

BiOM Test Fixture

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Abstract

The current project discusses the design for a BiOM Test Fixture. A BiOM is a fully computerized ankle-foot system, which imitates a human's lower limb, propelling the user forward with each step, developed by Hugh Herr, a survivor of lower limb amputation at MIT Media Lab's Biotronic research group. As part of the project the team was required to design a test fixture to test the BiOM before human use. A test fixture is a device that is able to assess the software and physical aspects of different devices. As per analysis, a strong firm frame was required to withstand all the forces acting on the frame.

Project Goal

"To design an automated, programmable test fixture for the robotic prosthetic lower limb." A single actuator, pneumatic design was assigned for reference but the team was requested to design with either a hydraulic or electric motor.

What is a Test Fixture ?

A Test Fixture is a device that is used to run tests on any other device (Testing Electronics, Software's and Physical Devices)

Design Constraints

Table 1: Engineering Requirements

Engineering Requirements	Specifications	Testing Procedure
Size	(80x40x35 cm)	Tape Measure
Time needed for testing	15-25 minutes	Stop Watch
Types of planes for testing weight	0°, level ground testing ≤ 15Kg, 33lbs	Protractor/Angle caliper Newton Meter/Electronic scale
Material	Carbon Fiber, Titanium and Aluminum Withstand force of 200 Kg	Hardness and Beam Deflection test in lab
Hydraulic system	90 psi	Pressure Sensor
A system able to respond exactly like a particular foot	Up to 2 degrees of freedom	Visually
Cost	≥ 500\$	Receipts from purchases

