A Study Dust Abatement by Combustion

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Synopsis

This paper deals with the abatement of the dust,
which is produced from combustion of wood which is used
in the process in the manufacture of "Bizen Yaki", by
means of combustion.

The experimental furnace disposal for after combus-
tion, is added to "Nobori Gama". The measurements are
done at both states without and with the furnace
disposal.

The results of the experiments show that process
exhaust gases containing combustible dust can be
destroyed effectively by the furnace disposal and the
obtained dust abatement efficiency is about 80%.

1. Introduction

It is considered that imperfect combustion in fuel-fired furnaces
produce the emission of combustible contaminants, and the best way to
prevent it, is to carry out perfect combustion. But a some of the metal
heating furnaces, incinerators and ceramic practice where wood is used
as fuel, emit combustible contaminants inevitably. Nuisance abatement
by combustion is described and reported in many references. [1,2] But,
fixed tables of autogenous ignition temperature or time, for the
design of furnace system, do not exist.

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In this paper, by means of combustion the abatement of the dust
which is produced from the process in the manufacture of "Bizen Yaki"
is studied experimentally.

2. Process in the manufacture of "Bizen Yaki" and Emitted Particles

The furnace "Nobori Gama" for the manufacture of "Bizen Yaki" is
shown in Fig. 1. It consists of four manufacturing chambers, those are
"Udo", "Ichiban", "Niban" and "Kedo", "Kemuriasobi", which is effective
to make the furnace pressure uniform and goods are not manufactured in
it, flue and stack. The total volume of four manufacturing chambers is
about 14 m³. The manufactured goods are made by sintering at about
1,200 °C in every chamber. Time of one operating process is about 160
hours. Firstly for 40 hours, L. P. G. is fired mainly, and then only
wood is fired. The fuel wood is pine deal. One block of it is about
700 g weight, 60 cm length, and property is shown in Table 1. Fuel
wood is thrown into "Udo" from front door about every ten minutes,
and amount of it is about 11 - 13 Kg a once. The property of emitted
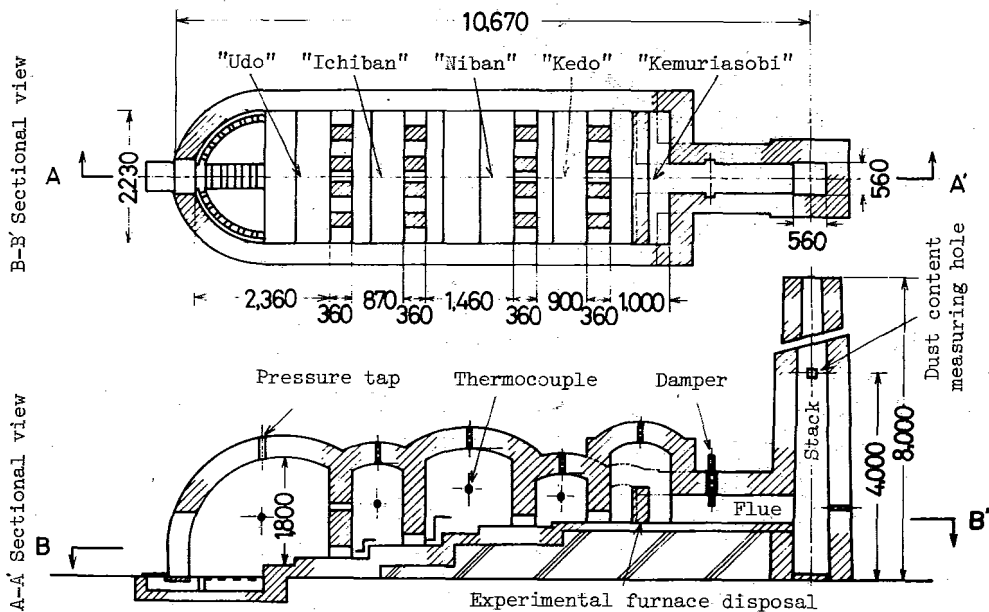particles is shown in Table 2. Size range in Table 2 is adoptted from

Fig. 1 "Nobori Gama" for "Bizen Yaki", with the furnace disposal,
       two-dotted chain line shows original form.

