INSHOT BURNER FLAME RETAINER

A flame retainer for an inshot burner has a plurality of secondary openings that take full advantage of the space available to limit their size in one dimension to prevent flashbacks but are sufficient in size to allow for the flow of sufficient primary air so as to prevent yellow tipping and soot formation. The slots are elongated in radially cross-sectional shape, and their widths are limited to a dimension of 0.13 inches. The width is also limited to dimensions equal to or greater than 0.09 inches so as to prevent the formation of soot.

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ABSTRACT
FIG. 5

METE OT SOOTING AND FLASHBACK REQUIREMENTS IN THIS RANGE OF SLOT WIDTH.
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INSHOT BURNER FLAME RETAINER

TECHNICAL FIELD

[0001] This invention relates generally to residential furnaces and, more particularly, to inshot burners with flame retainers.

BACKGROUND OF THE INVENTION

[0002] Gas fired appliances, such as residential and light commercial heating furnaces, often use a particular type of gas burner commonly referred to as an inshot burner. In this type of burner, fuel gas under pressure passes through a central port disposed at the inlet of a venturi burner nozzle. Atmospheric air is drawn into the burner nozzle and mixes with the fuel gas as it passes through the burner nozzle. In some constructions, a burner head insert, also referred to as a flame retention insert, made of compressed sintered or powdered metal is mounted in the outlet end of the tube. In operation, as gas is injected into the inlet end of the nozzle, it entrains air into the nozzle. This primary air/gas mix flows through the nozzle to the burner head insert. The primary air/gas mix passes through outlet openings defined by the insert and burns as it exits the insert forming a flame projecting downstream from the burner head insert. Secondary air flows around the outside of the venturi tube and is entrained in the burning mixture downstream of the insert in order to provide additional air to complete the combustion process.

[0003] Some of the problems associated with conventional inshot burner designs are improper ignition, flame instability, noise and nitrogen oxides formation. Ignition problems can arise when the ignition location is critical. The velocity of the primary air/gas flow from the insert can be greater than the flame speed. Under this condition, the flame lifts off from the burner insert, i.e. the flame begins to burn at a location spaced from the outer face of the flame retention insert. Flame liftoff is a major cause of the noise associated with the operation of inshot burner nozzles. If the velocity of the air/gas mixture is too slow, when compared to the flame speed, flashback can occur. Flashback is the burning of the gas within the burner nozzle itself. This condition can cause overheating and degradation of the nozzle.

[0004] Flame retention or burner head inserts have been designed in an attempt to achieve better flame stability and reduction of noise. U.S. Pat. No. 6,036,481 provides a burner head insert having an inner flow passage and a plurality of second flow passages with tapered splines therebetween. U.S. Pat. No. 5,186,620 provides a central passage, secondary openings of smaller diameters arranged circularly around the central insert and a plurality of peripheral openings with stepped notches. While such designs are helpful in addressing the problems discussed hereinabove, they do not adequately address the problem of flashback and the propensity for producing soot, particularly when using propane rather than natural gas as the fuel. That is, the applicants have found that flashback of the flame to the outer perimeter flow passages in a burner insert can be substantially reduced or prevented if certain dimensional limitations are placed on the passages. However, when dealing with other design limitations on the overall size of the burner, simply downsizing the perimeter passages results in insufficient primary air for combustion. That is, as the size of the passages is reduced to prevent flashback, there is a tendency to cause a yellowing of the flame tip which, in turn, tends to cause the formation of soot. Further, attempting to increase the number of the passages eventually reaches the minimum limit of wall thickness (i.e. the recognized industry standard of 0.045-0.060 inches) for powdered metal parts, which is the most viable and economical method of producing flame retainers.

DISCLOSURE OF THE INVENTION

[0005] The applicants have found that if the perimeter flow passages are formed having at least one dimension which is approximately 0.13 inches or less, a flamelet which might otherwise propagate upstream through that channel can be quenched and halted by the proximity of the channel wall. In order to obtain the necessary flow of air through the passages to prevent sooting, while maintaining the minimum limit of wall thickness, the passages are preferably formed having a radial cross sectional shape that is elongated in form, essentially by tying multiple holes together to form slots to increase the flow area while preserving the wall thickness between passages and also maintaining a criteria of having a passage dimension (i.e. slot width) no greater than the 0.13 inches.

[0006] In accordance with one embodiment of the invention, the passages are V-shaped in radial cross section. This is accomplished in one way by having a plurality of circular openings at one radius and a second plurality of openings at a greater radius, and removing the material between the outer openings and inner opening to provide a V-shape with the apex toward the center.

[0007] Another embodiment of the present invention is to provide passages having radial cross sections that are elongated in shape with their elongations being disposed radially. This, again, is accomplished by having a plurality of openings formed at a smaller radius and a plurality of openings at a greater radius, and removing material therebetween to provide elongated slots that are radially disposed.

[0008] According to another embodiment of the invention, the passages are formed such that in radial cross section, they are annular in form and are circumferentially equally spaced around a central opening. The restricted radial width prevents flashback, while the circumferential length is sufficient to prevent sooting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIGS. 1A and 1B are illustrations of a flame retainer device in accordance with the prior art.

