

Liquid Propulsion

Papers Presented at the AIAA Propulsion and Energy
Forum 2019

Indianapolis, Indiana, USA
19 - 22 August 2019

Volume 1 of 2

ISBN: 978-1-7138-0117-7

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 34922 Uwytkug'Xcmg{'Ftkxg.'Uwky'422, Reston, VA 20191, USA.

TABLE OF CONTENTS

VOLUME 1

DESIGN, FABRICATION, TEST, LAUNCH,, EARLY OPERATION OF THE PARKER SOLAR PROBE PROPULSION SYSTEM	1
<i>Seth Kijewski, Stewart S. Bushman</i>	
FINAL DAWN REACTION CONTROL SYSTEM (RCS) PROPULSION SYSTEM IN-FLIGHT CHARACTERIZATION	15
<i>Todd J. Barber, Barry Nakazono, Masashi Mizukami</i>	
AMC9 SUCCESSFUL REORBITATION - PROPULSION CHALLENGES	34
<i>Eric Kruch, Andrea Aresini, Antoine Iffly, Joel Deck</i>	
DESIGN OF THE EUROPA CLIPPER PROPELLANT MANAGEMENT DEVICE	48
<i>Robert E. Manning, Ian Ballinger, Manoj Bhatia, Mack Dowdy</i>	
DEVELOPMENT OF A LOX/ETHANOL GAS GENERATOR FOR A HYBRID-MOTOR-BASED MINI-LAUNCHER	67
<i>Enrico Paccagnella, Mario Kobald, Christian Schmierer, Ulrich Fischer, Konstantin Tomilin</i>	
LIQUID ROCKET ENGINE TORCH IGNITER FEED SYSTEM	77
<i>Atticus J. Vadera</i>	
EVALUATION OF AN AUGMENTED SPARK IGNITER'S FLAME LENGTH, COMPARISON OF NUMERICAL, EXPERIMENTAL INVESTIGATIONS	90
<i>Levent Ç. Öz, Ali Can Özer, Bülent Sümer, Abdullah Ulas</i>	
IMPACT OF SUPERCRITICAL, TRANSCRITICAL EFFECTS ON ROCKET ENGINE INJECTOR MASS FLUX, STIFFNESS	115
<i>Nicholas Gloria</i>	
UNCERTAINTY ANALYSIS OF EXPERIMENTAL DISCHARGE COEFFICIENTS IN ADDITIVELY MANUFACTURED LIQUID INJECTOR ELEMENTS	125
<i>James P. Venters, Melissa Costa, Evan C. Unruh, David M. Lineberry, Robert A. Frederick, Jessica Wood, James Hulka</i>	
SUPERCRITICAL GN₂/GH₂ JET MODELED BY THE ECS METHOD	149
<i>Wei Yao, Yichao Jin, Yachao Li</i>	
STUDENT DEVELOPMENT OF A LIQUID OXYGEN, LIQUID METHANE SOUNDING ROCKET, LAUNCH INFRASTRUCTURE	163
<i>Silas Meriam, Christopher Nilsen, Matthew Tanner, Kyle Runkle, Bartkiewicz Jacob, Robert Groome, Scott E. Meyer</i>	
UPDATE ON THE STUDENT DEVELOPMENT OF A NITROUS OXIDE-ETHANE BIPROPELLANT ROCKET ENGINE	215
<i>McKynzie Perry, Erik Korizon, Oakley Copeland, Adam J. Bower</i>	
MODULAR LIQUID PROPELLANT LAUNCH VEHICLE DESIGN	229
<i>Derek Y. Honkawa, Mahdi Yoozbashizadeh</i>	
DESIGN, TESTING OF A 500 LBF LIQUID OXYGEN/LIQUID METHANE ENGINE	252
<i>Manuel Herrera, Mariana Chaidez, Zachary Welsh, Jason Adams, Luz I. Bugarin, Jack Chessa, Ahsan R. Choudhuri</i>	
OPTIMIZATION OF REGENERATIVELY COOLED ROCKET ENGINES COOLING CHANNEL DIMENSIONS	266
<i>Ehsan Atefi, Mohammad H. Naraghi</i>	
CARBON DEPOSIT FORMATION IN SUPERCRITICAL METHANE-BASED, HYDROCARBON FUELS USING A COOLING CHANNEL SURROGATE	279
<i>Robert Driscoll, Teresa Moore, Brian B. Brady, Steven Frolik, James H. Morehart</i>	
NUMERICAL INVESTIGATION OF BULK VELOCITY, PRESSURE ON NEAR WALL CHEMISTRY IN FUEL RICH RP-2/GOX COMBUSTION	292
<i>Rufat F. Kulakhmetov, Timothee L. Pourpoint</i>	
A FIRST STEP INTO THE BLANCHING MODELLING OF LIQUID ROCKET ENGINES: TAKING INTO ACCOUNT THE ROUGHNESS INCREASE OF THE CHAMBER WALL	306
<i>Jörg R. Riccius, Micha Böttcher</i>	
DEVELOPMENT STATUS OF LE-9 ENGINE FOR H3 LAUNCH VEHICLE	313
<i>Hideto Kawashima, Yusuke Funakoshi, Akihide Kurosu, Teiu Kobayashi, Koichi Okita</i>	

