# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>THRUST AUGMENTATION OF AN ADDITIVELY MANUFACTURED HYBRID ROCKET</td>
<td>1</td>
</tr>
<tr>
<td>SYSTEM USING SECONDARY H₂O₂ INJECTION</td>
<td></td>
</tr>
<tr>
<td>S.A. Whitmore, M.C. Heiner</td>
<td></td>
</tr>
<tr>
<td>DIODE LASER IGNITION MECHANISM FOR HYBRID PROPULSION SYSTEMS</td>
<td>33</td>
</tr>
<tr>
<td>D.M. Dyrd, V. Kornevesya, B.J. Cantwell</td>
<td></td>
</tr>
<tr>
<td>NOVEL HYBRID ROCKET INTERNAL BALLISTIC CONFIGURATION WITH COAXIALLY</td>
<td>49</td>
</tr>
<tr>
<td>LOCATED TUBE INJECTOR</td>
<td></td>
</tr>
<tr>
<td>M. Kahraman, K. Gegeoglu, I. Otsol, M.A. Karabeyoglu</td>
<td></td>
</tr>
<tr>
<td>POROSITY AND TEMPERATURE EFFECTS ON AXIAL-INJECTION, END-BURNING</td>
<td>66</td>
</tr>
<tr>
<td>HYBRID ROCKET MOTOR REGRESSION</td>
<td></td>
</tr>
<tr>
<td>M.A. Hitt</td>
<td></td>
</tr>
<tr>
<td>VIABILITY STUDY OF ACRYLONITRILE BUTADIENE STYRENE POLYMER AS FUEL</td>
<td>72</td>
</tr>
<tr>
<td>FOR HYBRID ROCKET ENGINES IN COLOMBIA</td>
<td></td>
</tr>
<tr>
<td>H.M. Lozada, J.A. Urrego, R.M. Fabio</td>
<td></td>
</tr>
<tr>
<td>DEVELOPMENT OF HAPITH SMALL LAUNCH VEHICLE BASED ON HYBRID ROCKET</td>
<td>89</td>
</tr>
<tr>
<td>PROPULSION</td>
<td></td>
</tr>
<tr>
<td>Y.S. Chen</td>
<td></td>
</tr>
<tr>
<td>FEASIBILITY STUDY FOR HYPersonic FLIGHT TEST USING A REUSABLE HYBRID</td>
<td>97</td>
</tr>
<tr>
<td>ROCKET MOTOR</td>
<td></td>
</tr>
<tr>
<td>P. Nardozzo, S. Popkin, J. Smith</td>
<td></td>
</tr>
<tr>
<td>DEVELOPMENT OF THE NUCLEUS HYBRID PROPULSION SYSTEM: ENABLING A</td>
<td>109</td>
</tr>
<tr>
<td>SUCCESSFUL FLIGHT DEMONSTRATION</td>
<td></td>
</tr>
<tr>
<td>M.G. Faenza, A.J. Boiron, B. Haemmerli, O. Verberne</td>
<td></td>
</tr>
<tr>
<td>A SINGLE STAGE TO ORBIT DESIGN FOR A HYBRID MARS ASCENT VEHICLE</td>
<td>131</td>
</tr>
<tr>
<td>G. Story, A. Schnell, D. Yaghoubi, A. Karp, B. Nakazono, G. Zdiac</td>
<td></td>
</tr>
<tr>
<td>EVALUATION OF SAFETY DISTANCE FOR BLAST OF HYBRID ROCKET PROPELLANTS</td>
<td>150</td>
</tr>
<tr>
<td>A. Takahashi, K. Kitagawa, T. Shimada</td>
<td></td>
</tr>
<tr>
<td>RESPONSE MECHANISMS IN AXIAL-INJECTION END-BURNING HYBRID ROCKETS</td>
<td>176</td>
</tr>
<tr>
