

Description

This invention relates to a boiler steam temperature controller and a method of controlling the temperature of steam in a boiler.

Steam temperature control in a drum type boiler is difficult due to time lags and delays built into the design of the process. There are time delays between the location of an attenuator spray and its effect on final steam temperature leaving a secondary superheater. Time lags are also caused by the heat transfer characteristics of the superheater metals and the steam itself.

Any control with relatively long time constants (two minutes or longer) will operate in a more stable fashion if open loop predictive (feedforward) methods are employed to present the controlled medium. In addition, if intermediate control points are useful and somewhat predictive of the final steam temperature, then these are also useful in a cascade method of control.

Almost all drum type boilers are designed to have a generally rising uncontrolled secondary superheater outlet temperature profile with increasing boiler load. The design usually is such that the unit does not have to reach the required main steam outlet temperature at loads below 50% boiler load, and therefore is not controlled at these loads. Above such a load, the excess superheat temperature is "sprayed out" by the spray attenuator.

Classical control techniques commonly used in steam temperature control systems are feedforward, feedback using a proportional plus integral plus derivative (PID) controller, cascade, and anti-integral windup.

Figure 4 shows a previously proposed steam temperature control system. A feedforward predictor 20 presets an expected secondary superheater inlet temperature (T2) in accordance with a predicted load program 22. This prediction is then modified by the difference or deviation 24 between the firing rate required for a given boiler load and the actual firing rate. Overfiring raises temperature and underfiring reduces temperature.

A similar modifier 26 accounts for excess air (air flow deviation) which will also cause temperature to rise as air flow is increased.

A third modifier 28 accounts (compensates) for any reheat temperature control that may impact upon the superheat temperature.

The feedforward predictor 20 generates a set point for a secondary superheater inlet temperature cascade controller 30.

Since no feedforward is perfect, a final trim or correction is applied from the secondary superheater outlet temperature (T1) through a feedback controller 32. The final trim is effected through a

conventional proportional plus integral plus derivative (PID) controller 34 which compares the final steam temperature to the desired setpoint.

Because of the time delay and time lag, a standard proportional plus integral controller will either be detuned, providing a slow, sluggish control, or be unstable.

As the response time characteristics will vary with load, the control adjustments are usually set as a compromise between high and low load settings.

To prevent the controller from integrating when the spray valve is closed at low loads, controller limits are developed to prevent the PID controller from integrating upwardly.

Thus, the classical control system does not address two vital problems, namely true time delay and control tuning parameters which change with load.

US Patent No. US-A-4 549 503 discloses a boiler steam temperature controller provided with a feedback correction control means, in which an expected secondary superheater inlet temperature is preset on the basis of the boiler load, and the expected inlet temperature is corrected to allow for deviations between required and actual operational parameters, final feedback correction of the expected inlet temperature being effected on the basis of the secondary superheater outlet temperature. The disclosed controller is unable to compensate for true time delay in the temperature control path; neither can the tuning parameters of the feedback corrector be changed in accordance with boiler load.

According to the invention there is provided a boiler steam temperature controller for a boiler having means for changing the inlet temperature to a secondary superheater of the boiler, the controller comprising:

a feed forward predictor for presetting an expected secondary superheater inlet temperature with a boiler load and for generating a secondary superheater inlet temperature cascade controller set point;

a first modifier means for correcting said expected inlet temperature for deviation between a firing rate required for the boiler load and an actual firing rate;

a second modifier means for correcting said expected inlet temperature for deviation of an air flow rate required for the firing rate for the boiler load and an actual air flow rate;

a third modifier means for correcting said expected inlet temperature for reheat temperature control;

a feedback correction control means for final correction of said expected inlet temperature; and

a cascade control means responsive to the

secondary superheater inlet temperature, said feedforward predictor and said feedback correction control means for controlling the means for changing the secondary superheater inlet temperature on the basis of the finally corrected expected inlet temperature;

characterised in that the feedback correction control means comprises time delay control means responsive to the secondary superheater outlet temperature for correcting said expected inlet temperature with a controlled delay, and an adaptive controller for tuning the time delay control means according to boiler load variations.

