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Development of Boiler Tube-Cleaning Robot for Waste Incinerator "JFE-Boiler-Clean-DX"†

1. Introduction

In Japan, local governments were operating a total of 1 490 waste incineration facilities at the end of Mar. 2002. Among these, boilers have been installed at 1 034 plants, mainly at continuous waste incinerators in 24 h operation, and surplus heat is utilized by heat recovery, power generation, etc[1]. However, fly ash in the combustion gas is deposited on the boiler tube surfaces during operation of the incinerator, and tube cleaning must be performed during periodical inspections because heat recovery efficiency is reduced the fly ash covering the tube surfaces.

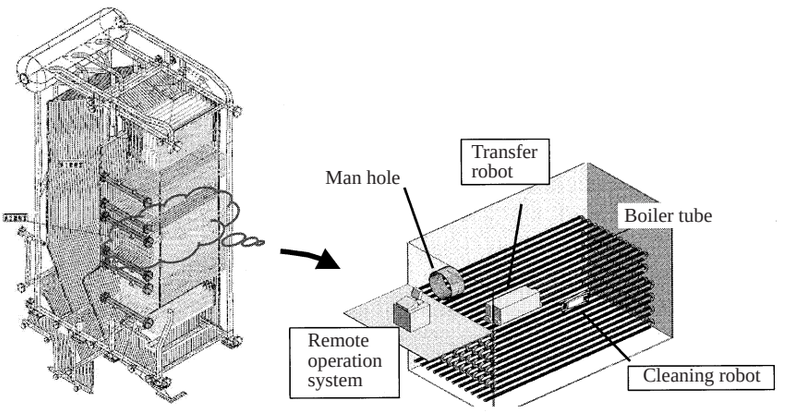
Photo 1 shows the current condition of boiler cleaning work. This work is performed by personnel who enter the boiler wearing protective clothing and use an air line mask. Work is performed in the extremely cramped space inside the boiler under a poor environment characterized by a high temperature atmosphere and scattering of harmful dust containing dioxins and heavy metals. Cleaning of the boiler accounts for the largest part of the work load in incinerator maintenance and has become a burden for personnel. Moreover, because the Ministry of Health, Labour and Welfare has also issued guidelines on work inside incinerators (Outline of Countermeasures for Prevention of Exposure to Dioxins in Work in Waste Incineration Facilities; Apr. 25, 2001), mechanization of work inside incinerators has been desired[2].

Photo 1 Cleaning work of incineration boiler system

Against this background, a boiler tube-cleaning robot called "JFE-Boiler-Clean-DX," which makes it possible to perform boiler tube cleaning work by remote operation from outside the incinerator, was developed in order to reduce the load of boiler tube cleaning work. The composition and features of Boiler-Clean-DX are presented here.

2. Outline and Features of Boiler-Clean-DX

Figure 1(a) shows the total composition of the boiler



(a) Waste-incinerator power generation boiler system

(b) Total system of JFE-Boiler-Clean-DX

Fig.1 System of JEF-Boiler-Clean-DX

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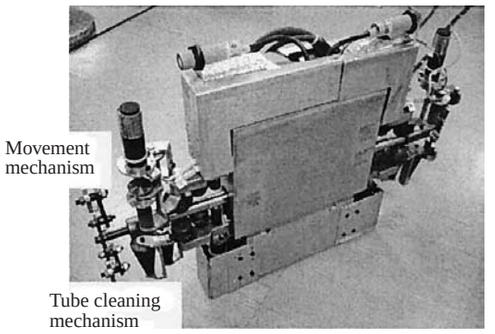


Photo 2 Outlook of JFE-Boiler-Clean-DX

tubes in a waste incinerator-power generation boiler system. The boiler tube part consists of several tube blocks, including the superheater tubes, horizontal evaporator tubes, and economizer tubes. The total system composition of Boiler-Clean-DX is shown in Fig. 1(b). The system comprises the cleaning robot, a transfer device, a cleaning mechanism mounted on the cleaning robot, and a remote operation system. Automatic operation or remote operation from outside the incinerator is possible.

