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**Datasheet for the decision
of 6 September 2011**

Case Number: T 0433/09 - 3.3.05

Application Number: 03778632.4

Publication Number: 1572327

IPC: B01D 53/86

Language of the proceedings: EN

Title of invention:

System and method for controlling NO_x emissions from boilers
combusting carbonaceous fuels without using external reagent

Patentee:

Foster Wheeler Energy Corporation

Opponent:

Metso Power Oy

Headword:

NO_x/FOSTER WHEELER

Relevant legal provisions:

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Relevant legal provisions (EPC 1973):

EPC Art. 56

Keyword:

"Inventive step (all requests): no - obvious alternative"

Decisions cited:

-

Catchword:

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Case Number: T 0433/09 - 3.3.05

D E C I S I O N
of the Technical Board of Appeal 3.3.05
of 6 September 2011

Appellant: Foster Wheeler Energy Corporation
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 8 December 2008
revoking European patent No. 1572327 pursuant
to Article 101(3)(b) EPC.

Composition of the Board:

Chairman: G. Rath
Members: J.-M. Schwaller
G. Weiss

Summary of Facts and Submissions

- I. This appeal lies from the decision of the opposition division revoking European patent No. 1 572 327.
- II. In the contested decision, the opposition division held the subject-matter of claim 10 of the main and first auxiliary requests then on file to lack novelty over the disclosure of document:

S1: EP 0 384 295.

The opposition division further held the content of document S1 to render obvious to a person skilled in the art the subject-matter of claim 1 of the second and third auxiliary requests.

- III. With its statement setting out the grounds of appeal dated 9 April 2009, the patent proprietor (hereinafter the "appellant") submitted three sets of claims as a main request and as first and second auxiliary requests.

Independent claim 1 of the main request reads as follows:

"1. A method for controlling NO_x emissions from a boiler that combusts carbonaceous fuels, the method comprising the steps of:

- (a) introducing carbonaceous fuel and combustion air into a furnace of the boiler for combusting the carbonaceous fuel in oxidizing conditions and producing flue gas that includes NO_x and CO; and*
- (b) leading flue gas from the furnace to a catalyst*

section disposed downstream from a heat transfer section in a flue gas channel for converting, free from introducing an external agent for NO_x reduction, NO_x to N₂ and CO to CO₂ on a catalyst in the catalyst section, wherein step (a) further comprises adjusting the operating conditions in the furnace so as to decrease the molar concentration of NO_x and to increase the molar concentration of CO at the furnace exit so that the molar concentration of CO at the furnace exit is at least 70% of the molar concentration of NO_x."

Claim 1 of the first auxiliary request reads as follows (differences to claim 1 of the main request shown in bold):

*"1. A method for controlling NO_x emissions **from a PC boiler or a CFB boiler** that combusts **solid** carbonaceous fuels, the method comprising the steps of:*
(a) introducing carbonaceous fuel and combustion air into a furnace of the boiler for combusting the carbonaceous fuel in oxidizing conditions and producing flue gas that includes NO_x and CO; and
(b) leading flue gas from the furnace to a catalyst section disposed downstream from a heat transfer section in a flue gas channel for converting, free from introducing an external agent for NO_x reduction, NO_x to N₂ and CO to CO₂ on a catalyst in the catalyst section, wherein step (a) further comprises adjusting the operating conditions in the furnace so as to decrease the molar concentration of NO_x and to increase the molar concentration of CO at the furnace exit so that the molar concentration of CO at the furnace exit is at least 70% of the molar concentration of NO_x."

Claim 1 of the second auxiliary request reads as follows (differences to claim 1 of the first auxiliary request shown in bold or struck through):

"1. A method for controlling NO_x emissions from a PC boiler or CFB boiler that combusts solid carbonaceous fuels, the method comprising the steps of:

(a) introducing carbonaceous fuel and combustion air into a furnace of the boiler for combusting the carbonaceous fuel in oxidizing conditions and producing flue gas that includes NO_x and CO; and

*(b) leading flue gas from the furnace to a catalyst section disposed downstream from a heat transfer section in a flue gas channel for converting, free from introducing an external agent for NO_x reduction, NO_x to N₂ and CO to CO₂ on a catalyst in the catalyst section, wherein step (a) further comprises adjusting the operating conditions in the furnace so as to decrease the molar concentration of NO_x and to increase the molar concentration of CO at the furnace exit so that ~~the molar concentration of CO at the furnace exit is at least 70% of the molar concentration of NO_x~~ **the ratio of the molar concentration of CO and NO_x at the furnace exit is from about 1 to about 3"**.*

IV. In reply dated 1 September 2009 to the grounds of appeal, the opponent (hereinafter the "respondent") contested the newly filed claims under Article 56 EPC, arguing inter alia lack of inventive step over S1,

S5: US 4 562 795, or

S6: US 5 676 912.

