

This is provided as an example proposal.

It is important that you follow the current guidelines.

The mentor letter has been removed.

A PROPOSAL TO STUDENT ENHANCEMENT AWARD REVIEW COMMITTEE

TITLE OF PROJECT: Investigation of Plasma Use in Rotating Detonation Wave Engines

NAME OF APPLICANT: Yonry Zhu

STATUS: Undergraduate Graduate Medical

CAMPUS/LOCAL ADDRESS: 5 Foster Place Apt. A

E-MAIL ADDRESS: yz183712@ohio.edu

DEPARTMENT: Mechanical Engineering & Physics

EXPECTED GRADUATION DATE (Month and Year): May 2017

RE-SUBMISSION: YES (Original Submission Date _____) NO

PROPOSAL CATEGORY (select one):

Life/Biomedical

Social/Behavioral

Arts/Humanities

Physical Sciences/Engineering

BUDGET: Total Request \$6,000
(May not exceed \$6,000)

FACULTY MENTOR INFORMATION:

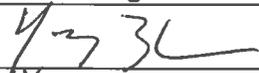
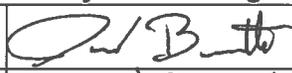
NAME: David Burnette
 E-MAIL ADDRESS: burnettd@ohio.edu
 CAMPUS ADDRESS: 225 Stocker Center
 DEPARTMENT: Engineering and Technology
 DEPARTMENT ADMIN./EMAIL: Jeff Giesey / giesey@ohio.edu

IRB AND IACUC APPROVAL:

To ensure that the University is in compliance with all federal regulations, complete the checklist below. *Note: your proposal can be approved prior to IRB or IACUC approval (put "pending" or "to be submitted" instead of approval number), but funding will be withheld until notification of approval or exemption.*

Yes	No	Office of Research Compliance	Policy #
	X	Human Subjects in Research (including surveys, interviews, educational interventions): Institutional Review Board (IRB) Approval #: Expiration Date:	19.052
	X	Animal Species: Institutional Animal Care & Use Committee (IACUC) Approval #: Expiration Date:	19.049

SIGNATURES

Applicant's Signature		Faculty Mentor's Signature	
Signature		Signature	
Name	<u>YONRY ZHU</u>	Name	<u>David Burnette</u>
Dept/School	<u>HTCENGINEERING PHYSICS</u>	Unit	<u>ENT</u>
Date	<u>1/20/16</u>	Date	<u>1/20/16</u>

Optional:

If selected for funding, I give permission to the Office of the Vice President for Research and Creative Activity to use my proposal as an example during training and workshop exercises.

(Sign below)

Signature:  Date: 1/20/16

STUDENT ENHANCEMENT AWARD APPLICATION CHECKLIST

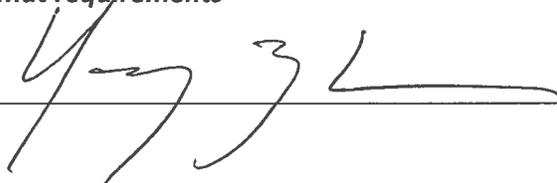
Applicants **must** complete and sign the checklist. The checklist should be included as the second page of the application (following the cover page).

<input checked="" type="checkbox"/> Cover page	use SEA form
<input checked="" type="checkbox"/> Checklist	use SEA form
<input checked="" type="checkbox"/> Abstract*	1 double-spaced page
<input type="checkbox"/> ResubmissionSummary (<i>For Re-submissions Only</i>)*	1 double-spaced page
<input checked="" type="checkbox"/> Project Narrative	5 double-spaced pages
<input type="checkbox"/> Glossary/Definition of Terms* (<i>Not required</i>)	2 double-spaced pages
<input checked="" type="checkbox"/> Bibliography (<i>Not required</i>)	2 pages
<input checked="" type="checkbox"/> Presentation of Results	1 double-spaced page
<input checked="" type="checkbox"/> Mentor's Endorsement	1 page
<input checked="" type="checkbox"/> Biographical information (<i>Applicant(s) and key personnel</i>)	3 pages per person
<input checked="" type="checkbox"/> Budget and Justification	no limit specified (Including the OHIO-Affiliated Travel Form, if applicable)
<input checked="" type="checkbox"/> Appended Materials/Multimedia Files	5 pages; and no more than 10 minutes of footage
<input checked="" type="checkbox"/> Electronic copy of proposal	Single Acrobat file, containing entire proposal and required signatures

Sections marked with a bullet (*) identify text sections that should be written in language understandable by an informed layperson to assist the Committee in its review.

