Facilities, Equipment and Other Resources available for NSF-REU Site: " Propulsion, Aerodynamics, Materials and Controls of Aerial Vehicles"

GSU state of the art research facilities are enclosed in the Allen E Paulson College of Engineering and IT Buildings on the Georgia Southern campus. They contain advanced research and computer laboratories, conference rooms and faculty offices. Other campus resources include networked office computers and printers, library, large group meeting space in the Russell Union, and the expertise of the Office of Sponsored Research (ORSSP). Capability and attributes of the major facilities are given below, along with the projects housed in the 80,000 ft^2 of the Engineering Building that encompasses the Aerospace, Energy and Bio-inspired technology labs, fabrication facilities, computer laboratories, and research space and classrooms, The machine shop (18,000 sqf) is staffed by two engineers (MS) and one technician with expertise in design and fast prototyping fabrication and technology, electronics and electrical design, software and networked computer systems. Approximately 8000 ft^2 for research, design and development rooms of newly renovated space houses the state of the art Energy and Automotive Technologies Research. A central Material Science laboratory is also available together with Electronics laboratories.

Advanced Fuels Testing Laboratories – Dr. Soloiu

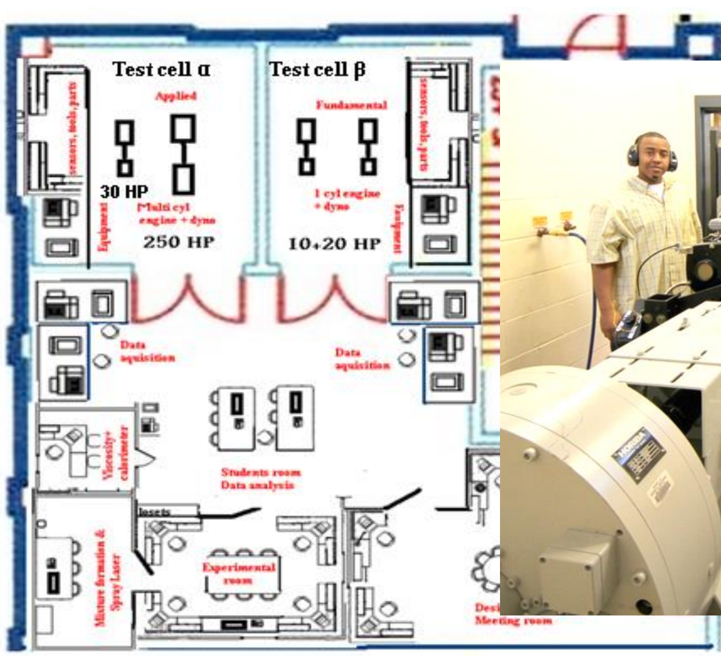


Fig. 1a Layout-test cells- Advanced Fuels Testing **Fig. 1b Dyno Test cell Alpha for fuels testing**

Equipment available for the NSF-REU
Dynos: Horiba-Schenk Eddy Current Dyno, 250HP; Dyno controller Type SPARCe; Schenk Driveshaft K010 with shaft guard; Driveshaft Taylor; bedplate with 4 air-spring isolators; dyno 30 HP horizontal shaft, dyno 20 HP vertical shaft; dyno 10HP horizontal shaft. Engines: JCB-TDI, 80 HP, turbocharged experimental diesel engine; Single-cylinder experimental diesel Yanmar CDI + PFI 23HP supercharged; Single cylinder experimental Kubota IDI 5HP; Single-cylinder Briggs & Stratton EFI, 20HP

Data acquisition systems: Fast-speed data acquisition system; 1 electronic rack, cDAQ-9172 8, National Instruments; 1 high-speed data acquisition board (16 channels 1.25 Ms/s); 1 high-speed data acquisition board (32 channels, 50 kS/sec 16 bit analog input NI 0205 32), National Instruments; 1 converter AEC-5505; 2

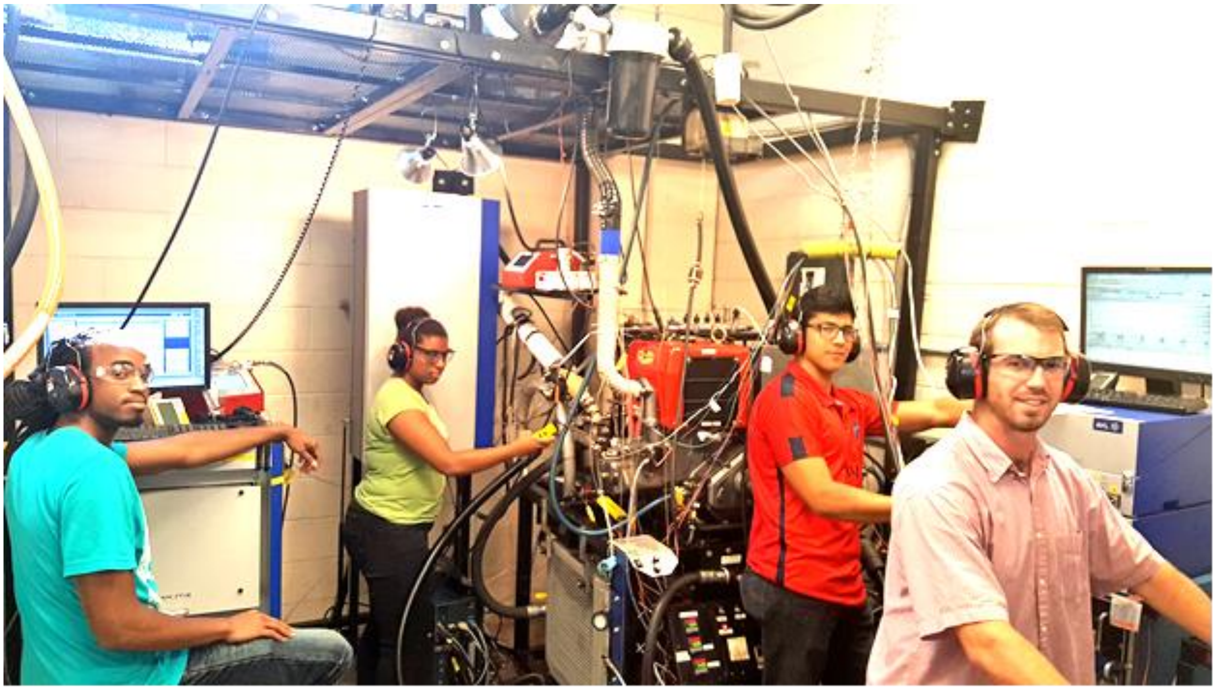


Fig. 2 Test Cell Beta during fuels research

Kistler 5010B dual mode charge amplifiers with RS-232, interface, 3 exhaust temperature measurement systems, Omron (20 thermocouples); 5 rotary encoders for incremental movement 3600P/S, Omron; high-speed data acquisition system/oscilloscope, Yokogawa 10MS/S, AVL-INDICOM

Sensors: 2 clamp sensor for injection line pressure Kistler; 1 miniature piezoelectric cylinder pressure probe noncooled, Kistler; 1 miniature piezoelectric cylinder pressure through spark-plug probe noncooled, Kistler; 1 miniature piezoelectric sensor through glow-plug, Kistler; 1 PCB

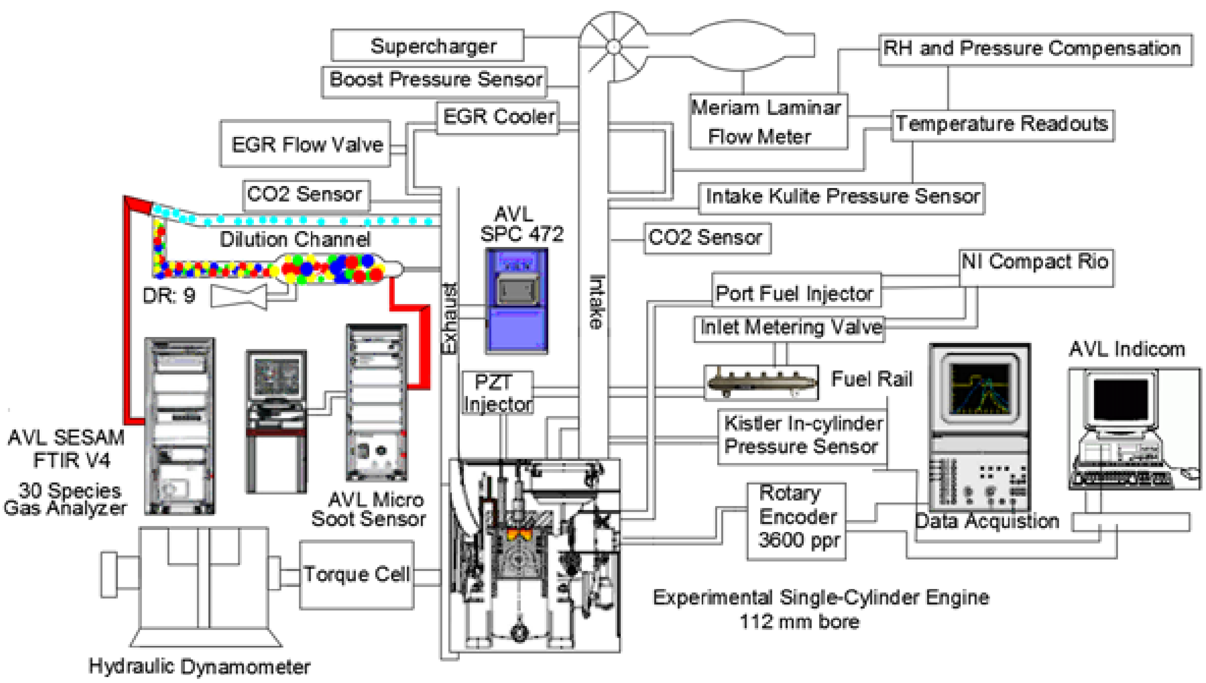


Fig. 3 Test Cell Beta -Advanced combustion characteristics – Equipment schematics

