PHMSA Internal Quarterly Report

Date of Report: *5th Quarterly Report- December 20th, 2024*

Contract Number: *693JK323RA0001*

Prepared for: *PHMSA, Government Agency: DOT*

Project Title: *Dual Purpose PIG for Cleaning and Internal Integrity Assessment for Hazardous Liquid Pipelines*

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1.1. Team Project Activity 1: Task 2: Development of the Attachment Set for Transferring the Cleaning Pigs into Dual-purpose Pigs

The previous version of the attachment for the Dual-Purpose Pig successfully met the requirements outlined in the proposal. Building on this success, the research team is continuing to optimize the design and aims to develop additional models to support both research advancements. The first part of this report provides a detailed processes involved in the development and fabrication of the updated Version 2 attachment. The design for this version was outlined in the previous report (Q4). Additionally, the test facility for pressurized water has been successfully completed and is now fully operational. Subsequently, the NDSU team conducted tests using both the Version 1 and Version 2 attachments under pressurized water conditions. Both attachments successfully withstood the operational stresses as the pig was propelled by pumped water, and they captured video footage of sufficient clarity for inspection purposes. The images and videos obtained during these tests will play a crucial role in image analysis and machine learning processes integral to this project.

1.1.1. Fabrication of the Version 2 Attachment (Task 2.1)

The last two reports (Q3 and Q4) detailed the design process and fabrication of the Version 2 housing (attachment). The completed fabrication of the Version 2 attachment, produced by the Mechanical Engineering Department at NDSU. Once fabrication was completed, the Version 2 attachment was integrated with the necessary accessories identified during the design phase to ensure compatibility. The final assembly was then mounted onto the pig and tested for functionality.

1.1.2. Experiment Setup for the Pressurized Water Condition (Task 2.2)

The design layout for the pressurized water test facility was introduced in the previous report (Q4). In this report, the facility was successfully fabricated to simulate real-world pipeline conditions and utilized for experimental testing.

1.1.3. Performance of Dual-Purpose Pig in Pressurized Water Testing (Task 2.2)

The primary goal of the pressurized water testing was to assess whether the designed attachments could successfully capture the images inside the pipeline and evaluate its ability to navigate the bend. The testing involved separate evaluations of the Version 1 and Version 2 housings to compare the quality of images captured from the pipeline. This approach provided critical insights into the performance and functionality of each housing design under pressurized conditions.

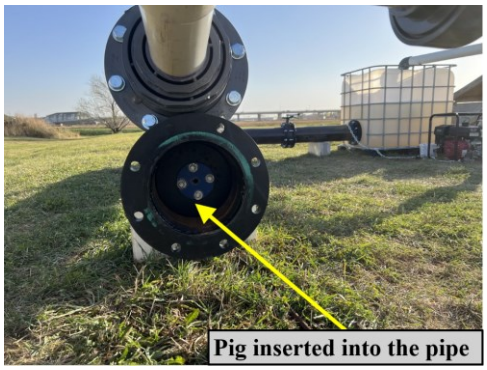

Figure 1. Image showing the insertion of the dual-purpose pig into the 8-inch pipe at the start of the testing.

The attachment successfully captured clear images of the pipeline walls, even in the presence of dirt and murkiness in the water, which simulated typical pipeline conditions. The pipeline walls were distinctly visible in the recorded videos, demonstrating the attachment's effectiveness in challenging environments. Images captured from within the pipeline were evaluated to further assess the performance of the Version 2 housing under pressurized conditions.

1.2.Team Project Activity 2: Task 3: Machine Learning based Computer Vision Analysis for Pipeline Integrity Assessment of Hazardous Liquid Pipelines

1.2.1. Pipeline Integrity Assessment Based on Computer Vision Analysis (Task 3.2)

After collecting images from various sources, including online resources and lab testing, their quality was enhanced using techniques such as image inpainting, which was employed to remove unwanted text from the images. These processed images were then utilized to develop an object detection model. However, certain defect types with limited image availability, such as leakage, were excluded from the modeling process due to insufficient data. Additionally, some defect categories with overlapping characteristics were merged. For instance, images of broken pipes were classified as severe cracks, leading to the integration of these images into the crack category. As a result, four defect categories were modeled: cracks, corrosion, settled deposits, and root insertion. The model was tested on one of the videos that were gathered from online resources. The results were in accordance with our assumptions. Although the crack class showed signs of overfitting, the model was unable to detect the corrosion at any level. Figure 2 shows the implementation of the model.

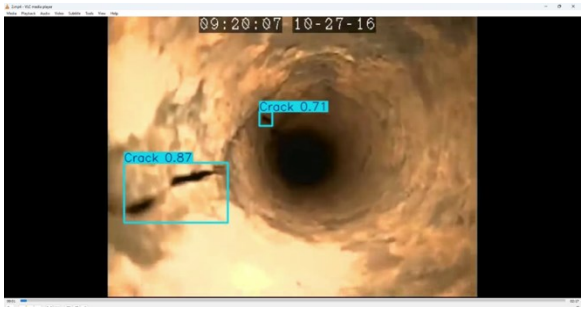

Figure 2. Testing of the overfitted model on a collected video from internet.

1.3.Team Project Activity 3: Task 4: User-friendly Software Development for the Dual-purpose Pig and Economic Analysis

1.3.1. Development of the User-friendly Software (Task 4.1)

During the reporting period, this task focused on integrating comprehensive computer vision into a user-friendly interface through the development of associated software. This effort utilized the attachment set developed in Task 2 and the image analysis conducted in Task 3. Significant progress has been made in software development, including the creation of key components such as a homepage, login page, video list page. The goal of the software is to present recorded images in a streamlined format, emphasizing only essential information such as potential defects, their locations, and the estimated dimensions of detected anomalies.

2. Project Schedule –

After thorough evaluation of the project progress and careful, we confirm that the project is currently on time, aligning with our projected timeline and milestones.