IMPROVING THE COMFORT AND MANUFACTURING PROCESS OF A TRANSTIBIAL PROSTHETIC SOCKET

INTRODUCTION

The requirement for prosthesis, orthosis and rehabilitation is likely to increase from the current estimated 0.5% of the global population to 1% [1]. No set manufacturing method is used within prosthesis manufacture and the process is heavily reliant upon the experience of the prosthetist and the solution which best suits an individual's residual limb [2]. Discomfort occurs when a socket is not well-fitted due to human error in manufacturing or natural fluctuation in the dimensions of the stump [3].

It was found that manufacturing through Multi-Material Additive Manufacturing (MMAM) could bring the benefits of easier manufacturing whilst implementing a more flexible material in areas which cannot withstand significant pressure, such as the Patella Tendon [4]. 2 materials with different material properties were used.

OBJECTIVES

1) Improve the comfort of a transtibial prosthetic socket
2) Improve the manufacturing process of a transtibial socket
3) Create a prototype of a MMAM socket

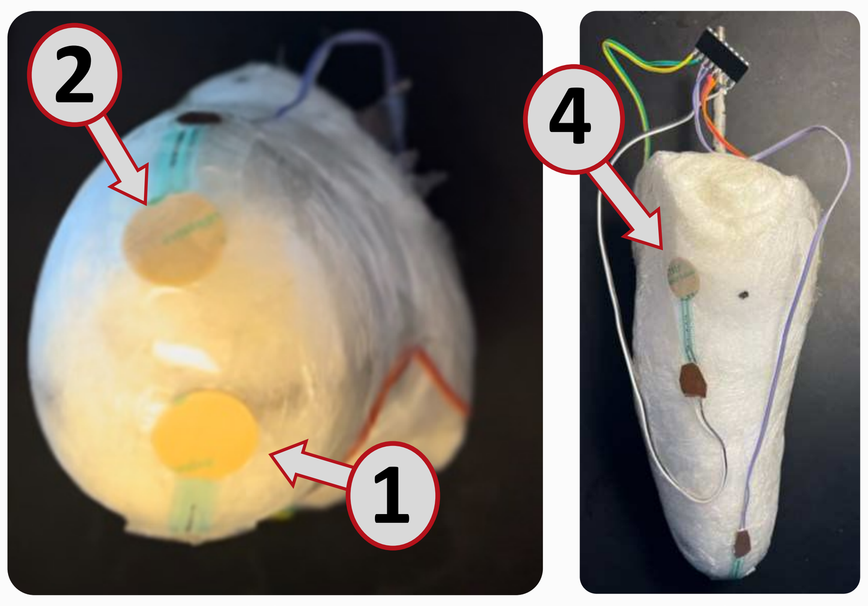

Fig 7: *Stump with **labelled sensors 2,3 and 4.***
(a) Bottom View, (b) Front View

Fig 8: *Load Testing*

Fig 1: *Final Prototype Build*

RESULTS

A 200N load was placed on the prototype and NHS Carbon Fibre socket. The Resulting force sensor readings and force applied are displayed in ***Fig 9*** and ***Fig 10.*** The peak sensor values are compared in ***Table 1.*** Sensor 3 failed and removed from the results.

Sensor	Peak Sensor Value		% Decrease in Peak Pressure
	NHS	Prototype	
1	3.60	2.50	30.56
2	3.67	2.27	38.15
4	1.64	0	100.0

Table 1: *Peak Sensor Value*

There is a large decrease in pressures in sensors 1 and 2 for equivalent loads. There was no reading within sensor 4 for the prototype indicating no pressure in that specific area for the MMAM socket.

METHODOLOGY

1) MATERIAL CHOICE:

Research and decision matrices were conducted to designate the material to the position on the socket. The desired materials were:

RIGID - Vero [5] (Due to cost PLA was used)
FLEXIBLE - Tango [6]

2) PROCESS:

A single additive manufacturing process was determined to be most optimal from the decision matrix of possible processes. This allows for improvement in manufacturing times. To do this, MMAM was used.

3) SOCKET CREATION:

A 3D scan of a random, unidentifiable stump ***(Fig 2)*** was manipulated using Autodesk Meshmixer to create a 5mm wall ***(Fig 3)***. This was processed through Solidworks to create the areas where Tango is positioned ***(Fig 4)***. The Solid (PLA) body was printed on a Ultimaker 2. A lattice is created within the Tango ***(Fig 5)*** and assembled with solid body ***(Fig 6)***. Postprocessing of the parts includes removal of support structure and adhesion of rigid and flexible parts. The resulting socket is shown in ***Fig 1***

4) TESTING:

A foam stump was moulded and fitted with force sensors ***(Fig 7)***, enabling the loading testing of the socket ***(Fig 8).***

