process. This concludes the description of the prior art.

The present refinements reflect the following ideas: In principle, the design and operation of the reactor could be optimized in the sense that the rate of generation of heat in the exothermic reaction, the rate of consumption of heat in the endothermic reaction, and the flow of heat from the exothermic to the endothermic reaction could be tailored to minimize the input energy needed to produce a given amount of H_2. In turn, the reaction rates could be tailored by tailoring gradients of temperature and chemical composition, which, in turn, could be tailored through adjustments in rates of flow of steam and liquid water into the reactor, recognizing a need to adjust the rates because the gradients of temperature and chemical composition evolve as MH_2 is consumed and MgO is generated.

For the purpose of illustrating the refinements, the figure schematically depicts a reactor that has a simple shape and inlets for steam and liquid water at one end only. One of the refinements would be to inject steam only at the beginning of operation, in no more than the quantity needed to initiate the exothermic reaction. The combination of heating and water vapor provided by steam would initiate both exothermic and endothermic reactions. With initiation of the exothermic reaction, sufficient heat is produced to allow the use of liquid water feed instead of steam. Some of the heat from the exothermic reaction would be consumed in heating the liquid water to steam. As operation continued, the steam front and the hydrogen-generating region would move farther into the region initially containing MgH_2, leaving behind the MgO and Mg waste product. The rate of the exothermic reaction would be adjusted by adjusting the rate of injection of liquid water. If the reactor were of a more-complex configuration featuring multiple injection points, then the rates of injection of water at those points could be adjusted individually to obtain a more nearly optimum spatial and temporal distribution of temperature throughout the reactor.

This work was done by Andrew Kindler and Yuhong Huang of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46064

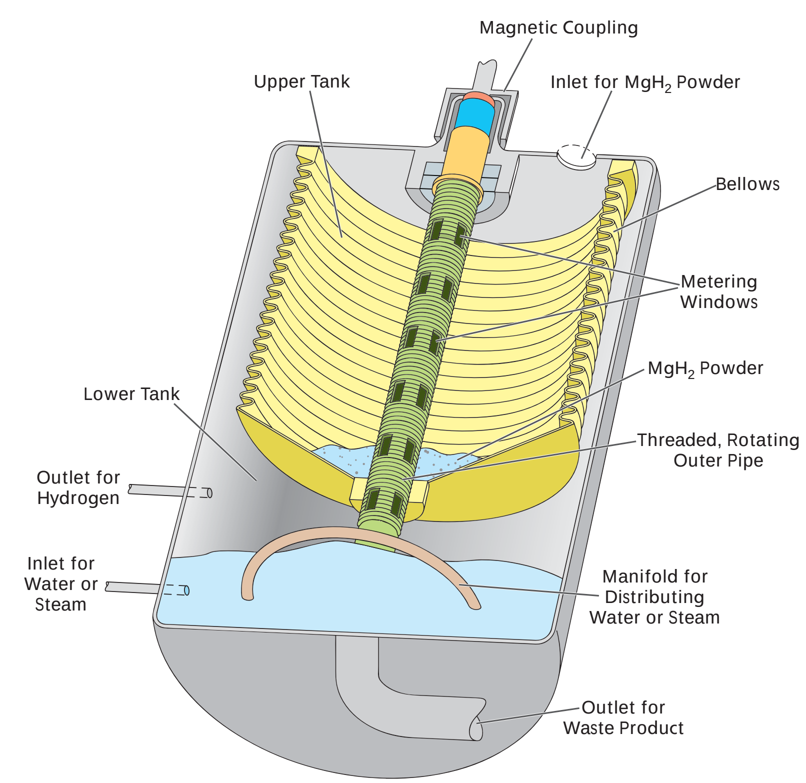
Continuous/Batch Mg/MgH_2/H_2O-Based Hydrogen Generator

Size and weight would be less than those of prior H_2 generators.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed apparatus for generating hydrogen by means of chemical reactions of magnesium and magnesium hydride with steam would exploit the same basic principles as those discussed in the immediately preceding article, but would be designed to implement a hybrid continuous/batch mode of operation. The design concept would simplify the problem of optimizing thermal management and would help to minimize the size and weight necessary for generating a given amount of hydrogen.

