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Title of the dissertation: Study on the gaseous fuels ignition phenomenon in high temperature oxidizer

Abstract.

High Temperature Air Combustion (HTAC) (also known as FLOX, MILD or Diluted Combustion) is a promising technology for energy saving, flame stability enhancement and decreasing of harmful substances emission (NO_x, CO, C_nH_n). In conventional burners, intensive chemical reactions are located in the flame front and are ended just behind it. This results in high concentration of flame components and high temperature increment (ΔT). Therefore classical combustion processes are characterized by high NO_x emission and high ΔT. HTAC is controlled simultaneously by mixing process of fuel and oxidizer and chemical kinetics. Therefore, combustion installations with HTAC burners are characterized by relatively uniform, mild temperature distribution and rather do not exceed the value of 1700K. Additionally there pyrolytic processes are stimulated, so reduction of NO_x is observed. Preheating of the oxidizer above autoignition point T_{ai} (for methane T_{ai}=810K and for propane T_{ai}=745K) and low level of volumetric composition of oxygen in reactor are main requirements of HTAC technique.

The HTAC technology has been applied in many industrial furnaces (especially fired with natural gas). Furthermore, it was also proved that this technology may be used for combustion of light liquid fuels. Also, the first trials have been made to burn solid fuels under HTAC technology. **However, HTAC is still a new promising combustion technology.** So, it is still a subject of scientist's research in many countries. Previously, many of the characteristic of high temperature air combustion have been investigated in laboratory-scale systems. But the knowledge of the gaseous fuel ignition phenomenon under high temperature and various concentrated oxidizers conditions is an example of the gap in the research of HTAC.

The work consists of two parts: experimental studies and mathematical modeling In experimental part of work, ignition processes of methane (CH_4>98%) and propane (C_3H_8>95%) using a high temperature oxidizer ($T_{oxi}>T_{ai}$) with varying oxygen concentration (z_{O2}=0.05÷0.21) were investigated. Two types of experimental installation: a constant-volume bomb (CVB) and a co-flow reactor (CFR) were used. The influence of the initial oxidizer temperature (for methane T_{oxi}=960÷1234K and for propane T_{oxi}=803÷1055K), the equivalence ratio and the oxygen concentration in oxidizer on ignition of gaseous fuels were analyzed and discussed. It is shown that in order to achieve effective reaction of ignition (taking into account the minimum value of ignition delay time τ_{ig} and maximal value of increment of temperature ΔT), it is not necessary to maximize the oxidizer temperature. There are optimal values of temperature oxidizer (for methane T_{oxi}≈1100K and for propane T_{oxi}≈950K) in which the ignition delay time reaches its minimum and the temperature increment reaches its maximum.

In second part, a mathematical model was formulated to predict the dependence of the equivalence ratio and temperature of oxidizer on the temperature increment. The

mathematical model incorporates the basic principles of the energy and mass balance. The theoretical predictions were correlated with the experimental data. The results of calculation were compared with experimental results which have been done on CVB reactor. It is shown that in order to achieve effective reaction of ignition (taking into account the maximal value of increment of temperature ΔT), it is not necessary to maximize the oxidizer temperature. There are optimal values of temperature oxidizer ($t \approx 830^{o}C$) in which parameters mentioned above reaches its extreme values.