Competitive Academic Agreement Program

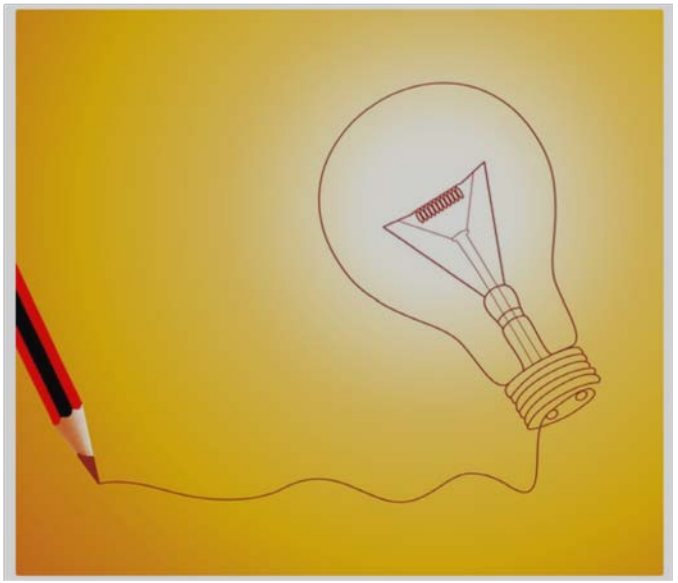
Moderator:

James Merritt

Engineering and Research Programs DOT/PHMSA

Competitive Academic Agreement Program (CAAP) Objectives

1. Spur innovation for pipeline safety
   a) Focus on high risk and high reward solutions
   b) Deliver solutions for possible core RD&D investigations
2. Students involvement
   a) Demonstrate pipeline safety challenges
   b) Illustrating need for engineering solutions to pipeline issues



CAAP Performance

CAAP Summary Totals

Annual Announcement	# Awards	PHMSA	Resource Sharing	# HS Students	# U-Grad Students	# Grad Students	# PhD Students	Total # Students	# Interns (a)	# Career Employed (b)
CAAP-1-13	8	$814K	$353K	1	23	19	16	59	3	4
CAAP-2-14	7	$704K	$391K		4	14	10	28	1	3
CAAP-3-15	11	$2,829K	$888K		15	17	19	51	2	
CAAP-4-16	3	$899K	$368K	*	*	*	*	*		
GRAND TOTALS:	**29**	**$5,247K**	**$2,002K**	**1**	**42**	**50**	**45**	**138**	**6**	**7**

Footnotes:
(a) Denotes the number of internships offered by engineering firms, research organizations, government agencies or pipeline operators to students involved with CAAP research projects.
(b) Denotes the number of full time career employment/jobs offered by engineering firms, research organizations, government agencies or pipeline operators to students involved with CAAP research projects.

* Student info was not available yet

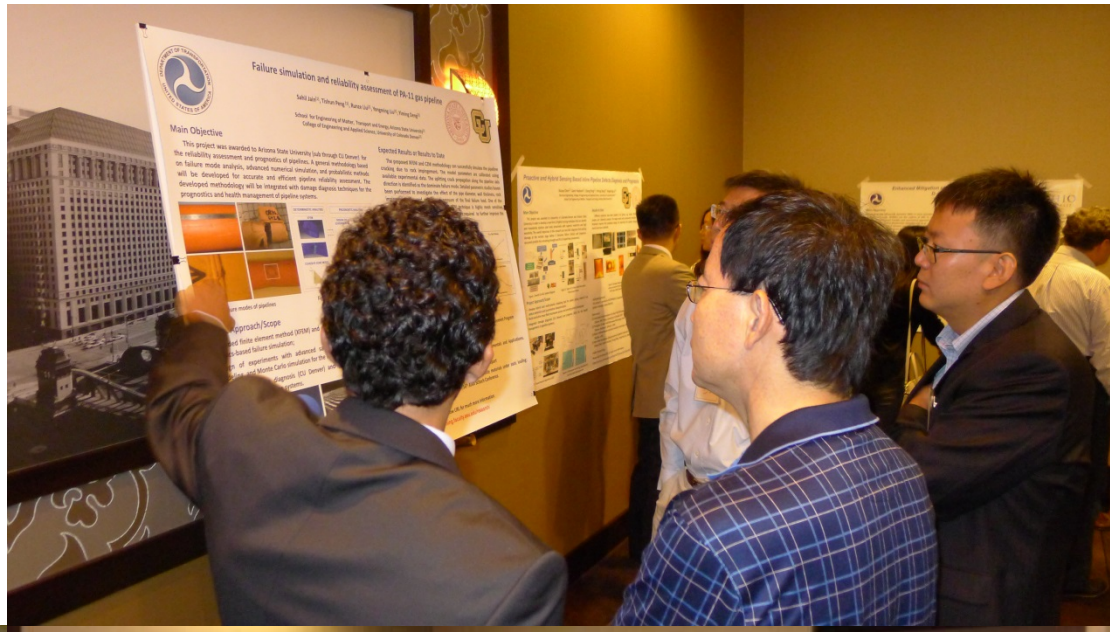
CAAP FY 2016 Awards

University	Award	Project Title	Main Objective
Iowa State University	$299,996	Fundamental Mechanochemistry-based Detection of Early Stage Corrosion Degradation of Pipeline Steels	To develop advanced detection methods to calculate the physical and mechanical changes associated with early stage stress corrosion cracking in high strength pipeline steel.
West Virginia University	$299,999	Glass-Polymer Composite High Pressure Pipes and Joints	To design manufacturing and component-system glass fiber reinforced polymer composite pipes and joints.
North Dakota State University	$300,000	Development of New Multifunctional Composite Coatings for Preventing and Mitigating Internal Pipeline Corrosion	To develop and implement new high-performance multifunctional composite coatings to seek lifetime prevention or mitigation of internal pipeline

2014 R&D Forum: CAAP Poster Session

8 Poster Papers presented to Pipeline Industry & Industry Researchers by:

Texas A&M, U. Tulsa, U. Buffalo, U. Colorado Denver/Arizona State, ND State, Columbia U., Iowa State, Ohio U.