The apparatus would include a vessel, the interior volume of which would be divided into an upper and a lower tank (see figure). The upper tank would serve as a fuel-storage/feeder unit: It would include a bellows initially filled with MgH_2 powder (the fuel), plus a mechanism that would include a rotating threaded outer pipe with metering windows and a non-rotating, non-threaded inner pipe with metering windows, for feeding the powder into the lower tank at a controlled rate. As the outer pipe was rotated, the widows in the pipes would alternately expose or occlude each other. The mechanism would be driven by an external motor via a magnetic coupling. The mechanism would also serve partly as a valve to prevent the undesired flow of steam from the reactor into the storage volume in



This **Hydrogen Generator** would function in a hybrid of batch and continuous modes.

that when powder was not being fed, the outer pipe would be rotated to a shaft angle at which the windows in the two pipes would occlude each other. The thread on the outer pipe would engage a threaded fitting on the bottom of the bellows, so that rotation of the outer pipe would compress the bellows as the powder was consumed.

The lower tank would serve as both a reactor and chamber for storing the solid waste end product (MgO) of the hydrogen-generating reactions. As the powder was fed from the upper tank to the lower tank and the bellows was compressed, the volume of the lower tank would grow, making room for the growing amount of waste material. Because fresh fuel would be dropped over the most recently reacted portion of the consumed fuel, it would always come in contact with the hottest part. There would be ample time for the fuel to react as nearly completely as possible because once the fuel was in the reactor, it would stay there. A thermally insulating layer (not shown in the figure) on the bottom of the bellows would reduce the undesired flow of heat from the reactor to the storage volume, thereby helping to suppress undesired decomposition of the MgH_2 in the storage volume.

As described thus far, the apparatus would operate in a batch mode. The upper tank could be refilled with MgH_2 powder from the top, and the MgO solid waste could be removed from the bottom. However, it would be necessary to interrupt operation during such refilling and emptying and during concomitant reverse rotation of the threaded outer pipe to reset the bellows to full storage volume. Thus, truly continuous operation would not be possible: The apparatus would operate in a quasi-batch, quasi-continuous mode.

This work was done by Andrew Kindler and Yuhong Huang of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-46058, volume and number of this NASA Tech Briefs *issue, and the page number.*

Strain System for the Motion Base Shuttle Mission Simulator

Lyndon B. Johnson Space Center, Houston, Texas

The Motion Base Shuttle Mission Simulator (MBSMS) Strain System is an innovative engineering tool used to monitor the stresses applied to the MBSMS motion platform tilt pivot frames during motion simulations in real time. The Strain System comprises hardware and software produced by several different companies. The system utilizes a series of strain gages, accelerometers, orientation sensor, rotational meter, scanners, computer, and software packages working in unison. By monitoring and recording the inputs applied to the simulator, data can be analyzed if weld cracks or other problems are found during routine simulator inspections. This will help engineers diagnose problems as well as aid in repair solutions for both current as well as potential problems.

The system is located with a line-of-sight to the Motion Base for real-time on-site monitoring. In addition to local monitoring, several off-site engineering computers are loaded with software allowing the user to remotely log onto the Strain System computer, monitor the system, and adjust the software settings as required. Additional commercial software products have been programmed to automate the Strain System software. This removes the typical daily manual interaction required by the system to boot, record, stop, and save the resultant motion data for future analysis.

This work was done by David C Huber, Karl G. Van Vossen, Glenn W. Kunkel, and Larry W. Wells of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC 24386-1

Ko Displacement Theory for Structural Shape Predictions

Prediction system enables real-time aero-elastic aircraft wing-shape control.

Dryden Flight Research Center, Edwards, California

The development of the Ko displacement theory for predictions of structure deformed shapes was motivated in 2003 by the Helios flying wing, which had a 247-ft (75-m) wing span with wingtip deflections reaching 40 ft (12 m). The Helios flying wing failed in midair in June 2003, creating the need to develop new technology to predict in-flight deformed shapes of unmanned aircraft wings for visual display before the ground-based pilots.

Any types of strain sensors installed on a structure can only sense the surface strains, but are incapable to sense the overall deformed shapes of structures. After the invention of the Ko displacement theory, predictions of structure deformed shapes could be achieved by feeding the measured surface strains into the Ko displacement transfer functions for the calculations of out-of-plane deflections and cross sectional rotations at multiple locations for mapping out overall deformed shapes of the structures. The new Ko displacement theory combined with a strain-sensing system thus created a revolutionary new structure-shape-sensing technology.

The formulation of the Ko displacement theory stemmed from the integrations of the beam curvature equation (second order differential equation). The beamlike structure (wing) was first discretized into multiple small domains so that beam depth and surface strain distributions could be represented with piecewise linear functions. This discretization approach enabled piecewise integrations of the