According to the invention there is also provided a method of controlling the temperature of steam in a boiler having a secondary superheater, the method comprising the steps of:

presetting an expected secondary superheater inlet temperature with a boiler load;

generating a secondary superheater inlet temperature cascade controller set point;

correcting said expected inlet temperature for deviation between a firing rate required for the boiler load and an actual firing rate;

correcting said expected inlet temperature for deviation between an air flow rate required for the firing rate for the boiler load and an actual air flow rate;

correcting said expected inlet temperature for reheat temperature control;

effecting final feedback correction of said expected inlet temperature; and

controlling the inlet temperature to the secondary superheater on the basis of the finally corrected expected inlet temperature;

characterised in that the final feedback correction of said expected inlet temperature is effected by the use of time delay control means responsive to the secondary superheater outlet temperature for correcting said expected inlet temperature with a controlled delay, the time delay control means being tuned by an adaptive controller according to boiler load variations.

The invention described hereinbelow solves or at least alleviates the above discussed problems associated with prior art control systems by using adaptive control techniques and time delay control techniques (Smith Predictor) in steam temperature control to provide for a specialised control to accommodate long delay times and process lags. Also, this control uses the dynamics of the boiler as temperature reacts to short term process excursions during load changes and deviations caused by upsets due to combustion air changes and/or sootblowing as well as changes due to reheat temperature control measures employed such as tilting burners, gas recirculation or biasing dampers.

A preferred embodiment resides in controlling superheat temperatures in applications involving the use of attemperator sprays injected into a superheating system between primary and secondary superheater surfaces.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a typical boiler;

Figure 2 is a graphic representation illustrating a typical reaction of superheat steam temperature to a change in attemperator water flow;

Figure 3 is a graphic representation of uncontrolled secondary superheater outlet steam temperature versus percentage full load;

Figure 4 is a schematic view of a previously proposed steam temperature control system; and

Figure 5 is a schematic view of a steam temperature control system embodying the present invention.

The drawings depict steam temperature control systems as function block diagrams which are well known in the art and are described in a Bailey Controls Company publication entitled "Functional Diagramming of Instruments and Control Systems", which publication is hereby incorporated by reference herein. Further, adaptive gain controls are generally known in the art and are described in Bailey Controls Company technical paper TP81-5 entitled "Adaptive Process Control Using Function Blocks", which publication also is incorporated by reference herein.

Figure 1 shows a typical boiler with feedwater 2 entering a steam drum 4 and passing down downcomers 6 into a boiler section 8 where the feedwater 2 is converted into a steam and water mixture. The steam is separated from the water in the drum 4 and dry saturated steam 10 is sent to a primary superheater 12. Superheated steam from the primary superheater 12 is cooled by a spray attemperator 14 (to which water is passed under the control of an attemperator (spray) valve) and passes through a secondary superheater 16. The superheated steam 18 then goes to either a turbine, a process or both.

There are time delays between the location of the attemperator spray 14 and its effect on final steam leaving the secondary superheater 16. Time lags are also caused by the heat transfer characteristics of the superheater metals and the steam itself.

Figure 2 illustrates a typical reaction of superheat steam temperatures to a change in attemperator water flow. The size and times will vary depending on boiler design, size and load rating; thus, actual temperatures and water flows are not quantified. The time illustrated is typical of a boiler

having a main steam flow of about 1.8 Gg/h (4.0 Mlb/h), operating at about half load. At full load the time response will be faster, resulting in a shorter dead time and some reduction in time lag. These changes must be accounted for.

Any control with relatively long time constants (two minutes or longer) will operate in a more stable fashion if open loop predictive (feedforward) methods are employed to present the controlled medium. In addition, if intermediate control points are useful and somewhat predictive of the final steam temperature, then these are also useful in a cascade method of control.

Almost all drum type boilers are designed to have a generally rising uncontrolled secondary superheater outlet temperature profile with increasing boiler load. The design usually is such that the unit does not have to reach the required main steam outlet temperature at loads below about 50% boiler load, and therefore is not controlled at these loads. Above such a load, the excess superheat temperature is "sprayed out" by the spray attemperator.

Figure 5 schematically depicts a preferred embodiment of the invention. A feedforward predictor 38 presets an expected secondary superheater inlet temperature (T2) with a load 40. This prediction is modified by the difference 42 between a firing rate required for a load and the actual firing rate. Overfiring raises temperature and underfiring reduces temperature. A similar modifier 44 accounts for excess air (air flow deviation) which will also cause temperature to rise as air flow is increased. A third modifier 46 accounts (compensates) for any reheat temperature control that may impact upon the superheat temperature.

