Roof Damper Operation for Apartment-House Incinerators

Abstract

The paper has as its main purpose, the establishment of a proper system of roof damper operation in two-flue apartment-house incinerators. This is accomplished by a step-by-step analysis of all possible configurations including the type of two-flue installation, location of the roof damper, proper position in the operating cycle, etc. The author suggests a possible solution to the one remaining unsolved problem with apartment-house incinerators, namely, fires in the refuse chutes.

Introduction

Over the years, the many problems associated with flue-fed or apartment-house incinerators have led to a continuous stream of new theories, new designs, and new air pollution codes and regulations. The old single-chamber incinerators, still permitted in some areas today, are notorious for lack of draft control, for smokeouts at the hopper doors, excess fly ash, incomplete burning etc. A few of the attempted improvements were:

1) Addition of roof settling chambers.
2) Double-chamber design, often called the retort or by-pass design.
3) Double-chamber design with roof settling chambers.
4) Double-chamber design with hopper locks.
5) Double-chamber design with independent flue and chute up through the building.
6) Semi-automatic units with two flues and utilizing gas washers with induced-draft fans.

7) 4-pass units with two flues.

Also, innumerable other variations and designs have been tried and sometimes discarded. These include special dampers, air curtains, elaborate control circuits and special cycles of operation. There have even been areas where air pollution codes do not permit the installation of chute-fed apartment-house incinerators.

This paper is primarily concerned with the two-flue or double-flue design and with a fairly new piece of equipment, the so called roof damper. The many variations possible in arrangement of the roof damper, its location, operating positions and methods of control have led to some confusion as to what configuration is best.

The double-flue design has one flue or chute for charging the waste and an entirely separate flue to carry the products of combustion up through the roof and to the atmosphere. The double-flue design can be installed in three different ways:

A) With both flues built all the way up through the roof.
B) The refuse chute entering the smoke flue just under the roof.
C) The smoke flue entering the refuse chute just under the roof slab with the refuse chute going through the roof.

These three possible double-flue installations will be referred to as Types A, B and C respectively and are illustrated in Fig. 1. Each type employs a roof damper.
The Type A flue arrangement is generally the best, as it eliminates some of the errors possible in design. However, it has a drawback in that construction costs are slightly higher and the stack screen costs a bit more since both flues should be covered.

The Type B flue arrangement reduces the construction and screen costs, but poses a potential problem because in all such designs the author has seen so far, there is a great reduction in cross sectional area of the gas passage at the point where the two flues join. No one has yet enlarged the smoke flue above the point where the two flues join. Yet, it should be fairly obvious that in an emergency, such as a fire in a blocked refuse chute or during a purge cycle, the products of combustion may not be able to escape through the smaller smoke flue as fast as they are generated in the larger refuse chute; and, therefore, may tend to seep out around the hopper doors on each floor.

The Type C flue arrangement seems to offer the best compromise between Types A and B as the costs are lower, although not quite as low as with Type B, and since it provides the more logical arrangement of a small passage entering a larger one.

Roof Damper

The roof damper consists of a butterfly or louver damper operated by a control motor. The motor is powered to close the damper and a spring returns the damper to the open position in order to have it fail safe on power failure. The roof damper is a piece of equipment first used by the author several years ago on his own semi-automatic double-flue incinerator design. The idea of using such equipment on all double-flue designs seems to have caught on quite rapidly since that time. However, it is in danger of losing favor some day because of improper arrangement and poor position in the operating cycle. The roof damper is always installed above the top hopper door, usually just below the roof, and is often operated in such a manner as to be fully open or fully closed.

On the Type A configuration, the damper is installed in the refuse chute. This is a normal installation and the author has seldom seen any variation of this arrangement. On the Type B configuration, the damper is installed either in the refuse chute or in the section where both flues join. Again, this is a normal installation and no variations have been noted.

On the Type C configuration, two distinctly different damper locations are possible and have been encountered. First is the normal installation in the rubbish chute between the top hopper door and roof. The second damper location in the Type C configuration is in the area where the smoke flue enters the chute. When located here, the damper has no effect on the draft in the chute, thus permitting the aforementioned problems to occur. The only purpose of the damper in this location is to close off the normal burning flue during a purge cycle, which is occasionally required to cleanse the rubbish chute. Heat from burners in the incinerator then must pass up through the unrestricted refuse chute and purge it.