V. At the oral proceedings, which were held on 6 September 2011, the issue of inventive step was extensively dealt with as regards the three requests on file.

VI. The parties' requests were established as follows:

The appellant requested that the decision be set aside and that the patent be maintained on the basis of the claims filed as main request on 9 April 2009, or alternatively on the basis of the claims according to the first or second auxiliary requests, also filed on 9 April 2009.

The respondent requested that the appeal be dismissed.

Reasons for the Decision

1. *Remark*

The scope of claim 1 of the second auxiliary request being the most restrictive in comparison to that of the claims 1 of the higher-ranking requests and - as can be seen from point 2 below - the board being of the opinion that the subject-matter of claim 1 of the second auxiliary request lacks inventive step, this issue will be dealt with first.

2. *Second auxiliary request - Inventive step*

2.1 The alleged invention concerns a method and system for controlling the NO_x levels in flue gases emitted from boilers combusting carbonaceous fuels, with the NO_x control scheme being free from injecting an external NO_x reducing agent.

2.2 Concerning the starting point for assessing inventive step, the question arises as to which of document S1, S5 or S6 represents the closest state of the art.

2.2.1 S1 (claim 1; description, column 1, lines 1 to 6) discloses a process for reducing noxious emissions (NO_x , SO_2 , CO, residual hydrocarbons) from a fossil fuel combustion process, wherein the combustion temperature is reduced by cooling the flame and in that one or more honeycomb catalysts are located before and after the first heating surfaces in the flue gas flow path. It is noted that the catalytic conversion according to S1 is operated without the introduction of an external agent for NO_x reduction.

In the specific example disclosed at column 6, lines 42 to column 7, line 14, the flue gas exiting from a boiler ("Heizkessel") fired with oil and operating under oxidising conditions with 17% of excess air ("Luftzahl 1.17") is treated by an oxidation catalyst on which CO is converted into CO_2 . In the boiler's combustion chamber - i.e. also at the combustion chamber exit - the CO concentration is between 100 and 200 ppm, and after the catalyst section the CO concentration drops to between 2 and 10 ppm. At the same time, the NO_x concentration before and after the catalyst section is between 20 and 40 ppm. Accordingly, at the boiler's furnace exit, the ratio of CO/NO_x is between 2.5 and 10, i.e. above the value (0.7) defined in claim 1 at issue.

The board observes that:

- the above oxidation catalyst is supposed to convert NO_x into nitrogen (S1, column 4, lines 41 to 47 and column 5, lines 1 to 7). However, owing to the fact that in the above example the NO_x concentration is described as being between 20 and 40 ppm before **and** after the catalyst section, it is not possible to conclude directly and unambiguously that any NO_x molecule had been converted into N₂ in this example.

- the oxidation catalyst is located before the first heating surfaces ("Berührungsheizflächen") - i.e. upstream from the heat transfer section - and not downstream as in the subject-matter of claim 1 at issue.

In view of these distinguishing features compared with the subject-matter according to claim 1, the board judges that this state of the art cannot represent the starting point for assessing inventive step.

2.2.2 As to document S6, the board comments as follows:

S6 relates to a process for treating exhaust gases from internal combustion engines (column 1, lines 5 to 7). In one embodiment (S6, column 5, lines 46 to 59), the exhaust gas is passed through a first zone containing a three-way catalyst effective to simultaneously catalytically reduce the NO_x and oxidise CO and residual hydrocarbons, then through a second zone containing a hydrocarbon sorbent and finally through a third zone containing a second catalyst. In order to allow a high degree of conversion of NO_x, hydrocarbons and CO over the three-way catalyst, the exhaust gas should have a

redox ratio, i.e. a mole ratio of reducing agents (such as CO, hydrocarbons and hydrogen) to oxidising agents (such as NO_x and oxygen), of about 1, e.g. between 0.9 and 1.1 (S6, column 6, lines 47 to 55).

