2020-21 BAE Systems Mod-Wire

Mechanical and Aerospace Engineering
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Abstract

The goal was to automate one or more steps of BAE Systems' mod-wiring process, where manual modifications are made to Circuit Card Assemblies (CCA). Currently, an experienced worker can take a shift or more to mod-wire one CCA by hand.

The team designed and built a wire-forming machine that would take various wire shapes that are designed using a Graphic User Interface (GUI) (developed by a Trine team in 2019-2020), then feed, bend, cut and strip the ends of wire from a reel to produce the desired wire shape.

The design consists of a dereeling system, a straightener, a forward feeding system, a cutter/stripper, and a bender. Two DC gear motors, two linear actuators, two linear actuators with built-in potentiometers, and a 270 ^{o} Servo Motor were used to successfully produce wires needed in the mod-wire process.

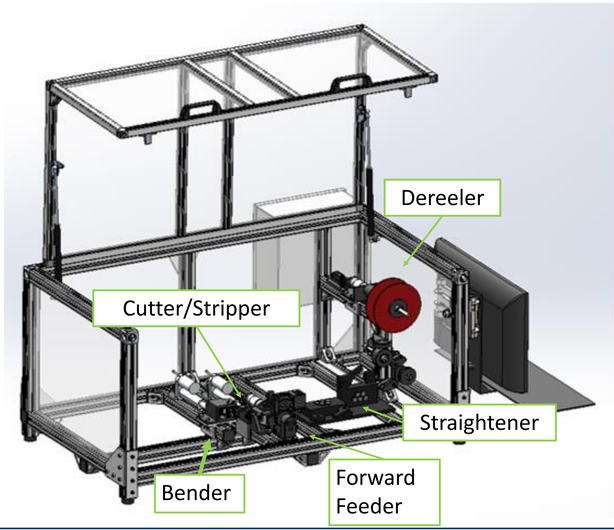
Customer Needs and Requirements

- Eliminate or automate at least one step of the current mod-wiring process.
- Deliver a cost-effective machine that reduces labor while maintaining consistency.
- Form wire geometries that meet distance tolerances based on circuit board design.
- Follow facility requirements and safety standards.

The wire bender must:

- Cost less than $5,000. (~$1600 remaining at the start of 2020-2021 year)
- Form 4 – 9 bends with 26- to 30-gauge insulated and magnet wire of 50 – 175 mm.
- Strip 1 – 3 mm of insulation from either end of insulated wire.
- Leave no visible denting, crushing, or gouging
- Straighten wire within ± 0.8 mm over 50 mm.
- Feed wire segment lengths accurate within ± 0.8 mm per 50 mm of wire.
- Form bend angles accurate within ± 5^{o}.
- Enclose moving parts and turn-off if the enclosure is removed.
- Store wire geometries in a GUI and use the Python coding language.
- Run on a 110 V, 15 A power supply, battery power, or be cost effective for 220 V.

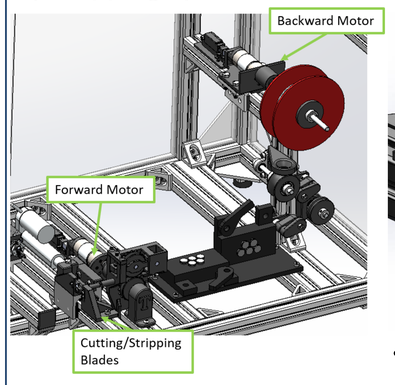
Design History



- The 2020 team built an 80/20 frame and added a wire straightener, a rudimentary dereeler, feeder, and cutter.
- The 2021 team designed, assembled, and integrated an improved dereeling, feeding, and cutting system, and added a bender, hood, user interface, and safety shutoff features.

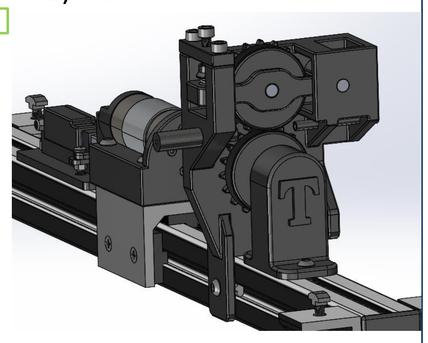
Innovative Design Solutions

1) Stripping System



- Wire slippage during stripping solved by adding a second motor to dereeler.

2) Geared Wheel Feeder



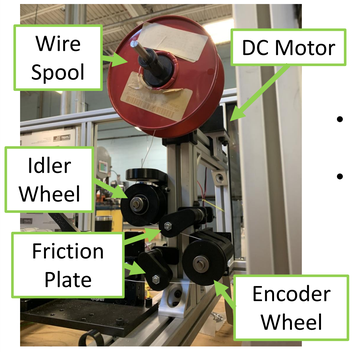
- Wire slipping between the feeder wheels was solved by adding gear teeth to the wheels, so both wheels are driven.

