been limited to about 33% in industrial operations within the United States.

[0011] Regardless of whether energy recovery is enhanced by injection of steam into the conversion gas entering the absorber, the potential for sulfuric acid mist formation in the gas stream is generally aggravated by operation of an SO_3 absorber at high temperature for recovery of absorption heat in useful form. High temperature operation increases the equilibrium concentrations of SO_3, sulfuric acid and water vapor in the gas stream. As the gas cools during flow countercurrently to the absorption acid in the absorber, and in the gas flow conduit downstream of the gas exit of the absorber, sulfuric acid condenses in fine droplets in the gas stream. Residual SO_3 combines with water in the gas stream to generate further quantities of sulfuric acid vapor which condenses to form additional mist. In both dry gas and wet gas operations, including but not limited to steam injection, mist has been a complex and often baffling problem. Where the heat recovery absorber functions as an interpass absorber, mist in the exit gas stream may deposit on downstream surfaces causing significant corrosion. Where the heat recovery absorber functions as a final absorber, the gas stream exiting the absorber is vented to the atmosphere where sulfuric acid mist becomes a pollutant.

SUMMARY OF THE INVENTION

[0012] In the contact sulfuric acid processes of the present disclosure~~invention~~, enhanced recovery of energy is obtained from the absorption zone wherein SO_3 is absorbed into sulfuric acid. Energy is recovered in useful form, for example, as intermediate pressure steam. Enhanced energy recovery is achieved while preserving control of corrosion at the heat exchange surfaces that are wetted with absorption acid, and without excessive or intolerable generation of acid mist. The quantity of

intermediate pressure steam than can be generated from the absorption loop can be increased significantly, e.g., by up to 25% or more, compared to commercial processes in which no more than about 33% of dilution water has been supplied in the form of water vapor contained in the gas stream entering the absorber.

[0013] Briefly, the present disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid in which an oxygen-containing gas is contacted with a desiccant to provide a desiccated oxygen-containing gas. Sulfur and the desiccated oxygen-containing gas are introduced into a combustion zone. The oxygen content of the oxygen- containing gas introduced into the combustion zone is in stoichiometric excess relative the sulfur introduced into the zone. Sulfur is burned with oxygen of the desiccated gas to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby transforming the sulfur oxide-bearing gas stream into a conversion gas containing SO_3. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0014] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid in which sulfur is burned in a dry gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide, oxygen and not more than 0.005 moles water vapor per mole SO_2. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing not more than 0.005 moles water vapor per mole SO_3. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0015] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid in which sulfur is burned in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream into a conversion gas containing sulfur trioxide. Water vapor is introduced into the sulfur oxide-bearing gas stream in a water vapor injection zone to increase

the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content. In an absorption zone downstream of the water vapor injection zone with respect to the gas flow direction, the conversion gas is contacted with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid, the conversion gas being introduced into the absorption zone without intermediate condensation of any component of the sulfur oxide-bearing gas stream between the water vapor injection zone and the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0016] In a further embodiment~~aspect~~, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing sulfur trioxide. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid, the mass flow ratio of the absorption liquid entering the absorption zone to sulfur trioxide entering the absorption zone being at least about 30. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of

the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0017] In a further embodiment~~aspect~~, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing sulfur trioxide. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and a indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid in a quantity of at least about 1160 KJ per Kilogram (500 Btu per pound) of equivalent SO_3 entering the absorption zone, thereby heating the heat transfer fluid to at least 150°C.