Final Design

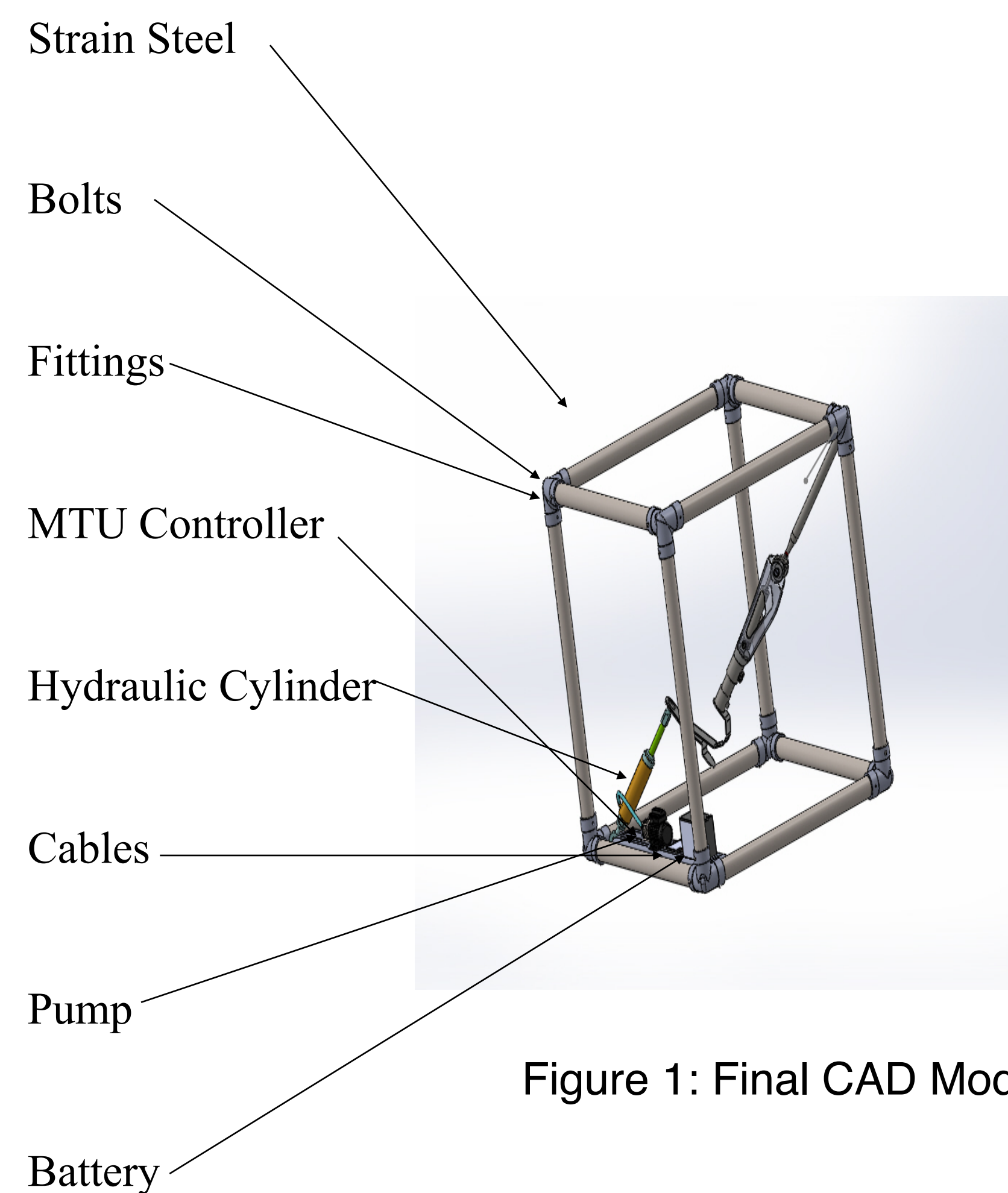


Figure 1: Final CAD Model

A cubic design was chosen in order to withstand forces from the cylinder and actuator. To help secure the frame, the connectors bolts were drilled through them. A lithium battery was chosen as a power supply.

