Case name: Nessus Block 0

Description: The first ever 69lbf engine

Thu Nov 14 19:58:45 2024

Table 1. Propellant Specification

Component	Temperature, K	Pressure, MPa	Enthalpy, kJ/mol	Enthalpy, kJ/kg	Mass fraction
C2H5OH(L)	298.1	0.1013	-277.5087	-6023.834	0.4000000
O2(L)	90.2	0.1013	-12.9790	-405.608	0.6000000
Total			-96.7031	-2652.898	

Propellant exploded formula:

$C_{0.633004}\,H_{1.899011}\,O_{1.683498}$ (based on 1 mole)

$C_{15.016054}\,H_{45.048163}\,O_{39.935783}$ (by mass %)

α: 0.7198465 (oxidizer excess coefficient)

O/F: 1.5000000

O/F_0: 2.0837775 (stoichiometric)

rho: 937.63159 kg/m^3

Table 2. Combustion Properties

Parameter	Injector	Nozzle inlet	Nozzle throat	Nozzle exit	Unit
Pressure	2.8958	2.8228	1.6481	0.1013	MPa
Temperature	3223.6150	3218.2576	3044.4694	2103.6377	K
Enthalpy	-59008.1683	-59362.4473	-74029.7377	-136226.8211	J/mol
	-2652.8993	-2668.4463	-3295.0344	-5919.1492	kJ/kg
Entropy	265.9365	266.0793	268.7225	275.2714	J/(mol·K)
	11.9560	11.9607	11.9607	11.9607	kJ/(kg·K)
Internal energy	-85810.8252	-86120.5597	-99342.8937	-153717.4582	J/mol
	-3857.8977	-3871.2704	-4421.7129	-6679.1294	kJ/kg
Specific heat (p=const)	5.1264	5.1243	4.5428	2.2645	kJ/(kg·K)
Specific heat (V=const)	4.4201	4.4189	3.9295	1.8945	kJ/(kg·K)
Gamma	1.1598	1.1596	1.1561	1.1953	
Isentropic exponent	1.1374	1.1373	1.1399	1.1948	
Gas constant	0.3738	0.3738	0.3701	0.3613	kJ/(kg·K)
Molecular weight	22.2429	22.2461	22.4671	23.0146	
Density	2.4032	2.3468	1.4628	0.1333	kg/m^3
Sonic velocity	1170.6983	1169.6060	1133.2560	952.8956	m/s
Mach number	0.0000	0.1508	1.0000	2.6822	
Area ratio	4.0000	4.0000	1.0000	4.8648	A/At
Mass flux	413.8282	413.8282	1657.7412	340.7642	$kg/(m^2 \cdot s)$
Viscosity	1.0405	1.0393	1.0010	0.7714×10^{-4}	kg/(m·s)
Conductivity, frozen	0.3501	0.3496	0.3323	0.2359	W/(m·K)
Specific heat (p=const), frozen	2.2342	2.2338	2.2199	2.0988	kJ/(kg·K)
Prandtl number, frozen	0.6641	0.6641	0.6687	0.6864	
Conductivity, effective	1.0258	1.0245	0.8692	0.2779	W/(m·K)
Specific heat (p=const), effective	5.1264	5.1243	4.5428	2.2635	kJ/(kg·K)
Prandtl number, effective	0.5200	0.5199	0.5232	0.6284	

