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Title: SE 296 Capstone Project Proposal for Katelyn Yeamans UCSD Fall 2018

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1. Scope

This project shall be a comprehensive evaluation in the changes in the physical attributes of PETN pellets when stored for prolonged periods under typical storage conditions. The scope of this project is intended to meet the Capstone Project requirements of the UCSD Structural Engineering Master's Degree and provide useful insight for pellet production and processing. The intended result is a summary report and an accompanying MATLAB program file. The duration of this investigation is not to exceed twelve weeks. If the project cannot be completed within the given time frame, report documentation shall consist of progress-to-date and recommended future work summary and a to a progress-to-date version of the MATLAB file.

2. Introduction

In 2001, a quantity of 200 small pellets of PETN were pressed using standard explosive pressing techniques. The pellets were evaluated for height and weight, with the diameter determined by the pressing cavity. From the gathered dimensions a density was calculated for each pellet. The pellets were then packaged in standard storage trays: 50 pellets per tray, each in its own well, each tray covered by a clear plastic lid. Each tray was then placed in a large polyurethane bag with 8 units of desiccant material and a humidity indicator card. The poly bag was double heat sealed at both ends, then placed in the storage bunker. Recently, a single tray of the pellets was removed from the bunker and the pellets were measured for diameter, height, and weight using similar methods as when originally evaluated. The questions to be answered by this investigation are what, if any, effect has the long term storage of these pellets had on their physical attributes and are resulting changes expected to affect the performance of the pellets.

3. Structural Health Monitoring (SHM) Component

This project will approach the inherent statistical pattern recognition issue of evaluating damage to the pellets using SHM definitions and methodology. Some parameters of the project, such as the data acquisition portion, were limited by the allowable methods for explosives handling and have already been completed.

A. Operational Evaluation and Environmental Effects

i. What are the life-safety and/or economic justification for performing the SHM?

Pellets with changes in shape are unlikely to perform as required, either due to chemical changes within the explosive or failure to fit next level assembly caused by changes in physical geometry. If the pellets are not the correct size, they will be unusable, and if they do not perform as expected, the results of costly experiments will be deemed unacceptable.

Abundant moisture absorption may also cause the PETN to behave in an unpredictable manner, making it a safety hazard during handling and storage. If there is no statistically significant change in the pellets after the long storage duration, an economic benefit may be gained by pressing pellets when other production demands are low and resources are readily available.

ii. How is damage defined for the system being investigated, and, for multiple damage possibilities, which cases are of the most concern?

Damage is defined as the absorption of moisture resulting in changes to the physical dimensions of the pellets to an extent that the chemical composition is fundamentally changed or the pellet exceeds tolerable part geometry. Of the two damage possibilities (physical or chemical), changes to the physical attributes of the pellets are the most concerning.

iii. What are the functional conditions, both operational and environmental, under which the system is to be monitored?

The physical traits of the pellets are evaluated in a temperature and humidity controlled environment, but stored in non-controlled bunkers with only desiccant packets within the sealed tray volume to moderate humidity conditions. Because the actual operation of the pellets results in their destruction, the operational functional condition for the purpose of this investigation will be defined as the pellet in an unrestrained resting state within its individual compartment of the standard storage tray. Monitoring will be focused on this operational condition of the pellets and is mostly affected by the bunker storage conditions; conditions that also define the environmental functional conditions. For safety reasons, the pellets must be removed from the operational condition to a controlled environment when actually measuring the pellets.

iv. What are the limitations on acquiring data in the operational environment?

Power supply to the storage bunkers is limited, and because the pellets are made from PETN explosive material, care must be taken to limit their exposure to electrical current, shock or impact loading, and extreme high temperatures. Access to the storage areas is also restricted, as are computational devices. The bunkers themselves have no monitoring systems, so it will not be possible to correlate the environmental conditions to the operational condition of the pellets.

B. Data Acquisition & Normalization

The data acquisition portion of this project was completed using approved methods and instruments for the safe handling and manipulation of explosive materials. For the initial measurements the mold used to form the pellets controlled the diameter, with the height of the pellet measured by an indicator-over-base and a high accuracy scale used to collect the weight of the pellet. An indicator-over-base and scale calibrated to the same specification as the tool used for the initial measurements was used to measure the height and weight of the pellets for the recent data set. A micrometer was used to measure the diameter of the pellets for the recent data collection, because re-inserting the pellets into the mold would only provide go/no go results and posed a high risk of damage to the pellets. All data was recorded by hand into an Excel workbook. MATLAB will be used to process the data.

As mentioned previously, the storage conditions for the pellets are not tracked, which will make data normalization relative to the bunker environment difficult. Data may be normalized by tray or by changes in the physical attributes of the pellets relative to the initial measurement conditions. Resources are not available to re-perform measurements if there are uncertainties in the collected data, so finding a promising method of data normalization will be a key aspect of this project.

C. *Features & Damage Detection*

The scope of this investigation limits the potential feature identification to those which may be determined from the collected data. From the size and weight of the pellets, the feature of physical change in these parameters must be extracted. Damage will be defined as either significant variation in a pellet's shape from the initial measurement to the newer data point or changes to the parameters that exceed the allowable tolerances for pellet geometry.

D. *Statistical Model Development*

Because the state of the pellets is either "good" for the initial measurements or "unknown" for the subsequent measurements and because outlier or novelty detection is the primary intention of this investigation, the basis for the initial statistical model development will be a cluster-based unsupervised learning model. This approach may change if anomalies or trends in the data indicate a different approach would more accurately assess or predict the operational condition of the pellets.

4. Schedule

The following schedule represents a ten week course of evaluation. An additional two weeks may be used prior to submission for review. Review to time-to-issue is not included in the schedule, and the final report may be submitted for grading after September 28, 2018 pending review release.

July 23rd – Aug 10th

- Organize initial pellet measurement data and extract basic statistical properties
- Identify and remove statistical outliers and perform basic statistical tests to develop baseline values
- Identify coding approach (algorithm selection)
- PETN research literature review

Aug 13th – Aug 31st

- Build program to characterize data based on ½ number of initial measurements
- Test program with remaining half of initial measurement data

Sept 3rd – Sept 21st

- Test new measurement data, troubleshoot as necessary
- Analyze results
- Draft report

Sept 24th – Sept 28th

- Finalize report & submit for review
- Submit report for grading

5. Resources

Resource values are based on the ten week schedule proposed above, with one one-hour mentor meeting at the conclusion of each schedule phase:

100 Student Project hours
4 Mentor hours
10 Reviewer Processing hours
Software: MATLAB License
Including Statistics and Machine Learning & Neural Network Toolboxes