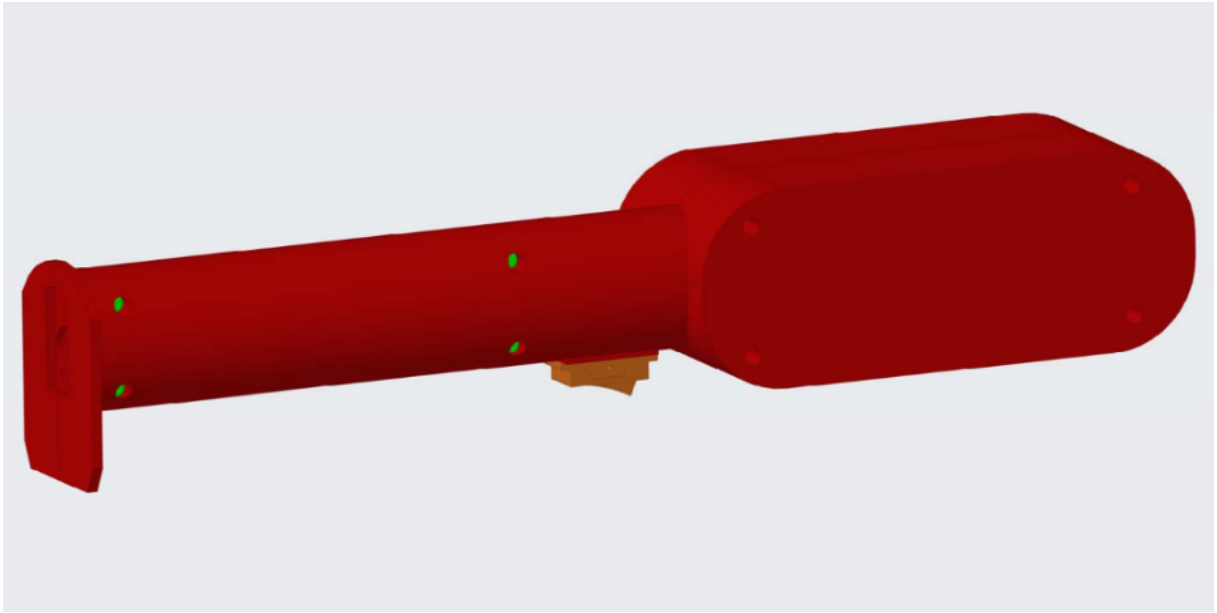
ME 170 Project Final Report: Power Belt Wrench

John Crispo, Songyuan Cui, Andrew Colin, Jessica Nicholson



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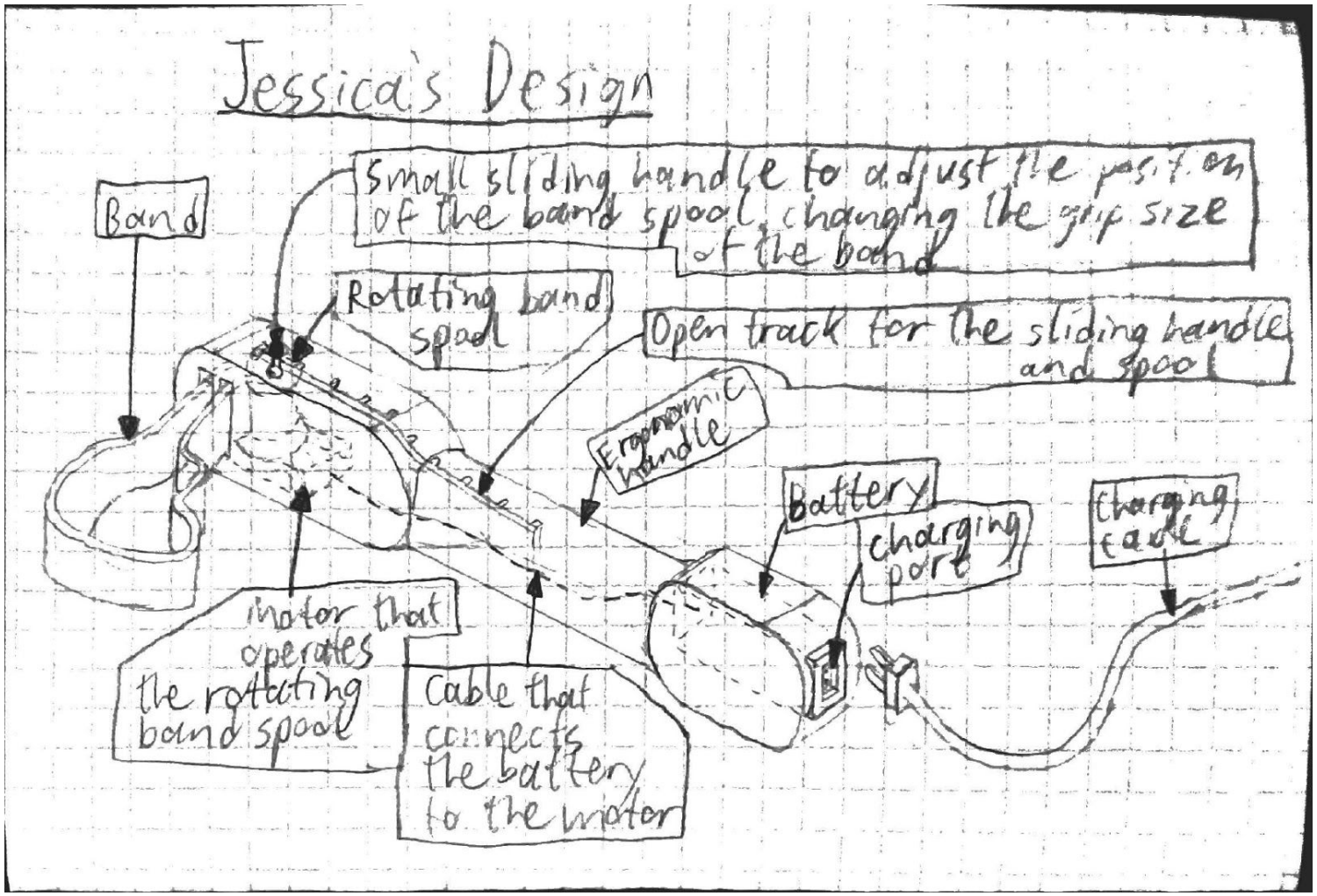
Product Description

