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SYSTEMS AND METHODS FOR MANAGING THE TEMPERATURE OF AN AFTERTREATMENT SYSTEM

Abstract

An aftertreatment temperature management system includes: an engine operative to combust a fuel; an aftertreatment system including an oxidation catalyst and operative to receive exhaust produced by the engine; a heat exchanger coupled to the aftertreatment system and operative to exchange heat between exhaust downstream of the oxidation catalyst and exhaust upstream of the oxidation catalyst; and an insulation at least partially enclosing the heat exchanger and the oxidation catalyst.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates generally to aftertreatment systems, and more particularly, to methods and systems for controlling the temperature of an aftertreatment system.

BACKGROUND

[0002] Internal combustion engines that generate at least part of the energy for operating a machine are subjected to various regulations regarding the type and/or amount of emissions emitted by the internal combustion engine. For example, some regulations set a limit on the amount of gaseous emissions, such as methane (CH_4), carbon dioxide (CO_2), ammonia (NH_3), or nitrogen oxides (NOx), and/or the amount of particulate emissions from the internal combustion engine. To this end, some internal combustion engines include an aftertreatment system that processes the exhaust produced by the internal combustion engine to reduce the amount of undesirable compounds included therein.

[0003] Aftertreatment systems often include one or more oxidation catalysts for oxidizing constituents of gaseous emissions into less harmful compounds. For example, an aftertreatment system may include an oxidation catalyst for oxidizing carbon monoxide into carbon dioxide or a methane oxidation catalyst for oxidizing methane into carbon dioxide. Oxidation catalysts are generally more efficient and less susceptible to sulfur poisoning at higher temperatures, but an aftertreatment system may be damaged if a temperature within the aftertreatment system becomes too high. Thus, the temperature(s) within an aftertreatment system should be carefully managed in order to optimize the efficiency of the oxidation catalyst(s) included in the aftertreatment system without compromising the health and safety of the aftertreatment system. Further, aftertreatment systems for gaseous fuel engines can take a relatively long period of time to warm, especially when operating with a lean air to fuel mixture.

[0004] Chinese patent number CN212563412U, granted to Jie et al. on Feb. 19, 2021 ("the '412 patent"), describes a method for purifying exhaust gases with the use of a heat exchanger. The '412 patent does not disclose, for example, activating and deactivating one or more additive heat components to manage a temperature of an aftertreatment system in response to increases and decreases to the temperature of the aftertreatment system.

[0005] The methods and systems of the present disclosure may solve one or more of the problems set forth above and/or other problems in the art. The scope of the protection provided by the present disclosure, however, is defined by the attached claims, and not by the ability to solve any specific problem.

SUMMARY

[0006] In one aspect, an aftertreatment temperature management system includes: an engine operative to combust a fuel; an aftertreatment system including an oxidation catalyst and operative to receive exhaust produced by the engine; a heat exchanger coupled to the aftertreatment system and operative to exchange heat between exhaust downstream of the oxidation catalyst and exhaust upstream of the oxidation catalyst; and an insulation at least partially enclosing the heat exchanger and the oxidation catalyst.

[0007] In another aspect, an aftertreatment temperature management system includes: an engine operative to combust a fuel; an aftertreatment system including an oxidation catalyst and operative to receive exhaust produced by the engine; a heat exchanger coupled to the aftertreatment system and operative to exchange heat between exhaust downstream of the oxidation catalyst and exhaust upstream of the oxidation catalyst; an additive heat component operative to add heat to the aftertreatment system; a temperature sensor operative to sense a temperature of the aftertreatment system; and a controller coupled to the additive heat component and operative to: monitor the temperature of the aftertreatment system sensed by the temperature sensor; and activate and deactivate the additive heat component in response to increases and decreases of the temperature of the aftertreatment system.

[0008] In another aspect, a method for managing the temperature of an aftertreatment system includes: receiving exhaust from an engine operative to combust a fuel, the exhaust being received by an aftertreatment temperature management system including an aftertreatment system and a heat exchanger operative to increase a temperature of the exhaust; determining the temperature of the exhaust; comparing the temperature of the exhaust to a threshold aftertreatment system temperature; and activating an additive heat component operative to add heat to the aftertreatment system in response to the temperature of the exhaust being lower than the threshold aftertreatment system temperature.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate various exemplary embodiments and together with the description, serve to explain the principles of the disclosed embodiments.

[0010] FIG. **1** depicts a schematic diagram of a machine including an internal combustion engine, an aftertreatment system, and one or more controllers;

[0011] FIG. **2** depicts a schematic diagram of an aftertreatment temperature management system including a heat exchanger;

[0012] FIGS. **3**A and **3**B illustrate a heat exchanger included in the aftertreatment temperature management system of FIG. **2**;

[0013] FIG. **4** depicts a block diagram of an aftertreatment temperature management system for managing the temperature of an aftertreatment system; and

[0014] FIG. **5** depicts a flowchart of a method associated with an aftertreatment temperature management system.