Participating CAAP Student Posters

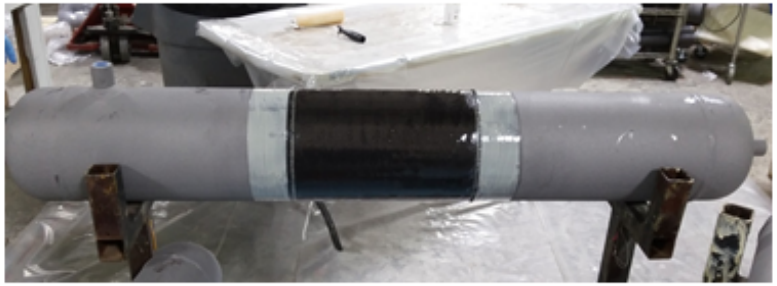
Wall-Breakthrough in Composite Repaired Pipe

PI – Michael Keller, PhD

Student – Omar Ramirez (M.S. Dec 2016)

Objective:

Understand the performance of composite repairs when applied to through wall defects with significant diffuse wall damage



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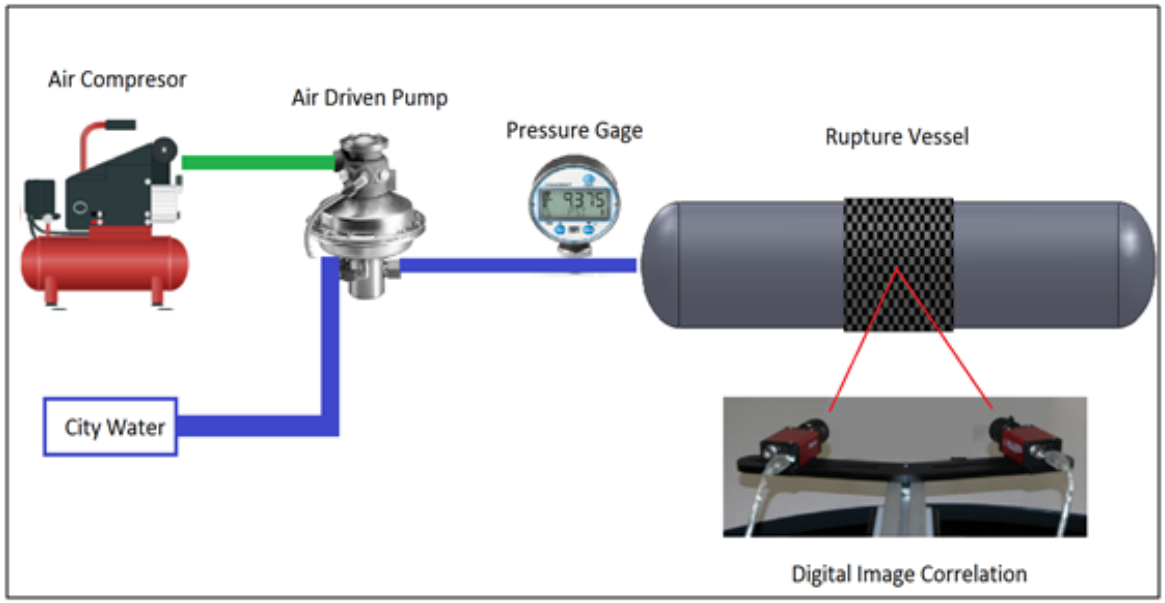
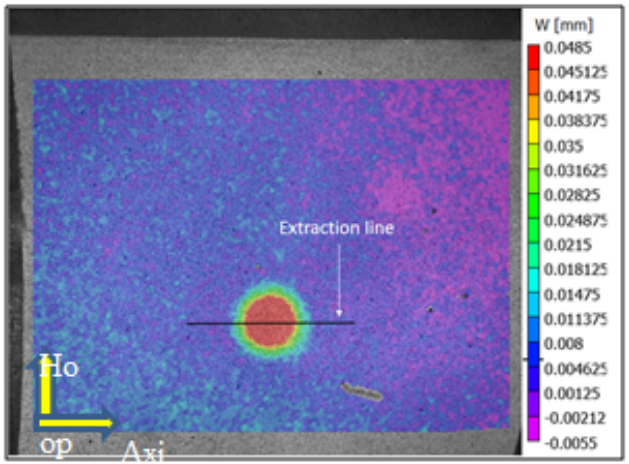
Wall-Breakthrough in Composite Repaired Pipe

- Part of a related project on composite repaired pressure equipment
- Combined Experimental and FEA study





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Electromagnetic Strategies for Locatable Plastic Pipe

- PIs
  - Michael W. Keller – TU Mechanical Engineering
  - Peter J. Hawrylak – TU Electrical Engineering
  - Raman Singh – OSU Mechanical and Aerospace Engineering
- Students
  - Laura Waldman – TU
  - Jordan Trewitt - TU
  - Ravi Venkata - OSU

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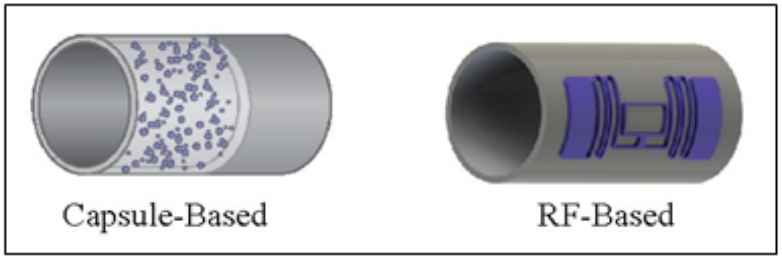
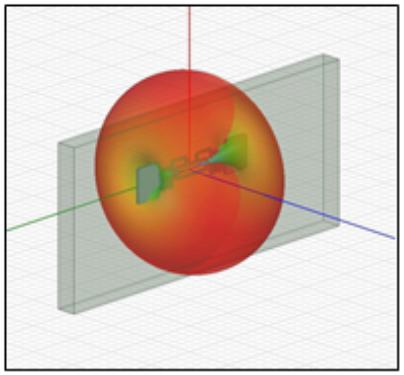
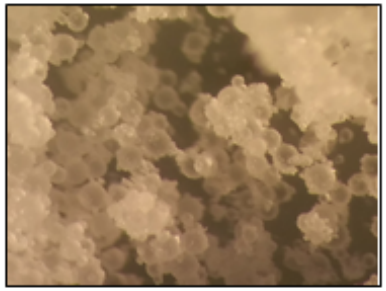
OKLAHOMA STATE UNIVERSITY