[0018] The disclosure~~invention~~ is also directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid. The concentration and temperature of the acid stream exiting the primary absorption zone and the temperature and dew point of the conversion gas stream entering the primary absorption zone are such as to enable controlling the gas stream leaving the secondary absorption zone to contain not more than 20 g/Nm^3 preferably not more than 15, 10, 5 or 1.0 g/Nm^3 sulfuric acid mist. In preferred embodiments, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. However, control of mist is applicable to

embodiments in which the conversion gas is either desiccated or contains only atmospheric moisture, in addition to embodiments in which water vapor is injected into the gas entering the absorber. In further preferred embodiments, with or without addition of water vapor to the conversion gas, the gas stream exiting the secondary absorption zone is passed through a mist eliminator system at a rate of at least 340 Nm^3 per hour per square meter of mist eliminator element surface area transverse to the direction of gas flow, the gas exiting the mist eliminator system containing less than 0.05 g/Nm^3 acid mist.

[0019] In a still further embodiment~~aspect~~, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. The primary absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid, the concentration and temperature of the primary absorption liquid exiting the primary absorption zone and the temperature and dew point of the conversion gas stream entering the primary

absorption zone being such as to enable controlling the gas stream leaving the secondary absorption zone to contain not more than 20 g/Nm^3 preferably not more than 15, 10, 5 or 1.0 g/Nm^3 sulfuric acid mist. The gas stream exiting the absorption zone is passed through a mist eliminator system at a rate of not greater than 500 Nm^3/hr per square meter of mist eliminator element surface area transverse to the direction of gas flow, the gas exiting the mist eliminator system containing less than 0.05 g/Nm^3 acid mist. In preferred embodiments, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. However, mist control features disclosed herein~~of the invention~~ are equally applicable to processes in which the conversion gas is dry or contains only atmospheric moisture.

[0020] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. Water vapor is introduced into the conversion gas in a proportion sufficient to increase the temperature of the conversion gas to between about 300°C and about 330°C. The conversion gas is introduced into an absorption zone at a temperature between about 300°C and 330°C. The conversion gas is contacted in the absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. The absorption liquid is circulated between the absorption zone and

an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0021] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid comprising burning sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and both a principal indirect heat exchanger and an auxiliary indirect heat exchanger, in each of which heat exchangers heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred from the circulating absorption liquid. Heat is transferred to a principal heat transfer fluid in the principal heat exchanger, thereby heating the principal heat transfer fluid to at least 150°C. Heat is transferred to a water stream in the auxiliary heat exchanger, thereby generating the water vapor for injection into the sulfur oxide-bearing gas stream upstream of the absorption zone.

[0022] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid comprising burning sulfur in a dry gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of gas flow in a proportion sufficient to provide a sulfuric acid vapor content of at least 0.4 moles per mole sulfur trioxide in the conversion gas entering the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0023] In a still further embodiment~~aspect~~, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning sulfur in a dry gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in an absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the

absorption zone with respect to the direction of gas flow, the proportion of water vapor introduced into the sulfur oxide-bearing gas stream, the sulfuric acid strength and temperature of the absorption liquid introduced into the absorption zone, and the L/G ratio in the absorption zone being such that the molar ratio of sulfuric acid vapor to SO_3 reaches a maximum of at least about 1.2 at a location within the absorption zone intermediate the gas inlet and gas exit thereof. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0024] In further embodiments, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone,

thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid, the mass flow ratio of the secondary absorption liquid entering the absorption zone to total gas flow entering the secondary absorption zone being between about 0.4 and about 5. In preferred embodiments, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. However, control of mist is applicable to embodiments in which the gas is either desiccated or contains only atmospheric moisture, in addition to embodiments in which water vapor is injected into the gas entering the absorber.

[0025] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid comprising burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. Optionally, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.40 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in

which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid. The relative flow rates of the gas stream entering the secondary absorption zone and the secondary absorption liquid stream entering the secondary absorption zone are such that the maximum local integrated average difference between the temperature of the gas phase and the temperature of the secondary absorption liquid phase with which the gas is in contact is not greater than 35°C, such local integrated average contact temperature difference being determined by integration across any locus of gas/liquid contact within the zone that is defined by a constant distance from the liquid inlet to the zone. In both those embodiments which comprise injection of water vapor into the gas stream entering the primary absorption zone and those which do not, control of the Δt between the gas stream and the acid stream in the secondary absorption zone is effective for control of acid mist exiting the secondary absorption zone.

