overcome the counter force. It therefore influences the output between two tool maintenance rates. A higher counter force acts the same as a thicker material or a higher tensile strength. The punch is the most heavily loaded of the tool.

6.1.4 Ejection force:

The ejection force is used f for takeout the scarp and the steel cut (part) part from the die plate.

$$F_{GA} = F_S \cdot f_3 [N]$$

$$F_{GA} = 2.212.430 \cdot 0.3 [N]$$

$$F_{GA} = 663.729 [N]$$

* Factor $f_3 = 0,1 - 0,3$, was determinate by empirical tests.

6.2 Forces calculations sheet:

	<h2>Calculation of the press capacity:</h2>	Cod.:							
		Date:							
Name of the part: Part number: Tool Number:									
Material thickness S : 5 mm Tensile strength max. R_m : 500 N/mm ² Vee-ring length L_{rz} : 0 mm Empirical factor f_2 : 4 Vee-ring height h : 0 mm Total cutting length l : (137,68 + 233,17) X 2 = 741,7 mm Fr. 50 % factor f : 0,5	Pressure surface A : N/mm ² Maximum pressure q_s : 500 N/mm ² (Qg select between 20-70 N(/mm)								
Cutting force: $F_S = l \cdot s \cdot R_m \cdot 0.9$ [N]		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="background-color: #e0e0e0;">$\Sigma F =$ [KN]</th> </tr> <tr> <td style="text-align: center;">2212,43</td> </tr> <tr> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">197,023</td> </tr> <tr> <td style="text-align: center;">663,079</td> </tr> <tr> <td style="background-color: #90ee90; text-align: center;">3072,532</td> </tr> </table>	$\Sigma F =$ [KN]	2212,43	0	0	197,023	663,079	3072,532
$\Sigma F =$ [KN]									
2212,43									
0									
0									
197,023									
663,079									
3072,532									
Vee-ring Force: $F_R = L_r \cdot h \cdot R_m \cdot f_2$ [N]									
Reduced vee-ring force: $F_{Rr} = F_R \cdot f$ [N]									
Counter force: $F_G = A \cdot q_s$ [N]									
Ejection force: $F_{GA} = F_S \cdot f_3$ [N]									
<h3>Type of fine blanking press: XXX Tn</h3>									
Date	Issued by:	revised:							
Comments									

Fig. 71[MTP16] (Press capacity calculation sheet).

6.3 Calculation of springs ejection force:

We can approximate the required force to apply in over the springs, as cutting force at 10%:

$$F_{es} = F_S \cdot 0.1[N]$$

$$F_{es} = 2.212.430 \cdot 0.1 = \mathbf{221.243[N]}$$

** This force is not included within the calculation press capacity, because this force is not involved in blanking process press needs.*

7. Process definition:

To produce the parts, meeting drawing requirements, we have defined 5 stages process:

- **Fine blanking**
- **Deburring by grinding**
- **Heat treatment**
- **Rounding edges by vibrating**
- **Packaging**

7.1 Fine blanking stage:

This is the most important process stage and which has the highest added value of the process.

7.1.1 Press definition:

Presses that we have available in our facilities:

- 2 Presses 160 Tn (SMG)
- 2 Presses 250 Tn (SCHMIDT)
- 2 Presses 450 Tn (FEINTOOL SMG)
- 2 Presses 750 Tn (FEINTOOL SMG)

Tacking in account that the calculation of forces need is **3072,532 KN**, we can choose a 450 Tn or higher power press to produce the part. Obviously if we produce the parts in the bigger force press, we will increase the costs production of the parts, because the fees for higher press are bigger, for this reason we have to choice for standard process the smaller press which cover the calculated force (including security margin).

7.1.1.1. Press characteristics:

As indicated we have chosen 450 T press, "FEINTOOL FHA 4500 Plus"



Fig. 72[FEH16] (Feintool hydraulic press, 450 Tn).

Press characteristics:

- Total force max KN: 4500
- Ram strokes at Max. tools heights mm: 230 mm
- Ram stroke rate (according to part) up to 1/min: 80
- Strip width max. Mm: 350 mm
- Material thickness Max.: 16 mm
- Upper bolster mm: 800 X 800
- Table mm: 810 X 100

To explain fine blanking stage we will follow the raw material path, during this stage.

7.1.2 Feeder system:

Feeder system for a fine blanking process is composed by:

- De-coiler with pressure roll
- Rolling flattening track
- Feeder

In this case following the calculations, we have chosen Fine blanking press FEINTOOL 4500HFA, which incorporates a rolling track and feeder inside the press household and before the press table in order to assure three points:

- **Centering of raw material inside the press.**
- **Break or at least deform the steel fibers which have round form due the coil.**
- **Flatness of raw material before go forward the tool.**

Fig. 73 shows de-coiler line and feeder line without rolling flattening track, for this machine is no needed due is incorporated in the press.



Fig. 73 [CAI16] (Feeder line by CARBIONERAS, SARONNI).

7.1.3 Tool and press. Tool Motion sequence during fine blanking process.

On the first step the bottom table of the press goes up in a high speed, until 5 mm before die plate get in contact with raw material, at this moment the speed of the table is reduced to slow speed (approximation speed) till three elements are completely in contact. During these two steps the security system of the tool is working in order to avoid any incidence inside the tool.

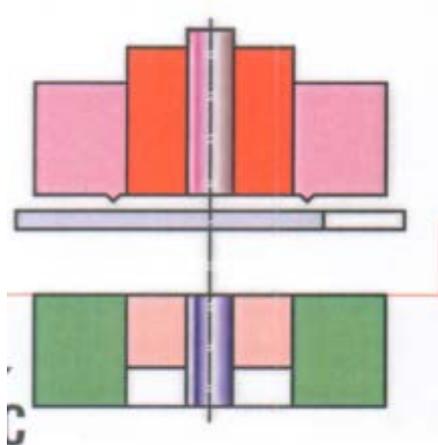


Fig. 74 [FTR03] (Step 1, motion sequence)

E.g. of incidence: One scrap remains inside the tool, because it was not ejected correctly by the blowers, then the tool closes again and the chip could break some several tool components.

During the second step the bottom table continues going up, but in this moment the guide plate has to go up winning the forces (reaction) of the springs, taking in account that the punches are fixed in their position, when the guide plate goes up, they go through the guide plate and coming out by the bottom side, at this moment this step has finished and get in touch with the raw material.

