DOE Office of Electricity TRAC

Peer Review, February 3, 2022

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

PROJECT SUMMARY

Al/Ca Composite Conductor Characterization

Lightweight aluminum/calcium (Al/Ca) metal/metal composite conductors are being developed to use in mono-type wound cable for low-loss overhead transmission lines, especially for HVDC power transmission. Results revealed high strength, conductivity, and sag resistance (likely) for heavily drawn Al/Ca (11.5vol.%) composite wires with filamentary Ca reinforcement within an Al matrix. Al/Ca cables will compete with cable types, ACSR and ACCR, which use a dissimilar core for strength and exterior Al-alloy for conduction.

PRINCIPAL INVESTIGATOR

Dr. Iver E. Anderson, Senior Metallurgist, Ames Lab (USDOE)

WEBSITE

www.ameslab.gov

The Numbers

DOE PROGRAM OFFICE:
OE – Transformer Resilience and Advanced Components (TRAC)

FUNDING OPPORTUNITY:
Agreement 1.22.510

LOCATION:
Ames, Iowa

PROJECT TERM:
10/01/2019 to 02/28/2022

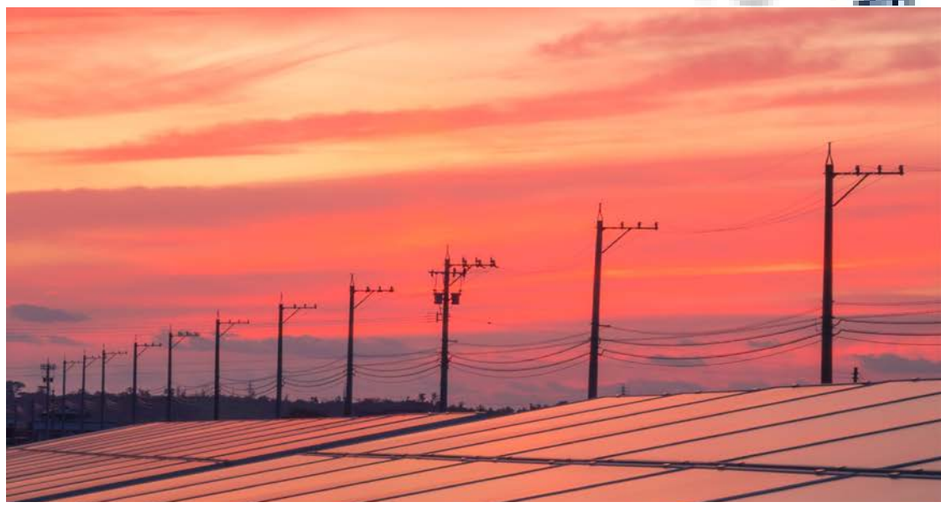
PROJECT STATUS:
Incomplete

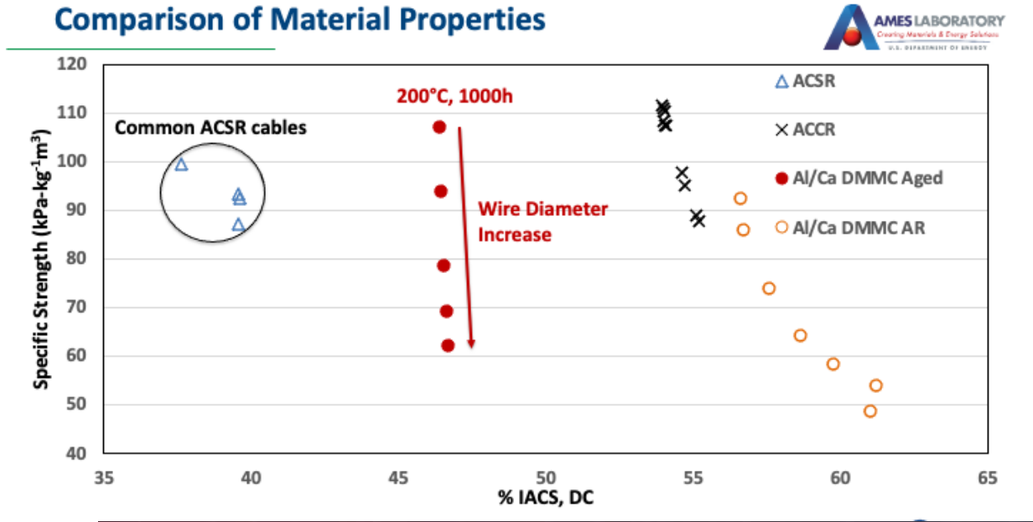
AWARD AMOUNT (DOE CONTRIBUTION):
$400,000

AWARDEE CONTRIBUTION (COST SHARE):
$0

Primary Innovation

- Compared to costly sag-resistant ACCR cables (~5X ACSR cost), strength and conductivity of as-drawn Al/Ca(11.5vol.%) mono-type cable (~2-3X ACSR) is higher in as-drawn form, up to 150C.
- Use above 150C (up to 220C) raises strength (up to 25%) without embrittlement, but conductivity dips to 9%IACS below ACCR (still above ACSR).
- Fortunately, reduced (starting) Ca% raises conductivity (due to increased Al matrix%), but loses some strength. This design flexibility is being exercised and tested to gain further advantage.





