Industrial Engineering

Design of an Ergonomic Knife for People with Disabilities

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Sponsors: University of Puerto Rico, Mayaguez Campus and National Science Foundation contract CBET-1403753

1 Introduction

The 2010 U.S. Census Bureau (2010 Census Data, 2012) statistics revealed the U.S. had an average of 11.9% of people with disabilities. The same statistics show Puerto Rico with a 19.7% of people with disabilities. These numbers position the island as the U.S. territory with the highest percentage of individuals with disabilities. Adults with disabilities have numerous special needs and are a community with low visibility and in occasions unattended. ***Making the Difference: Design of an Ergonomic Knife for People with Disabilities*** is part of a project consortium founded by the National Science Foundation (NSF) that seeks to benefit adults with disabilities.

The main purpose of this project is to design a specialized kitchen knife grip for people with physical disabilities to allow performance of kitchen tasks taking into consideration cost and accessibility.

2 Problem Statement

People with disabilities are frequently prevented from doing simple tasks due to their force and/or posture constraints, therefore, limiting their independence. For this research work the experimental subject had force and motor skills limitations in her hand, due to cerebral palsy, limiting her ability to cook or manipulate most kitchen tools. It was her desire to have a knife she could easily and safely handle. Currently, most of the kitchen tools in the market are designed for people without physical disabilities.

3 Objectives

The objective of this research work was the design, construction and validation of an ergonomic kitchen knife to allow a cerebral palsy patient perform simple cooking tasks, therefore improving the subject's independence and quality of life.

The force, temperature, grip, movement, and cost of the product were the main targets to address during the creation of this artifact. Also, the client's mobility and conditions were challenges influencing the design of the prototypes.

4 Methodology

The methodology used to achieve project objectives is depicted in Figure 1. The project was divided into three different phases: Product Design, Prototype Construction, and Product Validation. In the Product Design phase, the participant's force, grip, and motor limitations in her hands were taken into consideration. Pahl and Beitz Methodology, combined with an Ergonomic Evaluation, Anthropometric measures, and a Morphological analysis were used during the first phase which ended with three different ideas from which one final design was chosen. After the construction of the prototype an ergonomic and mechanical analysis was done in order to ensure the safety. Validation was performed with the experimental subject.

