

[54] REDUCING NO_x EMISSIONS BY ADDITIVE INJECTION

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[22] Filed: Jan. 24, 1972
[21] Appl. No.: 220,161

[52] U.S. Cl. 431/4, 431/10
[51] Int. Cl. F23j 7/00
[58] Field of Search. 431/4, 10, 351; 44/68, 70

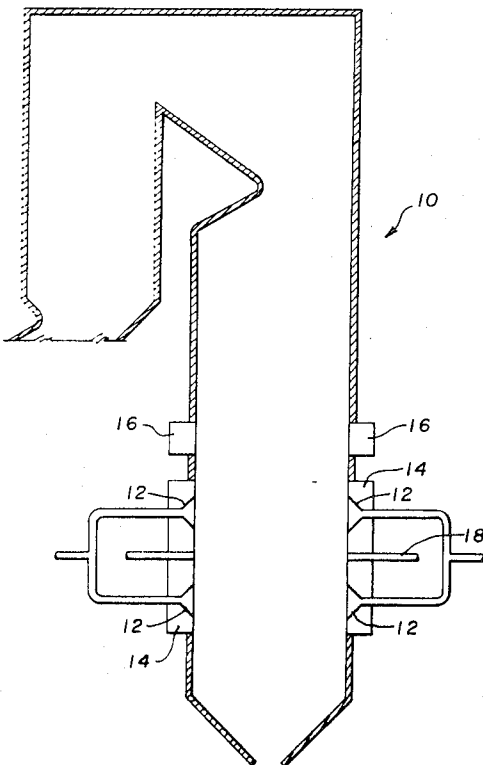
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942,055 11/1963 Great Britain 431/4

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[57] ABSTRACT

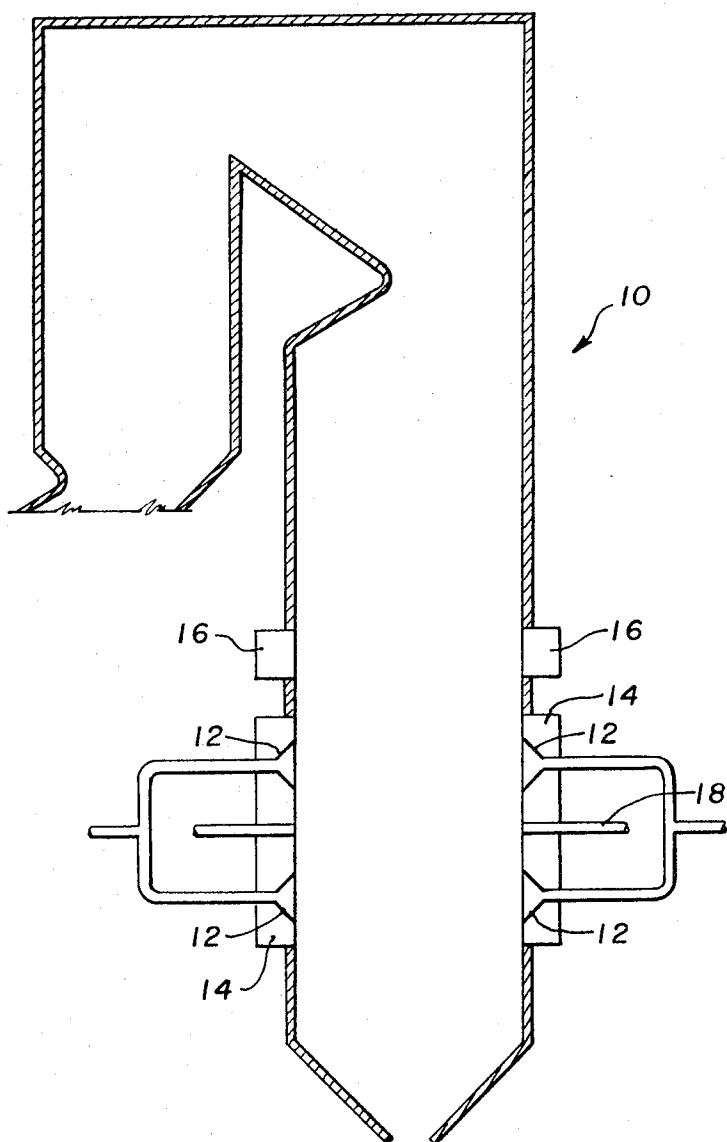
The nitrogen oxides formed during combustion processes are reduced by injecting materials into a fuel-rich combustion zone. These additives decompose to produce reducing agents such as hydrogen and carbon monoxide which in turn react with the nitrogen oxides to produce nitrogen. The additives may comprise formates and oxalates such as sodium formate and sodium oxalate. The carbonates which are formed are also useful to reduce sulfur oxide pollution.

