GALLOGLY COLLEGE OF ENGINEERING
SCHOOL OF AEROSPACE AND MECHANICAL ENGINEERING
The UNIVERSITY *of* OKLAHOMA

EV Battery Solutions
by Cox Automotive

Cable Storage Device

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Industry Sponsor: Evan Stone





Background

- **EV Battery Solutions:** Remanufactures, reuses, and recycles EV batteries by working with vehicle manufacturers
- **Problem:** Battery testing requires routing multiple high-powered cable bundles to an EV battery
  - The cable bundles weigh several pounds, are stiff, and bulky due to their construction making them difficult to organize which can create workflow inefficiencies and safety hazards
- **Project Goal: Produce a repeatable/stackable cable management device capable of neatly containing, dispensing, and retracting a high-powered electrical cable bundle**

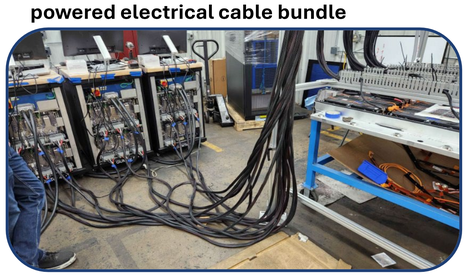




Figure 1: Initial cable bundle organization and storage during EV battery testing

Constraints

Category	Design Requirement
Function	• Dispense and retract cable to desired length
Cable Capacity	• Must handle bundles of cables up to 1.5” diameter • Must contain/store and dispense up to 12ft of cable
Physical	• Must provide strain relief at any dispensed length • Must maintain continuous electrical connection • Must allow for heat dissipation during high-capacity testing
Modularity	• Stackable/repeatable for multiple cable bundles
Cost	• A target cost of less than $250 per unit

Locking Mechanism

A **Ratchet & Pawl** is a mechanism that permits rotation in one direction while preventing rotation in the reverse direction.

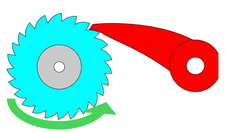


Figure 2: Standard Ratchet & Pawl

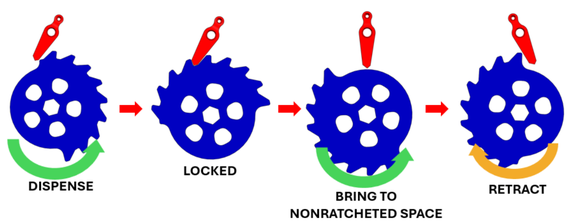


Figure 3: Custom Ratchet and Pawl Mechanism Process

After research, the team has found that by implementing a non-ratcheted section on the ratchet, it allows the ratchet to turn both directions while still maintaining the locking mechanism.

Design of Mechanism

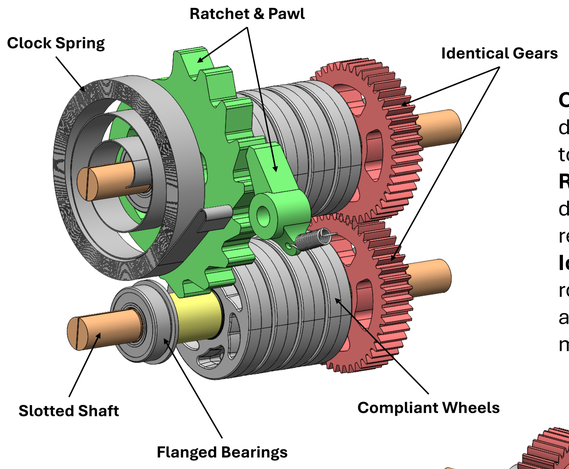


Figure 4.1: Assembly of the Mechanism

Clock Spring- Stores energy during dispensation. Uses the energy for torque to retract the cable
Ratchet & Pawl- Locks the dispensed cable in place till retraction
Identical Gears- Synchronizes the rotation of the upper and lower shaft allowing all compliant wheels to move at same speed

Slotted Shaft- Serves as an anchoring point for the clock spring allowing direct connection
Flanged Bearing- Minimizes rotational friction. Flanged edges prevent lateral movement of the components on the shafts
Compliant Wheels- Utilizes its flexibility to maintain constant contact with the cable

