

Case name: HyRoE project 2kN

Description: F=8 Mpa=3 needs be 5-10 sec working

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Table 1. Propellant Specification

Component	Temperature, K	Pressure, MPa	Enthalpy, kJ/mol	Enthalpy, kJ/kg	Mass fraction
C32H66(a)	298.1	0.1013	-967.8000	-2146.534	0.1111111
N2O(L),298.15K	298.1	0.1013	65.1000	1479.115	0.8888889
Total			52.6482	1076.259	

Propellant exploded formula:

$C_{0.385766} H_{0.795642} N_{1.975890} O_{0.987945}$ (based on 1 mole)
 $C_{9.306232} H_{19.194103} N_{47.666443} O_{23.833222}$ (by mass %)
 α : 0.8448571 (oxidizer excess coefficient)
O/F: 8.0000000
O/F₀: 9.4690572 (stoichiometric)
 ρ : kg/m³

Table 2. Combustion Properties

Parameter	Injector	Nozzle inlet	Nozzle throat	Nozzle exit Unit
Pressure	3.0000	2.9661	1.7144	0.1020 MPa
Temperature	3237.8358	3235.3129	3047.5339	2034.1642 K
Enthalpy	28563.7401	28412.3174	14331.8044	-45932.4914 J/mol
	1076.2565	1070.4684	534.0671	-1664.0026 kJ/kg
Entropy	261.7096	261.7768	264.6692	272.2478 J/(mol·K)
	9.8610	9.8628	9.8628	9.8628 kJ/(kg·K)
Internal energy	1642.8446	1512.3993	-11006.8311	-62845.4927 J/mol
	61.9009	56.9815	-410.1637	-2276.7122 kJ/kg
Specific heat (p=const)	3.9132	3.9137	3.6530	1.6092 kJ/(kg·K)
Specific heat (V=const)	3.3481	3.3487	3.1375	1.3046 kJ/(kg·K)
Gamma	1.1688	1.1687	1.1643	1.2335
Isentropic exponent	1.1486	1.1486	1.1484	1.2332
Gas constant	0.3133	0.3133	0.3098	0.3012 kJ/(kg·K)
Molecular weight	26.5399	26.5419	26.8352	27.6036
Density	2.9575	2.9266	1.8156	0.1665 kg/m ³
Sonic velocity	1079.4018	1078.9141	1041.3351	869.2642 m/s
Mach number	0.0000	0.0997	1.0000	2.6931
Area ratio	6.0000	6.0000	1.0000	4.8513 A/At
Mass flux	314.8841	314.8841	1890.6455	389.7209 kg/(m ² ·s)
Viscosity	0.9844	0.9838	0.9447	0.7166 x 10 ⁻⁴ kg/(m·s)
Conductivity, frozen	0.2346	0.2345	0.2222	0.1553 W/(m·K)
Specific heat (p=const), frozen	1.6141	1.6140	1.6079	1.5432 kJ/(kg·K)
Prandtl number, frozen	0.6772	0.6773	0.6835	0.7119
Conductivity, effective	0.7519	0.7515	0.6462	0.1714 W/(m·K)
Specific heat (p=const), effective	3.9133	3.9137	3.6530	1.6085 kJ/(kg·K)
Prandtl number, effective	0.5123	0.5124	0.5340	0.6724

