# Christian Tello
# 10731107


**MEGN 424 | Computer Aided Design | Section C**
**Analysis of a Bike Frame**
**Professor Ventzislav Karaivanov**

# Introduction

Historically, it has been seen that chainstays with “smooth” and monotonic stress distributions have had the best fatigue performance for “The Fat Calzone”, a bicycle that doesn’t rear suspension. MBP CycleWERKS, LLC has already purchased several thousand pre-fab. Chainstays, so as such the bicycle frame will be analyzed to optimize  the chainstay angular positioning. Ideally, the best form of testing would be to take to the streets and test the bicycle in environments of varying stresses such as “jumps”, hill climbs, and rapid deceleration, but this process would be too time intensive when considering all of the other possible factors that might inhibit the ability to draw a clear result on chainstay positioning, as such, Finite Element Analysis with predicted loading will take this place, and allow for the determination of the best angle for the chainstay in reference to the crankshaft. The purpose of this study was to model the von Mises Stress on the chainstay in the negative direction to decide which chainstay angle had the most monotonic distribution, and to use this information as a factor when considering the final chainstay positioning.

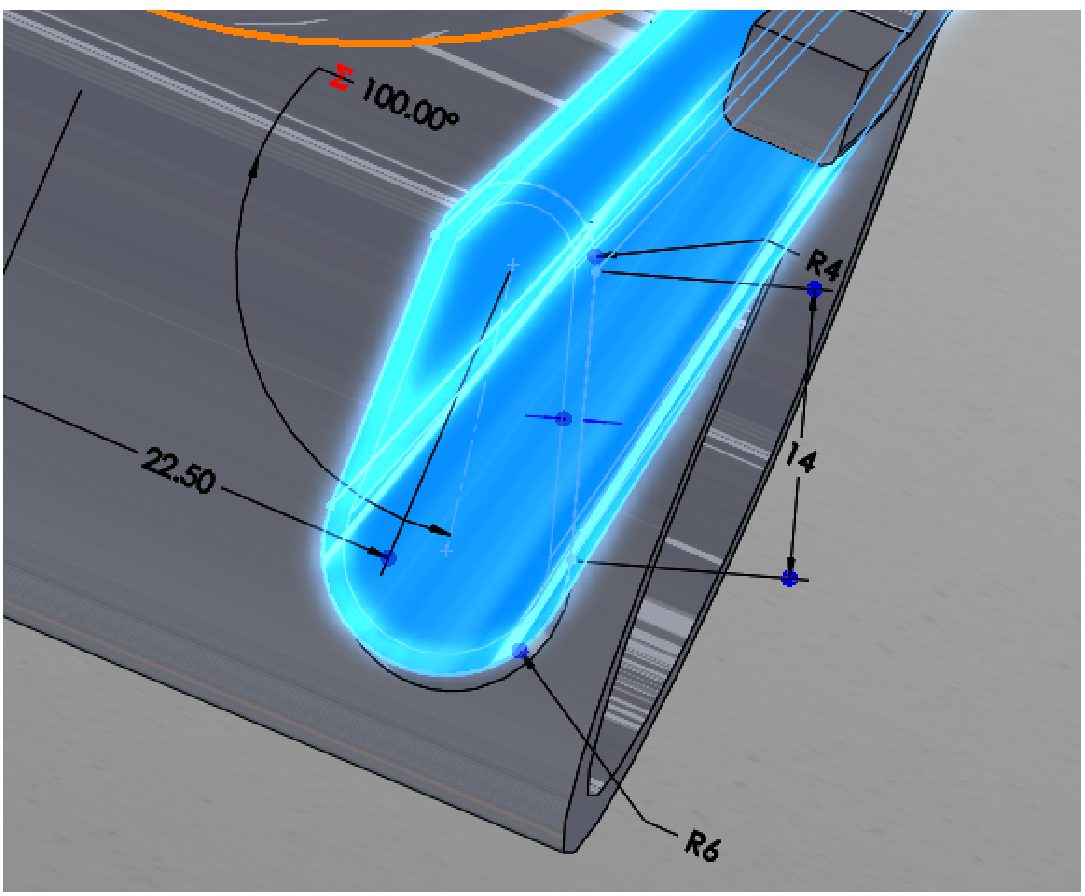



**Figure 1: Chainstay Angle is shown (100 deg)**

# Methods

The bicycle was tested using a pre-set loading, which include handlebar loads, pedal loads, and a bodyweight load on the seat, with an elastic support to simulate the front shock, and the rear axle is in a fixed position. This loading has its limitations when considering the riding experience, and conditions the riders will subject the bike to, but this loading has been determined to be representative of the 95th percentile ride, and to simulate the worse case in-service conditions. It is therefore seen as adequate for the tests we are conducting.
There are a few core considerations before getting into the testing,