The feedforward predictor 38 generates a set point for a secondary superheater inlet temperature cascade controller 48. As no feedforward is perfect, a final trim or correction is applied from the superheater outlet temperature (T1) through a feedback controller 50. Because of the time delay and time lag illustrated in Figure 2, a standard proportional plus integral controller will either be detuned, providing a slow, sluggish control, or be unstable. Thus, a time delay controller 52 is provided to provide improved speed of response with stable control. As the response time characteristics will vary with load, the time delay controller 52 will be tuned by an adaptive controller 54.

To prevent the time delay controller 52 from integrating when the spray valve is closed at low loads, controller limits 56 are developed to prevent the time delay controller 52 from integrating upwardly. The time delay controller 52 incorporates a process modelling technique which consists of a time delay which is adjusted to match the time delay illustrated in Figure 2 plus a first order time

lag as illustrated in the same figure. These two time constants are externally adjustable from load through the adaptive controller 54 to accommodate time constants that will vary with the steam production rate of the boiler.

The invention can be embodied in other ways than that described above by way of example. For instance, for the sake of clarity, an attemperator water spray valve(s) has been shown. The invention is however also applicable to temperature control devices such as tilting burners, mud drum attemperators, saturated steam condensers, gas recirculation, biasing dampers and similar applications.

Claims

1. A boiler steam temperature controller for a boiler having means (14) for changing the inlet temperature (T2) to a secondary superheater (16) of the boiler, the controller comprising:
 - a feed forward predictor (38) for presetting an expected secondary superheater inlet temperature with a boiler load and for generating a secondary superheater inlet temperature cascade controller set point;
 - a first modifier means (42) for correcting said expected inlet temperature for deviation between a firing rate required for the boiler load and an actual firing rate;
 - a second modifier means (44) for correcting said expected inlet temperature for deviation of an air flow rate required for the firing rate for the boiler load and an actual air flow rate;
 - a third modifier means (46) for correcting said expected inlet temperature for reheat temperature control;
 - a feedback correction control means (50,54) for final correction of said expected inlet temperature; and
 - a cascade control means (48) responsive to the secondary superheater inlet temperature (T2), said feedforward predictor (38) and said feedback correction control means (50,54) for controlling the means (14) for changing the secondary superheater inlet temperature (T2) on the basis of the finally corrected expected inlet temperature;
 - characterised in that the feedback correction control means (50,54) comprises time delay control means (52) responsive to the secondary superheater outlet temperature (T1) for correcting said expected inlet temperature with a controlled delay, and an adaptive controller (54) for tuning the time delay control means (52) according to boiler load variations.



having a main steam flow of about 1.8 Gg/h (4.0 Mlb/h), operating at about half load. At full load the time response will be faster, resulting in a shorter dead time and some reduction in time lag. These changes must be accounted for.

Any control with relatively long time constants (two minutes or longer) will operate in a more stable fashion if open loop predictive (feedforward) methods are employed to present the controlled medium. In addition, if intermediate control points are useful and somewhat predictive of the final steam temperature, then these are also useful in a cascade method of control.

Almost all drum type boilers are designed to have a generally rising uncontrolled secondary superheater outlet temperature profile with increasing boiler load. The design usually is such that the unit does not have to reach the required main steam outlet temperature at loads below about 50% boiler load, and therefore is not controlled at these loads. Above such a load, the excess superheat temperature is "sprayed out" by the spray attemperator.

Figure 5 schematically depicts a preferred embodiment of the invention. A feedforward predictor 38 presets an expected secondary superheater inlet temperature (T2) with a load 40. This prediction is modified by the difference 42 between a firing rate required for a load and the actual firing rate. Overfiring raises temperature and underfiring reduces temperature. A similar modifier 44 accounts for excess air (air flow deviation) which will also cause temperature to rise as air flow is increased. A third modifier 46 accounts (compensates) for any reheat temperature control that may impact upon the superheat temperature.

The feedforward predictor 38 generates a set point for a secondary superheater inlet temperature cascade controller 48. As no feedforward is perfect, a final trim or correction is applied from the superheater outlet temperature (T1) through a feedback controller 50. Because of the time delay and time lag illustrated in Figure 2, a standard proportional plus integral controller will either be detuned, providing a slow, sluggish control, or be unstable. Thus, a time delay controller 52 is provided to provide improved speed of response with stable control. As the response time characteristics will vary with load, the time delay controller 52 will be tuned by an adaptive controller 54.