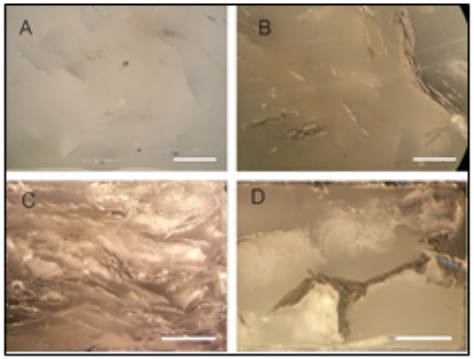
Objectives and Results

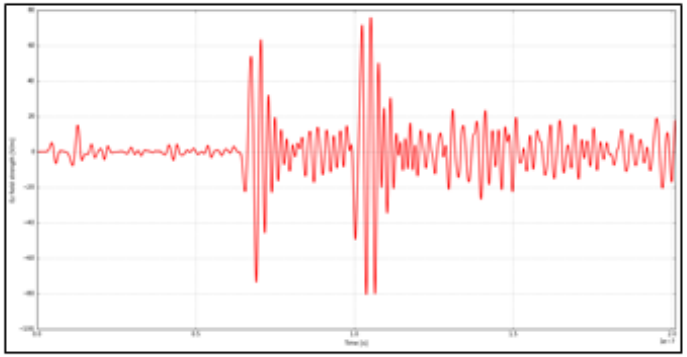
Achieve detection of plastic piping through the addition of simple-to-manufacture electromagnetically active materials and structures in plastic piping











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Small-Scale DIAL for Methane Detection

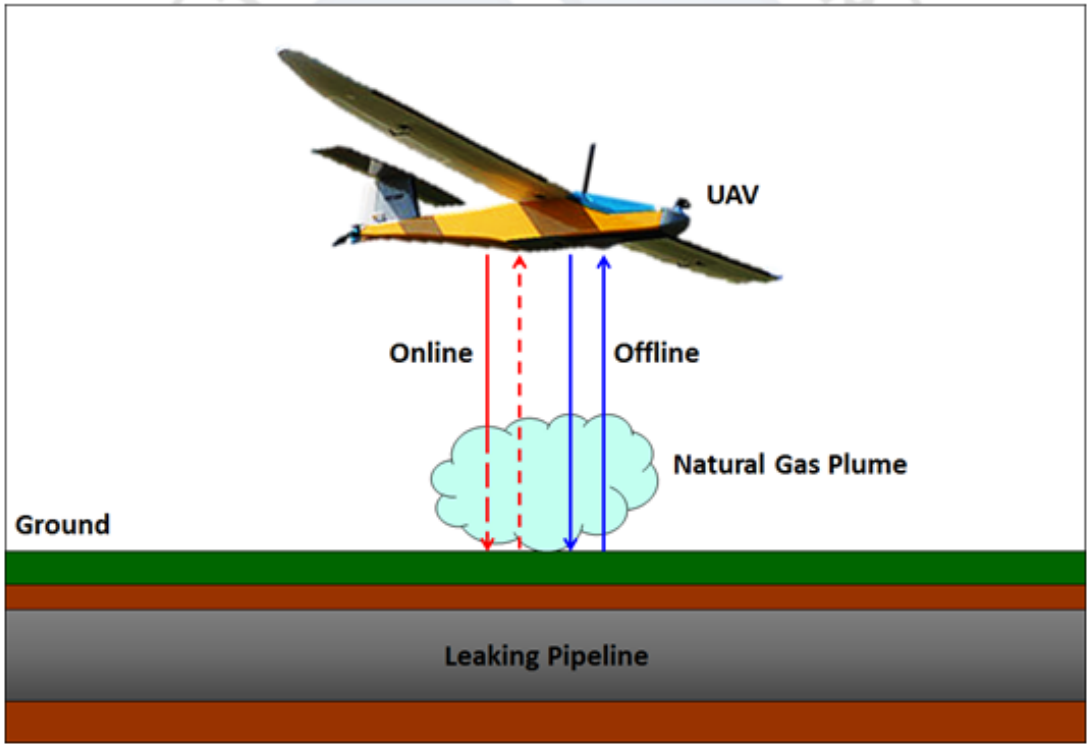
Ashwin Yerasi, William Tandy Jr., William J. Emery

Department of Aerospace Engineering Sciences

University of Colorado Boulder

Objective

To create a design for a UAV-based DIAL system that could be used to remotely detect leaks in natural gas pipelines.



Results

- **Suggested first-order system design characteristics are in place.**
- **Data from other airborne methane DIAL systems is being investigated.**

Methane maps created from Ball Aerospace's ALDL-NG (left) and LaSen's ALPIS (right)

- **Hardware tests to assess the feasibility of compactly generating desired laser beams are underway.**

CAAP 15 – Probabilistic pipe strength and toughness estimation through information fusion with Bayesian updating

ARIZONA STATE UNIVERSITY

- Arizona State University (lead, PI: Dr. Yongming Liu) and Michigan State University (sub, PI: Dr. Yiming Deng)
- Students: Sonam Dahire (ASU), Ankita Kardile (ASU), Xiaodong Shi (MSU)
- Objectives: ***Develop a novel Bayesian network tool to fuse detection information from multimodality diagnosis results for the probabilistic pipe strength and toughness estimation.***
- Tasks and approaches:

