CAAP Quarterly Report

Date of Report: <*Jan 15, 2016*>

Contract Number: <*DTPH56-15-H-CAP06*>

Prepared for: <Government Agency: U. S. DOT PHMSA >

Project Title: < *Mitigating Pipeline Corrosion Using A Smart Thermal Spraying Coating System* >

Prepared by: <*North Dakota State University*>

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For quarterly period ending: <*Jan 15, 2016*>

Business and Activity Section

(a) Generated Commitments

No changes to the existing agreement.

No equipment purchased over this reporting period.

No purchase made over this reporting period.

(b) Status Update of Past Quarter Activities

During this quarter, a kick-off meeting was facilitated at North Dakota State University in Dec 11, 2015. Accordingly, Task 1 Kick-off meeting in project agreement was performed and completed during this quarter. In addition, the automatic rotational fixer for thermal spray coating on pipes was completed (Task 2, Subtask 2.1 Development of Automatic Rotational Fixture). And a detail literature review for material selection for the corrosion mitigation using coating techniques (Task 2 Subtask 2.2) is ongoing. The results from the development of the automatic rotational fixer are presented below followed by the summary of the performed Kick-off meeting. In the next quarter, more detail literature review will be carried on to collect more information regarding selection of optimum material for coating (Task 2 Subtask 2.2) and progress on quantitative corrosion assessment using the embedded sensors (Task 3 Subtask 3.1).

1) Kick-off meeting (Task 1)

A Kick-off meeting was held on Dec 11, 2015. The PHMSA project manager, Mr. Harold Winnie visited NDSU campus and attended the Kick-off meeting. The meeting agenda and activities are shown in Table 1. PI meeting, with students involved in this project, and tours to labs and facilities were arranged during the Kick-off meeting. The important issues regarding the project were also discussed during the meeting as well.

Table 1 Kick-off Meeting Agenda

Meeting Title	Kick-off Meeting PHSMA Project Manager from NDSU
Date & Times	December 11st, 2015
Location	NDSU- College of Engineering, ME and CEE Departments

Objective(s)

1) Perform the project within expectations of PHMSA.
2) Communicate the project objectives, tasks, and schedule with the PHMSA.
3) Meeting with NDSU Personnel (Department Chairs, Dean of College of Engineering, PIs, Researchers, and Students).
4) Visit NDSU facilities, Labs, and equipment required for the project.

Participants:

ME Department	**CEE Department**	***COE***	***PHMSA***	***Students***
-Fardad Azarmi (PI) -Alan Kallmeyer (Chair) - Mehdi Salimi Jazi (Post-Doc Research Associate)	-Ying Huang (Co-PI) -Dinesh Katti (Chair)	-Garry Smith (Dean)	- Mr. Harold Winnie (Project Manager)	-Sahar Abuali (Ph. D. student) -Fodan Deng (Ph. D. student) -Babak Jahani (Master student) -Mu'ath Al-Tarawneh (Master student)