****Please Note: The committee has the right to return without review any proposals that do not conform to these format requirements****

Applicant signature: _____



Abstract

Rotating detonation wave engines (RDEs) are a new type of airbreathing jet propulsion, which have no moving parts and are theoretically more efficient than traditional gas turbine engines. The engine is an annular channel that generates thrust by sustaining a detonation wave which rotates along the channel. The large increase in pressure during the combustion process from the detonation wave increases engine efficiency, leading to an up to 9% reduction in fuel consumption. RDEs have the potential to be integrated into all gas turbine systems used in the aerospace and power generation industries. This reduction in fuel usage across all gas turbines in the United States is the equivalent of removing up to 12,240,000 cars off the road.

The technology is in its early stages of development and effort is being made to understand the physics of RDEs. Attempts are also being made to improve the commercial viability of RDE systems. A critical step towards practical usage of the RDE is the development of systems that are able to use commonly available fuels. The physical size of the engine is inversely related to the detonability of the fuel-oxidizer mix. Commonly found commercial jet fuel is too stable to be detonated in an RDE of practical size.

My project aims to develop and investigate the usage of nanosecond pulsed plasma discharges to increase the detonability of commonly used fuels in an RDE. In addition, I will investigate the viability of using the same system to initiate the detonation process. The plasma system has no moving parts and is simpler than current methods of detonation initiation. It also has potential to more reliably initiate detonation when compared to current methods. Detailed pressure, temperature, electrical, and photographic measurements will be taken and analyzed to determine the viability and efficacy of the system in small scale and eventually full scale tests. Test results will be compared against predictions made by plasma kinetics modeling.

Project Narrative

Context, Goals, and Scope: With increasing emphasis on improving efficiency and sustainability, government and industry focus has shifted towards finding ways to reduce fuel consumption. Pressure gain combustion (PGC), which utilizes detonation as a compression method, is a promising technology to improve efficiency of gas turbine systems. Rotating detonation wave engines (RDEs) utilize PGC and have compact, annular geometry which is ideal for integration into existing gas turbine systems (See an RDE diagram in the appendix). Low pressure behind the detonation wave pulls in fresh reactants, and high pressure in the shockwave ejects waste products. This means RDEs do not require complex valving and have detonation frequencies in the kilohertz range, providing smooth operation. These advantages have led to a significant increase in interest in RDE technology in recent years.

Several prototype RDE systems have been produced. Work now is focused on initiating the detonation process (especially for stable fuels that are difficult to detonate), maintaining stable combustion, and preventing excessive heat loading. My project aims to investigate a solution to the first problem. Because of the ability of plasma to inject initiation energy into a system and because of its ability to produce highly reactive radicals that aid in combustion, use of a plasma augmentation system is a promising method of initiating detonation. Aerojet Rocketdyne has produced an RDE plasma augmentation prototype, however, their results and method of plasma generation have not been published. At the time of writing this proposal, I have not been able to find any literature on the use or effects of an RDE plasma augmentation system. This project is one of the first of its kind and an opportunity for Ohio University to be a leader in an emerging technology with immense interest from public and private sectors.

The proposed use of nanosecond pulsed plasma is particularly well suited for application as a plasma augmentation system. Unlike thermal plasma sources, such as spark plugs, where most of the energy is converted to heat, the short time scale of nanosecond pulsed plasmas efficiently converts input energy into production of excited electronic species and reactive free radicals. These products greatly decrease the initiation energy requirements for fuel detonation. Additionally, because the pulse duration is shorter than the characteristic time for glow-to-arc transitions due to ionization instability, these pulses can be used to generate larger volume plasmas at higher pressures. This allows for more even production and distribution of relevant reactive species.