GENESIS, APPLICATION OF SMC-S-025: EVALUATION, TEST REQUIREMENTS FOR LIQUID ROCKET ENGINES.....	323
<i>Steven Fusselman, Wayne M. Van Lerberghe, Vinay Goyal, Kendricks Behring, Geoffrey Reber</i>	
DEVELOPMENT, TESTING OF A 5 LB_F LO₂/LCH₄ REACTION CONTROL ENGINE.....	337
<i>Steven A. Torres, Corey Hansen, Luz I. Bugarin, Jack Chessa, Ahsan R. Choudhuri</i>	
CHEMICAL PROPULSION FOR OUTER PLANET EXPLORATION.....	344
<i>Arturo R. Casillas, Jonathan R. Reh, James Gervasi, Shae Williams, Jacqueline Yager</i>	
PRELIMINARY RESULTS OF A MICROPUMP FOR MON-25/MMH PROPULSION, ATTITUDE CONTROL.....	356
<i>Andrea Besnard, Sudathsi Tennakoon, Jose Torres, Eric Besnard</i>	
SMALL-SCALE HYDROGEN PEROXIDE VAPOR PROPULSION SYSTEM: CATALYST PERFORMANCE, HEAT TRANSFER.....	372
<i>Brandie L. Rhodes, Evan R. Ulrich, Paul D. Ronney</i>	
UNSTEADY, TRANSVERSELY FORCED DYNAMICS OF TWO-PHASE MULTI-ELEMENT SHEAR COAXIAL FLOWS.....	383
<i>Mario Roa, Doug G. Talley</i>	
COMPUTATIONAL INVESTIGATION ON THE EFFECT OF THE OXIDIZER INLET TEMPERATURE ON COMBUSTION INSTABILITY.....	399
<i>Matthew E. Harvazinski, Taro Shimizu</i>	
SHUTDOWN INVESTIGATION IN A LOX-ETHANOL SUBSCALE THRUST CHAMBER.....	419
<i>Iago Dalmaso Brasil Dias, Levi Maia Araiijo, Leonardo Bartholomeu do Nascimento, Pedro Lacava, Cristiane M. Pagliuco, Daniel Soares de Almeida, Ronaldo C. Reis</i>	
EFFECTS OF THE RECESS LENGTH ON FLOW, COMBUSTION STABILITY OF GAS-CENTERED COAXIAL SWIRL INJECTORS.....	430
<i>Yuangang Wang, Young Jun Kim, Chae Hoon Sohn</i>	
CONJUGATED COMBUSTION, HEAT TRANSFER SIMULATIONS OF UPPER, LOWER MAIN COMBUSTION CHAMBERS OF LE-9 ENGINE.....	436
<i>Yu Daimon, Hideyo Negishi, Hideto Kawashima</i>	
ROCKET ENGINE DIGITAL TWIN – MODELING, SIMULATION BENEFITS.....	444
<i>David Jimenez Mena, Sylvain Pluchart, Stephane Mouvand, Olivier Broca</i>	
NUMERICAL TOOL OPTIMIZATION FOR ADVANCED ROCKET NOZZLE PERFORMANCE PREDICTION.....	460
<i>Antonietta Conte, Andrea Ferrero, Francesco Larocca, Dario Pastrone</i>	
NUMERICAL ACOUSTIC PREDICTION OF A QUADRATIC SUPERSONIC JET USING CAA HYBRID METHODS.....	470
<i>Eugeni Costa Ruiz, Ralf H. Stark, Stephan General, Dirk Schneider, Friedolin T. Strauss</i>	
DESIGN PROCEDURE, COLD FLOW EXPERIMENTS OF A PINTLE INJECTOR.....	479
<i>Berksu Erkal, Bilent Simer, Mehmet H. Aksel</i>	
EXPERIMENTAL STUDY OF SWIRL COAXIAL INJECTOR HYDRODYNAMICS UNDER HIGH-FREQUENCY SELF-PULSATION.....	494
<i>Isheeta S. Ranade, Robert A. Frederick</i>	
INVESTIGATION OF THE EFFECT OF GEOMETRICAL PARAMETERS OF PRESSURE SWIRL ATOMIZER ON THE HOLLOW CONE SPRAY.....	502
<i>Tolga Tokgöz, Bilent Simer, Abdullah Ulas</i>	