[0026] In a further embodiment~~aspect~~, the disclosure~~invention~~ is directed to a process for the preparation of sulfuric acid comprising burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption

liquid. Optionally, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.40 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid. The relative flow rates of the gas stream entering the secondary absorption zone and the secondary absorption liquid stream entering the secondary absorption zone is such that the maximum difference between the local bulk temperature of the gas phase and the local bulk temperature of the secondary absorption liquid phase with which the gas is in contact is not greater than 35°C within any locus of gas/liquid contact within the zone that is defined by a constant distance from the liquid inlet to the zone. Enhanced mist control is achieved in both those embodiments which comprise water vapor injection and those which do not.

[0027] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid comprising burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion

gas containing SO_3. The conversion gas is contacted in a primary absorption heat recovery zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. Optionally, water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.40 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, thereby recovering residual SO_3 as sulfuric acid in the secondary absorption liquid. The relative flow rates of the gas stream entering the secondary absorption zone and the secondary absorption liquid stream entering the secondary absorption zone are such that the difference between the local bulk temperature of the gas phase and the local bulk temperature of the secondary absorption liquid phase with which the gas is in contact is not greater than 35°C at either the liquid inlet or liquid exit of the secondary absorption zone. Enhanced mist control is achieved in both those embodiments which comprise water vapor injection and those which do not.

[0028] The disclosure~~invention~~ is further directed to process for the manufacture of sulfuric acid comprising burning a source of sulfur in air or oxygen-enriched air to produce a combustion gas comprising sulfur dioxide and excess unreacted oxygen. The combustion gas is passed over a catalyst for the conversion of

sulfur dioxide to sulfur trioxide, thereby producing a conversion gas containing sulfur trioxide. The conversion gas is contacted in a heat recovery absorption zone with an absorption liquid comprising concentrated sulfuric acid, the gas phase stream in the absorption zone being passed through the zone countercurrently to absorption liquid stream, the temperature of gas and liquid streams decreasing from the gas inlet to the gas outlet of the zone. The sulfuric acid concentration of the absorption liquid is controlled so that that the difference between the absorption liquid concentration and the azeotrope is not more than about +1.0 wt.% throughout the heat recovery absorption zone.

[0029] The disclosure~~invention~~ is still further directed to a process for the manufacture of sulfuric acid comprising burning a source of sulfur in air or oxygen-enriched air to produce a combustion gas comprising sulfur dioxide and excess unreacted oxygen, and passing the combustion gas over a catalyst for the conversion of sulfur dioxide to sulfur trioxide, thereby producing a conversion gas containing sulfur trioxide. The conversion gas is contacted in a heat recovery absorption zone with an absorption liquid comprising concentrated sulfuric acid, the gas phase stream in the absorption zone being passed through the zone countercurrently to absorption liquid stream, the temperature of gas and liquid streams decreasing from the gas inlet to the gas outlet of the zone. The sulfuric acid concentration of the absorption liquid is controlled so that the difference between the absorption liquid concentration and the azeotrope at the gas exit is not less than about -0.1 wt.%.

[0030] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid comprising burning elemental sulfur in a dry gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is

acid concentration of the absorption liquid is controlled so that that the difference between the absorption liquid concentration and the azeotrope is not less than about -0.2 wt.% or greater than about +1.0 wt.% throughout the primary absorption zone. The relative flow of primary absorption acid and conversion gas in the primary absorption zone are controlled so that the L/G on an equivalent SO_3 basis within the zone is between about 20 and about 70. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, residual SO_3 contained in the gas stream entering the secondary absorption zone being recovered as sulfuric acid in the secondary absorption liquid. The concentration and temperature of the acid stream exiting the primary absorption zone and the temperature and dew point of the conversion gas stream entering the primary absorption zone are such as to enable controlling the gas stream leaving the secondary absorption zone to contain not more than 20 g/Nm^3 sulfuric acid mist, wherein the relative flow rates of the gas stream entering the secondary absorption zone and the secondary absorption liquid stream entering the secondary absorption zone is such that the difference between the local bulk temperature of the gas phase and the local bulk temperature of the secondary absorption liquid phase with which the gas is in contact is between about 15° and about 35°C at both the liquid inlet or liquid exit of the secondary absorption zone. The gas stream exiting the secondary absorption zone is passed through a mist eliminator system at a rate of at least 300 Nm^3 per hour per square meter of mist eliminator element surface area transverse to the direction of gas flow, the gas exiting the mist eliminator system containing less than 0.1 g/Nm^3 acid mist.