The process according to S6 is also suitable for treating industrial exhausts produced e.g. in coal-, gas- or oil-fired furnaces or boilers (column 4, lines 49 to 54).

However, S6 **does not disclose** any adjustment of the operating conditions in the furnace or boiler so as to decrease the molar concentration of NO_x and to increase the molar concentration of CO at its exit, let alone that the molar ratio of CO and NO_x at the furnace exit is between about 1 to about 3.

So S6 is not an appropriate starting point for assessing inventive step.

- 2.2.3 S5 (claim 1) discloses a process for reducing the emission of pollutants in flue gases from a furnace to provide a selected thermal output comprising the steps of providing a first combustion stage and a second combustion stage, supplying excess air and fuel into the first combustion stage, flowing the flue gases with residual oxygen therein from the first combustion stage into the second combustion stage and supplying additional fuel into the second combustion stage in the stoichiometric range based on the residual oxygen for effecting combustion therein with the first and second combustion stages providing the combustion heat for the selected thermal output of the furnace, and supplying the preponderant amount of the combustion heat in the

first combustion stage in a conventional combustion operation with the excess air adapted to the fuel utilised, and catalytically reducing nitrogen oxides in the flue gases from the second combustion stage into nitrogen.

In the specific embodiment described at column 6, line 36 to column 7, line 47 and Figure 1, the furnace belongs to a steam boiler installation operated with an excess air of 15% (λ equal to 1.15) and fired with pulverised coal - i.e. a PC boiler - as in claim 1 at issue. The pollutants contained in the flue gas, namely unburned hydrocarbons, carbon monoxide and nitrogen oxides, are catalytically converted into carbon dioxide, water vapour and nitrogen on a reduction catalyst - a multi-functional platinum-rhodium three-way catalyst (S5; column 7, lines 13 to 19) - located downstream from the superheater surfaces 27 and feedwater preheater surfaces 28 (see Figure 1). So in S5 the catalyst is located downstream from the heat exchange section, as in claim 1 at issue.

The above boiler is operated with an excess air of 15%, i.e. within the terms of the most preferred range of from about 13% to about 20% described in paragraph [0032] of the contested patent. The contested patent explains (paragraph [0031]; Figure 1) that under such excess air levels the molar concentration of NO_x at the furnace exit is decreased and that of CO is increased.

The appellant argued that the process according to S5 differed from the subject-matter of claim 1 at issue, because the fuel gas introduced upstream from the three-way catalyst was an "external agent for NO_x

reduction" in the sense of claim 1 at issue. The board cannot accept this argument because - as explained in S5 (column 7, lines 6 to 9) - said fuel gas is added upstream from an oxidation catalyst 12 whereon the fuel gas is **completely burnt to CO₂ and H₂O**. So an "external agent for NO_x reduction" no longer remains in the flue gas to be converted on the three-way catalyst 13 located downstream from the oxidation catalyst. Furthermore, as explained in S5 (column 2, lines 15 to 21), one of the main objects of document S5 is precisely the catalytic removal of the nitrogen oxides **without addition of extraneous substances**, as in claim 1 at issue.

In view of the above, since document S5 discloses all the features of the subject-matter claimed, except the molar ratio between CO and NO_x at the furnace exit of the boiler, the board holds this document to represent the closest state of the art for assessing inventive step.

- 2.3 Starting from S5 as the closest state of the art, the question now arises as to which problem is supposed to be solved by the subject-matter claimed. The patent in suit (paragraphs [0011] to [0013] defines the latter as the provision of a process for controlling NO_x emissions from boilers combusting carbonaceous fuels, including a simple and advanced system-level integration between the combustion process and downstream flue gas NO_x reduction, maintaining high thermal efficiency of the boiler without increased emissions of other pollutants and without utilising an external agent for NO_x reduction.

The board observes on the one hand that the above objectives - which are formulated in broad and ambiguous terms - appear to have already been solved by the process disclosed in document S5. On the other hand, no quantitative comparison between the closest state of the art and the subject-matter claimed has ever been proposed by the parties, and therefore it cannot be assessed whether the process claimed provides for any improvement with respect to the process known from S5.