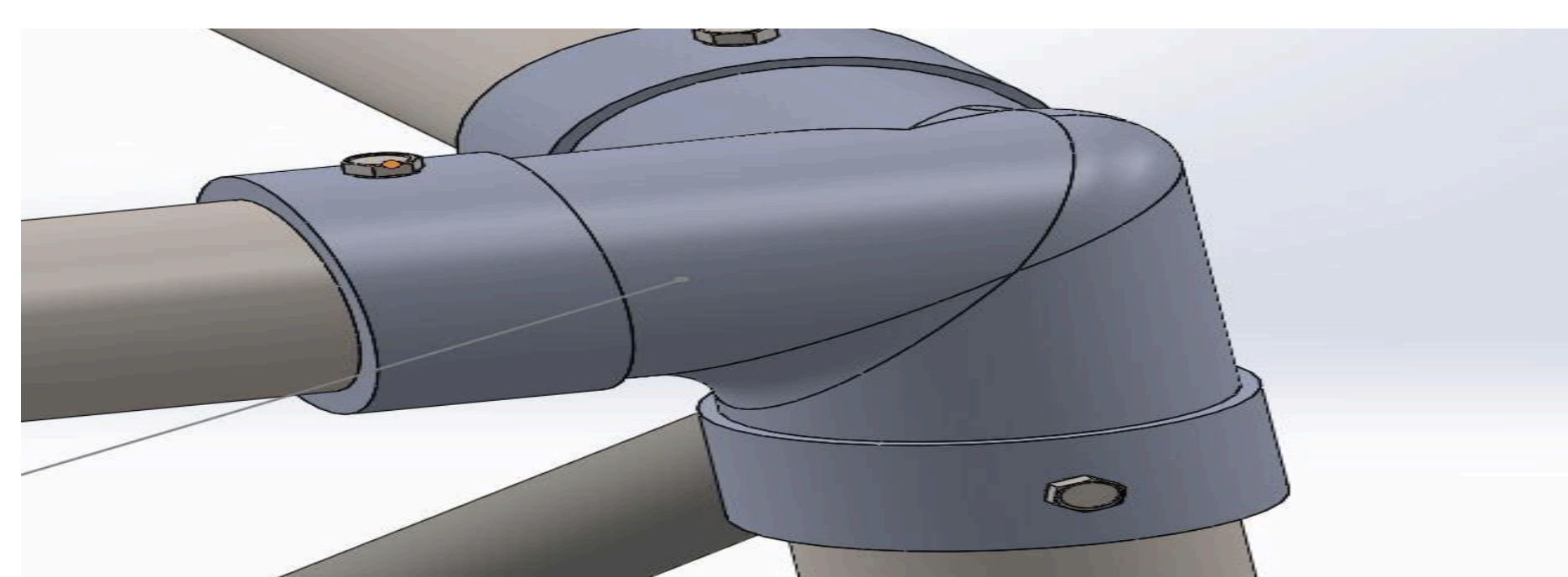


Figure 2: Fittings

Auto Pipe Analysis

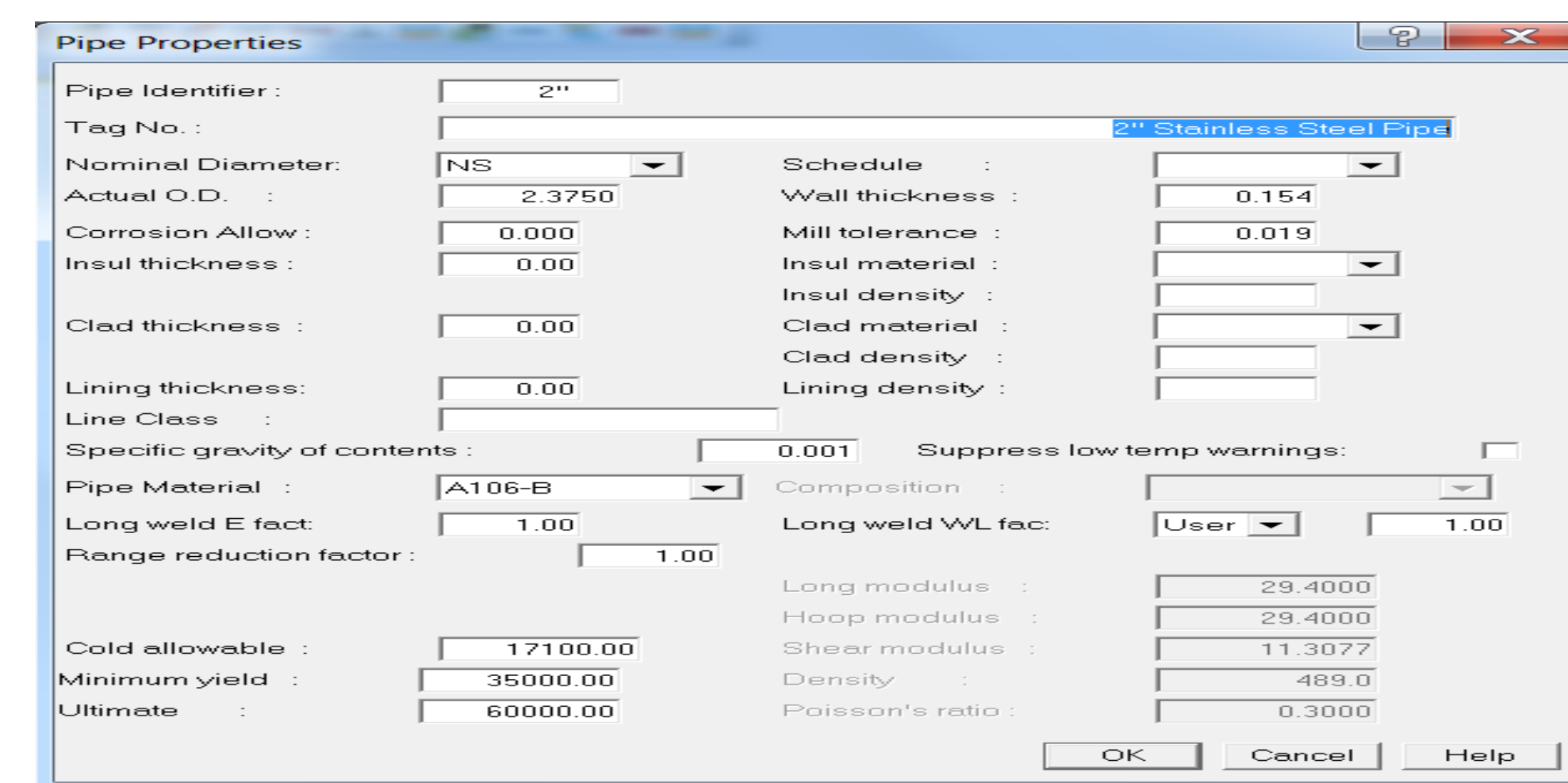


Figure 3: Material that was chose for the Frame

Displacement	Force/Moment	Anchor	Support	Code Stresses	Frequency	Mode Shape	General Stress	MZ	MR				
Seg	Point	Combination	Category	Stress	Allowable	Ratio	Pressure	Bending	Ma (Occ)	Mb (Exp)	Mc (Exp)	SF	Equation
A	A00	GR + Max P(1)	Sustain	57	17100	0.00	57	0	0	0	0	1.00	15
A	A00	TR.Amb to T(1)	Expansion	0	25650	0.00	0	0	0	0	0	1.00	17
A	A00	Amb to T(1)	Expansion	0	25650	0.00	0	0	0	0	0	1.00	17
A	A00	Max P(1)	Hoop	123	17100	0.01	0	0	0	0	0	0.00	3
A	A01	GR + Max P(1)	Sustain	9078	17100	0.53	57	9021	421	0	0	1.00	15
A	A01	TR.Amb to T(1)	Expansion	0	25650	0.00	0	0	0	0	0	1.00	17
A	A01	Amb to T(1)	Expansion	0	25650	0.00	0	0	0	0	0	1.00	17
A	A01	Max P(1)	Hoop	123	17100	0.01	0	0	0	0	0	0.00	3
A	A02	GR + Max P(1)	Sustain	4235	17100	0.25	57	4198	196	0	0	1.00	15
A	A02	TR.Amb to T(1)	Expansion	4235	25650	0.17	0	4235	0	0	198	1.00	17
A	A02	Amb to T(1)	Expansion	4235	25650	0.17	0	4235	0	0	198	1.00	17
A	A02	Max P(1)	Hoop	123	17100	0.01	0	0	0	0	0	0.00	3
A	A03	GR + Max P(1)	Sustain	3993	17100	0.23	57	3936	184	0	0	1.00	15
A	A03	TR.Amb to T(1)	Expansion	12704	25650	0.50	0	12704	0	0	594	1.00	17
A	A03	Amb to T(1)	Expansion	12704	25650	0.50	0	12704	0	0	594	1.00	17

