TUPV034

DEVELOPMENT OF AN AUTOMATED HIGH TEMPERATURE SUPERCONDUCTOR COIL WINDING MACHINE AT CERN

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The CERN High Temperature Superconductors Program

- CERN has initiated a 5 years R&D project aimed at the evaluation of REBCO (Rare Earth Barium Copper Oxide) HTS.
- Within the EuCARD-2 Project, CERN has been given responsibility of the work-package 10 (WP10) “Future Magnets”.
- WP10 main goal is to manufacture and qualify HTS cable within real demonstrator coils and magnets.
- The REBCO high-field tape will be tested on different HTS magnet prototypes (HDMS, GaToroid, small coils).

The Coil Winding Machine

- A new coil winding machine was needed to co-wind stacks of REBCO tapes, with the following requirements:
  - Setup and control in a closed loop the tension of the spools
  - Semi-automation of the winding process
  - Up to 7 tapes
  - Monitoring of the process
  - Report and saving of the results

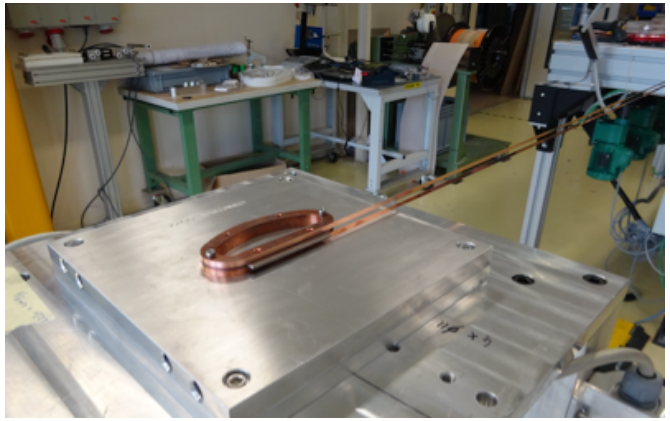
The Control System

- A CompactRIO controller (cRIO-9053) from National Instrument is used as control system.
- Some specific cRIO modules are used for Analogue Inputs, Digital Outputs and strain gages reading.
- Each spool axis is connected to a clutch, a gear motor and an electrical motor.
- Each tape is associated with a tension sensor
- The tape tension regulation is made with: a PID embedded in the FPGA of the cRIO + the tension sensor + the motor power supply

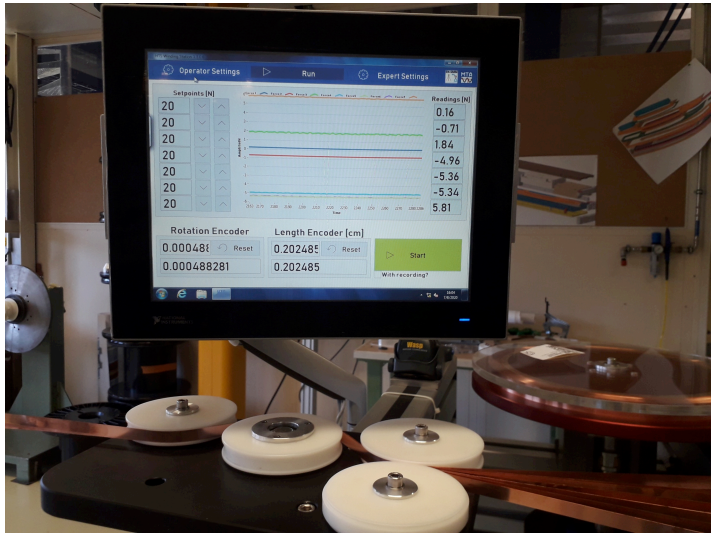
Results

- The complete control loop (strain gages, PID, clutch) is now setup with very good accuracy.
- The coil winding machine has allowed to build several types of HTS coil prototypes.
- The winding process has been validated on some coils and need to be improved for some others.