Fig 2: *Scan of Stump*

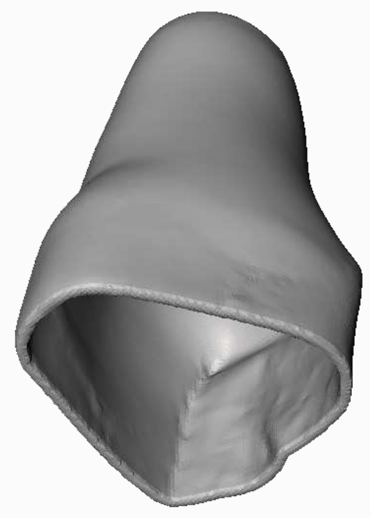

Fig 3: *5mm extrusion*

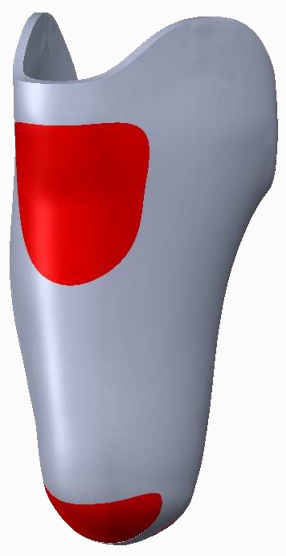

Fig 4: *Finished Design*

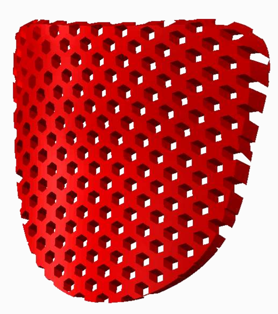

Fig 5: *Tango Lattice*

Fig 6: *Finished Design*

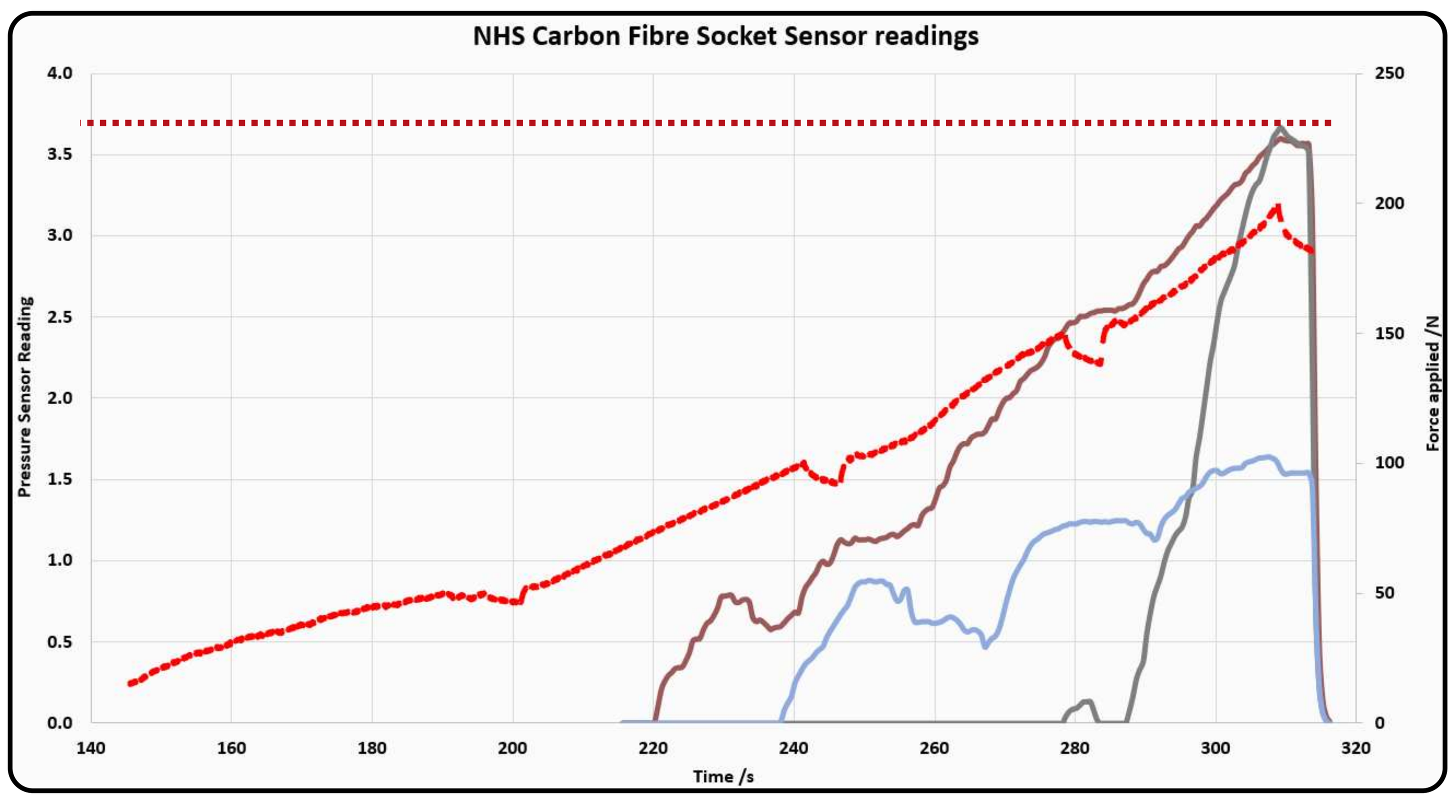

Fig 9: *NHS Carbon Fibre Socket - Pressure Sensor Readings with force applied*

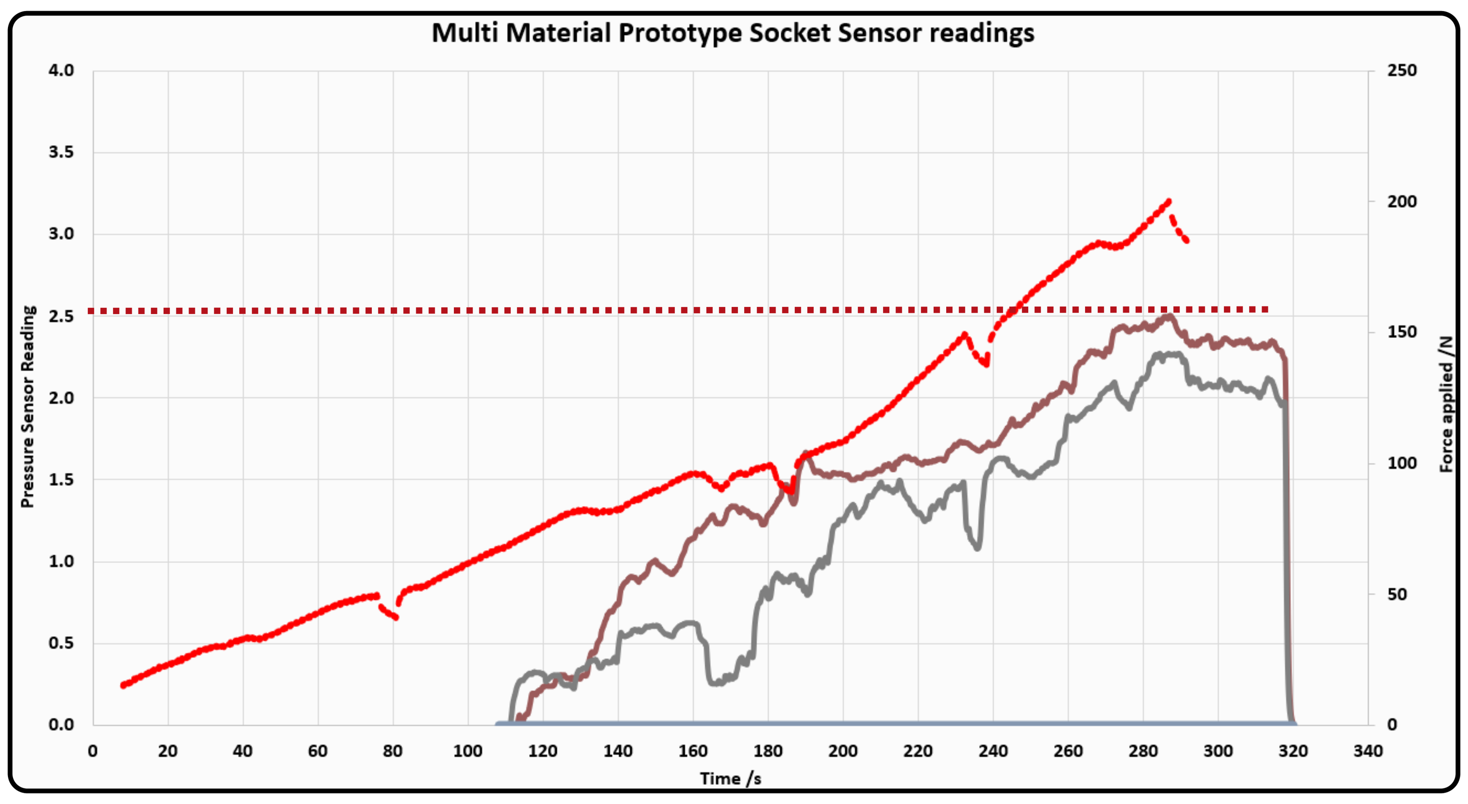

Fig 10: *MMAM Prototype Socket - Pressure Sensor Readings with force applied*

SENSOR 1 | SENSOR 2 | SENSOR 4 | FORCE APPLIED

CONCLUSION

The prototype produced lower pressure readings in each area tested which are not load tolerable; indicating more comfort within the socket. This was one of the objectives hit. However, the workflow of creating the socket is complex and costly. Expert training is required for the prosthetist to manipulate scan data. With MMAM still in its infancy, it is hopeful with time the cost of equipment, material, and time to produce parts will decrease. Additional work is required to validate the results of this project further. This can be achieved by implementing an array of accurate sensors within the stump used to load the socket; collecting significantly more data.

REFERENCES:

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Student: Nathan Welch (2022)
Course: Mechanical Engineering 3rd Year
Email: n.welch1@lancaster.ac.uk
Supervisor : Jenny Roberts

Engineering | Lancaster University