INCREASING THE DURABILITY OF THE PRESSING TOOL BY OPTIMIZING THE CONSTRUCTIVE SHAPE OF THE ACTIVE SURFACE

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ABSTRACT: This paper presents a practical solution to increase the life of a tool with which a pressing of 50 kN is performed on a 99.5 aluminum plate. The tool used is made of 90MnCrV8 hardened to 60-64 HRC and has a simple cylindrical geometry. The pressing will be done with a hydraulic press of 80 kN. Due to the repeated pressing as well as the fact that the plastic deformation achieved catches the tool, after approximately 2500 presses microcracks appear on the tool followed by the destruction of the tool. Thus this research presents geometric optimizations that can be implemented on the tool in order to ensure a high resistance and a much longer life.

Keywords: geometric optimization, press assembly, microcracks, increasing tool life.

INTRODUCTION

Press assembly is a type of non-removable assembly and is obtained by pressing two parts, by deformation. One of the assembly parts is deformed elastically or combined elastic and plastic, creating an appreciable contact pressure. The other will respond with equal force and the opposite direction. The friction force between the two parts becomes so high that it causes immobilization to each other. [1]

At this time, press assembly is widely used due to the advantages it provides, including the low cost of realization or the speed of assembly. In the application discussed in this article, the assembly speed is very important because 10 cylindrical elements must be assembled on an aluminium plate provided with holes. The cylindrical parts will be prepositioned in holes with clearance, and then by pressing the surface around the bores the tightening will be performed. [1]

The material from which the tool is made is a 90MnV8 alloy steel also called 1.2842 bought from SC Fine Metal SRL. The chemical composition expressed as a percentage and the physical properties for the said steel can be found below, which is in accordance with standard EN4957-2000.

Table 1. Chemical composition % of steel 90MnCrV8 (1.2842): EN 4957-2000 [2]

C	Si	Mn	P	S	Cr	V
0.85 - 0.95	**0.1 - 0.4**	**1.8 - 2.2**	**max 0.03**	**max 0.03**	**0.2 - 0.5**	**0.05 - 0.2**

Table 2. Physical properties of steel 90MnCrV8 (1.2842)

Density, g/cm3	**7,85**
Electrical resistivity, μΩ·m	**0,35 (20 °C)**
Specific heat capacity, J/(kg·K)	**460 (20 °C)**
Thermal conductivity, (W/m·K)	**33 (20 °C)**
	32 (350 °C)
	31.3 (700 °C)
Modulus of elasticity, GPa	**210**

The plate with holes in which the cylindrical elements will be inserted is made of 99.5% aluminium bought from SC Depo Materiale

Constructii SRL. The plate was previously processed on a CNC computer numerical control machine, on which 10 bores were made. The main features of this material are the following:

- Very good atmospheric corrosion resistance;
- Very good workability;
- High thermal and electrical conductivity (preferred alloy 1350);
- Attractive appearance;
- High reflectivity;
- Suitable for decorative anodizing;
- Very good weld ability;
- Low mechanical properties. [3]

The chemical composition of this material can be found below in Table 3.

Table 3. Chemical composition % of aluminium EN AW 1050A [4]

Fe	Si	Mn	Mg	Ti	Ti	Cu	Cr	Obs.
0.4	**0.25**	**0.05**	**0.05**	**0.05**	**0.07**	**0.05**	**-**	**min. 99.5 % Al**

The cylindrical parts that will be inserted in the holes made in the aluminium plate are pieces of simple geometries, made in steps with three different diameters. They are made of a common steel called C45 or 1.0503. The properties of this material are well known and will not be presented for objective reasons. The roughness of the outer cylindrical surfaces of these parts is 3.2 μm.

1. Description of the elements involved in the process

There are four main elements involved in the pressing process:

1. the plate on which it will be assembled
2. the part to be assembled
3. the tool with which the assembly is made
4. the press with which it will be made assembles

As previously mentioned, the purpose of this process is to assemble by pressing 10 pieces of C45 steel on a 99.5% aluminum plate. The steel parts will be prepositioned in the holes made on the aluminum plate in the drawing below.