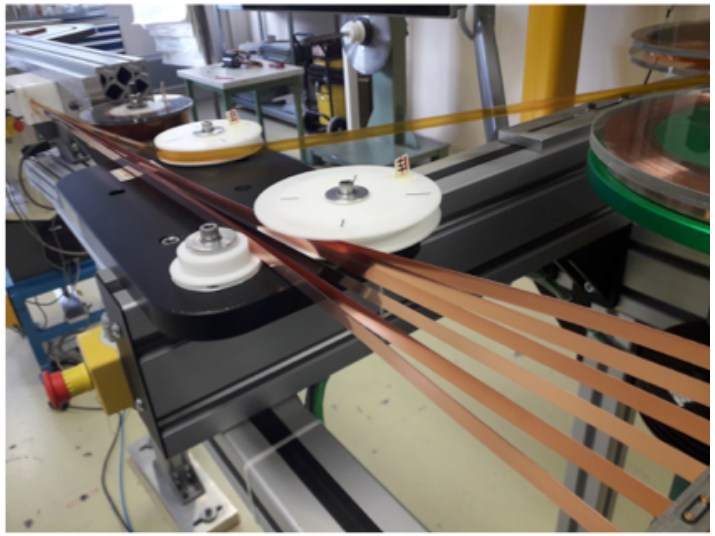
The Coil Winding Machine



Coil winding process



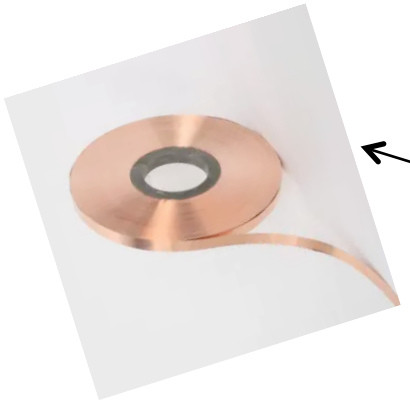
The control and monitoring panel

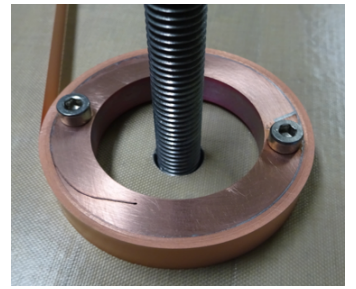


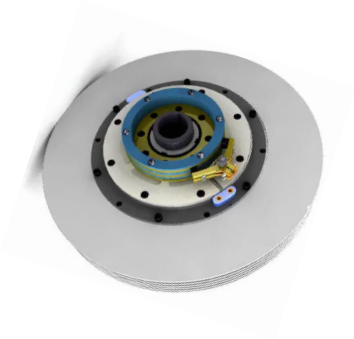
6 HTS tapes gathered into one

The 7 spools of HTS tape (only 6 used here)

