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System and method for operating a combustor with multiple liquid fuels

Abstract

Method and system for transitioning from a first liquid fuel supplied to a combustor of a gas turbine system to a second liquid fuel supplied to the combustor utilizing a fuel pump configured to supply both fuels from the fuel pump during the transition without shutting down the gas turbine system. Through utilizing a fuel pump and adjusting the operation of the fuel pump during the transition, the additional costs, size, and operational complexity associated with multiple liquid fuel trains to facilitate operation of the gas turbine system with multiple liquid fuels may be avoided. The utilization of multiple liquid fuels during operation of a gas turbine system increase the operational flexibility of the gas turbine system by enabling the utilization of varied liquid fuel sources and/or local liquid fuel sources during a steady-state operation, yet utilizing standardized fuel sources for startup or shutdown procedures.

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Background/Summary

BACKGROUND

(1) The subject matter disclosed herein relates to gas turbine systems, and more particularly, to gas turbine systems that combust multiple liquid fuels.

(2) Gas turbine systems generally include a compressor, a combustor, and a turbine. The combustor combusts a mixture of compressed air and one or more fuels to produce hot combustion gases directed to the turbine to produce work, such as to drive an electrical generator or other load. The compressor compresses an oxidant flow (e.g., air), and subsequently directs the compressed oxidant to the combustor. Gas turbine systems may be configured to operate with various fuels. It may be desirable for efficiency, availability, and/or cost reasons to use some fuels during a first period of operation of the gas turbine system, and other fuels during a second period of operation of the gas turbine system. However, separate fuel supply systems for separate fuels may increase the cost and footprint of the gas turbine system. Moreover, it may be undesirable to shut down the gas turbine system to change the fuel source of the gas turbine system.

BRIEF DESCRIPTION

(3) Certain embodiments commensurate in scope with the originally claimed subject matter are summarized below. These embodiments are not intended to limit the scope of the claims, but rather these embodiments are intended only to provide a brief summary of possible forms of the embodiments of the present disclosure. Indeed, the present disclosure may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

(4) In one embodiment, a system includes a fuel supply system. The fuel supply system includes a fuel pump having an inlet and an outlet. The fuel supply system also includes a first fuel feeding valve configured to control a first flow of a first liquid fuel to the inlet based at least in part on first feeding valve control signals. The fuel supply system further includes a second fuel feeding valve configured to control a second flow of a second liquid fuel to the inlet based at least in part on

second feeding valve control signals. In addition, the fuel supply system includes a motor coupled to the fuel pump. The motor includes a variable frequency drive device configured to drive the motor. The motor is configured to drive the fuel pump based at least in part on pump speed control signals. The fuel supply system also includes a main fuel control valve configured to regulate fuel flow to fuel manifolds/nozzles of a gas turbine system based at least in part on main fuel valve control signals. The main fuel valve control signals are based at least in part on load demands of the gas turbine system. The fuel supply system further includes a controller coupled to the motor, the first fuel feeding valve, the second fuel feeding valve and the main fuel control valve. The controller is configured to generate the first feeding valve control signals, the second feeding valve control signals, the pump speed control signals, and the main fuel control valve signals based at least in part on first fuel parameters of the first liquid fuel and second fuel parameters of the second liquid fuel. The controller is also configured to control a transition from the first flow to the inlet at a first time to a second flow at the inlet at a second time.

(5) In one embodiment, a method for transitioning between liquid fuel flows supplied to a gas turbine system during operation of the gas turbine system includes supplying a first liquid fuel to an inlet of a fuel pump through a first fuel feeding valve opened to a first liquid fuel threshold. The first liquid fuel threshold is based at least in part on a first fuel parameter of the first liquid fuel. The method also includes directing the first liquid fuel from an outlet of the fuel pump to a combustor of the gas turbine system. The method further includes combusting the first liquid fuel with an oxidant in the combustor to generate exhaust gas. In addition, the method includes expanding the exhaust gas through a turbine of the gas turbine system to drive a shaft coupled to the turbine and to a load. The method also includes transitioning over a transition period from combustion of the first liquid fuel in the combustor to combustion of a second liquid fuel in the combustor. The transitioning includes opening a second fuel feeding valve to a second liquid fuel threshold to supply the second liquid fuel to the inlet of the fuel pump while supplying the first liquid fuel to the inlet. The second liquid fuel threshold is based at least in part on a second fuel parameter of the second liquid fuel. The transitioning also includes closing the first fuel feeding valve from the first liquid fuel threshold to stop supplying the first liquid fuel to the inlet in response to opening the second fuel feeding valve to the second liquid fuel threshold. The transitioning further includes controlling a speed of a motor configured to drive the fuel pump to maintain a discharge pressure of a liquid fuel flow at the outlet to be within a range of a transition pressure. The liquid fuel flow includes the first liquid fuel, the second liquid fuel, or any combination thereof.

(6) In one embodiment, a fuel supply system includes a processor configured to control a first fuel feeding valve configured to direct a first liquid fuel to a fuel pump. The fuel pump is configured to supply the first liquid fuel, via a main fuel control valve, to a combustor during a startup period for a gas turbine system. The processor is also configured to determine a second liquid fuel threshold for a second fuel feeding valve based at least in part on first fuel parameters of the first liquid fuel and second fuel parameters of a second liquid fuel. The processor is further configured to control, during a transition period, the second fuel feeding valve to the second liquid fuel threshold to direct the second liquid fuel to the fuel pump while directing the first liquid fuel to the fuel pump. In addition, the processor is configured to control, during the transition period, the first fuel feeding valve to stop directing the first liquid fuel to the fuel pump in response to controlling the second fuel feeding valve to the second liquid fuel threshold. The processor is also configured to control, during the transition period, a speed of a motor configured to drive the fuel pump to maintain a discharge pressure of a fuel flow from the fuel pump at the main fuel control valve to be within a range of a transition pressure during the transition period. The fuel flow includes the first liquid fuel, the second liquid fuel, or any combination thereof. The processor is further configured to control the speed of the motor to drive the fuel pump to supply the second liquid fuel, via the main fuel control valve, to the combustor during a steady-state period for the gas turbine system.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

(2) FIG. **1** is a schematic block diagram of an embodiment of a gas turbine system with a fuel supply system having multiple fuels;

(3) FIG. **2** illustrate charts of speeds of a compressor shaft of the gas turbine system and a pump shaft of the multiple fuels supply system during operation of the gas turbine system;

(4) FIG. **3** is a flow chart of an embodiment to transition between fuel sources supplied from the fuel supply system to the gas turbine system; and

(5) FIG. **4** is a chart illustrating the control of fuel valves during the transition of fuel sources of the fuel supply system.