The appellant argued that the claimed subject-matter made possible the use of a catalyst functioning at a relatively low temperature. However, in view of the fact that the multifunctional platinum-rhodium three-way catalyst defined in S5 is of the same type as those exemplified at page 5, lines 20 and 21 of the patent in suit, namely one "formed of either platinum or palladium together with rhodium on a ceramic or metal substrate", this particular problem cannot apply.

Under these circumstances, the problem at the basis of the contested patent has to be reformulated in less ambitious terms as the provision of **an alternative process** for controlling NO_x emissions from boilers combusting carbonaceous fuels without using an external agent for NO_x reduction.

- 2.4 As a solution to this technical problem, the patent proposes the process according to claim 1, characterised in that the operating conditions in the furnace are adjusted so that the ratio of the molar concentration of CO and NO_x at the furnace exit is from about 1 to about 3.

2.5 The board is satisfied that the above problem is solved by the claimed process.

2.6 It remains to be decided whether the proposed solution is obvious in view of the state of the art.

2.6.1 Document S5 does not explicitly disclose the CO/NO_x molar ratio in the flue gas. However, owing to the fact that the excess air (15%) in the combustion process exactly falls within the most preferred range of from about 13% to about 20% described in paragraph [0032] of the contested patent, there is a high probability that the CO/NO_x molar ratio is close to or even falls within the range defined in claim 1 at issue. In the absence of a direct and unambiguous disclosure or teaching in S5 for the molar ratio claimed, it cannot however be concluded that S5 alone suggests the solution to the problem.

2.6.2 The skilled person starting from S5 and faced with the problem defined under point 2.3 is nevertheless aware of the content of document S6 (see item 2.2.2) which in particular discloses that to allow a high conversion degree of NO_x, hydrocarbons and CO over a three-way catalyst the exhaust gas contacting the catalyst should have a molar ratio of reducing agents (such as CO, hydrocarbons and hydrogen) to oxidising agents (such as NO_x and oxygen) of about 1 (S6, column 6, lines 47 to 55).

2.6.3 In this context, the skilled person faced with the above problem finds in the above teaching a strong incentive to adjust to about 1 the redox ratio of the

exhaust gas passing on the three-way catalyst in the process according to S5.

The board observes that the flue gas in the process according to S5 is not described as containing any appreciable amount of hydrogen and, as further explained in S5 (column 7, lines 6 to 9), the excess oxygen in the flue gas from the boiler is used to completely burn on the oxidation catalyst 12 the fuel gas added upstream from the three-way catalyst and so the gas entering the three-way catalyst 13 should not contain any appreciable amount of oxygen. It follows that the molar ratio of reducing agents to oxidising agents in the flue gas entering the three-way catalyst in the process according to S5 equals the molar ratio of $(\text{CO} + \text{hydrocarbons})/\text{NO}_x$.

Bearing in mind that the skilled person is encouraged by S6 to optimise this ratio to about 1, he would arrive without inventive skill at subject-matter falling within the terms of claim 1 at issue, because as explained in paragraph [0028] of the contested patent the CO/NO_x molar ratio defined in claim 1 at issue also includes the contribution of the residual hydrocarbons contained in the flue gas. Therefore, the optimised mole ratio of reducing agents to oxidising agents in the flue gas entering the three-way catalyst in the process according to S5 is equivalent to the "CO/NO_x" molar ratio defined in claim 1 at issue. It follows that the subject-matter of claim 1 of this request is obvious in view of the disclosure of document S5 taken in combination with the teaching of document S6, and lacks inventive step under Article 56 EPC 1973.

3. *Higher-ranking requests*

The scope of claim 1 of each of these requests is broader than that of claim 1 of the second auxiliary request. Since claim 1 of the second auxiliary request lacks inventive step for the reasons indicated above, the subject-matter of claims 1 of the main request and of the first auxiliary request also lacks inventive step (Article 56 EPC 1973) for the same reasons.

4. Due to the fact that none of the above requests can be allowed, the appeal cannot be successful.

Order

For these reasons it is decided that:

The appeal is dismissed

The Registrar:

The Chairman:

C. Vodz

G. Rath