Some refinements have been conceived for a proposed apparatus that would generate hydrogen (for use in a fuel cell) by means of chemical reactions among magnesium, magnesium hydride, and steam. The refinements lie in tailoring spatial and temporal distributions of steam and liquid water so as to obtain greater overall energy-storage or energy-generation efficiency than would otherwise be possible.

A description of the prior art is prerequisite to a meaningful description of the present refinements. The hydrogen-generating apparatus in question is one of two versions of what was called the “advanced hydrogen generator” in “Fuel-Cell Power Systems Incorporating Mg-Based H2 Generators” (NPO-43554), NASA Tech Briefs, Vol. 33, No. 1 (January 2009), page 52. To recapitulate: The apparatus would include a reactor vessel that would be initially charged with magnesium hydride. The apparatus would exploit two reactions:

- The endothermic decomposition reaction \( \text{MgH}_2 \rightarrow \text{Mg} + \text{H}_2 \), which occurs at a temperature \( \geq 300 \, ^\circ\text{C} \), and
- The exothermic oxidation reaction \( \text{MgH}_2 + \text{H}_2\text{O} \rightarrow \text{MgO} + 2\text{H}_2 \), which occurs at a temperature \( \geq 330 \, ^\circ\text{C} \).

Once the initial heating was complete and both reactions under way, the endothermic reaction would be sustained by the heat generated from the exothermic reaction. For every mole of \( \text{MgH}_2 \) oxidized, sufficient waste heat is generated to decompose an additional three moles of the hydride. As a consequence of these reaction ratios, the major reaction product is Mg, and the minor one MgO. Both have extremely low toxicity. MgH\(_2\) is easily recycled to Mg. In theory, no energy is required because regeneration produces enough heat to power the process. A practical system would not be 100-percent efficient so it would be expected that there would be a modest energy cost. The MgO can be safely and easily recycled in a magnesium-refining plant for less than the cost of smelting Mg because MgO is an intermediate product of that

This Brief describes a method of machining and assembly when the depth of corrugations far exceeds the width and conventional machining is not practical. The horn is divided into easily machined, individual rings with shoulders to control the depth. In this specific instance, each of the corrugations is identical in profile, and only differs in diameter and outer profile. The horn is segmented into rings that are cut with an interference fit (zero clearance with all machining errors biased toward contact). The interference faces can be cut with a reverse taper to increase the holding strength of the joint. The taper is a compromise between the interference fit and the clearance of the two faces during assembly.

Each internal ring is dipped in liquid nitrogen, then nested in the previous, larger ring. The ring is rotated in the nest until the temperature of the two parts equalizes and the pieces lock together. The resulting assay is stable, strong, and has an internal finish that cannot be achieved through other methods.

This work was done by John B. Sosnowski of Caltech for NASA’s Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47213
Continuous/ Batch Mg/MgH₂/H₂O-Based Hydrogen Generator

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 MgH₂ 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 windows 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 the liquid water to steam. As operation continued, the steam front and the hydrogen-generating region would move farther into the region initially containing MgH₂, 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

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

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