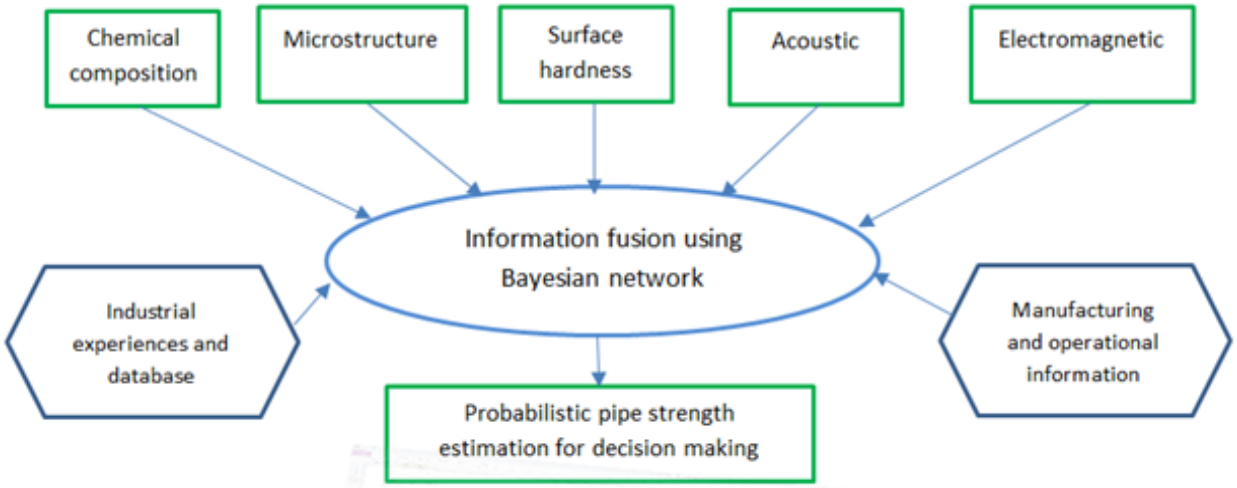
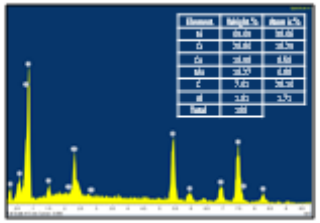
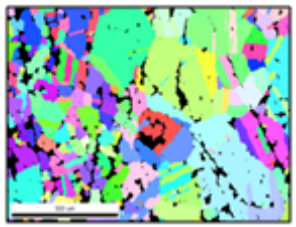
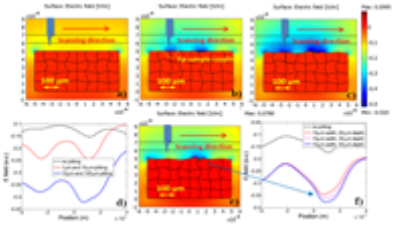


Fig. 1 Schematic illustration of the proposed pipe strength estimation framework

Overall technical review and results

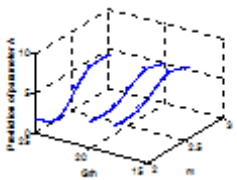
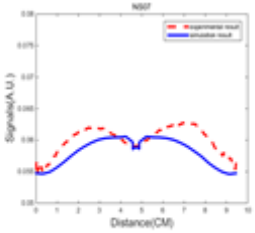
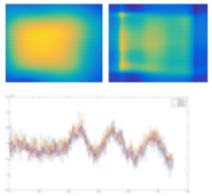
Multimodality detection

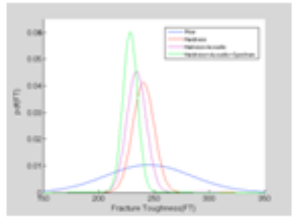
GTI collaborations

x_1 x_2

Data analysis and uncertainty quantification

Bayesian inference and information fusion

Understanding and Mitigating the Threat of AC Induced Corrosion on Buried Pipelines

#DTPH5615HCAP02

Profs. Scott Lillard & Hongbo Cong
University of Akron

Kevin Garrity
Mears Group, Inc.

Stephen Ernst
Marathon Pipe Line, LLC.

Overview

- The goal of this research is to develop new methods for assessing the threat of AC corrosion on buried pipelines. The project has four main tasks:
  1. *Laboratory Studies of AC Corrosion: Interfacial Capacitance (effect of deposits and soil properties).*
  2. *Studies of SCC* and Hydrogen Embrittlement.
  3. *Benchmarking of Critical Parameters at CP Test Facilities.*
  4. *Model development and Validation on In-service Pipelines*.
- The results will impact indirect inspection methods for assessing the impact of induced AC currents on pipeline corrosion rates and could be used for national and international standards such as part of the NACE External Corrosion Direct Assessment (ECDA).

Accomplishments

- Completed laboratory study on the effects of deposits and soil properties on interfacial capcacitance.
  - NACE Corrosion17 paper: "The Influence of Scale Formation on the AC Corrosion of API Grade X65 Pipeline Steel Under Cathodic Protection," E. Ghanbari, R.S. Lillard.
  - PhD Disertation, E. Ghanbari: "Corrosion behavior of buried pipeline in presence of AC stray current in controlled environment," Sept. 2016
- Plan-of-Work for experiments on CP test facilities at Marathon and Mears (La Grange TX facility).
- Two new students hired during summer of 2016:
  - Andrew Moran: *Benchmarking of Critical Model Parameters at CP Test Facilities and In-service Pipelines*
  - *Lizeth Sanchez: Stress Corrosion Cracking*

Advancement in the Area of Intrinsically Locatable Plastic Materials

University and PIs

- West Virginia University
- Udaya B. Halabe, Ph.D., P.E.
- Hota V. S. GangaRao, Ph.D., P.E.

Students on the Project

- Jonas Kavi (Ph.D. Student)
- Benjamin Imes (M.S. Student)
- Andrew Wheeler (M.S. Student)
- Patrick Sisler (B.S. Student)

Research Objective

- Develop, investigate, and compare alternative strategies for creating easily locatable Fiber Reinforced Polymer pipes (using GFRP, CFRP, and carbon nanoparticles).
- Investigate pipe detectability using Ground Penetrating Radar (GPR) and Infrared Thermography (IRT)

Intended Result

- A design for advanced fiber reinforced composite pipe that is easily detectable using above ground sensory technologies

An Inorganic Composite Coating for Pipeline Rehabilitation and Corrosion Protection

(DTPH56-15-H-CAP04)

- **Project Objectives:**
  - Develop an inorganic coating system for protection of pipeline from corrosion and mechanical damage
  - Expose students to subject matter that is important for pipeline safety challenges and engage talent to consider a career in the pipeline industry
- **Project Team**:
  - Dr. Hao Wang (PI); Dr. P.N. Balaguru (Co-PI) at Rutgers University, Dr. Ning Xie at Montana State University
  - Students: Milad Salemi and David Caronia (graduate student) at Rutgers University and Yujun Liang (undergraduate student) at Montana State University