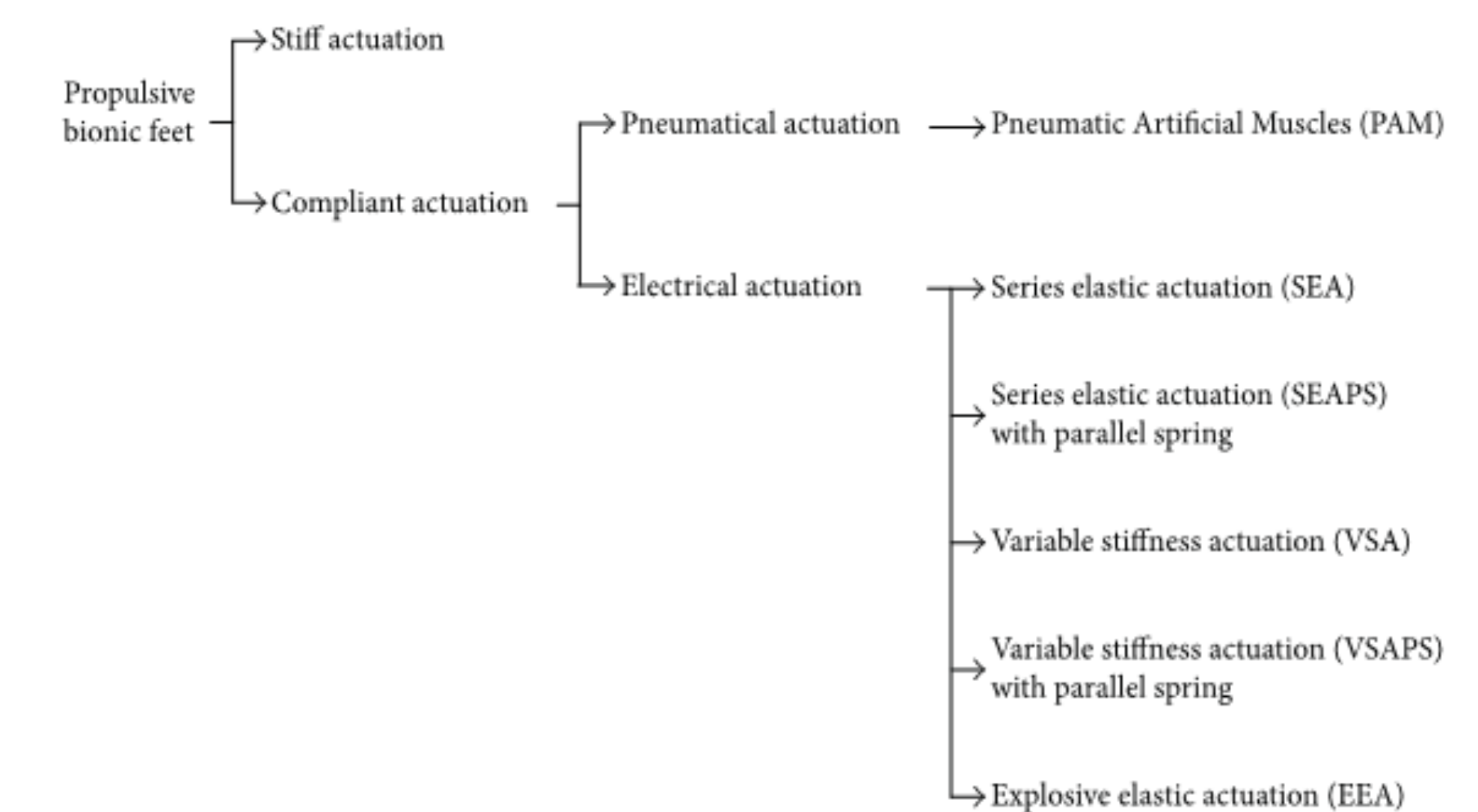
Figure 4: The table shows the stresses for the 2" schedule 40 stainless steel pipe used for the BiOM

Displacement	Force/Moment	Anchor	Support	Code Stresses	Frequency	Mode Shape	General Stress	MZ	MR		
Seg	Point	Combination	Category	FX	FY	FZ	FR	MX	MY	MZ	MR
A	A00	Gravity(1)		203	-203	0	207	0	0	0	0
A	A00	Thermal (1)		0	-43	0	0	0	0	0	0
A	A00	GRT(1)		203	-203	0	207	0	0	0	0
A	A01	Gravity(1)		0	-269	0	337	0	0	421	421
A	A01	Thermal (1)		0	-43	0	0	0	0	-43	0
A	A01	GRT(1)		203	-269	0	337	0	0	421	421
A	A01	Gravity(1)		292	-190	0	343	0	0	421	421
A	A01	Thermal (1)		-47	-47	0	66	0	0	-47	0
A	A01	GRT(1)		245	-227	0	334	0	0	421	421
A	A01	Gravity(1)		292	-191	0	349	0	0	196	196
A	A02	Thermal (1)		-47	-47	0	66	0	0	198	198
A	A02	GRT(1)		245	-238	0	342	0	0	394	394
A	A02	Gravity(1)		292	-191	0	349	0	0	196	196
A	A02	Thermal (1)		-47	-47	0	66	0	0	198	198
A	A02	GRT(1)		245	-238	0	342	0	0	394	394
A	A02	Gravity(1)		292	-191	0	342	0	0	184	184
A	A03	Thermal (1)		-47	-47	0	66	0	0	594	594
A	A03	GRT(1)		245	-260	0	357	0	0	410	410