Our product is a compact, handheld, and electrically-powered automatic wrench that tightens and loosens screws and bolts. It secures around a screw or bolt and a switch must be activated to loosen the screw or bolt. Little to no effort is required to operate this tool because it is electrical and automatic, unlike a manual wrench. This allows for added convenience, speed, and productivity among tool-users who purchase this product.

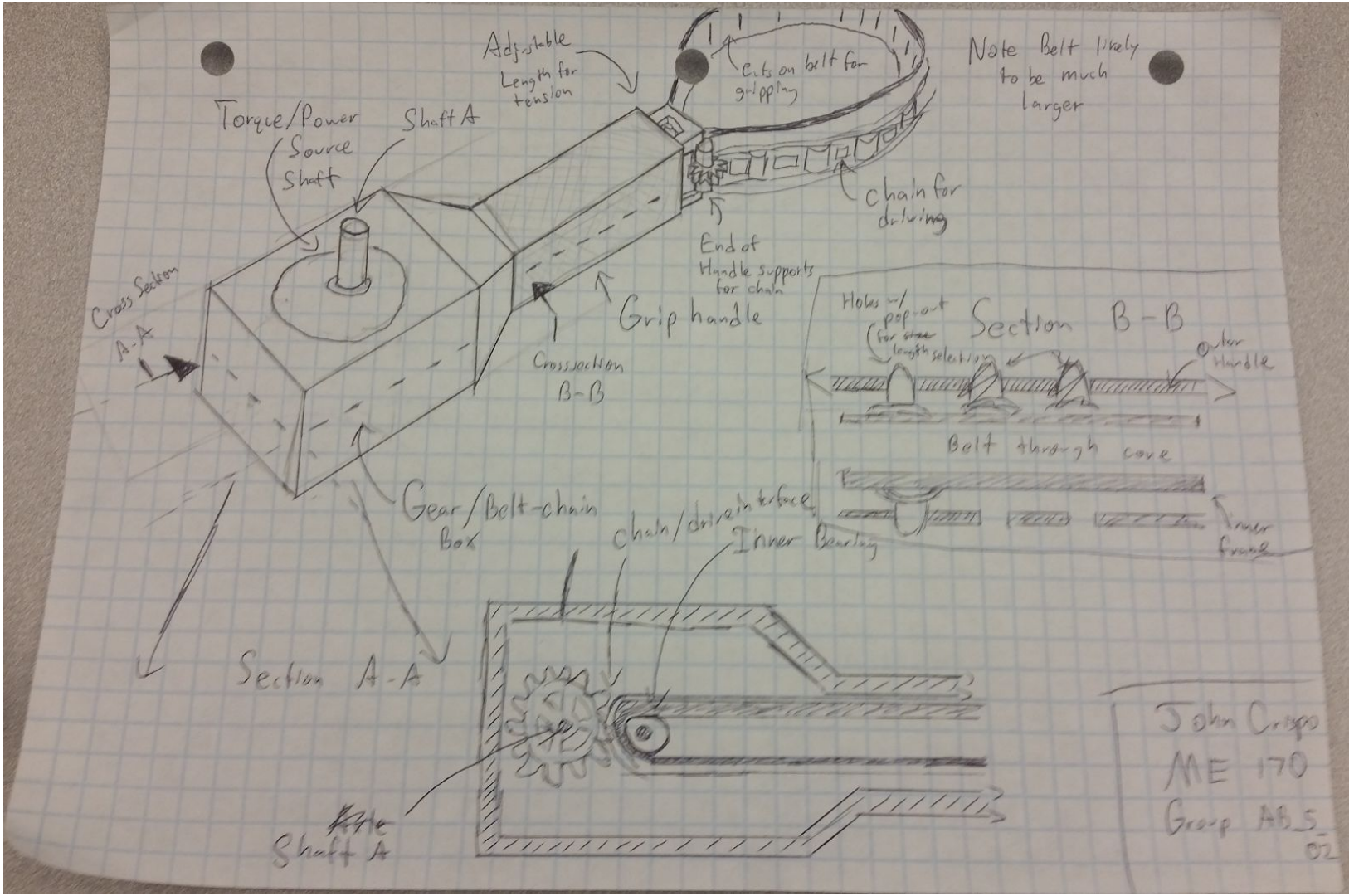
This design consists of a plastic injection-molded shell that incorporates an ergonomically-focused handle with a battery in the back and a standard charging port. The charging port connects to a standard charging dock, and the tool lasts for a few hours before it needs to be charged again. The battery within the tool connects to a motor at the front of the tool. The motor is positioned directly behind a spinning spool and locked in place relative to the spool, while a gear is connected to the bottom of each component to connect the two. The motor rotates the spool which moves a band that is mounted to the frontmost edge of the tool. Two slits and a guiding wall serve as the entry and exit for the band. The user can adjust the size of screw or bolt that the band accommodates by pulling the band tight against the screw or bolt while maintaining the pull to operate the tool. A pressure-sensitive switch is located on the handle and activates the motor. When the motor is activated, it drives the gears which move the spool and band. The motor applies an amount of force proportional to how much pressure the user applies to the switch, allowing for maximum adaptability on various projects.