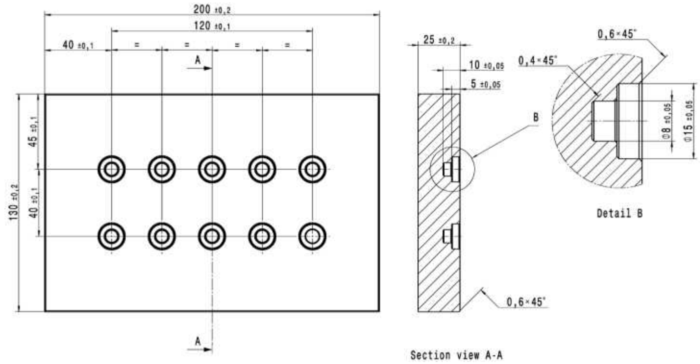


Figure 1. Technical drawing of the aluminium plate

The technical drawing of the parts to be assembled is presented below. This part is generated on three different diameters provided with certain chamfers or cylindrical connections, as well as with an M4 threaded hole. Its construction is very simple, the material is a C45 and the roughness to be obtained is 3.2 μm. The piece was made by turning.

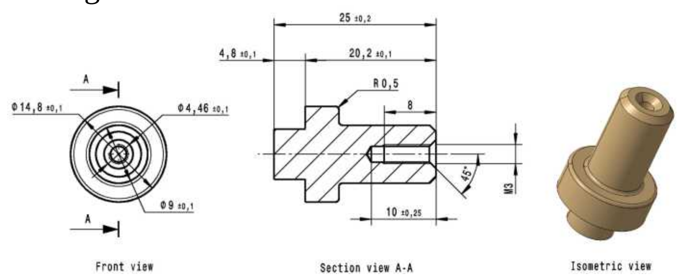


Figure 2. Technical drawing of the steel cylinder

The assembly will be done by positioning the steel piece in one of the holes on the aluminium plate. The next step is to press the pressing tool onto the flat surface of the aluminium plate. The tool is made of an alloy steel bar – 90MnCrV8 - and hardened to 60-64 HRC. The drawing of the press tool in its original form can be found below:

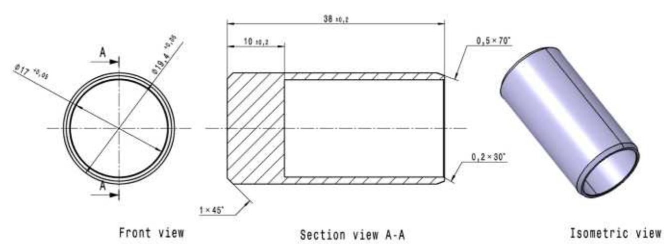


Figure 3. Technical drawing of the pressing tool

The machine to be pressed is a press from Flexmont, 80kN JPU-8003 mode. The press is hydraulically operated with a lever. The technical specifications can be found on the Flexmont supplier's page, and some of them have been taken in the table below.