The overarching project goal is to develop, test, and validate a plasma augmentation system for RDEs. The project is broken into four distinct components: modeling, construction, independent validation, and final system integration. Final integration will use the RDE system found at the University of Cincinnati (UC) Gas Dynamics and Propulsion Laboratory (GDPL). Details of each phase will be discussed in the methodology section of this proposal. The research conducted in this project will serve as the foundation for my senior thesis required for graduation from the Honors Tutorial College. Additionally, I hope to publish my results and present these results at the 2017 AIAA SciTech conference. I also plan on presenting results at the Student Research Expo spring of 2017. Because of the short time frame of this project (experimentation must be complete by a year from now) and because none of the necessary equipment is currently available on campus, funding from the SEA is critically important.

Methodology: As previously mentioned, the preliminary phase of the project will be conducting plasma kinetics simulations. The plasma kinetics simulation will be carried out using a 0 dimensional plasma model developed at The Ohio State University (OSU) described in [8]. This

open source model uses Bolsig+, a Boltzmann equation solver, custom MATLAB code, and ChemKin Plus for reaction kinetics simulation. It inputs initial conditions such as fuel-air composition, and signal waveform, and calculates the production of different chemical species, including electronically excited species and radicals. Initial conditions which maximize the production of species that aid detonation initiation will be determined. Reasonable values for initial conditions will be determined with data from previous RDE experiments. The model may also be used to determine if a reaction, with or without plasma, results in ignition or detonation.

Results from the plasma kinetics analysis will be used in the design of a plasma system. The system will consist of several components. It will require a high voltage (around 10kV) DC power supply, signal and delay generator, pulser, and discharge electrodes. The DC power supply and signal generator will be either found (potentially from the Engineering or Physics Departments) or purchased. The pulser is essentially a switch capable of operating on nanosecond timescales and providing smooth, high voltage DC pulses. Its design will be based on existing designs used at OSU, tailored for use in an RDE. However, it will have to be constructed from scratch. It essentially consists of a case, passive components, and a prebuilt high voltage switch. The design of the discharge electrodes will have to be optimized for the geometry of the RDE. Safety is a primary concern and the system design and experimental procedure will reflect this. All electrodes will be enclosed and all components will be discharged to a grounded connection to prevent electrocution.

Characterization and optimization of the plasma system will be an iterative process and will initially be performed independent of the RDE. Critical parameters that will be examined are the pulsed voltage wave form, voltage of the system, current of the system, visual characteristics of the plasma, and ease of integration into the RDE. Current will be plotted against voltage to

determine instantaneous power levels. To provide experimental results independent of a collaboration with UC, a small scale model, with geometry mimicking the UC RDE, will be constructed. Ignition of very lean fuel-air mixtures at realistic flow rates that, without the plasma would not be detonable, will provide enough proof-of-concept to warrant full scale testing. Conditions under which the computer model predicts detonation will be compared against experimental results and agreements or discrepancies will be discussed. These results will be sufficient for a thesis and publication.

Small scale tests do not fully capture nuances in the geometry and operating conditions of an RDE. To truly determine the efficacy and impact of a plasma augmentation system, time permitting, integration into an RDE and full scale testing would occur. Ohio University does not have facilities equipped to handle full scale engine testing. Building an RDE by itself would be a multi-year project. The UC GDPL is a state of the art gas turbine engine research facility with multimillion dollar test equipment and, more importantly, a functioning RDE prototype. The directing professor, Dr. Ephraim Gutmark, has agreed to let me integrate and test my plasma system with their RDE. Their RDE test rig is designed to be modular with many easily interchangeable components and sensors. According to [9] “The existing data acquisition (DAQ) system provides up to 24 channels of simultaneous MHz acquisition, and the system can be readily instrumented with Piezoelectric PCB Pressure Transducers, capillary tube averaged pressure sensors, ionization probes, water-cooled Kulite pressure transducers, embedded thermocouples. The facility can also be configured for visualization with high speed (40 kHz) video acquisition, or shadowgraph of the exhaust plume.” Data collected will be analyzed and compared to power consumption of the plasma to determine the efficacy and practicality of the augmentation system. Pressure measurements and high speed photography will be used to

determine successful detonation and engine operation for different fuel-air mixtures and flow rates. Results will be compared against modeling work and studies of RDEs without plasma.