DETAILED DESCRIPTION

(6) One or more specific embodiments of the present disclosure will be described below. To provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

(7) When introducing elements of various embodiments of the present disclosure, the articles “a,” “an,” “the,” and “said” are intended to mean that there are one or more of the elements. The terms “comprising,” “including,” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements.

(8) Gas turbine systems expand combustion gases through turbines to produce work that may drive one or more loads. Fuels provided to the gas turbine system may be provided to the combustor for generation of the combustion gases based on the chemical and physical parameters of the fuels, the cost of the fuels, and the availability of the fuels. Standardized fuels, such as diesel, natural gas, gasoline, jet fuel, may be available with consistent fuel parameters desirable for startup and shutdown operations. However, these standardized fuels may be more costly or less available than other fuel sources, such as those that may otherwise be flared near the site of the gas turbine system unless supplied to the gas turbine system to generate the combustion gases. Separate fuel pumps and/or compressors to deliver fuel from other fuel sources for steady-state operation of the gas turbine system may increase the footprint of the fuel supply system. However, analysis of the fuel parameters of the fuel sources as described herein enables the fuel supply system to provide different fuels to the combustor while avoiding a multi-phase fuel flow. For operation with multiple liquid fuels, through control of a variable speed motor to drive the fuel pump, and fuel control valves, the fuel supply system may maintain a discharge pressure of liquid fuel from the fuel pump while transitioning between liquid fuel sources of the fuel supply system. The systems and methods of controlling the liquid fuel supply system described herein maintain the stability of operation of the gas turbine system throughout the transition between liquid fuel sources.

(9) Turning now to the drawings, FIG. **1** illustrates a block diagram of an embodiment of a gas turbine system **10**. The diagram includes a compressor **12**, a turbine combustor **14**, and a turbine **16**. The turbine combustor **14** include one or more fuel manifolds/nozzles **18**, which route a liquid fuel and/or gas fuel (e.g., natural gas, syngas, or any other gaseous fuel) from a fuel supply system

30 into the turbine combustor **14**. The turbine combustor **14** ignites and combusts an air-fuel mixture to create hot, pressurized combustion gases **24**, which are subsequently directed into the turbine **16**. It may be appreciated that while FIG. **1** illustrates one turbine combustor **14**, certain embodiments of the gas turbine system **10** may include multiple turbine combustors **14** that direct the combustion gases **24** to the turbine **16**. Turbine blades of the turbine **16** are coupled to one or more shafts **26**, which may also be coupled to several other components throughout the gas turbine system **10**, such as the compressor **12** with a compressor shaft **26***c*. As the combustion gases **24** flow against the turbine blades in the turbine **16**, the turbine **16** is driven into rotation, which causes a turbine shaft **26***t* to rotate. Eventually, the combustion gases **24** exit the gas turbine system **10** as an exhaust gas **28**. The turbine shaft **26***t* may be coupled to a load **32**, which is powered via rotation of the turbine shaft **26***t*. For example, the load **32** may be any suitable device that may generate power via the rotational output of the turbine system **10**, such as a power generation plant or an external mechanical load. In certain embodiments, the load **32** may include an electrical generator, a propeller of a ship (e.g., in a marine application), and so forth.

(10) In an embodiment of the gas turbine system **10**, compressor blades are included as components of the compressor **12**. The blades within the compressor **12** are coupled to the compressor shaft **26***c* and will rotate as the compressor shaft **26***c* is driven by the turbine **16**, as described above. The rotation of the blades within the compressor **12** causes compression of a flow of air **20** received by the compressor **12** from an air intake **34**, thereby forming pressurized airflow **36**. For example, in certain embodiments, a first stream of pressurized airflow **36***a* may be fed into the one or more combustors **14**, where it is used to oxidize the fuel from one or more sources **38** of the fuel supply system **30** inside the combustor **14**. In certain embodiments, a second stream of pressurized airflow **36***b* may be fed into the fuel manifolds/nozzles **18** in which this pressurized airflow **36***b* is premixed with the fuel from one or more sources **38** of the fuel system **30** to produce a suitable air-fuel mixture **40** for combustion so as not to waste fuel or produce excess emissions.

(11) The fuel supply system **30** of the present disclosure supplies fuel to the one or more fuel manifolds/nozzles **18** from the one or more fuel sources **38**. The fuel supply system **30** may supply one or more liquid fuels to the fuel manifolds/nozzles **18** via a fuel pump **42**. The fuel pump **42** may be a centrifugal or positive displacement pump coupled to a motor **44** via a pump shaft **46**, controlling speed with a variable frequency control device **48**, such as a variable frequency drive (VFD) motor, a switched reluctance (SR) motor, or a pump controlling the discharge pressure by adjusting the geometry on its discharge side. In certain embodiments, the fuel supply system **30** has only one fuel pump **42** configured to couple the one or more fuel sources **38** to a fuel control valve **50** directing the proper fuel flow to the one or more fuel manifolds/nozzles **18**, thereby reducing a footprint of the fuel supply system **30** relative to a fuel supply system with multiple liquid fuel pumps in parallel.

(12) In certain embodiments, the VFD/SR **48** of the motor **44**, which is used to control the variable speed of the motor **44** and to control the discharge pressure to the fuel control valve **50**, may be monitored and controlled by a gas turbine controller **52**. In certain embodiments, the controller **52** may regulate the discharge pressure by controlling the output speed of the pump shaft **46** and the fuel pump **42** by continuously monitoring the discharge pressure by means of a pressure transmitter **54**, located near a discharge of the fuel pump **42**, which provides feedback to the controller **52** to close the control loop of pressure regulation. A processor **56** of the controller **52** may execute instructions stored in a memory **58** of the controller **52** to control the signals on the motor control line **60**. In certain embodiments, the controller **52** may execute the control functions described herein automatically, without human intervention, based solely on feedback from the sensors and transmitters described herein.

