Torsion Element Test
Bench Design

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ROSTA Element Description

- Outer body secured to fixed point
- Inner element connected to moving part
- Rubber inserts
- Primary uses include vibration damping and suspension elements

Picture Taken from ROSTA Product Catalog
Examples of Use

- Lever bearing in concrete mixer
- Pressure rollers in saw device
- Pendulum on harrow rollers
- Conveyor-belt scraper
- Handle-bar insulation
- See-saw support

Picture Taken from ROSTA Product Catalog
Example of Use
Project Need

- Test and certify new and existing elements
- Test range of angles and torque applied
- Display angle vs. torque in graphical form

Picture Taken from ROSTA Product Catalog
Original Specifications

• Capable of testing elements with a maximum torque of 700 N·m to 6500 N·m at ±30° of rotation
• Able to accommodate element from 50 millimeters to 100 millimeters in diameter and 250 to 450 millimeters in length
• Device must measure torque and angular displacement of test elements
• Torque measured at every ½ degree of rotation or better
• Display results graphically with ±1 N·m sensor accuracy
• Standard office computer for data collection
  – Labview software is required to be used for user interface
• All inclusive budget is around $5,000
Updated Specifications

- Torque and Angle sensing accuracy must be within <1.5% of the actual values for angles above 5°
- The element must be displaced by a 5° push and 30° pull
- Budget was increased as project continued
  - Driving Factors: Mechanical Design (Steel), Data Acquisition
- All else remained the same
Design - Overview

- **Mechanical Structure**
  - Designed by ROSTA
  - Multiple Configurations and Torque Arms

- **Hydraulic System**
  - Cooperatively Designed
  - Digital Control of Direction
  - Manual Flow Adjustment

- **Electrical System**
  - Designed and Assembled by Senior Design Team
  - Test Control
  - Sensor Measurement
Design - Block Diagram
Design - Hydraulics

- Hydraulic Power Unit
- Solenoid Valves
  - Forward Reverse Control
- Flow Control
  - Manually adjusted needle valve

Hydraulic Power Unit Mounted on Device
Design - Sensor Measurement

• Analog - Load Cells
  – Measures Force on Hydraulic Cylinder
  – Tensile and Compressive Measurement
  – High Accuracy
    • ±0.03% Linearity
    • ±0.02% Hysteresis
    • ±0.01% Repeatability
  – 3000 and 1500 pound ratings used
  – 3mV/V Output, 10-15V excitation
Design - Sensor Measurement

• Digital - Linear Encoder
  – 6 Channel Quadrature
  – Proprietary Magnetic Tape
  – 10..30V HTL push-pull
  – 10μm resolution
  – Measures Hydraulic Cylinder Travel

HK Series Linear Encoder
(image courtesy Baumer)
Data Acquisition System - Hardware

Analog:
- NI-9218 2-Channel Universal Analog Input Module
  - Sample Rate: 51.2kS/s per channel
  - DSUB Connectors
  - ±16.3 V measurement range
  - 24-bit Resolution
  - 12 V Excitation Voltage
- Two National Instruments cDAQ-9171 single slot chassis are used to house the modules

Digital:
- NI-9375 16 Channel Digital Input and 16 Channel Digital Output Module
  - 12 V and 24 V signal levels
  - Sinking Input, Sourcing Output
  - 24 V Output levels are possible with external power supply
User Interface - Description

- Analog DAQ Channel Settings
  - Continuous samples
    - 10 Hz sample frequency
    - 1500 Samples
  - Max Voltage: 45 mV
  - Min Voltage: 0 mV
- Labview block diagram converts electrical signal taken from the load cell and converts to a torque in ft*lbs based on mechanical system configuration
- Prints the output onto a graph and displays numerical values on an indicator
- Data can be exported to Excel

- Digital DAQ Settings
  - 6-Channels used for encoder input
  - 3-Channel used to output signal for control
- Edge counter created in Labview to work with encoder output
User Interface - Analog Input Block Diagram
User Interface - Front Panel, Setup Page
User Interface - Front Panel, Run Page

![User Interface - Front Panel, Run Page](image-url)
Performance Results - Simulated Analog Signal

- Simulated voltages from 36mV to 16mV using DC source in lab
- Read inputs from the DAQ and exported the data to Excel
<table>
<thead>
<tr>
<th>Simulated Sensor Output Voltage (mV)</th>
<th>Expected Sensor Force (lbs)</th>
<th>Expected Torque</th>
<th>Average Torque Measured (Ft*lbs)</th>
<th>% Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>3000.0</td>
<td>4921.28</td>
<td>4912.24</td>
<td>0.18%</td>
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<tr>
<td>35</td>
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<td>4742.65</td>
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<td>34</td>
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<tr>
<td>33</td>
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<td>4481.84</td>
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<tr>
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<tr>
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<td>4141.59</td>
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<tr>
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<tr>
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<tr>
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<td>3690.96</td>
<td>3710.87</td>
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</tbody>
</table>
Performance - Device Build
Performance - Device Build
Performance - Device Operation
Performance - Device Operation
Evaluating Performance

• Approximately 90% Complete
  – Output Torque Vs. Angle of Displacement Graph in Labview
  – Complete system testing is required
  – Test operation and calibration of sensors

• Difficulties
  – Encoder vs. DAQ
  – LabView Programming Environment
  – Component delays
  – Mechanical Structure Not On-Site
Recommendations

• Change Digital DAQ to utilize onboard encoder functionality
• Calibrate sensors for measurement accuracy
• Replace Manual Hydraulic Flow Control with PWM Proportional Valve
Questions?