[0031] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid comprising burning a sulfur source in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising

sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a heat recovery absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfur trioxide from the conversion gas to the absorption liquid. The absorption liquid is circulated between the absorption zone and a principal indirect heat exchanger in which heat is transferred to a principal heat transfer fluid, thereby heating the principal heat transfer fluid to at least 150°C. The absorption liquid stream exiting the principal heat exchanger is divided to provide a principal absorption liquid stream that is recirculated to the heat recovery absorption zone and an auxiliary absorption liquid stream. The auxiliary liquid stream is passed through an indirect heat exchanger auxiliary to a boiler feed water deaerator, heat being transferred in the deaerator auxiliary heat exchanger from the auxiliary liquid to a water stream for generation of deaerating steam. The deaerating steam is directed to the deaerator wherein boiler feed water is contacted with the deaerating steam for stripping non-condensables from the boiler feed water. A deaerator exhaust stream is removed from the deaerator, the deaerator exhaust stream comprising water vapor and non-condensable gases.

[0032] The disclosure~~invention~~ is still further directed to a process for the preparation of sulfuric acid in a contact sulfuric acid manufacturing facility comprising an interpass absorber wherein the facility is retrofitted to be operated in accordance with a process that recovers the heat of absorption of SO_3 in useful form at a temperature of at least about 150°C. The process comprises burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is

contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption zone with a primary absorption liquid comprising sulfuric acid, thereby absorbing sulfur trioxide and/or transferring sulfuric acid from the conversion gas to the primary absorption liquid. The absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, residual SO_3 contained in the gas stream entering the secondary absorption zone being recovered as sulfuric acid in the secondary absorption liquid. The secondary absorption zone is comprised by an interpass absorber existing in the facility prior to the retrofit, and the mass flow ratio of the secondary absorption liquid to gas in the secondary absorption zone is between about 1.0 and about 7.0 or between about 14 and about 18.

[0033] The disclosure~~invention~~ is still further directed to a method for retrofitting an existing contact sulfuric acid plant comprising an interpass absorber for recovery at high temperature of the heat of absorption of SO_3 in sulfuric acid. The method comprises installing (1) a new absorber for receiving converter gas comprising sulfur trioxide, the new absorber comprising a primary absorption zone designed for high temperature absorption of SO_3 in a primary absorption liquid comprising sulfuric acid to produce additional sulfuric acid therein; (2) a high temperature heat exchanger designed for transfer of the heat of SO_3 absorption from the primary absorption liquid to another fluid and thereby heat the other

fluid to a temperature of at least about 150°C; (3) means for circulating the primary absorption liquid between the primary absorption zone and the high temperature heat exchanger; (4) conduit for directing the gas stream exiting the high temperature absorber to an inlet of the existing interpass absorber; and (5) means for circulating a secondary absorption liquid through the existing interpass absorber wherein residual SO_3 can be removed from the gas stream exiting the primary absorption zone by transfer to the secondary absorption liquid, the means for circulating the secondary absorption liquid being sized and/or subject to flow control instrumentalities such that the mass flow ratio of the secondary absorption liquid to gas in the secondary absorption zone is between about 1.0 and about 7.0 or between about 14 and about 18.