<td>Y. Saito, A. Tsuji, A. Yamada, H. Nagata</td>
<td></td>
</tr>
<tr>
<td>SIMULATION OF SURFACE INSTABILITIES IN LIQUEFYING HYBRID ROCKET FUELS</td>
<td>186</td>
</tr>
<tr>
<td>I.M. Knol, B.A. Maicke</td>
<td></td>
</tr>
<tr>
<td>SUPPRESSING THE LFI WITH DUAL FUEL IN HYBRID ROCKET COMBUSTION</td>
<td>199</td>
</tr>
<tr>
<td>H. Chae, S.H. Kang, C. Lee</td>
<td></td>
</tr>
<tr>
<td>SELECTION CRITERIA FOR TACKIFIER ADDITION TO PARAFFIN WAX BASED</td>
<td>209</td>
</tr>
<tr>
<td>HYBRID ROCKET FUELS</td>
<td></td>
</tr>
<tr>
<td>K. Bilge, N.B. Emerce, U.C. Yildiz, U. Kokal, M. Baysal</td>
<td></td>
</tr>
<tr>
<td>PERFORMANCE ENHANCING ADDITIVES FOR HYBRID ROCKETS</td>
<td>222</td>
</tr>
<tr>
<td>H. Karakas, O. Kara, I. Otsol, A. Karabeyoglu</td>
<td></td>
</tr>
<tr>
<td>EXPERIMENTAL TEST OF N₂O/O₂, OXIDIZER MIXTURE WITH PARAFFIN BASED</td>
<td>236</td>
</tr>
<tr>
<td>ALUMINUM FUEL FOR MARS ASCENT VEHICLES</td>
<td></td>
</tr>
<tr>
<td>O. Kara, H. Karakas, M.A. Karabeyoglu</td>
<td></td>
</tr>
<tr>
<td>LOW PRESSURE IGNITION TESTING OF A HYBRID SMALLSAT MOTOR</td>
<td>253</td>
</tr>
<tr>
<td>E.T. Jens, A.C. Karp, K. Williams, B. Nakazono, J. Rabinovich, D. Dyrd, F. Mechtel</td>
<td></td>
</tr>
<tr>
<td>STATE OF ART AND CURRENT CHALLENGES OF THE PARAFFIN-BASED HYBRID</td>
<td>264</td>
</tr>
<tr>
<td>ROCKET TECHNOLOGY</td>
<td></td>
</tr>
<tr>
<td>G. Lecce, E. Cavallini, M. Pizzarelli</td>
<td></td>
</tr>
<tr>
<td>DEVELOPMENT AND TEST FLIGHT OF THE ATLANTIS I NITROUS OXIDE/PARAFFIN-</td>
<td>283</td>
</tr>
<tr>
<td>BASED HYBRID ROCKET</td>
<td></td>
</tr>
<tr>
<td>T. Messinger, C. Hill, D. Quinn, D. Stannard, G. Doerksen, C. Johansen</td>
<td></td>
</tr>
<tr>
<td>AN INVESTIGATION OF THE CENTRIFUGAL CASTING OF PARAFFIN WAX ON EARTH</td>
<td>293</td>
</tr>
<tr>
<td>AND IN MICROGRAVITY</td>
<td></td>
</tr>
<tr>
<td>DEMONSTRATION OF AN ALTERNATING-INTENSITY SWIRLING OXISIZER FLOW TYPE</td>
<td>316</td>
</tr>
<tr>
<td>HYBRID ROCKET FUNCTIONS</td>
<td></td>
</tr>
<tr>
<td>I. Nakagawa, D. Kishizato, Y. Koinuma, S. Tanaka</td>
<td></td>
</tr>
</tbody>
</table>
EXPERIMENTAL INVESTIGATION OF ABS-PARAFFIN 3D PRINTED HYBRID ROCKET FUELS ........................................................... 326