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	0.1237349	0.1172395	0.1236506	0.1171687	0.1127806	0.1080494	0.0796121	0.0784563
CO2	0.1526405	0.0920492	0.1527731	0.0921363	0.1698560	0.1035707	0.2219744	0.1392259
COOH	0.0000038	0.0000022	0.0000037	0.0000022	0.0000020	0.0000012		
H	0.0003595	0.0094661	0.0003590	0.0094538	0.0002624	0.0069850	0.0000115	0.0003141
H2	0.0021060	0.0277260	0.0021045	0.0277090	0.0018845	0.0250865	0.0017511	0.0239783
H2O	0.1160689	0.1709903	0.1161030	0.1710538	0.1210383	0.1802952	0.1306547	0.2001923
H2O2	0.0000031	0.0000024	0.0000031	0.0000024	0.0000016	0.0000013		
HCN	0.0000001	0.0000001	0.0000001	0.0000001				
HCO	0.0000022	0.0000020	0.0000022	0.0000020	0.0000010	0.0000009		
HCOOH	0.0000004	0.0000002	0.0000004	0.0000002	0.0000002	0.0000001		
HNCO	0.0000004	0.0000002	0.0000004	0.0000002	0.0000002	0.0000001		
HNO	0.0000062	0.0000053	0.0000062	0.0000053	0.0000029	0.0000026		
HNO2	0.0000015	0.0000009	0.0000015	0.0000008	0.0000007	0.0000004		
HO2	0.0000274	0.0000220	0.0000271	0.0000218	0.0000140	0.0000114		
N	0.0000040	0.0000077	0.0000040	0.0000076	0.0000017	0.0000033		
N2	0.5595110	0.5300776	0.5595316	0.5301380	0.5614308	0.5378149	0.5657386	0.5574596
N2O	0.0000051	0.0000031	0.0000050	0.0000030	0.0000026	0.0000016		
NCO	0.0000001	0.0000001	0.0000001	0.0000001				
NH	0.0000013	0.0000024	0.0000013	0.0000023	0.0000006	0.0000010		
NH2	0.0000005	0.0000009	0.0000005	0.0000009	0.0000002	0.0000004		
NH3	0.0000004	0.0000006	0.0000004	0.0000006	0.0000002	0.0000003		
NO	0.0133569	0.0118139	0.0133131	0.0117760	0.0092629	0.0082840	0.0000515	0.0000473
NO2	0.0000130	0.0000075	0.0000128	0.0000074	0.0000066	0.0000038		
O	0.0028073	0.0046568	0.0028004	0.0046456	0.0017395	0.0029175	0.0000015	0.0000026
O2	0.0135006	0.0111973	0.0134823	0.0111831	0.0098580	0.0082672	0.0000109	0.0000094
OH	0.0158448	0.0247256	0.0158134	0.0246785	0.0118521	0.0187008	0.0001935	0.0003140
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		1577.8213	m/s
Effective exhaust velocity	2342.7827	2341.0507	2602.7765 m/s
Specific impulse (by mass)	2342.7827	2341.0507	2602.7765 N·s/kg
Specific impulse (by weight)	238.8973	238.7207	265.4093 s
Thrust coefficient	1.4848	1.4837	1.6496
Thrust	2.0861	2.0846	2.3177 kN
Altitude	0.0000	0.0000	km
Ambient pressure	1.0000	1.0067	0.0000 atm

Table 5. Estimated Delivered Performance

Parameter	Sea level	Optimum expansion	Vacuum Units
Characteristic velocity		1537.4377	m/s
Effective exhaust velocity	2246.0420	2244.3543	2499.3813 m/s
Specific impulse (by mass)	2246.0420	2244.3543	2499.3813 N·s/kg

Parameter	Sea level	Optimum expansion	Vacuum Units
Specific impulse (by weight)	229.0325	228.8604	254.8660 s
Thrust coefficient	1.4609	1.4598	1.6257
Thrust	2.0000	1.9985	2.2256 kN
Altitude	0.0000	0.0000	km
Ambient pressure	1.0000	1.0067	0.0000 atm

Table 6. Altitude Performance

Altitude, km	Pressure, atm	Specific impulse, N-s/kg	Specific impulse, s	Thrust coefficient	Thrust, kN
0.0000	1.0000	2246.0420	229.0325	1.4609	2.0000

Table 7. Throttled Performance (delivered)

Throttle value	Mass flow rate, kg/s	Pressure, MPa	Specific impulse, N-s/kg Sea level	Specific impulse, s Sea level	Thrust, kN Sea level	Specific impulse, N-s/kg Optimum expansion	Specific impulse, s Optimum expansion	Thrust, kN Optimum expansion	Specific impulse, N-s/kg Vacuum	Specific impulse, s Vacuum	Thrust, kN Vacuum
1.0000	0.8905	3.0000	2246.0429	229.0326	2.0000	2244.1841	228.8431	1.9983	2499.2629	254.8539	2.2255

Table 8. Chamber Size

Combustion chamber size				Nozzle size		
Dc	59.21	mm	Type	TIC nozzle		
Dt	24.17	mm	Rn	6.04	mm	
Lcyl	314.73	mm	Tn	18.67	deg	
Lc	400.00	mm	Te	6.42	deg	
L*	2213.21	mm	De	53.24	mm	
R1	24.17	mm	Le	61.32	mm	
R2	186.43	mm	Le/Dt	2.54		
b	20.00	deg	Le/Lc15	113.03	%	
Ac/At	6.00		Ae/At	4.85		

Parameter	Engine		Chamber	
Thrust	sea level	2.0000	2.0000	kN
	opt exp	1.9985	1.9985	kN
	vacuum	2.2256	2.2256	kN
Specific Impulse	sea level	2246.0420	2246.0420	N-s/kg
	opt exp	2244.3543	2244.3543	N-s/kg
	vacuun	2499.3813	2499.3813	N-s/kg
Mass flow rate	total	0.8905	0.8905	kg/s
	oxidizer	0.7915	0.7915	kg/s
	fuel	0.0989	0.0989	kg/s
Number of chambers	1			

Table 10. Thermal Analysis