POSTER SESSION TOPICS

Poster Session (Monday 8/13/2012, 6:30PM to 9:30PM)

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TFAWS2012-PS-02	Orbital Heating in COMSOL via MATLAB	Jonathan Hoy	Cal Poly Pomona
TFAWS2012-PS-03	Thermal Design for a High Usability Host Spacecraft	Danny Forgette	Cal Poly Pomona
TFAWS2012-PS-04	RAMS Thermal Subsystem for Stratospheric Deployment	Alexander W Raymond	Jet Propulsion Laboratory
TFAWS2012-PS-05	Thermal Management of an Unmanned Ground Vehicle (UGV) using Siemens NX Advanced Thermal/Flow with ESC	Matthew Samson	Cal Poly Pomona/Northrop Grumman
TFAWS2012-PS-06	Mechanically Pumped Fluid Loops: Components and Systems for Space Applications	Michael Brown	Pacific Design Technologies, Inc.
TFAWS2012-PS-07	MSL Launch Pad Operation of the Pre-Cooling of the Rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)	Dave Bame	Jet Propulsion Laboratory
TFAWS2012-PS-08	MSL Heat Rejection System (HRS) Mechanical Fluid Connections and Flexlines	Dave Bame	Jet Propulsion Laboratory
TFAWS2012-PS-09	Extreme Environment Thermal Control Technologies for Long-Life Venus Mission	Michael Pauken	Jet Propulsion Laboratory
TFAWS2012-PS-10	Computational Fluid Dynamics Tool Assessment – Comparison of CFdesign2011 and STAR-CCM+ V6 using Test Case Suite	Bret J Naylor	Jet Propulsion Laboratory

TFAWS2012-PS-01

REGENERATIVELY COOLED ROCKET NOZZLE CFD COOLING SYSTEM ANALYSIS

Matthew E. DeVost, California State Polytechnic University, Pomona

ABSTRACT

The use of computational fluid dynamics (CFD) software in the design stages of various industries has proven to be a valuable and resourceful tool. Medical, mechanical and aerospace, are but just a few industries actively involved using CFD software to analyze prototype innovations before production. Using CFD software allows the manipulation of various physical parameters to simulate a working environment or even worst case conditions. Siemens offers a product lifecycle management tool known as NX. In this poster, the use of SIEMENS NX thermal/flow was used as a preliminary design tool to analyze the thermal cooling potential and fluid flow for the cooling fluid inside of a regeneratively cooled rocket nozzle. The results of the initial CFD analysis lead to a redesign of the cooling chamber and an overall improved cooling design for the high temperatures induced during a live fire of a rocket nozzle.

TFAWS2012-PS-02

ORBITAL HEATING IN COMSOL VIA MATLAB

Jonathan Hoy, California State Polytechnic University, Pomona
Dr. Kevin R. Anderson, California State Polytechnic University, Pomona

ABSTRACT

The objective was to program orbital heating codes for a cube orbiting the earth in space via MATLAB using three different orbit types: a sun synchronous orbit, a generalized orbit using a beta angle, and a generalized orbit using the six classical orbital elements. For the sun synchronous orbit, the input parameters are the location of the nodal crossings, altitude, and orbit angle. For the generalized beta angle orbit, the input parameters are the beta angle, altitude, and orbit angle. The three sources of heat flux are Direct Solar Radiation, Albedo, and Earthshine. The orbit codes are transferred into COMSOL via the LiveLink Interface for MATLAB. The calculated heat flux loads from the MATLAB codes are then compared to the heating loads calculated using the FEA software Siemens NX Space Systems Thermal. This project is unique because it allows for an extension of the computational capabilities of COMSOL via MATLAB subroutines.

TFAWS2012-PS-03

THERMAL DESIGN FOR A HIGH USABILITY HOST SPACECRAFT

Danny Forgette, California State Polytechnic University, Pomona
Augustine Smith, California State Polytechnic University, Pomona
Jonathan Hoy, California State Polytechnic University, Pomona
Matthew DeVost, California State Polytechnic University, Pomona
Kevin Mayer, California State Polytechnic University, Pomona
Sevan Kenderian, California State Polytechnic University, Pomona
Christine Sellerberg, California State Polytechnic University, Pomona
Maria Verastegui, California State Polytechnic University, Pomona
Michelle Alfonsi, California State Polytechnic University, Pomona