VOLUME 2

SHAPE MEMORY ALLOY ISOLATION VALVE (SMAIV) DEVELOPMENT, TESTING.....	536
<i>Joseph M. Cardin, Rajesh Bhandari, Ramin Rezaei, David B. Owen, William A. Hargus</i>	
MULTI-NODE MODELING OF CRYOGENIC TANK PRESSURIZATION SYSTEM USING GENERALIZED FLUID SYSTEM SIMULATION PROGRAM (GFSSP).....	552
<i>Alak Bandyopadhyay, Alok K. Majumdar, Andre LeClair, Juan Valenzuela</i>	
NUMERICAL MODELING OF PRIMING EVENT PEAK PRESSURES IN LIQUID PROPULSION SYSTEMS.....	564
<i>Jeffrey D. Moore, Grant A. Risha, Arpit Tiwari, Jonathan Harrison, Jon Zenker</i>	
ASSESSMENT OF USING ELECTRIC PUMPS ON HYBRID ROCKETS.....	573
<i>Kaan Gegeoglu, Mehmet Kahraman, Caglar Ucler, Arif Karabeyoglu</i>	
DESIGN, TESTING OF A 3D PRINTED 10 N HYDROGEN PEROXIDE MONOPROPELLANT THRUSTER.....	583
<i>Marco Santi, Igor Dornach, Francesco Barato, Daniele Pavarin</i>	