DETAILED DESCRIPTION

[0015] Both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the features, as claimed. As used herein, the terms “comprises,” “comprising,” “having,” including,” or other variations thereof, are intended to cover a non-exclusive inclusion such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements, but may include other elements not expressly listed or inherent to such a process, method, article, or apparatus. Moreover, in this disclosure, relative terms, such as, for example, “about,” “substantially,” “generally,” and “approximately” are used to indicate a possible variation of +10% in the stated value.

[0016] FIG. **1** depicts a schematic diagram of a machine **100** that includes an internal combustion engine **101**, an aftertreatment system **102**, and one or more controllers **103**. The machine **100** may also include an aftertreatment temperature management system **200** (FIG. **2**), which may include one or more components of the internal combustion engine **101**, the aftertreatment system **102**, or the one or more controllers **103**. Machine **100** may be configured to perform various operations associated with mining, earthmoving, paving, construction, farming, transportation, power generation, or other activities. For example, machine **100** may be a mobile machine, such as an on-highway vocational vehicle, an off-highway haul truck, an excavator, a dozer, a loader, a motor grader, paving machine, drilling machine or any other suitable mobile machine. Or, for example, machine **100** may be a stationary machine, such as a generator set, a furnace, or any other suitable stationary machine.

[0017] In general, internal combustion engine (ICE) **101** functions to receive a fuel, such as natural gas, combust the fuel, and output mechanical power. While the present disclosure discusses instances in which the ICE **101** is configured to combust gaseous fuel (e.g., natural gas, methane, butane, propane, hydrogen, biogas, etc.), it should be understood that the ICE **101** may be configured to combust other types of fuels, such as liquid fuel (e.g., gasoline or diesel fuel), either alone or in a dual fuel system that also combusts gaseous fuel. As depicted in FIG. **1**, in some instances, ICE **101** includes a plurality of components or subsystems, such as a plurality of cylinders **104**, a respective plurality of fuel injectors and/or gaseous fuel admission valves (collectively referred to as admission valves **105**), an intake manifold **106**, and an exhaust manifold **107**. ICE **101** may also include an exhaust gas recirculation system (not shown). Although the ICE **101** is depicted with six cylinders **104**, it should be understood that the ICE **101** may include any number of cylinders **104**, e.g., twenty or more cylinders **104**.

[0018] The intake manifold **106** may receive air (e.g., compressed air), such as from an air intake or forced induction system (not shown), and gaseous fuel (e.g., natural gas), to create a mixture of air and fuel. The mixture of air and fuel may be stoichiometric at least some of the time or lean at least some of the time. The mixture of air and fuel may then be delivered to a cylinder **104** downstream of admission valve **105**. The mixture of air and fuel is then ignited, e.g., using a spark plug or by compression ignition of diesel fuel, causing combustion that can then be converted into mechanical power, such as by driving a piston disposed within the cylinder **104** to turn a crankshaft (not shown). The product(s) **108** of the combustion of the air and fuel mixture (hereinafter, “exhaust”) may then be expelled from the cylinder **104**, collected by the exhaust manifold **107**, and delivered to the aftertreatment system **102**, such as via an exhaust passage **109**. In some instances, the ICE **101** also includes a turbocharger (not shown). The turbocharger includes a turbine downstream of the ICE **101** and a compressor upstream of the ICE **101**. The turbine captures energy in the exhaust **108** and uses the energy to drive the compressor, which in turn increases the pressure and flow of air through the intake manifold **106**.

