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EUROPEAN PATENT APPLICATION

21 Application number: 84304239.1

51 Int. Cl.⁴: **C 10 L 10/00**

22 Date of filing: 22.06.84

30 Priority: 22.06.83 GB 8316937

43 Date of publication of application:
02.01.85 Bulletin 85/1

84 Designated Contracting States:
AT BE CH DE FR IT LI LU NL SE

71 Applicant: **Hardy, Leonard Rhys**
"Meadford", Leicester Lane
Desford Leicester LE9 9JJ(GB)

71 Applicant: **Ayre, Richard Geoffrey**
Bybrook Farm
Thurcaston Leicester(GB)

72 Inventor: **Hardy, Leonard Rhys**
"Meadford", Leicester Lane
Desford Leicester LE9 9JJ(GB)

72 Inventor: **Ayre, Richard Geoffrey**
Bybrook Farm
Thurcaston Leicester(GB)

74 Representative: **Hallam, Arnold Vincent et al,**
E.N. LEWIS & TAYLOR 144 New Walk
Leicester LE1 7JA(GB)

54 **Improvements in and relating to combustion.**

57 During operation of a fossil fuel boiler the combustion process results in the deposition in the boiler flues and heat transfer pipes of scale, smut and soot and other solid products which have a serious effect on boiler efficiency. Regular cleaning therefore has to be undertaken in order to maintain a reasonable standard of boiler efficiency and this is both expensive and time consuming. The present invention introduces controlled amounts of ferric oxide (Fe₂O₃) the effect of which is to inhibit the deposition of further solid combustion products such as scale, soot and smut and also to alter the character of existing scale, reducing its adhesion and causing the scale to fall away. The effect is to improve boiler efficiency and reduce maintenance costs.

as above stated.

Title: Improvements in and relating to combustion

Abstract:

The present invention relates to the reduction of undesirable combustion by-products in boilers, incinerators and similar plant.

5 A major problem associated with the combustion of fossil fuels in, for example, boilers is the considerable amount of adherent scale, soot and smut deposits which build up in the boiler combustion chambers, flue systems and chimneys. The effect of these
10 deposits in the boiler tubes is to reduce boiler heat transfer rates dramatically, resulting in considerable increases in fuel consumption. Regular cleaning by vigorous mechanical means to remove these deposits is therefore necessary to maintain a reasonable level of
15 boiler efficiency, which causes damage to the tubes and is both time consuming and expensive. Also, this often requires the use of a "back-up" boiler while the main boiler is shut down for cleaning. Additionally, smut deposits within the flue
20 passes become entrained in the flue gases during load fluctuations causing smut emission and deposition in the immediate locality.

The above-mentioned problems are well known in the art and many attempts have been made to overcome them.

For example, organic compounds containing metals such as lead, cobalt, manganese, copper, nickel and chromium chromium can under certain conditions function as soot destroyers or combustion aids and it has been proposed
5 to add these metals to fuels to provide for more complete combustion of the fuel to CO_2 and H_2O . However, the relatively large amounts of these metals which must be added to the fuel to give a significant improvement causes the fuel to become so unstable that the catalytic
10 properties of these metals cannot be used. This effect can be offset by adding stabilisers or antioxidants to the fuel but again, large amounts are required which renders this economically impractical and gives rise to further disadvantageous secondary effects.

15 It has also been proposed to add lead or cobalt soaps to fuel, to reduce soot but again considerable problems are caused by the resulting unwanted byproducts.

It has also been suggested that a mixture of compounds of manganese
20 or copper and lead, cobalt, nickel, zinc, chromium, antimony, tin or vanadium in specified proportions can prove effective, in improving the burning properties of fuel without serious side effects and that the improvement is not obtained when using a compound of
25 only one of the metals.

Accordingly the present invention provides a combustion process comprising passing combustion air over an ignited fossil fuel in a combustion chamber and prior to or during combustion introducing into the combustion chamber finely divided iron oxide which acts during combustion to reduce the amount of solid combustion by-products deposited in flue passes and chimneys of the combustion chamber during the combustion process.

Preferably the substance is introduced during the combustion process, although it may also be introduced prior to combustion in the fuel.

A preferred substance is sesquioxide of iron ($\text{Fe}_2 \text{O}_3$).