To prevent the time delay controller 52 from integrating when the spray valve is closed at low loads, controller limits 56 are developed to prevent the time delay controller 52 from integrating upwardly. The time delay controller 52 incorporates a process modelling technique which consists of a time delay which is adjusted to match the time delay illustrated in Figure 2 plus a first order time

lag as illustrated in the same figure. These two time constants are externally adjustable from load through the adaptive controller 54 to accommodate time constants that will vary with the steam production rate of the boiler.

The invention can be embodied in other ways than that described above by way of example. For instance, for the sake of clarity, an attemperator water spray valve(s) has been shown. The invention is however also applicable to temperature control devices such as tilting burners, mud drum attemperators, saturated steam condensers, gas recirculation, biasing dampers and similar applications.

Claims

1. A boiler steam temperature controller for a boiler having means (14) for changing the inlet temperature (T2) to a secondary superheater (16) of the boiler, the controller comprising:

a feed forward predictor (38) for presetting an expected secondary superheater inlet temperature with a boiler load and for generating a secondary superheater inlet temperature cascade controller set point;

a first modifier means (42) for correcting said expected inlet temperature for deviation between a firing rate required for the boiler load and an actual firing rate;

a second modifier means (44) for correcting said expected inlet temperature for deviation of an air flow rate required for the firing rate for the boiler load and an actual air flow rate;

a third modifier means (46) for correcting said expected inlet temperature for reheat temperature control;

a feedback correction control means (50,54) for final correction of said expected inlet temperature; and

a cascade control means (48) responsive to the secondary superheater inlet temperature (T2), said feedforward predictor (38) and said feedback correction control means (50,54) for controlling the means (14) for changing the secondary superheater inlet temperature (T2) on the basis of the finally corrected expected inlet temperature;

characterised in that the feedback correction control means (50,54) comprises time delay control means (52) responsive to the secondary superheater outlet temperature (T1) for correcting said expected inlet temperature with a controlled delay, and an adaptive controller (54) for tuning the time delay control means (52) according to boiler load variations.



2. A boiler steam temperature controller according to claim 1, wherein the means for changing the secondary superheater inlet temperature (T2) comprises a spray valve (14), and wherein the feedback correction control means (50,54) includes low load controller limits (56) for said time delay control means (52) to prevent upward integration by said time delay control means (52) when the spray valve (14) is closed at low boiler loads.

3. A method of controlling the temperature of steam in a boiler having a secondary superheater (16), the method comprising the steps of:

presetting an expected secondary superheater inlet temperature with a boiler load;

generating a secondary superheater inlet temperature cascade controller set point;

correcting said expected inlet temperature for deviation between a firing rate required for the boiler load and an actual firing rate;

correcting said expected inlet temperature for deviation between an air flow rate required for the firing rate for the boiler load and an actual air flow rate;

correcting said expected inlet temperature for reheat temperature control;

effecting final feedback correction of said expected inlet temperature; and

controlling the inlet temperature (T2) to the secondary superheater (16) on the basis of the finally corrected expected inlet temperature;

characterised in that the final feedback correction of said expected inlet temperature is effected by the use of time delay control means (52) responsive to the secondary superheater outlet temperature (T1) for correcting said expected inlet temperature with a controlled delay, the time delay control means (52) being tuned by an adaptive controller (54) according to boiler load variations.

4. A method according to claim 3, wherein the final adaptive feedback correction is effected with low load controller limits (56) to prevent upward integration by said time delay control means (52) when a spray valve (14) is closed at low boiler loads.

Patentansprüche

1. Kesseldampftemperaturregler für einen Kessel, der eine Einrichtung (14) zum Verändern der Einlaßtemperatur (T2) für einen sekundären Überhitzer (16) des Kessels hat, wobei der Regler aufweist:

einen Modellvorhersager (38), um eine

erwartete Einlaßtemperatur für den sekundären Überhitzer bezüglich einer Kesselbelastung voreinzustellen und um einen Sollwert für einen Kaskadenregler für die Einlaßtemperatur eines sekundären Überhitzers zu erzeugen,

eine erste Modifiziereinrichtung (42), um die erwartete Einlaßtemperatur bezüglich einer Abweichung zwischen einer Feuerungsrate, die für die Kesselbelastung erforderlich ist, und einer tatsächlichen Feuerungsrate zu korrigieren,