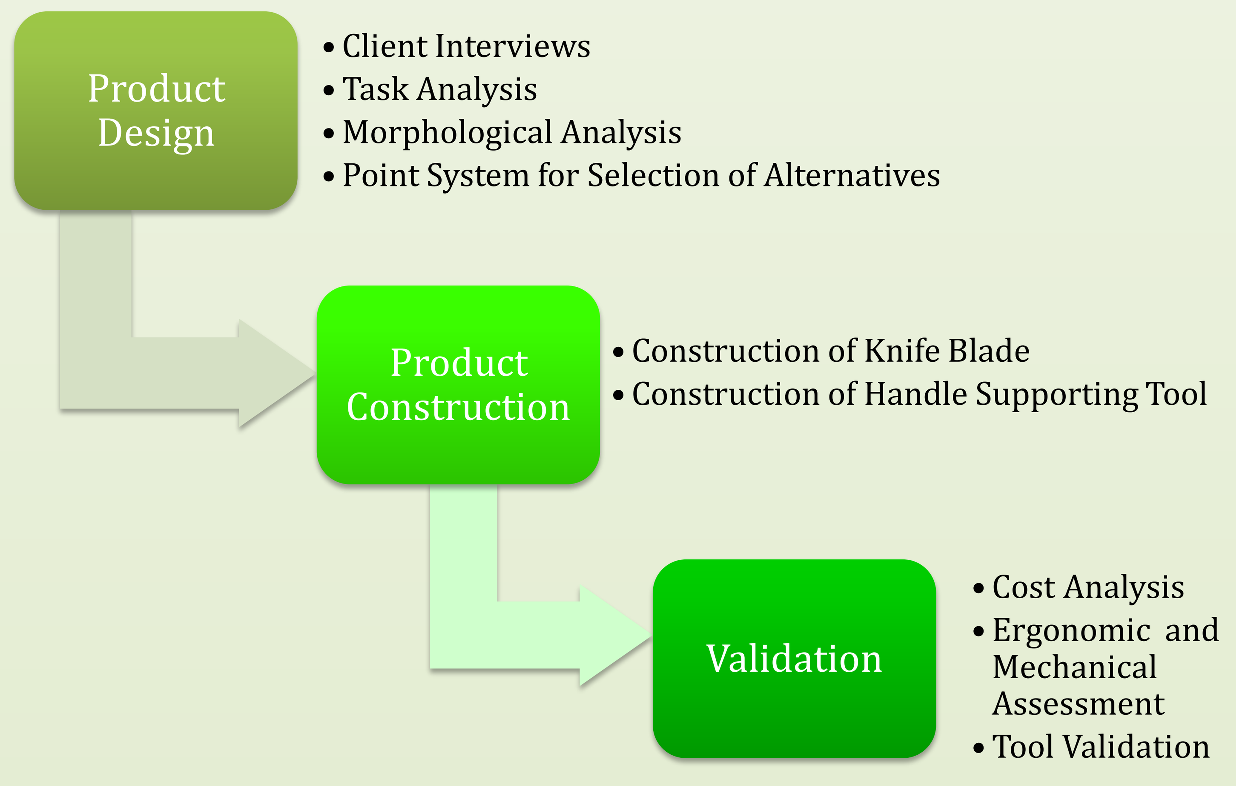

Figure 1: Methodology Flowchart

5 Results

Results from the morphological and point system analysis are presented in Figure 2. These pointed to an spherical grip with stronger hand position in pronation, location of the handle on the side, with cutting movements front and backwards. The blade type chosen is for meat and fish. Results from mechanical and electrical tests, and compliance with ISO are presented in Table 1. Blue print of components are presented in Figure 3 and the built prototype is presented in Figure 4.