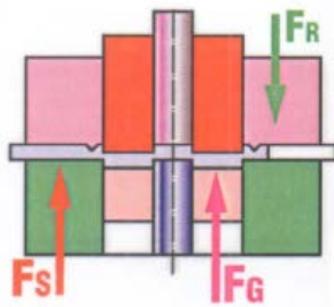


Fig. 75 [FTR03] (Step 2, motion sequence).

The third step is the cutting stage, at the beginning the punches are in contact with raw material and it is pressed by the guide plate. The bottom table for the press continues going up and the punches penetrate the raw material, it is possible because the counter punches goes back to their position due the punches win the force of springs placed below the counter punches. When the punches have to penetrate completely in the die plate and therefore in the raw material, this step is finished.

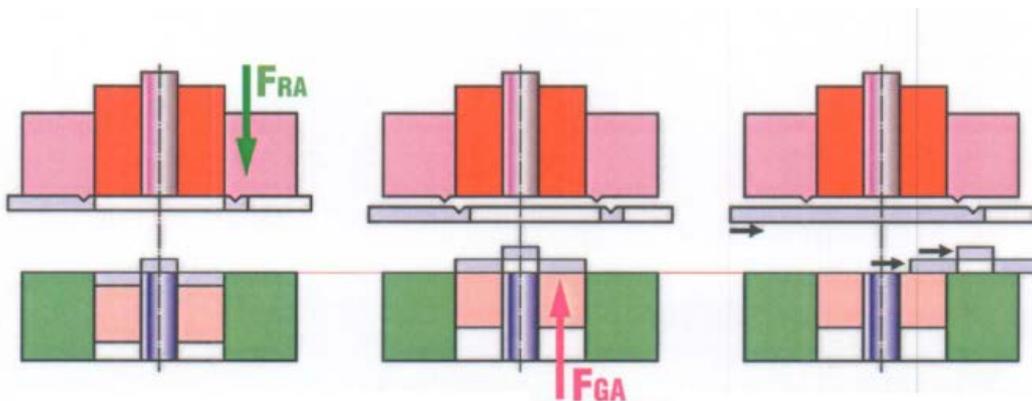


Fig. 76 [FTR03] (Step 3,4, motion sequence).

Fourth and final step, in this moment the below table of the press, draw back and goes down, it means that the punches goes out die plate and raw material, guide plate goes down returning to initial position and the springs under the ejectors punches begin to open and the raw material which is inside the die plate goes outside.

7.1.4 Evacuation system:

The evacuation system is the system which extracts the parts, from the press, automatically every stroke, and it is composed by:

- **Blowers (3x)**
- **Isolation cylinder**
- **Batch breaker**

7.1.4.1 Blowers:

After finish fine blanking process (after 4th step) and when the tool is completely opened, and the ejectors have arrived to initial position, the blowers start to blow, creating a wind current which is able to push the scraps and the part to rear of the press (rear window) where is located a ramp, where the parts shall fall and this ramp goes inside the next step, isolation cylinder.

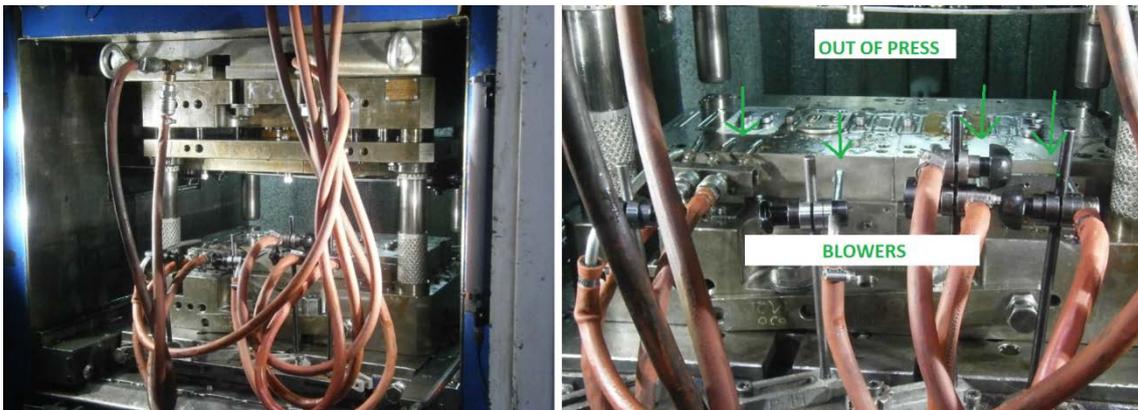


Fig. 77 [MTP16] (Fineblanking assembled in the press).

The Fig. 78, shows an sketch of blowing system, its components and how it works inside the tool :

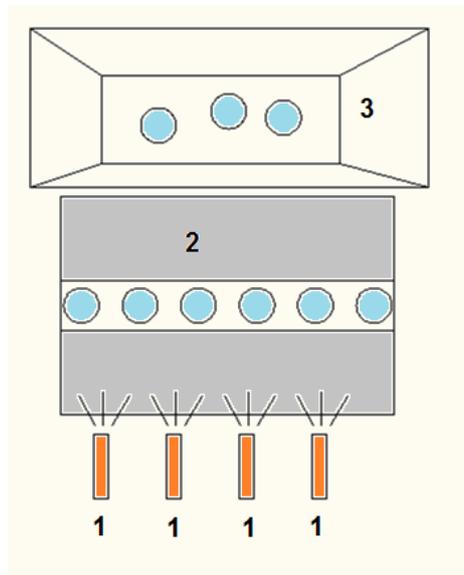


Fig. 78 [MTP16] (Blowing system sketch).

- 1- Blowers
- 2- Tool
- 3- Back press (rear window)

7.1.4.2 Isolation cylinder:

Isolation cylinder is a simple but effective system, to sort the raw material scrap and blanked part.

It consists in a rotatory perforated cylinder in which the holes are bigger than the scraps but smaller than the part. Inside of this cylinder also there is a flap as spiral form in order to help the parts go forward inside the cylinder. During the progress through the cylinder the scrap fall down in a tray and the parts arrives to the batch breaker system.

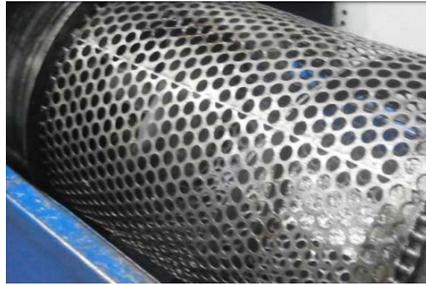


Fig. 79 [MTP16] (Rotatory perforated cylinder).