eine zweite Modifiziereinrichtung (44), um die erwartete Einlaßtemperatur bezüglich einer Abweichung einer Luftströmungsrate, die für die Feuerungsrate für die Kesselbelastung erforderlich ist, und einer tatsächlichen Luftströmungsrate zu korrigieren,

eine dritte Modifiziereinrichtung (46), um die erwartete Einlaßtemperatur aufgrund einer Zwischenüberhitzungstemperaturregelung zu korrigieren,

eine Rückkopplungskorrekturkontrolleinrichtung (50, 54) für eine Endkorrektur der erwarteten Einlaßtemperatur, und

eine Kaskadenregleinrichtung (48), die auf die Einlaßtemperatur (T2) des sekundären Überhitzers, den Modellvorhersager (38) und die Rückkopplungskorrekturregleinrichtung (50, 54) anspricht, um die Einrichtung (14) zu regeln, damit die Einlaßtemperatur (T2) des sekundären Überhitzers auf der Basis der endgültig korrigierten, erwarteten Einlaßtemperatur verändert wird,

dadurch gekennzeichnet, daß die Rückkopplungskorrekturregleinrichtung (50, 54) eine Zeitverzögerungsregleinrichtung (52) aufweist, die auf die Auslaßtemperatur (T1) des sekundären Überhitzers anspricht, um die erwartete Einlaßtemperatur mit einer geregelten Verzögerung zu korrigieren, und einen adaptiven Regler (54) aufweist, um die Zeitverzögerungsregleinrichtung (52) entsprechend Veränderungen der Kesselbelastung abzustimmen.

2. Kesseldampftemperaturregler nach Anspruch 1, wobei die Einrichtung zum Verändern der Einlaßtemperatur (T2) des sekundären Überhitzers ein Sprühnebelventil (14) aufweist und wobei die Rückkopplungskorrekturregleinrichtung (50, 54) Regelungsbegrenzer (56) der Zeitverzögerungsregleinrichtung (52) für niedrige Last einschließt, um ein Aufintegrieren durch die Zeitverzögerungsregleinrichtung (52) zu vermeiden, wenn das Sprühnebelventil (14) bei geringen Kessellasten geschlossen ist.



3. Verfahren zum Regeln der Temperatur des Dampfes in einem Kessel, der einen sekundären Überhitzer (16) hat, wobei das Verfahren die Schritte aufweist:

Voreinstellen einer erwarteten Einlaßtemperatur des sekundären Überhitzers auf der Basis einer Kessellast,

Erzeugen eines Sollwertes der Einlaßtemperatur des sekundären Überhitzers für einen Kaskadenregler,

Korrigieren der erwarteten Einlaßtemperatur bezüglich einer Abweichung zwischen einer Feuerungsrate, die für die Kessellast erforderlich ist, und einer tatsächlichen Feuerungsrate,

Korrigieren der erwarteten Einlaßtemperatur bezüglich einer Abweichung zwischen einer Luftstromrate, die für die Feuerungsrate für die Kessellast erforderlich ist, und einer tatsächlichen Luftstromrate,

Korrigieren der erwarteten Einlaßtemperatur bezüglich einer Zwischenüberhitzungs-temperaturregelung,

Bewirken einer endgültigen Rückkopplungskorrektur der erwarteten Einlaßtemperatur, und

Regeln der Einlaßtemperatur (T2) des sekundären Überhitzers (16) auf der Basis der endgültig korrigierten erwarteten Einlaßtemperatur,

dadurch gekennzeichnet, daß die endgültige Rückkopplungskorrektur der erwarteten Einlaßtemperatur bewirkt wird unter Verwendung einer Zeitverzögerungsregleinrichtung (52), die auf die Auslaßtemperatur (T1) des sekundären Überhitzers anspricht, um die erwartete Einlaßtemperatur mit einer geregelten Verzögerung zu korrigieren, wobei die Zeitverzögerungsregleinrichtung (52) durch einen Anpassungsregler (54) entsprechend Veränderungen der Kessellast abgestimmt wird.

4. Verfahren nach Anspruch 3, wobei die endgültige anpassende Rückkopplungskorrektur durch Regelungsbegrenzer (56) für niedrige Last bewirkt wird, um eine Aufintegrierung durch die Zeitverzögerungsregleinrichtung (52) zu vermeiden, wenn ein Sprühnebelventil (14) bei niedriger Kessellast geschlossen ist.