System Overview

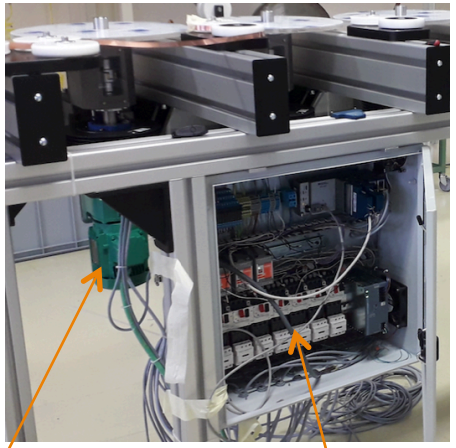


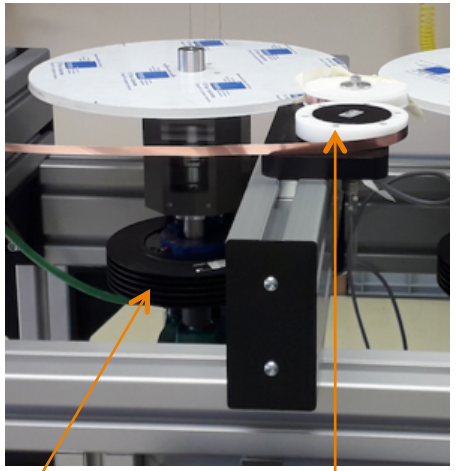




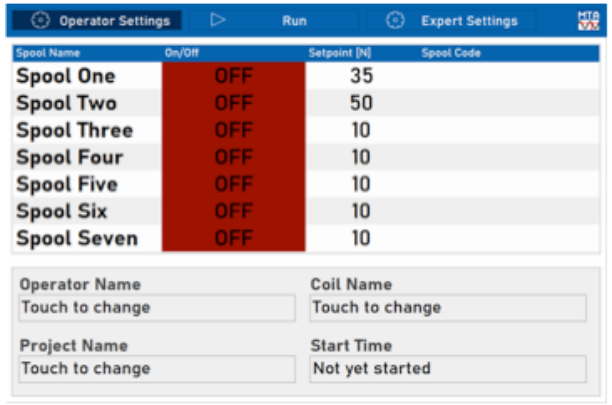
The Control System

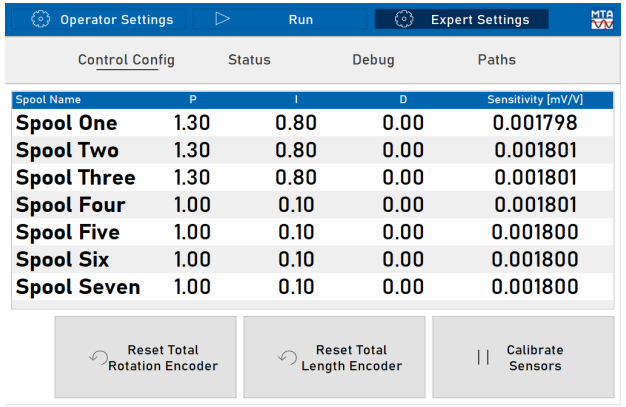
Hardware





GUI





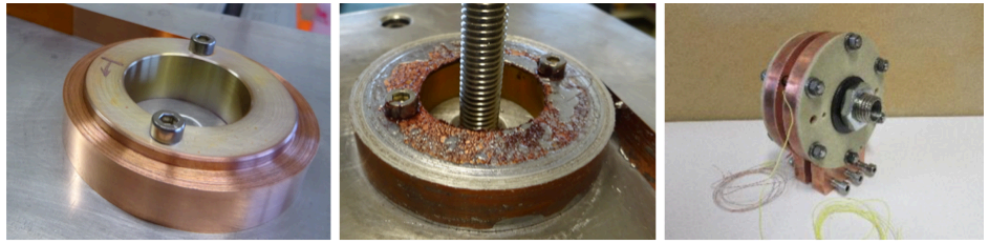
Software

- Based on LabVIEW
- GUI application is running on the Windows touch panel
- Main application is executed on the RT cRIO
- PID regulations, motor controls, encoder & DI readings are implemented in the cRIO FPGA

Results

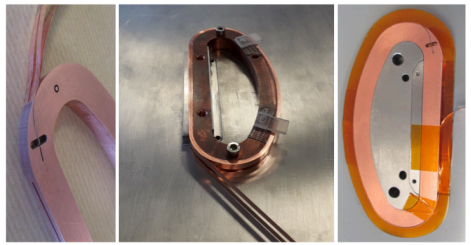
Coil Production Results

Solenoid Coil



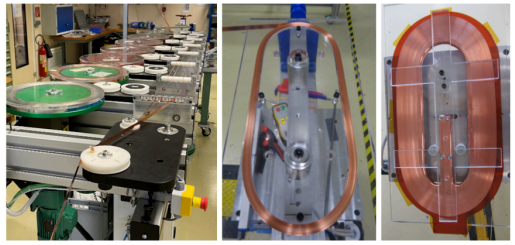
- One tape
- Tape tension 30 N
- Soldering paste and heating (T = 176°) between each turn
- Soldering of the first turn on the copper ring

Undulator Coil



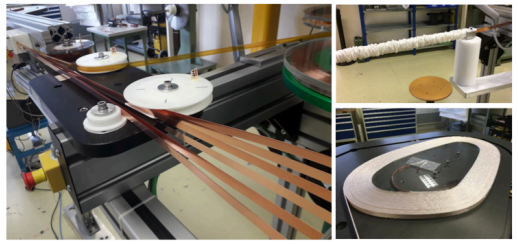
- Two tapes of 4 mm
- Horizontal winding not adapted (bad solder distribution)
- Following prototypes done on another winding machine (vertical)

HDMS Coil



- Three tapes of 12 x 0.1mm
- Tape tension 20 N
- Last turn fixing method to be improved
- External copper ring to maintain the coil to be studied

GaToroid Coil



- Six tapes (0.5, 0.1, 0.1, 0.1, 0.1, 0.5 mm)
- Tape tension 50 N, 30 N, 30 N, 30 N, 30 N, 50 N
- S-2 fiberglass sleeve used for insulation between layers