Significance and Impact: Besides the benefits to the environment, the potential for huge financial savings from reduced fuel consumption has led to immense interest in RDE technology. The Air Force Research Lab (AFRL), Office of Naval Research (ONR), Lockheed Martin, General Electric, and Aerojet Rocketdyne have all shown great interest in RDE research. This is an opportunity to be the first to understand and publish technology critical to the development of RDEs. It is an opportunity for Ohio University to be a leader in this field and to garner the interest of these organizations. It could lead to partnerships providing large amounts of funding and improving Ohio University's image. Most importantly to me, it provides an exciting way to pursue my lifelong passion for aeronautical engineering and to make a genuinely meaningful contribution to the field.

This project has the potential to expand beyond its original goals. Plasma systems could also be used to improve flame stability and maintain combustion in RDEs. The equipment constructed during the duration of this project also has potential for reuse beyond plasma assisted combustion. Plasmas have shown great promise in applications for active flow control, providing a means to reduce flow separation and improve the aerodynamic efficiency of aircraft and automobiles. Nanosecond pulsed plasmas may also have use in medical applications where they allow for targeted application of energy. Having the equipment that I will construct readily available reduces the difficulty in starting research in any of these areas. Studies of plasma are highly interdisciplinary, requiring knowledge of quantum mechanics, statistical thermodynamics, fluid dynamics, chemical kinetics, and electrodynamics. This project has potential to open new educational and research directions allowing for interdepartmental collaboration.

Bibliography

- [1] Scott M. Jones and Daniel E. Paxson. "Potential Benefits to Commercial Propulsion Systems from Pressure Gain Combustion", 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Joint Propulsion Conferences, (AIAA 2013-3623).
- [2] Daniel E. Paxson. "Pressure-Gain Combustion for the Gas Turbine", *University Turbine Systems Research Workshop*, Pennsylvania State University, 20, Oct. 2010.
- [3] D. A. Schwer and K. Kailasanath. "Rotating Detonation-Wave Engines", *NRL Review*, 2011
- [4] Jiro Kasahara and Sergey Frolov. "Present Status of Pulse and Rotating Detonation Engine Research," 25th ICDERS Conference.
- [5] Yuri P. Raizer. "Glow Discharge Instabilities and Their Consequences," *Gas Discharge Physics*, 2nd ed., Springer, New York, 1997, pp. 212-239.
- [6] Andrew C. St. George, Robert B. Driscoll, Vijay Anand, David E. Munday, and Ephraim J. Gutmark. "Fuel Blending as a Means to Achieve Initiation in a Rotating Detonation Engine", 53rd AIAA Aerospace Sciences Meeting, AIAA SciTech, (AIAA 2015-0633).
- [7] S. M. Starikovskaia. "Plasma Assisted Ignition and Combustion", *J. Phys. D: Appl. Phys.* 39 (2006). R265-R299.
- [8] Igor V. Adamovich, Ting Li, and Walter R. Lempert. "Kinetic Mechanism of Molecular Energy Transfer and Chemical Reactions in Low-Temperature Air-Fuel Plasmas", *Phil. Trans. R. Soc. A* 373: 20140336
- [9] Andrew C. St. George, Robert B. Driscoll, David E. Munday, and Ephraim J. Gutmark. "Development of a Rotating Detonation Engine Facility at the University of Cincinnati", 53rd AIAA Aerospace Sciences Meeting, AIAA SciTech, (AIAA 2015-0635).

Presentation of Results

Dr. Burnette and I plan to attend AIAA's 2017 SciTech conference. This is the premier conference for aerospace engineering and will take place in Grapevine Texas from January 9-13, 2017. Abstract submission typically ends in the middle of summer. Following my project timeline, by this point I will have preliminary results, sufficient for abstract submission. Should the abstract be accepted, I will present at SciTech as well. Below is a plan for submission of the research as well as corresponding major project milestones.