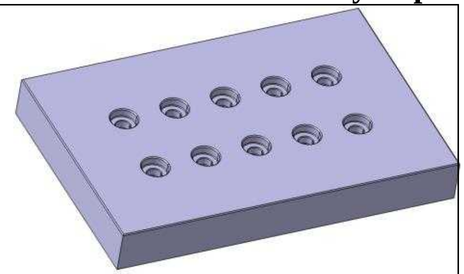
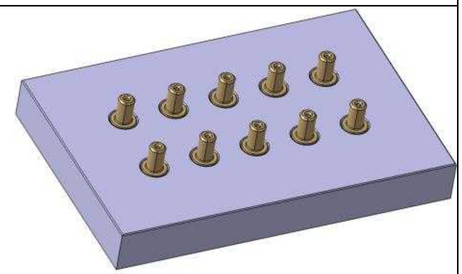
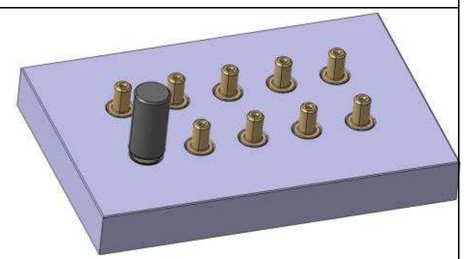
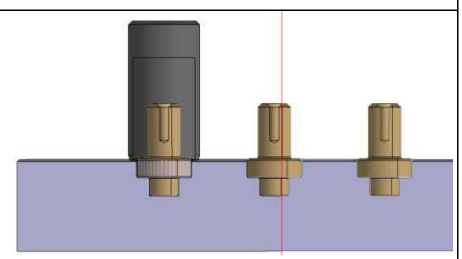
Table 4. Flexmont JPU-8003 technical specification [5]

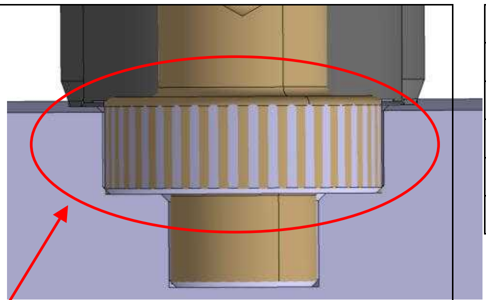
Model number		**JP-8003**
Pressure capacity	**Maximum**	80 KN (8,000 kgf)
	Range	8 - 80 KN (800 - 8,000 kgf)
	Step	10 N (1kgf)
	Minimum detection capability	80 N
Bear stroke	**Maximum**	200 mm
	Allowed range	0 - 200 mm
	Step	0.002 mm
Bear speed	**Approximation**	133 mm/s
	Pressing	0.01 - 23 mm/s
	Step	0.01 mm/s
	Return	200 mm/s
Accuracy		± 0.010 mm
Load detection range		8 - 80 KN (800 - 8,000 kgf)

2. Simulation of the stages of the assembly process in Catia

The assembly steps will be simulated by 3D models made in the Catia v5 program. These will be illustrated tabularly in Table no. 5 below, together with some technical remarks. This subchapter serves for a clearer picture of the technological process to be performed and which creates problems in terms of the durability of the press tool.

Table 5. Press assembly steps

Step 1: Prepare the part for assembly. The part must be clean, free of scratches or burrs and free of traces of cutting fluid.	
Step 2: Prepare the parts to be assembled on the bores made on the aluminum plate.	
Step 3: Position the pressing tool over the part. It will be considered that the tool will be concentric/coaxial with the assembly piece.	
Step 4: Press lightly until the analog indicator shows the force of 50 kN ± 3kN. At this pressing force the material from the pressed area will migrate to the cylindrical surface of the part and will ensure its tightening.	

Step 5: Check the assembly: rotation of the part or any clearance is not allowed. OBS. Where brown intersects gray, there is a tightening adjustment.	

3. Problem definition and finding the root cause

At least 10,000 presses will be required to complete the assembly of 1000 aluminium plates with steel components. It was found that after assembling between 2000 and 2500 pieces, the processing tool breaks in different areas. The most common damage to the assembly part is visible on the cylindrical surface of the parts, in the form of cracks from previous microcracks. The steel is hardened to 60-64 HRC, therefore the elastic component of the steel is more difficult to observe. For this reason, the tool cracks and does not bend, as it is very brittle. Before the appearance of each crack, an intense sound is heard, and from that moment the tool becomes unusable in safe conditions. For the performing of the present research, assemblies were made with 10 identical tools. It has been observed that most break in the range of 2300-2400 assemblies.