Impact/Commercialization

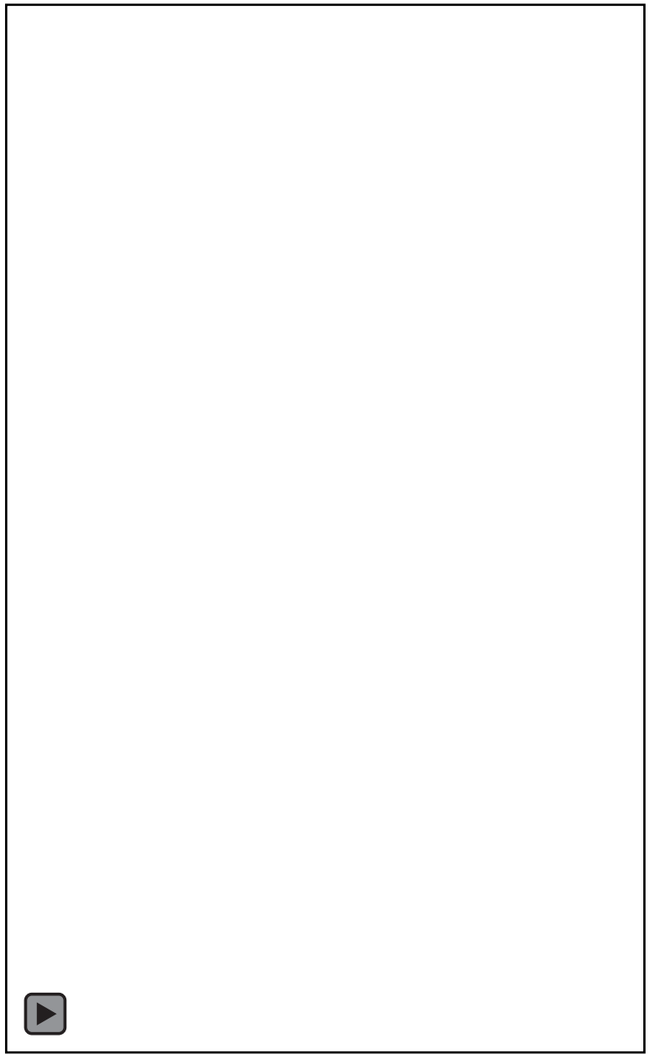
- If Al/Ca composite conductors are fully developed and their properties are verified in cable form, the benefits of this cable can be exploited to build out the US transmission grid with thousands of miles of HVDC and HVAC lines. Calculated estimates show that Al/Ca cable (compared to ACSR Bluebird), will have 12% lower losses and need 11% fewer towers to connect isolated renewable or C-free energy sources to cities/factories.
- Design and plan for full processing schedule and testing is being set with Ca powder (on-hand) and Al powder (from Valimet) to be compacted as short cylinders (@Gamma Alloys), canned (@Ames), warm extruded to billet (@ UAC), drawn to wire (@Fort Wayne Metals), wound as cable (@Southwire), and tested (@UNCC).

IP STATUS: Composite conductor and stranded cable technology granted 2014 US patent and available for license.

Innovation Update

- Achieved pilot-scale quantities of high-quality Ca and Al powders for producing sufficient Al/Ca conductor (1 mm dia.) to test wound cable.
- Developed gas atomization method (planned transfer to Ervin Industries by SBIR) to produce fine (<100 μm) passivated Ca powder in pilot-scale (3 kg) batch, sufficient for conductor/cable fabrication experiments.
- Experimental wire fab/testing also showed that commercial Al powder (from Valimet) has needed purity for Al/Ca conductors.
- Selection of optimum Ca vol.% range for Al/Ca is in-progress on experimental extruded billets with as-drawn wires.