DEVELOPMENT, CHARACTERIZATION OF A CATALYST FOR THE DECOMPOSITION OF HYDROGEN PEROXIDE	601
<i>Santiago Casu, Rainer Kiemel, Bastian Geiger, Jérôme Anthoine, Jean-Yves Lestrade</i>	
DESIGN, FIRST RESULTS OF AN INJECTOR TEST SETUP FOR GREEN HYPERGOLIC PROPELLANTS	611
<i>Felix Lauck, Jan Witte, Michele Negri, Dominic Freudenmann, Stefan Schlechtriem</i>	
THERMAL MODELING OF ZERO BOIL OFF TANK EXPERIMENT	621
<i>Erin M. Tesny, Daniel M. Hauser</i>	
SINDA/FLUINT, THERMAL DESKTOP MULTI-NODE SETTLED, UNSETTLED PROPELLANT TANK MODELING OF ZERO BOIL OFF TEST	634
<i>Barbara A. Sakowski, Daniel M. Hauser, Mohammad Kassemi</i>	
CFD JET MIXING MODEL VALIDATION AGAINST ZERO-BOIL-OFF TANK (ZBOT) MICROGRAVITY EXPERIMENT	653
<i>Olga V. Kartuzova, Mohammad Kassemi</i>	
SYNOPSIS OF LOX/LIQUID METHANE, LIQUID NATURAL GAS ROCKET PROPELLANT EXPLOSION HAZARDS	678
<i>Alan Sutton, Nils Sedano</i>	
LINEAR BURN RATE OF IONIC LIQUID MULTIMODE MONOPROPELLANT	694
<i>Nicolas Rasmont, Emil J. Broemmelsiek, Alex J. Mundahl, Joshua L. Rovey</i>	
A TEST APPARATUS FOR THE CHARACTERIZATION OF IGNITABILITY, FLAMMABILITY OF METALS IN HIGH PRESSURE OXYGEN	708
<i>Levon Gevorkyan, Shannon McCall, Jennifer Smolke, Robert Driscoll</i>	
PARTICLE-IMPACT IGNITION OF METALS IN HIGH-PRESSURE, OXYGEN-RICH ENVIRONMENTS	723
<i>King yiu (Brian) Lam, Mark W. Crofton, Dustin Arnold, James H. Morehart</i>	
DEVELOPMENT, CHARACTERIZATION OF THE PURDUE ALTITUDE CHAMBER FACILITY FOR 100 LB_F SCALE THRUSTERS	734
<i>Benjamin E. Whitehead, Caglar Yilmaz, Jacob McCormick, Jason R. Gabl, Timothee L. Pourpoint</i>	
PROPULSION TESTING IN COMMERCIAL RE-USABLE SUB-ORBITAL ROCKETS	749
<i>Steven H. Collicott, Alina Alexeenko</i>	
DESIGN METHODOLOGY FOR A CENTRAL INJECTION TYPE SUPERSONIC AIR EJECTOR, DIFFUSER SYSTEM FOR ALTITUDE SIMULATION	757
<i>Ataman Aydogdu, Bülent Sümer, Bora Yazici, Abdullah Ulas</i>	
MODELING FOR DESIGN OF A SUB-ORBITAL PAYLOAD SUPPORTING CRYOGENIC GAUGING DEMONSTRATION	774
<i>Samantha J. Alberts, Steven H. Collicott</i>	
ASYMMETRIC PROPELLANT POSITIONING IN SYMMETRIC TANKS, PMDS	784
<i>Steven H. Collicott, Boris Yendler</i>	
CFD MODELLING OF PHASE CHANGE IN CRYOGENIC ROCKET TANKS	795
<i>Philipp Behruzi</i>	
COMPOSITE OVERWRAP PRESSURE VESSEL CLASS 3 ACCEPTANCE TESTING – A RECOMMENDED STRATEGY OF AIRBUS DEFENCE & SPACE LTD.	809
<i>Alex Konietzke, David Catherall</i>	
SIMULATION OF AIRCRAFT FUEL SYSTEM WITH COMPLEX 3D TANK GEOMETRY USING A 1D FLOW SOLUTION	815
<i>Arpit Tiwari, Jonathan Harrison</i>	
BIMETALLIC CHANNEL WALL NOZZLE DEVELOPMENT, HOT-FIRE TESTING USING ADDITIVELY MANUFACTURED LASER WIRE DIRECT CLOSEOUT TECHNOLOGY	826
<i>Paul R. Gradl, Sandy Greene, Tal Wammen</i>	
ADDITIVE MANUFACTURING, HOT-FIRE TESTING OF LIQUID ROCKET CHANNEL WALL NOZZLES USING BLOWN POWDER DIRECTED ENERGY DEPOSITION INCONEL 625, JBK-75 ALLOYS	844
<i>Paul R. Gradl, Christopher S. Protz, Tal Wammen</i>	
THE EFFECT OF SURFACE ROUGHNESS ON LCH₄ BOILING HEAT TRANSFER PERFORMANCE OF CONVENTIONALLY, ADDITIVELY MANUFACTURED ROCKET ENGINE REGENERATIVE COOLING CHANNELS	864
<i>Linda Hernandez, Raul Palacios, Debra Ortega, Jason Adams, Luz I. Bugarin, MD Mahamudur Rahman, Ahsan R. Choudhuri</i>	
THERMOANALYTICAL STUDY OF HYDROXYLAMMONIUM NITRATE DECOMPOSITION AT HIGH PRESSURES	875
<i>Alan A. Esparza, Evgeny Shafirovich</i>	