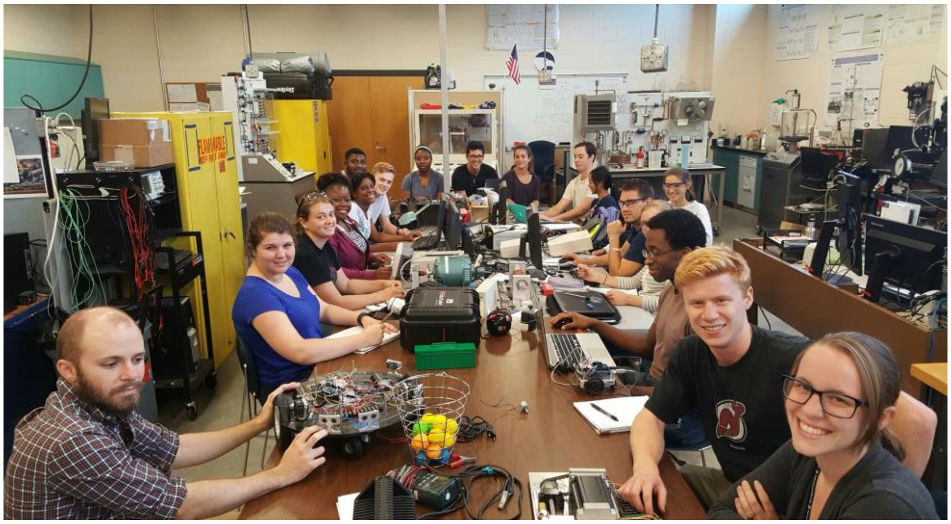


Fig. 4 REU-URGENT students during brainstorming session in GSU (2016)

accelerometer. Strain gages Vishay, Slip ring Michigan Scientific, fast needle lift data acquisition sensor PU-05-159-401 AEC America;
Air-Flow meters: 40-500 SCFM, 3x10-100 SCFM, 2-22 SCFM all Meriam with computer acquisition **Gas analyzers for EGR flow rate**: Emissions Systems, inc - EMS model 5002

Fuel flow meter: AVL KMA 4000 Flex fuel computerized+ Common Rail - 2 Max Machinery P213 Piston Flow Meters, PFI System - 1 Max Machinery P001 Piston Flow Meter, 2 Emerson Micro Motion Coriolis Flow and Density Meter

Instruments: MALVERN Mie scattering He-Ne, spray laser, Rancimat – oxidation stability analysis viscometer/rheometer Brookfield; Lambda probe, Paradigm biofuel analysis instrument; Shimadzu TGA-DTA60**,** PAC Ignition delay/DCN instrument

Gas analysis: AVL SESAM FTIR V4-25 species, AVL 483 Micro soot sensor, AVL PM Sampler 472, AVL soot/smokemeter 415S, MEXA-584L Otto gas analyzer, CO, HC, C02 (nondispersive infrared: NDIR) and air-to-fuel ratio (AFR) excess air ratio; 2x MEXA-720 NOx analyzer with zirconia-ceramic sensor for NOx concentrations measurement of air/fuel ratio and O2 sensor;

Controllers: National Instruments Direct Injector Driver System: cRIO 9073 - CompactRIO Integrated Systems with Real-Time Controller and Reconfigurable Chassis, NI 9215 (4 Channel Analog Module), NI 9411 (6 Channel Digital Module),NI 9751 (Direct Injection Driver Module), NI 9758 (Port Fuel Injector)

Software: ANSYS, Fluent, ADAMS, Pro-E, AVL-FIRE; AVL Concerto, DSpace, Matlab, Chemkin

The Computational Aerodynamics and Aeroacoustics laboratory

Dr. Marcel Ilie

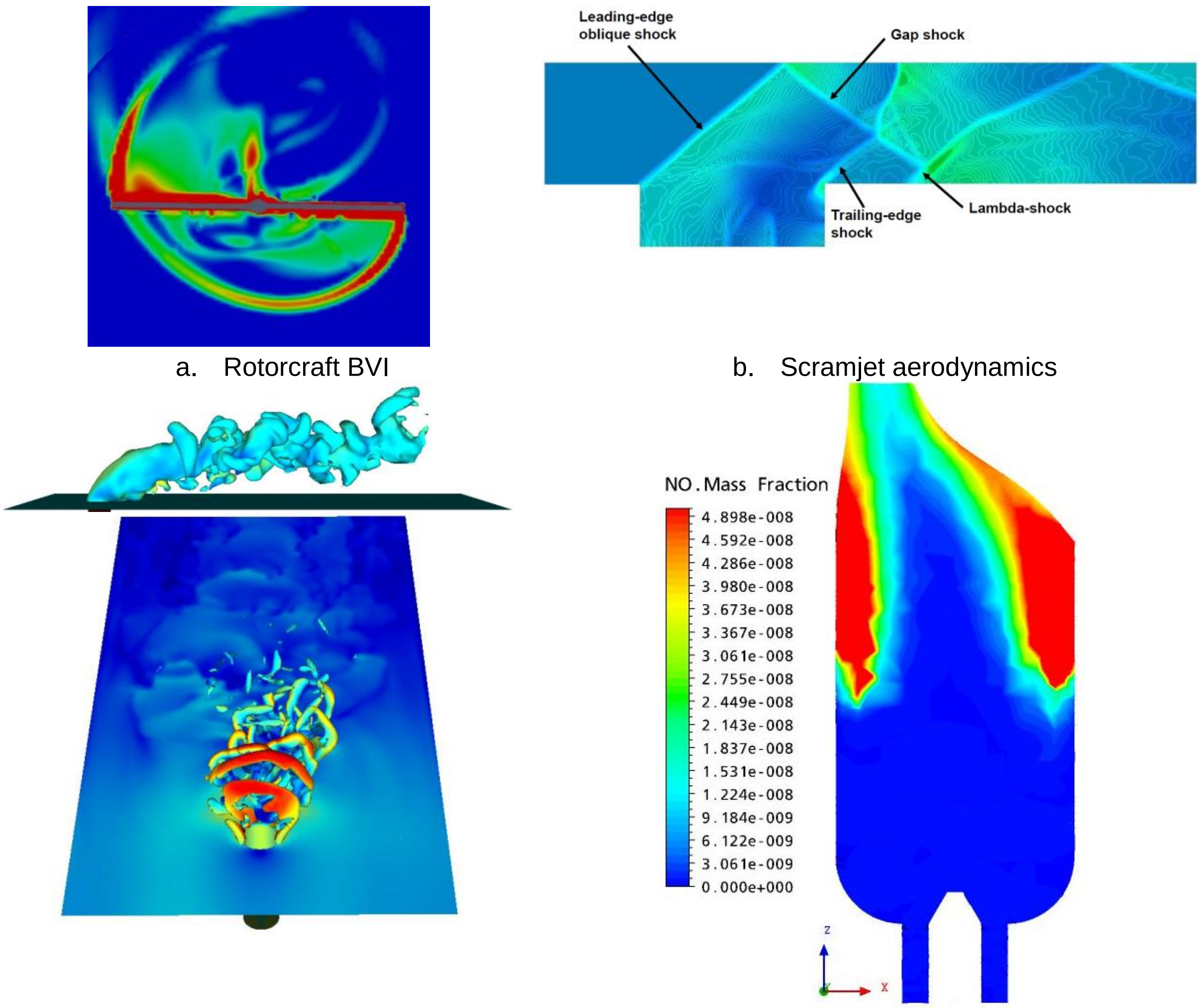
The laboratory is located in the Engineering building. Master students and undergraduates conduct theoretical and simulation type research.

Computing Facilities:

The Laboratory has access to two Linux High-Performance Computing (HPC) clusters maintained by Computational Research Technical Support (CRTS) at Georgia Southern. The “Talon” HPC cluster has 65 nodes, totaling 740 Xeon class processor cores, with access to 13 TB of shared storage and redundant backup.

The “Eagle” HPC cluster has 312 Xeon class processor cores interconnected via FDR Infiniband, 1 TB of memory, with access to 13 TB of shared storage and redundant backup.

Computational Research Technical Support is a specialized area of IT Services to build and support a comprehensive program to advance computational research at Georgia Southern University. That includes offering and supporting traditional high-performance computing (HPC) systems, as well as systems for high throughput and data – intensive computing.
The CRTS also helps researchers transition their analyses and models from the desktop to more capable and plentiful resources, providing the opportunity to explore their data and answer research questions at a scale typically not possible on desktops or departmental servers. Partnering with units like ICME as well as the NSF XSEDE program and vendors, the CRTS offers training and learning opportunities around HPC tools and technologies.



