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Erratum

Errata on Theoretical Performance of Frictionless Magnetohydrodynamics-Bypass Scramjet

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IN Ref. 1 two errors of numerical nature were found: 1) the enthalpy values calculated by the equilibrium subroutine used were mistakenly considered to be referenced to 0 K, whereas in fact they were referenced to 298 K, and 2) the sound speed was calculated imprecisely. The scramjet performances of Ref. 1 were recalculated to correct these errors. Also, the upper limits of allowed errors in various iterative processes were reduced in the new calculation.

The results of Ref. 1 and those for the updated calculations are based on an equilibrium flow model and use the JANNAF coefficients.[2] It has been known that the use of JANNAF coefficients can lead to inaccuracies at low temperatures. It is also known that utilization of McBride coefficients[3] will provide more accurate enthalpy values at low temperatures. However, the McBride method was found to lead to erroneous degrees of ionization and therefore was not used. Our calculation approach introduces a small inaccuracy in the equilibrium flow conditions over the first ramp. This small inaccuracy remains throughout the flow path because energy flow is conserved thereafter. Because this behavior affects the magnetohydrodynamics (MHD) and non-MHD results equally, the relative merit of the MHD scheme is unaffected.

Table 1a Summary of typical solution: Compression stage

Flow variable	Freestream	1st ramp	2nd ramp	3rd ramp	4th ramp
Velocity, m/s	4500	4233	3923	3583	3217
Temperature, K	250	1306	2274	2999	3560
Pressure, pascal	3.607e2	1.020e4	6.389e4	2.486e5	7.509e5
Mach number	14.17	5.830	4.359	3.522	2.880

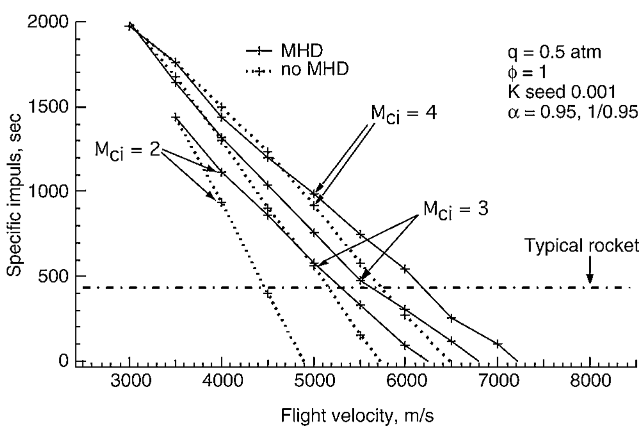

Fig. 1 Previous comparison of specific impulses between MHD and non-MHD cases (Fig. 6 of Ref. 1).

Table 1b MHD

Quantity	Generator entrance	Generator exit	Accelerator entrance	Accelerator exit
Height, cm	4.260	6.990	7.100	5.130
Length, m	——	2.689	——	2.780
B field, T	9.381	9.381	10.20	10.20
Hall parameter	3.423	3.894	2.454	2.675
Transverse E, V/m	−28,640	−19,870	21,610	32,650
Axial E, V/m	5,160	2,230	2,650	4,367
Voltage (electrodes), V	1,221	1,390	1,534	1,675
Current, A/m2	−8.540e4	−6.134e4	4.617e4	7.044e4
Velocity, m/s	3,213	2,230	2,012	3,040
Mach number	2.876	2.000	1.574	2.383
Ionization mole fraction	——	7.791×10^{-5}	7.136×10^{-5}	——
Conductivity, mho/m	——	56.670	42.750	——

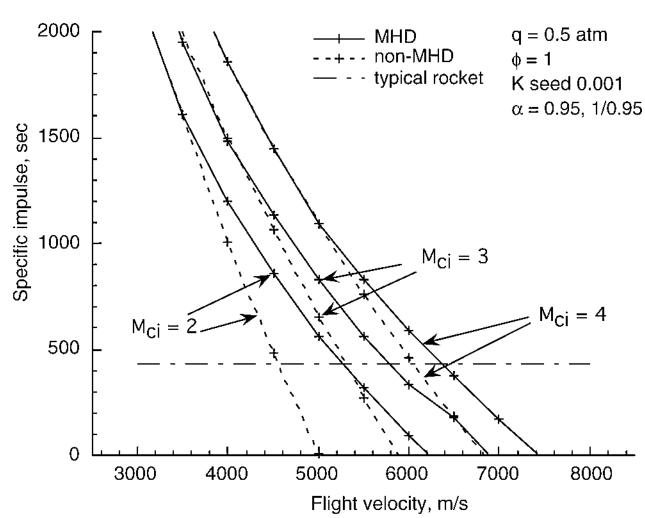

Fig. 2 New comparison of specific impulses between MHD and non-MHD cases.

Figure 6 of Ref. 1 is reproduced in Fig. 1. The corresponding new results are presented in Fig. 2. The new calculation shows slightly different numerical values. There is no difference in the qualitative features of the solutions and conclusions.

The new typical result is shown in Table 1, corresponding to Table 1 of Ref. 1. The lengths of the first ramp, the combustor, and the nozzle are set arbitrarily to 10, 0.4633, and 20.23 m, respectively (Fig. 2 of Ref. 1). The load factors are $\alpha_1 = 0.95$ for the generator and $\alpha_2 = 1/0.95$ for the accelerator. The combustor entrance Mach number is 2, and the equivalence ratio ϕ is 1. The mass fraction of the potassium seed is 10^{-3}. The new angle of all four ramps is 16.3 deg. This design consumes hydrogen fuel at a rate of 2.835 kg/s. The available chemical energy is 3.424×10^8 J/s. The airflow rate and the energy in the flow entering the combustor are 96.67 kg/s and 7.346×10^8 J/s, respectively. The available energy at the combustor exit and the calculated nozzle exit energy are 1.345×10^9 J/s and 1.222×10^9 J/s, respectively.

References

[1]Park, C., Bogdanoff, D. W., and Mehta, U. B., "Theoretical Performance of Frictionless MHD-Bypass Scramjet," *Journal of Propulsion and Power*, Vol. 17, No. 3, 2001, pp. 591–598.

[2]Perini, L. L., "Curve Fit of JANNAF Thermochemical Data," Johns Hopkins Univ., Applied Physics Lab., Rept. ANSP-M-5, Baltimore, MD, Sept. 1972.

[3]McBride, B. J., and Gordon, S., "Computer Program for Calculation of Complex Chemical Equilibrium Compositions and Applications," NASA-RP-1311, June 1996.