PROPULSION ENERGY FORUM

24–26 August 2020
Virtual Event

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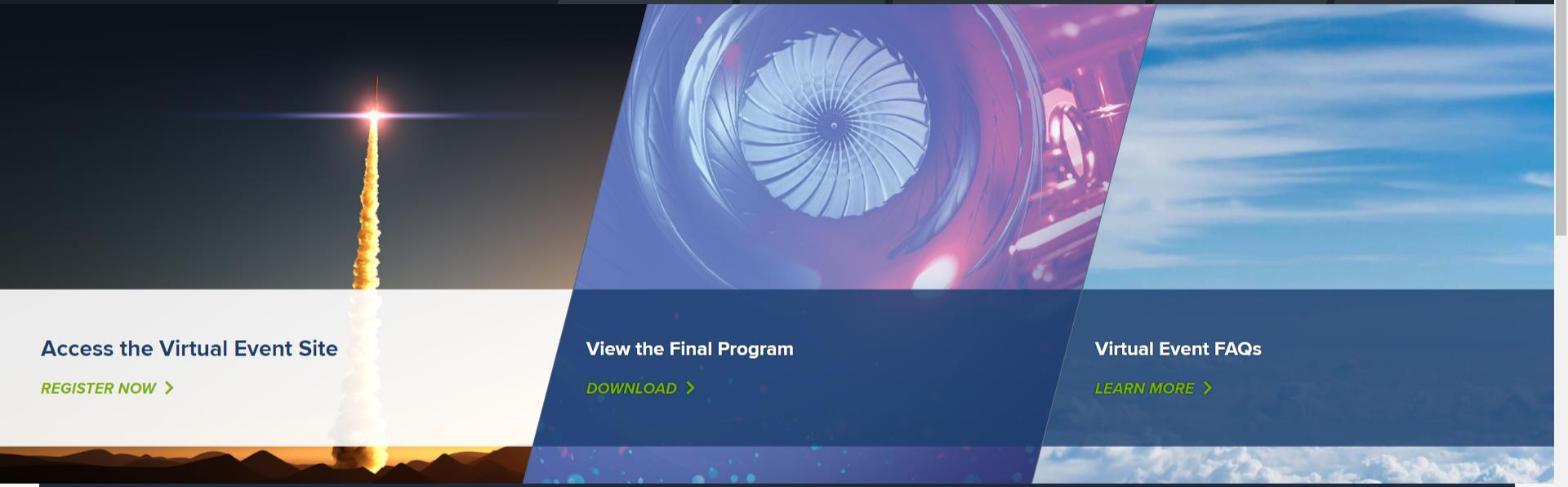

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PROPULSION ENERGY FORUM 24-26 AUGUST 2020 VIRTUAL EVENT AIAA

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Day

Event Type

Session Topic

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Mon 24 | Tue 25 | Wed 26 | Thu 27 | Fri 28

EDU-01: Propulsion Education I - University Program Overviews
3:00PM-4:00PM Aug 25 (EDT)

HR-08: Development and Evaluation of Novel Oxidizer and Fuel Formulations and Combinations
3:00PM-4:00PM Aug 25 (EDT)

INPSI-04: Nozzles and BLI
3:00PM-4:00PM Aug 25 (EDT)

LP-10: In-Space Liquid Propulsion System Development
3:00PM-4:00PM Aug 25 (EDT)

PC-06: Energetic Materials, Liquids, and Solid Propellants
3:00PM-4:00PM Aug 25 (EDT)

EATS-02: Student Challenge Workshop
3:00PM-5:00PM Aug 25 (EDT)

EERE-02: Terrestrial Energy Power Cycles and Microgrid Systems
4:00PM-5:00PM Aug 25 (EDT)

3394917: Developing a Theoretical Approach for Accurate Determination of the Density ...

