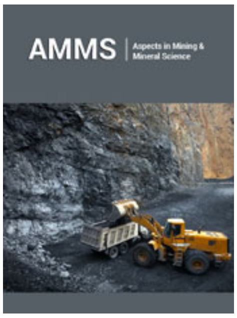
Crimson Publishers
Wings to the Research

Opinion

Most Common Misprints in Definitions of Zeldovich Number Fatally Affecting Preliminary Estimates of Combustion Thermal Activity

ISSN: 2578-0255



I A Filimonov*

Merzhanov Institute of Structural Macrokinetics and Materials Science (ISMAN) RAS, Russia

***Corresponding author:** I A Filimonov, Merzhanov Institute of Structural Macrokinetics and Materials Science (ISMAN) RAS, Academician Osipyan Str, 8, Chernogolovka, Moscow Region, 142432, Russia

Submission: September 16, 2024
Published: September 26, 2025

Volume 14 - Issue 2

How to cite this article: I A Filimonov. Most Common Misprints in Definitions of Zeldovich Number Fatally Affecting Preliminary Estimates of Combustion Thermal Activity. Aspects Min Miner Sci. 14(2). AMMS. 000833. 2025.
DOI: 10.31031/AMMS.2025.14.000833

Opinion

Any investigation concerning experimental data or computer modeling needs that the preliminary estimates have been already done. In the case of combustion thermal activity these estimates are based inevitably on the well-known Zeldovich number (Ze). Nevertheless, it turns out, that the existing Ze definitions are strongly different both from each other and from the correct version of them [1-3]. In the paper presented let's consider the most common misprints in definitions of Ze and explain the contradictory conclusions they lead to. In accordance with the electronic encyclopedia (Wikipedia 2025) the first definition of Zeldovich number has been published in proceedings of the ICDERS meeting [4], at Poitiers 1983: $\beta = \frac{E_a}{RT_b}\frac{(T_b - T_u)}{T_b}$ (1). Actually, β is the wave parameter providing its existence (at $\beta \ll 1$, $\gamma \ll 1$, see Table 1)

where,

β has been supposed to be the Ze number, while

E_a is the activation energy,

T_b is a burnt gas temperature,

T_u is an unburnt gas temperature.

Nevertheless, even earlier Zeldovich himself has written in his famous book (1) the following expression as definition of his number (introduced as z in the book): $Ze = \frac{E_a}{RT_b}\frac{(T_b - T_0)}{2RT_b^2}$ (2),

At the same time A.G. Merzhanov in his monography (2) uses the adiabatic temperature T_{ad} instead of the actual combustion temperature T_b (see (2)): $Ze = \frac{E_a}{RT_b}\frac{(T_{ad} - T_0)}{2RT_{ad}^2}$ (3). To illustrate the huge difference between expressions (2) and (3) leading to completely contradictory conclusions, let's consider the hydrogen-oxygen flame stability. It is well-known that there is practically no difference between T_b *and* T_{ad} in turbulent combustion [5-7]. In combustion synthesis *Tad* corresponds to the complete conversion, while T_b may be related with an incomplete transformation of the initial components [8]. Correspondingly, the turbulent combustion of premixed hydrogen-oxygen mixtures is absolutely stable ($Ze<Ze_{cr}=2+\sqrt{5}$)

while vice versa the hydrogen-oxygen flame with an incomplete conversion ($Ze \geq Ze_{cr}$=2+ √5) oscillates and demonstrates unstable propagation (see [3]). Thus, one have to understand that correct definition of Ze is described by the expression (2) only. The work presented above has been done under the state assignment for ISMAN (125021201988-9).

Table 1: Combustion reactions and the conditions of their activation.

1	Reaction/Production	E_a, kJ/mole	T_{ad}, K	Note, Conditions	Ze	β=, γ=
2	Zn+S in Argon	34	1916-2609	In Argon	0.69-0.89	0.5, 0.6
3	Zn+S in Air	275	5043-6768	In Air	3.08-2.33	0.04, 0.05
4	Ni+Al	1,55,159	3750	Not activated mechanically	2.35	0.04, 0.05
5	Ni+Al	50,80		Mechanically activated	1.18	0.04, 0.05
6	Ti+C in Argon	364	1000<T_{ad}<T_{melt}. Ti=1948		79.04	0.04, 0.05
7	Sphalerite in Air (S)	275	1000<T_{ad}<T_{melt}. S=1293		9.8	0.04, 0.05
8	Wurtzite in Air (W)	275	T_{ad}<T_{melt}.W=1991		7.05	0.06, 0.07
	C_2H_2+Air	150	T_{ad}<=2395K	On Pd catalyst	>4.2428	
	C_2H_2+Air	150	T_{ad}=>2397K	On Pd catalyst	<4.2387 53	
	Ti+C in Argon	364	T_{ad}<T_{boil}.T_i=3440K		48.29	>0.5, >0.6
	Hf+N_2	375	T_{ad}<T_{melt}.H_f=2495K		7.95	
	Hf+N_2	375	T_{ad}=5100K		4.161	>0.5, >0.6
	Zr+N_2, ZrN	192	1873<T_{ad}<2123< T_{melt}.ZrN		4.74	0.067, 0.080
	Zr+N_2, Solid Solution of N_2 in Zr (SSN)	234	T_{ad}<1873<T_{melt}.SSN~=2128		6.42	0.080, 0.095
	Zr+O_2, ZrO_2	118-210	2128~=T_{ad}<2988 =T_{melt}.ZrO_2	In Oxygen	2,86-5.098	

References

1. Zeldovich YB, Librovich VB, Makhviladze GM (1980) Mathematical theory of combustion and explosion. Nauka, Moscow, Russia, p. 263.
2. Merzhanov AG (2000) Solid flame combustion. ISMAN p. 127.
3. Vadchenko SG, Rogachev AS (2024) Evidence of an oscillating reaction during heating of TiH_2 in air. Internat J of SHS 33(3): 245-248.
4. (1945) Hinshelwood.
5. Lipatnikov AN, Sabelnikov VA (2020) An extended flamelet-based presumed probability density function for predicting mean concentrations of various species in premixed turbulent flames. Internat J of Hydrogen Energy 45(55): 31162-31178.
6. Lipatnikov AN, Sabelnikov VA, Hernandez-Perez FE, Song W, Im HG (2021) Prediction of mean radical concentrations in lean hydrogen-air turbulent flames at different Karlovitz numbers adopting a newly extended flamelet-based presumed PDF. Combustion and Flame 226: 248-259.
7. Poinsot T, Veynante D (2005) Theoretical and numerical combustion. Edwards. (2nd edn).
8. Gullis CF, Hinshelwood CN (1945) The mechanism of the hydrogen-oxygen reaction. IV. The activation energy of the initiating process. Publication of F R S.