



Department of Biomedical Engineering

COLLEGE OF ENGINEERING

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Advanced Amputee Donning Device

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Client: Mr. Daniel Kutschera P.T.

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Problem Statement

Client

Mr. Daniel Kutschera, P.T.

Motivation

- 2.3 million Americans impacted by limb loss [1]
- 300-500 new patients every day [2]

Goal

Sleek, portable, and easy-to-use design that simplifies applying a shrinker



Figure 1: Prosthetic Shrinker Donning Tube [3]



Background

- 55% of limb loss is due to diabetes or vascular disease [4]
 - 45% for traumatic injury
- A shrinker helps prepare the residual limb for a prosthesis
- Takes 3-12 months to receive a final prosthesis [5]
- Older patients & patients with arthritis struggle with shrinker application



Figure 2: Below-Knee Amputation with Shrinker Garment [6]



PDS - Client Requirements

- Simplify application of shrinker
 - Minimum manual effort
- Lightweight, ~10lbs
- Portable
- About \$500
 - Flexible price range



Figure 3: Amputation Shrinker Garment [7]



PDS - Characteristics

- Duration
 - Withstand 3-12 month recovery period [5]
 - 12 year shelf life of AA batteries [8]
- Dimensions
 - Average male thigh circumference 53.8 cm
 - Average male thigh diameter 17.1 cm
 - Existing : 20.3 cm diameter and 30.5 cm height [9]
- Materials
 - Withstand compressive forces of 30 N - 40 N [10]
 - Nontoxic
- Safety and Standards
 - IEC 60601-1-11 [11]
 - ISO 10993-1 [12]

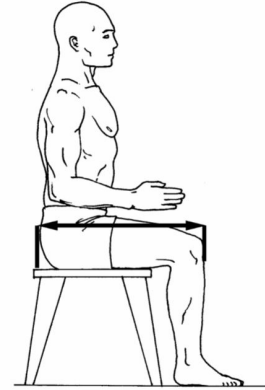


Figure 4: Anthropometric Measurements of Male [9]

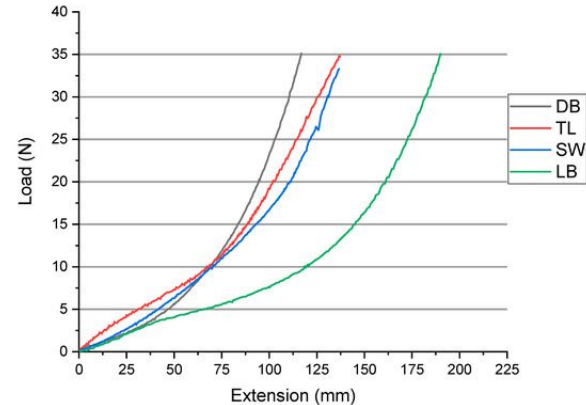


Figure 5: Load vs. Extension Curve for Shrinker Garment [10]

Competing Designs

- Shrinker Donning Tube
 - Acrylic cylinder [13]
 - Variety of diameters
 - Requires high levels of manual effort
 - Difficult for patients to use



Figure 6: Using A Shrinker Donner [14]



Figure 7: 8" and 6" Donning Tubes [15]



Competing Designs

- Liner Donning and Doffing Device- US20080004717A1
- Vacuum between the device and prosthetic liner
- Little or no frictional movement between the liner and the skin
- Airtight end cap
- Valve member to create vacuum [16]

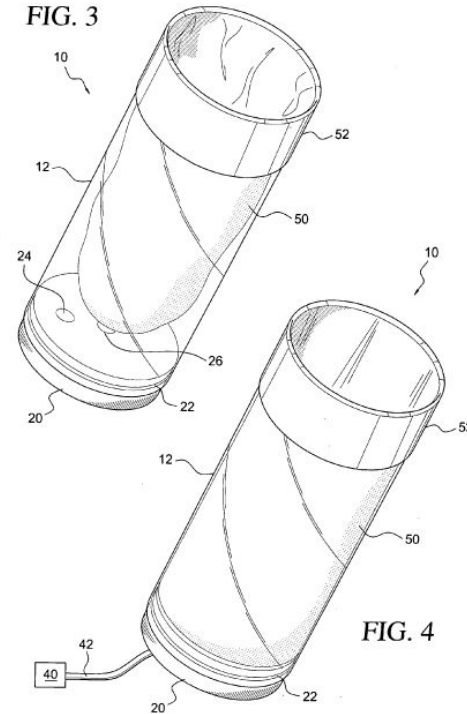


Figure 8: Liner Donning and Doffing Device- US20080004717A1 [16]

Design Ideas: Materials

Eleanor



Figure 9: Nylon [17]



Figure 10: Acrylic [18]



Figure 11: PVC [19]



Criteria (Weight)	Option #1 Nylon		Option #2 Acrylic		Option #3 Polyvinyl Chloride (PVC)	
	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Biocompatibility (25)	5/5	25	5/5	25	5/5	25
Weight (25)	4.6/5	23	4.6/5	23	4/5	20
Ease of Fabrication (15)	4/5	12	1.67/5	5	4.67/5	14
Durability (15)	4.33/5	13	4.33/5	13	3.33/5	10
Cost (10)	4/5	8	3/5	6	5/5	10
Aesthetics (10)	4/5	8	4.5/5	9	3.5/5	7
Total (100)	89		81		86	