An Inorganic Composite Coating for Pipeline Rehabilitation and Corrosion Protection

(DTPH56-15-H-CAP04)

- **Project Approach and Tasks**
  - Development of Inorganic Coating Formulations
  - Corrosion Testing of Coating with Electrochemical Measurements
  - Durability and Adhesion Testing of Coating
  - Strength Testing of Fiber-Reinforced Coating Composite
  - Analytical Study of Pipeline Strengthening System
- **Expected Results:** A durable, economical, and eco-friendly coating system for pipeline applications
  - Geopolymer material with zero VOC and least CO_2 emission
  - Used in the hybrid coating system for corrosion protection with long-term durability and abrasion resistance
  - Used with fiber reinforcement for repair system

Application of Amorphous Metals for Plastic Pipeline Detection

Contract: DTPH56-15-H-CAP05

Daniel Sprengelmeyer
Christopher Martin
David Dunham
University of North Dakota
Energy & Environmental Research Center
Grand Forks, ND
www.undeerc.org

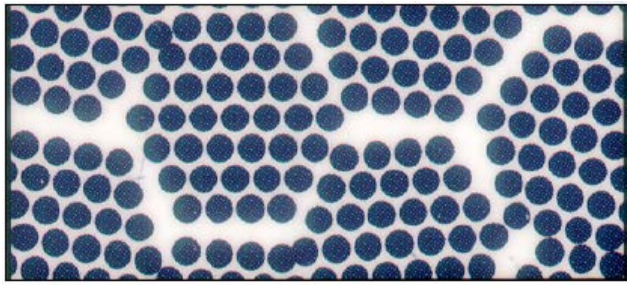
Eric Theisen
Metglas Inc.
Conway, SC
www.metglas.com

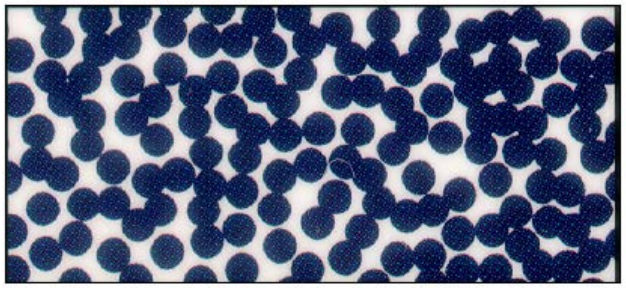
Application of Amorphous Metals for Plastic Pipeline Detection

Objective:

Investigate using the unique magnetic properties of amorphous metals for cost effective locating of plastic pipelines.

Crystalline



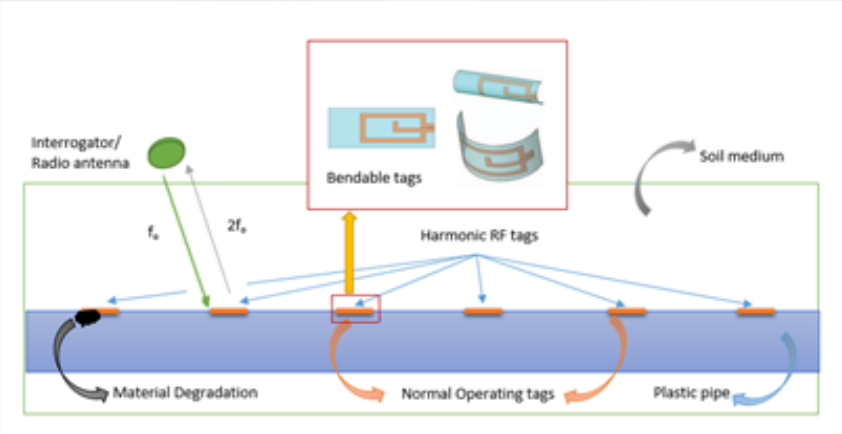


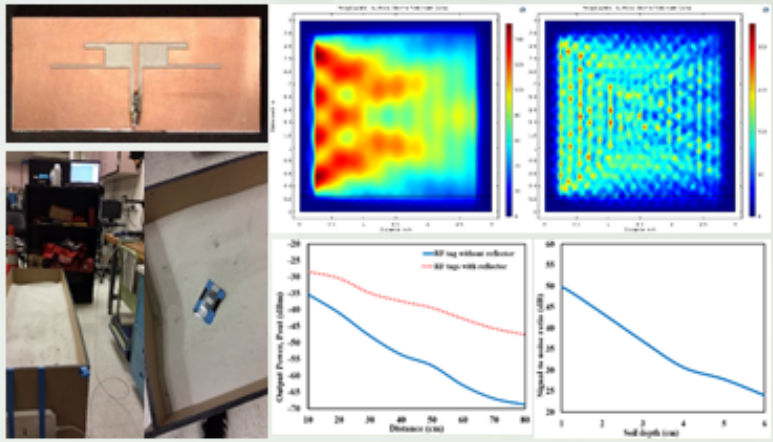
Amorphous

Material	Magnetic Field Relative Permeability
Vacuum	1
Air	≈ 1
Water	≈ 1
Concrete	≈ 1
Copper	≈ 1
Carbon Steel	100
Iron	5000
Amorphous Metals	50,000-1,000,000

CAAP15: Embedded Passive Tags Towards Intrinsically Locatable Buried Plastic Materials