If we stop here to use a little common sense, we would realize that to purge the rubbish chute, the charging gate must be open. The refuse chute then becomes a passage straight through to the roof that has at least twice the cross sectional area of the smoke flue and is completely unrestricted by any dampers or the many turns encountered in the secondary chambers. At least 90 per cent, if not 100 per cent of the purge gases from the burner will take the path of least resistance and flow through the rubbish chute. The roof damper in this application is ridiculous, as it is neither needed for a purge cycle nor does it control draft in the rubbish chute during the normal burning cycle.

On Types A, B and C, with the roof dampers in the chutes, the purpose of the dampers has been to block off the refuse chutes in order to drastically restrict natural draft and prevent loose papers from being blown out the stacks when any hopper doors are opened.
stricting the draft also reduces the chance of flames and heat being drawn up around the charging gate at the base of the refuse chute, thus reducing the likelihood of ignition of the stored waste above the charging gate.

We have now narrowed the possible ideal installations to the Type A configuration or the Type C configuration with the roof damper in the refuse chute. However, other variables must still enter into the best possible decision.

**Charging Gate**

What is the normal position of the charging gate at the base of the refuse chute? Certainly it must be closed during the burning cycle. But what happens after burning is completed? Again, two basic cycles are possible:

1) Gate is normally open and closes only during the burning period.
2) Gate is normally closed and opens to drop the refuse into the incinerator; then closes for burning or until the next cycle is called for.

These two basic cycles have both advantages and disadvantages. The *normally open* cycle is advantageous in that the danger of the waste blocking the chute is greatly reduced, because the waste is dropped directly into the incinerator. Also, the likelihood of fires in the refuse chute is greatly reduced, because there is little time for waste to accumulate above the charging gate. However, those who prefer this cycle overlook one basic problem; Burning and smoldering time can not be controlled or predicted adequately. Depending on the type of waste charged at the time, the day, the class of occupants and other variables, burning and smoldering time may last only a few minutes or they may last several hours. If smoldering continues after the gate is opened, freshly charged refuse is likely to be ignited and it will burn between cycles. Burning between cycles with the charging gate in the open position can easily lead to smoke, soot and fly ash rising in the rubbish chute and escaping out of the hopper doors.

The *normally closed* charging gate greatly reduces the problem of uncontrolled ignition of a fresh charge by the smoldering waste from the preceding charge, since the refuse is dropped into the ignition chamber only under a controlled cycle. However, blocked chutes become an increasing hazard, as the waste is accumulated and stored above the charging gates in the refuse chutes for relatively long periods of time. Similarly, the fire hazard in the refuse chutes is correspondingly increased. Both difficulties can be reduced somewhat by more frequent burning and/or dumping cycles.

Both charging gate cycles have drawbacks, but it appears that the *normally closed* cycle offers the better solution. The problems connected with it are only the occasional problems of blockage or burning in the refuse chute.

What have we concluded, so far, to be the best or most logical design? We have decided that we must use either two flues built all the way through the roof (Type A), or a smoke flue that enters the refuse chute just under the roof slab, with the refuse chute being built through the roof (Type C-1). We have located the roof damper in the chute above the top hopper door and below the roof slab, and we have settled on the fact that the charging gate offers the least objection when operated in the *normally closed* manner except for the charging period, when it opens briefly.

**Operation of Roof Damper**

Now, returning back up to the roof damper, we are confronted with the problem of choosing its proper position, one that is suitable during the burning cycle and between cycles.

The roof damper may be set to operate several different ways:

1) Open at all times.
2) Closed at all times except during emergencies, or purging.
3) Open during burning and closed at other times.
4) Closed during burning and open at other times.
5) Closed at all times except during charging of rubbish.
6) Operated to maintain a fixed minimum opening in its so called *closed* position.

Obviously, arrangement 1 would not even require the roof damper as it would be open at all times. We have cited the need for a roof damper to cut down the excessive draft created in the refuse chute.

For the same reason of regulating the excessive draft in the charging chute, arrangements 3, 4 and 5 are not practical since a fully open roof damper does not regulate. Also, experience has shown that a fully closed damper does not permit enough products of combustion to escape even though, as some argue, the roof damper does not form an air tight closure but rather permits a small amount of leakage around it to bleed off any smoke that may accumulate in the chute below it. Arrangement 2 is not satisfactory because gases cannot escape fast enough during a normal operation.