Material Selected:

- Low cost, \$1.80 - \$2.30 / kilogram
- 1.15 g/cm^3
- Can withstand up to 12,500 psi in compression
- Tough material requires high speed steel tools [20]



Figure 12: Nylon Plastic Tubes [17]

Design Ideas:

Eleanor

Figure 13: Finger Trap

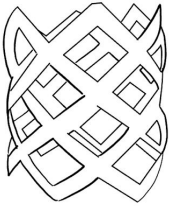


Figure 14: Expanding Pulley Mechanism

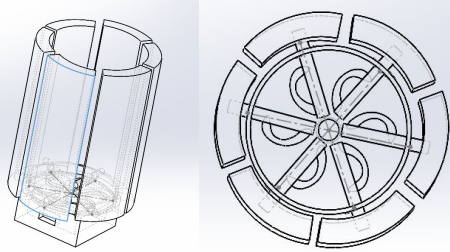
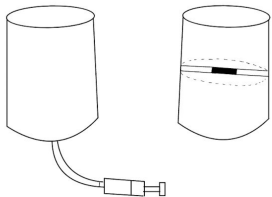


Figure 15: Piston



Criteria (Weight)	Design #1 Finger Trap		Design #2 Expanding Pulley Mechanism		Design #3 Piston	
	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Ease of Use (25)	3.6/5	18	4.8/5	24	4/5	20
Mechanical Function (20)	3.75/5	14	4.5/5	18	4/5	16
Safety (20)	4/5	16	4.25/5	17	4.5/5	18
Ease of Fabrication (10)	4.5/5	9	3/5	6	3.5/5	7
Size (10)	3/5	6	4/5	8	4/5	8
Cost (10)	4.5/5	9	3.5/5	7	4/5	8
Aesthetics (5)	4.5/5	4.5	5/5	5	5/5	5
Total (100)	76.5		85		82	



Final Design

- Low user input force compared to alternative designs
- Electronic expansion mechanism
- Activated by a switch
- Operates on replaceable batteries
- Lightweight and portable

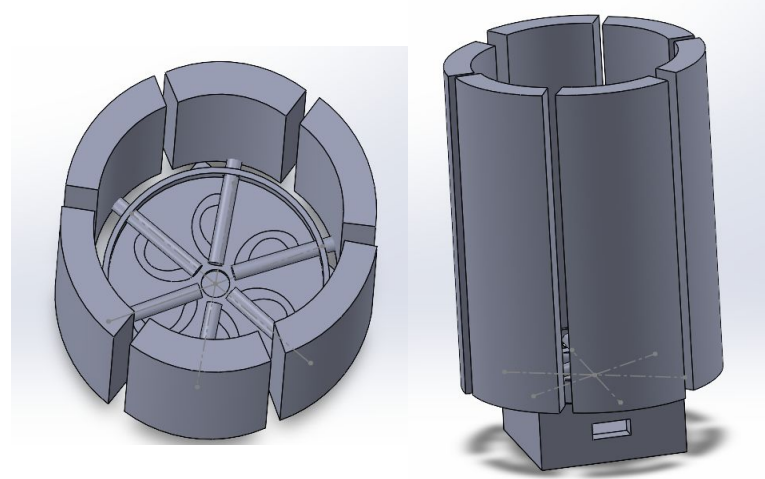


Figure 16: Final Design CAD



Figure 17: DPDT Switch [21]



Testing Plans:

Mechanical Testing:

- MTS testing
 - Compressive strength of machined material
 - Force required to stretch the shrinker



Figure 18: MTS testing Machine [22]



Figure 19: Shrinker application [14]

Functionality Testing:

- Performance expanding to desired diameters
- Ability to hold the shrinker

Future Work

- Order materials
- Build circuit and 3D printed holder
- Machine nylon cylinder
- Fabricate expanding mechanism

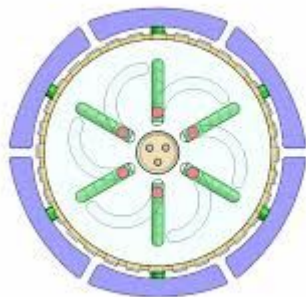


Figure 21: Expanding Mechanism [23]

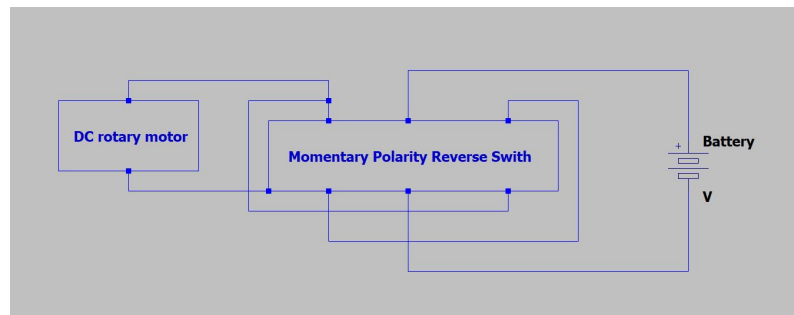


Figure 20: Circuit Schematic

Potential Pitfalls

- Difficulty securing shrinker
- Deformation of nylon pieces with expansion



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Client: Mr. Daniel Kutschera

Advisors: Dr. John Puccinelli & Isabelle Peters

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Questions?