Table 3. Combustion Products

Product	Injector mass fraction	Injector mole fraction	Nozzle inlet mass fraction	Nozzle inlet mole fraction	Nozzle throat mass fraction	Nozzle throat mole fraction	Nozzle exit mass fraction	Nozzle exit mole fraction
CO	0.3094818	0.2457604	0.3093108	0.2456596	0.3007642	0.2412447	0.2658618	0.2184462
CO2	0.2779567	0.1404824	0.2782262	0.1406387	0.2916682	0.1488980	0.3465229	0.1812128
COOH	0.0000126	0.0000062	0.0000123	0.0000061	0.0000067	0.0000033		
H	0.0008030	0.0177214	0.0008017	0.0176947	0.0006343	0.0141391	0.0000475	0.0010857
H2	0.0091672	0.1011497	0.0091665	0.1011564	0.0090302	0.1006416	0.0102678	0.1172241
H2O	0.3666639	0.4527083	0.3667465	0.4528749	0.3731451	0.4653535	0.3768458	0.4814220
H2O2	0.0000067	0.0000044	0.0000065	0.0000043	0.0000032	0.0000021		
HCHO,formaldehy	0.0000004	0.0000003	0.0000004	0.0000003	0.0000002	0.0000002		
HCO	0.0000101	0.0000078	0.0000099	0.0000076	0.0000053	0.0000041		
HCOOH	0.0000025	0.0000012	0.0000025	0.0000012	0.0000014	0.0000007		
HO2	0.0000307	0.0000207	0.0000302	0.0000203	0.0000139	0.0000095		
O	0.0023169	0.0032210	0.0023032	0.0032025	0.0013626	0.0019134	0.0000024	0.0000035
O2	0.0080924	0.0056252	0.0080495	0.0055961	0.0049692	0.0034890	0.0000085	0.0000061
OH	0.0254549	0.0332910	0.0253339	0.0331374	0.0183955	0.0243008	0.0004430	0.0005994
Gaseous fraction:	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
Condensed fraction:	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

Table 4. Ideal Performance

Parameter	Sea level	Optimum expansion	Vacuum	Units
Characteristic velocity		1724.9489		m/s
Effective exhaust velocity	2555.8756	2555.8756	2853.2219	m/s
Specific impulse (by mass)	2555.8756	2555.8756	2853.2219	N·s/kg
Specific impulse (by weight)	260.6268	260.6268	290.9477	s
Thrust coefficient	1.4817	1.4817	1.6541	
Thrust	0.3227	0.3227	0.3603	kN
Altitude	0.0000	0.0000		km
Ambient pressure	1.0000	1.0000	0.0000	atm

Table 5. Estimated Delivered Performance

Parameter	Sea level	Optimum expansion	Vacuum	Units
Characteristic velocity		1683.3120		m/s
Effective exhaust velocity	2423.7054	2423.7054	2721.0517	m/s
Specific impulse (by mass)	2423.7054	2423.7054	2721.0517	N·s/kg
Specific impulse (by weight)	247.1492	247.1492	277.4701	s
Thrust coefficient	1.4398	1.4398	1.6165	
Thrust	0.3060	0.3060	0.3436	kN
Altitude	0.0000	0.0000		km
Ambient pressure	1.0000	1.0000	0.0000	atm

Table 6. Altitude Performance

Table 7. Throttled Performance

Table 8. Chamber Size

Combustion chamber size			Nozzle size	
Dc	19.46 mm	Type	TIC nozzle	
Dt	9.73 mm	Rn	1.86	mm
Lcyl	245.07 mm	Tn	19.28	deg
Lc	259.34 mm	Te	7.83	deg
L*	1016.00 mm	De	21.46	mm
R1	7.30 mm	Le	22.76	mm
R2	14.50 mm	Le/Dt	2.34	
b	30.00 deg	Le/Lc15	104.00	%
Ac/At	4.00	Ae/At	4.86	

Parameter		Engine	Chamber	
Thrust	sea level	0.3060	0.3060	kN
	opt exp	0.3060	0.3060	kN
	vacuum	0.3436	0.3436	kN
Specific Impulse	sea level	2423.7054	2423.7054	N·s/kg
	opt exp	2423.7054	2423.7054	N·s/kg
	vacuun	2721.0517	2721.0517	N·s/kg
Mass flow rate	total	0.1263	0.1263	kg/s
	oxidizer	0.0758	0.0758	kg/s
	fuel	0.0505	0.0505	kg/s
Number of chambers		1		

