Fixturing for Double-Sided Incremental Forming Machine

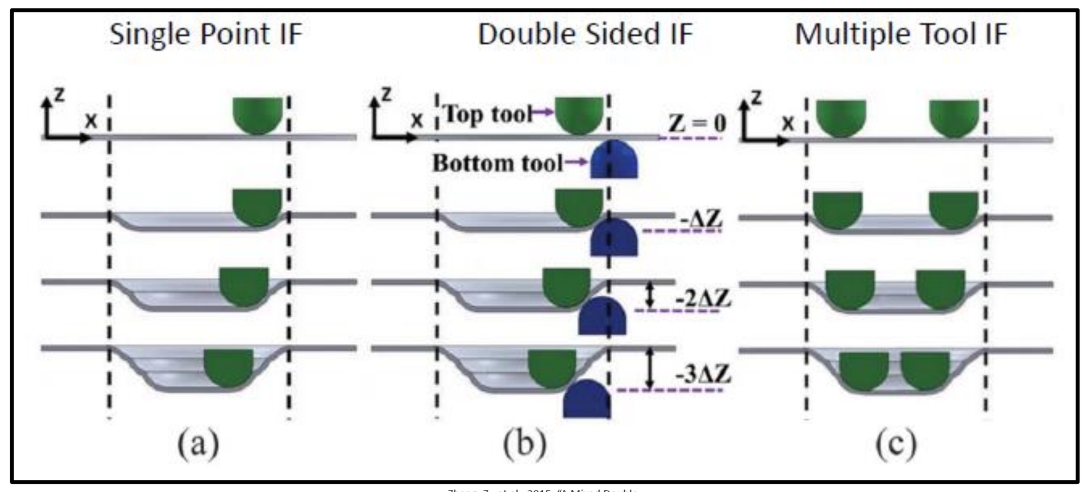
Zifeng Qiu & Noah Payeur

Department of Mechanical Engineering, University of New Hampshire

Advised by Brad Kinsey, Jinjin Ha, and Elizabeth Mamros

Background

- Ford Motor Company donated the Ingersoll DSIF machine to UNH
- DSIF machine is currently being used to conduct forming research and train & educate graduate and undergraduate students
- The goal is to produce individually designed biomedical trauma hardware
- An unwanted result of the process is that internal stresses and deformation result from forming in larger frames



Zhang, Z., et al., 2015, "A Mixed Double-Sided Incremental Forming Toolpath Strategy for Improved Geometric Accuracy," J. Manuf. Sci. Eng., **137**.

Objectives

- Reduce the operation window by **75%**
- Manufacture the design solution
- Implement the final design into the forming process
- Enable biomedical trauma hardware to be produced effectively

Design Requirements

- Be able to withstand force of the machine forming tips (**8 kN** normal and **11 kN** in the plane directions)
- <u>Compact</u> & <u>compartmental</u> design with **FOS of 2 or higher**
- <u>Easily</u> implemented into process

Methods

- Decision Matrix to compare Problem Statement solutions to the design criteria

Decision Matrix - DSIF

A Decision Matrix for the Final Design of Team Solution

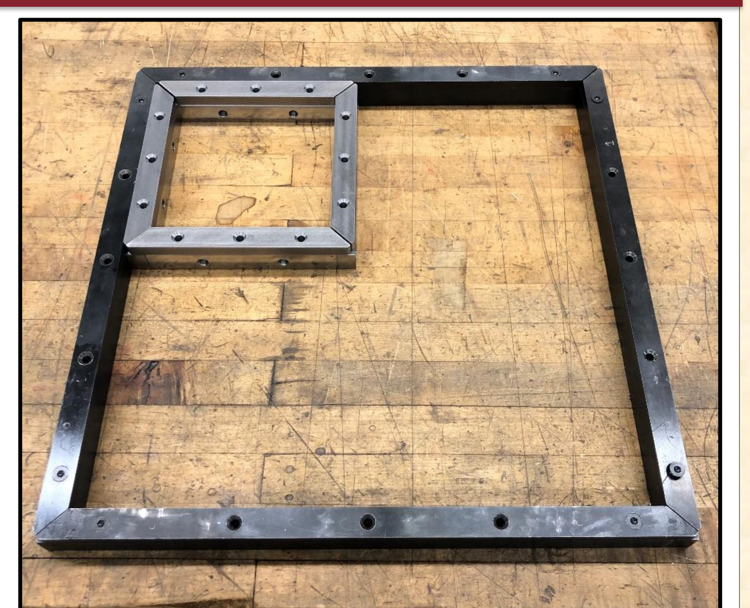
Decision model		Alternatives					
		Corner Operating Area		Adjustable Operating Area		Windowed Operating Area	
Criterion	Weight	Rating	Score	Rating	Score	Rating	Score
Have small forming area of 0.1 x 0.1 m^2	3	5	15	5	15	5	15
Withstand Forming Tip forces (8 - 11 kN)	3	3	9	4	12	4	12
FOS of 2	2	3	6	3	6	4	8
Easily attach/detach from frame	2	4	8	3	6	3	6
Lightweight under 10kg	1	2	2	2	2	2	2
Design is compact	1	2	2	2	2	2	2
Durable w/ higher than 4yr lifespan	2	3	6	2	4	3	6
Compartmental and easy to repair	1	2	2	4	4	5	5
Used of noncontaminated biomaterial	1	3	3	3	3	3	3
Function with every tip size of the machine	2	3	6	3	6	3	6
Total	18	30	59	31	60	34	65
		Design 1		Design 2		Design 3	

