Fuel Cell Spreadsheet Analysis

Contents:

This fuel cell spreadsheet contains an analysis of data gathered in an ENGR 115 Fuel Cell Lab. The lab was designed to measure the efficiency of energy conversion in the electrolyzer and fuel cell components of a fuel cell system.

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12/6/2016

Input Parameters	
Temperature (K)	296.2
Pressure (atm)	1
Gas Constant (L*atm/mol*K)	0.0821
Energy of H2 (kJ/mol)	237

Final Efficiencies (%)	
Run 1	10.90320973
Run 2	10.28648982
Run 3	10.48474313
Average	10.55814756

Run 1 Data

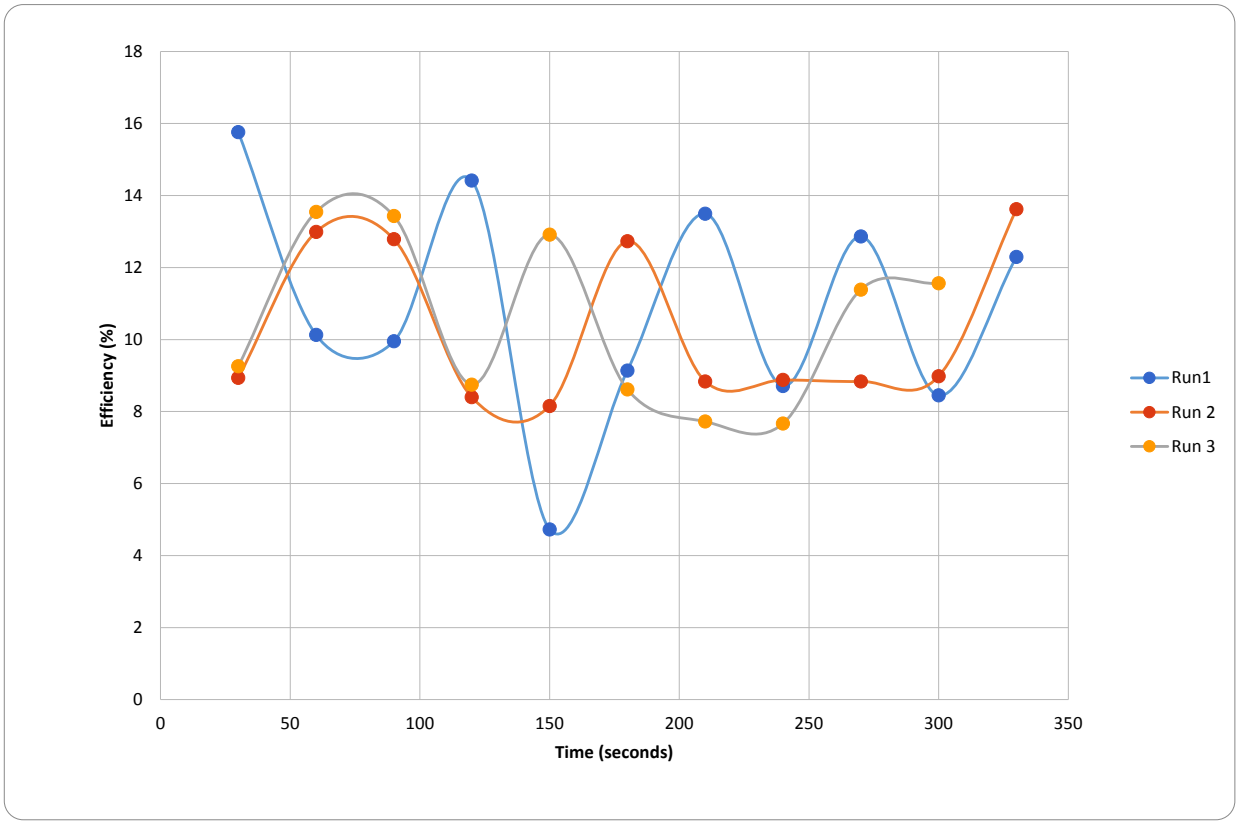
Time (seconds)	H2 Volume (mL)	H2 Volume (L)	Voltage (V)	Current (A)	Power (W)	Electrical Energy In (J)	Mols H2 (mols)	Chemical Energy Out (J)	Efficiency (%)
0	0	0	11.89	0.49	5.8261	--	--	--	--
30	3	0.003	11.89	0.52	6.1828	185.484	0.000123365	29.23757773	15.76285703
60	5	0.005	11.88	0.54	6.4152	192.456	8.22435E-05	19.49171849	10.12788299
90	7	0.007	11.87	0.55	6.5285	195.855	8.22435E-05	19.49171849	9.952116866
120	10	0.01	11.86	0.57	6.7602	202.806	0.000123365	29.23757773	14.41652502
150	11	0.011	11.85	0.58	6.873	206.19	4.11218E-05	9.745859243	4.72664011
180	13	0.013	11.85	0.6	7.11	213.3	8.22435E-05	19.49171849	9.13817088
210	16	0.016	11.84	0.61	7.2224	216.672	0.000123365	29.23757773	13.49393449
240	18	0.018	11.84	0.63	7.4592	223.776	8.22435E-05	19.49171849	8.710370409
270	21	0.021	11.84	0.64	7.5776	227.328	0.000123365	29.23757773	12.86140631
300	23	0.023	11.83	0.65	7.6895	230.685	8.22435E-05	19.49171849	8.44949541
330	26	0.026	11.83	0.67	7.9261	237.783	0.000123365	29.23757773	12.2959075

