Inverted Integrated Gate Bipolar Transistor Torque Tool

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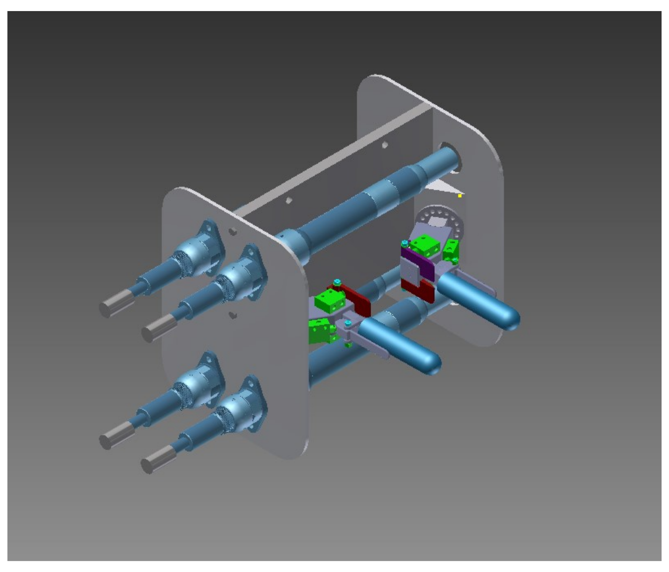
Abstract

General Electric Transportation has requested that TCU Senior Design team create a custom tool to improve the current system in place at the locomotive manufacturing plant for installing and torqueing nuts on an Inverted Integrated Gate Bipolar Transistor (IGBT). The major requirements include, but are not limited to:

- The system shall be capable of achieving the highest and lowest torque values required by the joints.
- Tighten all bolts on one IGBT unit to their final specification within 30 seconds.
- System shall be capable of the following operation modes: Torque Control-Angle Monitor, Angle Control-Torque Monitor, Yield Control, and Reverse.
- System shall have Ethernet communications for programming and data retrieval.

By creating a pseudo-weldment testing station to support the IGBTs, designing a custom torque tool, and building a control system, we were able to predict and test a completed system. It has been shown to decrease variability of results, and has simplified GE's current process in each aspect as required.

Tool Design



Define IGBT & What it Does

The term IGBT is an abbreviation for Integrated Gate Bipolar Transistor. An IGBT is a switch/regulator/inverter of current that is essential for the power delivery system in the locomotive. It is the combination of an isolated gate field-effect transistor (FET) for control input and a bipolar power transistor as a switch. Therefore, it is characterized by high efficiency and fast switching. An inverter for supplying power to an AC motor converts DC power to AC power at a controlled frequency and voltage. The inverter works by controlling a switching device, such as an IGBT, with an oscillator so that the control device is switched on and off between conducting and not conducting at a varying frequency.

What is Our Goal

General Electric Transportation tasked TCU Senior Design to design a custom tool that will install and torque four nuts on a locomotive IGBT. The tool is expected to provide accurate torque rundown of specified IGBT joints. Our design will collect performance data on the assembly process, scan serial number bar codes related to the individual IGBTs, and output all data in a format which interfaces with the GE Manufacturing Solutions quality system. In essence, our goal is to fabricate a design and provide a working tool that meets the specification of General Electric Transportation.

