Trends in Charging Refuse Into and Conveying Residue from the Furnace

Abstract

This paper deals with the latest trends in incinerator materials handling, and discusses ways in which residue conveyors can be adapted to newer continuous burning furnace designs, as well as improvements in materials used in conveyor components. Changes in location of charging gates and newer gate designs for use with continuous burning furnaces are also reviewed.

Introduction

Materials handling in refuse incinerators has become an ever increasing phase of new plants. This paper will concentrate on two areas which have shown the greatest improvements. The first part will deal with residue conveyors, and the second with charging gates. From the days of hand removal of residue to the present mechanical conveying of residue, most design modifications have come about through trial and error methods. This parallels the general history of incinerator design.

As happens in any new field, existing designs, proven in allied fields, are normally applied first, often with little or no modification. In the case of residue conveyors there was also the added complication of being forced to keep initial costs to a minimum. These two factors resulted in early incinerator residue conveyors having frequent breakdowns and high maintenance costs. As a result of this experience, after an initial surge in the use of residue conveyors just prior to World War II, real progress in incinerator residue conveyor design did not start until the early 1950’s. At about the same time the large plants, having capacities of from 600 to 1200 tons of refuse per day, became universally accepted along with extended operating periods of up to 24 hours per day and six or seven days a week. This required an efficient method for the continuous removal of residue.

An early furnace, as indicated in Fig. 1, was hand charged, hand stoked and the residue was removed by hand. Not only did this present a back-breaking problem, it was also dangerous to the physical health of the operating personnel who were then exposed to the hot ashes and hot dust laden fumes. Today’s plants have increased capacity through the use of larger furnaces and as normal evolution caused concern for the working conditions of the laboring staff, the residue removal problem became more critical.

Types of Recently Developed Conveyor Arrangements

Figure 2 (White Plains) shows a picture of a plant with residue being discharged directly into trucks from four hoppers and eight gates. This is about the maximum number of discharge points which can be accommodated without causing a traffic problem in a drive through truck tunnel or ash removal area. A side effect to not removing residue as it fills the ash storage hopper is the damage caused to the steel supporting structure of stoker or grate. An added problem, if larger hoppers are contemplated in the original design, is not only increased building costs but the problem of training the
ash floor man or residue truck driver to properly quench the residue. Ash gate designs are constantly being improved but, in the end, only the operator can control the character of the residue. A conveyor, on the other hand, quenches and dewateres the residue without attention from an operator. This results in less residue truck maintenance.

To eliminate the traffic problem, the conveyor system as shown in Fig. 3 (56th St.) was installed to replace residue storage hoppers and gates. This also eliminated a dusty operating problem which made working conditions very unhealthy and undesirable. Many other plants have made this changeover and others are in the process of doing this.

FIG. 1 TYPICAL INCINERATOR USING ALL HAND LABOR FOR CHARGING REFUSE AND REMOVING RESIDUE.

FIG. 2 TYPICAL TRUCK TUNNEL SHOWING RESIDUE HOPPERS DUMPING DIRECTLY TO TRUCKS.

FIG. 3 PLANT WHERE RESIDUE CONVEYOR REPLACED RESIDUE HOPPERS TO ELIMINATE A TRAFFIC AND OPERATING PROBLEM.

There are many plants built some thirty or more years ago in which ashes were raked out on the stoking or firing floor by means of long hoes. When attempts were made to modernize these plants with stokers and other labor saving devices, the increased burning rate that could be obtained was offset by the problem of removing the additional quantity of residue. Figure 4 (Pelham Manor) shows how an existing plant of this type was equipped with a residue conveyor to eliminate hand removal of ash residue. By discharging directly into a water filled trough and having the conveyor drag the residue up an incline out of the water, the ashes could be discharged into the truck in a dust-free manner with any unburned combustibles completely extinguished.

In an endeavor to reduce excavation and thus reduce plant costs, some small plants have placed the return run of the residue conveyor in the same trough as the residue carrying run. The residue when discharged from the furnace must fall through this run of chain and flights which is just about at the water level and traveling in the reverse direction. Where quantities of residue are low and no large metal or other noncombustible objects are discharged, this design has apparently been satisfactory. However, on large single or multiple furnace designs the return run drags residue back to the lower turn or take-up sprocket and requires constant supervision to keep the conveyor in operation. See Fig. 5.

With the universal acceptance of continuous burning furnace designs for all sizes of plants and furnace burning capacities, the improved residue conveyor designs, with their trouble free operation and lower and less frequent maintenance costs, resulted in the general acceptance of single conveyors for plants with one or two furnaces up to 250 ton/day furnace capacity. This has gen-
generally been done when plant operation has been on a one or possibly two shift basis. When three shift operation or over two furnaces are involved, the added cost of two conveyors can easily be justified.