Figure 5: The table shows the forces/ moments for the 2" schedule 40 stainless steel pipe used for the BiOM

Design Research

Based on the actuation principle, a primary distinction can be made between ankle foot prosthesis powered with stiff or compliant actuation. The compliant actuators can be divided as either pneumatic or electrical. Depending on the stiffness, the electrical actuation can be further subdivided into four categories – series elastic (SEA), series elastic with parallel spring (SEAPS), variable stiffness (VSAPS) and explosive type (EEA).



Analysis

The displacement of the flexible Steel is determined by utilizing the mathematical formulae below:

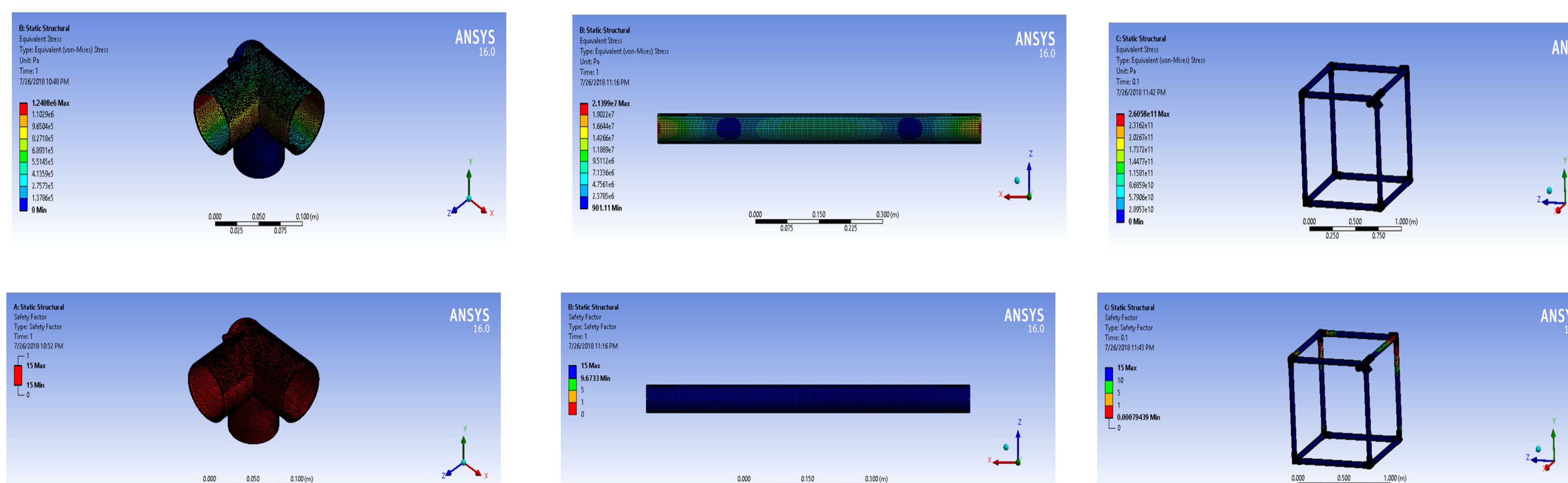
$$\Delta x = \frac{F \cdot l^3}{3 \cdot E \cdot I}$$

If the electric motor is estimated to operate for 20 minutes, the power required to move the hydraulic fluid from the pump to the pneumatic actuator can be calculated with the following:

$$power = \frac{work}{time \text{ in seconds}}$$

$$work = pressure \text{ force} \times \text{hydraulic displacement}$$

FEA Ansys



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