[0010] FIG. 2 is a modified version of a flame retainer.

[0011] FIG. 3 is a further modified flame retainer.

[0012] FIG. 4A is a flame retainer in accordance with a preferred embodiment of the invention.

[0013] FIG. 4B is an alternative embodiment thereof.

[0014] FIG. 4C is another alternative embodiment thereof.

[0015] FIG. 5 is a graphic illustration of the relationship between slot width and tendencies to form soot or allow flashback.
FIG. 6 is an alternative embodiment of the invention.

FIG. 7 is a further alternative embodiment thereof.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGS. 1A and 1B, there is shown a flame retainer structure in accordance with the prior art. The flame retainer, shown generally at 11 comprises a cylinder 12 having an outer surface 13 and a central passage 14 extending therethrough. A plurality of secondary openings 16 of smaller diameter are arranged circularly around the central passage 14.

While the size of the central passageway 14 is somewhat decided by other considerations, the designers have taken some liberty with the size of the secondary openings 16 to bring about desired results. Generally, the size of the secondary openings 16 has been chosen to bring about the desired performance characteristics. While the number and particular location of the secondary openings has been varied to bring about particular results, the secondary openings have generally been circular in form with their axes aligned with the axes of the central passage 14.

The applicants have found that the use of propane, as opposed to natural gas, presents problems because of propane flame characteristics. In particular, in order to prevent the formation of soot, the secondary openings must be sufficient in number and size to allow for the free flow of the primary air/gas mixture therethrough. However, it has also been found that as the size of the secondary openings 16 reaches a certain level, flashback is likely to occur.

Shown in FIG. 2 is a modified version of the flame retainer which includes a central passage 14 and a plurality of secondary openings 17. The secondary openings 17 comprise a first set of secondary openings 18 which are located on a radially inward circle 19 as shown in FIG. 2, and a second set of secondary openings 20 having their centers being located on a radially outer circle 21. The diameters of the first and second sets, 18 and 20, respectively, are identical, and, when tested it was found that flashback did occur. While the number of secondary openings 17 has been increased over the prior art design of FIGS. 1A and 1B, it was found that there was still not sufficient primary airflow therethrough to prevent the formation of soot. Further, to increase the number of secondary openings 17 in order to overcome the problem was not possible because of the need to maintain a certain wall thickness between the secondary passages 17 in accordance with industry standards.

Referring now to FIG. 3, in order to address the problems of flashback and insufficient primary air, the flame retainer was formed with secondary openings 22 that were smaller in size and greater in number. That is, the 24 secondary openings 22 were formed having a diameter of about 0.10 inch and were densely situated such that the number of openings was maximized while still maintaining the desired wall thickness. The total area of the secondary openings 22 was found to be 0.188 square inches. When the flash retainer was tested, it was determined that the design was adequate for the prevention of flashback, but there was insufficient primary air such that a yellowing of the flame tip occurs.

In an effort to increase the flow of primary air to prevent the flame yellow tipping, while at the same time restricting the dimensions of the secondary openings, the openings of the flame retainer of FIG. 3 were interconnected by removing material between an opening located in the radially inner set of openings and the adjacent radially outer openings to thereby form a plurality of V-shaped secondary openings 23 as shown in FIG. 4A. That is, the five V-shaped secondary openings 23 retained the dimension d1 of about 0.10 inches throughout its length, but the elongated shape increased the total area of the secondary openings 23 to about 0.322 square inches, thereby allowing for increased flow of primary air as compared with the FIG. 3 embodiment. When tested, this modified design was found to be acceptable in respect to the prevention of flashback and also with respect to the non-formation of soot. That is, the increased flow of primary air eliminated the flame yellow tipping that had occurred in the FIG. 3 embodiment.

A slight variation of the FIG. 4A embodiment is shown in FIG. 4B where, again, there are five V-shaped secondary openings 26 and five radially inner openings 27 as shown. Whereas the radially inner openings 27 are substantially identical to the radially inner openings 24 of the FIG. 4A embodiment, the V-shaped secondary openings 26 are somewhat shorter in length and somewhat wider than the secondary openings 23 of the FIG. 4A embodiment. Also, the ends of the V-shaped slots of the secondary openings 26 are flat as compared with the rounded ends of the slots of the secondary openings 23 of the FIG. 4A embodiment. It should be kept in mind, however, that although the width d2 of the slots 26 is slightly increased from that dimension d1 of the FIG. 4A embodiment, that dimension is limited by the need to prevent flashback as will be further discussed hereinafter.

When tested, the FIG. 4B embodiment was found to perform satisfactorily in preventing flashback while at the same time preventing the occurrence of yellowing at the flame ends. The total area of the secondary openings 26 and 27 was found to be about 0.334 square inches.

FIG. 4C illustrates yet another variation of a V-shaped secondary opening 28 wherein the number of V-shaped secondary openings 26 has been reduced to four, their angles widened, and the number of radially inner openings 29 has been reduced to four. Here the total area of the secondary openings 28 and 29 was found to be around 0.333 square inches. The design was tested and was found to be satisfactory in respect to the prevention of flashback and yellow tipping. The length of the secondary openings 28 are increased over the length of the V-shaped slots 26 of the FIG. 4B embodiment, and the dimension d1 is, again, limited in order to prevent the flashback occurrences.