[0034] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid comprising burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3. The conversion gas is contacted in a primary absorption (heat recovery) zone with a primary absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the primary absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the gas flow direction in a proportion sufficient to increase the equivalent water vapor content to at least about 0.40 moles per mole total equivalent sulfur oxide gas content in the gas entering the primary absorption zone. The primary absorption liquid is circulated between the primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or

absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C. The gas stream exiting the primary absorption zone is contacted with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, residual SO_3 contained in the gas stream entering the secondary absorption zone being recovered as sulfuric acid in the secondary absorption liquid. The rate of delivery of secondary absorption acid to the secondary absorption zone is controlled to maintain the difference between the local bulk temperature of the gas phase and the local bulk temperature of the secondary absorption liquid phase with which the gas is in contact not greater than about 35 °C at both the liquid inlet and liquid exit of the secondary absorption zone. The concentration of the secondary absorption acid entering the secondary absorption zone is controlled to provide a net available water supply to the secondary zone sufficient to assure that the composition of the gas exiting the secondary absorption zone is equal to or above the azeotrope composition with respect to water content and equal to or below the azeotrope composition with respect to SO_3 content.

[0035] The disclosure~~invention~~ is further directed to a process for the preparation of sulfuric acid comprising contacting an oxygen-containing gas with a desiccant to provide a desiccated oxygen-containing gas. Sulfur and the desiccated oxygen-containing gas are introduced into a combustion zone. The oxygen content of the oxygen-containing gas introduced into the combustion zone is in stoichiometric excess relative the sulfur introduced into the zone. Sulfur is burned with oxygen of the desiccated gas to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen. The sulfur oxide-bearing gas stream comprising the combustion gas is contacted with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby transforming the sulfur oxide-bearing gas stream into a conversion gas containing

SO_3. The conversion gas is contacted in a heat recovery absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid. Water vapor is introduced into the sulfur oxide-bearing gas upstream of the absorption zone with respect to the direction of sulfur oxide-bearing gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the absorption zone. The absorption liquid is circulated between the absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

[0035a] In one aspect, there is provided a process for the preparation of sulfuric acid in a contact sulfuric acid manufacturing facility comprising an interpass absorber wherein said facility is retrofitted to be operated in accordance with a process that recovers the heat of absorption of SO_3 in useful form at a temperature of at least about 150°C, the process comprising:

burning a source of sulfur in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen;

contacting the sulfur oxide-bearing gas stream comprising said combustion gas with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3;

contacting the conversion gas in a primary absorption zone with a primary absorption liquid comprising sulfuric acid, thereby absorbing sulfur trioxide and/or transferring sulfuric acid from the conversion gas to the primary absorption liquid;

circulating said absorption liquid between said primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the primary absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C; and

contacting the gas stream exiting the primary absorption zone with a secondary absorption liquid comprising sulfuric acid in a secondary absorption zone, residual SO_3 contained in the gas stream entering said secondary absorption zone being recovered as sulfuric acid in the secondary absorption liquid, wherein

said secondary absorption zone is comprised by an interpass absorber existing in said facility prior to said retrofit, and the mass flow ratio of said secondary absorption liquid to gas in said secondary absorption zone is between about 1.0 and about 7.0 or between about 14 and about 18.

[0035b] In another aspect, there is provided a method for retrofitting an existing contact sulfuric acid plant comprising an interpass absorber for recovery at high temperature of the heat of absorption of SO_3 in sulfuric acid, the method comprising:

installing a new absorber for receiving converter gas comprising sulfur trioxide, said new absorber comprising a primary absorption zone designed for high temperature absorption of SO_3 in a primary absorption liquid comprising sulfuric acid to produce additional sulfuric acid therein;

installing a high temperature heat exchanger designed for transfer of the heat of SO_3 absorption from said primary absorption liquid to another fluid and thereby heat the other fluid to a temperature of at least about 150°C;

installing means for circulating said primary absorption liquid between said primary absorption zone and said high temperature heat exchanger;

installing conduit for directing the gas stream exiting said high temperature absorber to an inlet of said existing interpass absorber; and

installing means for circulating a secondary absorption liquid through said existing interpass absorber wherein residual SO_3 can be removed from the gas stream exiting said primary absorption zone by transfer to said secondary absorption liquid, said means for circulating said secondary absorption liquid being sized and/or subject to flow control instrumentalities such that the mass flow ratio of said secondary absorption liquid to gas in said secondary absorption zone is between about 1.0 and about 7.0 or between about 14 and about 18.