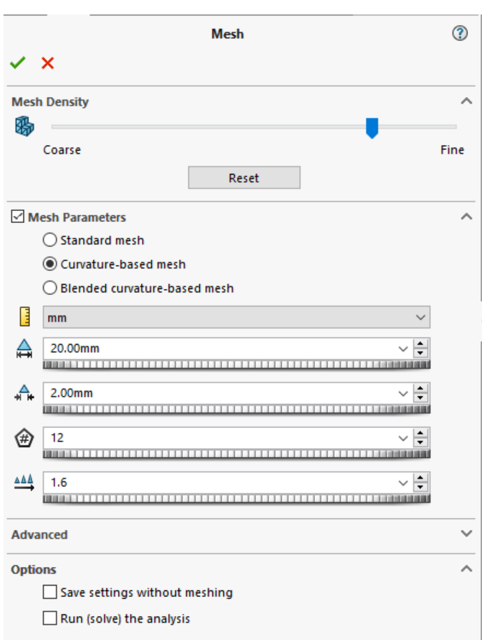
1. Material:
We'll be using Ti-6Al-4v, solution treated and aged (SS).

| Value | Property | Units |
|---|---|---|
| 1.0480031e+11 | Elastic Modulus | N/m^2 |
| 0.31 | Poisson's Ratio | N/A |
| 1050000000 | Tensile Strength | N/m^2 |
| 827370880 | Yield Strength | N/m^2 |
| | Tangent Modulus | N/m^2 |
| 9e-06 | Thermal Expansion Coefficient | /K |
| 4428.784 | Mass Density | kg/m^3 |
| 0.85 | Hardening Factor | N/A |

**Fig. 2: Material Properties**

2. Mesh Standards:
The basic mesh settings that successfully run and solve were as follows:

**Fig. 3: Mesh Settings**




These settings were run as preliminary standard to ensure mesh convergence for the figure, before "zero-ing" in on the clients exact specifications. This was determined to be a von Mises plot along <Edge 1> of the chainstay. With this factor clearly defined, the decision was made to apply a mesh control along the Edge with the most fine mesh density that SolidWorks supports.

This mesh will be created, run and converged, at three unique chainstay angles; 80, 90, and 100 degrees. Analytically this will fulfill the two boundary conditions and a nominal, and allow for comprehensive determination of the most monotonic chainstay angle.

However, before this is done, it's important to create a model that will save us time (and money) while conducting this analysis. This can be done by defeaturing the overall part via removal of unnecessary fillets, and the removal of details that are far away from the chainstays and won't impact the data we receive when conducting our probe. Thus we are only focusing the computer's power on meshing on the part that is essential to this study.

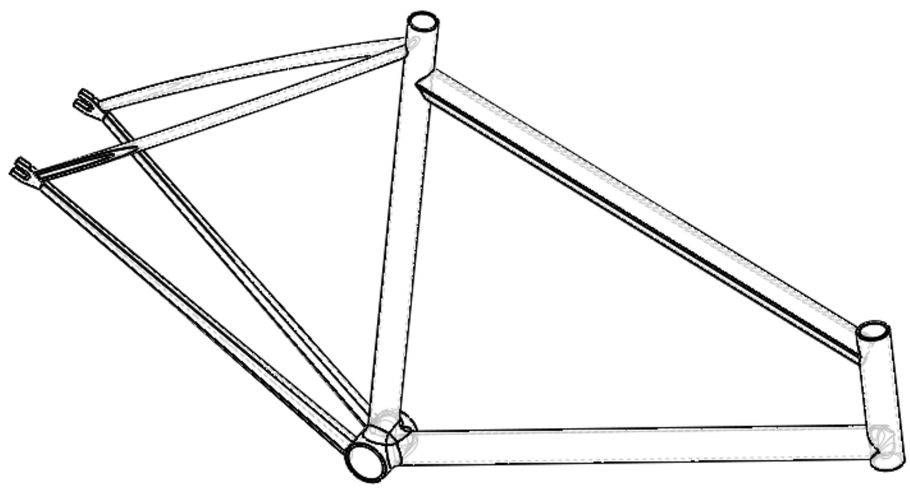


**Figure 4: Defeatured Frame**
**[Removal of Fillets: 2,4,8,9,10,12]**

| Initial Meshing Time | Initial Solving Time | Refined Solving Time: | Refined Meshing Time |
|---|---|---|---|
| 19 Seconds | 76 Seconds | 62 Seconds | 12 Seconds |

