Plasma Igniter for Reliable Ignition of Combustion in Rocket Engines

Marshall Space Flight Center, Alabama

A plasma igniter has been developed for initiating combustion in liquid-propellant rocket engines. The device propels a hot, dense plasma jet, consisting of elemental fluorine and fluorine compounds, into the combustion chamber to ignite the cold propellant mixture. The igniter consists of two coaxial, cylindrical electrodes with a cylindrical bar of solid Teflon plastic in the region between them. The outer electrode is a metal (stainless steel) tube; the inner electrode is a metal pin (mild steel, stainless steel, tungsten, or thoriated-tungsten). The Teflon bar fits snugly between the two electrodes and provides electrical insulation between them. The Teflon bar may have either a flat surface, or a concave, conical surface at the open, down-stream end of the igniter (the igniter face). The igniter would be mounted on the combustion chamber of the rocket engine, either on the injector-plate at the up-stream side of the engine, or on the sidewalls of the chamber. It also might sit behind a valve that would be opened just prior to ignition, and closed just after, in order to prevent the Teflon from melting due to heating from the combustion chamber.

The plasma jet deposits the energy required to initiate combustion, while highly reactive fluorine and fluorine compounds create free-radicals in the flow-field to further promote rapid ignition. The plasma jet is created and accelerated electrically, and the feedstock for the plasma is maintained in a solid, inert form, leading to a rugged, reliable and compact design. The device should promote rapid and reliable ignition in LOX/LCH$_4$ engines in particular, and in liquid propellant engines in general. It could also be used in gas-turbine engines where prompt and reliable restart is critically important; for example, in helicopter and jet aircraft engines.

This work was done by Adam Martin and Richard Eskridge of Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32557-1.

Wire Test Grip Fixture

This fixture can be used in any thin-gauge wire testing.

John H. Glenn Research Center, Cleveland, Ohio

Wire-testing issues, such as the gripping strains imposed on the wire, play a critical role in obtaining clean data. In a standard test frame fitted with flat wedge grips, the gripping action alone creates stresses on the wire specimen that cause the wire to fail at the grip location. When conventional wire grip fixtures are installed, the test span as well as the amount of wire used increase dramatically due to the large nature of the wire testing fixture. A new test frame, which is outfitted with a vacuum chamber, negated the use of any conventional commercially available wire test fixtures, as only 7 in. (17.8 cm) existed between the grip faces.

An innovative grip fixture was designed to test thin gauge wire for a variety of applications in an existing Instron test frame outfitted with a vacuum chamber. This unit was designed to adapt to a predetermined test span constrained by the vacuum chamber. The test frame was fitted with flat grips so that no gripping strain was induced into the brittle wire specimen.

In order to accomplish the task of testing small-diameter brittle wire, a very simple test fixture was designed. The first task was to create a technique to relieve the strains induced into the wire upon gripping. This was accomplished with two 1.5 in. (38 mm) wire spools. These spools were designed to relieve the gripping strains by wrapping the wire around the spools to grip the fixtures circumferentially. On each spool, a small bolt was installed to attach the wire to the spool. These bolts were placed 270° around the diameter of the spool so the wire contacted around the wheel. The concept employed ensured that the strains in the wire due to gripping would be reduced by the smooth transition around the wheel. A small groove was machined into the spools to center the wire.

In an effort to save test wire, as well as simplify the installation of the test wire to the spools, a locating rail was devised. This rail established the span of the gripping spools by pinning the spools to a thin, flat plate. When assembled, the wire is easily wrapped around and secured to the spools. The wire is pre-loaded slightly on the fixture to stay in place. This unit is then installed into the test frame. The leading edge of the rail was designed to match up to the grips installed in the test frame.

The machine was placed in the test-ready position. The loaded test rail was installed up against the sides of the flat test wedge grips, which, by design, established the test wire centered in the test frame. Pre-existing marks on the test spools allow the operator to center the fixture, top to bottom, prior to gripping. The test spools were machined to a width of 0.025 in. (0.64 mm), matching that of a standard, flat test specimen. When the flat wedge grips were closed, the wedges griped the spools and established the test span. After the grips seat, the test rail can be removed, and the wire is ready to test. If for some reason the specimen needs to be removed from the test frame, the installation rail can be reinstalled on the pinned spools and

the sample ungripped. This design uses about 8-in. (20-cm) of wire per tests. Multiple tests were conducted at both room and elevated temperature with no failures in the grip region.

The novelty of this wire test fixture lies in its simplicity. Its compact features allow the user to install the fixture in a test frame with little or no modifica-tions. The self-alignment feature de-signed into set-up places the wire speci-men in perfect alignment with the test frame. The loading spools, when gripped, are in direct contact with the test frame water-cooled wedge grips. This helps to draw temperature away from the fixture for ease of high-tem-perature testing.