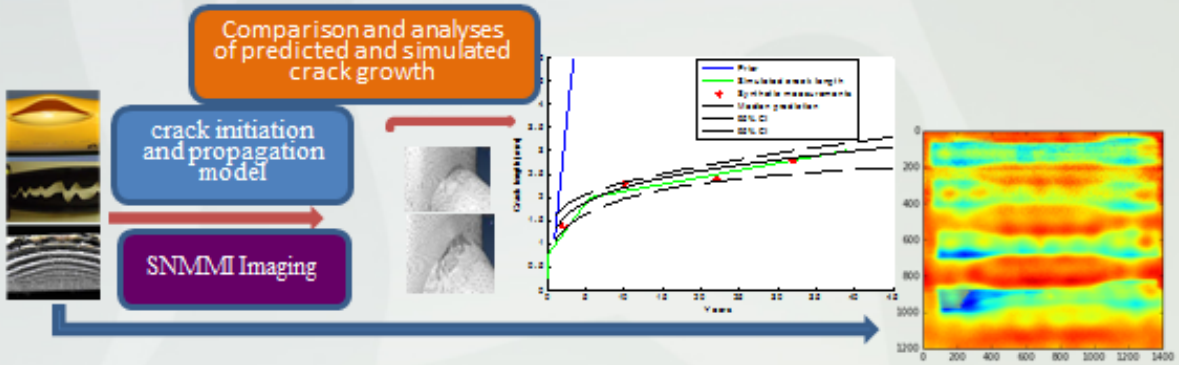
- **Michigan State University** (PIs: Dr. Yiming Deng, Dr. Prem Chahal, Dr. Lalita Udpa) and **University of Colorado, Denver** (PI: Dr. Dan Connors)
- **Students:** Ifwat Ghazali (MSU), Deepak Kumar (MSU), Quang Than (CU), Shuo Zhang (MSU)
- **Objectives:** Design and development of passive harmonic radar RF tags; investigate on-tag sensing capabilities and efficient data transmission; RF tag must be able to withstand high temperature processing of plastic and stress involved with horizontal tunneling/drilling of buried pipes; develop a learning based pipeline hazardous prognostics methodology using discrete sensing data.





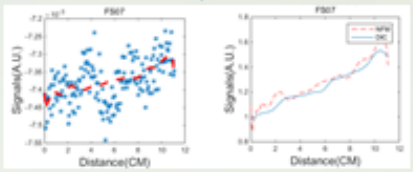
CAAP 14: Optimized Diagnosis and Prognosis for Impingement Failure of PA and PE Piping Materials

- **Michigan State University** (lead, PI: Dr. Yiming Deng) and **Arizona State University** (sub, PI: Dr. Yongming Liu)
- **Students:** Xiaodong Shi (MSU), Deepak Kumar (MSU), Mia Chen (CU), Varun Desai (ASU), Ankita Kardile (ASU)
- **Objectives:** Develop a novel multi-resolution sensing technique that can identify and characterize injurious pipe body proactively and deliver a decision making framework that fundamentally understand and characterize the failure modes and associated material behaviors for modern plastic piping materials with optimized diagnosis and prognosis.



Near-Field Microwave Microscope Probes development

Correlations between SNMMI and DIC data



Mitigating Pipeline Corrosion Using A Smart Thermal Spraying Coating System

PI: Fardad Azarmi

Assistant Professor
Mechanical Engineering Dept.
North Dakota State University

Co-PI: Ying Huang

Assistant Professor
Civil and Environmental Engineering Dept.
North Dakota State University

Graduate Students: Fodan Deng, Ph. D.
Mu'ath Al-Tarawneh, Ph. D.
Civil and Environmental Engineering Dept.
Sahar Abuali Galedari, Ph. D.
Babak Jahani, Master student
Mechanical Engineering Dept.

Funded by U.S. DOT Pipeline and Hazardous Materials Safety Administration
Program Manager: Harold Winnie

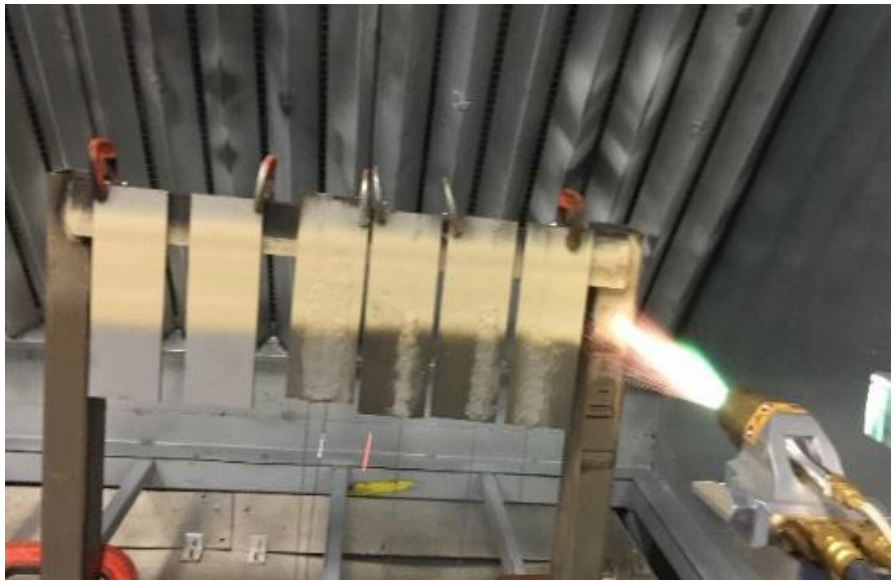
PHMSA
U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