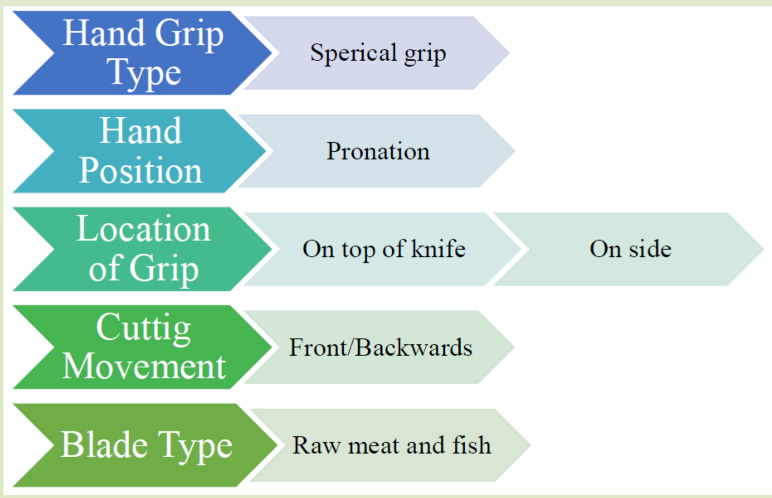

Figure 2. Results from the morphological and point system analysis

Table 1. Results from mechanical and electrical test and ISO compliance

Physical Properties	Metric	English	Comments
Density	0.930 g/cc	0.0336 lb/in³	ISO 1183
Water Absorption	<= 0.010 %	<= 0.010 %	ISO 62
Viscosity Test	3850 cm³/g	3850 cm³/g	ISO 307, 1157, 1628
Mechanical Properties	**Metric**	**English**	**Comments**
Tensile Strength, Yield	17.0 MPa	2470 psi	ISO 527-2/1A
Elongation at Break	>= 50 %	>= 50 %	ISO 527-2/1A
Elongation at Yield	<= 20 %	<= 20 %	ISO 527-2/1A
Tensile Modulus	0.680 GPa	98.6 ksi	ISO 527-2/1A
Tensile Creep Modulus, 1 hour	430 MPa	62400 psi	ISO 899-1
Tensile Creep Modulus, 1000 hours	220 MPa	31900 psi	ISO 899-1
Electrical Properties	**Metric**	**English**	**Comments**
Volume Resistivity	>= 1.00e+12 ohm-cm	>= 1.00e+12 ohm-cm	IEC 60093
Surface Resistance	>= 1.00e+12 ohm	>= 1.00e+12 ohm	IEC 60093
Dielectric Constant	2.1 @Frequency 100 Hz	2.1 @Frequency 100 Hz	IEC 60250
	3 @Frequency 1e+6 Hz	3 @Frequency 1e+6 Hz	IEC 60250
Dielectric Strength	45.0 kV/mm	1140 kV/in	IEC 60243-1
Dissipation Factor	0.00029 @Frequency 100 Hz	0.00029 @Frequency 100 Hz	IEC 60250
	0.001 @Frequency 1e+6 Hz	0.001 @Frequency 1e+6 Hz	IEC 60250
Comparative Tracking Index	600 V	600 V	IEC 60112
Thermal Properties	**Metric**	**English**	**Comments**
CTE, linear	200 µm/m-°C @Temperature 20.0 °C	111 µin/in-°F @Temperature 68.0 °F	ISO 11359-2
Deflection Temperature at 0.46 MPa (66 psi)	65.0 °C	149 °F	ISO 75-1/-2
Deflection Temperature at 1.8 MPa (264 psi)	42.0 °C	108 °F	ISO 75-1/-2
Vicat Softening Point	80.0 °C	176 °F	ISO 306
Flammability, UL94	HB	HB	

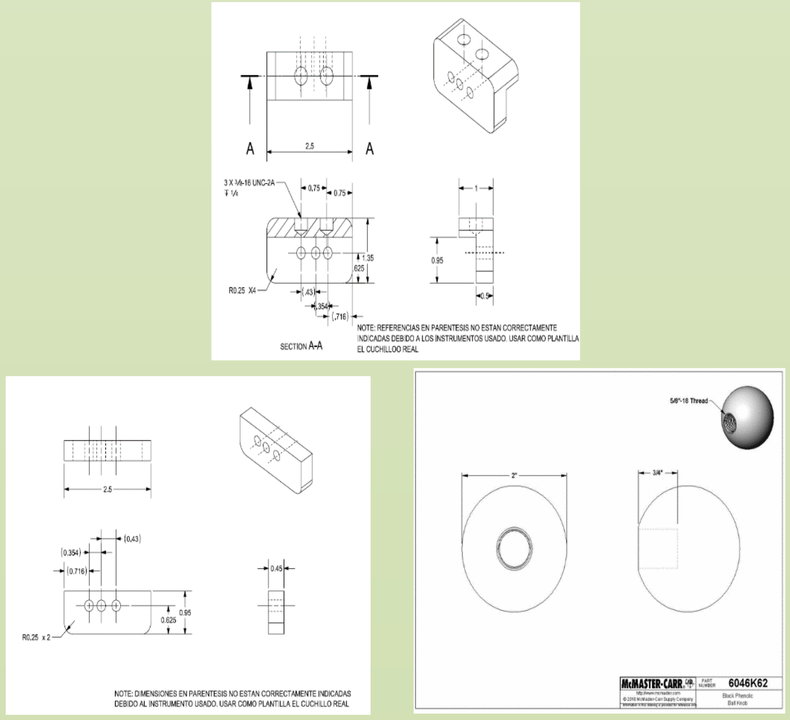

Figure 3. Components' Blue Prints

Figure 4. Built Prototype

6 Conclusion

It was possible to design and manufacture a knife for people with disabilities at a cost of $301.43 with a reproduction cost of $54.18. The product complies with 100% of product requirements and is suitable for persons with motor deficiencies. The unit was validated with the experimental subject resulting in great user satisfaction.

7 Acknowledgments

We would like to extend our gratitude to Dra. Mayra Mendez, Dra. Cristina Pomales, Dr. Pedro Quintero, Emmanuel Irizarry, María de Lourdes, Dra. María Irizarry for their collaboration in the execution of this project. We could not have done it without their help.