A Sub-Hertz, Low-Frequency Vibration Isolation Platform

This system can be used for vibration isolation in semiconductor manufacturing, for space-based imaging systems, or fine pointing of free-space optical communication transceivers.

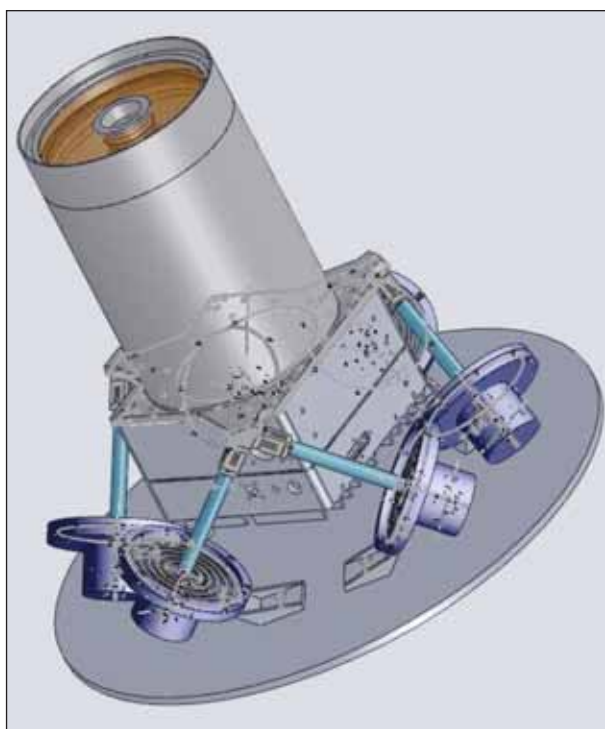*NASA's Jet Propulsion Laboratory, Pasadena, California*

One of the major technical problems deep-space optical communication (DSOC) sys-tems need to solve is the isola-tion of the optical terminal from vibrations produced by the spacecraft navigational control system and by the moving parts of onboard instruments. Even under these vibration perturba-tions, the DSOC transceivers (telescopes) need to be pointed l000's of times more accurately than an RF communication sys-tem (parabolic antennas).

Mechanical resonators have been extensively used to provide vibration isolation for ground-based, airborne, and space-borne payloads. The effective-ness of these isolation systems is determined mainly by the ability of designing a mechanical oscil-lator with the lowest possible resonant frequency. The Low-Frequency Vibration Isolation Platform (LFVIP), developed during this effort, aims to re-duce the resonant frequency of the mechanical oscillators into the sub-Hertz region in order to maximize the passive isolation afforded by the 40 dB/decade roll-off response of the resonator. The LFVIP also provides tip/tilt functionality for acquisition and tracking of a beacon signal. An active control system is used for platform posi-tioning and for dampening of the me-chanical oscillator.

The basic idea in the design of the iso-lation platform is to use a passive isola-tion strut with a ≈100-mHz resonance frequency. This will extend the isolation

A CAD rendering of the **Low-Frequency Vibration Isolation Platform** with payload. Shown is the configuration of the six LFVIP struts (four shown). One of the lower left struts clearly shows the steel membrane with its topology designed to have a reasonably high stiffness along the membrane plane.

range to lower frequencies. The har-monic oscillator is a second-order low-pass filter for mechanical disturbances. The resonance quality depends on the dissipation mechanisms, which are mainly hysteretic because of the low res-onant frequency and the absence of any viscous medium.

The LFVIP system is configured using the well-established Stewart Platform, which consists of a top platform con-nected to a base with six extensible struts (see figure). The struts are at-tached to the base and to the platform via universal joints, which permit the extension and contraction of the struts. The struts' ends are connected in pairs to the base and to the plat-form, forming an octahedron. The six struts provide the vibra-tion isolation due to the proper-ties of mechanical oscillators that behave as second-order low-pass filters for frequencies above the resonance. At high fre-quency, the ideal second-order low-pass filter response is spoiled by the distributed mass and the internal modes of mem-brane and of the platform with its payload.

The mechanical oscillator is implemented using a particular geometry of a stainless steel membrane. This geometry pro-vides a very soft mechanical compliance along the axis or-thogonal to the membrane and about axes coplanar to the membrane. It also allows the de-sign of a membrane with suffi-ciently stiff compliances on the other remaining directions.

The proposed LFVIP has the potential to yield a low-power, low-mass isolation system for payloads requiring stable plat-forms, such as imaging and free-space optical communications.