Title: A NOZZLE FOR AIR-ASSISTED ATOMIZATION OF A LIQUID FUEL

Abstract: A nozzle (100) for air-assisted atomizing of a liquid fuel comprises a fuel feed passage (110) and an air feed passage (114) and a swirling chamber (118) from which fuel and air may be passed to an exit orifice (126) for emerging a cone shaped spray. An air bypass passage (122) is provided for leading a fraction of the air flow in the air feed passage (114) past the swirling chamber (118) and to an air exit (124) arranged such with respect to the exit orifice (126) that, during operation of the nozzle, air emerging through the air exit (124) reduces depositing of residues of fuel on a downstream surface (130, 132, 136) of the nozzle element (108). Grooves or other flow-guiding elements may confer swirling or rotation of air in or downstream of the air feed passage (114) and/or the air bypass passage (122).
A NOZZLE FOR AIR-ASSISTED ATOMIZATION OF A LIQUID FUEL

Technical field

The present invention generally relates to the field of nozzles for air-assisted atomization of a liquid fuel, more specifically to such nozzles, wherein a fuel feed passage and an air feed passage lead fuel and air to a swirling chamber in which atomization of the fuel is initiated, there being provided means downstream of the swirling chamber for emitting a spray of atomized fuel.

Background of the invention

Various spray nozzles of the abovementioned type have been proposed in the prior art. WO 03/024611 discloses a low pressure spray nozzle with an elongated nozzle body. There is provided an air swirling insert and, within an interior bore in the air swirling insert, a fluid distribution insert which has a radially inner set of circumferentially disposed air swirling vanes on an inwardly tapered exterior surface thereof. The air swirling insert also has a radially outer set of circumferentially disposed air swirling vanes on an inwardly tapered exterior surface thereof. The latter air swirling vanes impart a rotational component of motion to low pressure air flowing between the exterior surface of the air swirling insert and a tapered wall portion of an interior chamber of the nozzle body. The air swirling vanes direct swirling air toward a downstream fluid mixing chamber to interact with sheared fluid drops exiting an upstream fluid mixing chamber of the air swirling insert. In the far downstream end of the nozzle body there is provided an outwardly tapered exit orifice through which a cone shaped spray distribution pattern is emitted.

Summary of the invention

It is an object of preferred embodiments of the invention to provide a spray nozzle which may decrease the presence of hazardous components in exhaust
gas emitted from a combustion appliance, such as a furnace, incorporating the nozzle.

 Accordingly, the invention provides a nozzle for air-assisted atomization of a liquid fuel, the nozzle comprising a housing and, within the housing:

- a fuel feed passage and an air feed passage;
- a swirling chamber arranged at a downstream end of the fuel and air feed passage, respectively;
- an exit orifice downstream of the swirling chamber through which a cone shaped spray of fuel may emerge out of a nozzle element;
- an air bypass passage for leading a fraction of the air flow in the air feed passage past the swirling chamber and to at least one air exit, the at least one air exit being arranged such with respect to the exit orifice that, during operation of the nozzle, air emerging through the air exit reduces depositing of residues of fuel on a downstream surface of the nozzle element.

It has been found that, by reducing the depositing of residues of fuel on the downstream surface of the nozzle element, the presence of hazardous components in exhaust gas emitted from a combustion appliance, in which the nozzle is incorporated, has shown to decrease during start-up and shutdown of the combustion appliance.

There may be provided one single air exit and one or more air bypass passages, or, alternatively, a plurality of air exits of a single air bypass passage or of distinct air bypass passages. The location and shape of the air exit(s) and the air bypass passage(s) will usually depend from the layout of the exit orifice or the exit orifices, if more than one exit orifice is provided in the nozzle. In a preferred embodiment of the invention, the air exit is provided as an annular, i.e. ring-shaped orifice or opening for forming an air cushion or an air flow around the exit orifice for reducing depositing of fuel on the downstream surface of the nozzle element. Alternatively, a plurality of distinct air exits may be radially displaced relative to the exit orifice, with the distinct air exits being
arranged so as to form a similar air cushion or air flow. The exit orifice is preferably provided centrally within the housing and/or the nozzle element. The cross-sectional shape of the air exit in a plane perpendicular to an axis of revolution of the housing or nozzle element may for example be circular, rectangular or arc-shaped. In case of only a single air exit being provided, such an air exit is preferably annular with an inner radius larger than an outer radius of the exit orifice. At least a part of the air bypass passage is preferably provided in the nozzle element, the nozzle element being either an integral part of the housing or a separate insert in the housing.