Spring 2016

- Conduct plasma modeling using OSU model, modified for the RDE plasma system
- Purchase equipment and begin construction of plasma system

Summer 2016

- Begin testing and characterizing plasma system
- Run small scale combustion experiments
- Submit SciTech abstract (Typically around June or July)

Fall 2016

- Integrate plasma system with RDE and run full scale experiments
- Finalize data collection
- Prepare for and present at SciTech Conference

Spring 2017

- Submit article to journal for review
- Write senior thesis
- Present at 2017 Student Research Expo

Biographical Information

Yonry Zhu

7386 Whitlind Lane • Athens, Ohio 45701 • Cell: 740 818 6988 • yonryzhu@gmail.com

Education

Ohio University, Athens, OH

Bachelor of Science in **Engineering Physics** (Honors Tutorial College)

Bachelor of Science in **Mechanical Engineering** (Russ College of Engineering)

Minor in **Mathematics**

GPA: **3.95** Expected Graduation: May 2017

Employment History

Russ College of Engineering (*Fall 2015 – Present*)

ET Fundamentals Grader

- Graded weekly homework assignments for two sections of ET 3200 (Thermodynamics) and two sections of ET 2220 (Strengths of Materials)

Ohio University Technology Depot

Sales Associate (*August 2013 – August 2014*)

- Sold computers and accessories while providing technical product information
- Provided customer service over the phone and in person

Computer Technician (Tech Guru) (*August 2014 – Present*)

- Repaired over 1000 computers (hardware repair, software assistance, virus removal)
- Provided technical support over the phone and in person

Subbit (*Spring 2015 – Fall 2015*)

- Co-founder of startup focused on creating an app for subleasing
- Front end web developer
- Won first place at Athens Startup Weekend

Engineering Projects

Ohio University Chemistry Department (*Winter 2014*)

- Automated a mass spectrometry experiment
- Designed circuit board to control solenoid valve and sample collector
- Coded scripts for an Arduino microcontroller to control a solenoid valve and sample collector
- Produced documentation over operating procedure for the controller

Ohio University Nanoscale and Quantum Phenomena Institute (*June 2014 – Winter 2015*)

- Designed an ultra-high vacuum pulsed laser deposition system to fabricate thin films
- Constructed UHV chamber, stand, and lens tube for the system
- Coded control scripts for stepper motors
- Utilized 3D printing for rapid fabrication
- Performed lab technician work conducting liquid helium and nitrogen fills in a low temperature scanning tunneling microscope cryostat

Skills

Coursework

- Advanced physics studies (Quantum mechanics, statistical mechanics, Lagrangian Mechanics)
- Advanced math studies (Partial differential equations, numerical methods, calculus of variations)
- Circuits lab and advanced physics lab work (requiring lab reports and documentation)
- Thermodynamics, Thermal Physics, Fluid Mechanics, Heat Transfer

Software

- AutoCAD, SolidEdge
- Proficiency in C, MATLAB, HTML/CSS
- Familiarity with C#, Javascript, Python
- Microsoft Office

Other

- Basic Machining/Woodworking Skills
- Fluent in Chinese
- Conversationally competent in Spanish

Other Activities

- Elected president of Theta Tau professional engineering fraternity (Fall 2014)
- Coached a local 7th-9th grade recreational soccer team
- Volunteered with the Timothy House, a local homeless shelter
- Volunteered in annual Physics Open Houses, a university STEM outreach activity

Scholarships

- Dean's Scholarship
- Crewson Scholarship
- James T. Shipman Scholarship
- Gateway Excellence Scholarship

About Me:

I am a junior pursuing an Engineering Physics degree through the Honors Tutorial College and a Mechanical Engineering degree through the Russ College of Engineering. I have maintained a GPA of 3.95 while taking 16-18 credit hours, working 16-18 hours a week, and remaining active in the community. I started and completed both projects mentioned in my resume independently, though I kept in constant communication with the supervising professor to establish and design around their functional requirements. In both projects, I created a budget, successfully followed it, and minimized project costs. In the latter project, I surmounted technical challenges that had stalled the implementation of the laser system by previous graduate students for almost 7 years. I have taken the coursework required to form a foundation for studies in plasma physics including quantum mechanics, statistical mechanics, thermodynamics, and partial differential equations. As previously mentioned, this project serves as an outlet for my lifelong passion for aerospace engineering, and I could not be more excited to begin it.