Fig. 80 [MTP16] (Rotatory perforated cylinder entrance).

In the Fig. 74 and 75, we can see the aspect of cylinder, the laps inside of it and the holes where the scraps fall down.

At the end of cylinder, the parts sorted from the scarps, arrive to a metallic belt conveyor, which will be able the carry the parts to the next step (batch breaker).



Fig. 81 [MTP16] (Belt conveyor)

Quality comments: Is very important to choose correctly the holes cylinder dimension in the scrap isolator because if the scrap is not correctly isolated, we could contaminate the vibration tanks (third step of the process), where the parts will be placed in a bulk and can appear this kind of problem:



Fig. 82 [MTP16] (Parts, scraps, and parts with blocked scraps).

In the Fig.,82 we can see how the force applied over parts during vibratory stage, could fix or block a scrap inside the hole, it means that several parts could provoke a functional problems to our customers, producing quality claims.

For this part we can choose isolator cylinder with **52 mm** holes, because the inner hole bigger scrap) is 45 mm).

7.1.5 Batch breaker:

Tacking in account that the defects in stamping and fine blanking process as well, mainly are dimensional, due the wearing of the components or defective shapes appearance, due a breakage of the punches or die plate, batch backer is the most efficiency industrial system to guarantee the capacity of the process and therefore the quality of the parts. It means that the defects on stamped parts don't appear randomly if not, when appear for the first time the defect always continues appearing in all following produced parts as a pattern.

It consist in validate the production batch by steps, it means that if any incidence appeared you will be able to limit the problem in a little quantity of the parts (less or equal to the defined self-control frequency) and not in complete production batch.

7.1.5.1 How does it work?

After the isolation cylinder sorting, there are two metallic drawers, which could be moved by a guide to give operator the possibility to change the receiver box without difficulty. One of those box is continuously filled, **never both at the same time!**

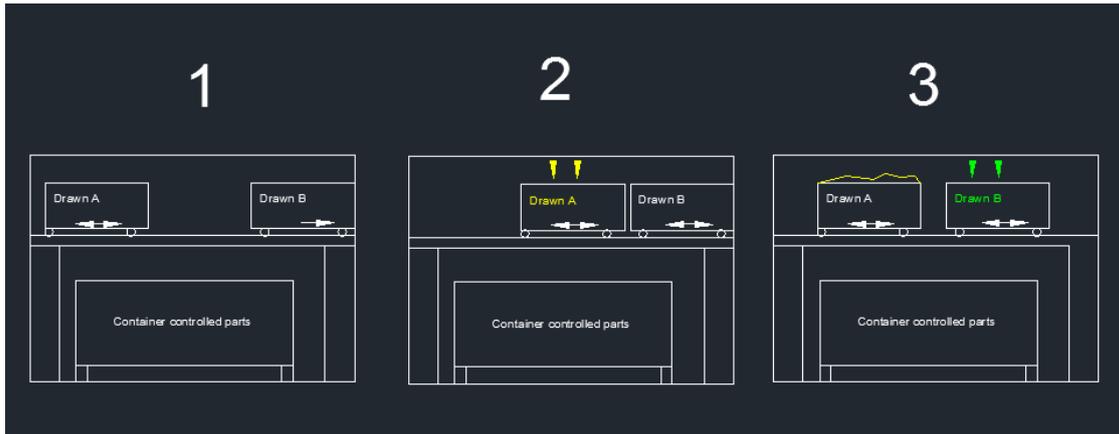


Fig. 83 [MTP16] (Batch breaker sketch).

As soon as the box 1 is at 90% of its capacity (defined the frequency or quantity defined in control plan) the operator changes the box 2 as a receiver of the parts, below the belt conveyor. After that, the operator takes two parts belong to box 1 (quantity defined previously in the control plan) and performs the controls in requested dimensions, using defined control tools. If no dimensional incidence/s appear/s, the operator open the gate in the bottom of the metallic box 1 and the parts fall down to the container as fine blanking finished and correct parts. With this system if any incidence appears we will be able to assure that all the parts in the container are meeting control plan.



Fig. 84 [MTP16] (Picture of a drawer).

Scrap:

The scrap outgoing of the press (strip layout), is cut by a shear every 250 mm and thrown in a metallic dumper container, which will be emptying in a big scrap container. Those scraps will be sold to the recycling company, in order to have revenues impact in raw material.

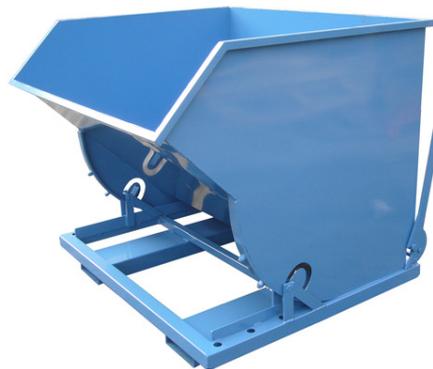


Fig. 85 [LGM16] (Dumper metallic container).

The Fig. 85 we can see the container with dumping system. It will give us a possibility to turn down it facilitating the emptying, pulling the lever.

7.2 Deburring by grinding (abrasive belt):

7.2.1 Deburring by grinding process definition:

This process consists in to eliminate the burr generated by the raw material plastic deformation, during fine blanking process, grinding the parts by abrasive belt, over the burr side. Tacking in account that 16MnCr5 is a ferritic steel, has a magnetic properties, and it is valid to deburr the parts in DEBURIRNG LINE FRIEDENERG, because it applies a magnetic field system to keep the parts blocked over the belt during deburring.

7.2.2 Grinding machine definition:

The whole deburring facility is composed by 5 mainly stages:

- Placement of the parts over the belt.
- Deburring by abrasive belt.
- Finishing by brushes.
- Showers (cleaning).
- Dryer.