[0019] As depicted in FIG. **1**, in some instances, an aftertreatment system **102** includes a plurality of components or subsystems, such as an oxidation catalyst (OC) **110** (e.g., a methane oxidation catalyst), a particulate filter (PF) **111**, and a selective catalytic reduction (SCR) system **112**. The OC **110** may be disposed downstream of exhaust manifold **107** and upstream of both PF **111** and SCR **112**. The PF **111** may be disposed downstream of OC **110** and upstream of SCR **112**. When exhaust **108** is delivered from the ICE **101** to the aftertreatment system **102**, the exhaust **108** is first passed through the OC **110**, where harmful or undesired emissions such as methane and carbon monoxide in the exhaust **108** are oxidized into carbon dioxide and water. Next, the exhaust **108** is passed through the PF **111**, where solid particles (e.g., carbon particulates) in the exhaust **108** are trapped before they can exit the machine **100**. Finally, the exhaust **108** is passed through an SCR system **112**, where nitrogen oxides in the exhaust **108** are reduced into nitrogen before they exit the machine **100**. After the exhaust **108** has been passed through the OC **110**, the PF **111**, and the SCR **112**, the remaining exhaust **108** (containing, e.g., carbon dioxide, water, and nitrogen) may be safely emitted from the machine **100**, such as through an exhaust pipe **113**. It should be understood that these components of an aftertreatment system **102** are exemplary only, and that additional and/or different components may be included in various instances depending on the configuration of the machine **100**. For example, an aftertreatment system **102** may include an OC **110** and a PF **111** but may not include an SCR **112**. Or for example, an aftertreatment system **102** may include a PF **111** and an SCR **112** but may not include an OC **110**. Or for example, an aftertreatment system **102** may include only a PF **111**. In some instances, a PF **111** may include or otherwise perform the function of an OC **110** (e.g., the PF **111** may be a catalyzed particle filter capable of oxidizing hydrocarbons and/or carbon monoxide included in the exhaust **108** and trapping solid particles included in the exhaust **108**). The relative location of each component of the aftertreatment system **102** may be changed without limiting the scope of the present disclosure.

[0020] As mentioned above, operation of the aftertreatment system **102** may be improved when the temperature(s) of the aftertreatment system **102** are managed. If the operating temperature of an oxidation catalyst (OC) **110** included in the aftertreatment system **102** is too low, one or more components of the aftertreatment system **102**, e.g., OC **110**, may not function as efficiently as possible, or may be more susceptible to sulfur poisoning. However, if a temperature of the aftertreatment system **102** is too high, the aftertreatment system **102** may be damaged.

[0021] FIG. **2** depicts a schematic diagram of an aftertreatment temperature management system (TMS) **200**. As depicted in FIG. **2**, a TMS **200** may include the ICE **101**, aftertreatment system **102**, and a heat exchanger **201**. In some instances, the TMS **200** includes one or more controllers **103**, one or more additive heat components (e.g., additive heat component **202**A or **202**B), one or more temperature sensors (e.g., temperature sensor **203**A or **203**B), or an insulation **204**, which may include one or more insulation layers that surround one or more components of the aftertreatment system **102** and/or the TMS **200**. In general, the components of the TMS **200** function cooperatively to manage the temperature of the aftertreatment system **102**.

[0022] The temperature(s) of an aftertreatment system **102** are dynamic and may vary considerably from one location within the aftertreatment system **102** to another. As mentioned above, when exhaust **108** from the ICE **101** is received by the aftertreatment system **102**, the exhaust **108** is typically exposed to an oxidation catalyst (OC) **110**, at which one or more components of the exhaust **108** may be oxidized in a chemical reaction that produces heat, e.g., an exothermic reaction. Thus, the temperature of the exhaust **108** upstream of the aftertreatment system **102** may be lower than the temperature of the exhaust **108** downstream of the OC **110** included in the aftertreatment system **102**. For example, as shown in FIG. **3**B, the temperature of the exhaust **108** upstream of the aftertreatment system **102** may be ˜400° C., and the temperature of the exhaust **108** downstream of the OC **110** may be ˜500 or ˜600° C. The temperature of the exhaust **108** upstream of the aftertreatment system **102** may be even less if the ICE **101** includes a turbocharger, which captures and uses energy from the exhaust **108** upstream of the aftertreatment system **102** to increase the pressure and flow of air through the intake manifold **106** of the ICE **101**, as mentioned above. Because the operating temperature of an OC **110** is significantly impacted by the temperature of the exhaust **108** as the exhaust **108** is received by the OC **110** (e.g., the temperature of the exhaust **108** upstream of the aftertreatment system **102**), the lower the temperature of the exhaust **108** upstream of the OC **110** is, the less efficient the OC **110** will operate, and the more susceptible the OC **110** will be to sulfur poisoning.

[0023] In some instances, to increase the temperature of the exhaust **108** upstream of an OC **110** included in an aftertreatment system **102**, the TMS **200** includes a heat exchanger **201**. Heat exchanger **201** is operative to exchange heat between exhaust **108** downstream of the OC **110** and exhaust **108** upstream of the OC **110**.

[0024] For example, as depicted in FIG. **2**, heat exchanger **201** may be a shell-and-tube heat exchanger. The shell-and-tube heat exchanger **201** may include a shell **206** and a plurality of tubes **205**. The shell **206** may be a pressure vessel that partially or completely surrounds the plurality of tubes **205**. The shell **206** may be constructed out of carbon steel, stainless steel, or any other suitable material. The tubes **205** may be constructed out of copper, aluminum, stainless steel, or any other suitable material. The material(s) used to construct the shell **206** and tubes **205** may be selected based on the properties of the fluid medium(s) to be passed through the shell-and-tube heat exchanger **201**, the desired or required corrosion resistance or heat transfer efficiency, or any other appropriate factor.

