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REVIEW ARTICLE

Conditions for Air Inflammation in the Reactors of Big Volume

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Abstract

The oxidation of atmospheric nitrogen initiated by electrical discharge near ferrite surface was studied in our work. This fast reaction reveals itself in a light flash without heat; its radiation spectrum belongs to NO (B $^2\Pi$) molecules. We used the term "Electronic Energy Explosion" (EEE) to describe this phenomenon. (Perhaps, "Air Inflammation" would be more expressive and figurative term). The EEE active zone is able to propagate in space at definite conditions. The aim of this study was an investigation these conditions for reactors of big volume (3 – 30 L). It was found that in the reactors with surface to volume relation S/V > 0.3 cm^{-1} the propagation EEE active zone took place at enhanced pressure or in the presence of light reflecting walls; when S/V<0.3 the EEE active zone propagated at atmospheric pressure and without reflective walls. An explanation of such kind of S/V dependence was proposed.

Keywords: Electronic Energy Explosion in Air; Reactor Volume; Nitrogen Oxidation Chain Reaction; Nitrogen Oxides Producing; Electronically Excited Particles, Photons, $O_2(A\ ^3\Sigma^+_u)$, NO(B $^2\Pi$).

Introduction

The electric discharge near the ferrite surface initiates the nitrogen oxidation chain reaction which reveals itself in the form of Electronic Energy Explosion (EEE) [1]. According to recent publications [2, 3], in case of EEE in the volume 1 L it is needed to enhance the air pressure to P>1.3 atm or to cover the reactor walls with light-reflecting Al foil for the flame propagation. For the practical use of EEE (producing nitrogen oxides, for example) it is of interest the enlarging of reactor volume: in this case the enhancing of reaction products mass can be expected. Technologically the pressure enhancement in the reactor of big volume is undesirable. The aim of this work was a study of conditions for EEE active zone propagation in the reactors of big volume (3 L, 6 L, 10 L, 20 L and 30 L).

Methods

Electrical discharge near the ferrite surface was used to initiate the EEE. The initiating arrangement consist of the ferrite ring with two steel electrodes pressed to it; the distance between the electrodes was about 2-3 mm; the voltage applied to the discharge gap was 440 V. The electrical connections chart was described earlier [4]. Camera Sony DSC-S650 was used for radiation video recording from the EEE active zone.

Five different reactors were used: 3 L, 6 L and 30 L of cylinder form with relation S/V = 0.34 cm^{-1}, 0.38 cm^{-1} and 0.44 cm^{-1} respectively; 10 L and 20 L of parallelepiped form with S/V = 0.27 cm^{-1} and 0.22 cm^{-1} respectively.

Results of experiments

A frame of video containing the image of EEE in the open air (outside the reactor) is placed on Figure 1. In this case the EEE light emitting zone was located close to the discharge gap. Its size did not exceed 2 cm.

Figure 1: EEE outside the reactor.

The frame of video in the case when EEE initiating ferrite ring was positioned inside the reactor of 20 L volume is placed on the Figure 2. In this case the whole surface of the reactor was illuminated uniformly. It means that the air in the full volume of reactor was inflamed. As usual [5] the frame foregoing to EEE-frame contains the image displaced in respect to the

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Figure 2: The radiating EEE active zone fulfills the entire reactor (20 L).

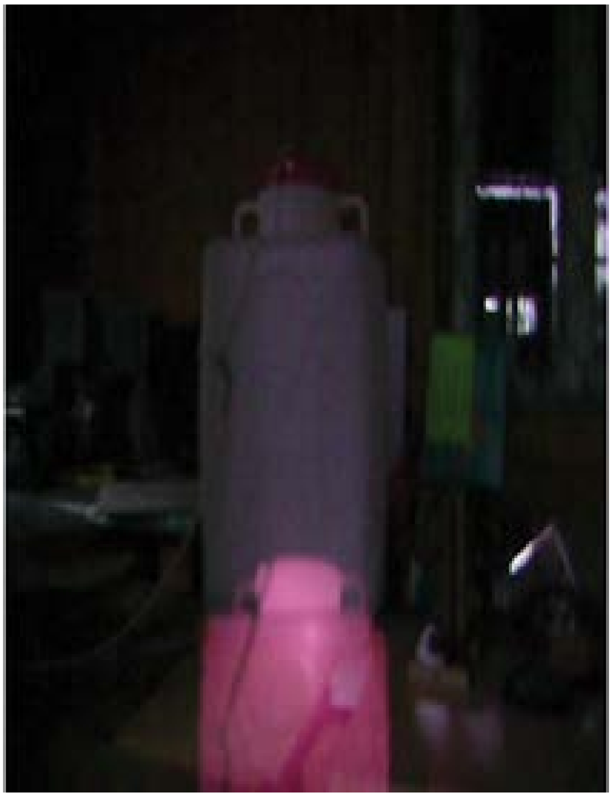

Figure 3: The image of reactor displaced in respect to real reactor position.

expected position (Figure 3). This phenomenon is caused by R. H. Dicke super radiance [5] from the EEE active zone.

Similar results were observed with 10 Liter volume reactor of parallelepiped form. EEE active zone propagation in reactors of cylinder form took place only when Al foil or enhanced pressure was used. So we can make a conclusion: pressure enhancement or Al foil are necessary for EEE active zone propagation only when $S/V > 0.3\ cm^{-1}$.

Discussion

Conditions of air inflammation propagation observed in [2, 3] were determined by the fate of electronically excited molecules and photons in the reaction zone. Using that concept, one can assume, that enlarging of the reactor volume makes unnecessary reflecting reactor walls, because the photons generated in the reaction zone are absorbed in the volume sooner then they reach the reactor walls.

Comparison of Figure 1 and Figure 2 leads to conclusion about the necessity of reactor walls for the inflammation propagation. We can suggest an explanation of this phenomenon: the shock wave produced by the discharge is reflected by reactor wall. It results in pressure enhancement at the border of flame after returning the shock wave, that pressure rising enables the flame to propagate according to [2].

Formation of an ensemble of radiators before the main explosion, which is demonstrated on Figure 3, makes evident that inflammation propagation mechanism is different from diffusion of active reaction products from point to point. The possible version is following: the photons radiated by NO ($B\ ^2\Pi$) molecules are absorbed by O_2 (in the Herzberg bands). This results in formation of $O_2\,(A\ ^3\Sigma^+_u)$ excited molecules. The energy of these molecules can result in formation of O (^1S) states:

$$O_2\,(A\ ^3\Sigma^+_u) + O_2\,(A\ ^3\Sigma^+_u) \Rightarrow O_3 + O\,(^1S) \qquad (1)$$

Then atoms O (^1S) take part in following reactions:

$$O\,(^1S) + N_2 + M \Rightarrow N_2\text{-}O\,(^1S) + M \qquad (2)$$

$$N_2\text{-}O\,(^1S) + O \Rightarrow NO + NO\,(B\ ^2\Pi) \qquad (3)$$

In such a way the positive feedback between excited particles is formed, which results in explosion like inflammation of air (Figure 2).

Conclusions

The technology of EEE initiation in big reactors (characterized by $S/V < 0.3$) is simpler then it seemed to be after previous publications [2, 3].

Due to photochemical reactions the EEE active zone propagation can proceed (very fast) without diffusion of reactive particles. Initiation of nitrogen oxidation chain reaction by UV radiation (reactions (1) – (3)) may be important for NO formation in the atmosphere. The investigation of possibility to initiate the air inflammation by pulse of UV radiation remains an interesting subject of future experiments.

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