Run 2 Data

Time (seconds)	H2 Volume (mL)	H2 Volume (L)	Voltage (V)	Current (A)	Power (W)	Electrical Energy In (J)	Mols H2 (mols)	Chemical Energy Out (J)	Efficiency (%)
0	0	0	11.92	0.59	7.0328	--	--	--	--
30	2	0.002	11.92	0.61	7.2712	218.136	8.22435E-05	19.49171849	8.935580778
60	5	0.005	11.91	0.63	7.5033	225.099	0.000123365	29.23757773	12.98876394
90	8	0.008	11.91	0.64	7.6224	228.672	0.000123365	29.23757773	12.7858145
120	10	0.01	11.9	0.65	7.735	232.05	8.22435E-05	19.49171849	8.399792496
150	12	0.012	11.89	0.67	7.9663	238.989	8.22435E-05	19.49171849	8.155906124
180	15	0.015	11.6	0.66	7.656	229.68	0.000123365	29.23757773	12.72970121
210	17	0.017	11.31	0.65	7.3515	220.545	8.22435E-05	19.49171849	8.837977958
240	19	0.019	11.09	0.66	7.3194	219.582	8.22435E-05	19.49171849	8.876737841
270	21	0.021	11.14	0.66	7.3524	220.572	8.22435E-05	19.49171849	8.83689611
300	23	0.023	10.96	0.66	7.2336	217.008	8.22435E-05	19.49171849	8.982027615
330	26	0.026	10.84	0.66	7.1544	214.632	0.000123365	29.23757773	13.62218948

Run 3 Data

Time (seconds)	H2 Volume (mL)	H2 Volume (L)	Voltage (V)	Current (A)	Power (W)	Electrical Energy In (J)	Mols H2 (mols)	Chemical Energy Out (J)	Efficiency (%)
0	0	0	10.84	0.66	7.1544	--	--	--	--
30	2	0.002	10.8	0.65	7.02	210.6	8.22435E-05	19.49171849	9.255326917
60	5	0.005	10.9	0.66	7.194	215.82	0.000123365	29.23757773	13.54720495
90	8	0.008	10.83	0.67	7.2561	217.683	0.000123365	29.23757773	13.43126369
120	10	0.01	10.92	0.68	7.4256	222.768	8.22435E-05	19.49171849	8.74978385
150	13	0.013	10.94	0.69	7.5486	226.458	0.000123365	29.23757773	12.9108169
180	15	0.015	10.93	0.69	7.5417	226.251	8.22435E-05	19.49171849	8.615086115
210	17	0.017	11.37	0.74	8.4138	252.414	8.22435E-05	19.49171849	7.722122579
240	19	0.019	11.3	0.75	8.475	254.25	8.22435E-05	19.49171849	7.666359287
270	22	0.022	11.26	0.76	8.5576	256.728	0.000123365	29.23757773	11.38854263
300	25	0.025	11.24	0.75	8.43	252.9	0.000123365	29.23757773	11.56092437


18
16
14
12
10
8
6
4
2
0
Efficiency (%)
0
50
100
150
200
250
300
350
Time (seconds)
Run1
Run 2
Run 3

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Gas Constant (L*atm/mol*K)	0.0821
Energy of H2 (kJ/mol)	237