(13) The fuel pump **42** delivers fuel received at an inlet **62** of the fuel pump **42** to the one or more fuel manifolds/nozzles **18** via an outlet **64** of the fuel pump **42**. The controller **52** may control which liquid fuels of the one or more liquid fuel sources **38** are directed to the inlet **62** via control

of one or more respective fuel feeding valves **66** via signals (e.g., valve control signals) communicated on feeding valve control lines **68**. For example, in certain embodiments, the supply of a first fuel source **38***a* (e.g., diesel) to the inlet **62** is controlled by a first fuel feeding valve **66***a*, the supply of a second fuel source **38***b* (e.g., liquid butane) to the inlet **62** is controlled by a second fuel feeding valve **66***b*, and the supply of a third fuel source **38***c* (e.g., naphtha) to the inlet **62** is controlled by a third fuel feeding valve **66***c*. As illustrated in FIG. **1**, any number of fuel sources **38** (e.g., an N.sup.th fuel source **38***d* illustrated in FIG. **1**) and corresponding fuel valves **66** may be used.

(14) In certain embodiments, one or more forwarding pumps **70** may be arranged between the fuel sources **38** and the inlet **62** of the fuel pump **42**. Each forwarding pump **70** may increase the pressure of the liquid fuel from the respective liquid fuel source **38** to reduce or eliminate two phase flows into the inlet **62** of the fuel pump **42**. The controller **52** may control operation of the one or more forwarding pumps **70** in conjunction with control of the fuel feeding valves **66**. For example, the controller **52** may stop a forwarding pump **70** when the respective fuel feeding valve **66** is closed, and may start a forwarding pump **70** when the respective fuel feeding valve **66** is opened.

(15) In addition, in certain embodiments, the fuel supply system **30** of the present disclosure may supply gaseous fuel from one or multiple gas fuel sources **72**. The controller **52** may command startup, shutdown, or steady-state operation with gaseous fuels, as well as command transfers from and to any of the multiple liquid fuels sources **38**.

(16) In certain embodiments, the liquid fuels may range by specific gravity: e.g., between 0.2 and 2.0; may range by vapor pressure at 20 deg C.: e.g., between 0.015 psi and 35 psi; may range by lubricity: e.g., between 350 μm and 1000 μm on high frequency reciprocating rig (HFRR) method; and may range by lower heating value: e.g., between 8,000 BTU/lbm and 20,000 BTU/lbm. This classification includes liquid hydrocarbons at ambient conditions, liquid alcohols at ambient conditions, liquid biofuels at ambient conditions, liquid fatty acids at ambient conditions, and so forth. Gas fuels may range by specific gravity: e.g., between 0.2 and 2.5; may range by hydrocarbon dew point at 14.696 psia (1 atm): e.g., between −100 and 100 F; may range by Modified Wobbe Index (MWI): e.g., between 10 and 80; may range by lower heating value by mass: e.g., between 5,000 and 22,000 BTU/lbm; and may range by lower heating value by volume: e.g., between 290 BTU/scf and 3700 BTU/scf.

(17) As discussed in detail below, the processor **56** of the controller **52** may execute instructions from the memory **58** of the controller **52** to control quantities of the one or more fuel sources supplied to the liquid fuel pump **42** according to various control schemes. For example, the controller **52** may control the fuel feeding valves **66** to provide fuel to the inlet **62** from only one fuel source **38**, to mix fuels in the liquid fuel pump **42** from two or more fuel sources **38**, and to transition between fuels or fuel mixtures provided to the inlet **62**. Although the embodiments discussed below discuss transitions between a first liquid fuel and a second liquid fuel, it is appreciated that the fuel supply system **30** may be controlled to control a transition from a first liquid fuel to a mixture of liquid fuels including the first liquid fuel, to control a transition from the first liquid fuel to a mixture of liquid fuels excluding the first liquid fuel, to control a transition from a mixture of liquid fuels to only the first liquid fuel of the mixture, or to control a transition from a mixture of liquid fuels to only a first liquid fuel that was not in the mixture. For such transitions, the controller may receive feedback from sensors, actuators, and/or input from an operator regarding the fuel parameters for each of the liquid fuels sources **38** of the fuel supply system **30**. The fuel parameters for the liquid fuel sources **38** facilitate operation of the controller to determine the liquid fuel transition values that may affect the fuel feeding valve thresholds, the motor speed, the speed of the gas turbine system, the load on the gas turbine system, or any combination thereof.

(18) The controller **52** of the fuel supply system **30** may receive feedback from one or more sensors

74 throughout the fuel supply system **30** and the gas turbine system **10**. The sensors **74** may include, but are not limited to, pressure sensors, composition sensors, flow meters, temperature sensors, load sensors, rotation sensors, or any combination thereof. The sensors **74** may provide feedback to the controller **52** regarding the temperature of the liquid fuel sources **38**, the pressure of the liquid fuel sources **38**, the discharge pressure at the outlet **64** of the one or more fuels directed from the liquid fuel pump **42** indicated by pressure transmitter **54**, the position of the fuel control valve **50**, the speed of the pump shaft **46**, the speed of the compressor shaft **26***c* of the gas turbine system **10**, the speed of the turbine shaft **26***t* of the gas turbine system **10**, the load **32** on the gas turbine system **10**, or any combination thereof. The controller **52** may control the liquid fuel pump **42**, the fuel feeding valves **66**, and the fuel control valve **50** based at least in part on feedback from the one or more sensors **74**.

(19) FIG. **2** depicts a chart **75** that illustrates the speed the compressor shaft **26***c* of an embodiment of the gas turbine system **10** of FIG. **1** during operation of the gas turbine system **10**, and a chart **76** that illustrates the speed of the pump shaft **46** during operation of the gas turbine system **10** of FIG. **1**. During a startup period **78**, the gas turbine system **10** starts by combusting the first liquid fuel **38***a* (e.g., diesel) in the combustor **14** while the compressor shaft **26***c* is driven at a starter speed **80**. During the startup period **78**, components of the gas turbine system **10** are heated through operation. For example, combustion of the first fuel heats the combustor **14** and the turbine **16**, the compression of the air **20** in the compressor **12** heats the compressor **12**, and friction may warm lubricants in the compressor shaft **26***c*, the turbine shaft **26***t*, and the driven load **32**. The load on the gas turbine system during the startup and shutdown operations may be less than approximately 50, 40, 30, 25, 20, or 10 percent of a rated load of the gas turbine system. The compressor shaft **26***c* may be initially driven at the starter speed by a starter until combustion of the fuel in the combustor **14** produces enough combustion gases to drive the turbine **16** and the compressor shaft **26***c* at speeds greater than the starter speed **80**.