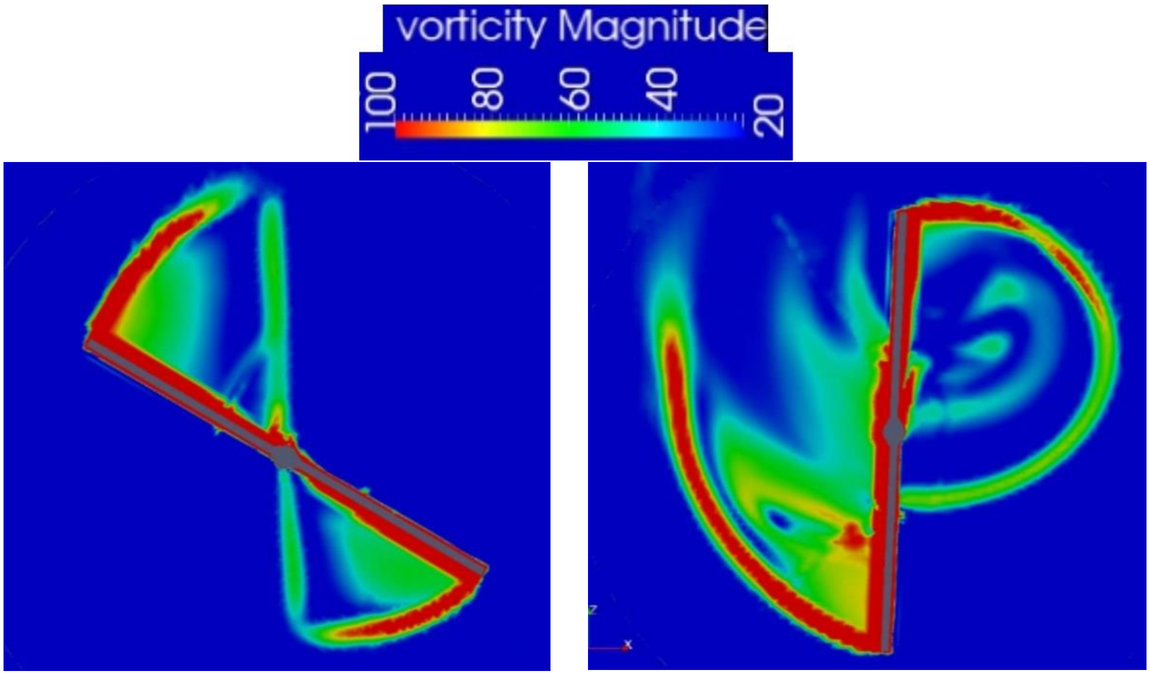
a. Rotorcraft BVI

b. Scramjet aerodynamics

c. Aircraft tubine blade cooling

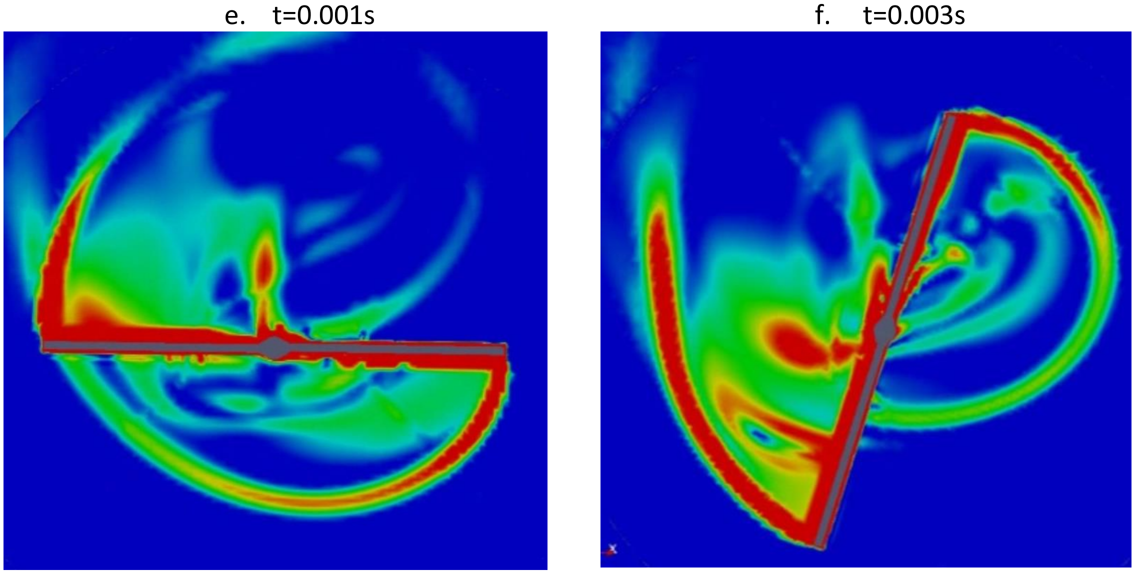
d. Aircraft can combustion

Fig. 4A Multi-scale, multi-physics computational studies of turbulent flows



e. t=0.001s

f. t=0.003s



g. t=0.006s

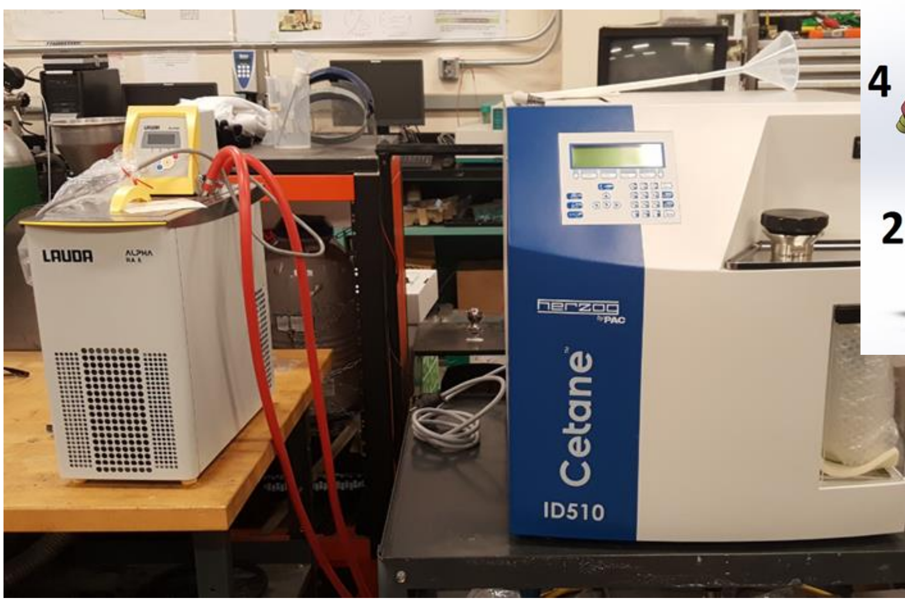
h. t=0.008s

Fig. 4B Time-dependent BVI simulations in the laboratory using LES

Fundamental combustion laboratory – Dr. Soloiu

Equipment set-up: The research apparatus is composed of a constant volume combustion chamber (PAC Cetane ID 510), has the characteristics according to ASTM D7668 standard:
Volume: 473 mL, Chamber Pressure (before injection): 20 bar, Chamber Temperature: 595 °C,
Injection Pressure: 1000 bar by a Bosch injector with 7 nozzles; Injection Duration: 2.5 ms.
Calibration gas: Compressed air 20% oxygen (+/- 0.02% abs) with balance nitrogen (THC < 0.05 ppm). The design of the combustion chamber mimics a practical diesel engine combustion chamber and the injector of the engine common rail system.

Component	Function
1	**Electronic Fuel Injection System with Pressure Multiplier**
2	**Uniform Heated Test Chamber**
3	**Chamber Pressure Sensor**
4	**Injection Pressure Sensor**



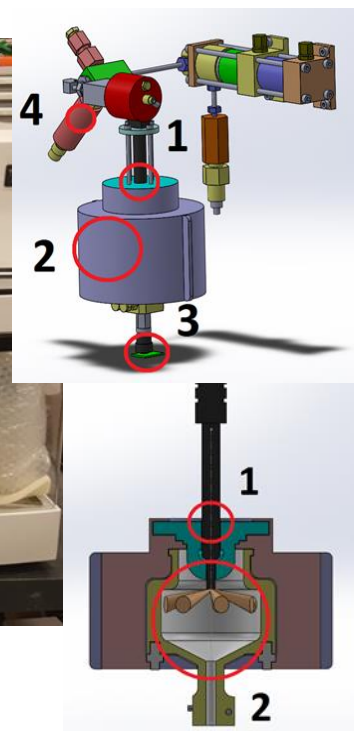


Fig.5 Constant volume combustion chamber

Aerospace laboratory – Dr. Soloiu

The SR-30 turbojet engine has a maximum operating speed of 77,000 rpm, maximum thrust of 40 lb_f, pressure ratio of 3.4 to 1, and specific fuel consumption of 1.22 lb_{fuel}/lb_f-hr.
The engine can operate on various types of fuels such as kerosene, diesel, biofuels, and synthetic fuels (SPK). The engine is run using reference fuel Jet A, and analyzed against S-8 and IPK operations. Each type of fuel possesses a unique set of properties, which lead to different reaction and evaporation times. Severe differences in these values can affect the fuel's combustion characteristics, leading to different sound and vibration signatures.

Gas Turbine Instrumentation

The engine is instrumented with Bruel & Kjaer sound and vibration measurement chain. The chain consists of transducers, data acquisition system, data acquisition software, and post processing software. A condenser type, multi-field microphone, Type 4961, was used for the unpredictable sound field of the engine's environment. The microphone is positioned one meter away at 0° incidence, normal to the engine viewing window. The microphone has a frequency range of 5 Hz to 20 kHz, dynamic range of 20 dB to 130 dB, and sensitivity of 60 mV/Pa. A piezoelectric type, triaxial accelerometer, Type 4527, was mounted on the supporting frame of the engine with a magnetic base and has a sensitivity of 10 mV/g and frequency range of 0.3 Hz to 10 kHz. The accelerometer was oriented so that its X axis was parallel to the gas turbine axis, the Y axis was tangential to the turbine axis, and the Z axis was radial to the turbine axis. The accelerometer can operate in the temperature range of -60°C to 180°C. MKS FTIR 20 species and Bosch smoke/soot analyzer 415S.