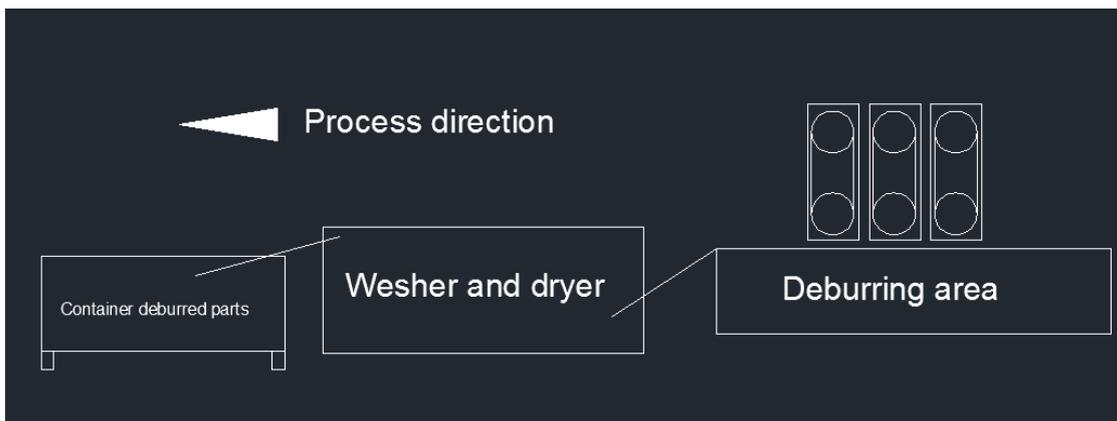


Fig. 86 [MTP16] (Deburring line sketch).

Following we can see a scheme of deburring area:

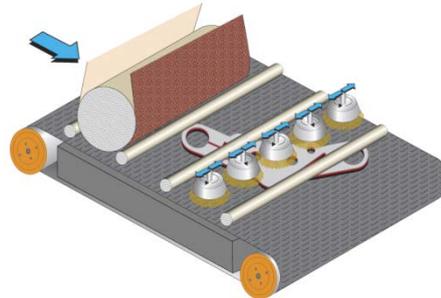


Fig. 87 [LOE16] (Dumper metallic container).

In fig. 86 we can see, the belt, the abrasive belt, the showers (to clean the parts), and the line direction advancement.

To start the process the container fulfilled with the blanked parts, has to be placed in a dumper (first step of the deburring line) which turn down the container, and fall down the parts in to a tray.



Fig. 88 [MTP16] (Picture of dumper box).

After that the operator place one by one and if it is necessary turning the part to be sure that the burr side is up, the parts over the belt:



Fig. 89 [MTP16] (Placed parts over the belt).

The parts could be placed in any position over the belt, avoiding the extremes of the wide (10% in each side, therefore the useful area of the belt is approx. 80% of its own wide).

After that the parts goes inside the machine going under the abrasive belts.

The machine is constituted by three rolls where is placed the abrasive belt. The first one is configured to apply more pressure on the part and the other two with lower pressure to assure a good surface finishing.



Fig. 90 [MTP16] (Roll where the abrasive belt is assembled) **Fig. 91 [MTP16]** (abrasive belt).

The next step after the three deburring rolls, is the named, brushes area. The parts go below brushes to finish correctly deburred side. The aim of brushes area is to eliminate the bent burrs or eliminate any little particle remained over burr side.



Fig. 92 [MTP16] (Picture of brushes).

As we can see in the fig. 92. The brushes turn over itself and orbit assembled in a metallic tray. Those are assembled and fixed by screws to upper tray.

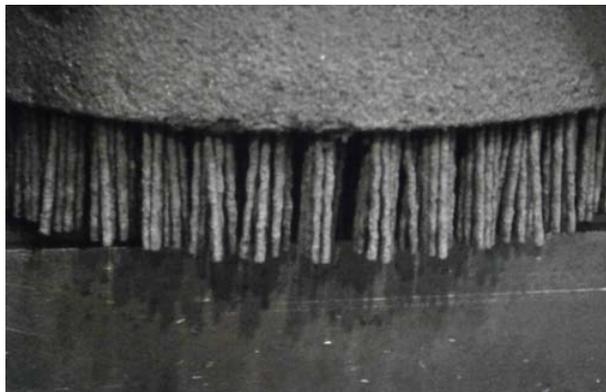


Fig. 93 [MTP16] (Detail of brush and its filament).

The filaments, are abrasive normally are manufactured with nylon.

Quality information:

This is the weakest process stage in terms of quality, because all responsibility for placement the parts by the correct side is falls over the operators. To avoid incidences is only available, frequency trainings and formations with operators to increase the awareness.

7.3 Heat treatment process:

7.3.1 Heat treatment (carbonitriding).

As defined in the drawing the parts must be treated by heat treatment. In this case to achieve the mechanical requirements for the defined raw material we have defined a carbonitriding process.

Carbonitriding will give a hard wear resisting surface combined with hardness gradient towards the core, as requested in the drawing:

Surface hardness: 700-780 Hv

Hardness Depth: 550 Hv 0.3 (0.25-0.4 mm)

Core hardness: not defined (resulting from the HT).

This kind of HT has several advantages and disadvantage, as well, in the next two paragraphs are defined most relevant:

Advantages of this heat treatment are, It has a greater resistance to softening during Tempering, increased fatigue and impact strength. Better case hardenability in lower alloy or plain carbon steels, the carbonitrided case has better wear and temper resistance than a straight carburized case, It is carried out at a lower temperature and for a shorter time than is gas carburizing, and reduced distortion due to lower temperature.

Several **disadvantages** of this heat treatment has to be identified, for example, It produces shallower cases. It is not possible to obtain higher core hardness and deeper case depths. Only useful for Plain carbon steel or Low alloy Steel. Ammonia can produce harmful effects.

During carbonitriding process several components are involved the atmosphere inside the oven but the main component is Ammonia. During the process 2 - 12 % Ammonia is added to the carburizing atmosphere, which provides a source of nitrogen.

“Gas Composition – Methane + Ammonia “

Ammonia decomposes at the surface of steel and remains there as: $2\text{NH}_3 \leftrightarrow \text{N}_2 + 3\text{H}_2$

* The molecular Nitrogen cannot be Absorbed to the steel surface.

The oven used for this kind of heat treatments, is transfer type:



Fig. 94 [MTP16] (Picture of IPSEN oven GmbH).

The fig. 94, shows a real oven currently in use in RUBISAN S.A, local heat treatment supplier. It is used to perform carbonitriding process over similar parts than the studied in this project.

Before to start the process in the oven, the parts should be placed one by one, in a jail hanging, by rods which passes through the center hole:



Fig. 95 [MTP16] (Handling jail).

