STABILITY LIMIT, RADIATION EFFICIENCY AND CO/NO_X EMISSION OF RADIANT BURNERS: STATE-OF-THE-ART*

A.S. MAZNOY[1]

[1]*Tomsk Scientific Center SB RAS, Tomsk, Russia*

Gas-fired radiant burners are widely used for heating industrial premises, as well as for drying and thermal processing of materials. In the last decade, the use of radiant burners has been increasing for: (i) domestic heating devices such as water boilers or gas kitchen stoves, (ii) thermoelectric (TE)- and thermophotovoltaic (TPV)-based power generators, (iii) appliances for clean burning of low-calorific gases, bio-gases, bio-syngases. Over recent years, the new design of radiant burner was proposed by a collaborative team from Tomsk Scientific Center SB RAS, Far Eastern Federal University and Khristianovich Institute of Theoretical and Applied Mechanics SB RAS [1–4]. The new burner is operated in the internal combustion mode, when the combustion reactions is aerodynamically stabilized in the cavity of annular cylindrical burner made from intermetallic alloy with advanced high-temperature properties.

The most important characteristics of radiant burners are stability limits, radiation efficiency, CO and NO_X emission, as well as fuel-interchangeability potential. In order to evaluate the prospects of the new burner a comprehensive literature survey was performed. As a result of the review, the operational mode of any radiant burner can be represented by a diagram in the coordinates «*firing rate* [kW/m^2]»-«*equivalence ratio*» (Fig.1). The A-B-D-F-G-A domain is of interest, in which the burner works in the stable radiant combustion mode and the emission of CO and NOx meets a regional eco standard. The eco-radiant mode is limited by: the lift-off limit on the left, thermal limit (AC isotherm) at the top, either increased CO/NOx emission or flash back limit on the right, and increased CO emission at the bottom. The design of the burner significantly affects the flash-back limit and CO/NO_X emission. The material used determines the maximum temperature for the long-term operation, i.e. thermal limit of the burner. However, the lift-off limit seems to be a universal characteristic for all types of radiant burners and is determined by the ratio of the fresh mixture flow rate to the laminar burning velocity. As for the requirements defined by environmental standards, the area of the eco-radiant mode expands when burning hydrogen-rich fuels or synthesis-gas blends and decreases when burning biogas. There is no the best burner over all operational parameters. Some burner' designs provide lower emissions, but radiation efficiency is decreased and stable range parameters are narrowed. The new burner design is the best in terms of stability range and radiation efficiency, but CO/NO_X emission is increased. Oral presentation will discuss all observations in detail.

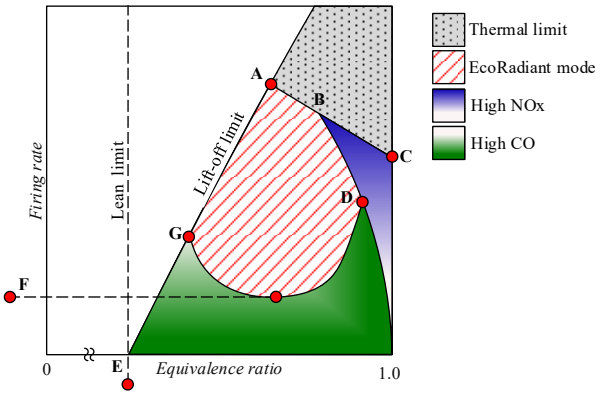

Fig.1. Diagram of combustion modes of radiant burners.

REFERENCES

[1] R. Fursenko, A. Maznoy, E. Odintsov, A. Kirdyashkin, S. Minaev, K. Sudarshan, "Temperature and radiative characteristics of cylindrical porous Ni–Al burners," Int. J. Heat. Mass. Transf., vol. 98, pp. 277–284, 2016.

[2] A. Maznoy, A. Kirdyashkin, S. Minaev, A. Markov, N. Pichugin, E.Yakovlev, "A study on the effects of porous structure on the environmental and radiative characteristics of cylindrical Ni-Al burners," Energy, vol. 160, pp. 399-409, 2018.

[3] A. Maznoy, A. Kirdyashkin, V. Kitler, N. Pichugin, V. Salamatov, K. Tcoi, "Self-propagating high-temperature synthesis of macroporous B2+$L1_2$ Ni-Al intermetallics used in cylindrical radiant burners," J. Alloys Compd., vol.792, pp. 561-573, 2019.

[4] R. Fursenko and A. Maznoy, "A simple model with detailed chemistry for estimation of NOx and CO emission of porous burners," Combust. Theory Model, 2019.

* The work was supported by Russian Foundation for Basic Research (grant № 20-38-70119)