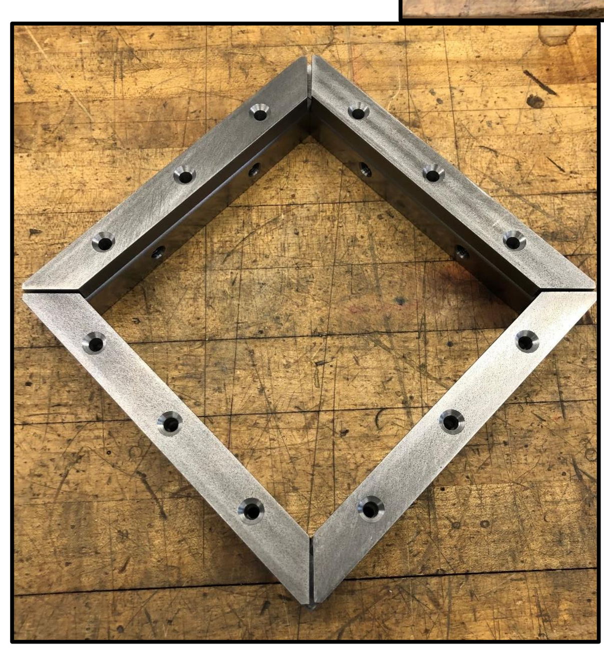
Rating	Description
1	No
2	Low fit
3	Fit
4	Good fit
5	Excellent fit

- Continually revisiting the design process allowed for development of a solution that exceeds project objectives
- The sub-frame design allows for a more compact and secure working area that is smaller than the 0.5m x 0.5m frame and can be handled with ease
- Hand calculations and simulations lead to determining new frame material and allowed for optimization of the design
- <u>Cold Rolled Steel</u> was selected as the material due to it having a high hardness and resistance against deforming which makes it optimal for use as a rigid frame

Results

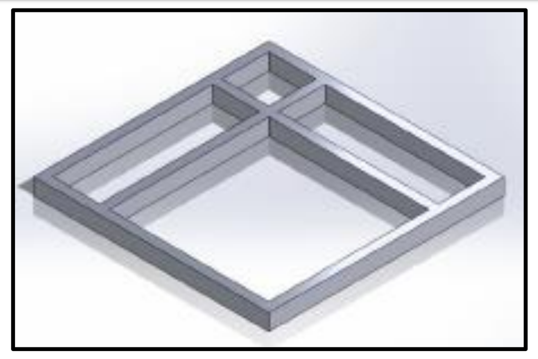
The operation window successfully reduced by **86.25%** into **2** sub-frames



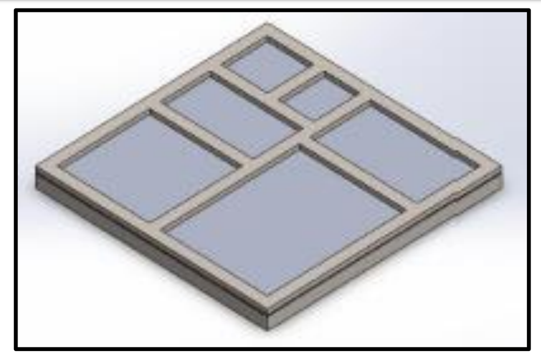


Sub-frame fits into larger 0.5m x 0.5m frame which was the previous smallest operation window