The present invention stems from the unexpected discovery that the addition into the combustion zone of finely divided iron oxide particles alone or mixed with an inert material in small quantities significantly reduces the formation and deposition of scale, smut and other solid combustion by-products and also acts to reduce existing scale. This results in the maintenance of heat transfer rates for very much longer periods and improved plant performance than in the absence of the substance with consequent saving in fuel consumption and maintenance costs.

Finely divided iron is introduced into the combustion chamber in any suitable manner, conveniently in the form of ferric oxide (Fe_2O_3) or in some other form which converts to ferric oxide under the conditions in the combustion chamber. The substance is preferably blown into or over the combustion zone repeatedly over short periods of time at intervals as desired, as a fine powder during combustion either in the combustion air or separately. The quantity of ferric oxide required to achieve the desired effect is very small, depending on the quality and type of the fuel. The substance may alternatively or additionally be added to the fuel itself and although the substance is described as being added during combustion it will be appreciated that quantities can be added prior to combustion. The substance may also be added continuously if desired and can be in the form of a powder, a suspension in a substantially inactive or combustible liquid, or in the form of small pellets.

The dosage rate of the substance is a minimum of 0.1134 Kg (0.25 lbs) to 0.4536 Kg (1 lb) per tonne of coal consumed, or the therm equivalent of oil, gas and other fossil fuels, a preferred range being 0.1134Kg to 0.4536 Kg (1lb).

The quantities of substance injected into the combustion chamber, because they are so small, can be more easily controlled by first mixing the substance intimately

with a neutral powder. This also aids dispersion of the substance throughout the chamber. A diluent powder composed, for example, of bentonite, synthetically organically modified bentonite, dolomite or calcined dolomite or other finely divided diluent powder which is inactive i.e. does not adversely affect the process of the present invention may be used.

In the combustion chamber itself, during combustion the ferric oxide causes an alteration in the character of existing scale deposits within the chamber, flue passes and chimney, the deposits becoming friable and easily removed. The property of the scale which causes it to adhere strongly to the boiler heat transfer surfaces, ducts and chimneys is reduced as a result of which the scale becomes detached from these areas and falls away, allowing for a greater rate of heat transfer and therefore increased boiler efficiency and performance. In addition, since this avoids the need for abrasive cleaning methods the life of the boiler tubes is improved. Further scale formation is reduced and the soot and carbonaceous content of deposits in the tubes and flues is reduced enabling easier removal. Soot content is also reduced in the boiler flue deposits resulting in a generally free-flowing powder which is easily removed and contains fewer oil and other carbon compounds. Acid smut emission due to entrainment of smut in the flue gases is considerably reduced.

The overall effect, therefore, is a cleaner combustion chamber, flue passes and chimneys resulting in the maintenance of the boiler at higher efficiency and performance for long periods with consequently lowered fuel costs, a significant reduction in the cost of maintenance and cleaning and reduction in smut emission due to entrainment.

The term "oxide" as used herein means one or more of the following: a suboxide, oxide of known valency, super-oxide, peroxide, hydroxide, hydrated oxide or carbonate.

The following examples are typical of the results achieved by the process of the present invention in some 30 installations involving Thompson, Cochran, Danks, Hartley & Sugden, Centrax, Robey, Vekos and Trianco boilers of various capacities for industrial and domestic use.

Example 1

A mixture of iron oxide (Fe_2O_3) as 30% by weight in an inactive finely divided naturally occurring clay powder was injected into the combustion chamber of a Colifax Hot Water boiler in the proportion of 0.227 Kg (0.5 lbs) weight of the mixture to each tonne of coal consumed. The powder was injected every 3 hours for the requisite period to achieve the above dose rate.

The boiler had not been cleaned prior to the use of the powder and contained adherent scale.

The boiler efficiency as measured by flue gas analysis and temperature method improved from 65% to 71% over a
5 period of 6 days and was associated with the removal of substantially all the adherent scale.

The reduction in the carbonaceous content of the boiler flue passes was some 50% as measured in before and after conditions.