[0025] In a shell-and-tube heat exchanger **201**, a first fluid of a first temperature flows through the tubes **205** of the heat exchanger **201** and a second fluid of a second temperature flows through the shell **206** of the heat exchanger **201**, outside and around the tubes **205**. Heat is transferred from the higher temperature fluid to the lower temperature fluid. In the example depicted in FIG. **2**, the OC **110** is positioned within the heat exchanger **201**, such that the heat exchanger **201** surrounds the OC **110**. Exhaust **108** from the ICE **101** enters the heat exchanger **201** at a relatively cold temperature (represented by the lighter-patterned arrow in FIG. **2**) and exits the OC **110** at a relatively hot temperature (represented by the darker-patterned arrows in FIG. **2**), due to the oxidation reaction that occurs within the OC **110** (as described above), represented in FIG. **2** by explosion symbols.

[0026] The exhaust **108** downstream of the OC **110** is funneled through the tubes **205** of the heat exchanger **201** before the exhaust **108** exits the heat exchanger **201** and continues onto one or more components of the aftertreatment system **102** (e.g., a PF **111** or an SCR **112**) or out of the machine **100**, such as through an exhaust pipe **113**. The exhaust **108** upstream of the OC **110** is funneled toward the OC **110** through the shell **206** of the heat exchanger **201**, outside and around exterior surfaces of the tubes **205**, absorbing heat from the exhaust **108** downstream of the OC **110** inside of the tubes **205** and increasing in temperature accordingly. When the exhaust **108** upstream of the OC **110** is received by the OC **110**, the exhaust **108** upstream of the OC **110** is warmer than it is when it is first received by the heat exchanger **201**, thereby increasing the operating temperature, and, accordingly, the efficiency, of the OC **110**.

[0027] FIGS. **3**A and **3**B illustrate an example of the shell **206** and tubes **205** of a shell-and-tube heat exchanger **201** built to partially or completely surround an OC **110**. In this example, the exhaust **108** is received by the heat exchanger **201** at an initial temperature of 400° C., and the exhaust **108** exits the OC **110** at a temperature of 620° C. Through the heat exchanger **201** (e.g., within the tubes **205**), the exhaust **108** reaches a temperature of 585° C. before it is received by the OC **110**.

[0028] Referring again to FIG. **2**, as mentioned above, in some instances, the TMS **200** includes an insulation **204** that traps heat within the TMS **200**, e.g., within the heat exchanger **201**, to maximize the efficiency of the heat exchanger **201**. For example, in some instances, the shell **206** of the shell-and-tube heat exchanger **201** is entirely covered or enclosed by one or more layers of insulation **204**. For example, insulation **204** may surround inlet **207** of the heat exchanger **201**, the heat exchanger **201** itself (e.g., the shell **206** in which the tubes **205** are secured), and the oxidation catalyst **110**. In some instances, insulation **204** is built into the shell **206** of the shell-and-tube heat exchanger **201**. The insulation **204** may be composed of rock fiber or other suitable materials. While the heat exchanger **201** is generally depicted and described herein as a shell-and-tube heat exchanger, it should be understood that the heat exchanger **201** may embody any other suitable form. For example, in some instances, the heat exchanger **201** is a primary-surface heat exchanger, such as a micro-channel heat exchanger. The primary-surface heat exchanger may be composed of folded foil and/or **3**D printed.

[0029] In some instances, the TMS **200** includes one or more additive heat components (e.g., additive heat component **202**A or **202**B) and one or more controllers **103**, such as an electronic control module (ECM) **115** and/or an actuator controller (AC) **117**, operatively coupled to the one or more additive heat components. For example, additive heat component **202**A may be a duct burner disposed near or within the exhaust passage **109** and operative to generate and add heat to the exhaust **108** upstream of the aftertreatment system **102** by burning a fuel. Or for example, additive heat component **202**B may be an electric heater (e.g., electric heating element(s) or electric grid) disposed near or within the OC **110** and operative to add heat to the aftertreatment system **102** near the OC **110** by generating heat using an electrical current. Or for example, an additive heat component may be a hydrocarbon fuel injector or gaseous fuel admission valve disposed near or within the OC **110** and operative to add heat to the aftertreatment system **102** by injecting or admitting fuel into exhaust **108** or the aftertreatment system **102** to be oxidized by the OC **110**. The hydrocarbon fuel injector or gaseous fuel admission valve may be downstream of the ICE **101** and upstream of the OC **110**. However, an additive heat component may be any device or system suitable to add heat to the aftertreatment system **102** and may be disposed anywhere within the aftertreatment system **102**. In some instances, when fuel is injected into the exhaust **108** by an additive heat component (e.g., a hydrocarbon fuel injector or gaseous fuel admission valve), additional air may be injected into the exhaust **108** upstream of the aftertreatment system **102**, such as by reversing the operation of a turbocharger (not shown), as described above. For example, after a stop condition (as described below), a bypass may be used to redirect air from upstream of the

ICE **101** to the exhaust passage **109** when a hydrocarbon fuel injector or gaseous fuel admission valve is used to inject or admit fuel into the exhaust passage **109**.