In one embodiment of the invention, an upstream portion of the air feed passage is provided as an annular passage extending along an outer surface of a core element of the nozzle, in which the fuel feed passage is provided as a central passage. The annular portion of the air feed passage may accordingly be formed by an inner surface of a bore or passage in the housing and an outer surface of the core element. In the core element there may be provided a plurality of inwardly extending passages forming part of the air feed passage. An upstream end surface of the nozzle element is preferably inwardly tapered. At the transition between the annular passage and the inwardly extending passages in the core element, an upstream portion of the air bypass passage may be formed as a gap between an outer circumferential surface of the nozzle element and an inner surface of the housing. The swirling chamber is preferably arranged centrally within the housing at a downstream end of the air and fuel feed passages.

The air exit is preferably arranged at a location downstream of the swirling chamber, so that the air exit may be focussed and directed toward that part of the downstream end surface of the nozzle element at which depositing of fuel residues is to be reduced. An inner circumferential surface at the downstream end of the housing may be outwardly tapered from the air exit to a far downstream end surface of the housing, or it may extend parallel to a longitudinal axis of the nozzle. A far downstream end portion of the housing
may form an indentation in the downstream end surface of the nozzle, in which indentation a downstream surface of the nozzle element is exposed.

With the aim of achieving an efficient air flow downstream of the air exit, a rotating air flow may be generated by at least a portion of the air bypass passage being curved in a cross-sectional plane perpendicular to the axis of revolution. Alternatively, the rotating air flow may be generated by guide vanes or grooves. The direction of rotation of the air flow may be the same as the direction of rotation of the fuel exiting the swirling chamber, or it may be opposite to the rotation of the fuel exiting the swirling chamber. Depending upon operational characteristics, such as air and fuel flow rate and pressure, it may be desired that the air flow at the air exit(s) and downstream thereof is turbulent. A portion of the air bypass passage may be substantially parallel to the axis of revolution in a cross-sectional plane parallel to the axis of revolution.

An exit passage may be provided downstream of the swirling chamber, preferably as a central orifice in the nozzle element, for causing a controlled dispersing of the fuel, an upstream end of the exit passage being in fluid communication with the swirling chamber. The swirling chamber may extend into the exit passage. The exit orifice, i.e. the outlet of the exit passage, may be arranged downstream of the air exit(s) with the exit orifice being defined by a short tubular projecting portion at the downstream surface of the nozzle element. Tests have indicated that such a tubular projection has a beneficial effect in terms of reducing depositing of residues of fuel on the downstream end surface of the nozzle element. A planar portion of the end surface of the nozzle element may thereby be exposed upstream of the exit orifice, the air exit(s) being preferably arranged upstream of and preferably radially outwardly in relation to the exit orifice. In one embodiment, the exit orifice is located in a plane defined by a far downstream end surface of the housing.

The invention also relates to a method for reducing depositing of residues of fuel on a downstream surface of a nozzle element in a nozzle for air-assisted
atomization of a liquid fuel, the nozzle comprising a housing and, within the
housing:
- a fuel feed passage and an air feed passage;
- a swirling chamber arranged at a downstream end of the fuel and air feed
  passage, respectively;
- an exit orifice downstream of the swirling chamber through which a cone
  shaped spray of fuel may emerge out of the nozzle element;
- an air bypass passage for leading a fraction of the air flow in the air feed
  passage past the swirling chamber and to at least one air exit;
the method comprising leading at least a part of the air emerging through the
air exit past the downstream surface of the nozzle element.

It should be understood that any function and feature of the nozzle discussed
herein also applies to the method of the invention.

The invention may be applied throughout a wide interval of fuel and air flow
rates and pressures. A particular relevant field of usage is the low-pressure
field, in which pressurized fluid fuel and pressurized air enter the nozzle at a
relatively low operating pressure, e.g. 0.01 – 0.5 bar.

