OPTIMIZATION OF MOUNTAIN BIKE SUSPENSION TRIANGLE

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Abstract:

The objective of this project is to design a full suspension ATV Triangle. The module designed must meet certain criteria. The ultimate goal is to design the lightest and strongest triangle possible and thus find the best combination of lightness and strength.
The design of the triangle and the optimization of its mass will be realized with the help of CATIA V5 software.

CUVINTE CHEIE: All-suspension mountain bike suspension triangle - Optimization – mass - strength.

1. Introducere

To start with, I was interested in the existing suspension ATV Triangle, so I was interested in the raw I want to have. The blank of this part is obtained by the shell casting process (no gravity) from a permanent mold. The material of the triangle is an aluminum alloy with a yield strength of 120 MPa (including safety factor).
Then I identified the functional surfaces of this room, they will be presented in the figure below:

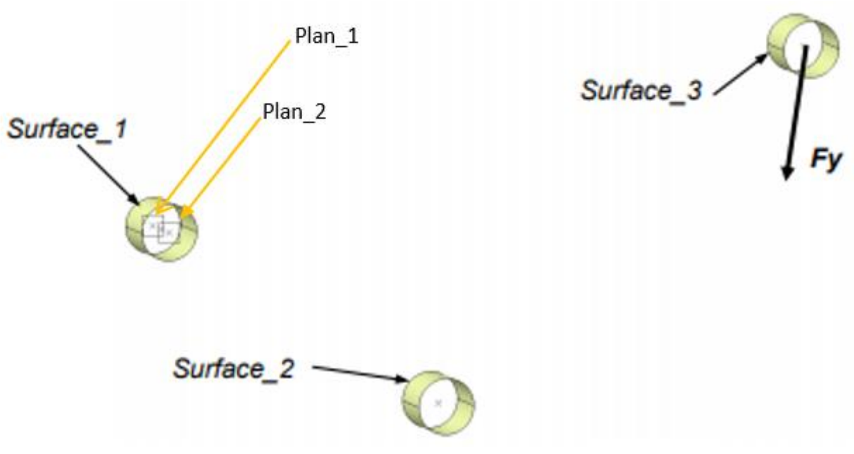

Figure 1: Functional Surfaces + planes limit of the thickness of the part

These functional surfaces will be kept during our study. The maximum thickness of the suspension triangle will be defined by Plan_1 and Plan_2.

Then, I decided to study the load applied on the triangle and the fixation that will be applied to it. To summarize, the suspension triangle is pivotally connected to the other suspension elements at the two functional surfaces 1 and 2.

A load of 2000 N is applied to surface 3. The force is directed along the Y-axis of the skeleton and oriented towards negative values.

Thus, I will try to find an optimal shape for this triangle to minimize its mass while respecting the following constraints:

- Respect the functional surfaces.
- Ensure the mechanical strength and rigidity of the part (maximum displacement < 0.25mm; maximum stress < 120MPa).
- Integrate the constraints of obtaining a rough casting: radii, draft, homogeneity of the part.

2. Stadiul actual

In the bicycle industry, rear suspension wishbones have a mass of about 1300g. Below is an example of the MTB Suspension Triangle sold on the website " COMMANCAL ". This triangle has a mass of 1384g.

Figure 2: MTB Suspension Triangle on Commancal website

There are several frame materials options: aluminum, carbon fiber, titanium, and steel. Each has its advantages and disadvantages, and the choice of material is based on budget and intended use. The first step is to define your desired criteria: lightness? reliability? budget? and then the choice will be based on these criteria.

	Price	lightness	rigidity	solidity	vibration damping
Aluminum	Low	+++	+++	+++	+
Carbon Fiber	+++	++	+++	+++	+++
Steel	++	-	-	-	+++
Titanium	++++	+++	+++	+++	-

Depending on our needs, I prefer to opt for aluminum.

Based on the specifications announced above, I started by making the general shape of the triangle. This shape will be presented below:

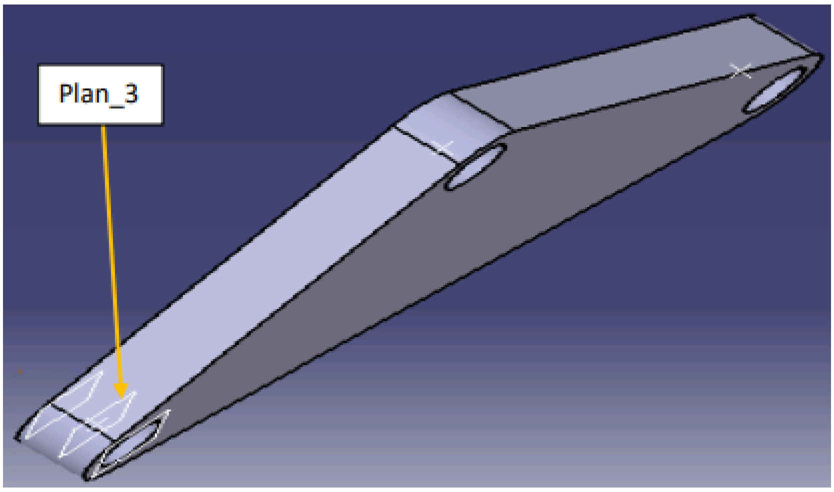

Figure 3: CATPART model of the start

This first modeling is rather rough, it is used to define the external shape of the triangle and to study the presence and location of the constraints and displacement.

The plane_3 is added to allow me to realize a symmetrical material removal and also to foresee the realization of the drafts.

I started by making a first analysis of the model on CATIA (thanks to the GSA workshop). This first study makes it possible to determine the zones subject to the majority of the constraints and those which are less.

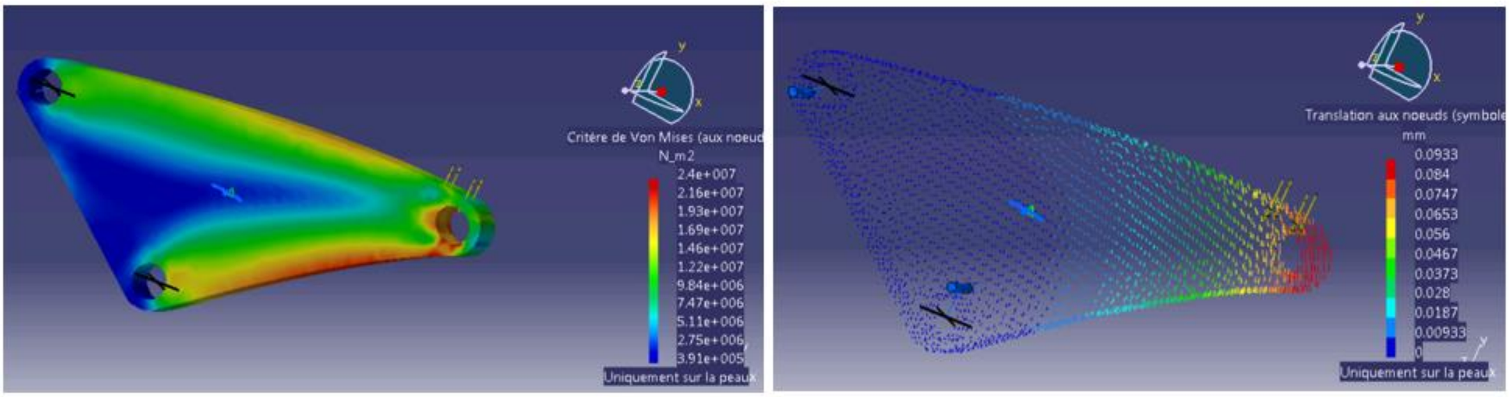

Figure 4: 1st stress simulation and 1st stress simulation of displacement

By analyzing the shape of the triangle in the picture above, we have:

- The mass: 1002g

- Displacement max: 0.0933 mm

- Contraintes : $2.4*10^7$ N_m^2

This first model guides us and gives us an idea of the possible modifications that can be considered for the shape of the triangle. It will be necessary to remove material from the low stress areas, and to add material -if necessary- from the high stress areas.

We can clearly see the areas where material can be removed (the blue areas = low stresses).

In order to optimize the part, I proceeded to several tests. Each time, I remove the material based on the analysis of before, I make a simulation and I integrate the result in my model.
After all the optimizations, my piece has the form presented below:

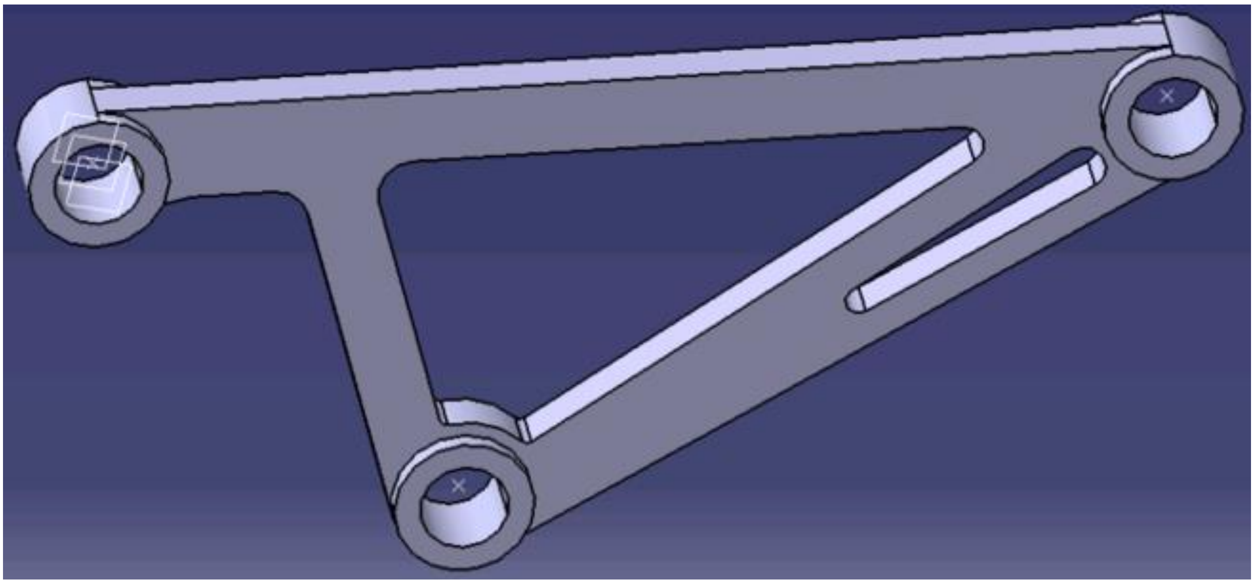

Figure 5:final shape of the triangle

With this shape, the mass of the triangle is optimized by checking the constraints, such as:

Mass = 82g * Yield strength = 79 MPa * Displacement = 0.245mm

In this study, we have a foundry blank. I must include in my triangle the radii and the drafts to facilitate the recovery of the part.
The attached plane was defined beforehand (it is 1plane_3). The drafts will be constructed through this plane (by symmetry with respect to plane_3). Such as:

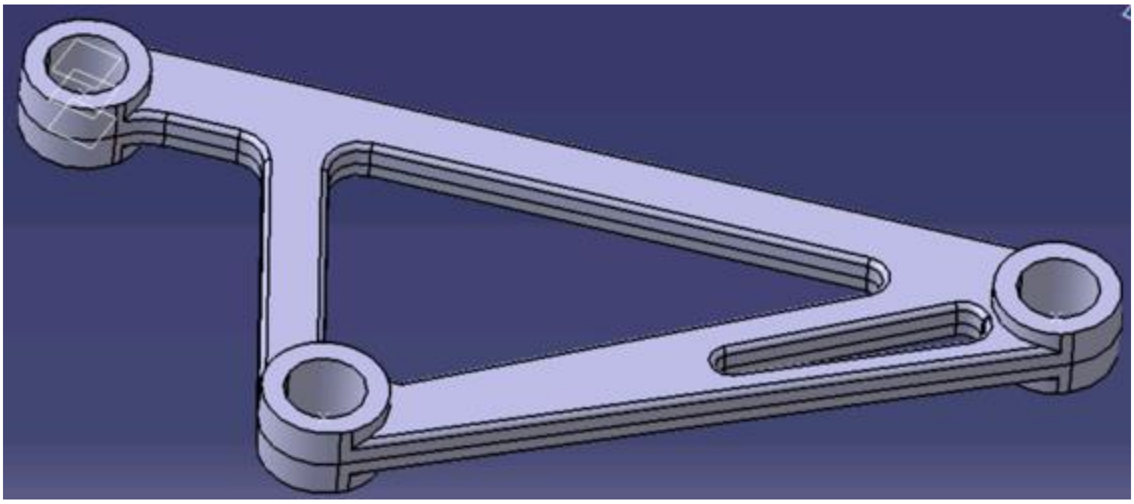

Figure 6: Gross of the triangle

After adding the leaves and the remains, I rechecked the validity of the constraints. Such as:

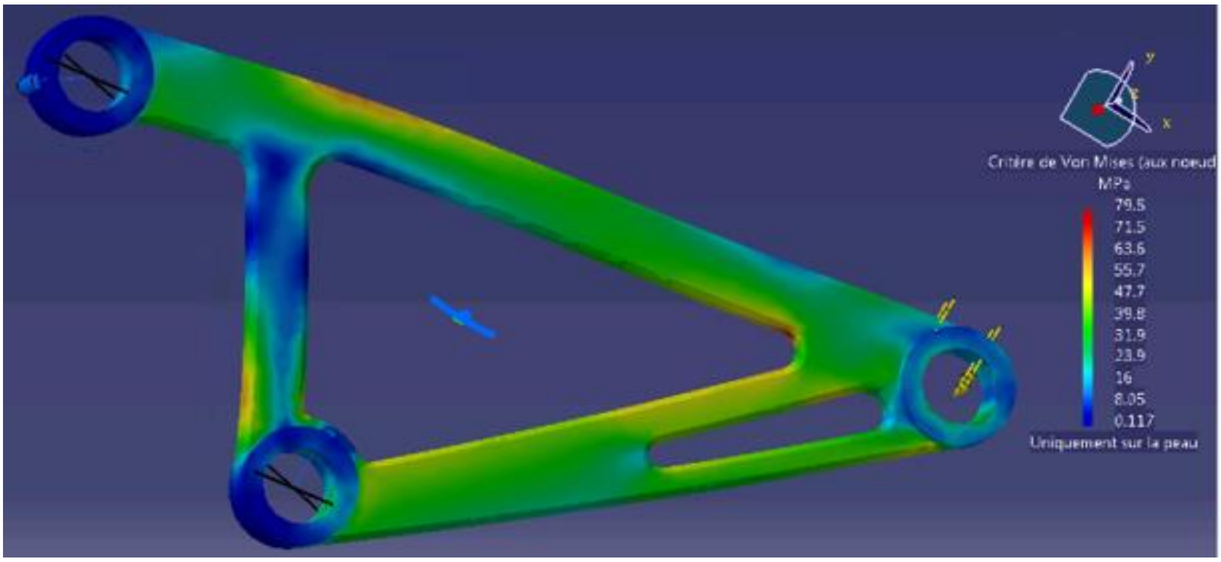

Figure 7: Elasticity limit of the Crude

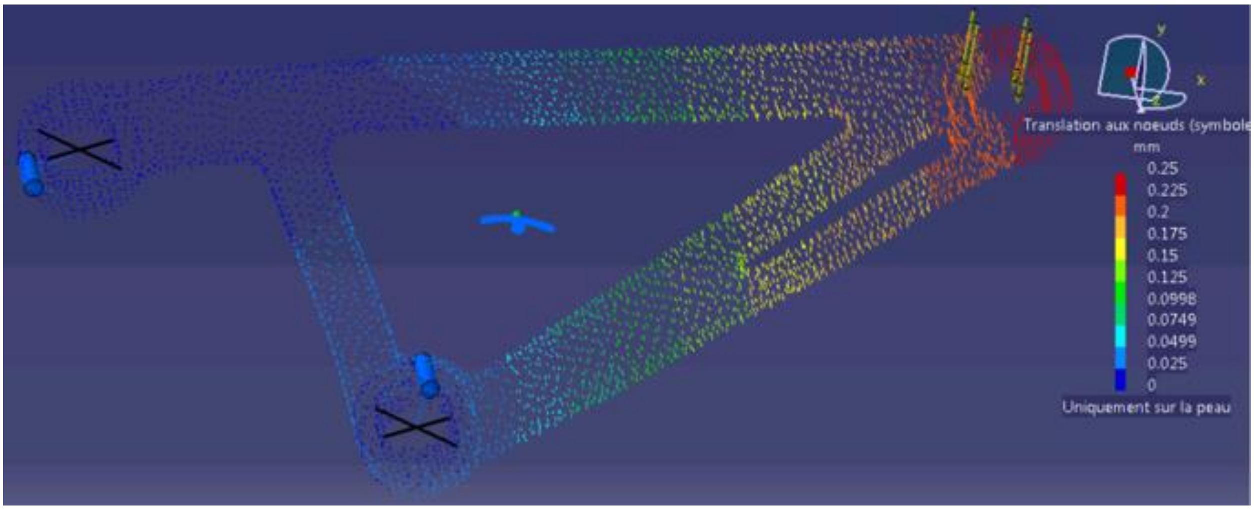

Figure 8: Calculation of gross displacement

According to the calculation, my raw part respects the specifications mentioned above (maximum displacement < 0.25mm; maximum stress < 120MPa). With a final optimized weight of 82g.

6. Concluzii

Characteristics	Before	After
Mass	1002 g	82.2 g
Maximum stress	24 MPa	79,5 MPa
Maximum total displacement	0,033 mm	0,25 mm

- The purpose of this analysis was to find the best configuration of the lightness and the strength of a mountain bike, respecting the allowable values for the stress and the displacement.
- According to the standards stipulated for this type of bikes, the maximum allowable values for the displacements are 0,3 mm.
- However, I considered a severe condition to be in the safe side of 0,25 mm. Consequently, a margin of security has been taken into account.
- Even if in such a case the stress is higher than in the first one, it is totally acceptable since it does not exceed the allowable limit of 120 MPa.

8. Bibligrafie

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9. Notații

Următoarele simboluri sunt utilizate în cadrul lucrării:
A_{SL} = aria suprafeţei laterale [mm^2];
A_t = aria totală [mm^2]