Table 1 Property of fuel wood

Lower heating value [Kcal/Kg]	Combustible content [%]	Ash [%]	Moisture content [%]
4,330	90.59	0.62	8.79

Table 2 Property of particles

Lower heating value [Kcal/Kg]	Combustible content [%]	Ash [%]	Ignition temperature [°C]	Particles size [μ]
6,710	97.23	2.77	420	0.02 – 300

reference [3], because some of them join together and so mass-median diameter of a particle is not able to be measured accurately.

3. Experimental Apparatus and Procedure

A schematic diagram of the experimental apparatus is shown in Figs. 2 and 3. The material for furnace construction is refractories of SK-32. In the center of the furnace, to avoid short path from "Kedo" to flue, bridge wall is built, and is used for regenerator. The thirdly air is induced to flow into the combustion chamber at atmospheric pressure by action of the draft provided by the combustion system itself.
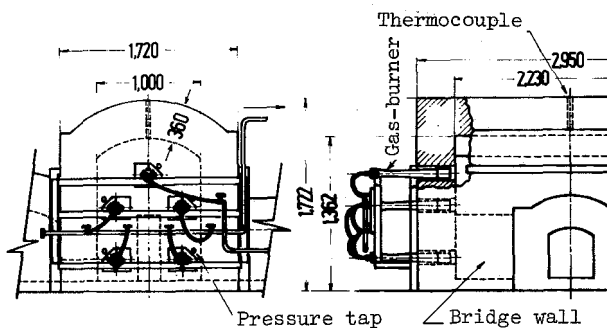
Gas fired equipment generally is found to produce a minimum of air pollution, and so the gas-burner is adopted to combustion the dust. The fuel used on the experiment is L. P. G. (Butane 70%, Propane 30%, Heating value 12,000 Kcal/Kg). Schematic diagram of fuel pipeline of
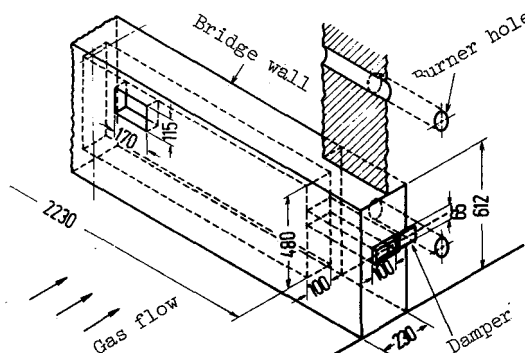

Fig. 2 Experimental furnace disposal.

Fig. 3 Bridge wall.

L. P. G. is shown in Fig. 4.
To obtain uniformity of the
furnace temperature, the
gas-burners are installed
both side of the furnace
walls, and fuel consumption
is controlled by one flow
control valve only.

Dust content is measured
according to J. I. S. Z-
8808 "Method of Measuring
Dust Content in Stak Gas".
The used filter paper is
made of quartz fiber and is

Fig. 4 L. P. G. pipeline.

cylindrical. To avoid the effect of loss in weight at high temperature,
it is used after heating for 3 hours at 800 °C. As gas flow in stack
is turblent and particles size is very small, dust content is measured
at the center of the cross section of the stack, as shown in Fig. 1.