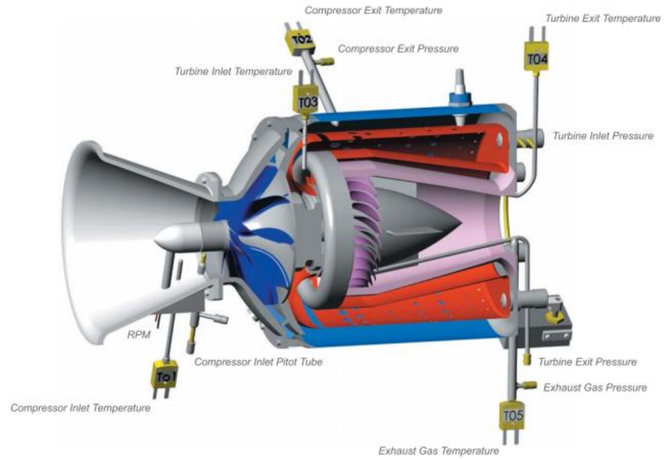


Fig. 6a Jet engine instrumentation

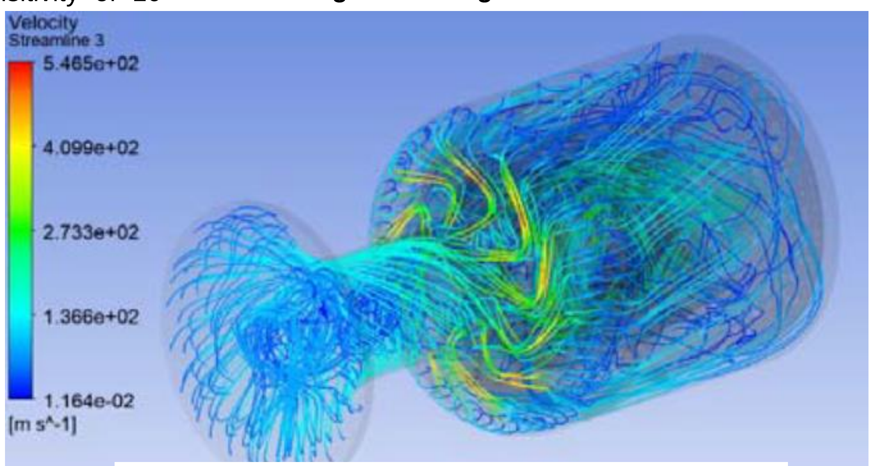


Fig. 6b Jet engine simulation

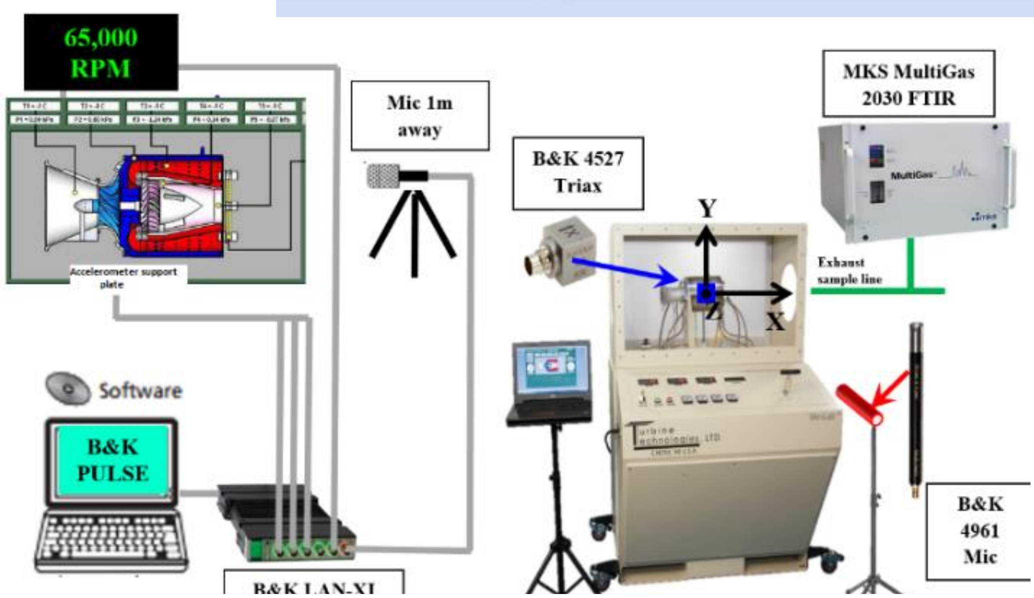


Fig. 7 Jet engine – experimental set-up for combustion, emissions and NVH

Subsonic Wind Tunnel and Wind Energy Laboratory (SWT-WEL)

Experimental and Computational research -Dr. Rahman

Dr. Mosfequr Rahman is the founding director of Georgia Southern Subsonic Wind Tunnel and Wind Energy Laboratory (SWT-WEL). This lab has both experimental and computational research facilities and has been using for both research and teaching purpose. More than 12 graduate students have pursued graduate research on experimental and computational fluid mechanics and successfully completed their degree under the direct supervision of Dr. Rahman. Also 13 undergraduate students have successfully performed undergraduate research and 2 others are currently working in this laboratory. This laboratory has also been using as one of the NSF-RET site for “**ENgaging Educators in Renewable EnerGY (ENERGY)”** Award # 1609524.

Subsonic Wind Tunnel and Wind Energy Laboratory (SWT-WEL) is equipped with a subsonic open-type wind tunnel for experimental testing. This laboratory has various model testing facilities as shown in Figure 19 which includes model test set-up, data acquisition system, Vernier Energy Sensor which will collect data for the current and voltage produced by test models are connected to a computer and the data are generated in LabQuest software. To ensure accuracy in data collection, the Vernier Energy Sensor source terminals are conjoined with a wire lead which created a short circuit and zeroed sensor. This lab also has pressure sensors for surface pressure measurement, static torque sensor for reaction torque measurement, laser tachometer for RPM measurement, dynamic torque sensor for dynamic torque measurement. This laboratory has computing facilities include computers, all necessary software such as ANSYS FLUENT, SOLIDWORKS, LabVIEW, LabQuest, and network connection for internet use

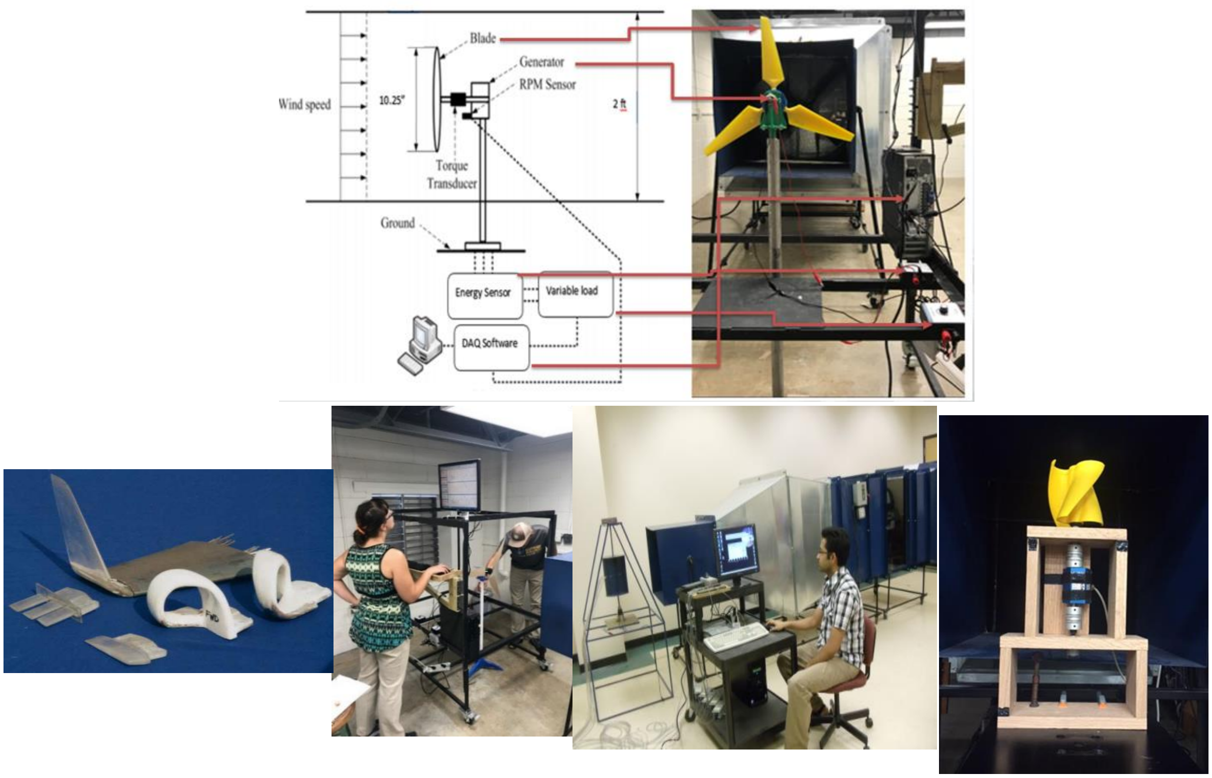
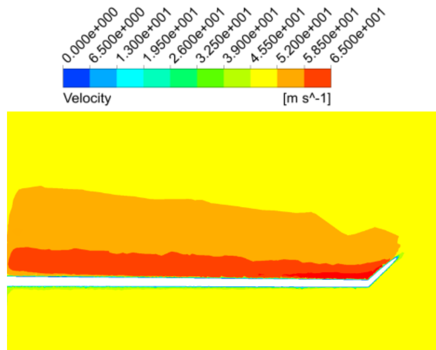
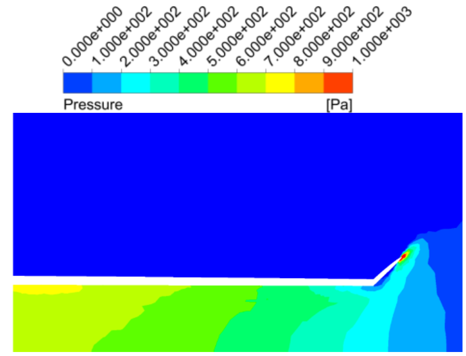