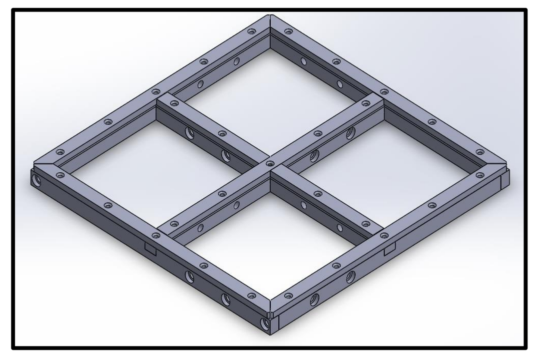
Design Process



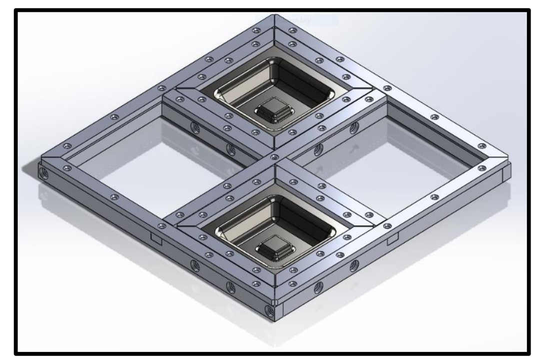
Rev 1



Rev 2

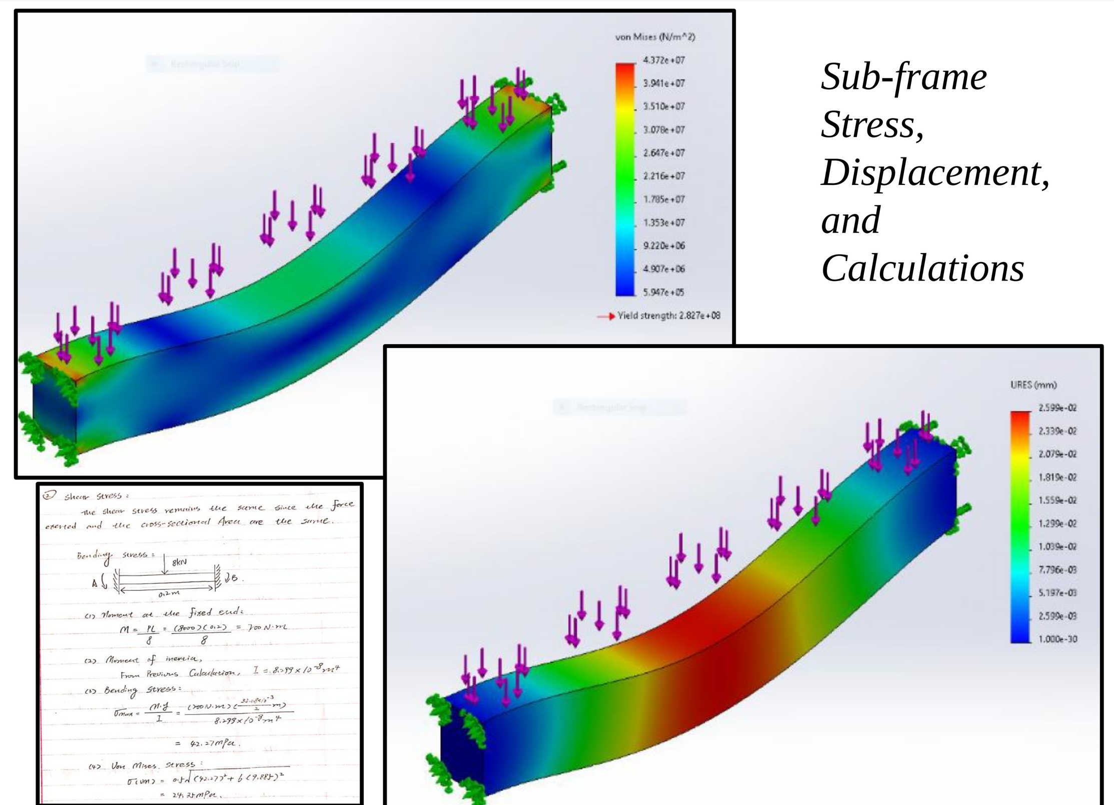


Rev 3

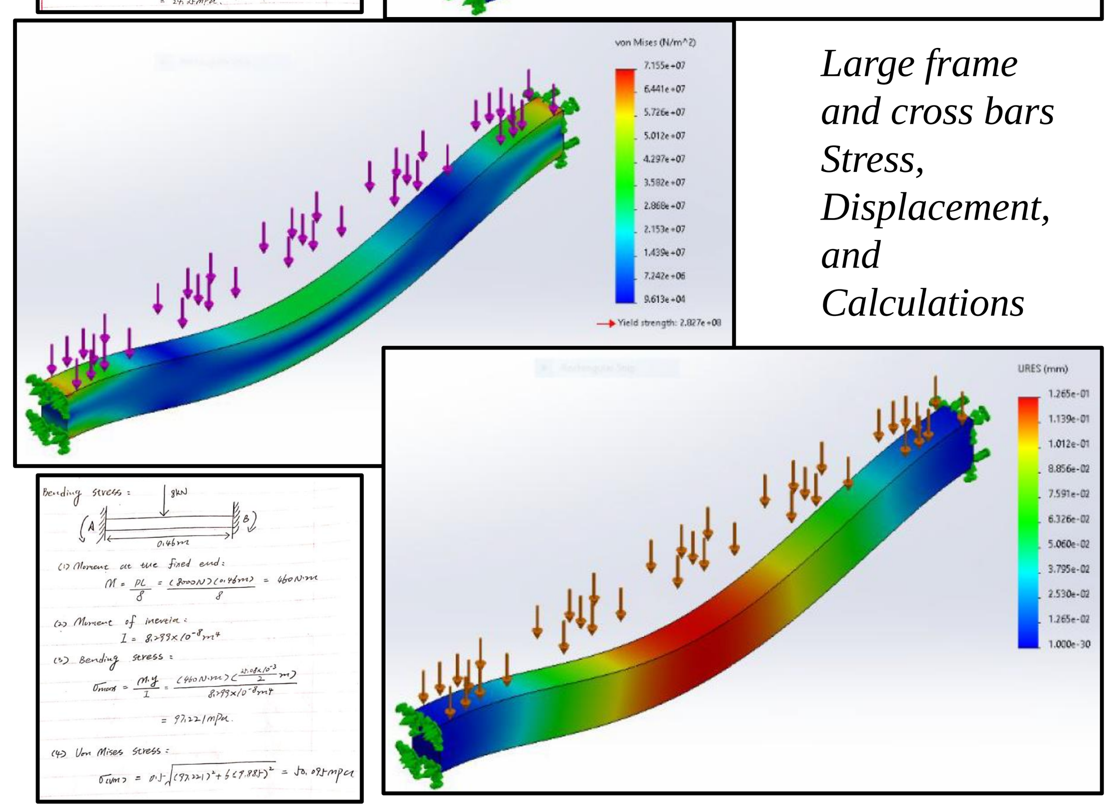


Rev 4

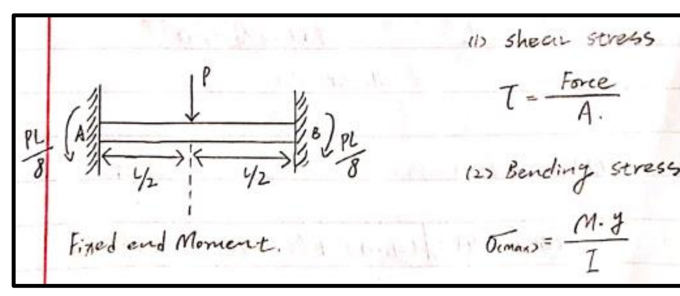
Calculations and Simulation



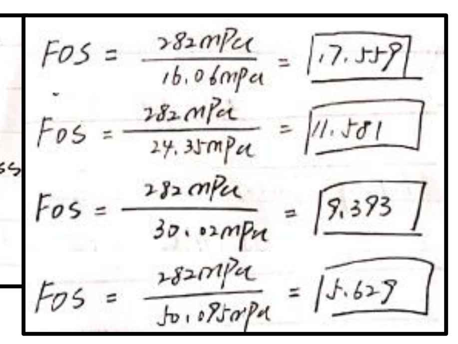
Sub-frame Stress, Displacement, and Calculations



Large frame and cross bars Stress, Displacement, and Calculations



Equations



FOS Calculations

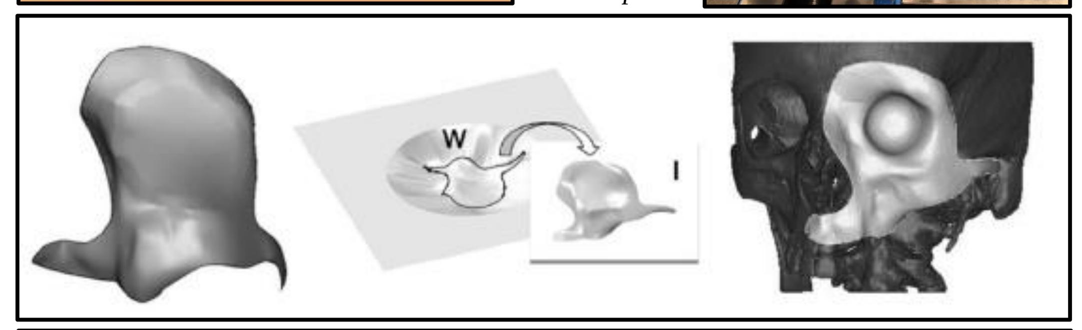
Conclusions

- The incremental forming process improves manufacturing accuracy and formability in research
- Having a smaller working area will improve part accuracy and sheet metal stability
- Sub-frame design allows for on-site heat treating and other material conditioning processes

Biomedical Hardware Example <-

Manufacturing ->

Trauma Research Example



Next Steps

- Complete the manufacturing
- Implement design solution
- Produce test parts
- Continuation of biomedical trauma research and part production