**Brief description of the drawings**

A preferred embodiment of the invention will be further described with
reference to the drawings, in which:

Fig. 1 shows a cross-sectional cut through an embodiment of a nozzle
according to the invention,

Fig. 2 shows an enlarged detail view of a downstream portion of the nozzle of
Fig. 1,

Fig. 3 shows a cross-sectional cut through a nozzle element comprised in the
nozzle of Figs. 1 and 2,
Fig. 4 shows an end view of the nozzle element of Fig. 3,

Fig. 5 shows a cross-sectional cut through a core element comprised in the nozzle of Figs. 1 and 2,

Fig. 6 shows a downstream end view of the core element of Fig. 5,

Fig. 7 shows a downstream end view of a second embodiment of a nozzle according to the invention.

**Detailed description of the drawings**

A nozzle 100 as shown in Fig. 1 comprises a housing 102, a fuel supply member 104, a core element 106, and a nozzle element 108. A fuel feed passage 110 extends through the fuel supply member 104 and the core element, the fuel supply member defining an inwardly tapered portion 112 at a transition between a large diameter section of the fuel feed passage and a reduced diameter section thereof. An air feed passage 114 extends from an upstream end 116 of the housing 102 to a swirling chamber 118 arranged centrally within the housing in alignment with the fuel feed passage 110. An upstream portion of the air feed passage 114 is formed as three distinct grooves arranged along an outer circumferential surface of the fuel supply member 114, the grooves being provided in a threaded portion 115 of the fuel supply member. A downstream portion of the air feed passage 114 is formed as grooves 120 (see Fig. 2) in the core element, the grooves extending inwardly toward the swirling chamber 118. The grooves 120 provided in the core element 106 are shown more clearly in Figs. 5 and 6. As shown in Fig. 1, the threaded portion 115 of the fuel supply member 104 engages a corresponding inner threaded portion of the housing, so that the fuel supply member 104 abuts and presses against the core element 106 which in turn abuts the nozzle element 108, the nozzle element 108 abutting an inner surface in an end wall or flange or the housing.
It has been found that during operation of the nozzle, residues of fuel tend to deposit at outer surfaces 130 and 132 of the nozzle element.

Accordingly, an air bypass passage 122 is provided for leading a fraction of air in the air feed passage past the swirling chamber 118 and to an air exit or slit 124. An exit orifice 126 for fuel is provided at a downstream end of a tubular projecting portion 128 of the nozzle element 108. It has been found that less residues of fuel tend to deposit at the downstream surfaces of the nozzle element 108 in embodiments with such a tubular projecting portion 128 than in embodiments in which the exit orifice 126 is provided as a simple bore in the nozzle element 108, i.e. embodiments in which the downstream surface of the nozzle element 108 is entirely planar. In order to efficiently prevent residues of fuel from being deposited at the outer surfaces 130 and 132 of the nozzle element during operation of the nozzle, the air exit 124 is arranged radially outwardly with respect to the tubular projecting portion 128 and the surfaces 130 and 132, and upstream thereof. An outwardly tapered portion 134 is provided at an inner circumferential surface at the far downstream end of the housing. In an alternative embodiment, the inner circumferential surface is parallel to the axis of revolution.

The nozzle element 108 is shown in detail in Figs. 3 and 4. A groove 124a with a circular inner wall defines a border of the air bypass passage 122 and of the opening 124 when the nozzle element is mounted in the housing 102. At its outer circumferential surface, the groove 124a defines four transversely extending portions 122a which extend to an outer circumferential surface of the nozzle element, so as to thereby allow air to pass from the air feed passage 114 to the groove 124a when the nozzle element is mounted in the housing 102. Due to the circularity of the groove 124, the air flowing in the air bypass passage 122 when the nozzle is assembled and in operation rotates when it exits through the air exit 124.
Figs. 5 and 6 show an end view of the core element 106 with grooves 120, cf. above.