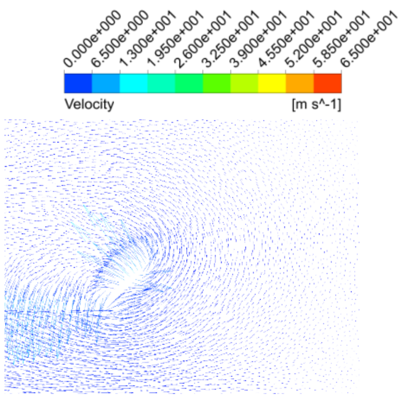
Fig. 8: Different models testing facilities in the Subsonic Wind Tunnel and Wind Energy Laboratory.



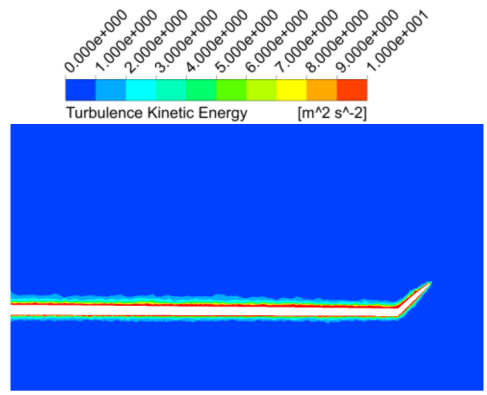
a. Velocity field



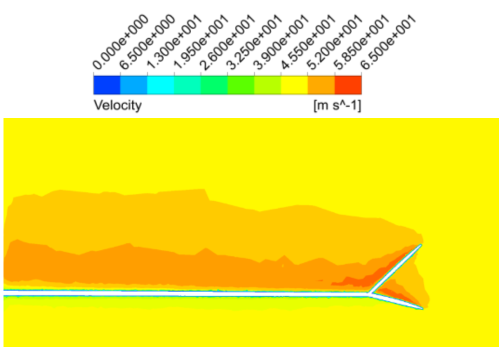
b. Pressure field



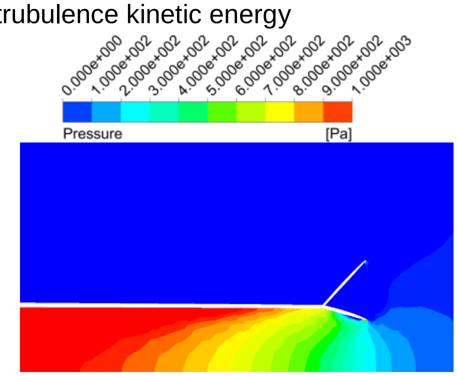
c. vortex field



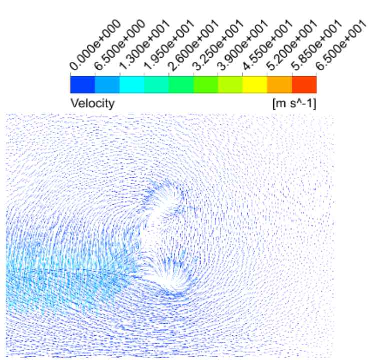
d. trubulence kinetic energy



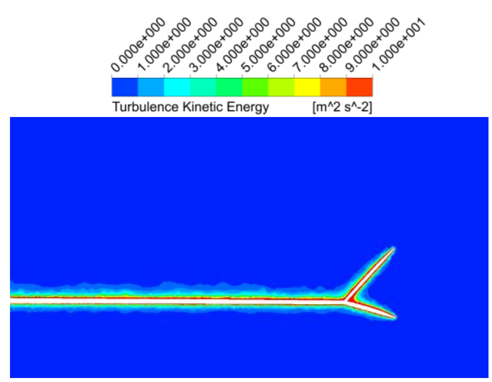
a. Velocity field



b. Pressure field



c. vortex field



d. trubulence kinetic energy

Fig. 9a Different modeling results in the Subsonic Wind Tunnel and Wind Energy Lab

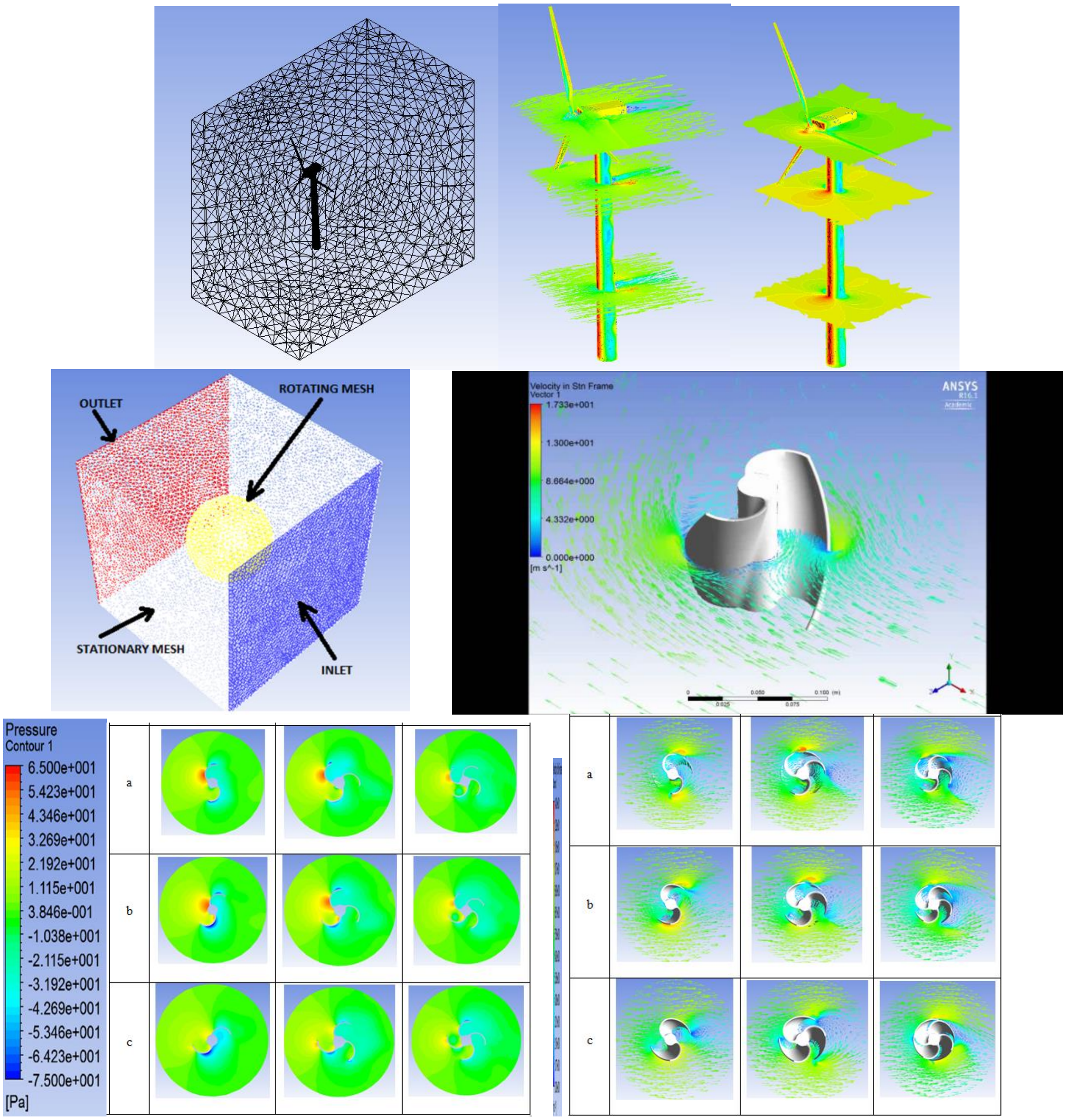


Fig. 9b Some simulation results from the Subsonic Wind Tunnel and Wind Energy Laboratory

Noise Vibrations and Harshness Laboratory – Dr. Soloiu

Equipment

2 multifield microphones (B&K)
5 free field microphones (B&K)
two tri-axial accelerometers (B&K)
4 uni axial accelerometers (B&K)
three cables for one of the accelerometers, with three charge converters (B&K)
1 PCB low frequency triaxial accelerometer (cable included)
1 multifield microphone cable (B&K)
6 back up cables for the triaxial accelerometers (B&K)
one small uni axial PCB accelerometer
2 laser tachometer (B&K), Reflective tape
1 diffuse field microphone(B&K)
One DAQ Battery (B&K), 5 DAQs (B&K)
1 holder for the DAQs (B&K Sound Camera)
1 backpack to hold (Handheld Device) (B&K)
1 Case to Hold Sound Camera (B&K)
1 Lenovo Thinkpad with Pulse v21 platform with Reflex, Labshop, and Array Analysis
Beamforming 0.50m diameter with camera and 30 microphones/30 channels