J.A. Bresler, B. Natun

DIODE LASER IGNITION TESTING FOR PMMA/GOX HYBRID MOTORS ................................................................. 342


ROBUST DESIGN OF HYBRID ROCKET ENGINE FOR SMALL SATELLITE LAUNCHERS .......................................................... 356

L. Casalino, D. Pastrone, F. Masseni

EXPERIMENTAL VALIDATION OF THE X-RAY DETERMINED PORE SIZE DISTRIBUTION OF POROUS HYBRID MOTOR GRAINS ................................................................. 365

J.B. Buckley, R.T. White, G.J. Nelson

SPECTROSCOPIC TECHNIQUES FOR MEASURING REGRESSION RATES OF LIQUEFYING HYBRID ROCKET FUELS ................................................................. 375

C.C. McDougall, C.D. Hill, C.J. Heinrichs, C.T. Johansen

RECONSTRUCTION OF ATTENUATED HYBRID MOTOR CHAMBER PRESSURE SIGNALS USING MAXIMUM LIKELIHOOD ESTIMATION AND OPTIMAL DECONVOLUTION .................................................................................. 384

S.A. Whitmore, E.M. Zelesnak

BOUNDARY-LAYER COMBUSTION OF WAX-BASED FUELS AT VARIOUS CHAMBER PRESSURES UNDER TWO STATIC ACCELERATION ENVIRONMENTS ................................................................. 407

K. Ozawa, T. Yoshino, H.W. Wang, N. Tsuboi

AN EXPERIMENTAL STUDY OF FACTORS AFFECTING HYPERGOLIC IGNITION OF AMMONIA BORANE ................................................................................................................................. 430

K.A. Clements, M.J. Baier, P.V. Ramachandran, S.F. Son

FUEL REGRESSION CHARACTERISTICS IN HYBRID ROCKETS USING N2O/HDPE ................................................................. 440

S. Ito, L. Kamps, K. Sakurai, L. Kagayama, T. Okuda, H. Nagata

MEDICAL GRADE N2O/O2 MIXTURES AS INEXPENSIVE AND VOLUMETRICALLY EFFICIENT OXIDIZERS FOR SMALL SPACECRAFT HYBRID PROPULSION SYSTEMS .......................................................................... 451

S.A. Whitmore, R.L. Stoddard, R.S. Babb, D.J. Horlacher

DEVELOPMENT AND PRELIMINARY TESTING OF PARAFFIN HYBRID ROCKET FUEL GRAINS WITH HELICAL PORT STRUCTURES ................................................................................................. 484

L.L.B. Pabarcius

CHARACTERISTICS OF SOLID FUEL BASED ON WAX WITH ADDED POLYPROPYLENE FOR HYBRID ROCKET ................................................................................................................................. 495

K. Kinoshita, Y. Matsumori, K. Takahashi

ALUMINUM POWDER EFFECTS WITH AFT-CHAMBER EXTENSION AND BAFFLE PLATE INSTALLATION FOR HYBRID ROCKET ................................................................................................................................. 502

Y. Kanbayashi, K. Takahashi, A. Takahashi

SWEATING HYBRID ROCKET FUELS; INCLUSION AND TEMPERATURE ACTIVATED RELEASE OF LIQUID FUELS IN SOLID BINDERS ................................................................................................................................. 511

M.S. McClain, M. Paik, C. Farrell, J.P. Youngblood, T.L. Pourpoint

MODIFICATION OF PARAFFIN-BASED HYBRID ROCKET FUELS USING STRUCTURAL LATTICES ................................................................................................................................. 522

C.D. Hill, C.C. McDougall, T.L. Messinger, C.T. Johansen

OPTICALLY RESOLVED FUEL REGRESSION OF A CLEAR PMMA HYBRID ROCKET MOTOR ................................................................................................................................. 532

F.S. Mechentel, B.R. Hord, B.J. Cantwell

DATA CLUSTERING OF HYBRID ROCKET COMBUSTION FLAME ................................................................................................................................. 549

A. Petrarolo, M. Kobald, A. Rutgers

NUMERICAL INVESTIGATION OF A LOW THRUST PARAFFIN/N2O HYBRID ROCKET ................................................................................................................................. 565

S. Srivastava, A. Ingenito, R. Andriani

RECENT ADVANCEMENTS IN EXPERIMENTAL AND NUMERICAL CHARACTERIZATION OF PARAFFIN-BASED FUELS FOR HYBRID ROCKET APPLICATION ................................................................................................................................. 581

G.D. Di Martino, G. Gallo, S. Mungiguerra, C. Carmicino, R. Savon, D. Cardillo, F. Battista

PREDICTIVE CFD MODEL FOR INTERNAL BALLISTICS OF HYBRID ROCKET ENGINES USING SUPERCritical PARAFFIN-WAX AND OXYGEN ................................................................................................................................. 593

M.T. Migliorino, D. Bianchi, F. Nasuti

EVALUATION OF DISCRETIZATION SCHEMES IN BIGLOBAL STABILITY ANALYSIS OF CYLINDRICALLY-SHAPED SOLID AND HYBRID ROCKETS ................................................................................................................................. 609