In the Fig. 95 can be seen how the parts are placed within the jail. As soon as the jail is prepared, is placed inside the oven, and the heat treatment process can be started.

7.3.2 Process parameters.

Carbonitriding and tempering.

The parameters defined for the oven, during the process should be, as follows:

Process moment	Temperature (°C)	Carbon potential (%C)
Start	880 ° C	0.85 %
Medium	850 °C	0.85 %
End value	850	0.85 %

Fig. 96 [RUB16] (temperature and C %, process values).

Item #	Time (min) / Temperature (°C)
Purge	60
GAS	45
GAS + NH3	45
Fast cooling in oil bath	30
Cooling total time in oil bath	20
Drained time	10
Oil temperature	60

Fig. 97 [RUB16] (Components process values).

Tempering:

Values (700-780 Hv)	Tempering oven
Temperature	200-210 ° C
Time	2 hours
Nitrogen	NO

Fig. 98 [RUB16] (tempering process values).

Quality information: To avoid premature corrosion over the parts should to be oiled by spry at the end of the process.

7.4 Rounding edges by vibrating and cleaning.

7.4.1 Vibration process definition.

Deburring by means of vibratory finishing is an economical and effective method to remove edges and little burrs fraying from components (usually metallic ones) which are results formed during processing or manufacturing process.

Functional description Vibratory surface finishing takes place in a work bowl placed on coil springs. The vibratory energy is induced by a special vibratory motor that is mounted in the center of the work tank. The vibration creates a continuous movement of media (ceramic chops) against parts. The continuous feeding of water and compound (soap) supports the finishing process. Frequently, rotary vibrators are equipped with an integrated separation flap. This allows separating the finished parts from the media in the machine: Via the separation screen the parts are transferred to the machine exit or to a post-treatment system, for example, a dryer, while the media remains in the machine.

The first step of the deburring line, like deburring by belt, is a dumper where the container is placed to be turned down and let fall down to the parts, inside the vibratory tank.



Fig. 99 [MTP16] (Deburring machine dumper).



Fig. 100 [MTP16] (Deburring machine tank).

The Fig. 100 shows the tank, where the parts, liquids and chips are placed to perform the process applying the vibration movements.

To give a general idea of the machine, the next picture shows a sketch of vibratory machine where can be identified, mainly the tank the motor and the control panel.



Fig. 101 [ROE 16] (Machine sketch)

After vibration tank, the parts are placed in a drilled cylinder (similar than isolator system) where the parts are sorted from the chips and also is applied warm atmosphere to dry the parts.



Fig. 102 [MTP16] (Drilled cylinder).

Consumables:

For the vibration process there are two main consumables that have to be taken in account at the moment of design the process, ceramic chips and liquid compounds. The consumables producers market, offers a very big range of products, shapes, sizes, and compositions.



Fig. 104 [ROS16] (Consumable tipology).

For deburring (round edges and cleaning process) we have had in account four characteristics of the consumables:

Chip Composition

Chip Shape

Chip Size

Compound type

In the case of our part, we don't need very high chips abrasive properties because we only have to round edges due a previous deburring by belt. Taking in advantage of the knocks which will made by the parts between them, for this reason we will choose RÖSLER consumables:

Chips:

RSS low abrasive properties

10/20 dimensions (higher than inner parts to avoid blocking chip)

ZS chosen due the part geometry

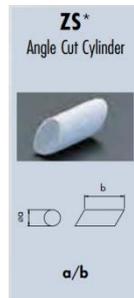


Fig. 105 [ROS16] (Consumable tipology).

The fig. 101, shows the consumable coded by: RSS 10/20 ZS

Definition of the code to purchase the consumables:

AAA 11/22 BB

AAA: quality of the chip

11/22: Measurement

BB: Chip shape

The useful life of the consumables depends on multiple factors of the process, mainly, the vibration frequency of the tank, raw material of the part, weight of bulk in every load, shape of the part.

In the case of longer utilization of consumables than producer recommends, several quality problems could appear on the parts, after vibration process. In the case of liquid compounds the parts could get out dirty and without complete degreasing, on the other hand if the chips are used longer, these may be broken and fix inside the holes or inner forms.



Fig. 106 [MTP16] (Part with blocked broken chip).



Fig. 107 [MTP16] (Parts with defect).

7.5 Packaging:

At the end of the process the parts should be placed in a handle unit, in order to be placed them in a pallet and be able to deliver to our customer using an industrial transport. The minimum handling unit has to be movable by an operator without mechanical aids.

According our internal rules, framing in European directive 90/269/CE, maximum load 15 Kg, and maximum dimensions 50 X 50 X 30.

Therefore we have chosen a standard carton box A16 (used currently for most of our customers)

Dimensions: 190 X 290 X 120

Gross volume: 6600 cm³

Net volume: 4600 cm³

Number of parts in the box: 100

The process of packaging consist in, place the container with the finished parts in a dumper which turn down the container progressively and let the pieces fall in a tray, where the operator has in front of him.



Fig. 108 [MTP16] (Drilled cylinder).

The previous image, Fig. 108, shows the tray where the parts are placed after being turned down the container in the dumper machine.

The operator pulls along the parts from the tray to the box, approximating visually the quantity defined previously (100 units). This operator pushes the filled box over the rolling track until a scale, with a previous setup, can account the quantity of the parts in the box. Before filling the boxes, they are placed in a roller line to facilitate the movement of them after filling.



Fig. 109 [MTP16] (Boxes fill in roll line).



Fig. 110 [MTP16] (picture of used)

Fig. 110 shows, an example of scale which could be used for packaging.

Every box has stacked one Odette label where can be identified:

Reference

Quantity

EAN13 (bar code for every data)

Serial number of label

Batch number

After that the boxes are placed over a pallet according customer requirements, which indicates 48 boxes per pallet, and rolled with extensible film.



Fig. 111 [SUG16] (Prepared pallet)

8. Advanced Quality activities Control plan:

8.1 Control plan:

For this part we have defined a control plan for each production stages, as fine blanking stage, deburring, heat treatment process and vibration stage. Also has been defined a quarterly control of raw material, sending a test sample to be tested (mechanical properties and chemical composition).

We have defined in each stage work layout a control work station as, equipped by:

- 1- Micrometer 0 ÷ 25 mm
- 2- Depth gage 0÷ 50 mm
- 3- Digital caliper 0 ÷ 150 mm
- 4- Form Gauge



Fig. 112 [MTP16] (Control station).