Considering the dimensions d1, d2 and d3 of the FIGS. 4A, 4B and 4C embodiments, respectively in greater detail, there is shown in FIG. 5 a relationship which exists between the width of the slots for the secondary openings and the occurrence of flashback. Briefly stated, if the slot width is maintained at a dimension no greater than 0.13 inches, flashback will not occur. When that dimension is increased beyond the 0.13 inches, flashback is likely to occur and will increase with an increase in that dimension. On the other hand, if the slot width is decreased too far, sooting is more likely to occur. That is, if the dimension is reduced below 0.09 inches, then sooting is likely to occur.
In each of the 4A, 4B and 4C embodiments, it will be recognized that the secondary openings 23, 26 and 28 are all V-shaped, with an included angle that points toward the central passage 14. In an analysis of these different designs, the applicants have recognized a relationship as follows:

\[ N \text{-the number of V-shaped patterns in the flame retainer} \]

\[ \theta = \frac{1}{2} \text{ of the included angle of the V-shaped opening in degrees} \]

Applying the above formula to the FIGS. 4A, 4B and 4C embodiment we obtain:

| FIG. 4A | \[ 14(5) = 126.56 - 59 = 67.56 \] |
| FIG. 4B | \[ 14(5) = 126.56 - 56 = 70.56 \] |
| FIG. 4C | \[ 14(4) = 126.56 - 71 = 55.56 \] |

In addition to V-shaped patterns for secondary openings, the applicants have found that other shapes of elongated slots may also be employed to obtain the results contemplated by the present invention. For example, in the FIG. 6 embodiment, there are 12 secondary openings 32 which are formed as elongated slots aligned with their long axes in a radial direction with the width \( d_s \) being restricted as discussed hereinabove. The FIG. 6 embodiment was found to have a total open area for the combined secondary opening 32 of 0.380 square inches, and was found to perform satisfactorily both with respect to the prevention of flashback and the prevention of soot.

The FIG. 7 embodiment is yet another possible embodiment and is similar to the FIGS. 4A and 4B embodiments except that, rather than the V-shaped secondary openings, the secondary openings are curvilinear in form with their long dimension being along the periphery and having a width \( d_s \) that is in compliance with the requirements as discussed hereinabove. Further, there are five radially inner openings 33 as shown. The combined open area of the slots 32 and the openings 33 was about 0.364 inches. In addition to the diameter of the slots 32, the diameter of the openings 33 is also limited to prevent flashback as discussed hereinabove.

While the present invention has been particularly shown and described with reference to a preferred embodiment and modified embodiments as illustrated in the drawings, it will be understood that one skilled in the art may make various changes in detail without departing from the spirit and scope of the invention as defined by the claims.

We claim:

1. A burner insert for placement within an outlet end of an inshot burner nozzle, said burner insert having an axially elongated annular body with an axially extending inner flow passage and further comprising:
   a plurality of axially extending secondary openings formed in said insert, said secondary openings being radially spaced from said inner flow passage and at least some of said secondary openings being formed as elongated slots in radial cross-sectional shape.

2. A burner insert as set forth in claim 1 wherein said elongated slots have a uniform width which is equal to or less than 0.13 inches.

3. A burner insert as set forth in claim 2 wherein said slot width is equal to or greater than 0.09 inches.

4. A burner insert as set forth in claim 1 wherein said secondary openings are generally V-shaped in radial cross-sectional shape.

5. A burner insert as set forth in claim 4 wherein said V-shaped openings having their apex extending towards said inner flow passage.

6. A burner insert as set forth in claim 4 wherein said secondary openings have a relationship as follows:

\[ b = 14(5) = 126.56 - \frac{1}{2} \theta \text{ inches} \]

wherein \( N \text{-the number of V-shaped openings and } \theta \text{ the included angle of the V-shaped opening.} \]

7. A burner insert as set forth in claim 1 include a plurality of openings having a circular radial cross sectional shape.

8. A burner insert as set forth in claim 1 wherein the space between said secondary openings is no less than 0.045 inches.

9. A method of preventing flashback in a flame retainer of an inshot burner nozzle for use with propane comprising the steps of:

   providing an insert having an axially elongated annular body with an axially extending inner flow passage;

   providing a plurality of axially extending openings in said insert, said secondary openings being radially spaced from said inner flow passage and at least some of said secondary passages being formed as elongated slots in radial cross sectional shape.

10. A method as set forth in claim 9 and including the further step of limiting the width of said secondary passages to be equal to or less than 0.13 inches.

11. A method as set forth in claim 10 and including the further step of forming the secondary passages such that the width of the slots is uniform and is equal to or greater than 0.09 inches.

12. A method as set forth in claim 9 wherein said at least some of said secondary openings are generally V-shaped in radial cross sectional shape.

13. A method as set forth in claim 9 wherein said plurality of secondary openings are formed such that the thickness of the walls therebetween is no less than 0.045 inches.

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