Other Funding Sources:

Physics Department Discretionary Funds - \$2000
Honors Tutorial College Discretionary Funds - \$1000

Budget and Justification

Because of the short time frame of the project, most funding sources will come from within Ohio University. Beyond funding from the SEA, I have secured \$2000 from the Department of Physics, and \$1000 from the Honors Tutorial College. This will total to approximately \$9,000 in available funds for this project. Because of limited funding, most equipment will be purchased used from reputable sources. Highlighted items will be purchased with funding from the SEA.

Item	Comments	Approx. Cost
DC High Voltage Supply	Likely 10kV depending on system requirements. Will likely be purchased used if one cannot be found on campus.	\$1000
Passives	Passive components for the pulser. Consists of a box, insulation, resistors, capacitors, wiring, etc. Some extra has been included for backups.	\$500
High Voltage Switch	Prebuilt switch capable of operating under high voltage with a nanosecond timescale. Will be purchased new	\$1500
Voltage Probe	Able to withstand high voltage and have sufficient time resolution for nanosecond pulses	\$1500
Current Probe	Based on induction and required to have sufficient time resolution for nanosecond pulses	\$500
Delay Generator	Generates delay and sends signal to the pulser. Will purchase a used 4-channel.	\$1500
Workstation	Stable support frame with breadboard that will be grounded to ensure safety.	\$1000
Misc.	Reserved for machining costs or other miscellaneous items.	\$500
Conference/Travel	See detailed travel description	\$1000
TOTAL		\$9000

Travel:

The AIAA conference we plan to attend will be held in Grapevine, Texas. As of writing this proposal, a roundtrip flight is approximately \$200-\$250. Staying at the entire conference will require five nights of lodging. To keep costs down, Dr. Burnette and I will stay at an AirBnb in Grapevine. Renting an AirBnb in Grapevine is approximately \$100 per night, so split amongst two people, this amounts to \$50 dollars per night. This is \$250 in lodging total. Registration for a student is \$120. Assuming a budget of \$40 per day for meals, the total travel costs will total to \$820. Adding another \$180 for taxis/transportation and other costs, the total travel funding requested is \$1000.

Equipment:

After searching the Physics Department, Mechanical Engineering Department, and Electrical Engineering Department, I have not been able to find the requested equipment with specifications required for my experiment. I have not been able to find any power supplies that output the required voltage for plasma generation. Characterization of the wave forms used to generate the plasmas and the plasmas themselves require measurement tools able to withstand extremely high voltages and have time resolution on the order of nanoseconds. Equipment currently available does not meet these functional requirements. The delay generator also must operate on the nanosecond timescale and there is no such equipment available to my knowledge.