When dust emission from the stack become visible, the experimental
furnace is operated and the temperature is raised untill it become
unvisible. Accoding the raise of operating temperature of "Udo", the
temperature of the experimental furnace raise, but consumption rate of
L. P. G. is not changed. Again dust emission become visible, then the
temperature of the experimental furnace is raised by addition of L. P.
G. consumption. To retain the state that dust emission from the stack
is unvisible, observing by a video camera, L. P. G. consumption and
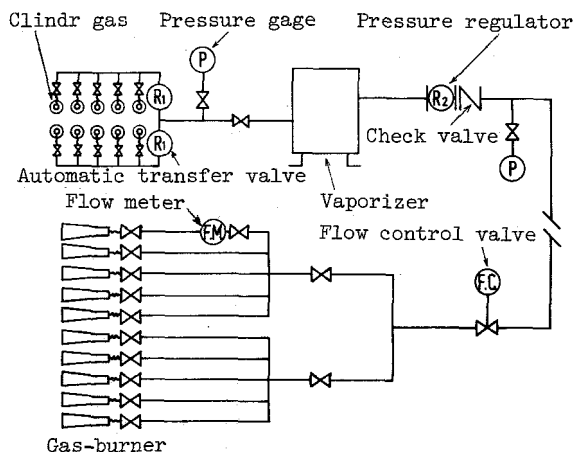firstly, secondary and thirdly air are controlled.

4. Experimental Results and Discussion

4.1 Dust Emission

The rate of dust emission versus the elapsed time of the operating
of the manufacturing furnace is shown in Fig. 5. Before the experiment-
al apparatus is installed, the maximum rate of the dust emission is
2.4 g/Nm^3, after installing, when it is operated normally, it is 0.3
g/Nm^3. The efficiency of the experimental apparatus is unable to
obtain accurately, because it is difficult to measure dust content in
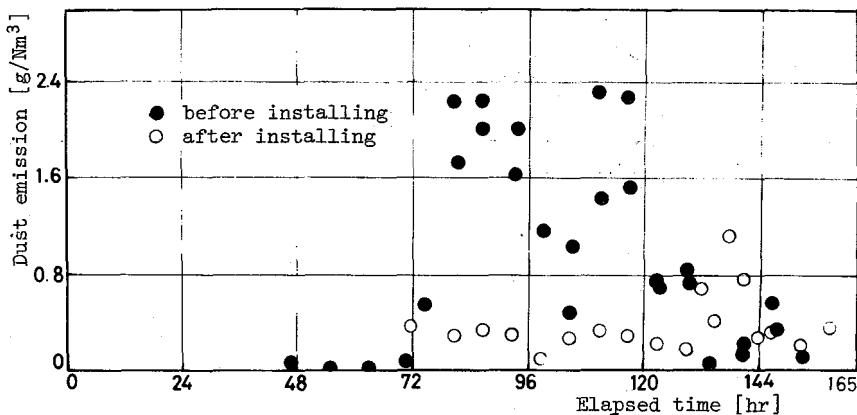gases before and behind the passage of the experimental furnace. But

Fig. 5 The rate of dust emission versus the elapsed time.

according to the following relations, adopting the mean value of all measured values of the dust emission, the obtained dust abatement efficiency is about 80% and efficiency of combustion is about 82%.

dust abatement efficiency [%]

$$= \frac{\text{the mean value of the dust emission after installing}}{\text{the mean value of the dust emission before installing}} \times 100$$

and

efficiency of combustion [%]

$$= \frac{\text{the emission of combustible matter contained in the dust after installing}}{\text{the emission of combustible matter contained in the dust before installing}} \times 100$$

4.2 The Dust Combustion

The relation between the dust emission, the residence temperature and the holding time at the experimental apparatus is shown in Fig. 6. Comparing the dust emission each other at two conditions, one is the low residence temperature and the long holding time, and other is the high residence temperature and the short holding time for wast gases at the experimental apparatus, the difference is not obvious.
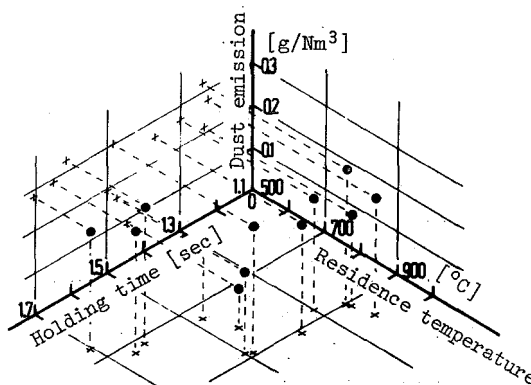

Fig. 6 The relation between the dust emission, the residence temperature and the holding time.