[0030] FIG. **4** depicts a block diagram of the aftertreatment temperature management system (TMS) **200**. In general, TMS **200** includes an aftertreatment system **102** and one or more components or systems suitable for monitoring and/or increasing one or more temperatures within the aftertreatment system **102**, such as one or more controllers **103**, one or more additive heat components, and one or more temperature sensors. In some instances, the one or more controllers **103** are communicatively coupled. In some instances, the electronic control module (ECM) **115** and the actuator controller (AC) **117** are two parts of a single controller **103**. As used herein, the term "controller" includes both single controllers and multiple controllers. One or more controllers **103**, such as ECM **115**, may be executed on a processor **421**. One or more controllers **103**, such as ECM **115**, may be operative to execute instructions stored on a memory **422**. AC **117** may be operatively coupled to one or more actuators, such as one or more additive heat components.

[0031] In some instances, the one or more controllers **103** can generate commands to activate the one or more additive heat components to increase a temperature within the aftertreatment system **102** and thereby increase the operating temperature of the OC **110**. For example, in some instances, when the ICE **101** is operated following a stop condition (e.g., during a cold start), there is no exhaust **108** downstream of the OC **110**, and therefore the heat exchanger **201** may not be configured to immediately increase the temperature of the exhaust **108** upstream of the OC **110**. In such an instance, a controller **103**, such as actuator controller **117**, may be configured to automatically, and temporarily, activate a duct burner disposed near or within the exhaust passage **109** (e.g., additive heat component **202**A) for a predetermined amount of time when the ICE **101** is first operated following a stop condition, to increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110**. For example, when the ICE **101** is operated following a stop condition, the actuator controller **103** may be configured to automatically and temporarily activate the duct burner for one minute, five minutes, one hour, or longer.

[0032] Or for example, in some instances, the one or more controllers **103** can activate and/or deactivate the one or more additive heat components based on temperature data generated by the one or more temperature sensors. For example, in some instances, the TMS **200** includes a single temperature sensor **203**A disposed near or within the heat exchanger **201**, upstream of the OC **110**, and operative to determine the temperature of the exhaust **108** upstream of the OC **110**, e.g., the temperature of the exhaust **108** just before the exhaust **108** is received by the OC **110**. Temperature sensor **203**A may be an air charge temperature (ACT) sensor. The temperature sensor **203**A may generate and provide, e.g., on an ongoing basis, first temperature data **423**A representing the temperature of the exhaust **108** upstream of the OC **110** to a controller **103**, such as electronic control module (ECM) **115**. In such an instance, ECM **115** may be operative to monitor, using the first temperature data **423**A generated by the temperature sensor **203**A, the temperature of the exhaust **108** upstream of the OC **110** (e.g., exhaust **108** inside of the heat exchanger **201** immediately upstream of OC **110**). If the temperature of the exhaust **108** upstream of the OC **110** is below a threshold upstream temperature, or if the temperature of the exhaust **108** upstream of the OC **110** remains below the threshold upstream temperature for a threshold duration of time, one or more controllers **103**, e.g., ECM **115** or AC **117**, functioning separately or cooperatively, may activate one or more additive heat components to increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110**, such as by generating an additive heat control command **424** and transmitting the additive heat control command **424** to AC **117**.