Concept Sketches

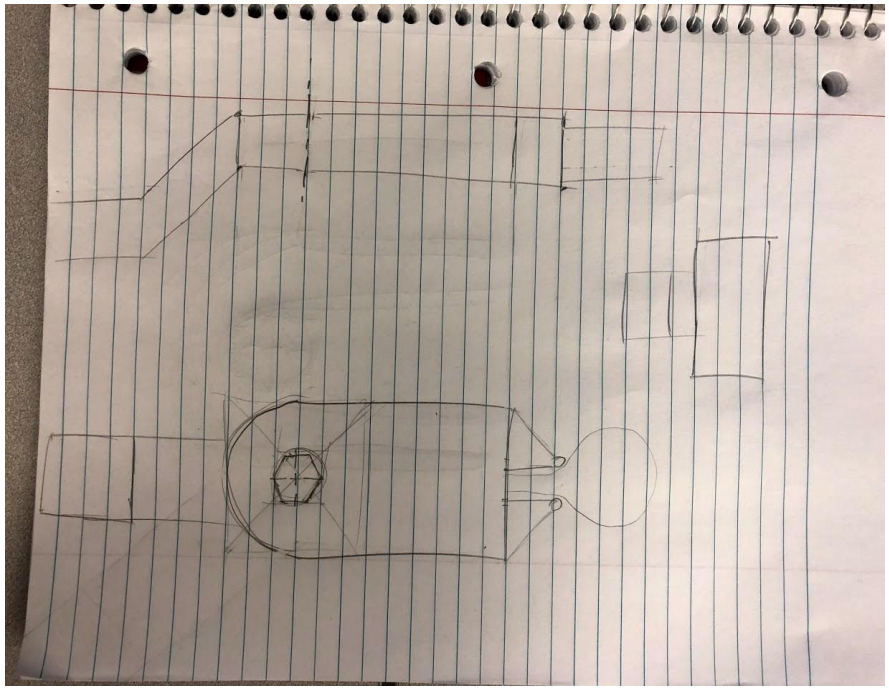
a. Jessica Nicholson

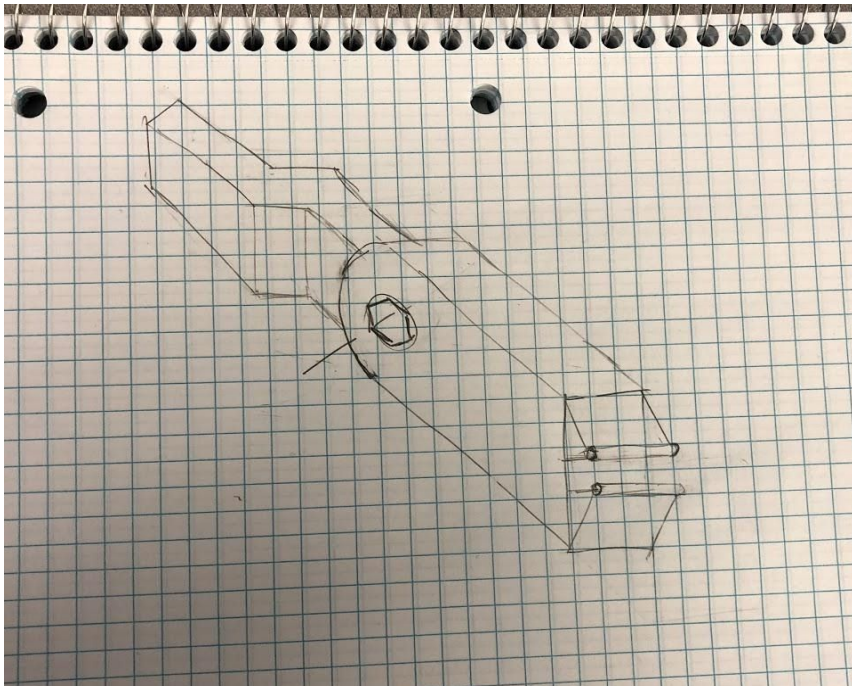


b. John Crispo

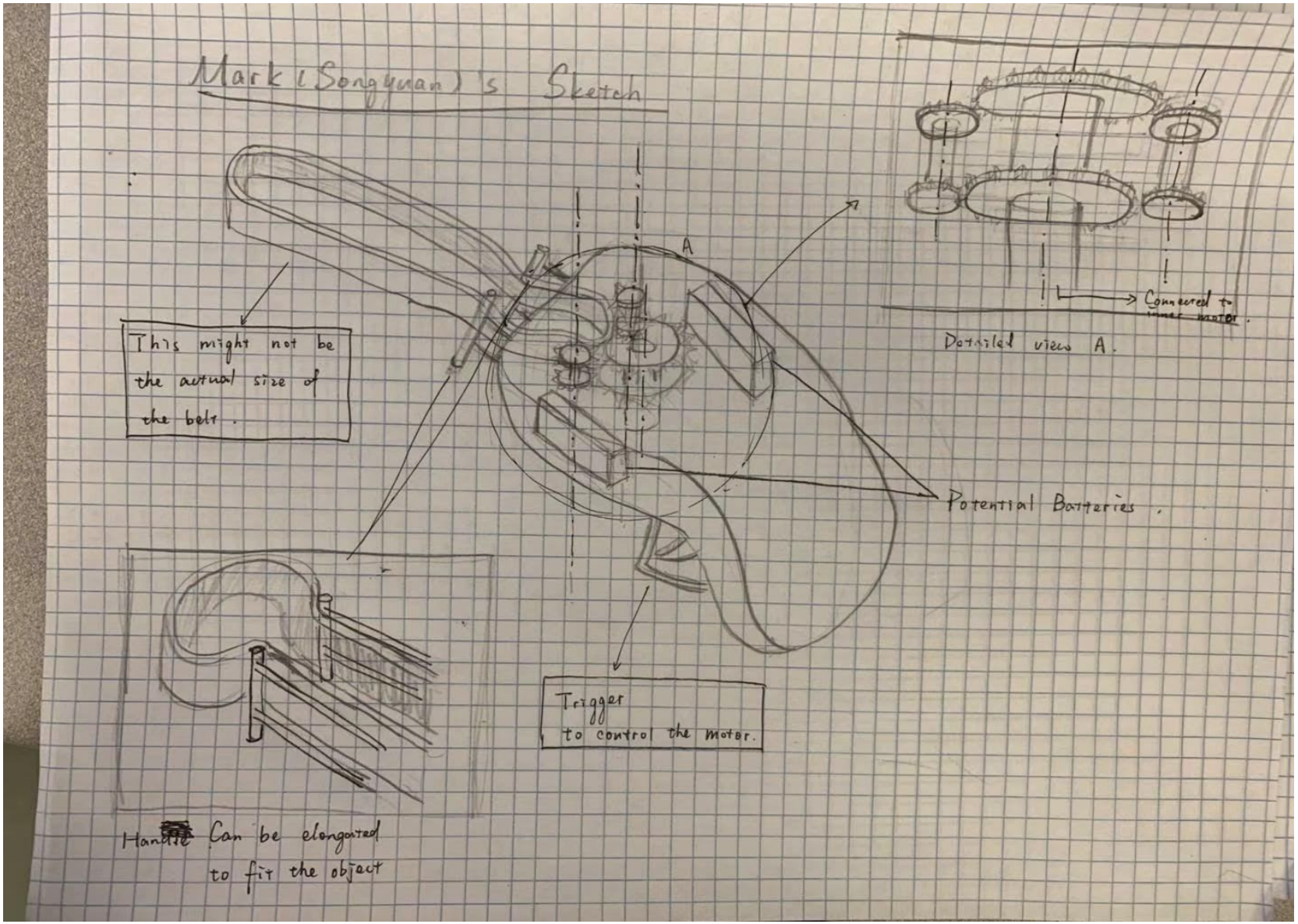


c. Andrew Colin





d. Mark (Songyuan) Cui



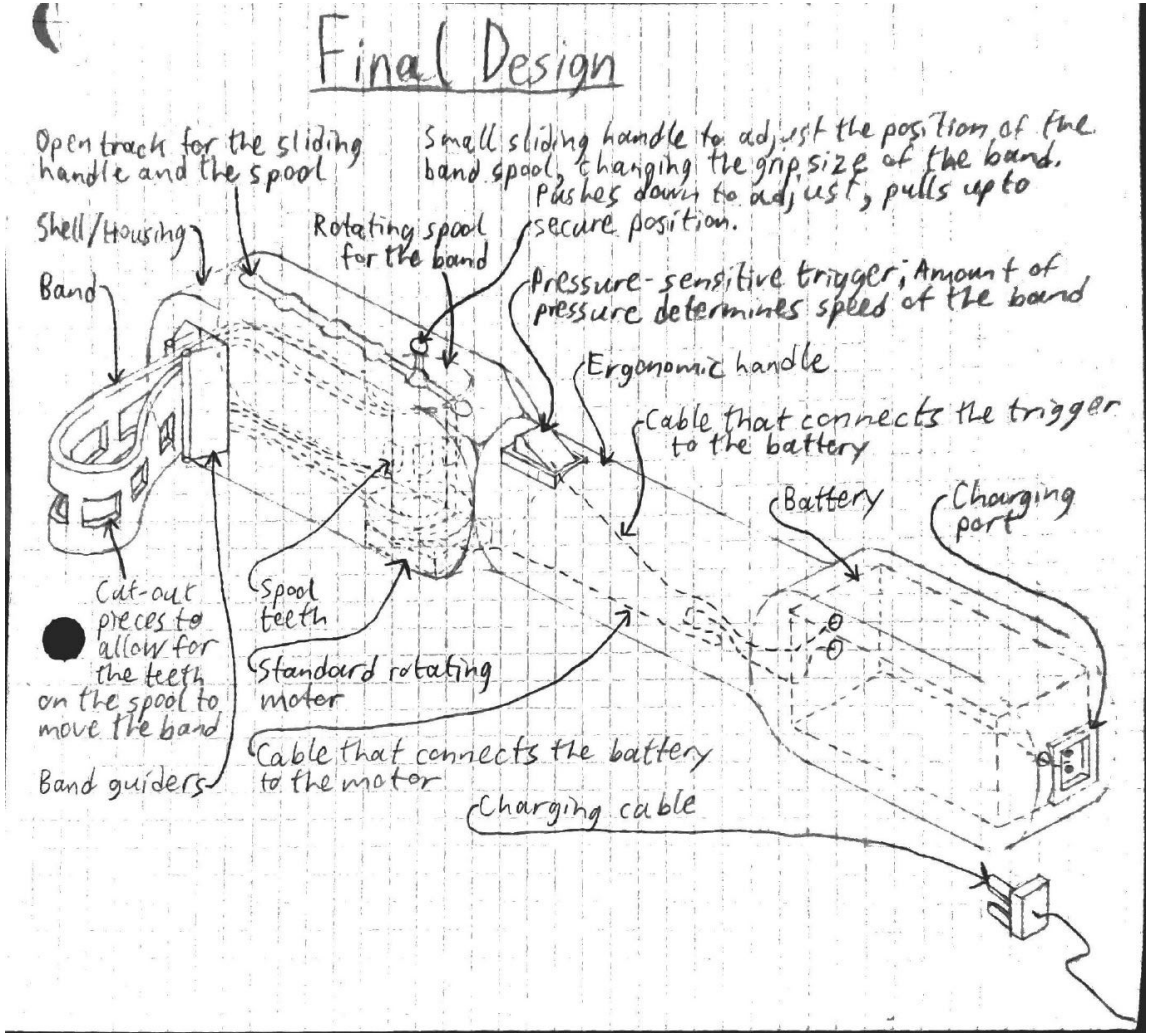
Concept Selection Process

Specifications:	Weight Factor (out of 5):	Design Rating(out of 10)				Design Weighted Rating			
		Jessica's	Mark's	John's	Andrew's	Jessica's	Mark's	John's	Andrew's
Performance	5	8	8	9	7	40	40	45	35
Service Life	3	8	6	8	6	24	18	24	18
Target Costs	4	7	7	7	6	28	28	28	24
Size and Weight	4	9	8	8	5	36	32	32	20
Aesthetics	2	9	6	9	5	18	12	18	10
Maintenance	3	7	9	6	6	21	27	18	18
Ergonomics	4	9	8	6	7	36	32	24	28
Quality/Reliability	5	8	7	8	8	40	35	40	40
Safety	4	8	9	7	9	32	36	28	36
Customer Reach	2	9	8	9	8	18	16	18	16
Max Total	360				**Totals:**	293	276	275	245

Jessica scored the greatest amount of points in the categories with the greatest weight factor. The design was extremely detailed and easy to understand from a customer point-of-view. When it came to assessing for performance the electric and rechargeable design was found to give consistent, high torque performance. The minimalist design lead to a compact configuration that was quite ergonomic. Finally, when it came to the durability and life of the product, having less mechanical interfaces and rubbing parts made for superior quality and the lowest manufacturing costs.

Final Sketch

Our group created a final sketch to further revise our product and implement many of our best component ideas into Jessica's design.



