until the mixed fuel flow start time 440a, the density of the second fuel type ρ_2 may not be determined until after the mixed fuel flow end time 440b.

Once the concentrations of the first and second fuel type *X*, *Y* are solved over the period of time, the flow of the first and second fuel type may be totalized. The totalization may also include fuel flow before and after the mixed fuel flow. The total mass flow of the first and second fuel type may also be determined by, for example, using the following third and fourth equation:

$$M_{FuelType1} = \int X(t) \cdot m_{total} dt \quad (3)$$

$$M_{FuelType2} = \int Y(t) \cdot m_{total} dt \quad (4)$$

Where:

m_{total} is the total mass of the mixed fuel consumed during the mixed fuel flow period;

$M_{FuelType1}$ is the total mass of the first fuel type consumed during the mixed fuel flow period;

$M_{FuelType2}$ is the total mass of the second fuel type consumed during the mixed fuel flow period;

$X(t)$ is the concentration of the first fuel type over time; and

$Y(t)$ is the concentration of the second fuel type over time.

As can be appreciated, although the foregoing discusses the mixed fuel flow period 440 being determined where the fuel is switched from the first fuel type to the second fuel type, the mixed fuel flow period 440 can be determined when the fuel is switched from the second fuel type to the first fuel type. Accordingly, in this alternative embodiment, the mixed fuel flow period 440 may be determined from a start time on the right side of the graph 400 and to an end time on the left side of the graph 400. As can also be appreciated, various methods may be employed to determine a time period of the mixed fuel flow period.

Although the foregoing refers to percent concentrations of the first and second fuel type TYPE 1, TYPE 2, other concentrations may be employed. For example, volume concentrations of the first and second fuel type TYPE 1, TYPE 2 may be determined. The volume concentrations of the first fuel type TYPE 1 may be determined using the following equation (5):

$$C_1 = \frac{V_1}{V_1+V_2}. \qquad (5)$$

A differential equation, as seen below in Equation 6, can be used to express the change of fuel concentration as a function of the amount of fuel present in the fuel loop and the rate of fuel leaving/entering the flow loop Q_{in} and Q_{out} represent the volume flow rate of fuel being added to the flow loop and the volume flow rate of fuel being consumed:

$$\frac{dc}{dt} = \frac{Q_{in}}{V_1+V_2} + \frac{c \cdot Q_{out}}{V_1+V_2}. \qquad (6)$$

The foregoing equation (6) is a differential equation that may be integrated with respect to time to determine the concentration of the first fuel type TYPE 1 as a function of time. As can be appreciated, integrating the foregoing equation (6) can result in the following equation (7):

$$C_1(t) = 1 - e^{\left(-t \cdot \frac{Q_{out}}{V_1+V_2}\right)}. \qquad (7)$$

Equation (7) may be used as an approximation for empirically refining a characterization of a mixed fuel flow period. For example, equation (7) may be used to refine theoretical solutions for total flow of the mixed fuel flow based upon known values and parameters such as, for example, mixture rates, etc. These and other methods may be employed, as the following discussion with reference to FIG. 6 illustrates.

Method

FIG. 6 shows a method 600 of characterizing a mixed fuel flow period. As shown in FIG. 6, in step 610, the method 600 begins by flowing a mixed fuel. The mixed fuel is comprised of at least a first fuel type and a second fuel type. In step 620, the method 600 determines a density of the first fuel type and the second fuel type. The

We claim:

1. A method of characterizing a mixed fuel flow period, the method comprising:

flowing a mixed fuel during the mixed fuel flow period when fuel is switched from a first fuel type to a second fuel type;

determining a density of the first fuel type and a density of the second fuel type; and

determining a total flow of the mixed fuel flow period, the total flow being determined from the density of the first fuel type and a concentration of the first fuel type and the density of the second fuel type and a concentration of the second fuel type.

2. The method of claim 1, further comprising determining a mixed fuel flow start time and a mixed fuel flow end time.

3. The method of one of claim 1 or claim 2, further comprising determining the concentration of the first fuel type and the concentration of the second fuel type during the mixed fuel flow period.

4. The method of one of any of the foregoing claims 1 through 3, further comprising adding the total flow of the mixed fuel flow period with a total flow of a single fuel flow of at least one of the first fuel type and the second fuel type.

5. The method of one of any of the foregoing claims 1 through 4, wherein the total flow of the mixed fuel flow period is comprised of a total flow of at least one of the first fuel type, the second fuel type, and the mixed fuel flow.

6. The method of one of any of the foregoing claims 1 through 5, wherein the mixed fuel flow period is determined from at least one of a temperature change, a density change, and a signal associated with the mixed fuel flow.

7. The method of one of any of the foregoing claims 1 through 6, wherein the mixed fuel flow period is comprised of a mixed fuel flow start time and a mixed fuel flow end time.

8. The method of one of any of the foregoing claims 1 through 7, wherein the total flow is comprised of a total mass flow.

9. A fuel control system (300) for characterizing a mixed fuel flow period, the system (300) comprising:

a first fuel source (312) having a first fuel type;

a second fuel source (314) having a second fuel type;

a flow meter (5) fluidly coupled to the first fuel source (312) and the second fuel source (314), the flow meter (5) being configured to measure a mixed fuel flow during a mixed fuel flow period when fuel is switched from the first fuel type and the second fuel type and measure a density of the first fuel type and a density of the second fuel type; and

a controller (360) communicatively coupled to the flow meter (5), the controller (360) being configured to determine a total flow of the mixed fuel flow period, the total flow being determined from the density of the first fuel type and a concentration of the first fuel type and the density of the second fuel type and a concentration of the second fuel type.

10. The fuel control system (300) of claim 9, further comprising a first valve (322) fluidly coupled to the first fuel source (312) and a second valve (324) fluidly coupled to the second fuel source (314), the first valve (322) and the second valve (324) being communicatively coupled to the controller (360).

11. The fuel control system (300) of one of claim 9 or claim 10, further comprising a re-circulator (350) fluidly coupled to the flow meter (5) and an engine (20), the re-circulator (350) being configured to recirculate unconsumed fuel provided by the engine (20) back to the engine (20).

12. The fuel control system (300) of one of any of the foregoing claims 9 through 11, wherein the controller (360) is further configured to determine a mixed fuel flow start time and a mixed fuel flow end time.

13. The fuel control system (300) of one of any of the foregoing claims 9 through 12, wherein the controller (360) is further configured to determine the concentration of the first fuel type and the concentration of the second fuel type.

14. The fuel control system (300) of one of any of the foregoing claims 9 through 13, wherein the controller (360) is further configured to add the total flow of the mixed fuel flow period with a total flow of a single fuel flow of at least one of the first fuel type and the second fuel type.

15. The fuel control system (300) of one of any of the foregoing claims 9 through 14, wherein the total flow of the mixed fuel flow period is comprised of a total flow of at least one of the first fuel type, the second fuel type, and the mixed fuel flow.

16. The fuel control system (300) of one of any of the foregoing claims 9 through 15, wherein the mixed fuel flow period is determined from at least one of a temperature change, a density change, and a signal associated with the mixed fuel flow.

17. The fuel control system (300) of one of any of the foregoing claims 9 through 16, wherein the mixed fuel flow period is comprised of a mixed fuel flow start time and a mixed fuel flow end time.

18. The fuel control system (300) of one of any of the foregoing claims 9 through 17, wherein the total flow is comprised of a total mass flow.