TEAM #1 ALGALCO

Drying Hydrogen Gas

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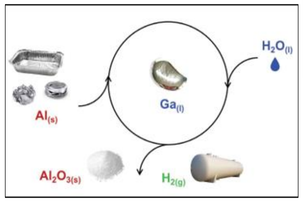
OBJECTIVE

Team 01 is looking to condense the steam byproduct of AlGalCo's H.O.T. system to remove 95 percent of moisture from the hydrogen output line.



CUSTOMER PROBLEM AND BACKGROUND

AlGalCo is an Indiana-based hydrogen energy startup that is commercializing their patented "Hydrogen-on-Tap" system (H.O.T.). By adding water to an aluminum alloy, their technology generates pure hydrogen on demand that can be used to power internal combustion engines. Benefits of this technology include:

- As large as 12% MPG increase and 20% CO2 emissions decrease for gas engines
- Completely renewable/sustainable aluminum feedstock
- No high-pressure storage required
- Bolt-on application requires no ECM or motor modifications
- Scalable from 5.4L V8s to 15L Class 8 Diesel motors

The exothermic reaction that takes place in AlGalCo's H.O.T. technology generates pure hydrogen gas as well as steam as products. While this combined output does not have noticeable effects on gasoline-powered motors, it is not compatible with large diesel motors that use turbochargers, which is very common in large fleet and transportation vehicles that want to use the H.O.T. system. AlGalCo needs a way to extract the steam byproduct from the hydrogen reaction to be able to safely use the reaction output in turbo-diesel applications.

CONCEPTS AND EXPERIMENTATION

Approach:

- Design a system that generates steam output at a constant rate and can supply it to a testing chamber
- Testing chamber can be used to evaluate multiple cooling configurations in conjunction with a circulating water trap

Conceptual cooling methods:

- *Passive heat sinks*
- *Radiator/forced convection combo*
- *Peltier/forced convection combo (selected)*

Design influence:

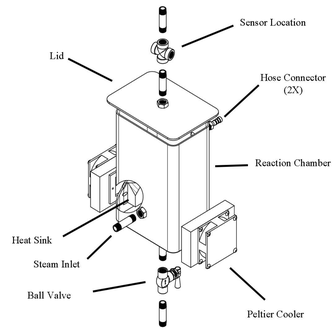
$2Al + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2 + Q$

From H.O.T.:

- *H.O.T. cylinder volume: 932.66 cubic inches*
- *3.38 kg excess water required to generate 0.1 kg Hydrogen*
- *7790.56 kJ heat energy must be removed to condense the steam*

Peltier Design:

- *Submerging the internal heat sink in the water trap yields the most efficient and effective cooling configuration*
- *Thermal resistance of 0.030 C/W allows for 666.667 W of heat removal*



REQUIREMENTS AND FINAL DESIGN

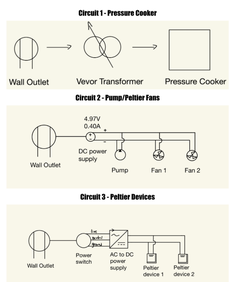
Remove 95% of moisture

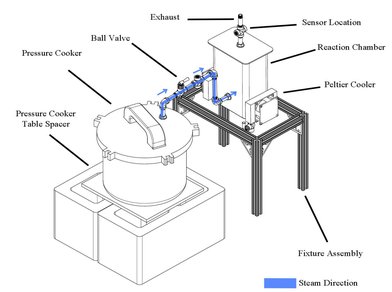
No extra maintenance

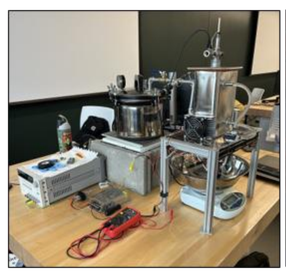
Low cost

Low weight

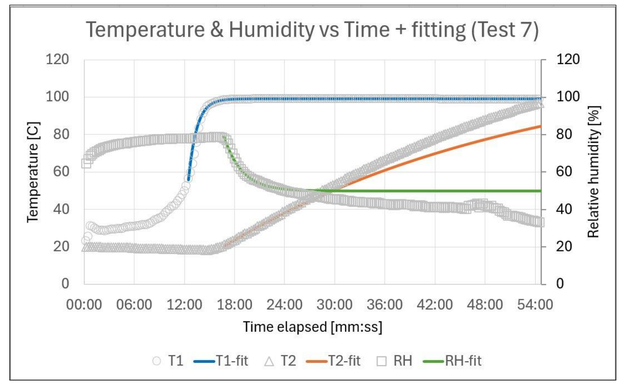
Standard parts







TESTING RESULTS



Test	Duration (mm:ss)	Δ Chamber Temperature (T2) (deg C/min)	Δ Exhaust Temperature (T3) (deg C/min)	Δ Humidity (Relative Humidity %)	Mass Recovery (grams)
2	30:00	2.36	0.050	-23.76	N/A
3	30:00	2.32	-0.003	-22.44	152.39
4	30:00	2.38	-0.040	-5.270	182.43
5	30:00	2.17	-0.005	-25.76	148.72
6	40:00	*2.28	*-0.020	*-26.59	*289.9
7	56:45	*1.91	*-0.261	*-46.64	**619.3
Average (30 min. tests only)		2.3075	0.0005	-19.2925	161.18

* Data not included in averages due to unique test duration
** Rough measurement; some steam was lost due to overheating test chamber
*** Allow some variation for all steam recoveries due to evaporation and leaking

CONCLUSION AND RECOMMENDATIONS

Coefficient of Performance/Mass Steam Recovery Summary:

30-minute tests: 161.2 grams steam recovered, COP = 0.229

40-minute test: 289.9 grams steam recovered, COP = 0.308

56:45-min. test: 619.3 grams steam recovered, COP = 0.464

Achievements:

- Designed and created a system with constant steam generation, a cooling method and a circulating water trap
- Decreased steam temperature and humidity consistently to recover steam (repeatably)

Deviations from ideal:

- Change in heat conductivity of water as temperature changes
- Fluid mechanical change (release of energy in bubbles, sound energy from rolling boil)
- Water trap feature had contamination with high temperature gasket maker

Improvements:

- Testing multiple power input settings would determine the ideal power supply and maximize cooling per unit of water and time
- Mitigate leakage