(20) The controller **52** may control the VFD/SR **48** of the motor **44** to drive the fuel pump **42** at an initial pump speed **82**. The starter speed **80** of the compressor shaft **26***c* may be approximately 2400 RPM. In certain embodiments, driving the pump shaft **46** at the initial pump speed **82** of approximately 3500 RPM causes the fuel pump **42** to direct the first liquid fuel **38***a* (e.g., diesel) to the fuel manifolds/nozzles **18** at approximately 600 psig. After the combustion gases drive the turbine **16** and rotate the compressor shaft **26***c* at an idle speed **84** at T.sub.1, the controller **52** may control the VFD/SR **48** of the motor **44** at T.sub.2 to increase the pump speed from the initial pump speed **82** to a startup fuel speed **86** at T.sub.3. In certain embodiments, the idle speed **84** of the compressor shaft **26***c* of the gas turbine system **10** is between 6800 and 7000 RPM. In certain embodiments, driving the pump shaft **46** at the startup fuel speed **86** of approximately 5150 RPM causes the fuel pump **42** to direct the first liquid fuel **38***a* to the fuel manifolds/nozzles **18** at a transition pressure (e.g., approximately 1200 psig). The shaft speed may increase from the idle speed **84** at T.sub.1 to a minimum load speed **88** between 7100 and 7500 RPM at T.sub.2 in response to the control of the fuel from the pump to the combustor **14** at T.sub.2.

(21) The combustion gases from combustion of the first liquid fuel **38***a* in the combustor **14** may continue to increase the speed of the compressor shaft **26***c* from the minimum load speed **88** between 7100 and 7500 RPM at T.sub.2 to a fuel transfer speed **90** at T.sub.4. At the fuel transfer speed **90**, the gas turbine system **10** may be configured stably operate and drive a fuel transfer with the first liquid fuel **38***a*, the second liquid fuel **38***b*, or any combination thereof. In certain embodiments, the fuel transfer speed **90** for stable operation of the gas turbine system **10** is between 8200 and 10000 RPM. In certain embodiments, the pressure of the first liquid fuel **38***a* provided by the variable-speed fuel pump **42** at the startup fuel speed **86** is determined based on a vapor pressure of the second liquid fuel **38***b* that is to be added with the first liquid fuel **38***a* during a first transition period **92**. That is, the controller **52** may control the VFD/SR **48** linked to the fuel pump **42** to the startup fuel speed **86** with the first liquid fuel **38***a* during the startup period **78** to

facilitate a transfer during the first transition period **92** from the first liquid fuel **38***a* to the second liquid fuel **38***b* without changing the phase of the first liquid fuel **38***a* or the second liquid fuel **38***b*. It may be appreciated that if the fuel pump **42** receives the first liquid fuel **38***a* at a pressure less than the vapor pressure of the second liquid fuel **38***b*, then the fuel pump **42** may receive a two-phase flow in which the first liquid fuel **38***a* is received as a liquid and the second liquid fuel **38***b* is received as a gas. The controller **52** may control the VFD/SR **48** linked to the fuel pump **42** and the startup fuel speed **86** to avoid providing a two-phase flow to the fuel pump **42** from any of the fuel sources. The controller **52** may determine the startup fuel speed **86** based at least in part on feedback from the sensors of the fuel pressure of the fuel sources, the fuel temperatures of the fuel sources, fuel properties entered by the operator, or any combination thereof.

(22) During the transition period, the controller **52** may maintain a first flow of the first liquid fuel **38***a* to the fuel pump **42** and increase a second flow of the second liquid fuel **38***b* to the fuel pump **42**. The controller **52** may control the VFD/SR **48** of the motor **44** to increase the speed of the fuel pump **42** during the transition period from the startup fuel speed **86** at T.sub.4 to the primary fuel speed **94** at T.sub.5 to facilitate directing the additional second liquid fuel **38***b* to the fuel pump **42** without adjusting the pressure (e.g., discharge pressure) of the fuels supplied by the fuel pump **42**. That is, the controller **52** may control the VFD/SR **48** of the motor **44** to adjust the speed of the fuel pump **42** during the transition period to maintain the discharge pressure within a range of a desired pressure (e.g., transition pressure). In an embodiment in which the first liquid fuel **38***a* is a diesel liquid fuel and the second liquid fuel **38***b* is a liquid butane fuel, the primary fuel speed **94** may be approximately 6060 RPM. The controller **52** may determine the primary fuel speed **94** of the fuel pump **42** based at least in part on the fuel parameters of the one or more fuels directed to the combustor during the ramp up period **96**, the steady-state period **100** and/or the ramp down period **102**. In certain embodiments, the controller **52** determines the primary fuel speed **94** of the fuel pump based at least in part on the lower heating value of the second liquid fuel **38***b*, the lubricity of the second liquid fuel **38***b*, the specific gravity of the second liquid fuel **38***b*, or the vapor pressure of the second liquid fuel **38***b*, or any combination thereof. In certain embodiments, the controller **52** may determine the composition of the fuel from feedback of the sensors **74** and the pressure transmitter **54**, then determine the one or more parameters of the fuel from a table that is stored in the memory **58** or is otherwise accessible by the processor **56** of the controller **52**. During the first transition period **92**, the controller **52** may control the fuel feeding valves **66** to increase the quantity of the second liquid fuel **38***b* provided to the fuel pump **42** and to decrease the quantity of the first liquid fuel **38***a* provided to the fuel pump **42**. In certain embodiments, the first transition period **92** is between 15 to 180 seconds, 30 to 150 seconds, or 60 to 120 seconds. As discussed in detail below, the controller **52** may first increase the quantity of the second liquid fuel **38***b* provided to the fuel pump **42** from zero to a second quantity, then decrease the quantity of the first liquid fuel **38***a* provided to the fuel pump **42** from a first quantity to zero. In general, via the control described herein, the controller **52** is configured to ensure that the first liquid fuel **38***a* and the second liquid fuel **38***b* each remain in a liquid phase during the first transition period **92**.

(23) In certain embodiments, the fuel transfer process described above may occur gradually with a predetermined ramp up from gas turbine shaft speed **88** to speed **90** without having to hold the gas turbine shaft speed at **90**; that is, opening the second fuel feeding valve **38***b* to the second threshold value, while closing the first fuel feeding valve **38***a* from the first threshold value to zero. In certain embodiments, this process may be done in part by adjusting the speed of the pump **42** based on the fuel properties of the first and second fuel, the ambient properties and the gas turbine shaft ramp up speed rate.