Table 6. The life of the tool expressed in no. of assemblies

Nr. crt.	Tool number	Assembly number
1	Cylindrical tool 1	2416
2	Cylindrical tool 2	2101
3	Cylindrical tool 3	2631
4	Cylindrical tool 4	1986
5	Cylindrical tool 5	2322
6	Cylindrical tool 6	2406
7	Cylindrical tool 7	2315
8	Cylindrical tool 8	2415
9	Cylindrical tool 9	2386
10	Cylindrical tool 10	2398

As a result of the over 23300 assemblies made, the pressing tools were severely or very severely damaged. The cracks on the cylindrical surfaces of the tools are visible in most cases. In none of the 10 cases was the active edge - the one that deforms the aluminum plate - completely broken. Below are some images with the most obvious cracks on the tools.

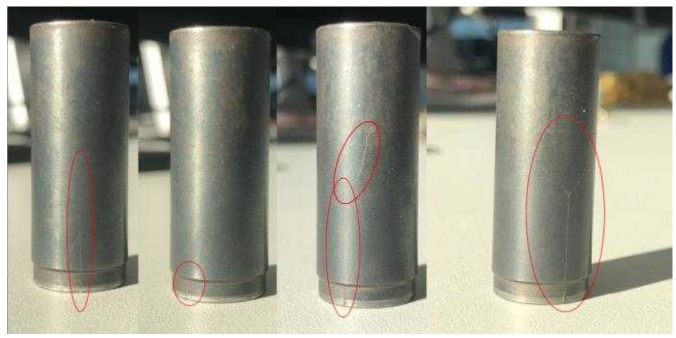


Figure 4. Cracks on the pressing tool

The cracks inside the tool were more obvious on the other tools. Some of them spread very little or not at all to the outside of the piece. All these cracks had as a starting point the active edge because this is the most affected part of the piece. From all these photos as well as from the ones below it can be proved that there are three main causes: too high hardness of the material, the geometry of the thin-walled part cannot deviate the pressing force in less important areas, the geometry of the active edges makes the tool to be retained by the aluminum plate. shocks are inserted into the tool. Thus, different geometries will be checked for the active edges and for the tool body.

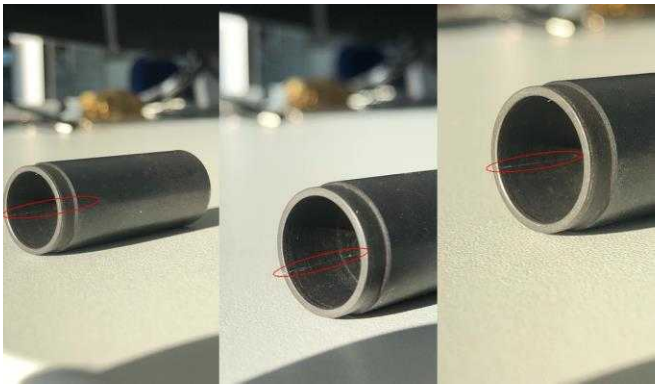


Figure 5. Cracks in the pressing tool

4. Tool geometry optimization

In order to improve the geometry of the piece, several variants are proposed to be tested. It is considered that it will be very difficult to increase the service life only by optimizing the geometry so that the tool can withstand at least 10,000 assemblies. In this sense, for a future scientific article will be determined the parameters of heat treatment that can influence the life of the tool.

The first proposed variant has as reasoning the increase of the diameter of the pressing tool, the improvement of the active edge and the reduction of the chamfer from 70 degrees to 45 degrees. The expected effect is that the stress will be taken over by the tool body through the thicker walls and will be directed to the active edge. The active edge will change in the direction of changing the chamfer with an annular surface with two connecting radius: inside a radius of 0.4, and outside a radius of 0.6 mm. In this way, the tool will no longer be stuck in the aluminium plate when pressed, no longer having a sharp edge from which to attach the less hard material. Also, by changing the height of the surface that will perform the pressing, the angle was reduced from 70 degrees to 45 degrees on a length of 9.8 mm.