3) Additive Manufacturing

- Allowed the team to efficiently perform rapid prototyping, saving the team time and money throughout the year.
- Number of 3D Printed Components on the Machine: 50
- Estimated Time Saved in Machining: 200 hrs.

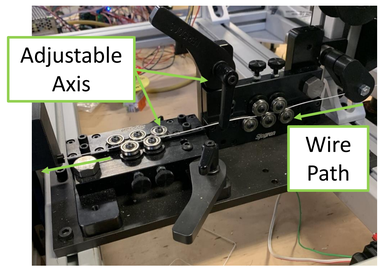
Subsystems

Dereeler/Reverse Feeder



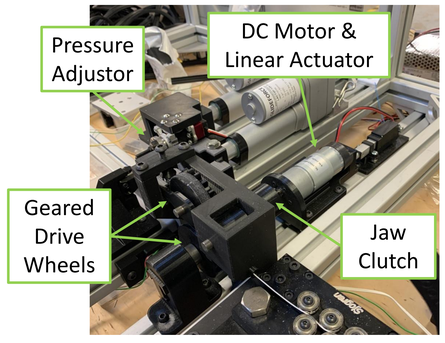
- Dereels wire spool
- Runs in reverse to strip the wire

Straightener



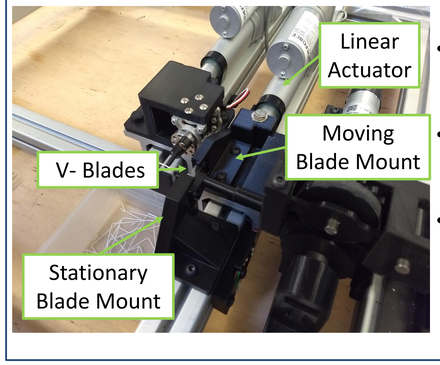
- Removes bends in the wire caused by the spool or the dereeler

Feeder



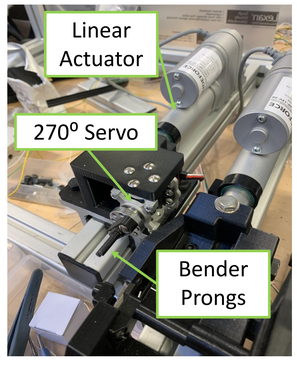
- Pulls wire through the rest of the machine
- Bolt and spring adjusts pressure between wheels

Cutter/Stripper



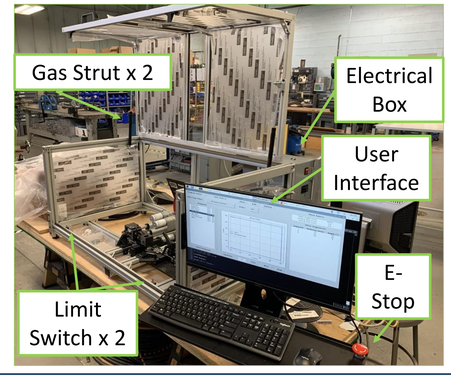
- Blades close fully to cut the wire
- Blades are partially closed to strip the wire
- Limit switches prevent blades from crashing

Bender



- Servo motor rotates to bend the wire to the correct angle

Enclosure/User Interface



- GUI allows users to input wire types
- Gas struts hold hood open
- E-stops and limit switch shutoffs keep users safe

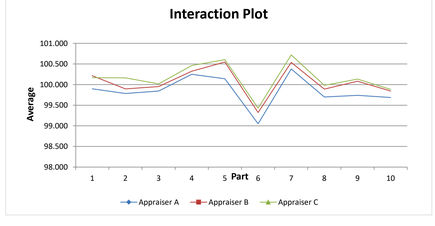
Testing and Validation

Crossed Gage R&R tests were performed to validate reliability/ reproducibility:

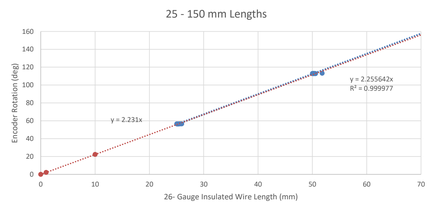
- Wire Length
- Wire Angle
- Strip Lengths

Sample Test: Wire Length

- Procedure: 10 Measurements, measured by 3 different appraisers, 3 times each, for 3 different wire lengths.



Gage R&R Plot for 100 mm Wire Lengths



Encoder Correlation for 26- Ga Insulated Wire.

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