Product Design Specifications

1. Performance
    - Can secure its high-friction band around objects ranging from at least 2 cm to 20 cm in diameter
    - The band is electrically operated
    - The band rotates clockwise, rotating the object along with it
    - Has a speed range of 30 rpm to 180 rpm
    - Has enough force to tighten and loosen objects such as screws and bolts via the circular motion band
    - Requires no manual effort
2. Environment
    - Is capable of operating in temperatures up to 260 degrees celsius
    - Can operate at all altitudes
    - Is unaffected by humidity
    - Must be kept out of water to prevent corrosion
    - Must not be put under a force greater than 177,930 newtons
    - Must not reach a noise level higher than 100 decibels
    - Must be operated by people age 15 and above
3. Service Life
    - Has to last for at least 10 years to benefit the customers and the product's image
    - Can be operated for a maximum of 8 hours per day
    - Must be able to operate for at least 4 hours between each charge
4. Maintenance
    - Must not require regular maintenance
    - In the event that a product breaks, however, maintenance must be provided free of charge
    - Customers must receive a year-long warranty
5. Target Costs
    - Has a maximum retail cost of $50 and a minimum cost of $10
    - Tooling costs must not exceed $5000

- Tooling costs should be recovered after a maximum of 2 months

6. Competition
    - The standard wrench design may challenge the customers' desire for this product
