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MAGNETIC FIELDS AND EQUILIBRIUM COMBUSTION CHARACTERISTICS

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Abstract

The impact of a uniform magnetic field on equilibrium combustion characteristic has been explored. An expression for the Gibbs free energy that includes a magnetic field contribution has been developed. Using the method of Lagrange multipliers, changes in the Gibbs free energy for a mixture of paramagnetic and diamagnetic ideal gases is minimized. A model reaction of methane in air is used to quantitatively examine the changes in equilibrium compositions in the presence of a uniform magnetic field. Plots are presented showing the equilibrium mole fractions as a function of temperature and magnetic induction for all the product species. In general, the results indicate that within a certain temperature range a magnetic field decreases the mole fraction of major product species and increases the mole fraction of minor product species at a specified temperature. The maximum equilibrium mole fraction of NO; however, was observed to decrease an order of magnitude for an increase in magnetic induction of 0 to 0.04 Tesla.

Nomenclature

a_{ij} atoms of element *j* in product *i*
B magnetic induction
b_j atoms of element *j* in reactants
C_W Curie-Weiss constant
C damping constant
F Lagrange multiplier function
G Gibbs free energy
$\bar{g}_i^o$ molar specific reference Gibbs free energy
H magnetic field strength
I enthalpy
M intensity of magnetization
n number of moles
n_e number of constituent elements
n_s number of product species
n_T total number of moles
p pressure
p_i partial pressure of species *i*
R_u universal gas constant
S entropy
T temperature
U internal energy
V volume
y_i mole fraction of species *i*

θ Curie-Weiss constant
λ_i Lagrange multiplier of species *i*
μ_o permeability of free space
χ magnetic susceptibility

Superscript
o reference conditions

Subscript
i respective specie

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1. Introduction

Since the time of Faraday[8] the impact of magnetic fields on combustion behavior has been recognized. This interaction has primarily been attributed to the diamagnetic and paramagnetic nature of the gases involved in the combustion process. Diamagnetic behavior is observed in gases consisting of atoms with no permanent magnetic dipole moments. In the presence of an external magnetic field, the atoms of a diamagnetic substance develop a net dipole moment. This induced moment opposes the applied field and thus a diamagnetic gas exhibits a weak repulsion to an applied magnetic field. The stronger the external magnetic field, the stronger the repulsion. On the other hand, a paramagnetic gas is a gas consisting of atoms with at least one unpaired electron and thus the atoms exhibit permanent dipole moments. In the absence of a magnetic field the magnetic dipole moments of a