10 Example 2

A mixture of iron oxide (Fe_2O_3) as 25% by weight in an inactive powder was injected as for Example 1 into the combustion chambers of three Centrax coal-fired boilers over a period of 6 months. The boilers became free from
15 adherent scale within the first 3 to 4 weeks and the flue deposits become substantially free from soot and greasy smut which made them extremely free flowing and easily removed.

Heavy falls of hard sooty scale occurred in the breach
20 ducts and stack which, once removed, left the passes in an almost new condition.

Fuel savings of 11% overall were recorded after allowing for seasonal differences in ambient conditions.

Example 3

A 100% mixture of iron oxide ($\text{Fe}_2 \text{O}_3$) was used by injection or added to the coal in a number of smaller coal-fired domestic boilers over a period of some 6 months. All boilers, although
5 initially heavily contaminated with scale and soot deposits soon became substantially free of deposits with very little cleaning being necessary (and then only with a brush) once the main detached scale debris was removed.

Example 4

10 A 40% mixture of iron oxide ($\text{Fe}_2 \text{O}_3$) mixed with a neutral clay based powder was injected into the combustion chamber of a Thermax oil fired (3500 secs.) boiler at the rate of 0.1134 Kg (0.25 lbs.) per 300 galls. of oil consumed. Although new, prior to the injection of the iron
15 oxide mix the boiler was subject to heavy deposition of hard scale on the flue side of the boiler tubes which was difficult to remove and meant that the boiler had to be shut down monthly for cleaning.

The injection of the iron oxide mixture removed
20 the hard scale and prevented further formations. As a result the boiler was operated for a period of 4 months without any deterioration in performance or shut down for cleaning being necessary.

An accurate evaluation of the fuel savings achieved by the use of iron oxide (Fe_2O_3) is difficult to establish because of the many variables involved and the well known difficulties encountered in monitoring boiler performance accurately even with the most sophisticated instrumentation. It will be appreciated, however, that it is self evident that a boiler which is free from adherent scale, soot and smutty products will give a substantially better performance than one which is not free of such deposits and the boiler condition will be obvious on inspection and sophisticated instrumentation would not be required to establish this.

CLAIMS:

1. A combustion process comprising passing combustion air over an ignited fossil fuel in a combustion chamber and prior to or during combustion introducing into the combustion chamber finely divided iron oxide which acts during combustion to reduce the amount of solid combustion by-products deposited in flue passes and chimneys of the combustion chamber during the combustion process.
2. A combustion process as claimed in claim 1 wherein said iron oxide is ferric oxide (Fe_2O_3).
3. A combustion process as claimed in claim 1 or 2 wherein said iron oxide is introduced during the combustion process.
4. A combustion process as claimed in any of claims 1 to 3 wherein said iron oxide is introduced into the combustion chamber as a powder.
5. A combustion process as claimed in any of claims 1 to 4 wherein prior to the introduction of said iron oxide into the combustion chamber the iron oxide is mixed substantially uniformly with a substantially inert material.

6. A combustion process as claimed in claim 5 wherein said iron oxide is a finely divided powder and is uniformly mixed with a diluent powder selected from at least one of the following: bentonite, synthetically
5 organically modified bentonite, dolomite, calcined dolomite.

7. A combustion process as claimed in any of claims 1 to 6 wherein said iron oxide is mixed with a combustible liquid to inhibit coagulation.

- 10 8. A combustion process as claimed in any of claims 1 to 7 wherein said iron oxide is introduced into the combustion chamber over the fuel combustion area.

9. A combustion process as claimed in any of claims 1 to 8 wherein said iron oxide is introduced into the
15 combustion chamber for a preselected time period at preset intervals of time.

10. A combustion process as claimed in claim 1 and substantially as hereinbefore described.



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. C. 3)
X	FR-A-2 510 237 (STEINMULLER) * claims 1-3; figure 1 *	1-4, 8, 10	C 10 L 10/00
A	US-A-4 191 115 (YANG et al.) * claims 1,5-7,11-15 *	5,6	
A	GB-A-1 335 462 (V.P. CHEMICALS) * claims 1-7 *	7	
A	DE-A-2 361 091 (GÖRGÜN GEB. BAYKAM) * claims 1,2 *	1,2,5,6	
			TECHNICAL FIELDS SEARCHED (Int. C. 3)
			C 10 L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14-09-1984	Examiner MEERTENS J.
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			