Spray Visualization: Ca Gas Atomization

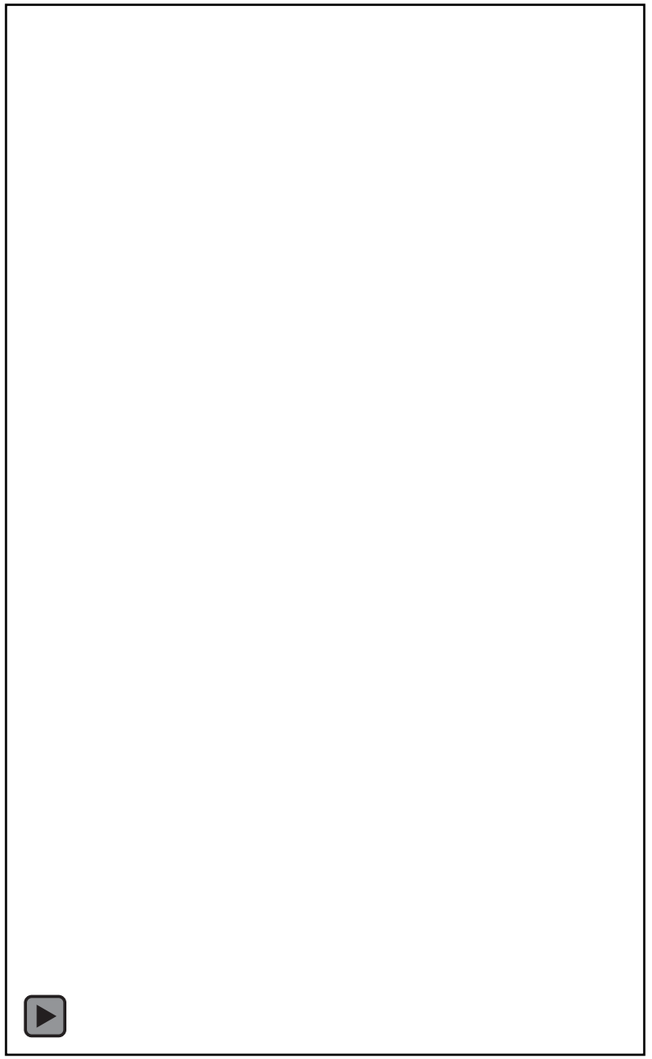


Normal video

- **First Pilot-scale Run: Third run using free fall with Coanda stream stabilization.**

~180 sec

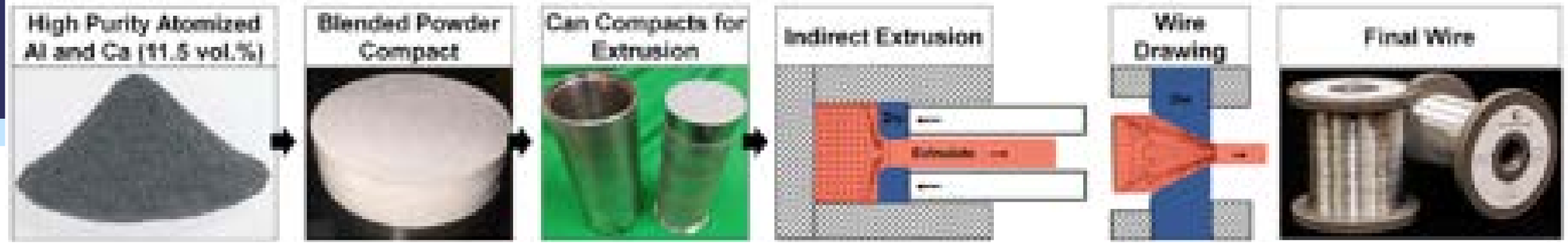
~2767g Ca powder collected



4000 frames/sec.

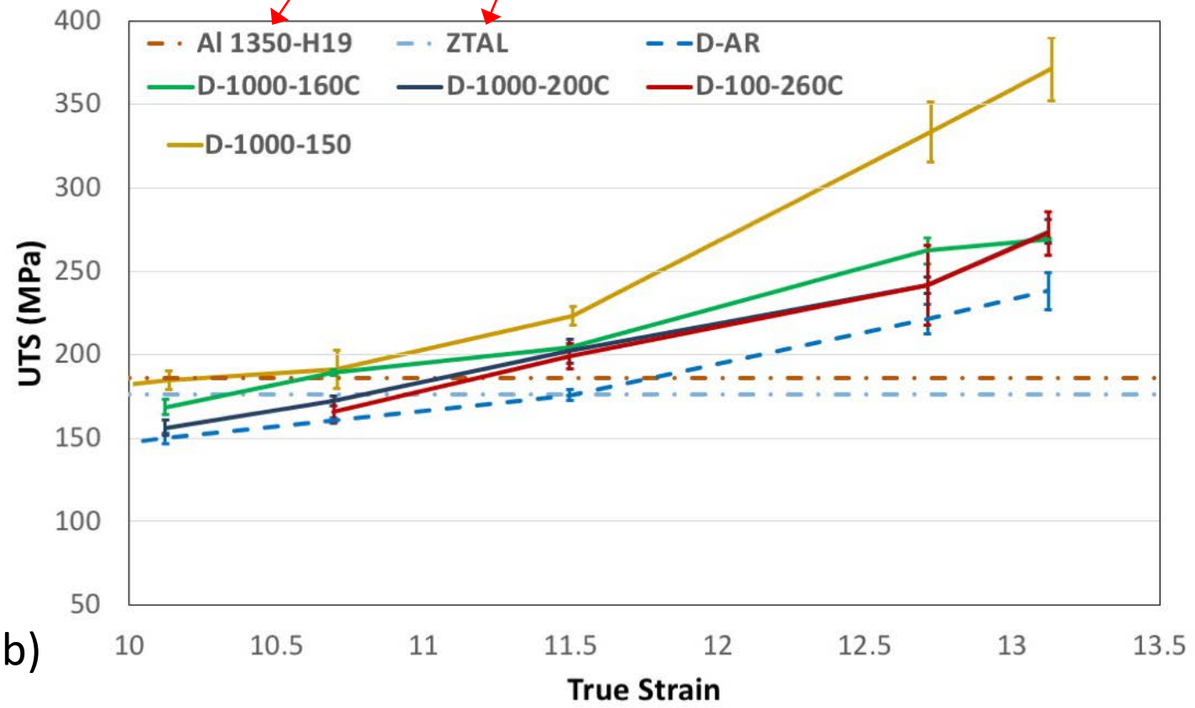
Figures:

a)



Conductors for: ACSR & ACCR

b)



Conductors for: ACSR & ACCR

c)

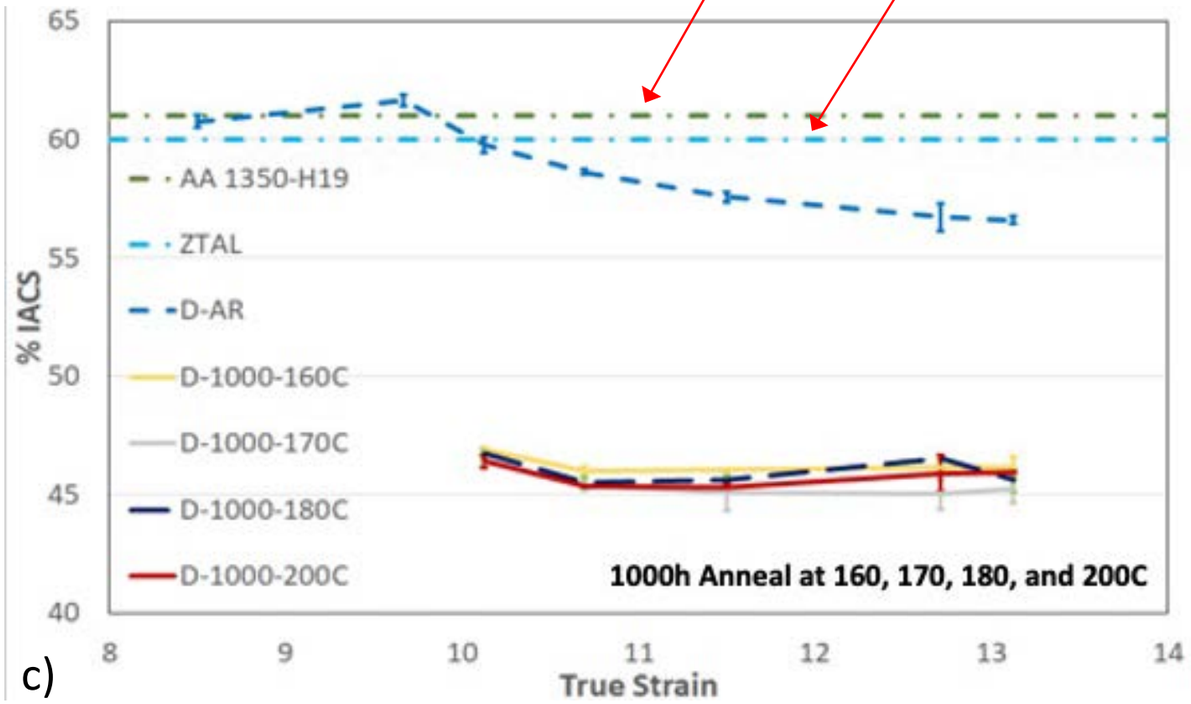


Figure description: Summary of a) complete process schematic, b) UTS results for Al/Ca wire samples comparing as-drawn (AR) to aged at 150, 160, and 200C for 1,000h and 260C for 100h, and c) conductivity results for Al/Ca wire samples comparing as-drawn (AR) to aged at 160, 170, 180, and 200C for 1,000h.

Acronyms

HVDC: High Voltage Direct Current
HVAC: High Voltage Alternating Current
ACSR: Aluminum Conductor Steel Reinforced
ACCR: Aluminum Conductor Composite Reinforced
%IACS: % International Annealed Copper Standard
SBIR: Small Business Innovative Research
UTS: Ultimate Tensile Strength

THANK YOU

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