In the fig. 112, we can see the four main control tools that will be used for perform control plan.

We have designed a control sheet to be filled by quality engineers in every stage. Fig. 113 shows the designed template. (Complete document in annexes).

		PRODUCTION CONTROL PLAN				Code: DOC. 12.002.00		
<input type="checkbox"/> Fine Blanking <input checked="" type="checkbox"/> Deb. by grinding <input type="checkbox"/> Heat treatment <input type="checkbox"/> Deb. by vibration						Ed.: Rev.00		
						Date: 20/04/2012		
CUSTOMER:	Automotive seat assembler	Product name:	Pinion		Prepared by:	Process Technician		
Plant (Facilities):	Lahnwerk (DE)	References:	203040		Revised by:	Process Manager		
Involved Suppliers	Raw material/ Heat treatment	Drawing engineering revision:	Rev. 01 (20/04/2016)		Approved T.O.:	Technical Office Manager		
			Num	Characteristic	Specification	Control device	Frequency	Quantity
			1	▽		Go/ NO-Go		
			2	CS		HT certificate		
			3	CI		Raw M. Cert		
			4			Caliper		
			5			Shape Gauge		
			6					
			7					
			8					
			9					
			10					
			11					
			12					
			13					
			14					
			15					
Check the parts as starting production, after any machine stop								

Fig. 113 [MTP16] (control sheet template).

The tools that we have designed to use in each stage are:

Fine blanking stage

- 1- Micrometer 0 ÷ 25 mm
- 2- Depth gage 0÷ 50 mm
- 3- Digital caliper 0 ÷ 150 mm
- 4- Form Gauge (inner and outer shape)

Deburring stage.

- 1- Micrometer 0 ÷ 25 mm
- 2- Depth gage 0÷ 50 mm
- 3- Digital caliper 0 ÷ 150 mm
- 4- Form Gauge (inner and outer shape)

Heat treatment.

- 1- Micrometer 0 ÷ 25 mm
- 2- Depth gage 0 ÷ 50 mm
- 3- Digital caliper 0 ÷ 150 mm
- 4- Form Gauge (inner and outer shape)

Raw material quarterly control:

In the case of heat treatment, has been defined a monthly heat treatment test in laboratory. This test is intended to assure that the raw material is able to achieve the mechanical properties after heat treatment.

As explained, quarterly one test sample has to be manufactured by Wire EDM, and polished in the cut surface. The EDM is the best technology to prepare a test sample because the risk of using machining technology the process can generate micro cracks, which could detract the obtained results.

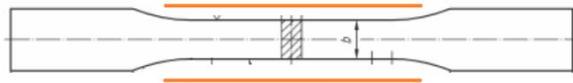


Fig. 114 [MTP16] (Test sample critical areas).

The test sample has to be prepared following next table (defined in UNE-EN ISO 6892-1: Method B):

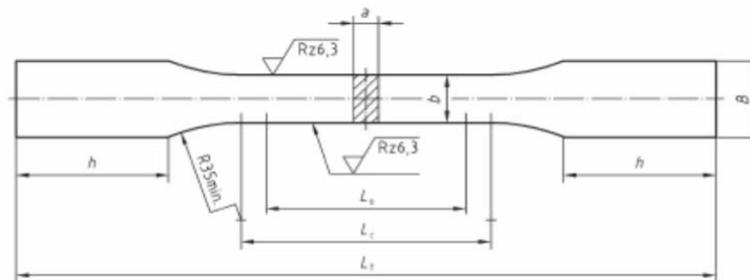


Fig. 115 [TSI16] (Test sample variables sketch ISO 6892-1).

Table 6: Dimensions of type E tensile test pieces (examples)

Test piece thickness, <i>a</i>	Test piece width, <i>b</i>	<i>L₀</i>	<i>B</i> min.	<i>h</i> min.	<i>L_c</i> min.	<i>L_t</i> min.
3 4	8 10	30 35	12 15	26 30	38 45	115 135
5 5	10 16	40 50	15 22	30 40	50 65	140 175
6 7	20 22	60 70	27 29	50 55	80 90	210 230
8 10	25 25	80 90	33 33	60 60	105 115	260 270

Fig. 116 [MTP16] (Values for variables sketch ISO 6892-1).

In our case taking in account at the thickness of the part is X we will choose XXXX raw.

Then the test sample is mixed with the parts during whole heat treatment process in order to reproduce the achieved mechanical properties on the parts, also in the test sample.

The tensile strength test, generates a charts similar like the following:

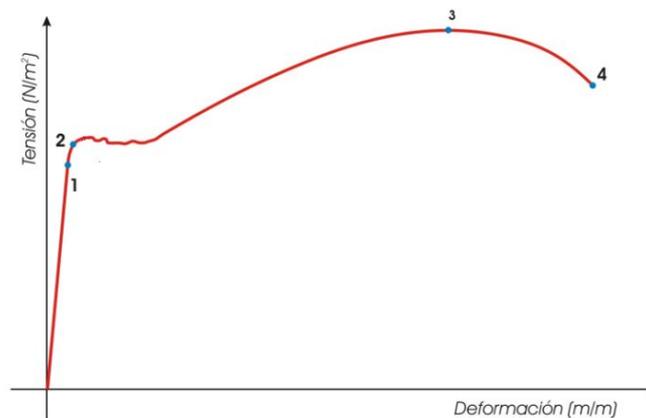


Fig. 115 [WKP16] (Tensile strength test chart).

In this chart we can identify 4 turnaround points.

- 1- Proportionality limit.
- 2- Elongation.
- 3- Necking tension (necking area)
- 4- Rupture point

Example of tensile strength sample test (UNE EN ISO 6890-1:210 Method B):

LÍMITE ELÁSTICO 0.2% (Rp) N/mm ² (kg/mm ²) Yield strength	RESISTENCIA A LA TRACCIÓN (Rm) N/mm ² (kg/mm ²) Tensile strength	ALARGAMIENTO (A) % 80 m/m Elongation
1050 N/mm ²	1085 N/mm ²	12,5 %

Fig. 116 [ITE15] (Reference values, Rp, Rm, A, to be achieved by the sample).

The next picture shows a tested sample and its aspect. The flag indicates the necking are (breakage section):



Fig. 117 [ITE15] (Tested test sample, for tensile strength).