[0035c] In another aspect, there is provided a process for the preparation of sulfuric acid comprising:

burning a sulfur source in a gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide and oxygen;

contacting the sulfur oxide-bearing gas stream comprising said combustion gas with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing SO_3;

contacting the conversion gas in a heat recovery absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfur trioxide from the conversion gas to the absorption liquid;

circulating said absorption liquid between said absorption zone and a principal indirect heat exchanger in which heat is transferred to a principal heat transfer fluid, thereby heating said principal heat transfer fluid to at least 150°C;

dividing the absorption liquid stream exiting said principal heat exchanger to provide a principal absorption liquid stream that is recirculated to said heat recovery absorption zone and an auxiliary absorption liquid stream;

passing said auxiliary liquid stream through an indirect heat exchanger auxiliary to a boiler feed water deaerator, heat being transferred in said deaerator auxiliary heat exchanger from said auxiliary liquid to a water stream for generation of deaerating steam;

directing the deaerating steam to said deaerator wherein boiler feed water is contacted with the deaerating steam for stripping non-condensables from the boiler feed water; and

removing a deaerator exhaust stream from said deaerator, said deaerator exhaust stream comprising water vapor and non-condensable gases.

[0035d] In another aspect, there is provided a process for the preparation of sulfuric acid comprising:

burning sulfur in a dry gas comprising excess oxygen to produce a sulfur oxide-bearing gas stream comprising a combustion gas comprising sulfur dioxide, oxygen and not more than 0.005 moles water vapor per mole SO_2;

contacting the sulfur oxide-bearing gas stream comprising said combustion gas with a catalyst for conversion of sulfur dioxide to sulfur trioxide, thereby converting the sulfur oxide-bearing gas stream to a conversion gas containing not more than 0.005 moles water vapor per mole SO_3;

contacting the conversion gas in a primary heat recovery absorption zone with an absorption liquid comprising sulfuric acid, thereby transferring sulfuric acid from the conversion gas to the absorption liquid;

introducing water vapor into the sulfur oxide-bearing gas upstream of the primary absorption zone with respect to the direction of gas flow in a proportion sufficient to increase the equivalent water vapor content of the gas to at least about 0.55 moles per mole total equivalent sulfur oxide gas content prior to entry of the gas stream into the primary absorption zone; and

circulating said absorption liquid between said primary absorption zone and an indirect heat exchanger in which heat generated by reaction of sulfur trioxide and water, condensation of sulfuric acid, and/or absorption of sulfur trioxide into the absorption liquid is transferred to a heat transfer fluid, thereby heating the heat transfer fluid to at least 150°C.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Fig. 1 is a process flow sheet for a prior art SO_3 absorption and absorption energy recovery system comprising primary and secondary countercurrent absorption zones, in which up to about one third of reaction water is supplied by injection of steam into the SO_3-bearing stream entering the primary zone;

[0037] Fig. 2 is a process flow sheet for an SO_3 absorption and absorption energy recovery system according to a preferred embodiment of the invention, comprising a primary heat recovery countercurrent absorption zone and a secondary countercurrent absorption zone, in which 95-100% of reaction and dilution water is supplied by injection of steam into the SO_3-bearing stream entering the primary zone;

[0038] Fig. 3 is a process flow sheet similar to that of Fig. 2 in which the circulating absorption acid is divided between a stream that is returned to the primary absorption zone