This still leaves arrangement 6 to be investigated. This arrangement requires that the roof damper be set in such a way that it is never fully closed. If the damper can be set accurately for all conditions, it reopens the possibility of using arrangement 2 with the roof damper open fully only during emergencies or purging. However, we all know that conditions in a chute vary depending on such variables as temperature, wind velocity and direction, barometric conditions, etc. Therefore, any setting of the roof damper is not likely to be correct for all conditions although it may be satisfactory for many of
them. This combination of arrangements 2 and 6 offers the best solution so far.

Throughout this discussion, no specific mention has been made concerning the matter of how the damper should be actuated. Should it be controlled automatically or should it be controlled by the incinerator operator? In the simplified version of a double-flue incinerator with roof damper, we have chosen the "partially closed at all times except for emergencies or purging" position. This means that there is no need for any automatic operation. However, if a daily or weekly purge cycle is required, it is best accomplished automatically. An operator generally cannot be relied upon to initiate the purge cycle with any degree of regularity, nor is he likely to be available in the wee hours of the morning when a purge cycle is best initiated.

Up to this point we have considered the most important points regarding proper configuration, location, and operation of the roof damper. At least we have considered and oriented those points that have generally been given independent consideration in the past. However, in addition to the problems of proper roof damper settings, we have only briefly mentioned what appears to be a relatively serious problem with apartment-house incinerators namely, the problem of fires in the refuse chute and the automatic adjustment of the equipment to prevent smoke from billowing out of the hopper doors. To the best of the author's knowledge, no satisfactory solution has yet been offered by anyone.

One possible solution to the problem of refuse-chute fires, which often occur in a blocked refuse chute, would be a temperature controller wired in series with the damper motor. The temperature controller would be required to have normally closed contacts which would be made to open, thereby automatically opening the roof damper when the temperature in the refuse chute rises beyond a certain preset limit. However, bearing in mind that any temperature controller protruding into the rubbish chute would have to be located high up in the chute between the top hopper door and the roof damper, we cannot overlook the disadvantage that it would take some time for the build up of heat around the temperature controller and it would take additional time for the temperature controller to sense the heat and cause a reaction to open the roof damper. This time delay of perhaps several minutes is enough to cause considerable smoke to be emitted from the hopper doors, a condition the temperature controller is supposed to correct. While this system might ultimately remedy the problem of a fire in the chute, serious damage or discomfort could occur before it does so.

In order to solve this serious problem of the lack of automatic smoke release caused by refuse chute fires, the author believes that a practical solution is one based upon the pressure conditions at the top of the refuse chute. Since first arriving at the basic theory, the author has been fortunate in being able to put the theory into use on an existing incinerator.

Burning in the refuse chute, with no sizeable place for the gases to escape, causes a positive pressure to build up in the refuse chute. Normally there must be a negative pressure in the chute. In order to maintain this negative pressure in the chute under all conditions, a floating type motor operator was used to regulate the damper. To control the motor, a floating type draft controller was used between the last hopper door and the roof damper.

The operation of this installation indicated that the theory was correct. Under varying conditions such as fluctuations in back drafts on the stack caused by wind variations, temperature changes in the refuse chute, broken hopper doors that would not close, etc., the controls positioned the roof damper properly at all times.

Unfortunately, one fault in the stack system design prevented complete success. As pointed out earlier in this paper, proper design requires that both the refuse chute and the smoke flue must be built through the roof or at least the smoke flue should be made to enter the larger refuse chute above the top hopper door. However, this installation had been constructed so that the larger refuse chute entered the smaller smoke flue. This prevented the large volume of gases generated by refuse chute fires from escaping fast enough to prevent smoke outs from the hopper doors.

If the tested unit had been properly designed, the author is confident that this roof damper operation would have been completely satisfactory. In addition, the automatic control of the roof damper position as described above eliminates the previously mentioned problem of trying to determine and set an optimum partially open position of the roof damper for all conditions.

Any motor operator used to control the roof damper position must include the provision for automatic opening in the event of power or equipment failure. This is true whether a two position motor or a floating type of draft controlled motor is used.

**Conclusions**

A properly designed double-flue apartment-house incinerator must be one that incorporates the following design features:

1) Both flues must be built up through the roof or the smoke flue must enter the refuse chute just under the roof slab with the refuse chute going through the roof.
2) The roof damper must be located in the refuse chute.
3) The charging gate must normally be closed, opening only briefly to drop the refuse into the incinerator.
4) The roof damper must be partly closed at all times, except for emergencies or for purging.
5) The roof damper must be controlled automatically.
6) The roof-damper control circuit should include a draft controller.