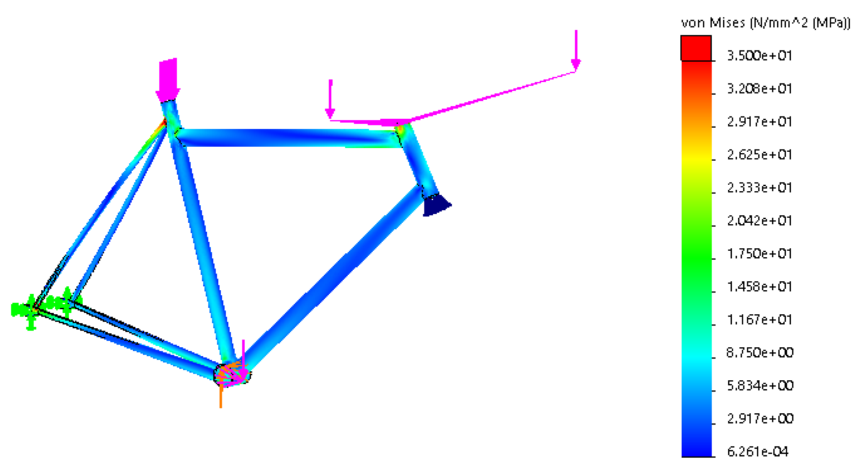



**Figure 5: Defeatured Frame von Mises**

With this configured, the strategy to get definitive results was to apply a manual mesh control to <Edge 1>, the edge along the top side of the chainstay, in the most positive Z and Y directions. From here, the mesh was created and run in accordance with the basic mesh criteria described before, and the data was probed alongside <Edge 1> for each potential angle.

# Results

The most monotonic stress distribution was found at the boundary condition of 100 degrees. The first plot below shows the difference in a plot with a mesh control applied versus the basic convergence. It illustrates the differences and increases in stress along <Edge 1>, and the fact that the stresses are greater for the results with a mesh prove that it is a more accurate result.