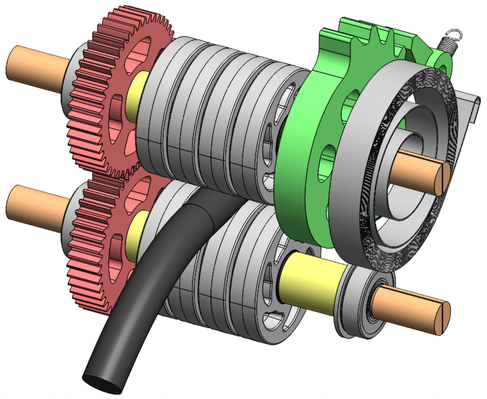


Figure 4.2: Assembly of the Mechanism with Demonstrated Cable

Finite Element Analysis

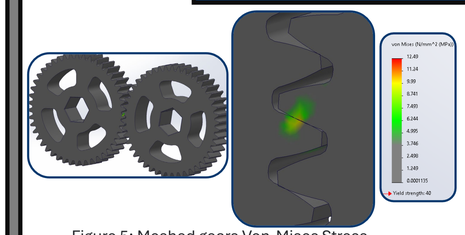


Figure 5: Meshed gears Von-Mises Stress

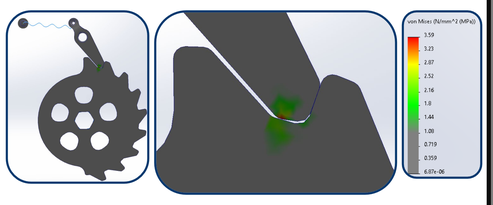


Figure 6: Ratchet and pawl Von-Mises Stress

Metric	Meshed Gears	Ratchet & Pawl
Boundary Condition	Applied torque: 0.9377 N·m	Applied torque: 0.9377 N·m + 465.84 N/m extension spring rate
Max Von Mises Stress (MPa)	12.49	3.59
Factor Of Safety	3.2	9.74
Yield Strength (MPa)	40 (*Approximate)	35
Material	PETG	PLA Basic

*Rotor spring torque and extension spring rate from McMaster-Carr

Design of Storage

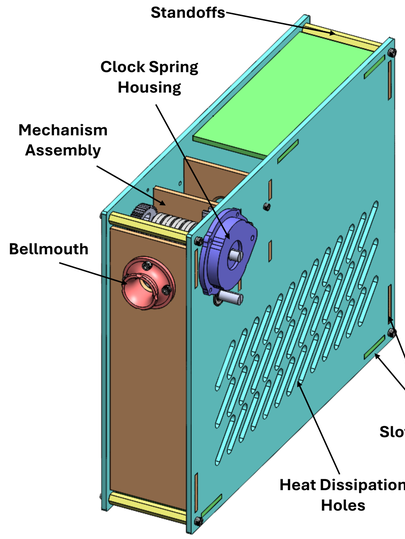


Figure 7: Assembly of the Storage

Bellmouth-
Provides strain relief during dispensing
Clock Spring Housing-
Encloses the clock spring to maintain proper alignment
Standoffs-
Holds the storage together
Heat Dissipation Holes-
Allows for the transfer of heat to ambient surroundings
Slots & Flanged Edges-
Connects the main plate to the side plates

Results

A prototype of the mechanism was fabricated and assembled using machined aluminum shafts and standoffs, commercial fasteners and bearings, and custom-designed 3D-printed components.

Testing the prototype showed a mechanical limitation during its retraction. The mechanism was only able to retract around 50% of the cable due to the insufficient torque from the clock spring.

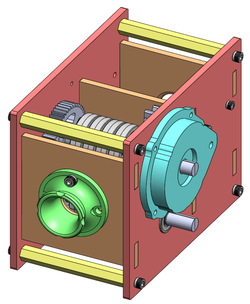


Figure 8: Mechanism Prototype

Suggested Improvement:
- Further pre-wind the clock spring
- Add an additional clock spring on the opposite side of the shaft end

Codes & Standards

- **ASME B1.1 – Unified Inch Screw Threads**
- **ASME B18.3 – Socket Cap, Shoulder, Set Screws, and Hex Keys**
  - Standard for socket head cap screws general and dimensional data
- **ASME B18.2.2 – Nuts for General Applications: Machine Screw Nuts**
  - Standard used for hex nuts and nuts for general applications
- **ASME B18.16.6 – Prevailing Torque Locknuts**
  - Standard for prevailing torque nylon-inserts locknuts and all metal types to resist loosening by vibration