TOTAL AMOUNT REQUESTED FROM THE SEA: \$6,000

Appended Materials

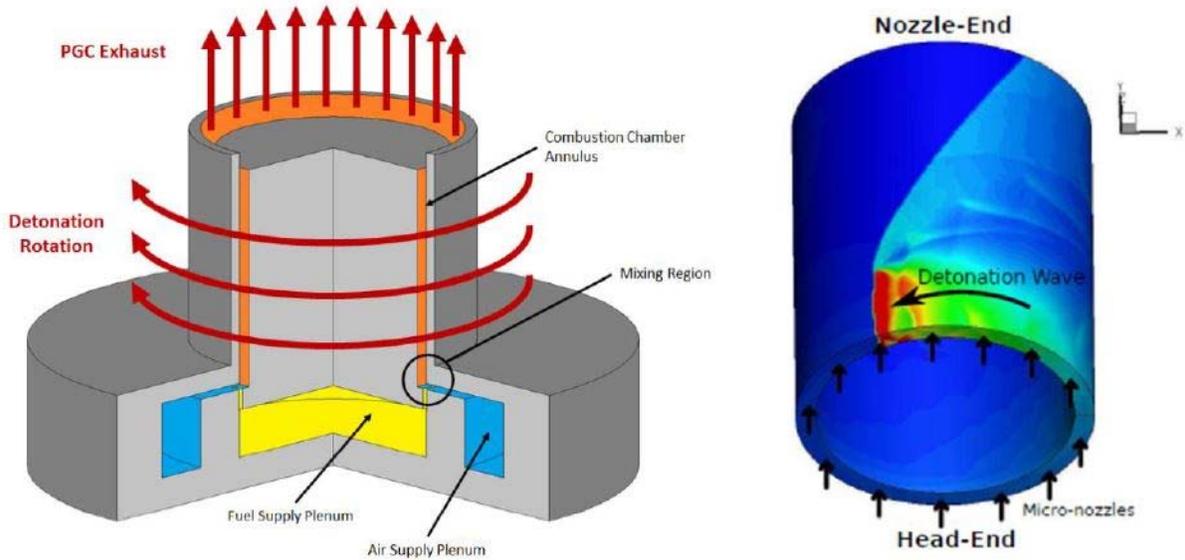
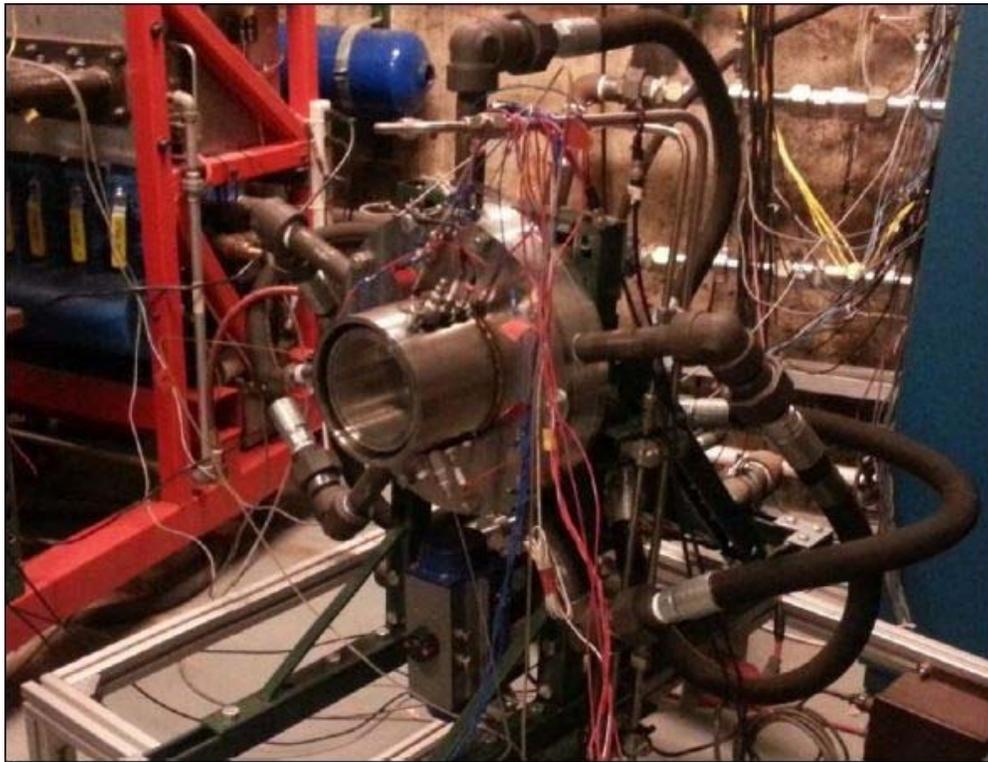


Diagram of a Rotating Detonation Wave Engine



Rotating Detonation Wave Engine at the University of Cincinnati Gas Dynamics and Propulsion Laboratory