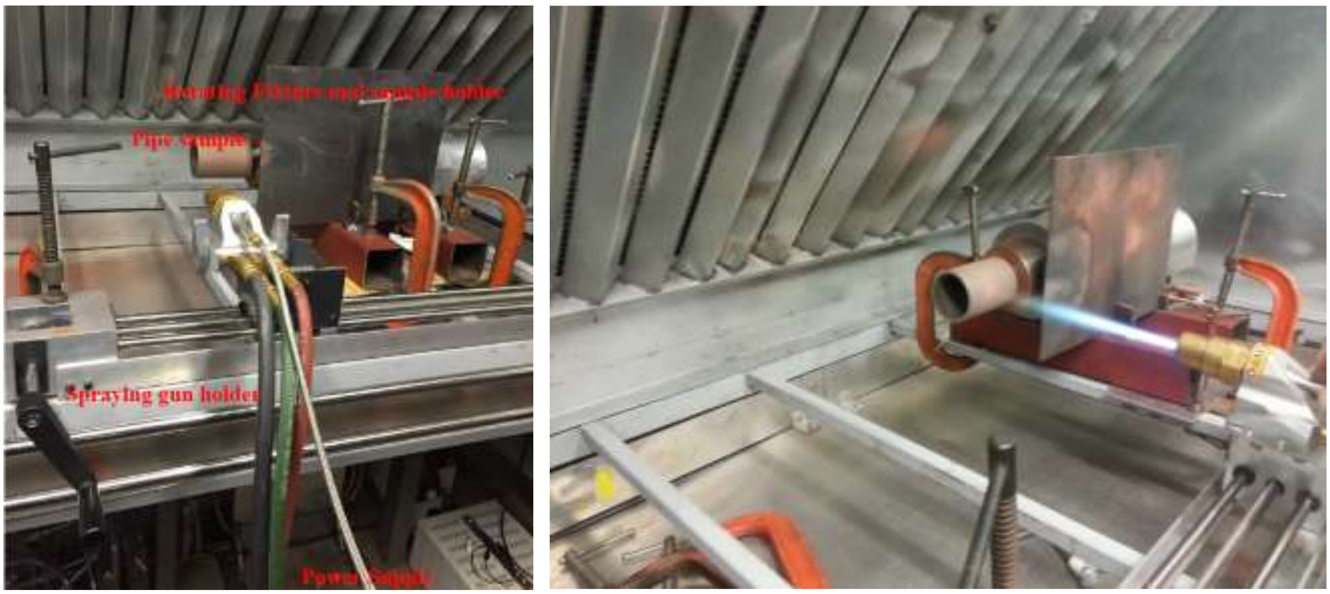
Topics

1) Entrance Meeting (8:30-10:00)-COE 106
   a. Introduction of Project Personnel (PIs and Students)
   b. Agenda Review
   c. Visit Objectives
   d. Presentation by PHMSA Project Manager (Optional)
2) Tour of CEE Labs (10:00-10:45)
3) Tour of ME Department Labs & HCRL (11:00-11:45)
4) Lunch with Fardad Azarmi and Ying Huang (12:00-13:30)
5) Meeting with Chairs (ME and CEE Departments) and Dean (COE) (14:00-14:30)-Meadow-Memorial Union
6) Meeting with PIs (14:45-15:30)- Meadow- Memorial Union
   a. Presentation (Project Plan) by PIs
   b. Discussion
   c. Guidelines and standards
7) Exit Meeting (15:30-16:00) – Meadow-Memorial Union
   a. Review of general findings
   b. Q & A.

Next Steps *(to be completed at meeting)*

2) Development of Automatic Rotational Fixture (Task 2, Subtask 2.1)

An automatic rotating fixture capable of holding round objects in front of spraying gun was designed and optimized during the first quarter of the project. This fixture can hold and rotate pipes in front of spraying gun during coating deposition. Figure 1 (a) shows the newly designed spraying set-up for deposition process. The new fixture includes an adjustable pipe fixing holder, a rotational axle connected to a speed-controlled power supply, and a screw driven custom made movable spraying gun holder. Pipes with inner diameter from 1 inch to 12 inches can be placed on the holder for coating deposition. The pipe can be rotated at various speeds from low to high during the spraying process to meet the requirement for different spraying thickness. The spraying gun holder could move horizontally at constant speed to provide a uniform deposition on the surface of the pipe samples. The spraying setup containing the pipe and gun holder are shown in Figure 1 (a) while spraying process is shown in Figure 1 (b).



(a) (b)

Figure 1(a) Setup for automatic rotational fixture for HVOF spraying and (b) spraying process.

3) Literature review on coatings for corrosion mitigation (Task 2, Subtask 2.2)

Various coating techniques can be applied to assist corrosion mitigation for steel pipes, including polymeric and metallic coatings.

Polymeric Coatings: Polymer based coatings showed good performances on corrosion mitigation by separating the metal pipes from the surrounding corrosive environments. Polymeric coatings using coal tar[1] were applied to pipelines before 1970s. However, since the coal tar coatings were not environmental friendly and difficult to apply in practice, they were replaced by Solid Rigid Polyurethane (SRP) coatings[2] after 1970s. The SRP coatings provided relatively safer, faster, stronger, and easier to apply coatings, but thin SRP layers may fail at long-term service. Therefore, thicker layered polymer based coatings were developed in 1990s using polychloroprene[3], Fusion-Bonded Epoxy-(FBE)[4], and 3-layer-polyurethane (3LPE) [5]. Combined with concrete, the FBE or 3LPE coatings were widely deployed in off-shore pipeline industry. Although mitigate corrosion effectively, these thick polymer coatings have a high cost and high potential for initial defects in the polymer layer. These initial defects would degrade over time and fail the corrosion protection of the coating. These limitations of polymeric coatings open potentials for the development of metallic coatings.

Metallic Coatings: Metallic coatings which are mostly deposited by thermal spraying techniques had also been investigated for corrosion protection in modern manufacturing such as electronics and aerospace[6]. Gaining interests in thermal spraying of metallic coatings were expanded to the corrosion mitigation for off-shore pipelines [7, 8] and successfully applied to waste related structures such as Mormon Flat dam[9, 10].

The thermally sprayed metallic coatings can act both as cathodic protection and separation layer. The cathodic measures of these metallic coating drastically reduced the dependence on external supplemental anodes. In addition, the thermal sprayed metallic coating could also significantly enhance the service time of the pipelines in harsh environments. Although the equipment for thermal spraying seems to be expensive, in long term, the high performance of the developed coating makes this process to be a cost-effective corrosion mitigation method. Generally, the thermally sprayed coatings have shown better protection and longevity compared to the other traditional coating technology. Although under development by this research team[11], more investigations on thermal sprayed coatings to effectively mitigate the onshore buried pipelines are still in great needs before their potential field applications.

(c) Description of any Problems/Challenges

No problems are experienced during this report period.

(d) Planned Activities for the Next Quarter

The planned activities for next quarter are listed as below:

1) A scientific material selection for appropriate thermal spray coating materials of pipeline corrosion mitigation (Task 2 Subtask 2.2);
2) Data analysis for quantitative corrosion assessment using the embedded sensors (Task 3 Subtask 3.1).

References:

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4. AWWA C213-96, "Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipeline," AWWA, Denver, CO., 1996
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