Advanced Conductor Technologies LLC
www.advancedconductor.com

SuperPower Inc.
A Furukawa Company

Cost-effective Conductor, Cable, and Coils for High Field Rotating Electric Machines

Contract Number DE-EE0007872

Florida State University, Advanced Conductor Technologies, and SuperPower Inc.

June 2017 – June 2020

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FAMU-FSU College of Engineering, Tallahassee, Florida

Partners:

Prof. David Larbalestier	–	Florida State University
Prof. Lance Cooley	–	Florida State University
Dr. Danko van der Laan	–	Advanced Conductor Technologies, LLC.
Dr. Drew Hazelton	–	SuperPower Inc.

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Project Objective

- To address the unacceptably **high cost** of Second Generation High Temperature Superconductors (2G HTS) for commercial applications and to enhance the **reliability** of HTS magnet coil based motors and other devices

- Currently, coils are wound using single strand conductor. Insulated single strand conductors cannot current share around defects in conductors, often leading to local burning and coil failure

- This project will **demonstrate that use of Conductor on Round Core (CORC) cables** instead of single strand conductors will eliminate the risk of damage to the coils due to the many localized defects still present in coated conductors

- This project hopes to show that low cost, run-of-the-mill conductors, which contain defects, can be used to **make reliable coils for industrial motors by winding the coils using CORC cables that facilitate sharing of current**

Fundamental Knowledge to be Gained

- Understanding the implications in using single conductor for high temperature superconductor (HTS) coils and magnets
  - What does the experience from several test coils reveal?
  - Role of slow quench propagation in the stability of HTS coils
  - Role of inevitable defects in HTS conductors on the reliability of superconducting motors and other coil based HTS applications

- What are different possibilities in using bundled conductors and cables?
  - Are there differences in how various cable designs address the problem?
  - Role of current sharing among the conductors in enhancing the reliability of superconducting motors and other magnet based HTS applications?

- Understanding of the possibilities to increase manufacturing yield and reduction of cost of HTS conductor and enhance reliability of HTS motors by using cables instead of individual conductors

Technical Innovation

- Manufactured 2G HTS conductor is run through quality controls to identify and isolate sellable sections. The yield is reduced and the cost of long piece lengths is high
- Typical self field quality controls miss some defects that will manifest only in operating conditions of high currents and magnetic fields
- We will characterize the manufactured conductors using a specialized tool "YateStar" to **map the density and distribution of defects in field at 65 K**
- We will fabricate and test CORC cables with the thoroughly characterized conductor to **compare the performance of cables made with the best conductor with the cables made from run-of-the-mill conductor**
- Establishing the **relationship between the defect density and distribution and the performance of CORC cables** allows appropriate design of the cables for reliable operation of HTS machines
- The goal is to show that properly designed CORC cables allow significant current sharing that can tolerate use of manufactured conductor with defects that would otherwise be cut out **thus increasing the yield, lowering the cost, and increasing the reliability of HTS machines**

Technical Approach

- Collaborative approach
  - SuperPower - HTS conductor manufacturer
  - Advanced Conductor Technologies - CORC Cable manufacturer
  - Florida State University – Advanced HTS characterization, coil and cable characterization capabilities at variable temperatures and magnetic fields

1. SuperPower will provide HTS conductor batches in long lengths
2. Florida State University will characterize the conductor using "YateStar" to map the density and distribution of defects in field at 65 K
3. Advanced Conductor Technologies will fabricate CORC cables with varying cable designs and winding parameters
4. Florida State University will test the cables and ultimately test coils with CORC cables at 65 K

- Iterations of the process will lead to knowledge of
  - Correlations between defect density and distribution and the performance of CORC cables
  - Relative performance of CORC cables with run-of-the-mill conductor and CORC cables with best available conductor
  - Cable design and winding parameters that produce best CORC cables for motor applications

Transition (beyond DOE assistance)

- Original Equipment Manufacturers are waiting for inexpensive HTS conductor and reliable motor designs
- Success in this project will pave the way to low cost HTS cables suitable for industrial motor applications
- Successful demonstration of CORC cables for motor applications will lead to commercial transition of the technology
  - The HTS conductor and cable manufacturers have strong partnership
  - both companies have strong collaborations and joint projects with the University partner
  - CORC cable technology is rapidly developing with the support from DOE High Energy Physics, DOE Fusion Sciences, and US Navy

Measure of Success

- Successful demonstration of CORC cables fabricated with "unsorted" conductor will lower the cost and increase reliability of HTS machines
- This project will be a success if we demonstrate the current sharing in CORC cables that will enhance the reliability of HTS motors and other coil based applications
- Success will be measured by the reduction in cost of HTS conductors obtained through higher yield
- HTS adoption in industrial motors will significantly increase the energy efficiency of industrial motors – Positive economic and environmental impact

Project Management & Budget

- Duration of the Project: 3 years
- Expected start in July 2017

Total Project Budget	
DOE Investment	$1,000,000
Cost Share	$250,000
Project Total	$1,250,000

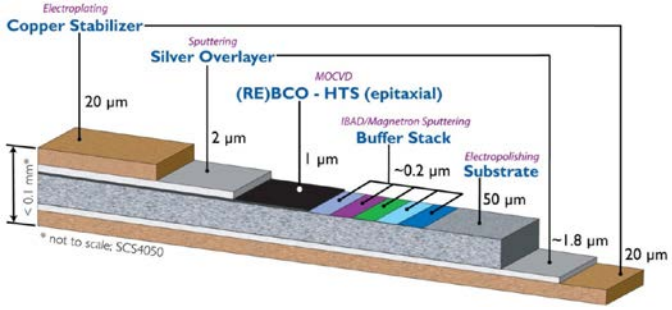
Results and Accomplishments

- The project has not started
  - The Statement of Work has been agreed upon
  - AMO is conducting the final review
  - We expect the project to start in July 2017

Technical Strengths of Project Partners

- Florida State has generated the highest field (42.5 T, 11.5 T REBCO in 31 T resistive) test magnets and is presently commissioning the first >30 T all superconducting magnet (15 T LTS + 17 T REBCO)

- SuperPower provided the coated conductor for both the magnets above



- ACT has contracts for coated conductor cable from 5 customers and has provided the only macroscopically isotropic REBCO conductor made to date, with the highest current density of any HTS cable (344 A/mm² at 4.2 K and 20 T)