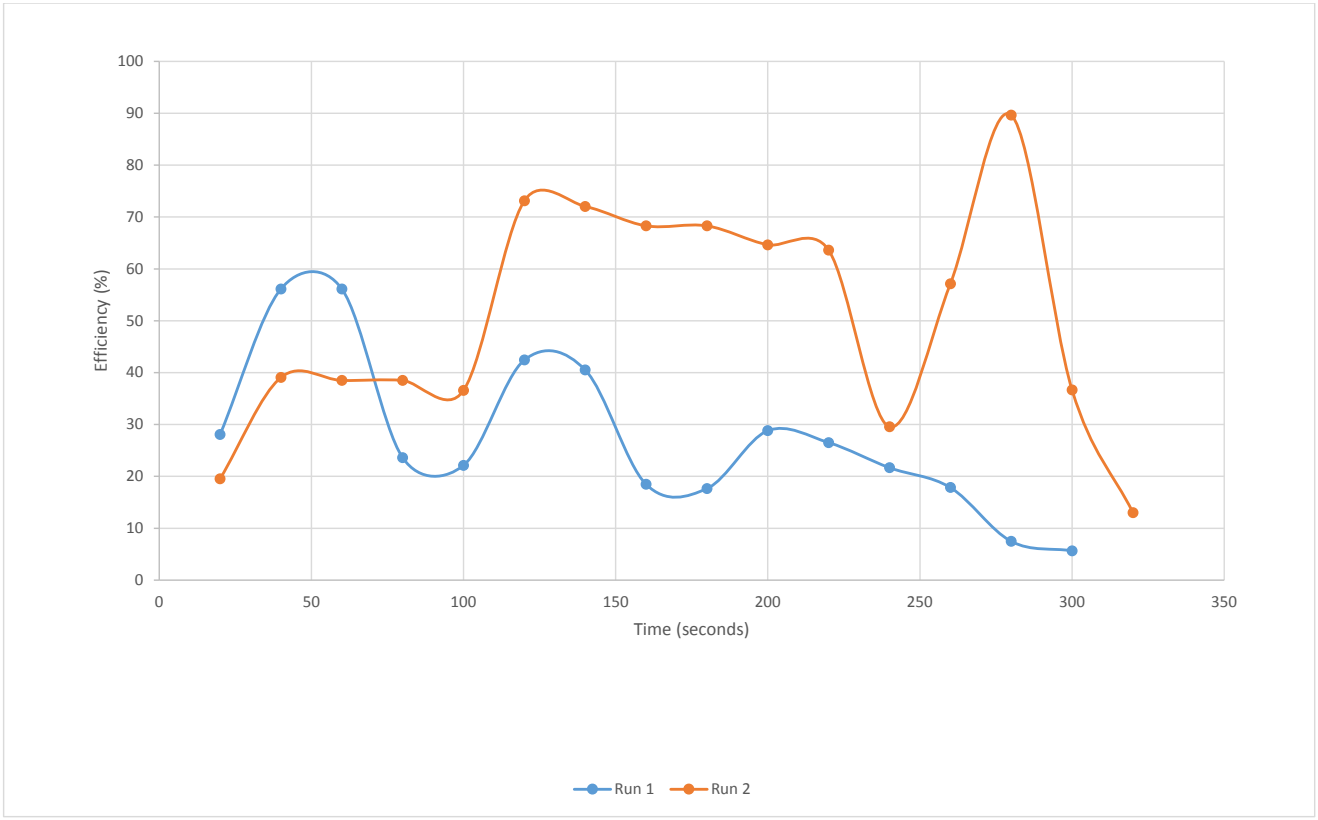
Final Efficiencies (%)	
Run 1	27.54263734
Run 2	50.5120504
Average	39.02734387

Run 1 Data

Time (seconds)	H2 Volume (mL)	H2 Volume (L)	Voltage (V)	Current (A)	Power (W)	Electrical Energy Out (J)	Mols H2 (mols)	Chemical Energy In (J)	Efficiency (%)
0	44	0.044	0.57	0.24	0.1368	--	--	--	--
20	43	0.043	0.57	0.24	0.1368	2.736	4.11218E-05	9.745859243	28.07346106
40	42.5	0.0425	0.57	0.24	0.1368	2.736	2.05609E-05	4.872929622	56.14692213
60	42	0.042	0.57	0.24	0.1368	2.736	2.05609E-05	4.872929622	56.14692213
80	41	0.041	0.5	0.23	0.115	2.3	4.11218E-05	9.745859243	23.59976624
100	40	0.04	0.49	0.22	0.1078	2.156	4.11218E-05	9.745859243	22.12221566
120	39.5	0.0395	0.47	0.22	0.1034	2.068	2.05609E-05	4.872929622	42.43853617
140	39	0.039	0.47	0.21	0.0987	1.974	2.05609E-05	4.872929622	40.5095118
160	38	0.038	0.45	0.2	0.09	1.8	4.11218E-05	9.745859243	18.46938228
180	37	0.037	0.43	0.2	0.086	1.72	4.11218E-05	9.745859243	17.64852084
200	36.5	0.0365	0.39	0.18	0.0702	1.404	2.05609E-05	4.872929622	28.81223635
220	36	0.036	0.38	0.17	0.0646	1.292	2.05609E-05	4.872929622	26.51382434
240	35.5	0.0355	0.33	0.16	0.0528	1.056	2.05609E-05	4.872929622	21.67074187
260	35	0.035	0.29	0.15	0.0435	0.87	2.05609E-05	4.872929622	17.8537362
280	34	0.034	0.28	0.13	0.0364	0.728	4.11218E-05	9.745859243	7.469839055
300	33	0.033	0.23	0.12	0.0276	0.552	4.11218E-05	9.745859243	5.663943899