4.3 Effect of Experimental Apparatus on Manifacturing Chamber

The furnace pressure and temperature before and after the apparatus is installed on every measuring position are shown in Fig. 7. Between "Udo" and "Kedo", the furnace pressure and temperature is approximately equal before and after the installing.

Fig. 7 The furnace pressure and temperature before and after installing.

① "Udo" ② "Ichiban"
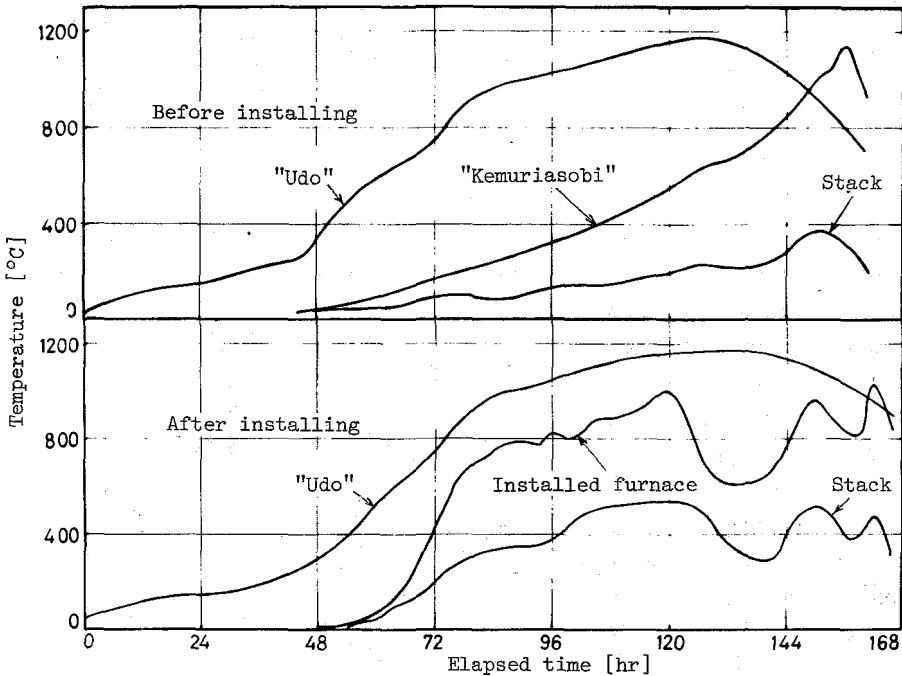③ "Niban" ④ "Kedo"
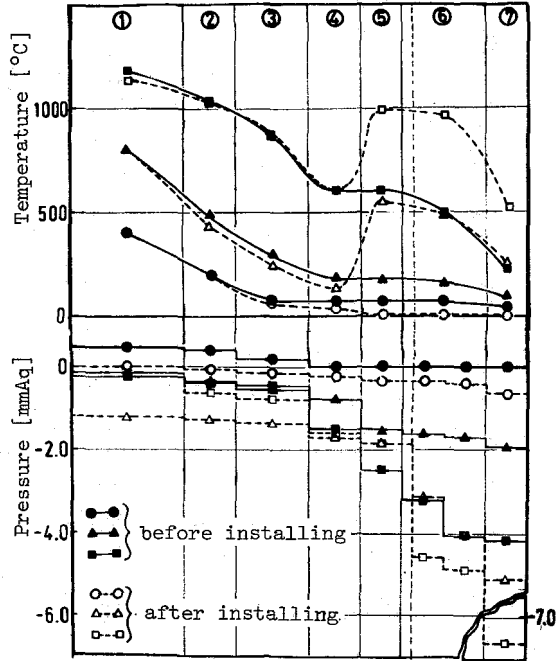⑤ "Kemuriasobi" & installed furnace
⑥ Flue ⑦ Stack

Fig. 8 The temperature of "Udo", "Kemuriasobi" and stack versus the elapsed time.