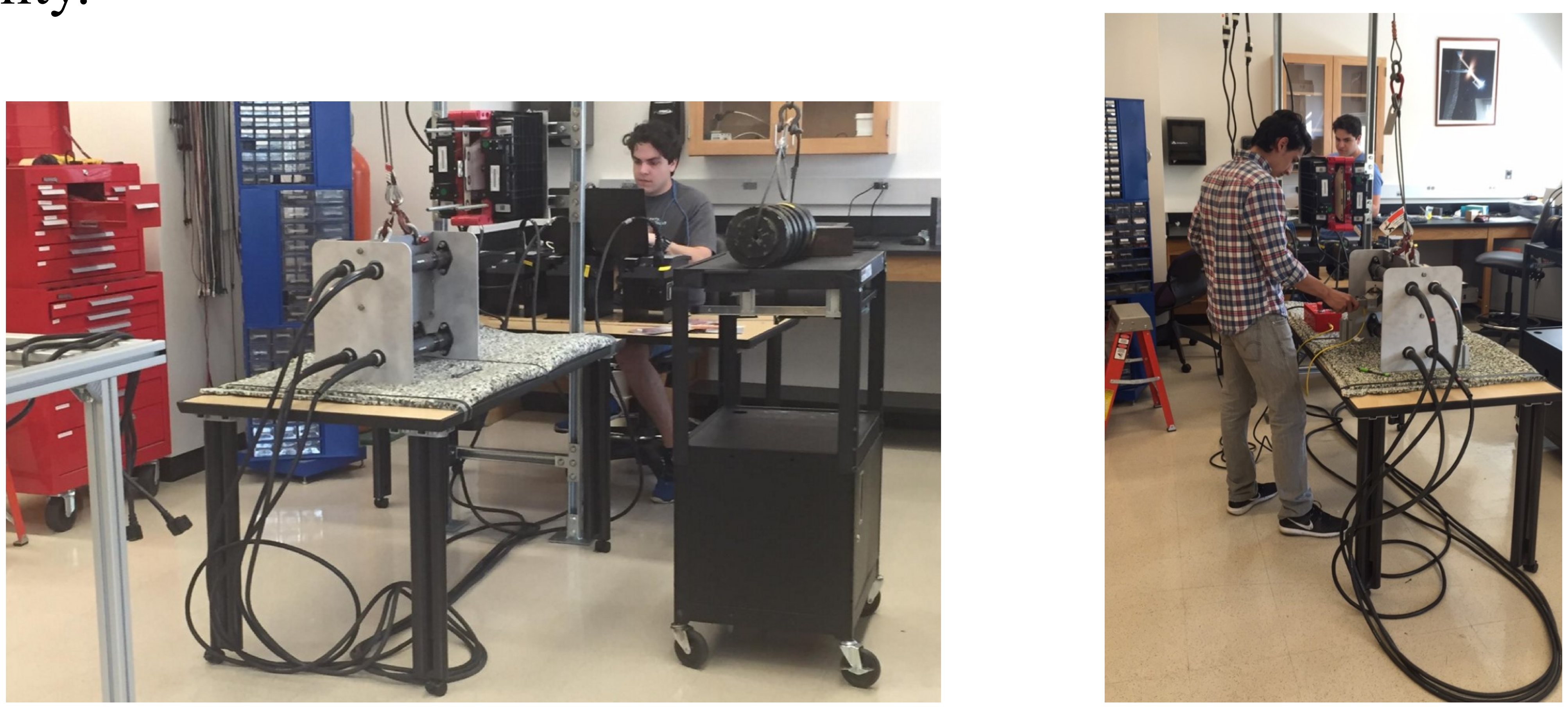
Description of the Tool and its Functions

The tool design is a DC multi-spindle nut runner capable of tightening four nuts in no more than 30 seconds. The tool will tighten the nuts to a desired torque specified in ft-lb and a specific torque angle in degrees. The system will also have the ability to report a number of data sets via Ethernet cable including the date, time, employee ID, control limits, OK/NOK status, and spindle position numbers, amongst others.

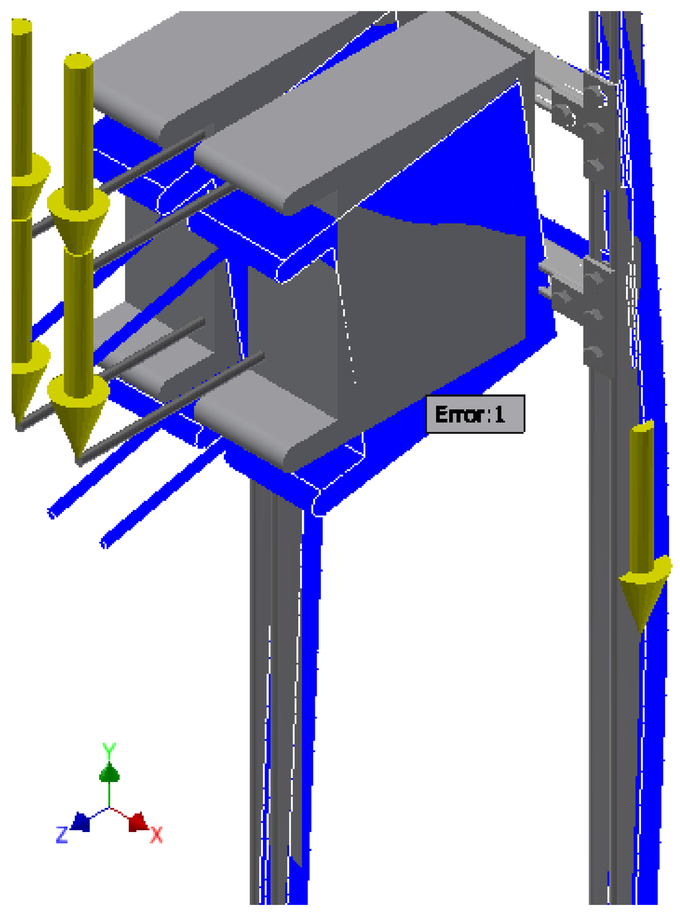
The individual nut runners are housed in a stainless steel casing to make the tool body rigid and protected. The motorized nut runners and controllers are manufactured by Ingersoll Rand Inc. The tool's control system will function using four electronic controllers, an industrial PC, and a barcode scanner. The Operator will begin by choosing the Job Torque Down Configuration on custom software using open protocol over a TCP/IP connection. The scanner will be used to scan the individual IGBTs as well as record employee information. Data recovered will be stored in a Comma Separated Value (CSV) file to be printed out at the end of the work day.