6 Claims, 1 Drawing Figure



PATENTED JUL 17 1973

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REDUCING NO_x EMISSIONS BY ADDITIVE INJECTION

BACKGROUND OF THE INVENTION

The combustion of fuels produces a quantity of nitrogen oxides. The quantity of nitrogen oxides formed during the combustion process is primarily a function of the temperature developed during the combustion of the fuel. It has been determined that irritating atmospheric contaminants observed during smog conditions are primarily due to a photochemical reaction with organic materials in the presence of nitrogen oxides. Thus, one desirable means for reducing atmospheric contaminants, is to reduce the amount of nitrogen oxides which are formed during the combustion of fuels and discharged into the atmosphere. While the production of nitrogen oxides is small per unit of fuel burned, the large quantities of fuel consumed such as in central power plants makes even small reductions in the discharged nitrogen oxides highly desirable.

One of the methods which has been used in the past to reduce the amount of nitrogen oxides which are formed is the two-stage combustion process. In this process, the first-stage combustion is carried out under fuel-rich conditions, i.e., significantly less than the amount of air required for complete combustion is introduced into the first stage. The additional air required for complete combustion is then introduced at a second stage downstream in the combustion chamber from the first stage. The result of this two-stage combustion is that the maximum temperatures present in the combustion chamber are reduced. Since the formation of the nitrogen oxides is a temperature dependent reaction, the formation of the nitrogen oxides is also reduced. However, this particular procedure for reducing the formation of nitrogen oxides does not entirely solve the problem particularly in view of more stringent pollution control regulations which have recently been introduced or which may come into effect in the future.

SUMMARY OF THE INVENTION

An object of the present invention is to decompose nitrogen oxides which have been formed during the combustion process. This is accomplished by introducing additives into the combustion zone which will decompose and form reducing agents which will in turn react with the nitrogen oxides to reform the nitrogen. This is accomplished by introducing the additives into a fuel-rich combustion zone in which reducing conditions are present such that the reducing agents formed by the decomposition reaction will be available to react with the nitrogen oxides rather than with the free oxygen which would be present. The additives employed in the present invention are formates and oxalates.

BRIEF DESCRIPTION OF THE DRAWING

The drawing illustrates a furnace adapted to operate in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

It is well-known that nitrogen oxides are formed during combustion processes and that these nitrogen oxides contribute to air pollution problems. This subject and some measures which can be taken to reduce the amount of nitrogen oxides formed is discussed in the publication "Formation and Control of Oxides of Ni-

trogen in Combustion Processes" by J. D. Sensenbaugh, published by Combustion Engineering, Inc. and presented at the Air Pollution Training Course — Robert A. Taft, Sanitary Engineering Center, presented on Mar. 3, 1966 and identified as TIS-2772.

It is pointed out in this publication that the reactions for the formation of nitrogen oxides during combustion are temperature dependent reactions, i.e., the higher the temperature, the greater the amount of nitrogen oxides formed. Although the reactions for the formation of nitrogen oxides are reversible, the rapid quenching or cooling of the combustion products after initial combustion prevents the reverse reaction from being effective to reduce the concentration.

One procedure discussed in the above noted publication for controlling the amount of nitrogen oxides is two-stage combustion. This involves firing in the first stage or primary combustion zone with less than the theoretical air required for complete combustion. For example, 80–95 percent of the theoretical air may be introduced into the first stage. This fuel-rich firing reduces the maximum flame temperature and thus reduces the amount of nitrogen oxides formed. The remaining air to complete combustion is then introduced into the furnace at a second stage downstream of the first stage. Although this technique is of practical value in reducing nitrogen oxide emissions, it may not be the total answer as more stringent emission control requirements become effective.