(24) After the first transition period **92** at T.sub.5, the controller **52** may control the gas turbine system **10** during a ramp up period **96** to increase the speed of the compressor shaft **26***c* from the fuel transfer speed **90** to an operating load speed **98** at T.sub.6. In certain embodiments, the operating load speed **98** is between 9500 and 15000 RPM. At the operating load speed **98**, the gas

turbine system **10** supplied by the second liquid fuel **38***b* is configured to drive the load during a steady-state period **100**. The gas turbine system **10** may be configured to operate in the steady-state period **100** for hours, days, weeks, or more. At T.sub.7, the controller **52** may control the gas turbine system **10** during a ramp down period **102** to decrease the speed of the compressor shaft **26***c* from the operating load speed **98** to the fuel transfer speed **90** at T.sub.5. At T.sub.5, the controller **52** controls the fuel feeding valves **66** during a second transition period **104** to decrease the quantity of the second liquid fuel **38***b* provided to the fuel pump **42** and to increase the quantity of another liquid fuel of the fuel supply system **30** provided to the fuel pump **42**. Although the charts **75**, **76** of FIG. **2** illustrate an embodiment of the transition between the first liquid fuel **38***a* and the second liquid fuel **38***b*, the controller **52** may also control transitions among more than two liquid fuels. During the second transition period **104**, the controller **52** may control the feeding valves **66** to increase the quantity of the first liquid fuel **38***a* provided to the fuel pump **42** from zero to the first quantity, then decrease the quantity of the second liquid fuel **38***b* provided to the fuel pump **42** from the second quantity to zero. At T.sub.9, the controller **52** may control the gas turbine system **10** in a shutdown period **106** to decrease the speed of the compressor shaft **26***c* from the fuel transfer speed **90** to the minimum load speed **88** at T.sub.10. The controller **52** may decrease the speed of the pump shaft **46** at T.sub.10 from the startup fuel speed **86** to the initial pump speed **82** at T.sub.11, thereby preparing the fuel supply system **30** for shutdown. At T.sub.11, the controller **52** may reduce the speed of the compressor shaft **26***c* and the pump speed **76** so that the speeds respectively decrease to be zero RPM at T.sub.12. Although FIG. **2** illustrates the speed of the compressor shaft **26***c* and the speed of the pump shaft **46** at zero RPM at T.sub.12, it is appreciated that in certain embodiments of the gas turbine system **10**, the speed of the compressor shaft **26***c* and the speed of the pump shaft **46** may decrease at different rates and decrease to zero RPM at different times during the shutdown period **106**. In general, via the control described herein, the controller **52** is configured to ensure that the first liquid fuel **38***a* and the second liquid fuel **38***b* each remain in a liquid phase during the second transition period **104**.

(25) The availability and cost of the liquid fuel sources **38** may vary among sites for gas turbine systems **10**. For example, diesel fuel, kerosene, or gasoline may be utilized for standardized startup and shutdown procedures for the gas turbine system **10**. However, some liquid fuels, such as diesel, may have less availability, higher costs, or both less availability and higher costs relative to other liquid fuels, such as distillate fuels, jet fuels, naphthas, liquid butanes, liquid propanes, liquefied petroleum gas (LPG), and other hydrocarbons or hydrocarbon mixtures, or biofuels. Furthermore, the heating values of liquid fuels differ, such that a first liquid fuel with a higher heating value may be desired for operation with higher loads than a second liquid fuel with a lower heating value. Accordingly, the controller **52** may control the fuel feeding valves **66**, the VFD/SR **48** and the fuel control valve **50** to transition from a first flow of one or more liquid fuels of the fuel supply system **30** to a second flow of one or more liquid fuels of the fuel supply system **30** based on the availability of the one or more liquid fuels, the cost of the one or more liquid fuels, and/or the desired load to be driven through combustion of the one or more liquid fuels. When available and convenient to operators, startup and shutdown may be performed with any gaseous fuel through the gas fuel system train.

(26) FIG. **3** illustrates a flow chart of an embodiment of a method **120** of operating the gas turbine system from a startup with the first liquid fuel to driving a full load with the second liquid fuel or liquid fuel mixtures. The controller of the fuel supply system controls (block **122**) the VFD/SR linked to the fuel pump to direct the first liquid fuel toward the one or more fuel manifolds or nozzles of the fuel supply system. The controller also opens (block **124**) the fuel feeding control valve to permit flow of the first liquid fuel to the inlet of the fuel pump. The controller may execute blocks **122** and **124** at approximately the same time (e.g., within 1 to 10 seconds). The gas turbine system starts (block **126**) the compressor and turbine of the gas turbine system, thereby initiating the rotation of the shaft of the gas turbine system. In certain embodiments, the controller that starts

(block **126**) the gas turbine system also controls the fuel supply system. When the first liquid fuel is routed to the combustor from the fuel pump by the main fuel control valve and oxidant from the compressor is routed to the combustor, the controller may control combustion (block **128**) of the oxidant-fuel mixture in the combustor. As described above during the startup period **78**, the controller controls the fuel and the oxidant supplied to the combustor to warm up (block **130**) components of the gas turbine engine, thereby increasing the stability of the gas turbine system.
(27) The controller determines (block **132**) fuel transition values based at least in part on fuel parameters of the fuel sources of the fuel supply system. In certain embodiments, the controller determines (block **132**) fuel transition values based at least in part on the fuel parameters and environmental parameters (e.g., temperature, pressure, humidity) of the ambient environment of the gas turbine system. The fuel transition values may include, but are not limited to, the startup fuel speed for the fuel pump to initiate the transition from the first liquid fuel to the second liquid fuel, the transfer load on the gas turbine system during the transition from the first liquid fuel to the second liquid fuel, a transition threshold for the one or more fuel feeding valves of the fuel supply system, a mixture of liquid fuels of the second liquid fuel provided to the combustor after the transition, or any combination thereof. The controller then controls (block **134**) the VFD/SR linked to the fuel pump to the startup fuel speed based at least in part on fuel parameters of the first liquid fuel and the second liquid fuel. As discussed above, the startup fuel speed may be determined based on a vapor pressure of the second liquid fuel that is to be added with the first liquid fuel during a transition period. The controller may control (block **134**) the VFD/SR linked to the fuel pump to the startup fuel speed that facilitates a transfer from the first liquid fuel to the second liquid fuel without supplying a multiphase fuel flow to the fuel pump or to the one or more fuel manifolds/nozzles. For any of these scenarios, the main fuel control valve will regulate the startup fuel flow, the liquid fuel mixture flow during the transition, and the second liquid fuel flow to the manifolds/nozzles as a supplement to the variable-speed fuel pump for liquid fuel flow control purposes.
(28) The controller controls (block **136**) the load on the gas turbine system to the transfer load at which the controller may stably transition the fuel supplied to the combustor from the first liquid fuel to the second liquid fuel by means of the main fuel control valve and the individual fuel feeding valves. The startup fuel may be diesel, kerosenes, or gasoline or a gaseous fuel, respectively. The second fuel may be a liquid fuel such as a butane, kerosene, or jet fuel, among others. As discussed above, the controller may determine (block **132**) fuel transition values, like the transfer load, based at least in part on fuel parameters of the second liquid fuel. For example, if a first idle load supported by combustion of the first liquid fuel is less than a second idle load supported by combustion of the second liquid fuel, then the transfer load may be the second idle load such that the gas turbine may stably provide the transfer load during the transition from the first liquid fuel to the second liquid fuel. After the gas turbine system is supporting the transfer load, the controller transitions (block **138**) from the first liquid fuel to the second liquid fuel. To transition between the fuels, the controller opens (block **140**) a second fuel feeding valve for the second liquid fuel while maintaining stable operation of the gas turbine system. When the second fuel feeding valve has been opened to a second liquid fuel transition threshold, the controller closes (block **142**) a first fuel feeding valve for the first liquid fuel while maintaining stable operation of the gas turbine system. To maintain stable operation of the gas turbine system, the controller may gradually open (block **140**) and close (block **142**) the fuel feeding valves over respective transition periods.
(29) The transitions to open or close the fuel feeding valves may be 5, 10, 15, 20, 30, 45, or 60 seconds or more, such that the controller executes blocks **140** and **142** over a period of 10, 20, 30, 40, 60, 90, or 120 seconds or more. In certain embodiments, the controller may pause for 5, 10, 15, 30, or 60 seconds or more between opening (block **140**) and closing (block **142**) the fuel feeding valves during the transition (block **138**). The second liquid fuel transition threshold for opening