The temperature of "Udo", "Kemuriasobi" and stack versus the elapsed time is shown in Fig. 8. The maximum temperature of waste gases is about 400 °C at "Kemuriasobi" and 550 °C in stack before the apparatus is installed.

The pressure of "Udo", "Kedo" and stack versus the elpsed time is shown in Fig. 9.

Exhaust gas flow rate, excess air ratio to wood, gas flow rate of stoichiometric combustion from Rosin formula and fuel consumption before and after installing are shown in Figs. 10 and 11 respectively, versus the elapsed time. Before the furnace is installed, the exhaust gas flow rate increase with temperature and pressure of stack. After the furnace is installed with the burner operating, the exhaust gas flow rate increase rapidly and excess air ratio to wood for Rosin formula increase too. The manufacturing furnace is affected considerably with it and this is uneconomical in fuel consumption. For the state that the dust emission is unvisible, when thirdly air is introduced, after several minutes it become visible. This is considered that cooling surface of heat transfer increase and cooling air is induced to the flow of the chamber.

5. Conclusion

Using the process in the manufacture of "Bizen Yaki", combustible contaminants abatement by furnace disposal for after combustion is examined and
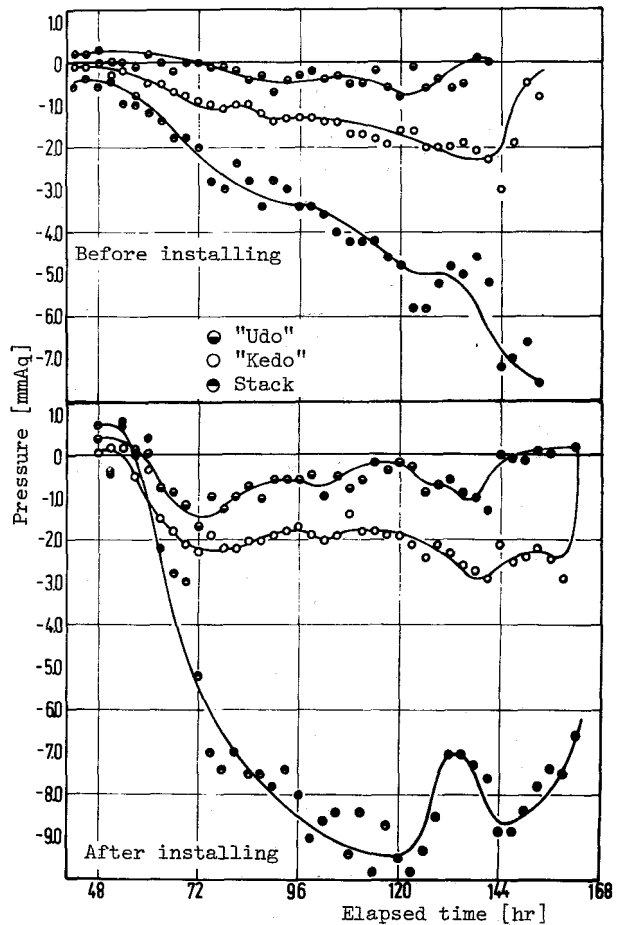