Project Tasks and Timeline	Start Date	End Date
Task 1. Begin Modeling Efforts	1/25/16	4/1/16
Task 1.1 - Determine Functional Requirements of System	1/25/16	2/1/16
Task 1.2 - Determine Reasonable Parameter Value Ranges	1/25/16	2/1/16
Task 1.3 - Conduct Modeling Using OSU NETL Model, Modifying if Needed	2/1/16	4/1/16
Task 2. Purchase Equipment and Begin Construction	3/21/16	5/1/16
Task 2.1 - Search for Best Prices on Required Equipment and Components	3/21/16	3/28/16
Task 2.2 - Set Up Workstation in Stocker 295, Ensuring Proper Safety	3/28/16	4/4/16
Task 2.3 - Construct Pulser and Preliminary Electrode Geometry	4/4/16	4/18/16
Task 2.4 - Integrate and Calibrate Measurement Equipment	4/19/16	5/2/16
Task 3. Independent Experimentation and Characterization	5/2/16	7/4/16
Task 3.1 - Conduct Initial Plasma System Testing	5/2/16	5/16/16
Task 3.2 - Characterize Plasma System Power Output (Generate I-V Curves)	5/16/16	5/23/16
Task 3.3 - Optimize Electrode Geometry	5/23/16	6/13/16
Task 3.4 - Conduct Small Scale Combustion Testing in OCRC Fume Hood	6/13/16	7/4/16
Task 4. Full RDE System Integration (Time Permitting)	7/4/16	12/20/16
Task 4.1 - Integrate into UC RDE System	7/4/16	8/1/16
Task 4.2 - Set Up Appropriate Sensors and Measurement Tools	7/25/16	8/1/16
Task 4.3 - Conduct Full Scale Engine Testing	8/1/16	12/20/16
Task 5. Write Senior Thesis	1/25/16	4/15/17
Task 5.1 - Technical Coursework	1/25/16	5/2/16
Task 5.2 - Thesis Prospectus	4/1/16	5/1/16
Task 5.3 - Thesis Writing	12/20/16	4/15/17
Task 5.4 - Thesis Presentation Preparation	4/1/17	4/15/17
Task 6. Conference/Journal Submission	6/1/16	4/30/17
Task 6.1 - SciTech Abstract	4/4/16	7/4/16
Task 6.2 - Create Poster and Prepare for SciTech	7/4/16	1/8/17
Task 6.2 - Attend SciTech	1/9/17	1/13/17
Task 6.2 - Register for Student Research Expo	1/14/17	2/27/17
Task 6.2 - Attend and Present at Student Research Expo	4/9/17	4/9/17
Task 6.3 - Submit Journal Article for Review	1/13/17	4/30/17



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January 18, 2016

CRSCA Committee
Office of the Vice President for Research
Ohio University

Dear Dean Shields and CRSCA Committee,

I am writing this letter with great enthusiasm in support of Yonry Zhu's application for a Student Enhancement Award under the supervision of Dr. David Burnette on his senior thesis, "Investigation of Plasma Use in Rotating Detonation Wave Engines". I have spoken with Yonry and Dr. Burnette and am happy to be working with them on this project.

Rotating Detonation Wave Engines (RDE) are a revolutionary technology in aerospace propulsion, as well as industrial turbine generators and engines, which promises significant fuel saving and reduction in exhaust pollutants. The Gas Dynamics and Propulsion Laboratory at the University of Cincinnati is one of the leading research centers on RDEs, with over \$3M annual expenditures for sponsored research, over 100 published journal papers and over 50 patents in the past 15 years.

While it is highly desirable to use stable fuels in practical RDEs, such fuels are difficult to detonate. Based on my discussions with Dr. Burnette, the nanosecond pulse plasma generation technique sounds like it holds great promise for detonation initiation and for reduction of the detonation temperature, pressure, as well as the size of the combustion chamber.

To support his research, our lab will provide RDE design and combustion data to facilitate his theoretical modeling and bench experimental validation.

With the understanding that the scope of the proposed research is only for benchtop experimental validation of his theoretical model, we are committed to supporting the validation of his model on our RDE research platform beyond his current study.

Sincerely,

A handwritten signature in black ink, appearing to read 'E. Gutmark'.

Ephraim Gutmark
Distinguished Professor and Ohio Eminent Scholar
Professor of Aerospace Engineering and Engineering Mechanics
University of Cincinnati