ABSTRACT

Recent efforts in space exploration have focused on budget solutions for monitoring Earth's climate and astrophysics. One such solution is the 10cm cubic satellite (Cubesat), however, the size and power restrictions severely limit the types of instruments they can carry. A budget spacecraft with a modular instrument interface and multiple orbit options would provide considerable benefit to the scientific community. Implementing such a satellite requires thermal design in order to maintain the scientific instruments and bus components within their ideal operating temperatures. Implementing thermal system design for such a spacecraft is the focus of an ongoing industry/university collaborative senior project between Jet Propulsion Laboratory (JPL) and California State Polytechnic University, Pomona. In this collaborative project, a team of students operate within the industry-standard design cycle under a team of mentors. The students are given a set a thermal requirements as well as power, volume and mass restrictions and a design subject to these requirements as the deliverable. This poster will outline thermal system design for a High Usability Host Spacecraft using Siemens' NX Space Systems Thermal (SST). Additionally, the results from SST will be compared to preliminary results obtained from JPL-standard design calculations. Preliminary results suggest that the High Usability Host Spacecraft is viable for low-cost scientific instrumentation.

TFAWS2012-PS-04

RAMS THERMAL SUBSYSTEM FOR STRATOSPHERIC DEPLOYMENT

Alexander W Raymond, Jet Propulsion Laboratory
Michael Pauken, Jet Propulsion Laboratory
Evan Neidholdt, Jet Propulsion Laboratory

ABSTRACT

The Rapid Acquisition Mass Spectrometer (RAMS) will fly on the Analog Site Testbed for Readiness Advancement (ASTRA) stratospheric balloon mission scheduled for launch in August, 2012. ASTRA is a JPL Phaeton Class-D mission meant to train early career hires through all phases of an immersive flight project. RAMS is a commercial-off-the-shelf (COTS) instrument that has been modified to measure trace atmospheric gases at an altitude of 113,000 ft. During ascent through the troposphere and three hour float at altitude, RAMS will be subject to -65^{o}C temperatures and pressures as low as 4 mbar. Because the COTS thermal control system was intended for operation in a convective environment between 5 and 40^{o}C, it has been replaced to enable survival and functionality of the instrument. The new design relies on eight sintered wick heat pipes and four flexible thermal straps to transfer heat generated by the electronics and vacuum assembly to two radiators. A total of 50 W of dedicated, thermostat-controlled heater power has been allocated to maintain part temperatures above allowable limits on ascent. This poster describes experimental and modeling efforts to understand the instrument thermal characteristics as well as the thermal control solution that has been implemented on the balloon flight hardware.

TFAWS2012-PS-05

Thermal Management of an Unmanned Ground Vehicle (UGV) using Siemens NX Advanced Thermal/Flow with ESC

Matthew Samson, Cal Poly Pomona/Northrop Grumman

ABSTRACT

With the recent advancements in unmanned aerial and unmanned ground vehicles (UAVs/UGVs), more complex electronics are required for them to perform their functions. As such, it is crucial to ensure that these electronic components are kept within their operating temperatures. The vehicle described here is the product of a Northrop Grumman-funded, multi-disciplinary student project which entailed the design, analysis, fabrication, and testing of an autonomous UGV. This presentation focuses on the use of computational fluid dynamics (CFD) to model the cooling from forced flow. Simulations were performed in Siemens NX 8 using the Advanced Thermal/Flow with ESC module to determine an optimal flow path through the housing of the vehicle.

TFAWS2012-PS-06

MECHANICALLY PUMPED FLUID LOOPS: COMPONENTS AND SYSTEMS FOR SPACE APPLICATIONS

Michael Brown, Pacific Design Technologies, Inc

ABSTRACT

The paper presents an overview of components in a typical mechanically pumped fluid heat transfer loop, system considerations, testing protocol and means to quantify performance. A brief discussion of systems used in past missions and future trends is also included.

The fundamental system design and sizing considerations addressed include operating temperature, heat transfer rate, mass, power and volume limitations. A discussion of fluid selection criteria, materials compatibility, pump types and power sources is included.

The paper also provides a description of several systems that have been used for on-orbit and deep space missions. The paper will also draw comparisons to active thermal control systems used in conventional airborne vehicles. The systems and missions addressed include:
Past Missions: Mars Pathfinder, Mars Exploration Rovers, Mars Science Laboratory, Alpha Magnetic Spectrometer II
Future Missions: Solar Probe Plus
Airborne Systems: Various manned and un-manned Intelligence, Surveillance and Reconnaissance (ISR) platforms

Special considerations for space missions will be addressed, such as system design, reliability, cleanliness and filtration.

A discussion of typical testing methods will be provided; this will include thermal and thermal-vacuum, vibration/shock, EMI and endurance testing.

Standard methods to assess the performance of pumped fluid systems through measurement of flow, pressure drop and temperature will be briefly described.