The present invention is therefore directed to a method of further reducing the amount of nitrogen oxides formed by the introduction of additives and the invention will be described with reference to the drawing which illustrates an example of a furnace arrangement for practicing the invention. The furnace 10 contains burners 12 which fire into a furnace zone which will be referred to as the first stage combustion zone. The first stage combustion air is introduced into the furnace adjacent the burners 12 from the air chamber 14. The second stage combustion air is introduced into the furnace from the air chamber 16 which is downstream of the first stage.

The additives employed in the present invention are materials which will decompose in the combustion environment to form reducing materials which will react with and reduce the nitrogen oxides to form nitrogen. These additives are formates and oxalates which may be selected from the following list which also indicates the decomposition temperatures taken from the "Handbook of Chemistry & Physics", 45th Edition, published by The Chemical Rubber Co., 1964.

Oxalates

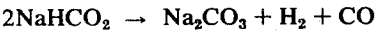
	Decomposition Temperature °C
Iron (II)	190
(III)	100
magnesium	150
calcium	
barium	400
manganese (II)	150
zinc	100
lithium	
ammonium	
cadmium	340
sodium	250–270

Roman numerals in parenthesis indicate valence state.

Formates

	°C
calcium	
barium	
manganese	
potassium	>170
zinc	>140
lithium	230
ammonium	180
cadmium	
sodium	>253

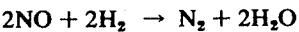
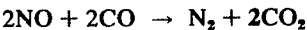
The preferred materials from this list are the sodium, ammonium, magnesium and calcium compounds for reasons which will be explained hereinafter. The invention will be further described with reference to sodium. Sodium formate decomposes at about 253°C according to the following reaction:



Sodium oxalate decomposes as follows:



The additives are introduced into the first stage combustion zone in which there is a deficiency of oxygen through the nozzles 18. Since there is a deficiency of oxygen in this zone, the carbon monoxide and hydrogen available from either the additive or the fuel will be competing for the oxygen available in the nitrogen oxides. This has the effect of increasing the concentration of the reducing agents, carbon monoxide and hydrogen, in the immediate proximity of the nitrogen oxides as they are formed by the combustion process. This will tend to increase the probability of the carbon monoxide and hydrogen molecules coming into contact with the nitrogen oxides such that the following reactions occur:



The time lag that is provided by the decomposition reaction will permit the primary combustion process to consume the available oxygen and form the nitrogen oxides such that the primary source of oxygen for reaction with the reducing agents will be the oxygen that is combined with the nitrogen.

A further benefit from the use of additives such as sodium, ammonium, calcium, and magnesium formates is that the corresponding carbonate formed is beneficial in certain sulfur oxide removal systems. For example, the sodium carbonate which is formed will be calcined

in the furnace to form sodium oxide which can then be reacted with sulfur oxides such as in flue gas wet scrubbing systems.

While preferred embodiments of the invention have been shown and described, it will be understood that they are by way of example only and that changes may be made without departing from the spirit and scope of the invention as claimed.

What is claimed is:

1. A method for reducing the nitrogen oxides emitted into the atmosphere from a furnace having a first stage combustion zone and a second stage combustion zone downstream from said first said stage combustion zone comprising the steps of:

- a. introducing fuel to said first stage combustion zone;
- b. introducing first stage combustion air into said first stage combustion, said first stage combustion air being less than that required for complete combustion of said fuel whereby said fuel is partially combusted and whereby nitrogen oxides are formed;
- c. introducing an additive into said first stage combustion zone, said additive being selected from materials which decompose under furnace operating conditions to form reducing agents which reduce said nitrogen oxides; and
- d. introducing second stage combustion air into said second stage combustion zone.

2. A method as recited in claim 1 wherein said additive is selected from the group consisting of formates and oxalates.

3. A method as recited in claim 2 wherein said formates and oxalates are selected from the group consisting of sodium, ammonium, magnesium, and calcium formates and oxalates.

4. A method as recited in claim 1 wherein said first stage combustion air comprises between about 80 and 95 percent of the theoretical air required for complete combustion.

5. A method as recited in claim 1 wherein said additive comprises a formate selected from the group consisting of calcium, barium, manganese, potassium, zinc, lithium, ammonium, cadmium and sodium formate.

6. A method as recited in claim 1 wherein said additive comprises an oxalate selected from the group consisting of iron, magnesium, calcium, barium, manganese, zinc, lithium, ammonium, cadmium and sodium oxalate.

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