(block **140**) the second fuel feeding valve may be approximately 50, 60, 70, 80, 90, or 100 percent open. During the transition (block **138**) of the liquid fuels, the controller may adjust (block **144**) the speed of the fuel pump by means of the VFD/SR while controlling the fuel feeding valves and the main fuel control valve over the transition periods. For example, the controller may increase the speed of the fuel pump during a transition to the second liquid fuel with a higher vapor pressure than the first liquid fuel while adjusting the position of the main fuel control valve to sustain the gas turbine load. The controller may increase the speed of the fuel pump to maintain a discharge pressure of the fuel supplied from the outlet of the pump to the combustor to be within a range (e.g., 0.5 to 10%) of a transition pressure during the transition periods, and to adjust the position of the main fuel control valve to maintain the gas turbine load. Maintaining the discharge pressure of the liquid fuel supplied to the combustor within a transition pressure range may facilitate stable combustion within the combustor during the transition period. In some instances, a gaseous fuel may be used to startup and shutdown the gas turbine system and the transition to a liquid fuel source, allowing the gas turbine system to perform transition to a second liquid fuel or mixture of other liquid fuels at steady-state or at loads higher than the transition load for startup and shutdown processes.

(30) After the controller has closed (block **142**) the first fuel feeding valve and the gas turbine system is operating fully through combustion of the second liquid fuel, the controller may control (block **146**) the gas turbine system based on a desired load while operating the gas turbine system with the second liquid fuel. As may be appreciated, the controller may adjust the quantity and/or pressure of the second liquid fuel supplied to the combustor during steady-state operation of the gas turbine system in response to changes in the load on the gas turbine system by means of the main fuel control valve. The controller may repeat blocks **132-144** as described above to transition from the second liquid fuel to the first liquid fuel, to a third liquid fuel, or to a mix of one or more liquid fuels of the fuel supply system.

(31) FIG. **4** illustrates a chart **160** of an embodiment of the control of the fuel feeding valves for the transition between liquid fuels described above. Prior to a fuel transition **162**, a first position **164** of a first fuel feeding valve configured to supply a first liquid fuel to the fuel pump is opened to a first liquid fuel threshold **166**. The first liquid fuel threshold **166** may be determined by the controller of the fuel supply system based on a determined transfer load for the gas turbine system. As discussed above, the transfer load may be determined based on the fuel parameters of the first liquid fuel and the second liquid fuel and ambient conditions for the gas turbine system. For example, the controller of the fuel supply system may determine from an analysis of the fuel parameters of the first liquid fuel and the second liquid fuel that a stable transition from the first liquid fuel to the second liquid fuel may occur at a transfer load that is supported by combustion of a first quantity of the first liquid fuel supplied when the first fuel feeding valve is opened to the first liquid fuel threshold. The controller may also determine from the analysis of the fuel parameters of the first liquid fuel and the second liquid fuel that the transfer load may be supported by combustion of a second quantity of the second liquid fuel when a second position **168** of the second fuel feeding valve is opened to a second liquid fuel threshold **170**. The controller may analyze the fuel parameters of the first liquid fuel and the second liquid fuel based on feedback from the sensors monitoring the respective liquid fuels, from inputs to the controller associated with the fuel parameters of the respective liquid fuels, or any combination thereof. In certain embodiments, the first liquid fuel threshold **166** is between approximately 25, 30, 40, 50, 60, 70, 75, 80, 90, or 100% open. In certain embodiments, the second liquid fuel threshold **170** is between approximately 25, 30, 40, 50, 60, 70, 75, 80, 90, or 100% open. For example, the first liquid fuel threshold **166** may be approximately 40% open, and the second liquid fuel threshold may be approximately 75% open.

(32) To begin the fuel transition **162**, the controller adjusts the second position **168** of the second fuel feeding valve at TA to open the second fuel feeding valve. A second rate **172** of opening the second fuel feeding valve may be controlled based at least in part on the valve-type (e.g., butterfly,

ball, gate, globe) of the second fuel feeding valve, the stability of the gas turbine system, and parameters (e.g., viscosity, vapor pressure, specific gravity, lubricity) of the second liquid fuel, or any combination thereof. A second transition period **174** for opening the second position **168** of the second fuel feeding valve to the second liquid fuel threshold **170** may be between approximately 5, 10, 15, 20, 30, 45, or 60 seconds. The controller opens the second fuel feeding valve to the second liquid fuel threshold **170** while the first feeding valve remains open to the first liquid fuel threshold **166**. At TB, the second fuel feeding valve is opened to the second liquid fuel threshold **170** and the first fuel feeding valve remains opened to the first liquid fuel threshold **166**. Accordingly, the first liquid fuel and the second liquid fuel are supplied to the fuel pump during the fuel transition **162**. As discussed above, the speed of the fuel pump may be controlled by the VFD/SR during the fuel transition **162** based on fuel parameters of the first liquid fuel and the second liquid fuel, and based on the discharge pressure from the pressure transmitter, to avoid a two-phase flow within the fuel pump and/or downstream of the fuel pump. The gas turbine system combusts a mixture of the first liquid fuel and the second liquid fuel during the fuel transition **162**.