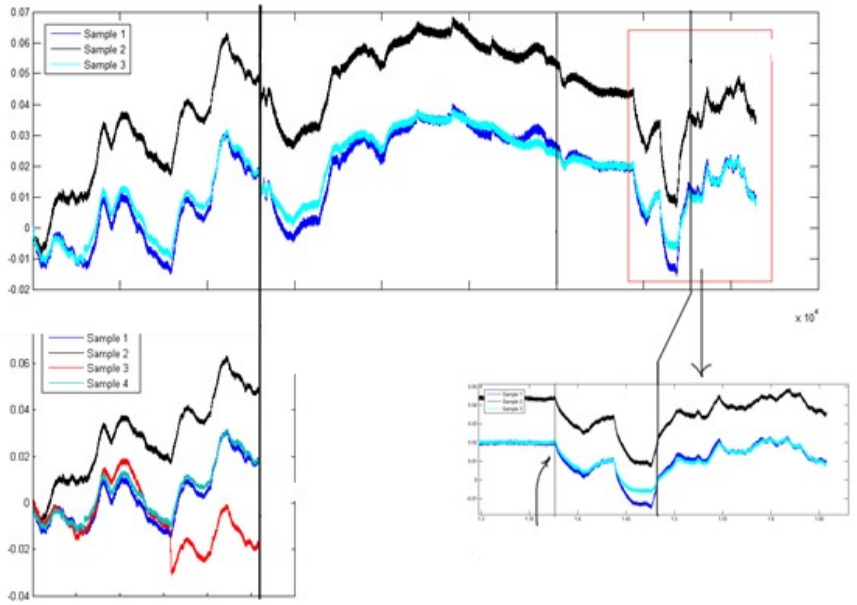
NDSU NORTH DAKOTA STATE UNIVERSITY

Project Planning

❖ ***Objective of the project***

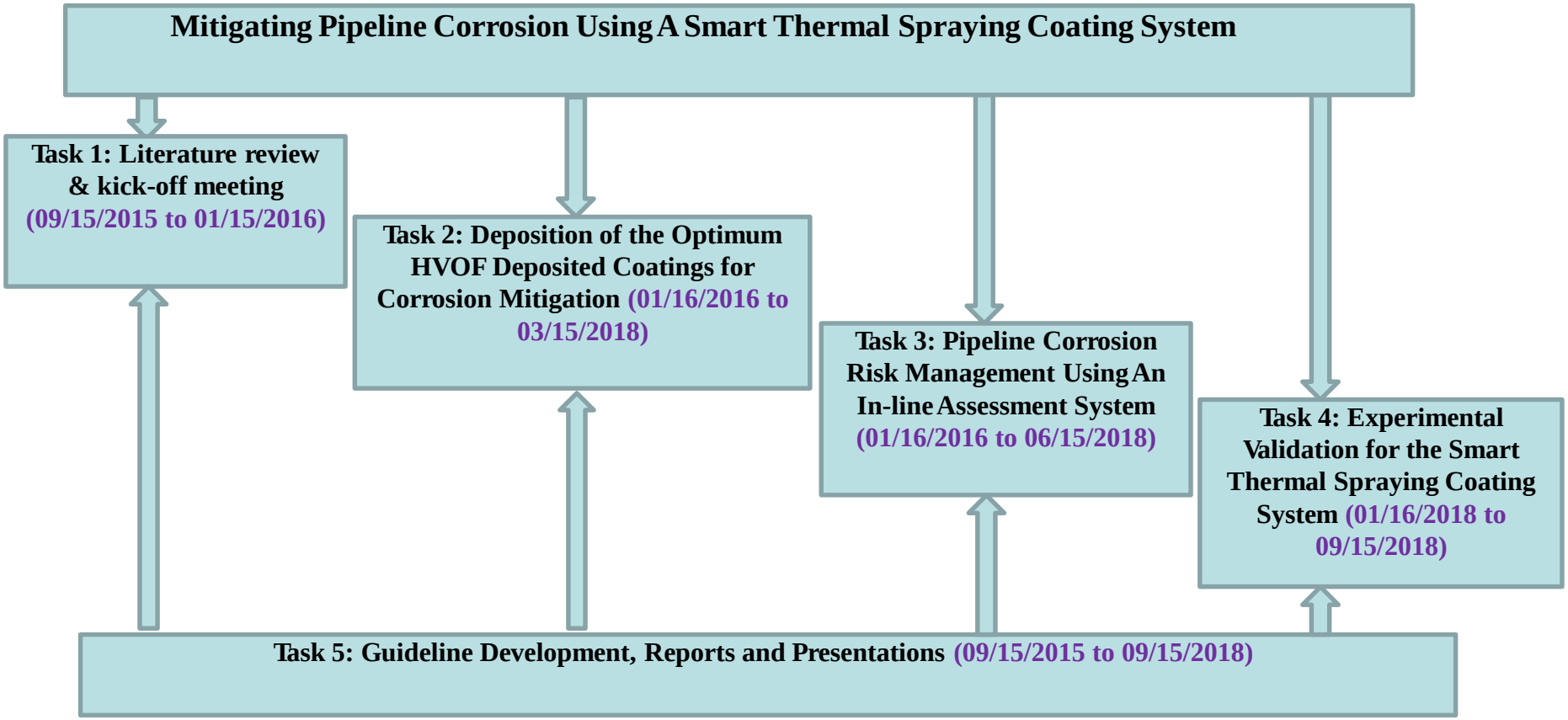
Achieve an ultimate and affordable corrosion mitigation solution for onshore pipelines through the advances of smart thermally sprayed coatings. Thus, systematical study will be performed on various thermally sprayed coatings to obtain the coating with the best performance which is high corrosion resistivity at low cost.