[0033] In some instances, one or more controllers **103** of the TMS **200** are operative to activate one or more additive heat components based on temperature data generated by a plurality of temperature sensors. For example, in some instances, the TMS **200** includes a first temperature sensor **203**A disposed near or within the heat exchanger **201** and upstream of the OC **110** and a second temperature sensor **203**B disposed near or within the heat exchanger **201** and downstream of the OC **110**. The first temperature sensor **203**A is operative to determine the temperature of the exhaust **108** upstream of the OC **110**, and the second temperature sensor **203**B is operative to determine the temperature of the exhaust **108** downstream of the OC **110**. The first temperature sensor **203**A may generate, e.g., on an ongoing basis, first temperature data **423**A representing the temperature of the exhaust **108** upstream of the OC **110**, and the second temperature sensor **203**B may generate, e.g., on an ongoing basis, second temperature data **423**B representing the temperature of the exhaust **108** downstream of the OC **110** and/or downstream of the heat exchanger **201**. The first and second temperature data **423**A and **423**B may be provided to a controller **103**, such as ECM **115**, with which the controller **103** may monitor the temperature of the exhaust **108** upstream of the OC **110** and the temperature of the exhaust **108** downstream of the OC **110**. If the temperature of the exhaust **108** is below a threshold upstream temperature, of if the temperature of the exhaust **108** remains below the threshold upstream temperature for a threshold duration of time, and if the temperature of the exhaust **108** downstream of the OC **110** is below a threshold downstream temperature, the one or more controllers **103** may activate one or more additive heat components to increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110**, such as by generating an additive heat control command **424** and transmitting the additive heat control command **424** to AC **117**. However, if the temperature of the exhaust **108** downstream of the OC **110** is above the threshold downstream temperature, the one or more controllers **103** may not activate one or more additive heat components, to increase efficiency and prevent overheating. Both the threshold upstream temperature and the threshold downstream temperature may be referred to as "threshold aftertreatment system temperatures." However, the TMS **200** may include any number of temperature sensors, and the one or more controllers **103** may activate one or more additive heat components based on any number of threshold aftertreatment system temperatures, or without considering any threshold aftertreatment system temperatures.

[0034] In some instances, when the one or more controllers **103** activate one or more additive heat components to increase a temperature of the aftertreatment system **102**, such as the temperature of the exhaust **108** upstream of an OC **110** or the operating temperature of the OC **110**, the one or more controllers **103** activate the one or more additive heat components for a predetermined amount of time, such as one minute, five minutes, one hour, or longer. In some instances, when the one or more controllers **103** activate an additive heat component to increase a temperature of the aftertreatment system **102**, the one or more controllers **103** activate the additive heat component until the temperature of the aftertreatment system **102** reaches a target or threshold temperature. In some instances, after activating one or more additive heat components to increase a temperature of an aftertreatment system **102**, the one or more controllers **103** deactivate the one or more additive heat components when the temperature of aftertreatment system **102** reaches a target or threshold temperature. In this way, the TMS **200** can manage the temperature of an aftertreatment system **102** by activating and deactivating one or more additive heat components in response to increases and decreases of the temperature of the aftertreatment system **102**.

INDUSTRIAL APPLICABILITY

[0035] The disclosed aspects of the present disclosure may be applied to a variety of engines, and machines and/or vehicles that incorporate these engines to generate power to move the machine, power an implement, generate electricity, etc. For example, the aftertreatment temperature management system of the present disclosure may increase the efficiency and sustainability of oxidation catalysts used in aftertreatment systems of machines that include internal combustion engines.

[0036] As described above, an ICE **101** of a machine **100** combusts fuel, such as natural gas, to produce mechanical power that can be used by the machine **100** to move or perform other work, such as generating electricity. The combustion of fuel within the ICE **101** produces exhaust **108** that may include harmful or undesirable emissions. These emissions may be reduced or eliminated by an aftertreatment system **102** operatively coupled to the ICE **101**. The efficiency of one or more components of the aftertreatment system **102**, such as an oxidation catalyst (OC) **110**, may generally increase at higher temperatures, but the aftertreatment system **102** may be damaged if a temperature of the aftertreatment system **102** becomes too high. The aftertreatment temperature management system (TMS) **200** may include a heat exchanger **201** that is operative to exchange heat between exhaust **108** downstream of an OC **110** included in the aftertreatment system **102** and exhaust **108** upstream of the OC **110**, thereby increasing the temperature of the exhaust **108** upstream of the OC **110** and ultimately increasing the operating temperature of the OC **110** as well. One or more components of the TMS **200**, such as the heat exchanger **201** and the OC **110**, may be insulated to retain heat and minimize the amount of time that additive heat components **202**A and **202**B are activated. In some configurations, the insulation **204** may be facilitate the omission additive heat components (e.g., allowing the omission of a duct burner in the TMS **200**). The TMS **200** may additionally or alternatively include one or more additive heat components, one or more temperatures sensors, and/or one or more controllers **103** operatively coupled to the one or more additive heat components and/or the one or more temperature sensors. The one or more controllers **103** may be operative to activate or deactivate the one or more additive heat components automatically or based on temperature data generated by the one or more temperature sensors, such that the operating temperature of the OC **110** reaches a more optimal temperature.