Event Type
Technical Paper Session

Session Topic
Propellants and Combustion

Submission Topic(s)
Propellants and Combustion

Presentations

3394917: Developing a Theoretical Approach for Accurate Determination of th...
3:00pm-4:00pm Aug 25 (EDT)

AIAA-2020-3898: The Application of Energetic Materials Genome Approach for...
3:00pm-4:00pm Aug 25 (EDT)

AIAA-2020-3899: Burning Rate Characterization of Ammonium Perchlorate Pel...
3:00pm-4:00pm Aug 25 (EDT)

AIAA-2020-3900: Measurements of the Vapor Pressure of Liquid Hydrazine Ab...
3:00pm-4:00pm Aug 25 (EDT)

AIAA-2020-3901: Evaluation of Plateau Burning Behavior in HTPB-AP-Al Com...
3:00pm-4:00pm Aug 25 (EDT)

AIAA-2020-3902: Characterization of the Melt Layer of Ammonium Perchlorate...
3:00pm-4:00pm Aug 25 (EDT)

PROPULSION ENERGY FORUM
24-26 AUGUST 2020 | VIRTUAL EVENT

Technical Session Q&A:

Energetic Materials, Liquids, and Solid Propellants, SESSION SP-06

Session Co-Chairs: **Dr. Bruce Chehroudi and Dr. Subith Vasu**

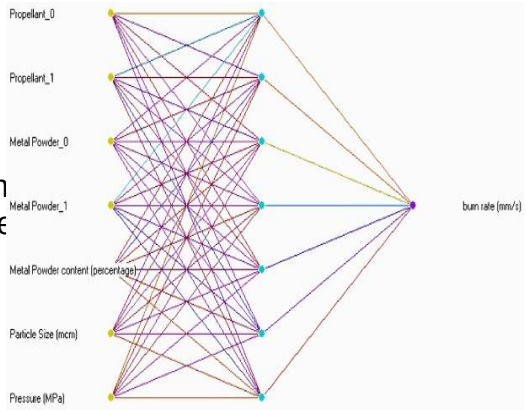
Presenters & Presentations:

1. The Application of Energetic Materials Genome Approach for Development of the Solid Propellants through the Space Debris Recycling at the Space Platform (Presenter: *Amrith Mariappan*: Grad Aeronautical Engineering of Univ of Buffalo, NY)
2. Burning Rate Characterization of Ammonium Perchlorate Pellets Containing Micro- and Nano-Catalytic Additives (Presenter: *Felix A. Rodriguez*, Grad Student at Texas A&M Univ)
3. Measurements of the Vapor Pressure of Liquid Hydrazine Above Its Normal Boiling Point (Presenter: *Dr. John DeSain*: Graduated from Siena College (NY); Rice Univ (in chemistry- PhD); worked for SANDIA CRF; Propulsion Sciences at Aerospace Corp (>2003)
4. Evaluation of Plateau Burning Behavior in HTPB-AP-Al Composite Propellants (Presenter: *Dr. Luiz Eduardo N. de Almeida;* PHD Aeronautical Institute of Tech; Brazillian AF; Currently works at Avibras Divisao Aerea e Naval Company for 34 years as Product Develop Manager, experience in ammunitions, rockets, guided rocket, combustion, internal ballistics, etc)
5. Characterization of the Melt Layer of Ammonium Perchlorate Single Crystals (Presenter: *Monique McClain*: Grad RA; Purdue Zucrow la; with background in Propulsion Additive)
6. Developing a Theoretical Approach for Accurate Determination of the Density (Presenter: *Dr. Yang Li*: Postdoc in King Abdullah Unv of Science and Tech (KAUST); specialized in ignition delay time experiments of real gasoline/diesel mixture; detailed Chem Kinetic model; quantum chemistry; core developer of AramcoMech 2.0 model)

PC-06: Energetic Materials, Liquids and Solid Propellants

- ***AIAA 2020-3898***
  - ***The Application of Energetic Materials Genome Approach for Development of the Solid Propellants Through the Space Debris Recycling at the Space Platform***

Presenter: Mr. Amrith Mariappan, Email: amrithaaron@gmail.com



The ANN-model structure for solving the direct task

- **Summary**
  - We suggest the new strategy for an accelerated development of solid propellants through the space debris recycling at the platform of international space station (ISS) through the Energetic Materials Genome (EMG) approach and machine learning.
  - We have created the new artificial neural networks models (ANN) for suggested approach for various propellants that contain various powders obtained through the space debris recycling method.

- **Key results**
  - We have demonstrated the capability of the ANN models to solve direct and inverse problems as well as to execute virtual experiments for a number of combination of variables such as: propellant type, metal powder type, metal powder content, metal particle size and pressure.
  - Using developed ANN-model, we were able to predict the burn rate for various combination of parameters viz., different pressure, different particle size of Al, Ti, Ni, and Zr, and for different propellant type.