Table 10. Thermal Analysis

Location, mm	Radius, mm	Conv.heat coeff, kW/m²·K	Conv.heat flux, kW/m²	Rad. heat flux, kW/m²	Total heat flux, kW/m²	Twg, K	Twi, K	Twc, K	Tc, K	pc, MPa	wc, m/s	ρ, N kg/m³	Helix angle, degrees	A, m²	de, mm	hc, mm	a, mm	b, mm	Type / Comments
0.00	9.73	1.6531	3204.1846	165.0274	3369.2121	1400.0000													
3.95	9.73	1.6530	3204.0350	185.0112	3389.0462	1400.0000													
7.90	9.73	1.6529	3203.8854	203.7057	3407.5912	1400.0000													
11.85	9.73	1.6528	3203.7359	221.1110	3424.8469	1400.0000													
15.81	9.73	1.6528	3203.5864	237.2269	3440.8134	1400.0000													
19.76	9.73	1.6527	3203.4370	252.0536	3455.4906	1400.0000													
23.71	9.73	1.6526	3203.2877	265.5910	3468.8787	1400.0000													

Location, mm	Radius, mm	Conv. heat coeff, kW/m²·K	Conv. heat flux, kW/m²	Rad. heat flux, kW/m²	Total heat flux, kW/m²	Twg, K	Twi, K	Twc, K	Tc, K	pc, MPa	wc, m/s	ρ, N kg/m³	Helix angle, degrees	A, m²	de, mm	hc, mm	a, mm	b, mm	Type / Comments
27.66	9.73	1.6525	3203.1384	277.8391	3480.9775	1400.0000													
31.61	9.73	1.6524	3202.9892	288.7980	3491.7872	1400.0000													
35.56	9.73	1.6524	3202.8400	298.4676	3501.3075	1400.0000													
39.52	9.73	1.6523	3202.6908	306.8479	3509.5387	1400.0000													
43.47	9.73	1.6522	3202.5418	313.9389	3516.4807	1400.0000													
47.42	9.73	1.6521	3202.3928	319.7406	3522.1334	1400.0000													
51.37	9.73	1.6521	3202.2438	324.2531	3526.4969	1400.0000													
55.32	9.73	1.6520	3202.0949	327.4763	3529.5712	1400.0000													
59.27	9.73	1.6519	3201.9461	329.4102	3531.3563	1400.0000													
63.23	9.73	1.6518	3201.7973	330.0548	3531.8521	1400.0000													
67.18	9.73	1.6518	3201.6485	330.0548	3531.7034	1400.0000													
71.13	9.73	1.6517	3201.4999	330.0548	3531.5547	1400.0000													
75.08	9.73	1.6516	3201.3512	330.0548	3531.4061	1400.0000													
79.03	9.73	1.6515	3201.2027	330.0548	3531.2575	1400.0000													
82.98	9.73	1.6514	3201.0541	330.0548	3531.1090	1400.0000													
86.93	9.73	1.6514	3200.9057	330.0548	3530.9605	1400.0000													
90.89	9.73	1.6513	3200.7573	330.0548	3530.8121	1400.0000													
94.84	9.73	1.6512	3200.6089	330.0548	3530.6638	1400.0000													
98.79	9.73	1.6511	3200.4607	330.0548	3530.5155	1400.0000													
102.74	9.73	1.6511	3200.3124	330.0548	3530.3673	1400.0000													
106.69	9.73	1.6510	3200.1642	330.0548	3530.2191	1400.0000													
110.64	9.73	1.6509	3200.0161	330.0548	3530.0710	1400.0000													
114.60	9.73	1.6508	3199.8680	330.0548	3529.9229	1400.0000													
118.55	9.73	1.6508	3199.7200	330.0548	3529.7749	1400.0000													
122.5	9.73	1.	3199.	330.0	3529.	1400.													