Photo 2 shows the appearance of the cleaning robot. In order to perform fly ash removal work while moving inside the boiler tube blocks, the robot has a thin, compact structure with a width of only 40 mm. It is equipped with a rotating hammer-type cleaning before/after the device and removes the fly ash adhering to the tubes while traveling in the tube longitudinal direction, using the tubes themselves as guide rails. The transfer device is equipped with a crawler-type transfer mechanism and performs the function of moving the cleaning robot between rows of boiler tubes with the robot housed in the transfer device.

The features of Boiler-Clean-DX are as follows:

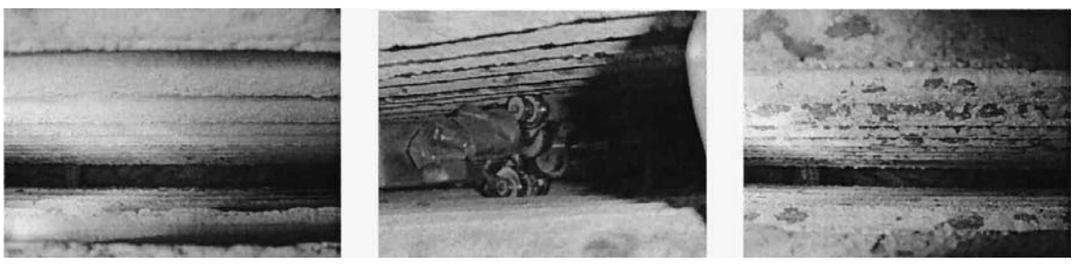
(1) The cleaning robot can travel in the boiler tube axial direction, moving freely in the vertical direction inside the tubes rows, using the boiler tubes themselves as guide rails.
(2) The cleaning robot is combined with a transfer device which houses the robot, enabling free automatic vertical and horizontal movement.
(3) An X-ring mechanism is adopted in the transfer device, making it possible to follow heat deformation of the boiler tubes and irregularities in the surface due to adhering fly ash, thereby enabling stable travel.
(4) A rotating hammer-type ash removal mechanism is adopted, enabling efficient removal of hard ash which has deposited and accumulated on the boiler tubes without damaging the tubes.
(5) The robot is compact in size and can be moved into the boiler through the manhole without dismantling.
(6) Automatic or remote operation from outside the incinerator is possible.
(7) A CCD camera is mounted on the robot, enabling remote monitoring of the condition of cleaning and travel.

3. Condition of Operation in Actual Incinerator

When an incinerator is operated for 3 to 6 months, 5 mm–10 mm of fly ash is deposited on the surface of the boiler tubes (**Photo 3**(a)). The condition of operation of Boiler-Clean-DX in the actual incinerator is shown in Photo 3(b). While traveling in the tube longitudinal direction, using the tubes as guide rails, the robot removes the hard fly ash adhering to the tube surface with the rotating hammer-type cleaning mechanism. The condition after tube cleaning using Boiler-Clean-DX is shown in Photo 3(c). An investigation of the boiler tube surface after mechanical cleaning confirmed that removal of adhering fly ash equal or superior to that in manual cleaning work is possible, and heat recovery efficiency is also improved.

4. Conclusion

The features of a boiler tube-cleaning robot for waste incinerators and the condition of application to an actual incinerator were reported. "Boiler-Clean-DX" lightens manual maintenance work in incinerators, which had been performed under a poor environment characterized by scattered harmful dust containing dioxins and heavy metals. Moreover, by improving fly ash removal perfor-



(a) Before condition (b) In operation (c) After condition

Photo 3 Application example of JFE-Boiler-Clean-DX

mance, it also enhances boiler heat recovery efficiency, and as a result, can also be expected to improve power generating efficiency.

Operational improvements are planned for the future, including a further shortening of tact time in cleaning and improvement of remote operability.

References

1) Ministory of Environment. “Waste management in Japan.” Information data book 2005.
2) Engineering Advancement Association of Japan. Proposal of developmental concept of the integrated remote technology. 2001.

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