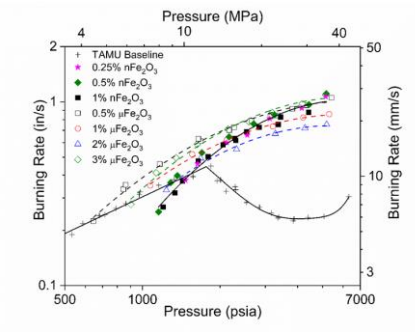
  - Using the suggested models we can increase the life span of the existing satellites as well as the future space missions by creating and providing additional propellants onboard using the space debris powder.

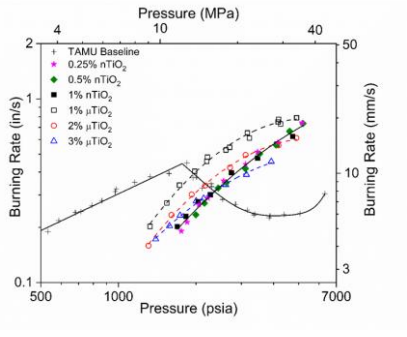
PC-06: Energetic Materials, Liquids and Solid Propellants

Burning Rate Characterization of Ammonium Perchlorate Pellets Containing Micro- and Nano-Catalytic Additives

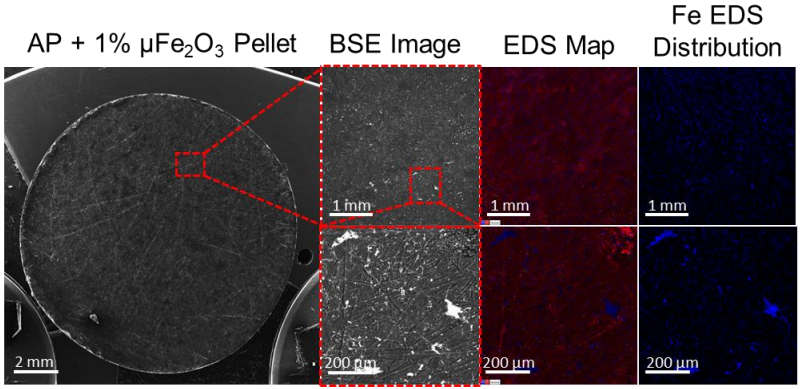
Felix A. Rodriguez, James C. Thomas, David S. Teitge
and **Eric L. Petersen**
Email: frod1214@tamu.edu

TEES Turbomachinery Laboratory
J. Mike Walker '66 Department of Mechanical Engineering
Texas A&M University





- Micro- and Nano-Iron Oxide and Titania were incorporated and burned over 500-5000 Psi
- SEM and TEM imaging was done for additives and samples
- 1% micro-Iron Oxide had the highest increase over global burn rate



TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

PC-06: Energetic Materials, Liquids and Solid Propellants

Summary

Measurements of the Vapor pressure of Liquid Hydrazine above Its Normal Boiling Point.

- The **vapor pressure of liquid hydrazine was measured directly** over the temperature range of 324 to 414 K by using a small-scale vapor pressure chamber.

- These are the **first direct measurements** since the 19th century of hydrazine's vapor pressure above its normal boiling point.

- The current results are compared to previous measurements in the literature, previously published vapor pressure correlation functions, and those predicted by previously published equations of state for hydrazine.

- The **current measurements agree well with most previously published experimental values** and previously published hydrazine correlation functions.

- A new correlation function was fit to current data, previous published experimental values, and vapor pressure values suggested by a previously published Peng-Robinson equation of state analysis that focused on fugacity.

PC-06: Energetic Materials, Liquids and Solid Propellants

AIAA Paper Number 3399954

Evaluation of Plateau Burning Behavior in HTPB-AP-Al Composite Propellants

Luiz Eduardo N. de Almeida Ph.D (1st Author)

eduardo_nunesalmeida@hotmail.com

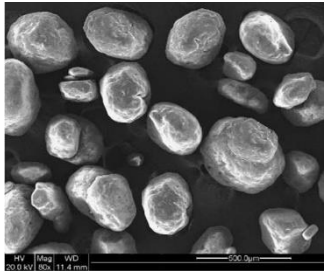
Summary of work

This work presents burning rates as a function of pressure of several propellant formulations based on HTPB-AP-Al, in order to evaluate values of the pressure exponent of the burning rate in distinct pressure ranges, termed as plateau burning rate trends**.**

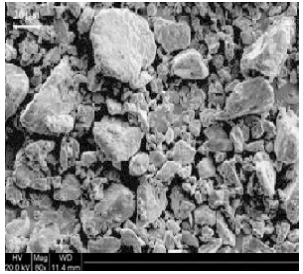
Key results

- A “Pressure plateau” is observed in some formulations in the pressure range from 4 to 6 MPa, which is related to the shrinking effect of the near-surface leading-edge parts of the oxidizer/fuel diffusion flamelets (LEFs) in the gas-phase flame complex.