(33) In certain embodiments, the controller adjusts the first position **164** of the first fuel feeding valve at TB to close the first fuel feeding valve as soon as the second fuel feeding valve is opened to the second liquid fuel threshold **170**. In certain embodiments, the controller may pause at TB for a stability interval (e.g., between 1 and 60 seconds) to ensure combustion stability of the gas turbine system prior to adjusting the first position **164** of the first fuel feeding valve. A first rate **176** of closing the first fuel feeding valve may be controlled based at least in part on the valve-type (e.g., butterfly, ball, gate, globe) of the first fuel feeding valve, the stability of the gas turbine system, and parameters (e.g., viscosity, vapor pressure, specific gravity, lubricity) of the first liquid fuel, or any combination thereof. A first transition period **178** for closing the first position **164** of the first fuel feeding valve from the first liquid fuel threshold **166** to a fully closed position **180** may be between approximately 5, 10, 15, 20, 30, 45, or 60 seconds. The controller closes the first fuel feeding valve while the second feeding valve remains open to the second liquid fuel threshold **170**. At T.sub.C, the second fuel feeding valve remains opened to the second liquid fuel threshold **170**, and the first fuel feeding valve is commanded to the fully closed position **180**. Accordingly, only the second liquid fuel is supplied to the fuel pump after the fuel transition **162**. After T.sub.C, the controller may adjust the position of the main fuel control valve and the speed of the fuel pump by means of the VFD/SR to supply desired a quantity and pressure of the second liquid fuel to the combustor of the gas turbine system to drive a desired load.

(34) Technical effects of the present disclosure include transitioning from a first liquid fuel supplied to a combustor of a gas turbine system to a second liquid fuel supplied to the combustor utilizing one fuel pump configured to supply both fuels from one fuel pump during the transition without shutting down the gas turbine system. Through utilizing one fuel pump and adjusting the operation of the pump during the transition, the additional costs, size, and operational complexity associated with multiple liquid fuel trains to facilitate operation of the gas turbine system with multiple liquid fuels may be avoided. The utilization of multiple liquid fuels during operation of a gas turbine system increase the operational flexibility of the gas turbine system by enabling the utilization of varied liquid fuel sources and/or local liquid fuel sources during a steady-state operation, yet utilizing standardized fuel sources (e.g., diesel, kerosene, gasoline and in some cases, gaseous fuels) for startup or shutdown procedures.

(35) This written description uses examples to disclose the embodiments of the present disclosure, including the best mode, and also to enable any person skilled in the art to practice the present disclosure, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the present disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from

the literal languages of the claims.

ELEMENT LIST

(36) **10**—gas turbine system **12**—compressor **14**—combustor(s) **16**—turbine **18**—fuel manifolds/nozzles **20**—air **24**—combustion gases **26***c*—compressor shaft **26***t*—gas turbine shaft **28**—exhaust gas **30**—fuel supply system **32**—load **34**—air intake **36**—pressurized airflow **38**—liquid fuel sources **40**—fuel or air-fuel mixture **42**—fuel pump **44**—motor **46**—pump shaft **48**—variable frequency driver (VFD) or switch reluctance (SR) motor speed variation device **50**—main fuel control valve **52**—controller **54**—pressure transmitter **56**—processor **58**—memory **60**—motor control line **62**—pump inlet **64**—pump outlet **66**—fuel feeding valve **68**—feeding valve control line **70**—forwarding pump **72**—gas fuel sources **74**—sensors **75**—gas turbine compressor shaft speed **76**—fuel pump shaft speed **78**—startup period **80**—starter speed **82**—initial pump speed **84**—idle speed (gas turbine shaft) **86**—startup fuel speed (pump) **88**—minimum load speed (gas turbine shaft) **90**—transfer load speed (gas turbine shaft) **92**—first transition period **94**—primary fuel speed (pump) **96**—ramp up period **98**—operating load speed (gas turbine shaft) steady state period **102**—ramp down period **104**—second transition period **106**—shut down period **120**—method **122**—control fuel pump to direct first fuel to fuel manifolds/nozzles **124**—open fuel feeding control valves **126**—start gas turbine system **128**—combust liquid fuel mixture **130**—warm up gas turbine system **132**—determine fuel transition values **134**—control fuel pump to startup fuel speed **136**—control load on gas turbine system to transfer load **138**—transition fuels during transition period **140**—open fuel feeding valve to increase second liquid fuel **142**—close fuel feeding valve to decrease first liquid fuel **144**—adjust fuel pump speed **146**—control gas turbine system based on load **160**—chart **162**—fuel transition period **164**—first fuel feeding valve position **166**—first liquid fuel threshold **168**—second fuel feeding valve position **170**—second liquid fuel threshold **172**—second rate (second liquid fuel) **174**—second transition period (second fuel feeding valve open) **176**—first rate (first liquid fuel) **178**—first transition period (first fuel feeding valve close) **180**—fully closed position (first fuel feeding valve)

Claims

1. A system comprising: a fuel supply system comprising: a fuel pump comprising an inlet and an outlet; a pump discharge pressure sensor configured to monitor a discharge pressure from the fuel pump; a first fuel feeding valve configured to control a first flow of a first liquid fuel to the inlet based at least in part on first feeding valve control signals; a second fuel feeding valve configured to control a second flow of a second liquid fuel to the inlet based at least in part on second feeding valve control signals; a motor coupled to the fuel pump, wherein the motor comprises a variable frequency drive device configured to drive the motor, wherein the motor is configured to drive the fuel pump based at least in part on pump speed control signals; a main fuel control valve configured to regulate fuel flow to fuel manifolds/nozzles of a gas turbine system based at least in part on main fuel valve control signals, wherein the main fuel valve control signals are based at least in part on load demands of the gas turbine system and based at least in part on costs and availabilities of the first and second liquid fuels; and a controller coupled to the motor, the first fuel feeding valve, the second fuel feeding valve and the main fuel control valve, wherein the controller is configured to generate the first feeding valve control signals, the second feeding valve control signals, the pump speed control signals, and the main fuel control valve signals based at least in part on one or more first fuel parameters of the first liquid fuel and one or more second fuel parameters of the second liquid fuel, wherein the controller is configured to control a full transition from the first flow to the inlet at a first time to the second flow to the inlet at a second time while maintaining the load demands of the gas turbine system during operation of the gas turbine system, wherein the controller is configured to ensure that the first and second liquid fuels each remain in a liquid phase and the discharge pressure remains within a transition pressure range during the full