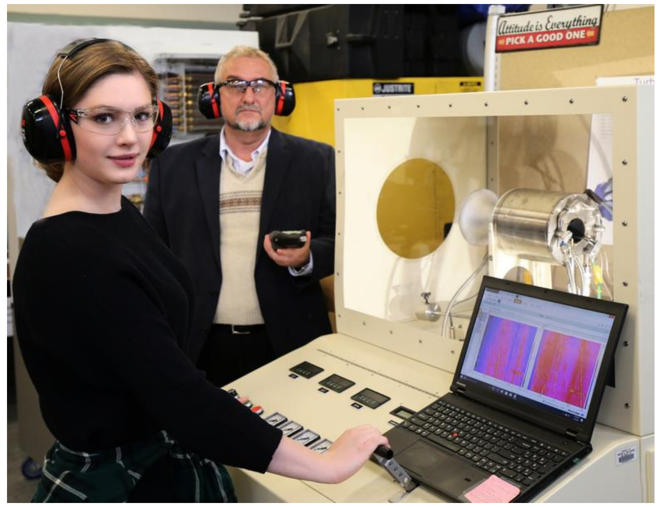


Fig 10. NVH experiments on turbo-jet engine

Optical Investigation Laboratory Malvern Mie He-Ne scattering laser – Dr. Soloiu

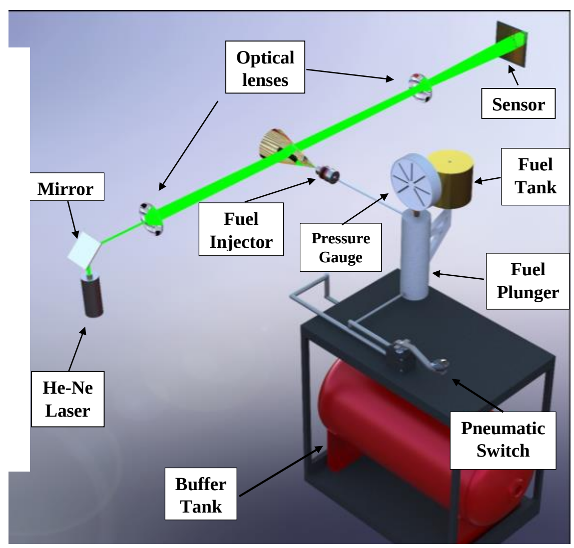


Fig. 11 Mie scattering He-Ne laser system for investigations of spray development and mixture formation

Competitive Students Research Awards won under Dr. Soloiu's supervision, with research in Aerospace, Automotive, Combustion and Intelligent vehicles laboratories:
2009 First prize College of Graduate Studies,
2010 Second prize College of Graduate Studies,
2012 Student Employee of Year, (nominated) Georgia Southern University,
2012 First and third prize College of Graduate Studies,
2012 Third prize at the UGA-Bioenergy Research Center Spring Retreat;
2012 Excellence in presentation, UGA,
2012 US Army Core of Engineers Award for Engineering Excellence:
2012 Energy and Transportation (Georgia Tech Savannah);
2012 RICOH Sustainable Development Award;
2012 Advancement to Georgia State Science and Engineering fair;
2012 US Forest Service Best Integration of Social and Physical Biosciences;.
2012 First place Georgia Science and Engineering Fair Grand Award ISEF;
2012 Natural Resources Conservation Service Award of Excellence;
2012 Advanced Academy of Georgia Science Creativity Award;
2012 Top 10 State recognition, UGA Renewable Energy Conference-2nd prize,
2012 Savannah regional science and engineering fair
2013 Second prize COGS Graduate research,
2013 Best Graduate Poster, CEIT
2013 Runner-up Graduate Poster, CEIT,
2013 Best Undergraduate Poster, CEIT,
2013 Runner-Up Undergraduate Poster, CEIT,
2013 Jack N. Averitt Graduate Studies Excellence in Research (nominated) GSU,
2013 GSouthern University, Student Employee of Year 2013)
2013 National Prize EPA-P3 Washington DC,
2013 First prize EPA-P3 Am. Inst. of Chem. Eng. Washington DC,
2014 National Prize Vibralign- Aligning America: REU participant
2015 National Science Foundation Washington DC-Graduate Research Fellowship Program/GRFP: REU participant
2015 Virginia Space Grant Consortium Award - REU participant
2015 First Prize: 10th Georgia Environmental Conference REU participant
2015 First Prize: Georgia Undergraduate Research Conference - REU participant
2016 Averitt Research Award Georgia Southern University - REU participant
2016 11th Georgia Environmental Conference Outstanding Graduate Student Research Scholarship and Poster Award- REU participant
2017 SAE World Congress Detroit MI, 7 Awards for paper presentations- 4 REU students and 3 tutors
2018 Georgia Power Innovation Awards, 3rd Place: D. Mothershed, J. Curtis, and Keith Russell
2018 John Scarano Memorial Scholarship, Sophia Fleri
2018 GSU Undergraduate research grant; Margaret Kilpatrick, Sophia Fleri
2019 ASME Petroleum Division Grant, Margaret Kilpatrick, Sophia Fleri
2019 CEC Research Symposium Margaret Kilpatrick, best female researcher by Gulfstream
2019 Best undergraduate paper at ICEF Conf. Chicago,
2019 First Prize Georgia Environmental Conf.

Advanced Sensing and Intelligent Control Lab, Dr. Alba Flores and Dr. Fernando Rios

This lab is equipped with facilities to carry out research on advanced sensors, multi-sensor fusion methods, signal and data processing, real-time data processing, intelligent control, and classification of signals using artificial intelligence techniques. Current research in this lab is focused on control of autonomous vehicles using bio-signals and artificial intelligence techniques. State-of-the art facilities include multifunction I/O modules for high-speed data acquisition, NI MyDAQ; PicoScopes 300 series; Tektronix Digital Scopes (DP02024B); Spectrum Analyzers (Keysight E5063A); computing workstations with GPU architecture for high computing performance; variety of advanced sensors (GPS, inertial measurement units, digital compass, lidars, etc); bio-sensors systems such as a surface EMG wireless system (Noraxon Ultium EMG), four Myo EMG gesture control armbands (Thalmic Labs), two portable wireless neurohead sets (Emotiv Epoc 14)), advanced motion capture systems (XSens 3D motion tracking systems), and a variety of drones and quadcopters. Software tools include Matlab, Simulink, LabView, and flight-simulation packages.

Fig. 12a. EEG-based control of a small scale electric vehicle

Fig.12b. Control of a 3D printed robotic hand using face gestures

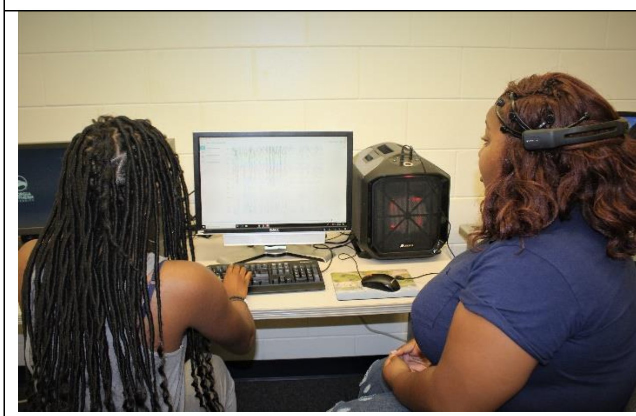


Fig. 13a. Collecting face gesture signals

Fig 13b. ANN training to classify thoughs

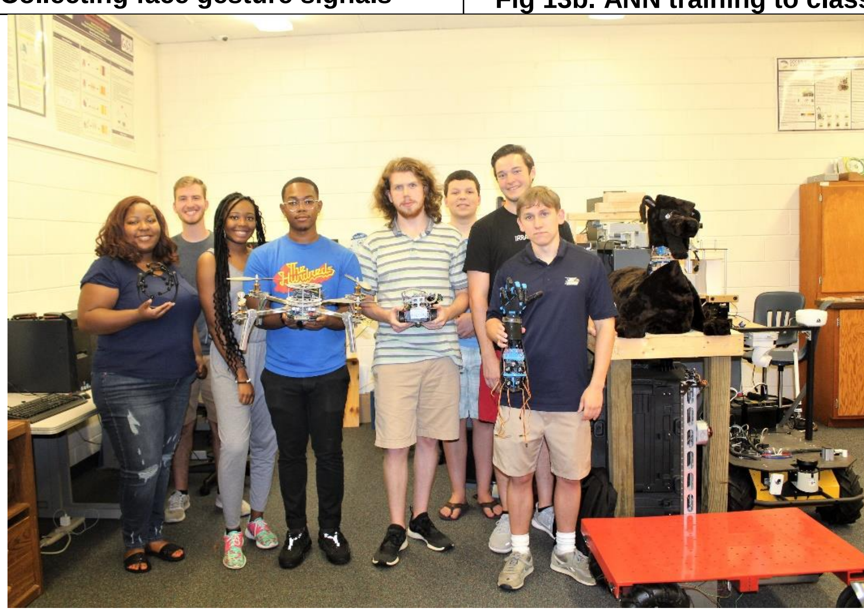


Fig. 14 The research team: Brain-computer interface for Intelligent systems

Robotics Laboratories competitive awards
In the last 15 years Dr. Alba-Flores and Dr. Rios have encouraged the creation and supervised teams of undergraduate students to participate in International Robotic and Programming competitions
Their students have attended the following competitions:
The IEEE hardware competition - attend every year since 2007 and *won the first place this year (2016)* and fourth place in 2008
The Robotic Firefighting competition - attended every other year and won first place in 2010
The Robowaiter competition - attended in 2013
The Autonomous Lawn Mower competition attended in 2006, 2007 and 2010, *won first place* in 2010
The IGVC (International Ground Vehicle Competition) attended 2005, 2006 , got 4th place in 2006
The IEEE Xtreme programming competition, have competed every year since 2010

Two GSU teams competed against 42 universities in the southeast region including GA Tech, Clemson, University of Florida, Virginia Tech, and others. GSU Robotics team **finished in FIRST place in the IEEE SoutheastCon Region 3 Robotic open hardware competition in Norfolk, Virginia**. Both Teams finished within the best 5 in Hardware competition.