[0037] FIG. **5** depicts a flowchart of a method **500** associated with an aftertreatment temperature management system (TMS) **200**. In some instances, as depicted in FIG. **5**, the method **500** begins with step **501**, in which a TMS **200**, e.g., an aftertreatment system **102** included in the TMS **200**, receives exhaust **108** generated by an ICE **101**. The exhaust **108** is received by the TMS **200** at an initial temperature, which may be lower than an optimal operating temperature (e.g., a light-off temperature) of an oxidation catalyst (OC) **110** included in the aftertreatment system **102**. For example, the exhaust **108** generated by the ICE **101** and received by the TMS **200** may have an initial temperature of 400° C., and the optimal operating temperature of the OC **110** may be 550° C. The TMS **200** may include a heat exchanger **201** configured to exchange heat between exhaust **108** downstream of the OC **110** and exhaust **108** upstream of the OC **110**, thereby increasing the temperature of the exhaust **108** upstream of the OC **110**, as described above. However, in some instances, the heat exchanger **201** may not be capable of increasing the temperature of the exhaust **108** to the optimal operating temperature of the OC **110**, such as after a stop condition, as described above.

[0038] In some instances, after the TMS **200** receives exhaust **108** generated by an ICE **101**, the method **500** continues with step **502**, in which the TMS **200** receives temperature data representing one or more temperatures of the exhaust **108** from one or more temperature sensors. For example, the TMS **200** may include a first temperature sensor **203**A disposed near or within the aftertreatment system **102** and upstream of the OC **110**. The temperature sensor **203**A can generate and provide to the TMS **200**, on an ongoing basis, temperature data **423**A representing the temperature of the exhaust **108** upstream of the OC **110**. Or for example, the TMS **200** may include a first temperature sensor **203**A disposed near or within the aftertreatment system **102** and upstream of the OC **110** and a second temperature sensor **203**B disposed near or within the aftertreatment system **102** and downstream of the OC **110**. The first temperature sensor **203**A can generate and provide to the TMS **200**, on an ongoing basis, temperature data **423**A representing the temperature of the exhaust **108** upstream of the OC **110**, and the second temperature sensor **203**B can generate and provide to the TMS **200**, on an ongoing basis, temperature data **423**B representing the temperature of the exhaust **108** downstream of the OC **110**.

[0039] In some instances, after the TMS **200** receives temperature data representing one or more temperatures of the exhaust **108**, the method **500** continues with steps **503** and **504**, in which the

TMS **200** compares the one or more temperatures of the exhaust **108** to one or more threshold aftertreatment system temperatures and, if appropriate, activates one or more additive heat components, respectively. For example, the TMS **200** may compare a temperature of the exhaust **108** upstream of the OC **110** to a threshold upstream temperature. In this example, if the TMS **200** determines that the temperature of the exhaust upstream of the OC **110** is below the threshold upstream temperature, the TMS **200** may activate one or more additive heat components, such as a duct burner or an electric heating grid, to increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110**. Or for example, the TMS **200** may compare a temperature of the exhaust **108** upstream of the OC **110** to a threshold upstream temperature and compare a temperature of the exhaust **108** downstream of the OC **110** to a threshold downstream temperature. In this example, if the TMS **200** determines that the temperature of the OC **110** upstream of the OC **110** is below the threshold upstream temperature, and that the temperature of the OC **110** downstream of the OC **110** is below the threshold downstream temperature, the TMS **200** may activate one or more additive heat components, such as a duct burner or an electric heating grid, to increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110**. However, in this example, if the TMS **200** determines that the temperature of the exhaust **108** downstream of the OC **110** is above the threshold downstream temperature, the TMS **200** may not activate one or more additive heat components, for efficiency and to protect the aftertreatment system **102** from overheating.

[0040] By including a heat exchanger **201** in an aftertreatment system **102**, as described above, the TMS **200** can efficiently increase the temperature of exhaust **108** upstream of an OC **110** included in the aftertreatment system **102**, thereby increasing the operating temperature and, by extension, the efficiency and sustainability of the OC **110**. One or more components of the TMS **200**, such as the heat exchanger **201** and the OC **110**, may be partially or completely enclosed by an insulation layer **204**, to further increase the efficiency of the aftertreatment system **102**. By including one or more additive heat components that may be activated or deactivated based on one or more temperatures of the aftertreatment system **102**, as described above, the TMS **200** can increase the temperature of the exhaust **108** upstream of the OC **110** or otherwise increase the operating temperature of the OC **110** when the temperature of the exhaust **108** upstream of the OC **110** or the operating temperature of the OC **110** is less than an optimal temperature, and prevent the aftertreatment system **102** from reaching a temperature at which the aftertreatment system **102** may be at risk of damage. In at least these ways, the TMS **200** manages the temperature of the aftertreatment system **102** to increase the efficiency of the aftertreatment system **102** while protecting the aftertreatment system **102** from damage.