transition, and wherein the controller is configured to control a speed of the motor by: determining a first speed of the motor based at least in part on the one or more first fuel parameters of the first liquid fuel, wherein the one or more first fuel parameters comprise a first vapor pressure of the first liquid fuel; determining a second speed of the motor based at least in part on the one or more second fuel parameters of the second liquid fuel, wherein the one or more second fuel parameters comprise a second vapor pressure of the second liquid fuel; and controlling the speed of the motor from the first speed to the second speed during the full transition from the first flow to the second flow, wherein controlling the speed comprises increasing the speed of the motor from the first speed to the second speed in response to the second vapor pressure being greater than the first vapor pressure.
2. The system of claim 1, wherein the controller is configured to control the full transition during a startup operation or a shutdown operation of the gas turbine system.
3. The system of claim 1, wherein the pump speed control signals are configured to control the speed of the motor, and wherein the fuel pump comprises a centrifugal pump.
4. The system of claim 1, wherein the pump discharge pressure sensor is coupled to the outlet of the fuel pump, the pump discharge pressure sensor is configured to provide feedback of the discharge pressure to the controller, and the controller is configured to generate the first feeding valve control signals, the second feeding valve control signals, and the pump speed control signals during the full transition based at least in part on the feedback of the discharge pressure from the pump discharge pressure sensor.
5. The system of claim 4, wherein the controller is configured to generate the pump speed control signals during the full transition to control the discharge pressure at the outlet to be within the transition pressure range.
6. The system of claim 1, comprising one or more fuel sensors configured to provide feedback to the controller of the one or more first fuel parameters, the one or more second fuel parameters, or any combination thereof, wherein the controller is configured to generate the first feeding valve control signals, the second feeding valve control signals, and the pump speed control signals during the full transition based at least in part on the feedback from the one or more fuel sensors.
7. The system of claim 1, comprising the gas turbine system, wherein the gas turbine system comprises: a combustor configured to receive a flow from the outlet of the fuel pump, to combust a mixture of the flow and an oxidant to generate exhaust gas, and to expand the exhaust gas through a turbine; the turbine configured to expand the exhaust gas to drive a shaft; and the shaft coupled to the turbine and to a load, wherein the controller is configured to generate the first feeding valve control signals, the second feeding valve control signals, the pump speed control signals, and the main fuel valve control signals during the full transition based at least in part on a speed of the shaft, the load on the shaft, or any combination thereof.
8. The system of claim 1, wherein a transition period is equal to or less than 120 seconds.
9. The system of claim 1, wherein the controller is configured to: determine a transition load based at least in part on the one or more first fuel parameters of the first liquid fuel and the one or more second fuel parameter of the second liquid fuel; and control the load during a transition period based at least in part on the transition load.
10. The system of claim 9, wherein the transition load ensures that the first liquid fuel and the second liquid fuel each remain in the liquid phase during the transition period.
11. The system of claim 1, wherein the one or more first fuel parameters comprise a first specific gravity of the first liquid fuel, and the one or more second fuel parameters comprise a second specific gravity of the second liquid fuel.
12. The system of claim 1, wherein the transition pressure range is 0.5 to 10% of a transition pressure during the full transition.
13. A method for fully transitioning between liquid fuel flows supplied to a gas turbine system during operation of the gas turbine system, comprising: supplying a first liquid fuel to an inlet of a

fuel pump through a first fuel feeding valve opened to a first liquid fuel threshold, wherein the first liquid fuel threshold is based at least in part on a first fuel parameter of the first liquid fuel; directing the first liquid fuel from an outlet of the fuel pump to a combustor of the gas turbine system; combusting the first liquid fuel with an oxidant in the combustor to generate exhaust gas; expanding the exhaust gas through a turbine of the gas turbine system to drive a shaft coupled to the turbine and to a load; determining a transition load based at least in part on the first fuel parameter of the first liquid fuel and a second fuel parameter of a second liquid fuel; and fully transitioning over a transition period from combustion of the first liquid fuel in the combustor to combustion of the second liquid fuel in the combustor, wherein the transition period is equal to or less than 120 seconds, wherein fully transitioning comprises: controlling the load during the transition period based at least in part on the transition load; opening a second fuel feeding valve to a second liquid fuel threshold to supply the second liquid fuel to the inlet of the fuel pump while supplying the first liquid fuel to the inlet, wherein the second liquid fuel threshold is based at least in part on the second fuel parameter of the second liquid fuel; closing the first fuel feeding valve from the first liquid fuel threshold to stop supplying the first liquid fuel to the inlet in response to opening the second fuel feeding valve to the second liquid fuel threshold; controlling a main fuel control valve configured to regulate fuel flow of the gas turbine system based at least in part on load demands of the gas turbine system and based at least in part on costs and availabilities of the first and second liquid fuels and to ensure that the first liquid fuel and the second liquid fuel each remain in a liquid phase during the transition period; and controlling a speed of a motor configured to drive the fuel pump to maintain a discharge pressure of a liquid fuel flow at the outlet to be within a range of a transition pressure and to ensure that the first liquid fuel and the second liquid fuel each remain in a liquid phase during the transition period, wherein the liquid fuel flow comprises the first liquid fuel, the second liquid fuel, or any combination thereof, wherein controlling the speed of the motor comprises: determining a first speed of the motor based at least in part on the first fuel parameter of the first liquid fuel; determining a second speed of the motor based at least in part on the second fuel parameter of the second liquid fuel; and controlling the speed of the motor from the first speed to the second speed during the full transition from combustion of the first liquid fuel in the combustor to combustion of the second liquid fuel in the combustor.

14. The method of claim 13, comprising: monitoring the second liquid fuel with a sensor to determine the second fuel parameter of the second liquid fuel; and determining the second liquid fuel threshold.

15. The method of claim 13, wherein the transition load ensures that the first liquid fuel and the second liquid fuel each remain in the liquid phase during the transition period.

16. The method of claim 13, wherein the first fuel parameter comprises a first vapor pressure of the first liquid fuel, the second fuel parameter comprises a second vapor pressure of the second liquid fuel, and controlling the speed comprises increasing the speed of the motor from the first speed to the second speed in response to the second vapor pressure being greater than the first vapor pressure.

17. The method of claim 13, wherein the transition period occurs during a startup operation or a shutdown operation of the gas turbine system.