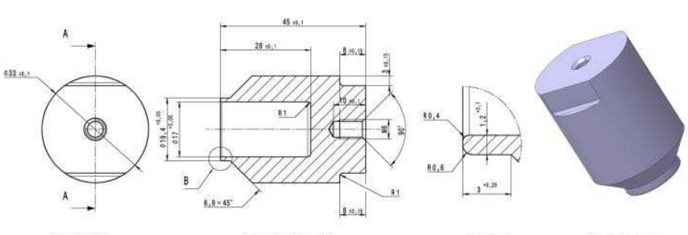


Figure 6. Geometry optimisation – variant 1

Also, to remove the shocks when detaching from the aluminum plate, the piece was provided with two distinct systems. The first system comprises an M6 threaded hole to a depth of 10 mm. An M8 screw can be inserted in this hole and the detachment can be made perfectly vertical. This will not introduce additional shocks. Also, two millings were made which will be used to be able to detach the tool by means of a semi-open annular wrench.

The tool life has been improved; this tool being used at 4315 presses. Unfortunately, during the detachment of the tool from the aluminum plate by means of the wrench the active edge of the part was broken.

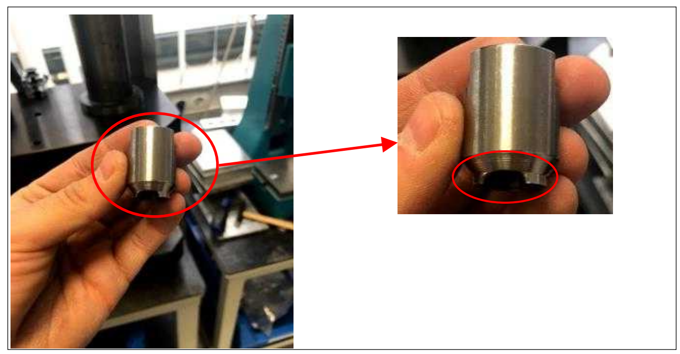


Figure 7. Broken tool

The third proposed variant to improve the geometry of the pressing tool consists in making a conical tool. This tool was made of the same material, 90MnCrV8 alloy steel, but the hardness was reduced to 58 HRC. In its current form, the tool has been used more than 5,000 times, without any defects being observed. It has been analyzed and so far, it has no microcracks, no burrs, it is not bent.

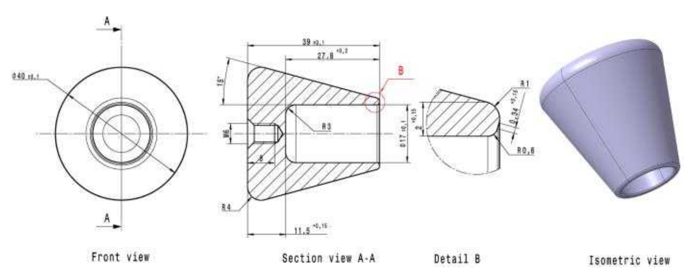


Figure 8. Geometry optimisation – variant 2

CONCLUSIONS

After researching the geometry of the pressing tools, it was possible to conclude that the too high hardness of the parts contributes to their faster deterioration. Also, the thin walls of the press parts do not have the ability to take over the load evenly so that microcracks appear on the cylindrical surfaces. The microcracks advance rapidly and damage the part until it becomes obsolete. An increase in the thickness of the walls in the idle area of the tool contributes to the increase of the service life.

Of all the constructive forms presented, so far it has been proven that the most efficient constructive solution is the conical one. In this way the pressing force is evenly distributed in the tool body, and the unloading of the force takes place strictly in the desired area. Also, the geometry of this variant creates a higher clamping force of the part to be assembled, in this way the pressing force can be reduced by up to 10kN. Maintaining the hardness at a value below 60 HRC proved to be a very good solution in this case because it increased the elasticity of the steel and implicitly the tool life.

REFERENCES

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