The tool and its components will reside on a cart made of Rex-Roth Material (aluminum). The cart will have upper and lower storage areas. The tool, barcode scanner, and computer monitor will rest on the upper area of the cart while the four controllers and will be housed on the lower area. The cart will sit on four locking castors for easy mobility.

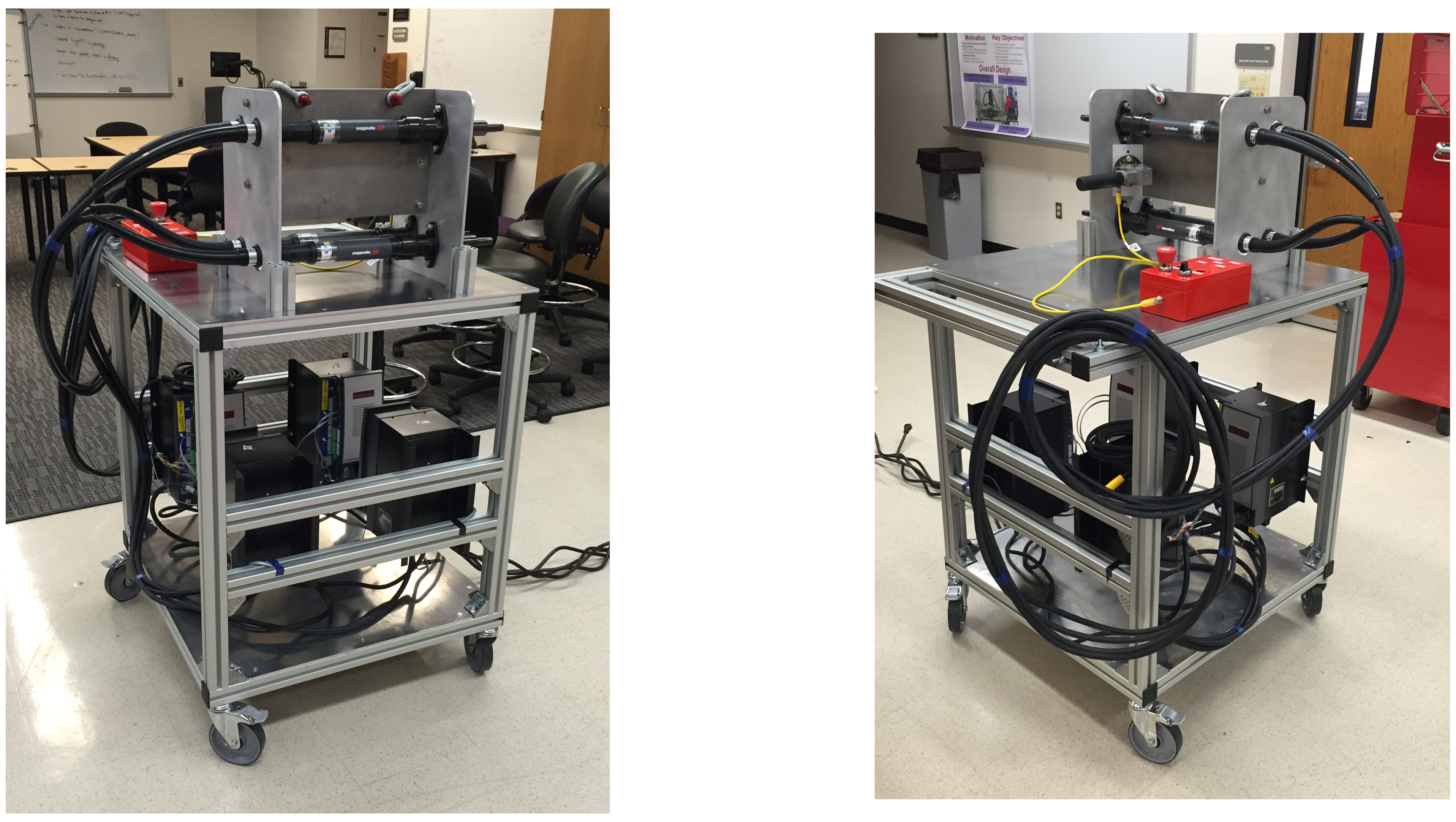
Antonio Ruiz, Julio Sanchez, and Wesley Mwanzia setting up controllers



Test station



IGBT Pseudo Weldment Model FEA Analysis



Complete Tool System

Testing & Conclusions

Testing of the tool was done at TCU on a "pseudo-weldment," which models the actual attachment point on the locomotive engine and allows for in-house testing within the senior design lab space. The pseudo-weldment was analyzed for stress and displacement using Finite Element Analysis (FEA) software and verified with hand calculations. Additional testing will be done soon at the GE-Transportation manufacturing facility. Ultimately, the tool will be integrated into the manufacturing plant, and ideally serve them for many years to come!