Revendications

1. Unité de commande de température de vapeur de chaudière pour une chaudière possédant un moyen (14) pour modifier la température d'entrée (T2) dans un surchauffeur secondaire (16) de la chaudière, l'unité de commande comprenant :

un prédicteur de précompensation (38) pour prérégler une température attendue d'entrée de surchauffeur secondaire en fonction d'une charge de chaudière et pour produire un point de réglage d'unité de commande en cascade de température d'entrée de surchauffeur secondaire ;

un premier moyen de modification (42) pour corriger ladite température attendue d'entrée en fonction d'un écart entre une allure de chauffe requise pour la charge de chaudière et une allure de chauffe réelle ;

un deuxième moyen de modification (44) pour corriger ladite température attendue d'entrée en fonction d'un écart entre un débit d'air requis pour l'allure de chauffe pour la charge de chaudière et un débit d'air réel ;

un troisième moyen de modification (46) pour corriger ladite température attendue d'entrée en fonction d'une commande de température de réchauffage ;

un moyen de commande de correction à contre-réaction (50, 54) pour la correction finale de ladite température attendue d'entrée ; et,

un moyen de commande en cascade (48) réagissant à la température d'entrée (T2) de surchauffeur secondaire, audit prédicteur de précompensation (38) et audit moyen de commande de correction à contre-réaction (50, 54), pour commander le moyen (14) de modification de la température d'entrée (T2) de surchauffeur secondaire sur la base de la température attendue d'entrée finalement corrigée ;

caractérisé en ce que le moyen de commande de correction à contre-réaction (50, 54) comprend un moyen de commande de retard (52) sensible à la température de sortie (T1) de surchauffeur secondaire pour corriger ladite température attendue d'entrée en fonction d'un retard commandé, et une unité de commande adaptative (54) pour accorder le moyen de commande de retard (52) en fonction des variations de charge de la chaudière.

2. Unité de commande de température de vapeur de chaudière selon la revendication 1, dans laquelle le moyen pour modifier la température d'entrée de surchauffeur secondaire (T2) comprend une vanne de pulvérisation (14) et dans laquelle le moyen de commande de correction à contre-réaction (50, 54) comprend des limites d'unité de commande aux charges faibles (56) pour ledit moyen de commande de retard (52) pour empêcher l'intégration vers le haut par ledit moyen de commande de retard (52), aux faibles charges



de chaudière, lorsque la vanne de pulvérisation (14) est fermée.

3. Procédé de commande de température de vapeur dans une chaudière ayant un sur-chauffeur secondaire (16), le procédé comprenant les étapes de :
 - préréglage d'une température attendue d'entrée de surchauffeur secondaire en fonction d'une charge de chaudière ;
 - production d'un point de réglage d'unité de commande en cascade de température d'entrée de surchauffeur secondaire ;
 - correction de ladite température attendue d'entrée en fonction de l'écart entre une allure de chauffe requise pour la charge de chaudière et une allure de chauffe réelle ;
 - correction de ladite température attendue d'entrée en fonction de l'écart entre un débit d'air requis pour l'allure de chauffe pour la charge de chaudière et un débit d'air réel ;
 - correction de la dite température attendue d'entrée en fonction d'une commande de température de réchauffage ;
 - exécution d'une correction à contre-réaction finale de ladite température attendue d'entrée ; et,
 - commande de la température d'entrée (T2) dans le surchauffeur secondaire (16) sur la base de la température attendue d'entrée finalement corrigée ;
 - caractérisé en ce que la correction à contre-réaction finale de ladite température attendue d'entrée est effectuée en utilisant un moyen de commande de retard (52) sensible à la température de sortie (T1) de surchauffeur secondaire pour corriger ladite température attendue d'entrée en fonction d'un retard commandé, le moyen de commande de retard (52) étant accordé par une unité de commande adaptative (54) en fonction des variations de charge de la chaudière.
4. Procédé selon la revendication 3, dans lequel la correction finale à contre-réaction adaptative est effectuée avec des limites d'unité de commande aux charges faibles (56) pour empêcher l'intégration vers le haut par ledit moyen de commande de retard (52), aux faibles charges de chaudière, lorsque la vanne de pulvérisation (14) est fermée.