Heat treatment tests (over the part):

As defined in the drawing the mechanical characteristics of treated parts have to be:

Surface hardness: 700-780 Hv

Hardness Depth: 550 Hv 0.3 (0.25-0.4 mm)

Core hardness: 340-450 Hv

After prepare the test sample, using a solution of hardened resin, as:



Fig. 118 [RUB 16] (Resin prepared test sample).

Using the micro hardness tester we can find the values over treated parts:



Fig. 119 [RUB16] (NIKON eclipse MA100).

Area A (inner zone):

Surface hardness: 716- 724 Hv

Hardness Depth:

Sample	0,1	0,2	0,3	0,4
Area A	730	705	644	543

Fig. 120 [ITE15] (Obtained hardness values in different depths).

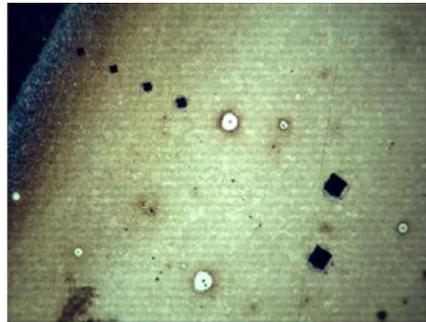


Fig. 121 [ITE15] (Micrography of tested sample, with tester marks)

Core hardness: 340-450 Hv

Area B (outer zone):

Surface hardness: 700-780 Hv

Hardness Depth: 550 Hv 0.3 (0.25-0.4 mm)

Sample	0,1	0,2	0,3	0,4
Area A	775	736	614	533

Fig. 122 [ITE15] (obtained values at core).

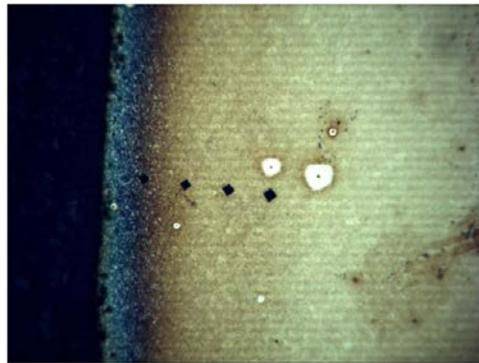


Fig. 123 [ITE15] (Micrography of tested sample, with tester marks).

9. Costs project calculations:

9.1 Tool manufacture costs:

9.1.1 Design costs:

- **Design costs (Engineering):** 50 hours (Engineering design fees 90 €/ h)

9.1.2 Production tool costs:

- **Purchase elements costs: 1. 250 €** (Standard components, screws, step punches, die holder, upper and lower, etc....)
- **Raw materials** for special elements: **6. 200 €**

- **Machining costs:** 65 hours € (Tooling generic fees 115 € / hour (Average including, EDM, turning, and milling)

$$65 \cdot 115 = 7.475 \text{ €}$$

- **Assembly costs:** 15 hours (Senior mechanic operator fees 75 € /hour)

$$75 \cdot 15 = 1.125$$

9.1.3 Total design & construction costs:

$$4.500 + 1.250 + +6.200 + 7.475 + 1.125 = 20.550 \text{ €}$$

9.2 Part production costs:

- **Raw material costs:**

Net weight: 75,24 g

Gross weight: 546 g

Gross weigh/part: 273 g

Raw material (BROCKHAUS STAHL): 1.060 € / tone

$$\frac{1060 \cdot 546}{10^6 \cdot 2} = \mathbf{0.289 \text{ €/part}}$$

**Weight calculated with an average 7.8 Kg /dm³*

- **Fine blanking costs:**

Press cadence: 20 Strokes/min

Parts per stroke: 2 parts

Press fees: 110 € /hour

$$\frac{110}{20 \cdot 2 \cdot 60} = \mathbf{0.04583 \text{ €/part}}$$

- **Deburring costs:**

Part surface: 2598.892 mm²

Belt speed: 2.5 m/min

Belt wide: 300 mm

Belt surface: 750.000 mm²/ min

Useful surface (Max. 75 %): 562.500 mm²/ min

Deburring machine fees: 45 € /hour

$$45 \cdot \left[\frac{0.75 \cdot 300 \cdot 2500 \cdot 60}{2598.892} \right]^{-1} = 0.03465 \text{ €/part}$$

- **Heat treatment costs:**

Carbonitriding: 1.080 € /Tn

Part weight: 75,24 g

$$\frac{1.080}{10^6} \cdot 75,24 = 0.081259 \text{ €/part}$$

- **Vibration costs (rounding edges):**

Part weight: 75,24 g

Chips load: 100 Kg/ batch

Parts load: 250 Kg/ batch

Rounding process time: 20 Min/batch

Vibration machine fees: 56 € /hour

$$\left[\frac{56 \cdot 75,24}{250 \cdot 3 \cdot 10000} \right] = 0.005617 \text{ €/part}$$

- **Packaging costs:**

Box costs: 0.19€ / box

Parts per box: 100 units

Operator costs: 18 € / hour

Boxes prepared by the operator per hour: 50 boxes / hour

$$\frac{0.19}{100} + \frac{18}{100 \cdot 50} = \mathbf{0.0055 \text{ € / part}}$$

9.2.1 Tool maintenance fees:

We have calculated maintenance of the tool, every 8.000 strokes (16.000 parts). The maintenance of the tool consists in grinding die tool (postiches) and punches. The punches will be grinded 2 mm approx. every maintenance (if any breakage appears, so the grinding distance will be higher).

Maintenance tool operator fee: 38 € /hour

Grinding machine fees: 65 € /hour

Complete maintenance works calculated time: 2 hours.

$$\left[\frac{(65 \cdot 2) + (38 \cdot 2)}{8.000 \cdot 2} \right] = \mathbf{0.012875 \text{ € / part}}$$

9.2.2 Scrap revenues:

Taking in account that our scrap is almost 56 % of purchased raw material, we have to profit the scarp to reduce part /costs.

At date of (10/03/2016), the carbon steel (16mnCr5) could be sold to the at best prices of 250€/ton (Price reference OBULCO S.A.)