TFAWS2012-PS-07

MSL LAUNCH PAD OPERATION OF THE PRE-COOLING OF THE ROVER'S MULTI-MISSION RADIOISOTOPE THERMOELECTRIC GENERATOR (MMRTG)

Dave Bame, Jet Propulsion Laboratory

ABSTRACT

The Mars Science Laboratory (MSL) rover was launched on November 26, 2011 on an Atlas V rocket. Numerous preparations were carried out immediately prior to launch in order to close out the spacecraft's complex heat rejection system (HRS), which consists of two mechanically pumped fluid CFC-11 loops. The first HRS loop, onboard the Curiosity rover, was fully integrated, filled with CFC-11, and successfully operated prior to launch pad operations. However, the second thermal loop, called the Cruise HRS loop, required final mechanical and thermal integration activities to occur while on the launch pad in order to accommodate the last minute installation of the Rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) power source. In order to prevent overheating of propellant tanks and critical avionics equipment buried deep within the spacecraft's Aeroshell, the MMRTG needed to be pre-cooled using a separate ground based Chiller (designed and built by Advance Thermal Systems, ATS, Anaheim, Ca.) The non-flight chiller mechanically pumped the fluid prior to and during the final closeout and subsequent startup of the flight loop on the Spacecraft.

TFAWS2012-PS-08

MSL HEAT REJECTION SYSTEM (HRS) MECHANICAL FLUID CONNECTIONS AND FLEXLINES

Dave Bame, Jet Propulsion Laboratory
Gaj Birur, Jet Propulsion Laboratory

ABSTRACT

Two mechanically pumped fluid loops provide thermal control of the Mars Science Laboratory (MSL) rover. These two loops are part of two Heat Rejection Systems (HRS), one for the Cruise phase and the other is for the Rover. The Cruise HRS removes waste heat from the Rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) power source during Cruise phase. The Rover HRS either recovers or rejects MMRTG waste heat during Mars surface operations depending on the environmental conditions. The Cruise system has a fluid flow rate of 1.5L/min, pump ΔP 10 psid, operating pressure of 200 psia and temperature range of -55 to +70°C. The Rover fluid system has a flow rate of .75 L/min, ΔP of 10.5 psid, operating pressure of 200 psia and operating temperature range of -55 to +90°C

TFAWS2012-PS-09

EXTREME ENVIRONMENT THERMAL CONTROL TECHNOLOGIES FOR LONG-LIFE VENUS MISSION

Michael Pauken, Jet Propulsion Laboratory
Linda Del Castillo, Jet Propulsion Laboratory
Marissa Van Luvender, Jet Propulsion Laboratory
John Beatty, Jet Propulsion Laboratory
Mike Knopp, Jet Propulsion Laboratory
Jay Polk, Jet Propulsion Laboratory

ABSTRACT

This RTD effort will enable Venus Surface Missions such as SAGE to operate up to 5 times longer than any other previous Venus surface mission. It will also enable Deep Atmospheric Probes to reach greater depths into the atmospheres of Jupiter and Saturn than the Galileo Probe did at Jupiter. Longer survival time results in greater science return and increases odds for anomaly recovery.

TFAWS2012-PS-10

COMPUTATIONAL FLUID DYNAMICS TOOL ASSESSMENT – COMPARISON OF CFDESIGN 2011 AND STAR-CCM+ V6 USING TEST CASE SUITE

Bret J. Naylor, Jet Propulsion Laboratory

ABSTRACT

As part of an internal review of computational fluid dynamics software packages, several test cases of restricted fluid flow and heat transfer were developed and analyzed using CFdesign 2011 from Blue Ridge Numerics, Inc. and STAR-CCM+ V6 from CD-adapco. The simple test cases described in this paper can be simulated quickly in modern computer hardware and are useful for both novice user training and tool evaluation. The simulation results from both packages are compared for numerical agreement and graphical presentation of simulation data. Agreement between the two evaluated packages is generally quite good however some localized discrepancies are found. One of the test cases, two-dimensional flow between parallel plates, has an arithmetic solution to which the simulation results are compared. While both packages produced results within 10% of the analytical solution, STAR-CCM+'s results were much more accurate and improved as the mesh density was increased. The convergence time for the test cases is analyzed to provide a very-coarse estimate of the computation time required for CFD analysis based on simulation volume, expected feature size and meshing primitive. Based on this simulation-time estimator, STAR-CCM+ is 6 to 12 times faster than CFdesign on a modern multi-core, single-processor desktop computer. Based on the results of this tool assessment and that of others, JPL has adopted STAR-CCM+ for CFD analysis in fiscal year 2012 and will continue to evaluate the utility and appropriateness of this package in the coming years.