Project Planning

❖ *The flow chart of the task planning*



NDSU NORTH DAKOTA STATE UNIVERSITY

University of Nebraska-Lincoln

Department of Electrical and Computer Engineering

Laser-Assisted Nano-Engineering Lab

Project: Laser Peening for Preventing Pipe Corrosion and Failure

Contract Number: DTPH56-14-S-N000006

PI: Prof. Yongfeng Lu

Post Doc: Leimin Deng

Ph.D. student: Chenfei Zhang

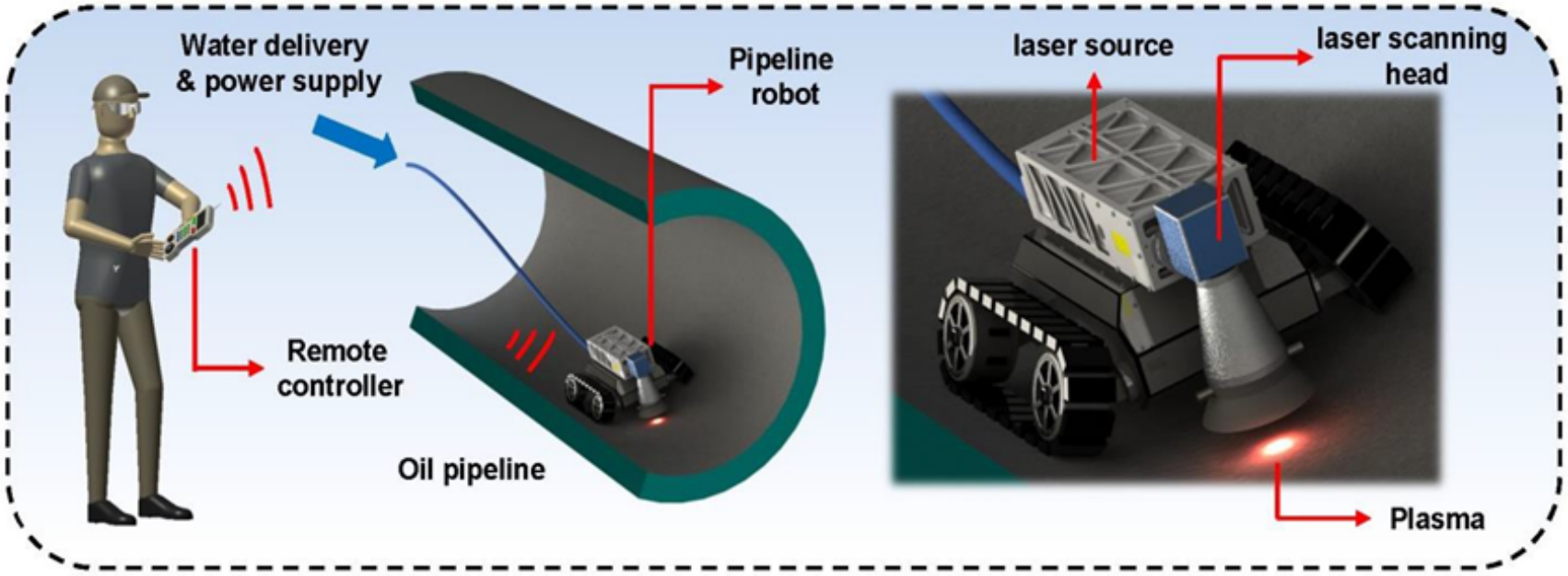
Ph.D. student: Shiding Sun

Web: http://lane.unl.edu Email: ylu2@unl.edu

Laser Peening for Preventing Pipe Corrosion and Failure

DTPH56-14-S-N000006

- The ***goal*** of the proposed work is to investigate and develop laser peening of pipeline steels to improve the corrosion resistance of carbon and stainless steels used for pipeline construction.



The major tasks to achieve the objective of this proposed project are as follows:

I. Develop low energy laser peening for pipeline steels

II. Investigate plasma and shock wave behavior control to enhance peening effect

III. Optimize peening parameters to prevent corrosion and failure of pipeline steels

IV. Design an on-site high speed laser peening system for pipelines

Chemically Bonded, Porcelain Enamel Coated Pipe for Corrosion Protection and Flow Efficiency

Genda CHEN, Ph.D., P.E., F.ASCE, F.SEI (PI of the Project)

Professor and Robert W. Abbett Distinguished Chair in Civil Engineering

Director of System and Process Assessment Research Laboratory

Dr. Chen received his Ph.D. degree from State University of New York at Buffalo in 1992 and joined Missouri S&T in 1996 after over three years of bridge design, inspection, and construction practices with Steinman Consulting Engineers (later merged to Parsons Transportation Group) in New York City. He was granted two patents and authored over 350 publications in structural health monitoring, structural control, interface mechanics and deterioration, bridge engineering, and multi-hazard effects. He received the 1998 National Science Foundation CAREER Award, the 2004 Academy of Civil Engineers Faculty Achievement Award, and the 2009, 2011, and 2013 Missouri S&T Faculty Research Awards. He is Chair of the 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure in 2019, Associate Editor of the Journal of Civil Structural Health Monitoring, Editorial Member of Advances in Structural Engineering, a council member of the International Society for Structural Health Monitoring of Intelligent Infrastructure, and an executive member of the U.S. Panel on Structural Control and Monitoring. He was a member of post-disaster reconnaissance teams after the 2005 Category III Atlantic Hurricane, the 2008 M7.9 China Earthquake, the 2010 M8.8 Chile Earthquake, and the 2011 M9.0 Great East Japan Earthquake. He was elected to ASCE Fellow in 2007 and Structural Engineering Institute (SEI) Fellow in 2013. In 2016, he was nominated and inducted into the Academy of Civil Engineers at Missouri S&T.

Liang FAN (Ph.D. Student on the Project)

Mr. Fan received his M.S. degree from Southwest Jiaotong University, China, in 2014. He then joined Missouri University of Science and Technology as a Ph.D. student. His research interest includes steel pipeline corrosion, organic/inorganic protective coatings, cathodic protection, corrosion-induced failure analysis, and finite element analysis of pipelines. To date, he has published two conference papers and submitted one journal article for review.

Chemically Bonded, Porcelain Enamel Coated Pipe for Corrosion Protection and Flow Efficiency

Main Objectives of Research

The overarching goal of this study is to improve the corrosion protection and safety, and reduce the pressure loss and operation cost of hazardous liquid and natural gas pipelines. To achieve the goal, this study aims to 1) explore and develop chemically-bonded enamel powder coating (100~150 μm) for bond strength and corrosion resistance, and 2) develop and demonstrate a rapid field-applicable coating process for coating uniformity and flow efficiency. The performance objectives will be established and evaluated both experimentally and numerically in the following four research tasks:

1. Optimization of enamel materials for durability, particle distribution, and thermal compatibility with steel
2. Enameling process for coating uniformity, surface roughness, and efficiency without adverse effect on steel properties
3. Characterization of enamel-coated pipes for microstructure/porosity, chemical adhesion, and corrosion resistance
4. System performance of in-situ enamel-coated pipelines - stress distribution under thermal, external and internal pressure, and stress corrosion cracking

Intended Results/Outcomes of Research from Each Task

1. Particle degradation curves of enamel powders between mesh 80 and mesh 150, coefficient of thermal expansion and melting temperatures, and their sensitivities to the mix design.
2. The documentation of advantages and disadvantages of the enamel slurry (wet) and enamel powder (dry) applications; the coating uniformity and surface roughness as a function of the moving speed of spraying gun and heating coils, respectively; and the coating uniformity and surface roughness as a function of the moving speed of a spraying and heating system.
3. The summary microstructure and porosity of the optimized enamel coating, enamel-steel adhesion or enamel cohesion as a function of enamel mix, and corrosion mechanism and evolution of enamel-coated steel with or without damage to the optimized enamel coating.
4. The distribution and level of residual thermal stress at enamel-steel interface, the effect of coating thickness on the residual stress, and the overall stress distribution of the underground pipeline under combined thermal effect, internal pressure, and external pressure.

Thank You!/Program Contacts

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