[0041] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed method and system without departing from the scope of the disclosure. Other embodiments of the method and system will be apparent to those skilled in the art from consideration of the specification and practice of the systems disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

Claims

1. An aftertreatment temperature management system comprising: an engine operative to combust a fuel; an aftertreatment system including an oxidation catalyst and operative to receive exhaust produced by the engine; a heat exchanger coupled to the aftertreatment system and operative to exchange heat between exhaust downstream of the oxidation catalyst and exhaust upstream of the oxidation catalyst; and an insulation at least partially enclosing the heat exchanger and the oxidation catalyst.

2. The aftertreatment temperature management system of claim 1, wherein the insulation at least partially surrounds an inlet of the heat exchanger, the heat exchanger, and the oxidation catalyst.
3. The aftertreatment temperature management system of claim 1, wherein the heat exchanger is a shell-and-tube heat exchanger.
4. The aftertreatment temperature management system of claim 1, wherein the heat exchanger is a primary-surface heat exchanger.
5. The aftertreatment temperature management system of claim 1, further comprising: an additive heat component operative to add heat to the aftertreatment system; and a controller operatively coupled to the additive heat component and operative to generate commands to activate the additive heat component.
6. The aftertreatment temperature management system of claim 5, wherein the additive heat component is a duct burner.
7. The aftertreatment temperature management system of claim 5, wherein the additive heat component is an electric heater.
8. The aftertreatment temperature management system of claim 5, wherein the additive heat component is a hydrocarbon fuel injector or a gaseous fuel admission valve.
9. The aftertreatment temperature management system of claim 8, wherein the hydrocarbon fuel injector or the gaseous fuel admission valve is downstream of the engine and upstream of the oxidation catalyst.
10. The aftertreatment temperature management system of claim 5, further comprising a temperature sensor communicatively coupled to the controller and operative to determine the temperature of the aftertreatment system.
11. The aftertreatment temperature management system of claim 10, wherein the controller is further operative to compare the temperature of the aftertreatment system to a threshold aftertreatment system temperature and activate the additive heat component in response to the temperature of the aftertreatment system being below the threshold aftertreatment system temperature.
12. The aftertreatment temperature management system of claim 10, wherein the controller is further operative to monitor the temperature of the aftertreatment system and activate and deactivate the additive heat component in response to increases and decreases of the temperature of the aftertreatment system.
13. The aftertreatment temperature management system of claim 1, further comprising: an additive heat component operative to add heat to the aftertreatment system; a first temperature sensor operative to determine a first temperature of the aftertreatment system upstream of the oxidation catalyst; a second temperature sensor operative to determine a second temperature of the aftertreatment system downstream of the oxidation catalyst; and a controller coupled to the additive heat component, the first temperature sensor, and the second temperature sensor and operative to activate and deactivate the additive heat component based on the first and second temperatures of the aftertreatment system.
14. An aftertreatment temperature management system comprising: an engine operative to combust a fuel; an aftertreatment system including an oxidation catalyst and operative to receive exhaust produced by the engine; a heat exchanger coupled to the aftertreatment system and operative to exchange heat between exhaust downstream of the oxidation catalyst and exhaust upstream of the oxidation catalyst; an additive heat component operative to add heat to the aftertreatment system; a temperature sensor operative to sense a temperature of the aftertreatment system; and a controller coupled to the additive heat component and operative to: monitor the temperature of the aftertreatment system sensed by the temperature sensor; and activate and deactivate the additive heat component in response to increases and decreases of the temperature of the aftertreatment system.
15. The aftertreatment temperature management system of claim 14, further including an insulation

at least partially enclosing the heat exchanger and the oxidation catalyst.

16. The aftertreatment temperature management system of claim 14, wherein the heat exchanger is a shell-and-tube heat exchanger.

17. The aftertreatment temperature management system of claim 14, wherein the heat exchanger is a primary-surface heat exchanger.

18. The aftertreatment temperature management system of claim 14, wherein the additive heat component is a duct burner or an electric heater.

19. The aftertreatment temperature management system of claim 14, wherein the additive heat component is a hydrocarbon fuel injector or a gaseous fuel admission valve.

20. A method for managing the temperature of an aftertreatment system, the method comprising: receiving exhaust from an engine operative to combust a fuel, the exhaust being received by an aftertreatment temperature management system including an aftertreatment system and a heat exchanger operative to increase a temperature of the exhaust; determining the temperature of the exhaust; comparing the temperature of the exhaust to a threshold aftertreatment system temperature; and activating an additive heat component operative to add heat to the aftertreatment system in response to the temperature of the exhaust being lower than the threshold aftertreatment system temperature.