Design, Manufacturing and Rapid prototyping Laboratories: 18,000 sqf

The facilities in the Carruth building at Georgia Southern University serve the students to enable research with advanced equipment.

The **Robotic Research Laboratory and Composite Material Laboratory** are used for researching human robot interactive manufacturing, human indoor localization, and human mental and physical intervention. The equipment needed for this includes: KUKA robot, Fanuc LR Mate 6 axis robot, Vicon camera, Adept mobile robot, TIP TIG Hot-wire feeder, Dynasty welder, Formlab 3d printer, and ultrasonic inspection.

The Machine Shop, Machine Shop, and Additive Manufacturing Laboratory house machines for manufacturing. CNC Machining (all 2016 or newer).Haas J750 5 axis cnc,2-TM2P CNC Mill, 2-Haas Mini Mill, 2-Haas ST10 Lathe, Haas TL CNC Lathe, Mitsubishi Wire EDM, Omax Waterjet, CNC Tubing Notche.

Additive Manufacturing lab, Fortus 450 FDM Printer, Stratasys j750 Poly Jet Printer, 8-Stratasys Uprint, Solidscape Wax Printe, 6 Small form factor FDM Printers, Laser Sintered metal printer (2018), 3D Scanners, Precision Measuring and Imaging, Faro Arm, Keyence VXH 5000, Keyence LJ-V7000 series, Keyence VR-3000, Artec SPACE Spider Scanner, Artec LEO Scanner, .CMM Hexegon

Introductory level machines would be a Manual Lathe, Manual Milling, Vertical and Horizontal Bandsaw, MIG and TIG welding. These shops also include a wide array of CNC equipment. HAAS TL2, HAAS ST10,

Fig. 15 Rapid prototyping laboratory

Fig. 16 Advanced Manufacturing CNC laboratory

Fig. 17 Manufacturing laboratory

Materials testing lab

Mitutoyo SJ-310
MTS 10KN, 30KN load frames

Computational facilities available to REU students

65 Nodes, 740 Intel Xeon Processors
13TB Lustre based scratch volume
120TB Storage Tanks.
1Gig Ethernet Interconnects, (12 Nodes have FDR Infiniband)
Currently running Centos 6.7 with the Slurm Scheduler.
Supplementary a High Performance Computing (HPC) Linux cluster running CentOs 6.5 as the Operating System (OS), 312 Intel Intel(R) Xeon(R) CPU E5-4620 v2 clocked at 2.60GHz and 1TB available memory

Fig. 18 R&D computer laboratory in ME Department

Chemistry laboratory– Dr. Koehler

Department of Chemistry Major Equipment available for NSF-REU

A. **<u>NMR Spectrometer</u>**
Equipment: Agilent 400 MHz NMR spectrometer

B. **<u>FT-IR Spectrophotometers</u>**
Equipment: Thermo iS10 FTIR (x2), Shimadzu IR-Prestige-21, Thermo Nicolet Avatar 370-FTIR (x2), and Thermo Nicolet Nexus 470 w/ ATR, SMART, ARK, & diffuse reflectance accessories.

C. **<u>UV-Vis Spectrophotometers</u>**
Equipment: Carry 5000 UV-VIS NIR Spectrometer, Shimadzu UV-2401PC (x2), Shimadzu UV-1601 (x2), Molecular Devices Plate Reader – Spectrophotometer, and Shimadzu UV-2401PC (x2).

D. **<u>Materials Characterization</u>**
Equipment: Rigaku XtaLAB Mini X-ray Diffractometer, Epsilon DEA 230/1 dielectric analyzer, Micrometrics ASAP 2020 Surface Area & Porosity Analyzer, Bio-Rad Experion automated electrophoresis, JEOL JSM-7600F field emission SEM, NT-MDT Ntegra Atomic Force Microscope, Malvern Nano-ZS90 Zetasizer, TA Instruments Q800 Dynamic Mechanical Analyzer, TA Instruments Q50 TGA, Johnson Matthey Magnetic Susceptibility Balance, TA Instruments Q100 DSC w/ cooling unit, Micromeretics Gemini Series Surface Area Analyzer, Ro-Tap RX-29 particle size sieve shaker, Coherent Innova 90 (5W Ar-Ion) Laser, and Vreeland Spectrix Direct reading Microscope.

E. **Fluorimeters**

Equipment: PerkinElmer LS55 w/ well plate reader, PerkinElmer LS55 (x2), Shimadzu RT 5301, ISS K2 Multi-Frequency Lifetime Fluorimeter, and Shimadzu RT 5301.

F. **Gas Chromatographs**

Equipment: Shimadzu GC-2014 (x4), Shimadzu GCMS-QP2010S w/ dual flow control and FID secondary detection, Shimadzu GCMS-QP5000, and Gow-Mac Series 600 w/ TCD

G. **HPLC**

Equipment: Shimadzu CBM-20A w/ UV/vis detection (x2), Waters 2487 HPLC, Waters Fraction Collector III, Shimadzu CBM-20A w/ column oven, ref. index, and viscotek, Shimadzu LCMS-2020 Single Quad, Shimadzu LC-20AD GPC option w/ RI & UV detection, PerkinElmer Series 200 w/ UV detection, Shimadzu SCL-10A w/ degasser & UV/vis detection, Shimadzu LCAT 4 solvent system w/ UV detection, Waters Delta 600 4 solvent system w/ UV and Fluor det, and Perkin Elmer HPLC.

H. **Electrochemical Apparatus**

Equipment: CH Instruments, Electrochemical Analyzer and BAS-100B w/ HDME.

I. **Elemental Analysis**

Equipment: Thermo Scientific Flash 2000 organic element analyzer, Bruker Microflex MALDI-TOF, PerkinElmer ICP-HPLC-MS w/speciation/ laser ablation, PerkinElmer Aanalyst 200 (x2), Shimadzu Total Organic Carbon Analyzer TOC-Vcsn shared and housed in COPH, Perkin-Elmer Aanalyst 100, and Perkin-Elmer Aanalyst 100.

J. **Centrifuges**

Equipment: Beckman Avanti J-20 XPI, and Beckman Avanti J-25-1

K. **Other Miscellaneous Equipment**

Equipment: Denton Vacuum sputter coater, BioLogic VMP3 potentiostat, LC Technology TD400C glove box, Carver 4386 Hydraulic Press, Malverin Nano-ZS Zetasizer, Jasco P-2000 polarimeter, Anton-Paar MW3000 microwave digestion/reactor, Paar high pressure reactor, Table Top Steam Sterilizer, and Milestone Ethos Microwave Lab Station.

Fig. 19 Chemistry laboratory tutorial

Bio-inspired hierarchically structured composites and multiscale structured materials Laboratory - Dr. Shaowen XU

Present project: ***Research on the dynamic loading on the behavior of anisotropic aerospace materials and full field displacement and strain under static and impact loading condition***.

Material Science Laboratory is a major research and teaching laboratory for engineering materials synthesis and behavior characterization in the Department of Mechanical Engineering at the Georgia Southern University. It is facilitated with 3D Digital Image Correlation System, High Speed Camera, finite element modeling and simulation software (Solidworks, ANSYS and ABAQUS), Split Hopkinson Bar, and several material testers (MTS Model 810 Hydraulic Testing, two MTS Criterion 43 Electromechanical Universal Testing Systems, ADMET Stress-Strain-Torsion Frame and Controller eXpert 2601 and ADMET Micro EP Universal Testing System).

In the Laboratory the Digital Image Correlation (DIC) is used extensively. It is optical method which uses tracking and image registration techniques for accurate 2D and 3D measuring the changes in images. This non-contact method is widely applied in the areas of science and engineering applications to determine full-field displacement and strains. It could capture fine details of deformation during mechanical tests and provide both local and average information in the tested samples.

Major equipment: Split Hopkinson Pressure Bar (SHPB) is used for determining response of material and dynamic property under high strain rate (500-20,000/s) loading condition. The SHPB (Fig. 20) in Georgia Southern University was designed and built by senior students in the Department of Mechanical Engineering in the course – Mechanical System Design advised by Dr. Xu.

With the devices in the **Material Science Laboratory**, the students are accurately measuring 3D full field displacement and stain in isotropic/anisotropic materials under statics and impact loading conditions (Fig. 21 a, c and d). The students could capture non uniform local deformations materials, and also capture the wave propagation in the materials under high speed impact events. With the stero-microscope or SEM, students could explore the behavior of materials in micro and nano-scales (Fig. 21 b).