Location, mm	Radius, mm	Conv. heat coeff, kW/m²·K	Conv. heat flux, kW/m²	Rad. heat flux, kW/m²	Total heat flux, kW/m²	Twg, K	Twi, K	Twc, K	Tc, K	pc, MPa	wc, m/s	ρ, N kg/m³	Helix angle, degrees	A, m²	de, mm	hc, mm	a, mm	b, mm	Type / Comments
0		6507	5721	548	6269	0000													
126.45	9.73	1.6506	3199.4242	330.0548	3529.4790	1400.0000													
130.40	9.73	1.6505	3199.2763	330.0548	3529.3312	1400.0000													
134.35	9.73	1.6505	3199.1285	330.0548	3529.1834	1400.0000													
138.31	9.73	1.6504	3198.9808	330.0548	3529.0356	1400.0000													
142.26	9.73	1.6503	3198.8331	330.0548	3528.8880	1400.0000													
146.21	9.73	1.6502	3198.6855	330.0548	3528.7403	1400.0000													
150.16	9.73	1.6501	3198.5379	330.0548	3528.5928	1400.0000													
154.11	9.73	1.6501	3198.3904	330.0548	3528.4452	1400.0000													
158.06	9.73	1.6500	3198.2429	330.0548	3528.2978	1400.0000													
162.02	9.73	1.6499	3198.0955	330.0548	3528.1504	1400.0000													
165.97	9.73	1.6498	3197.9482	330.0548	3528.0030	1400.0000													
169.92	9.73	1.6498	3197.8009	330.0548	3527.8557	1400.0000													
173.87	9.73	1.6497	3197.6536	330.0548	3527.7085	1400.0000													
177.82	9.73	1.6496	3197.5064	330.0548	3527.5613	1400.0000													
181.77	9.73	1.6495	3197.3593	330.0548	3527.4141	1400.0000													
185.72	9.73	1.6495	3197.2122	330.0548	3527.2671	1400.0000													
189.68	9.73	1.6494	3197.0652	330.0548	3527.1200	1400.0000													
193.63	9.73	1.6493	3196.9182	330.0548	3526.9731	1400.0000													
197.58	9.73	1.6492	3196.7713	330.0548	3526.8262	1400.0000													
201.53	9.73	1.6492	3196.6244	330.0548	3526.6793	1400.0000													
205.48	9.73	1.6491	3196.4776	330.0548	3526.5325	1400.0000													
209.43	9.73	1.6490	3196.3309	330.0548	3526.3857	1400.0000													
213.39	9.73	1.6489	3196.1842	330.0548	3526.2390	1400.0000													
217.34	9.73	1.6489	3196.0375	330.0548	3526.0924	1400.0000													

Location, mm	Radius, mm	Conv. heat coeff, kW/m²·K	Conv. heat flux, kW/m²	Rad. heat flux, kW/m²	Total heat flux, kW/m²	Twg, K	Twi, K	Twc, K	Tc, K	pc, MPa	wc, m/s	ρ, N kg/m³	Helix angle, degrees	A, m²	de, mm	hc, mm	a, mm	b, mm	Type / Comments
221.29	9.73	1.6488	3195.8909	330.0548	3525.9458	1400.0000													
225.24	9.73	1.6487	3195.7444	330.0548	3525.7993	1400.0000													
229.19	9.73	1.6486	3195.5979	330.0548	3525.6528	1400.0000													
233.14	9.73	1.6486	3195.4515	330.0548	3525.5063	1400.0000													
237.10	9.73	1.6485	3195.3051	330.0548	3525.3600	1400.0000													
241.05	9.73	1.6484	3195.1588	330.0548	3525.2137	1400.0000													
245.00	9.73	1.6483	3195.0125	330.0548	3525.0674	1400.0000													
245.07	9.73	1.6483	3195.0098	330.0530	3525.0628	1400.0000													
247.05	9.59	1.6949	3285.3820	326.2820	3611.6641	1400.0000													
249.02	9.18	1.8504	3586.6296	328.7482	3915.3778	1400.0000													
251.00	8.46	2.1757	4217.2528	324.2070	4541.4598	1400.0000													
252.98	7.41	2.8310	5487.4362	320.7867	5808.2229	1400.0000													
254.95	6.27	3.9333	7624.1000	308.3215	7932.4215	1400.0000													
256.93	5.27	5.4758	10613.8473	262.7770	10876.6242	1400.0000													
258.90	4.88	6.2238	12063.9021	195.8733	12259.7754	1400.0000													
259.34	4.86	6.2023	12022.1839	186.5260	12208.7100	1400.0000													
263.29	6.08	3.3717	6535.4235	49.6422	6585.0658	1400.0000													
267.24	7.42	2.0006	3877.8186	28.5589	3906.3775	1400.0000													
271.19	8.57	1.3657	2647.2432	19.5124	2666.7556	1400.0000													
275.15	9.52	1.0399	2015.6022	14.8185	2030.4207	1400.0000													
282.10	10.73	0.7641	1481.0452	10.8165	1491.8618	1400.0000													