    - This product must require less time to operate than a standard wrench
7. Shipping
    - Must be delivered in bulk to the company's warehouse by land once manufactured
    - Some products will be delivered from the company's warehouse to various retail locations around the world. This will be done using the most convenient form of transportation depending on location, which could be by land, sea, or air
    - The company's own distribution fleet will be used
8. Product Volume
    - The company must start by gaining a revenue of at least $30000 per year, which translates to 600 items sold per year at the maximum retail cost
9. Packing
    - No more than $5 should be spent on packing per product
    - Each product will have a casing around the belt section made out of biodegradable "plastarch material" for display
    - Products will be grouped together in 2 by 2 by 2 foot boxes during storage and transit
10. Manufacturing Facility
    - An existing manufacturing plant will be used to create these products
    - The company will adopt a make-in policy for manufacturing rather than buy-out
11. Size
    - The maximum size is 28 by 6 by 4 cm and the minimum size is 14 by 3 by 2 cm
    - Sizes made must be determined based on the distribution of customers' hand sizes
12. Weight
    - In order to allow for convenient handling, shipping, and use by the customer, the weight of the product must not exceed 5 pounds
    - The minimum weight is 1 pound
13. Aesthetics and Finish
    - The texture of the product should be smooth with a shiny finish

- One exception is the electrically-operated band, which should be rough to create extra friction
- This product can be produced in a variety of colors

14. Materials
    - The handle and body of the product are made of plastic
    - The electrically operated band is made of high-friction rubber
    - The casing that surrounds the electrical and gears/mechanical components is made of ABS plastic
    - The display packaging is made of plastarch material
15. Product Life Span
    - With a developed manufacturing system, each product will take about 1 hour to produce
    - A product may take about 2 months to sell on average
    - Once in use, the product must last for a minimum of 10 years
    - The total lifespan of the product will be about 10 years and 2 months
16. Standards, Specifications, and Legal Aspects
    - Must be designed to current international standards
17. Ergonomics
    - The handle must be shaped to accommodate a person's hand
    - The handle must have a good grip
    - The handle must be proportional to the size of the product itself
    - Weight should be evenly distributed to allow for ease of use
    - Edges must be rounded off on the band and the handle for safety
18. Customer
    - Product must be durable enough to be efficient on construction work sites
19. Quality and Reliability
    - Able to withstand up to 177,930 Newtons of force
    - Able to tighten and loosen bolts and screws up to 125 grams in mass
    - No more than 6 DPU
20. Shelf Life
    - Coated in a fine plastic material to prevent rusting