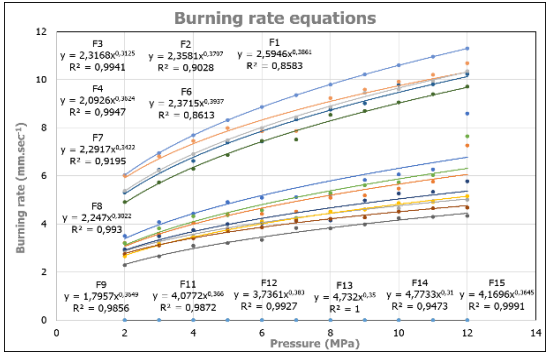
- The present results show that the low-pressure plateau is mostly only appears when using an optimized ratio of coarse and fine AP size, with other parameters remaining unchanged.



AP 400 µm



AP 30 µm

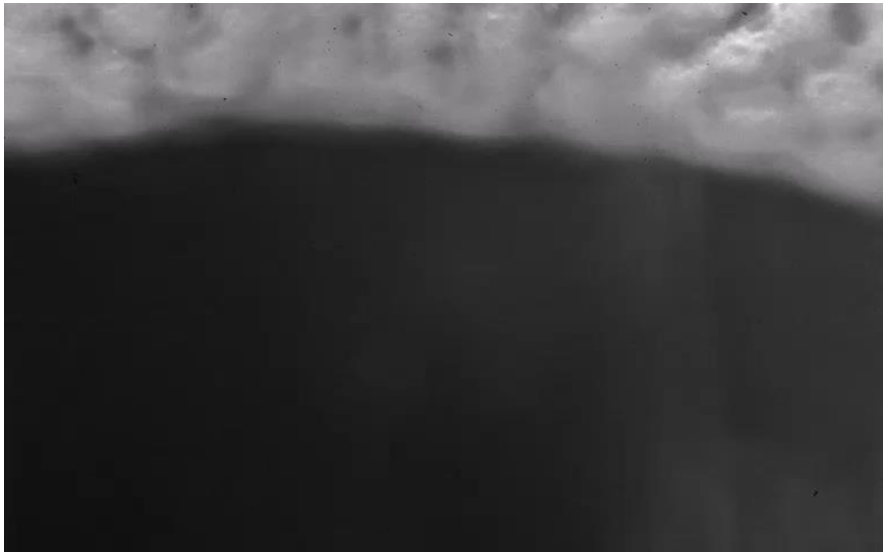


AIAA-2020-3902

Characterization of the Melt Layer of Ammonium Perchlorate Single Crystals

Monique S. McClain (mcclain5@purdue.edu), Morgan D. Ruesch, Ryan J. Tancin, Claresta Dennis, Christopher S. Goldenstein, Steven F. Son

- **Summary of work**
  - Showed the cellular structure of the AP melt layer on AP single crystals *in-situ* at 400, 600, and 800 psi in a nitrogen environment
  - Used laser regression to show the formation of liquid droplets and the orthorhombic to cubic phase change in AP single crystals at atmospheric conditions
- **Key results**
  - Melt-phase cells become more connected at higher pressure
  - The Darrieus-Landau instability and/or surface sublimation, subsurface decomposition, and rapid AP phase changes could influence the ordered cellular melt-phase structure



Melt-phase cells on the surface of an AP single crystal burning at 400 psi.

Oral Presentation Only

Developing a Theoretical Approach for Accurate Determination of the Density and Thermochemical Properties of Energetic Ionic Liquids

Authors: Yang Li; Charlie Oommen; S. Mani Sarathy

Contact information: yang.li@kaust.edu.sa

جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

Summary of work:

- **To develop a reliable theoretical approach for predicting the key phisico-chemical properties of EILs:**
  - **Temperature-dependent heat of formation (ΔHf), entropy (S) and heat capacity (Cp) of cation/anion pairs in the gas phase;**
  - **298 K density (ρ) and heat of formation (ΔHf) of EILs in the condensed phase.**