T.S. Elliott, A.M. Sam, T.D. Grider, J. Majdalani

CFD ANALYSIS OF PARAFFIN-BASED HYBRID ROCKETS WITH COUPLED NOZZLE EROSION CHARACTERIZATION ................................................................................................................................. 623

D. Bianchi, M.T. Migliorino, F. Nasuti, M. Onofri
INVESTIGATION OF GRAPHITE NOZZLE EROSION IN HYBRID ROCKETS USING N2O/HDPE ................................................................. 639
L. Kamps, K. Sakurai, K. Ozawa, H. Nagata

BASIC RESEARCH ON IMPROVEMENT OF COMBUSTION EFFICIENCY OF WAX FUEL HYBRID ROCKET .................................................................................................................................................. 657
K. Yasuda, I. Nakagawa

REAL-TIME DEEP THROTTLING TESTS OF A HYDROGEN PEROXIDE HYBRID ROCKET MOTOR .................................................................................................................................................................................. 667
A. Ruffin, E. Paccagnella, M. Santi, F. Barato, D. Pavarin

FLIGHT TESTING OF TECHNOLOGY DEMONSTRATOR WITH HYDROGEN PEROXIDE HYBRID ROCKET .............................................................................................................................................................................. 687
Y. Yan, J. Seo, K. Park, J. Jeong, J. Kim, S. Kwon

DEVELOPMENT OF A 2D OPTICALLY ACCESSIBLE HYBRID ROCKET MOTOR ................................................................................................................................................................. 695
S.M. Boyle, D.E. Scarborough

EFFECT OF AFT CHAMBER VOLUME ON HYBRID ROCKET COMBUSTION EFFICIENCY ............................................................................ 706
L. Kageyama, L. Kamps, H. Nagata

PERFORMANCE OF SOLID STATE EMULSIONS OF ISOAMYL ALCOHOL IN EVA-STABILIZED LOW-MW POLYETHYLENE, STRUCTURED BY LASER-SINTERED NYLON SCAFFOLDS AS FUELS IN N2O HYBRID ROCKET ENGINE ........................................................................................................................................................................... 721

EXPERIMENTAL FINDINGS ON PRE- AND POST-COMBUSTION CHAMBER EFFECTS IN A LABORATORY-SCALE MOTOR ................................................................................................................................. 740
F.S. Mechentel, B.J. Cantwell

THERMOCHEMICAL STRUCTURE OF A HYBRID ROCKET REACTION LAYER BASED ON LASER ABSORPTION TOMOGRAPHY ................................................................................................................................. 760
F.A. Bendana, J.J. Castillo, C.G. Hagstrom, R.M. Spearrin

HYPERGOLIC HYBRID ROCKET MOTOR CHARACTERIZATION WITH MON-25 AT ATMOSPHERIC AND REDUCED PRESSURES ........................................................................................................................................................................... 769
A. Benhidjeb-Carayon, J.M. McCormick, C. Yilmaz, J.R. Gabl, B.E. Whitehead, T.L. Pourpoint

CFD MODELING OF A HYBRID ROCKET USING A GENERALIZED ONE-DIMENSIONAL MODEL OF THE FLAME TEMPERATURE ................................................................................................................................. 788
N.S. Uddanti, Y. Crispin

NUMERICAL SIMULATION OF COMBUSTION IN A HYBRID ROCKET WITH LIQUEFYING FUELS ........................................................................................................................................................................... 801
G.M.D. Prasad, S. Menon, A. Baran

STUDY OF REGRESSION RATES IN A HYBRID ROCKET MOTOR ................................................................................................................................. 814
J. Dhanasekaran, V. Ramanan

THE DEVELOPMENT OF A POWDER-FILLED, ABS MATRIX FOR USE AS FUEL IN A HYBRID ROCKET MOTOR ........................................................................................................................................................................... 821
T. Aarant, J. Bass, T. Grinsel, S. Holladay, M. McVey, W. Patthoff, A. Shave, P. Tarle, R. Nickel, C. Little, J.E. Lyne

BURNING BEHAVIOR INVESTIGATION OF A VORTEX FLOW PANCAKE HYBRID ROCKET ENGINE ........................................................................................................................................................................... 834
C. Paravan, F. List, P. Massimo, R. Bissin, L. Galfetti

Author Index