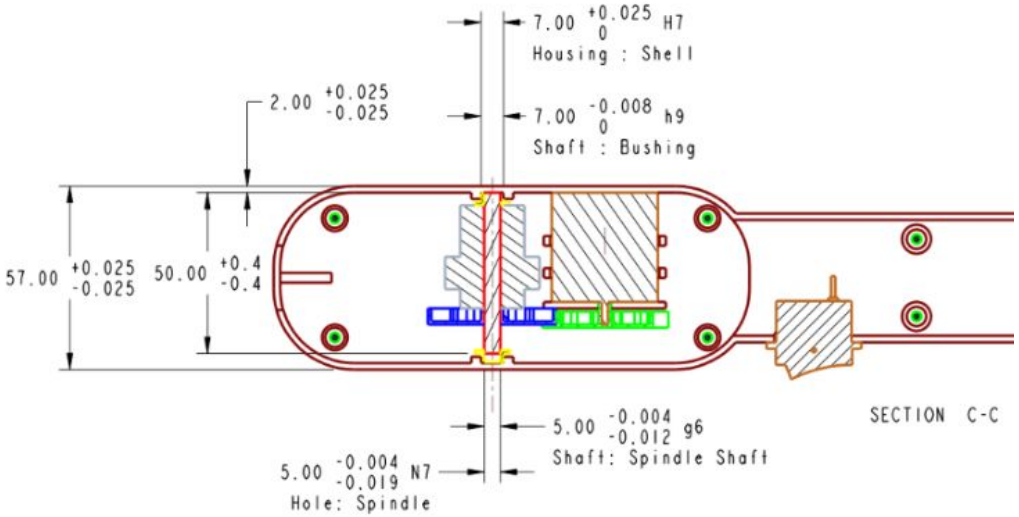
- Non-removable lithium battery
- Band replacements available to customers in the event that the product's band breaks

21. Processes
    - The handle and body should be produced with metal stamping
    - The circular, continuous band must be made with a detachable end in case the band must be replaced
22. Timescales
    - The design process should take about 2 weeks
    - Design revisions should be made in 1 week
    - Prototyping should take about 4 weeks
    - Tool and die manufacturing should take 1 week
23. Testing
    - Must be tested for functionality on a variety of sizes of screws and bolts, with repeated trials
    - Needs to be tested for both tightening and loosening bolts/screws
    - Must be tested for rust resistance and durability
    - Equipment needed consists of screws, bolts, water, and surfaces for the screws and bolts.
24. Safety
    - Has a warning about possible harm due to its weight (ex. dropped on toes)
    - Must be labeled with a warning next to the band about its high speed motion and that fingers must be kept clear while it is in motion
25. Company Constraints
    - No previous products or company practices constrain this product
    - A manufacturing center and tool shop are necessary to successfully develop this product
26. Market Constraints
    - No national or organizational affiliation symbols should be present on the product besides the company's logo
    - Should not be marketed or sold to children under age 15
27. Patents, Literature, and Product Data
    - Need to evaluate other solutions similar to wrenches, conveyor belts, and belt sanders
    - Need to find if an automatic wrench already exists

- Patent for a similar product with grant # US1811666A, named “automatic power driven pipe wrench”

28. Political and Social Implications
    - Varies in size to allow for use for both men and women; for people of all hand sizes
29. Disposal
    - Initial packaging must be recycled
    - When the product is no longer functional it should be given to the company, where the band will be recycled and the metal reused

Tolerance Analysis of Product



Radial Analysis 1: Bushing(shaft) to Shell(housing)

- Supplier recommended h9 location clearance fit for a snug stationary fit
- Worst Case Allowance:
  - 7.00mm - 7.00mm = 0mm
- Worst Case Clearance:
  - 7.025mm - 6.992mm = 0.032mm

Radial Analysis 2: Spindle Shaft(shaft) to Spindle(hole)

- Stock g6 shaft to spindle N7 hole for a push fit to secure spindle to axle for rotation
- Worst Case Allowance:
  - 4.981mm - 4.996mm = -0.015mm
- Worst Case Clearance:
  - 4.996mm - 4.988mm = 0.008mm

Axial Analysis: Shell & Shell thickness vs. Shaft Length

- General Shell Tolerance (hole) vs. Shaft Tolerance(Shaft)
- Worst Case Allowance:
  - 56.75mm - 2*2.25mm - 50.4mm = 1.85mm
- Worst Case Clearance:
  - 57.25mm - 2*1.75mm - 49.6mm = 4.15mm