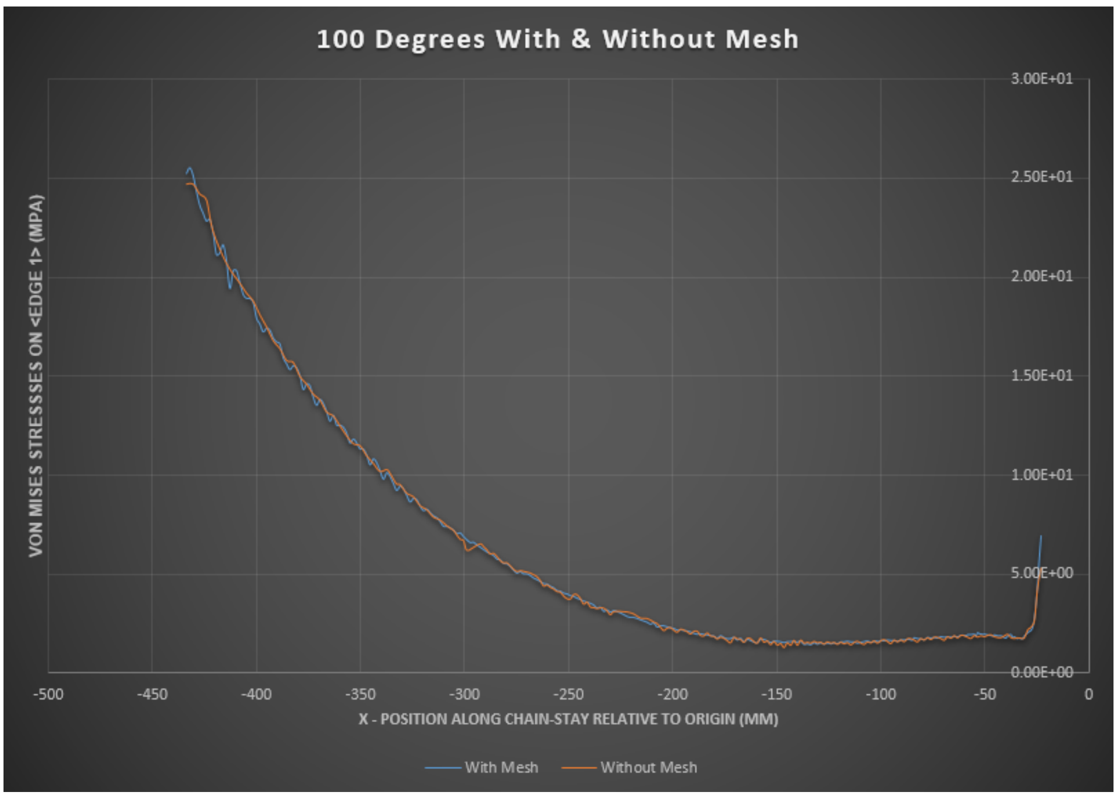



**Figure 6: Graph illustrating differences in recorded von Mises Stress (Mesh vs. No Mesh)**

The following plots show the von Mises stress distributions for the boundary conditions and the nominal angle, with only the plot for 100 degrees being monotonic