Fig. 20 SHPB in Material Science Laboratory

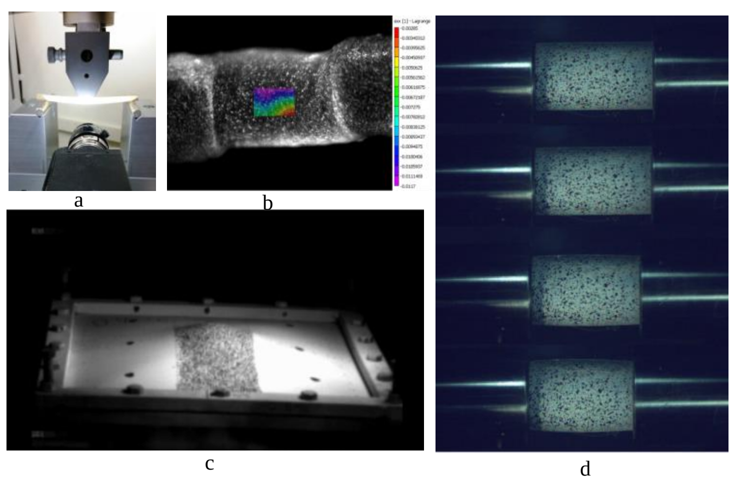


Fig. 21 Behavior characterization of with DIC for a) structure of bamboo b) mouse carotid artery c) aluminum plate under explosion d

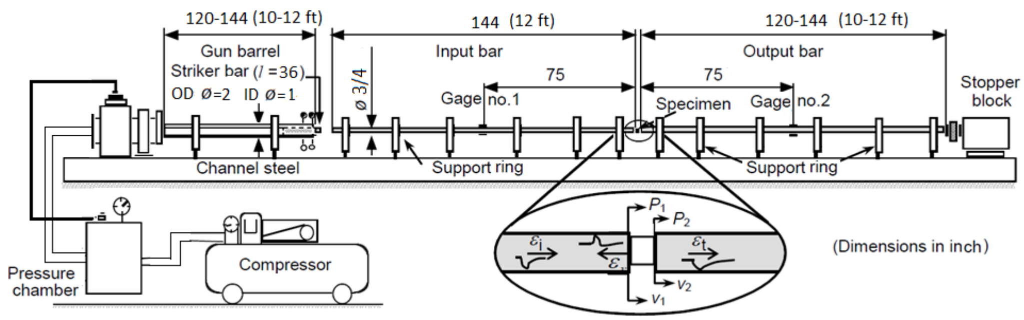


Fig. 22 Split Hopkinson Pressure Bar (SHPB) in the laboratory

Dr. Xu has 15 years of experience conducting research in the fields of mechanics of materials, computational and experimental mechanics. His projects cover a broad spectrum of scientific research and engineering applications.

Dr. Xu's research work has focused on structure and material behavior characterizations, digital image correlation analysis for structure failure and buckling analysis, experiment and numerical simulation integrated methods. He has successfully employed Digital Image Correlation (DIC) technology to determine the deformation and constitutive model of blood vessels, and capture the high speed structural responses of metal plate in explosive events, as well as determining the interaction load between the explosive products and structures experiment-numerical simulation integrated method. Dr. Xu also applied DIC to investigate the structural buckling of temporary structures, determine accurate deformation and strain fields and the histories of the structures, and predict the Critical Stages and Failure Points of the structure.

Currently Dr. Xu is working on synthesis and material behavior characterization of bio-materials, bio-inspired hierarchically structured composites and multiscale structured materials for engineering applications. In this years, new low-cost, scalable and self-assembled fabrication method was developed, and a multiscale structured material - Coaxial Fibrous Silicon Asymmetric Membranes has been synthesized. The membranes have been successfully applied to improve the long term cyclability of high capacity lithium Ion battery.

The bio-inspired hierarchically structured composites potentially could be used for sound mitigation, thermal insulation, impact and blast resistant for engineering application, such as, Aerial Vehicles.

Research Equipment

3D Digital Image Correlation System
Phantom V710 High Speed Camera
FAE software: ANSYS, ABAQUS
Split Hopkinson Bar
MTS Model 810 Hydraulic Testing Machine with TestStar II controller
MTS Criterion 43 Electromechanical Universal Testing Systems
ADMET Stress-Strain-Torsion Frame and Controller eXpert 2601
ADMET Micro EP Universal Testing System
Vickers Hardness Tester
Digital Rockwell Hardness Testers
Stereo Microscope
Metallurgical Microscopes
Pace Technologies Nano 1000T Grinder & Polisher

Catalytic Fast Pyrolysis laboratory- Dr. Bhoi

1. **Thermo Scientific Nicolet iS10 Mid Infrared FT-IR Spectrometer:**
   The qualitative and quantitative analysis of the biofuel samples will be determined using a Thermo Scientific Nicolet iS10 Mid Infrared Fourier transform infrared (FTIR) spectrometer (Thermo Electron North America LLC - a division of Thermo Fisher Scientific, Madison, WI 53711). Sample spectra will be analyzed using the OMNIC standard software accompanied with the spectrometer. OMNIC software is capable to analyze biofuels compounds including hydrocarbons, alcohols, phenols, aldehydes, ketones and many more.

Fig. 23. Thermo Scientific Nicolet iS10 Mid Infrared FT-IR Spectrometer

VST 12, TVS 12 vertical split tube furnace: A vertical split tube furnace is accompanied with a temperature controller. A split tube furnace will be used to provide heat (maximum temperature: 1200°C) to the reactor for thermal decomposition of waste carbon resources including fatty acids and lipids.

Fig. 24. Experimental set-up of catalytic fast pyrolysis

2. **A fixed bed catalytic fast pyrolysis reactor (Under construction):** A fixed bed reactor is under construction for catalytic fast pyrolysis experiments using variety of waste carbon feedstocks including fatty acids and lipids.

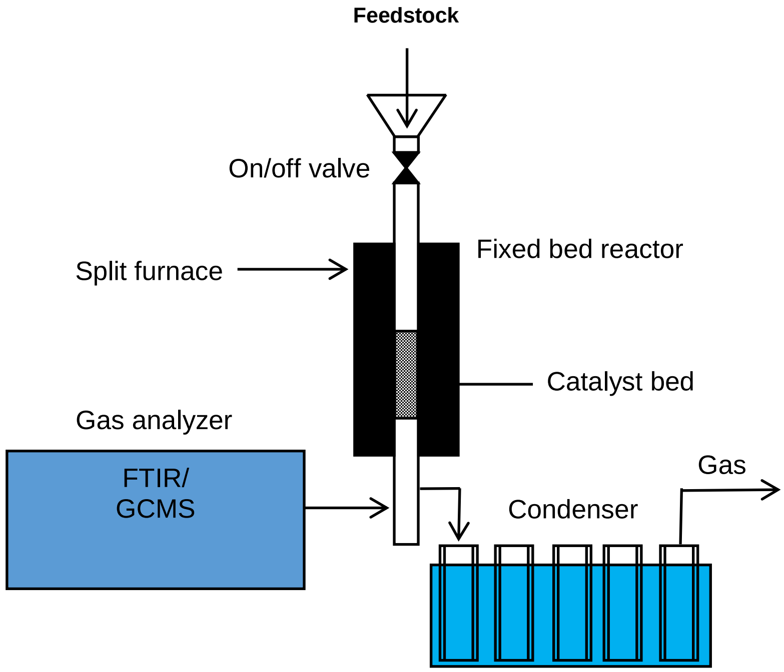


Fig. 25 Fixed bed catalytic fast pyrolysis reactor (Under construction

Fig. 26 Oxidation stability – Methrom Rancimat apparatus-in the lab

Fig. 27 Shimadzu TGA-DTA60 in the lab

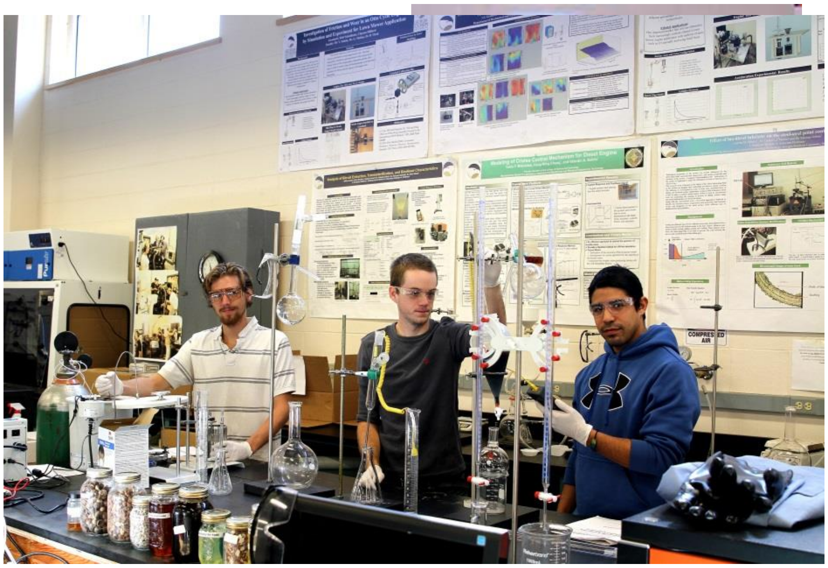


Fig. 28 Biofuels formulation in the laboratory

Fig. 29 LHV-Parr Calorimeter -in the lab

Fig. 30 Spray tester-Bosch

Fig.31 Brookfield Viscometer