A downstream end view of a second embodiment of the nozzle is shown in Fig. 7. The nozzle of Fig. 7 is identical to the nozzle of Figs. 1 and 2, with the exception that the inner circumferential surface at the far downstream end of the housing (denoted 134 in Fig. 2) is not tapered but parallel to the axis of revolution of the housing. The fuel supply passage 110 and the exit orifice 126 are arranged centrally within the housing, the exit orifice 126 being defined by the tubular projecting portion 128. The downstream end surface 132 of the nozzle element and the air exit 124 are arranged radially outwardly with respect to the exit orifice 126. An outer surface of the housing defines surface portions 136 and 138 and a hexagonal nut portion 140.
CLAIMS

1. A nozzle (100) for air-assisted atomization of a liquid fuel, the nozzle comprising a housing (102) and, within the housing:
   - a fuel feed passage (110) and an air feed passage (114);
   - a swirling chamber (118) arranged at a downstream end of the fuel and air feed passage, respectively;
   - an exit orifice (126) downstream of the swirling chamber through which a cone shaped spray of fuel may emerge out of a nozzle element (108);
   - an air bypass passage (122) for leading a fraction of the air flow in the air feed passage (114) past the swirling chamber (118) and to at least one air exit (124);
   characterised in that
   the at least one air exit (124) is arranged such with respect to the exit orifice (126) that, during operation of the nozzle, air emerging through the air exit (124) reduces depositing of residues of fuel on a downstream surface (130,132,136) of the nozzle element (108).

2. A nozzle according to claim 1, wherein the housing (102) defines an axis of revolution which extends through the exit orifice (126), the air exit (124) being arranged radially displaced relative to the exit orifice.

3. A nozzle according to claim 1 or 2, further comprising means (124a) for achieving a rotating flow of air out of the air exit.

4. A nozzle according to any of the preceding claims, wherein at least a portion (122a;124a) of the air bypass passage (122) is provided in the nozzle element (108).

5. A nozzle according to any of the preceding claims, wherein the air exit (124) is formed as an annular orifice.
6. A nozzle according to any of the preceding claims, wherein the air exit (124) is arranged at a location downstream of the swirling chamber (118).

7. A nozzle according to any of the preceding claims, wherein the air exit is provided between a surface of the nozzle element (108) and a surface of the housing (102).

8. A nozzle according to any of the preceding claims, wherein the housing (102) is outwardly tapered from the air exit (124) to a far downstream end surface of the housing.

9. A nozzle according to any of claims 2-8, wherein, in a cross-sectional plane parallel to the axis of revolution, the air bypass passage (122) is substantially parallel to the axis of revolution in the area of the air exit (124).

10. A nozzle according to any of claims 2-9, wherein, in a cross-sectional plane perpendicular to the axis of revolution, at least a portion the air bypass passage (122) is curved.

11. A nozzle according to any of the preceding claims, wherein the exit orifice (126) is provided at a downstream end of an exit passage, an upstream end of which is in fluid communication with the swirling chamber (118).

12. A nozzle according to claim 11, wherein the exit passage is formed as a tubular portion (128) projecting from a downstream surface of the nozzle element (108).

13. A nozzle according to claim 11 or 12, wherein the exit passage is constituted by a central orifice in the nozzle element (108).

14. A nozzle according to any of the preceding claims, wherein the exit orifice is located in a plane defined by a far downstream end surface of the housing (102).
15. A method for reducing depositing of residues of fuel on a downstream surface (130,132,136) of a nozzle element (108) in a nozzle (100) for air-assisted atomization of a liquid fuel, the nozzle comprising a housing (102) and, within the housing:

- a fuel feed passage (110) and an air feed passage (114);
- a swirling chamber (118) arranged at a downstream end of the fuel and air feed passage, respectively;
- an exit orifice (126) downstream of the swirling chamber (118) through which a cone shaped spray of fuel may emerge out of the nozzle element (108);
- an air bypass passage (122) for leading a fraction of the air flow in the air feed passage (114) past the swirling chamber (118) and to at least one air exit (124);

the method being characterised by leading at least a portion of air emitted through the air exit (124) past the downstream surface (130,132,136) of the nozzle element (108).
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7  F23D11/10  F23D11/38

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7  F23D  B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**X** Patent family members are listed in annex.

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Date of the actual completion of the international search: 3 December 2004

Date of mailing of the international search report: 10/12/2004

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