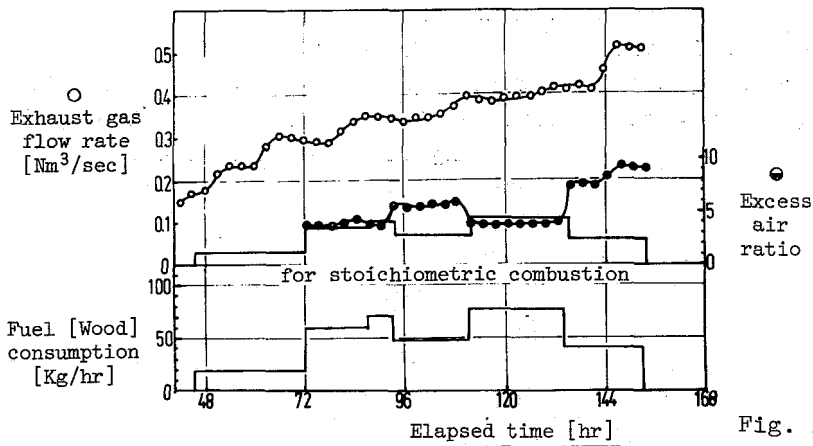Fig. 9 The pressure of "Udo", "Kedo" and stack versus the elpsed time.
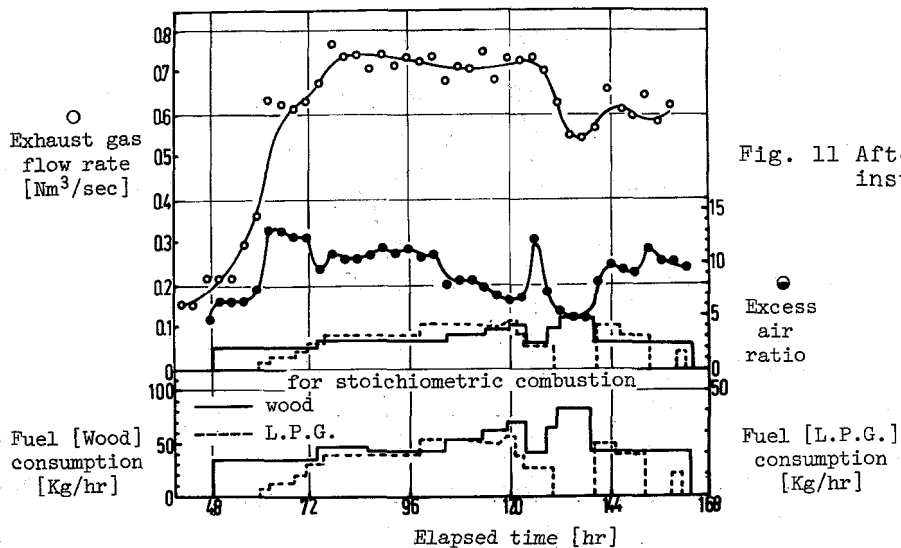
Fig. 10 Before installing

Fig. 11 After installing

Figs. 10 and 11 Exhaust gas flow rate, excess air ratio to wood, gas
flow rate of stoichiometric combustion and fuel con-
sumption before and after versus the elopsed time.

following results are obtained.
1. For the most part, combustible contaminants can be destroyed
   effectively by furnace disposal.
2. It is considered that the furnace disposal which is designed in low
   residence temperature and long holding time to care of heat transfer
   and ignition temperature of dust, is economical in fuel consumption.
3. On the point of view of fuel consumption and operating of manufactur-
   ing furnace, air rate introduced from burner attending hole is to
   be controlled carefully enough.

Acknowledgment

Reference

    (1) Arthur, C. Stern: "Air Pollution (Ⅲ)", Accademic Press (1968),
        521
    (2) S. Yagi and T. Kunii: "Kōgyō Yōro", Kyoritsu Shuppan (1962),
        264
    (3) S. Tsuzi: "Nenshō Kiki Kōgaku", Nikkan Kōgyō Shinbunsha (1971),
        99