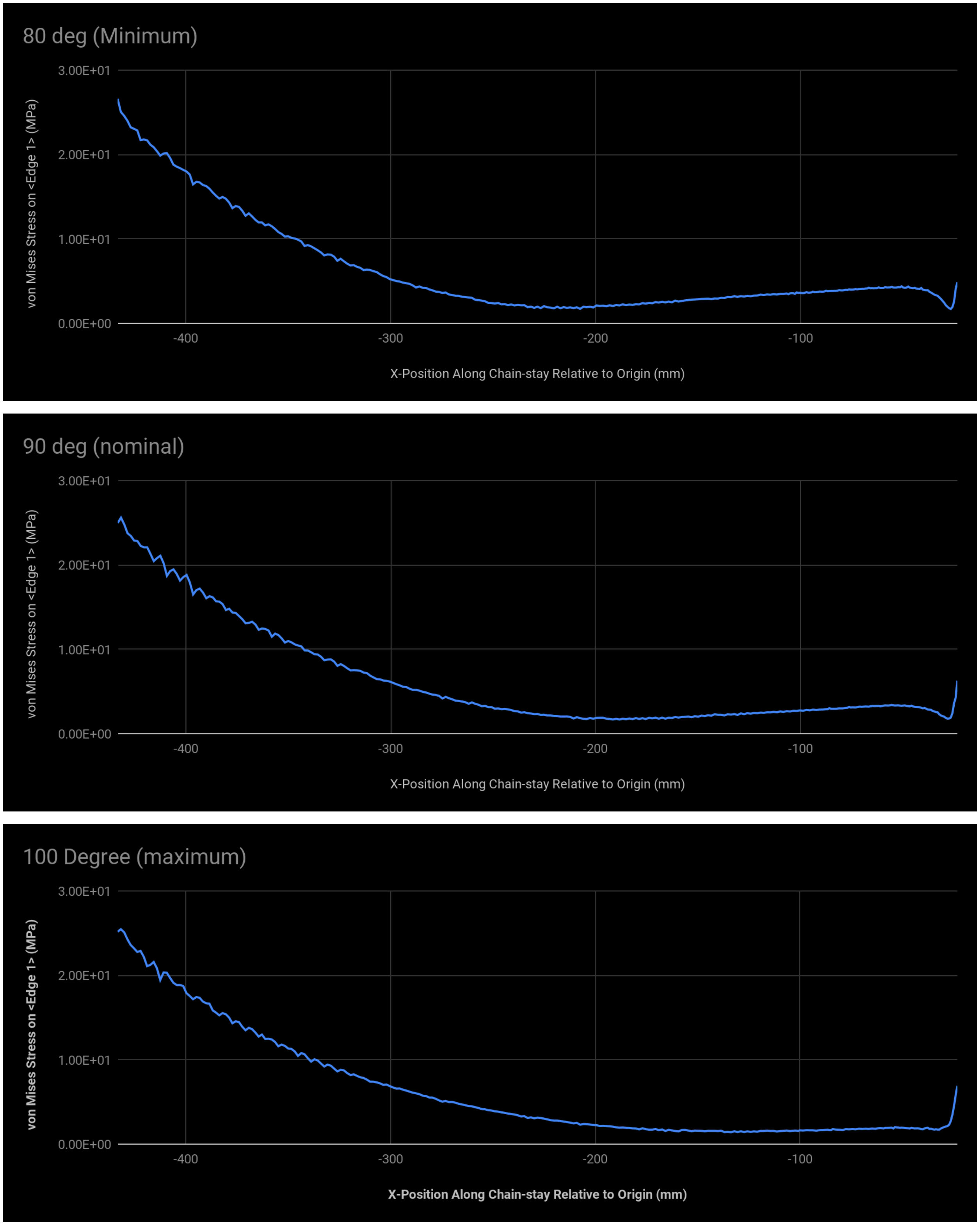
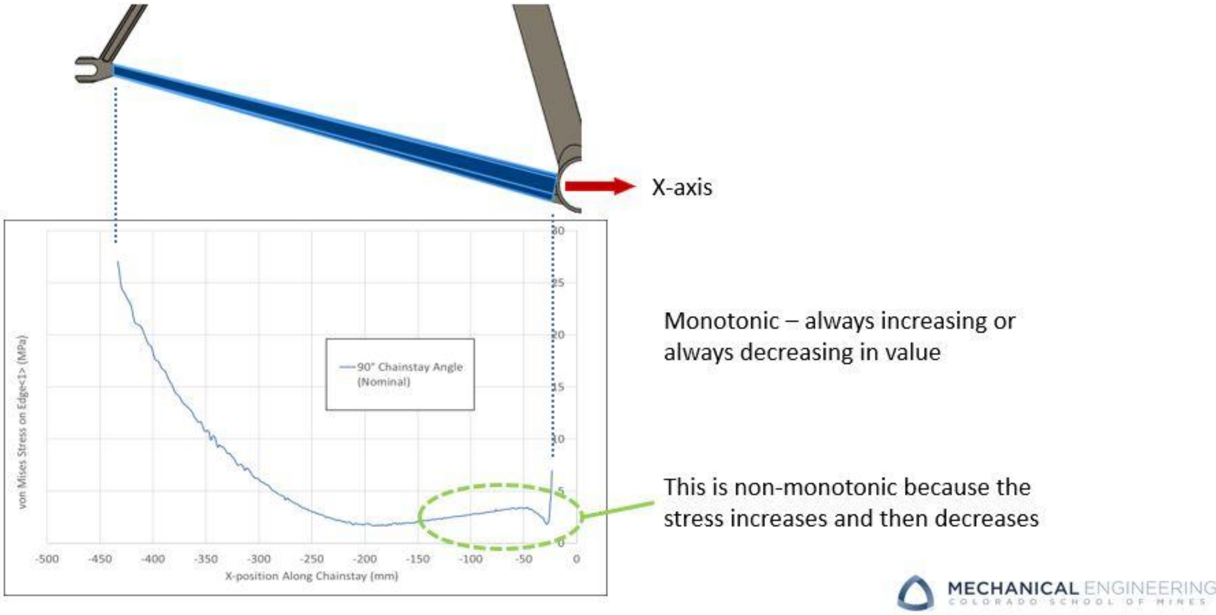



**Figure 7: <Edge 1> Stress Distribution Plots along Chainstay X-Position**

100 Degrees is seen as the optimal angle based on the slides shown in class that clearly defined what a monotonic stress distribution would look like. That is seen below in Figure 8.




# Discussion

The purpose of this study was to develop and validate a generalized FEA study to determine the best chainstay angle to produce a monotonic stress distribution. The proposed study was implemented in SolidWorks Simulation and successfully used alongside a predetermined external loading to model stress distributions for various potential angles. The successful implementation of a manual mesh convergence, and experimental data alongside with “The Fat Calzone’s” past history of success with monotonic von Mises stress distributions illustrates a propensity toward the selection of the 100 Degree chainstay angle as the best configuration for the pre-fabricated parts.

# References

**https://www.solidworks.com/sw/resources/solidworks-tutorials.htm**

**MEGN424_HW11_bike_frame_F18.pdf**

**MEGN424_HW11_tempate.docx**

**MEGN424_HW11_bike_frame_v3.SLDPRT**

**MEGN424_Lecture24_hw11_F18.pptx**