Materials, Manufacturability, and Cost Analysis

Our product's parts are made up of a variety of materials. Our non-catalog parts include both sides of the shell, the spindle, and the two gears, all of which we have decided to create through plastic injection molding. Plastic injection molding is the cheapest and most efficient solution for each part that provides sufficient durability for tool operation. The tooling investment cost totals $61,812.39, which covers the cost of a laser cutter and molds to carry out plastic injection molding. The laser cutter will cut our rubber strips into 1.5 foot sections and cut holes in the strips to fit over the spool teeth. This process forms the moving band for each of our products. The plastic injection molds, however, will form both sides of our shell, the spindle, and the two gears that connect the spool to the motor.

Our target retail/selling price is $60. Although our selling price is significantly less than our investment cost and initial production cost, it is a reasonable selling cost because we will make up for the deficit over time as we sell greater quantities and our production cost decreases. We predict that our product will be fairly successful, as it is a convenient and user-friendly adaptation of the wrench with minimal extra cost. It provides users with an effortless way to undo screws and bolts that maximizes productivity. The risk associated with manufacturing and selling our product is fairly high, however, due to our high tooling and investment costs. This high cost creates a significant initial debt, meaning that we must make a significant revenue

to recover our investments and be successful as a business. In order to do this we must ensure that our product has a sizeable market, long-term relevance, and a lack of competition to mitigate this risk. Once our business takes off and we can manufacture greater quantities, our profit margin will increase.

Bill of Materials

Part Name	Part Number (catalog name)	Material: Process	Material Cost	Piece Part Cost	Fully Burdened Cost	Total Capital Investments	Quantity	Unit	Total Fully Burdened Cost	Link
12V Motor	a17082900ux0328(Uxcell)	Metal, electronic parts: Bought	-	-	$11.81	$0.00	1	Item	$11.81	https://www.amazon.com/uxcell-10000RPM-Encoder-Remote-Control/dp/B077SY212B/ref=sr_1_11_sspa?ie=UTF8&qid=1543432863&sr=8-11-spons&keywords=motor&psc=1
Switch	1552.2602(Marquardt)	Polyamide with silver plating: Bought	-	-	$3.70	$0.00	1	Item	$3.70	https://www.marquardt-shop.com/products/switches/rocker-switches/1550/1552.2602.html
Rubber Strip	RSWNEOCG60-062x1x12"(Rubber SheetWarehouse)	Neoprene: Bought, Laser cut	$10.00	$1.50	$1.00	$3,997.00	1.5	Feet	$1.50	https://www.amazon.com/Neoprene-Rubber-Commercial-Grade-Thick/dp/B01CUQ51L4/ref=sr_1_2_sspa?ie=UTF8&qid=1543433614&sr=8-2-spons&keywords=rubber&psc=1
Shaft	A 7X 1M050050(SDP/SI)	303 ST. Steel Shaft: Bought	-	-	$4.57	$0.00	1	Item	$4.57	http://shop.sdp-si.com/catalog/product/?id=A%207X%201M050050

Bushing Bearing	ASTEPBF 0507-04(AS TBearings)	Metal-polymer composite: Bought	-	-	$0.15	$0.00	2	Items	$0.30	https://www.astbearings.com/catalog.html?page=product&id=ASTEPBF_0507-04
Plastic Shell/Chassis Left	AB5-02_00 1	ABS: Plastic injection molding	$0.25	$0.98	$1.05	$18,722.29	1	Item	$1.05	
Plastic Shell/Chassis Right	AB5-02_00 2	ABS: Plastic injection molding	$0.25	$0.74	$0.80	$15,642.83	1	Item	$0.80	
Spindle	AB5-02_00 3	ABS: Plastic injection molding	$0.04	$1.01	$1.05	$8,147.95	1	Item	$1.05	
Motor Gear	AB5-02_00 4	ABS: Plastic injection molding	$0.01	$0.06	$0.10	$7,685.15	1	Item	$0.10	
Spindle Gear	AB5-02_00 5	ABS: Plastic injection molding	$0.01	$0.06	$0.10	$7,617.17	1	Items	$0.10	
Screws	a15070200 ux0077(Uxc ell)	Aluminum, stainless steel: Bought	-	-	$0.08	$0.00	8	Items	$0.64	https://www.amazon.com/Uxcell-a15070200ux0077-Stainless-Phillips-Screws/dp/B012TE167U/ref=sr_1_6?ie=UTF8&qid=1543971493&sr=8-6&keywords=m3+x+20mm+screws#feature-bullets-btf
				Total Investments:		$61,812.39	Total Fully Burdened Piece Part Costs:		$25.62	