SAFE 0.5N GREEN MONOPROPELLANT THRUSTER FOR SMALL SATELLITE PROPULSION SYSTEMS.....	884
<i>Shinji Igarashi, Yoshiki Matsuura, Hirohide Ikeda, Keigo Hatai</i>	
INFLUENCE OF PROPELLANT COMPOSITION ON THE PERFORMANCE OF A GEL ROCKET COMBUSTION CHAMBER.....	893
<i>Christoph U. Kirchberger, Dominic Freudenmann, Helmut K. Ciezki</i>	
AN EXPERIMENTAL STUDY OF A NITROUS OXIDE / ETHANOL (NOEL) PROPULSION SYSTEM.....	904
<i>Shinichiro Tokudome, Ken Goto, Tsuyoshi Yagishita, Naohiro Suzuki, Takayuki Yamamoto</i>	
THE DEVELOPMENT STATUS OF LE-9 ENGINE TURBOPUMPS FOR H3 LAUNCH VEHICLE	916
<i>Nobuyuki Azuma, Makoto Kojima, Teiu Kobayashi, Koichi Okita, Taiichi Motomura, Kazuki Niiyama</i>	
NUMERICAL MODELING OF DIFFERENT DESIGNS FOR A ROCKET PROPELLANT TURBOPUMP INDUCER.....	925
<i>Juan M. Torres Zanardi, Federico Bacchi, Ana Scarabino</i>	
DESIGN, TESTING OF CENTRIFUGAL FUEL PUMP FOR LIQUID PROPELLANT ROCKET ENGINE L75.....	937
<i>Ronaldo C. Reis, Lucas D. Silva, Cristiane M. Pagliuco, Daniel S. Almeida, Daniel Bourdon</i>	
NUMERICAL STUDY OF TIP CLEARANCE EFFECTS IN A CENTRIFUGAL PUMP WITH UNSHROUDED IMPELLER FOR LIQUID ROCKET ENGINES	952
<i>Hideyo Negishi, Shinji Ohno, Teiu Kobayashi</i>	
DEVELOPMENT OF A HYDROSTATIC JOURNAL BEARING WITH MICRO POROUS CMC MATERIAL	968
<i>Helge Seiler, Markus Ortelt, Martin Böhle</i>	
SSPD RESTORE-L PROPELLANT TRANSFER SUBSYSTEM PROGRESS	977
<i>Gregory T. Coll, Graham Webster, Oliver Pankiewicz, Keith Schlee, Thomas Aranyos, Brian Nufer, Jenna Fothergill, Gabor Tamasy, Max Kandula</i>	
CRITICAL REVIEW OF DAMPING PREDICTION METHODS FOR ANNULAR RING SLOSH BAFFLES.....	996
<i>Shane B. Coogan, Steven Green</i>	
DYNAMICS OF LOW-GRAVITY SLOSHING IN SPHERICAL TANKS DURING TOUCHDOWN PHASES OF LANDERS	1012
<i>Keitaro Aonii, Takehiro Himeno, Yasunori Sakuma, Toshinori Watanabe, Mitsuhsa Baba, Masatsugu Otsuki, Yutaka Umemura</i>	
EFFECT OF TEMPERATURE, PRESSURE MEASUREMENT UNCERTAINTIES ON PHASE CHANGE CALCULATIONS WITH LIQUID HYDROGEN.....	1021
<i>Praveen Srikanth, Steven H. Collicott</i>	
NUMERICAL SIMULATION ON LIQUID HYDROGEN CHILL-DOWN PROCESS OF VERTICAL PIPELINE	1028
<i>Yutaka Umemura, Takehiro Himeno, Kiyoshi Kinofuchi, Yasuhiro Saito, Barbara A. Sakowski, Daniel M. Hauser, Jason W. Hartwig, Wesley L. Johnson, Andre LeClair</i>	
Author Index	