Run 2 Data

Time (seconds)	H2 Volume (mL)	H2 Volume (L)	Voltage (V)	Current (A)	Power (W)	Electrical Energy Out (J)	Mols H2 (mols)	Chemical Energy In (J)	Efficiency (%)
0	20	0.02	0.7	0.28	0.196	--	--	--	--
20	18	0.018	0.68	0.28	0.1904	3.808	8.22435E-05	19.49171849	19.53650214
40	17	0.017	0.68	0.28	0.1904	3.808	4.11218E-05	9.745859243	39.07300429
60	16	0.016	0.67	0.28	0.1876	3.752	4.11218E-05	9.745859243	38.49840128
80	15	0.015	0.67	0.28	0.1876	3.752	4.11218E-05	9.745859243	38.49840128
100	14	0.014	0.66	0.27	0.1782	3.564	4.11218E-05	9.745859243	36.56937691
120	13.5	0.0135	0.66	0.27	0.1782	3.564	2.05609E-05	4.872929622	73.13875382
140	13	0.013	0.65	0.27	0.1755	3.51	2.05609E-05	4.872929622	72.03059089
160	12.5	0.0125	0.64	0.26	0.1664	3.328	2.05609E-05	4.872929622	68.29567136
180	12	0.012	0.64	0.26	0.1664	3.328	2.05609E-05	4.872929622	68.29567136
200	11.5	0.0115	0.63	0.25	0.1575	3.15	2.05609E-05	4.872929622	64.64283797
220	11	0.011	0.62	0.25	0.155	3.1	2.05609E-05	4.872929622	63.61676118
240	10	0.01	0.6	0.24	0.144	2.88	4.11218E-05	9.745859243	29.55101165
260	9.5	0.0095	0.58	0.24	0.1392	2.784	2.05609E-05	4.872929622	57.13195585
280	9.25	0.00925	0.52	0.21	0.1092	2.184	1.02804E-05	2.436464811	89.63806866
300	8.75	0.00875	0.47	0.19	0.0893	1.786	2.05609E-05	4.872929622	36.65146305
320	8	0.008	0.34	0.14	0.0476	0.952	3.08413E-05	7.309394433	13.02433476


100
90
80
70
60
50
40
30
20
10
0
Efficiency (%)
0
50
100
150
200
250
300
350
Time (seconds)
Run 1
Run 2

1. The average efficiency of our fuel cell is 39.0%. The average efficiency of our electrolyzer is 10.6%. The wire to wire efficiency is 4% (because 100%* .39* .106=4%)

2. Charge/discharge cycle efficiency for a lead-acid battery appears to hang out around the 70% rate. That is much better than our result for the fuel cell. From my research, it appears that the hydrogen fuel cells used in cars often have efficiencies between 40-60%. Based on that, I would say that battery electric vehicles are superior in terms of efficiency. Fuel cell vehicles have greater range because hydrogen can be stored in greater energy-producing quantities than electricity, so that is an argument for driving a fuel cell car.

3. I would increase the efficiency of the electrolyzer, because it has a much lower efficiency than the fuel cell.

4. Since I'm already measuring electrical energy into the fan motor, I would only need a means of measuring mechanical energy out of the fan motor to calculate efficiency. Some kind of braking force could be applied on the fan motor, and the amount of braking force that it took to stop the motor would be the value of the mechanical energy output.

5. I would expect everything to become more efficient. I would expect a dramatically improved electrolysis process. I would also hope to see improvements in efficiency of hydrogen fuel cell production. The greatest opportunity for waste energy recovery would likely be capturing the heat given off by the fuel cell itself. Waste fuel leftover from the electrolysis process could also be recovered.