Net weight: 75,24 g

Gross weight: 546 g

Gross weigh/part: 273 g

$$\left[\frac{(273 - 75.24) \cdot 250}{10^6} \right] = \mathbf{0.04944 \text{ €/part}}$$

9.2.3 Total production part costs:

Raw material costs: 0.289 €/parts

Fine blanking costs: 0.04583 €/parts

Deburring costs: 0.03465 €/parts

Heat treatment costs: 0.081259 €/parts

Vibration costs (rounding edges): 0.005617 €/parts

Packaging costs: 0.00551 €/parts

Tool maintenance fees: 0.012875 €/parts

Scrap revenues: **0.04944 €/parts**

$$0.289 + 0.04583 + 0.03465 + 0.081259 + 0.005617 + 0.00551 + 0.012875 \\ - 0.04944 = \mathbf{0.4709665 \text{ €/part}}$$

10. Bibliography

[MTP16]

Original own material / Author, Alfredo Bueno / Created from January to June 2016

[TDM16]

https://6e14fddd31b7cc4f19fbed1e0038fb5e85dd1ec7-www.googledrive.com/host/0ByHAzRyG40A_ZIFESXdyRWgxd1U/new-page/28-fine-blanking.html (Consultaded, March 2016)

"TOOL AND DIE MAKING"

[FTA12]

Tool material and coatings (module PT/3) / Rev. date 19/04/2012

"Feintool technologie AG lyss"

[FTR03]

FEINTOOL TRAINNING (module PT/3) Rev. Date. 01/01/2003

"Feintool technologie AG lyss"

[CAI16]

<http://www.carboneras.biz/productos/lineas-de-alimentacion-para-prensas/convencionales/>

CARBONERAS INTERNACIONAL (Ref. date. March 2016)

[STS13]

<http://www.keytosteel.com/en>

"Verlag Stahlschlüssel I SBN: 9783922599098) (Rev. date 2013)

[LOE16]

LOESER GmbH / We invent your solution

<http://www.loeser.de/en/products/deburring-machines-deburring-system/sheet-metal-deburring.html> (Consultated, February 2016)

“Deburring lines”

[TEC14]

TÉCNICAS DE CORTE FINO (MODULO 4) (Doc. w/o revision date, Consultated April '16).

FUNDACIÓ ASCAMM

[WKP16]

ENSAYO DE TRACCIÓN

https://es.wikipedia.org/wiki/Ensayo_de_tracci%C3%B3n

https://upload.wikimedia.org/wikipedia/commons/4/4f/Curva_tensi%C3%B3n_deformaci%C3%B3n_zonas.png (Consultated, February 2016)

WIKIPEDIA.org

[BAL16]

BALANZAS COMERCIALES / Gequipameintos.

<http://www.grequipamientos.com.ar/balanzas-electronicas-comerciales-digitales.php> (Consultated, March 2016)

[FEH16]

Hydraulic fineblanking presses (The right press for every requirement profile for strengths from 3,200 kN to 15,500 kN.

<http://www.feintool.com/en/products-and-services/complete-press-systems/presses-and-systems/hydraulic-fineblanking-presses/> (Consultated June '16).

[FEP16]

<http://www.feintool.com/technologie/feinschneiden/> (Consultated June '16).

“Das pirnzip der erfolgreiche technologie”

[MED16]

“PRECIOS DE COMPRA DEL ACERO”

<http://metalday.es/precios.php> (Consultated June '16).

[ABO11]

ACEROS PARA TRABAJO EN FRÍO (Rev. Date 04/2011).

BÖHLER Edelstahl GmbH & Co KG

[ITE 15]

Determinar características muestra flejes S/FM 04 04 04.00 (Rev. Date 20/07/2015)

METAL QUALITY / Juan Alarcón (Ing. TEC).

[OBA 16]

<http://www.oerlikonbalzerscoating.com/bes/spa/01-products-services/02-balinit-coatings/031-balinit-alcrona-pro/indexW3DnavidW261.php> (Consulted June '16).

“Recubrimientos cerámicos”

[INM16]

ACCESORIOS DE MATRICERIA I / II / III

(Doc. w/o revision date, Consulted April '16).

[SVK12]

Material definitions and recommendations

UDDEHOLM SVERKER® 21 (Rev.date07/2012)

UDDELHOLM

[FBT16]

Tooling technology

<http://www.fineblanking.org/process/tooling.htm> (Consultated May '16).

[VMS16]

Von mises stresses representation.

<http://blogs.solidworks.com/solidworksblog/2012/06/assuming-linearity-linear-static-vs-nonlinear.html> (Consultated Jan '16).

[VDI94]

Verein Deutscher Ingenieure, "*fine blanking*", paragraph 4, Norm VDI 2906 (Blatt 5, May 1994)

[DOL16]

"Understanding cemented carbide"

Destiny tool

<http://www.destinytool.com/carbide-substrate.html>

[FAU16]

<http://www.plastico.com/temas/Faurecia-presento-asiento-mas-ligero-y-mas-delgado-durante-el-NAIAS-2015+102765> (consultated, June '16)

[ERS10]

"Acero rapido pulverimetalurgico ASP 2005"

(Revision 0, Rev. Date 2010)

ERASTEEL

[OCO16]

<http://oceaniaorthopaedics.com/advanced-technology/tin-coating/> (consultated, July 2016)

"Why Should You Consider a Ceramic Coating?"

[DIY16]

<http://www.directindustry.es/fabricante-industrial/electrodo-67316-3.html> (Consultated, july '16)

"Productos -> electrodos."

[ELD16]

www.Eldrachersl.es (Consultated, June 16).

"Products-> bearings"

[TRP16]

www.traceparts.com (Consulted May '16)

"Bearings"

[UGA16]

<http://www.ugatu.com/tienda/tornillos/din-912.html> (Consultated July '16)

"Tornillos hexagonal DIN 912"

[LGM16]

<https://www.logismarket.es/tallers-tio-pratdesaba/contenedor-volquete/897404988-26135404-p.html> (Consulted May '16)

"Contendores volquetre"

[RUB16]

RUBISAN S.A. (local heat treatment supplier)

Counseling by RUBISAN technical department.

Meeting performed May '16

[ROS16]

Publ.-Nr. GB.130.23 (Consultated March 2016)

RÖSLER Oberflächentechnik GmbH · www.rosler.com

"Vibratory technology"

[ROE16]

Publ.-Nr. GB.1145.17 (Consultated March 2016)

RÖSLER Oberflächentechnik GmbH · www.rosler.com

"Consumbales"

[SUG16]

<http://www.sugar.es/catalogo/embalaje/cubre-palets/> Consulted July '16

"Suministros industriales"

[TSI16]

(Test sample sketch ISO 6892-1)