With the trend to single conveyors, some means of eliminating the need for even a small tunnel had to be found. The overhead return had been found the most desirable from a plant housekeeping standpoint. The layout shown in Figs. 6 and 7 was developed to achieve this goal. As practically all of the dripping from the return run occurs by the time the return run passes the chain washer, which in turn should be placed after the first return idler after the head sprocket, a light gauge metal drip pan over the top of the furnace and over any walkway areas is sufficient to protect the under side of the return run. If the furnace can be designed as shown in Fig. 7 (Greenwich) very little additional conveyor chain is required. Two support beams resting on the building or furnace structure is all the additional supporting steel required. In other cases when the furnace is designed as shown in Fig. 6 (Jefferson Parish) the return run is carried over the top of the furnace roof arch. Based on the relationship of the operating floor to the outside elevation of the residue removal truck area, the additional chain rarely exceeds fifteen feet. No additional supporting steel is required as the furnace and roof steel are
sufficiently strong to carry the slight additional load imposed by the return run and any access footwalk required.

Today's incinerator plant designer has considerable latitude in developing new and more economical plant layouts. He can use the past conveyor arrangements with twin conveyors in which furnace and building design allow a basement, or the newer arrangements, where the conveyor path is adapted to the furnace design parameters as well as the topography.

Early residue conveyor designs had been based on standard conveyor chains and other components easily and cheaply obtained. Designs were based on the theoretical tons of residue produced by the 24 hour per day refuse burning rate of the furnace or total plant. Batch dumping of residue, starting and stopping under overloaded conditions, large metal objects such as 50 gallon drums, and many other actual operating problems faced by the plant operators were overlooked or compromised to reduce first costs. It was soon found that higher first costs were very cheap when compared to high maintenance material and labor costs, not to mention the downtime of the whole plant.

After World War II new materials were becoming available and operating experiences were proving that their higher initial costs were more than justified by lower operating and maintenance costs, as well as overall dependability. The first point of maintenance was the conveyor chains themselves. By the use of proper steels, chains were made very much harder without becoming brittle. Most residue conveyor designs now require 460 to 512 Brinnell hardness throughout the cross section of links, side bars and pins. Sprockets were the next source of wear. They were also hard to replace. The material was changed from cast iron to cast steel with a tooth surface hardness of 625 to 640 Brinnell. The sprockets were split to allow for easy replacement without the necessity of removing shafts or resorting to wheel pullers which were not always readily available.

To protect the machinery, shear pins were utilized. However, commercial shear pin design, based on normal engineering design criteria, not only were difficult to remove but also broke too often. By adopting a design from a stoker drive, the shear pin could readily be replaced without removing the entire roller chain case. Further, as will be discussed later, the machinery was designed so that what would be considered normal overloads could be withstood safely without breaking shear pins.

As conveyors were required to start up much more frequently under full load, or in some cases with discharge chutes from one or more furnaces jammed full, the motors had to be specified accordingly. In one outstanding test, where normally only a 7 horsepower load was imposed, when the conveyor was started up as mentioned above, the full 15 hp of the motor was required. To assist operators in eliminating jams, reversing motor
FIG. 7 FURNACE ARRANGEMENT ALLOWING RETURN RUN TO BE ABOVE RESIDUE TROUGH.

When speeds are reduced motor horsepower and some of the other drive components can also be reduced. However, a complete analysis must be made of each part. Shafting must be designed for the very low speeds and high torque loads which can be imposed. Head shaft bearings must be designed for high impact loadings. For this reason, Babbitted bearings are not suitable for use...
on head shafts, but can be used for idler shaft bearings. Take-ups must be carefully designed. Standard take-ups under high impact loads often fail. Shafting must be designed for reversing service.

It is accepted conveyor practice to design speed reducers on the basis of applying a service factor to the so-called brake or required design horsepower, which is less than the motor nameplate horsepower. However, residue conveyor requirements vary considerably and therefore the service factor should be applied to the motor nameplate horsepower. The added cost, if any, is more than compensated for in dependability.

It has been found that conveyor troughs made of copper bearing steel prior to World War II, and Corten or Mayar R steel since, hold up very well. By painting troughs every couple of years they have stood up for over 20 years in actual practice. The availability of T-1 steel with a 320 Brinnell hardness has eliminated most of the trouble with bent flights and also eliminated the need for stiffeners which carries back a lot of residue ash on the return run. Abrasion resisting steel on the bottoms of steel and concrete troughs has resulted in longer life. Abrasion resisting liner flats on the carrying run for the conveyor chains and also raising them several inches above the bottom plate has increased both the life of the flats as well as the chain.

Although the cost of these special materials may be twice that for standard material, they usually last twice as long and thus there is an added saving in less maintenance labor, plus the dependability and less loss of operating time.

One of the most important items is to have the manufacturer of the equipment do the actual installation. As the nature of the conveyor design prevents complete shop assembly, the proper fit and alignment must be done in the field. As normal building structural tolerances, as well as brick setting and concrete tolerances are not close enough for proper machinery operation, considerable field adjustment is required. This is especially true when concrete troughs are used.

**Plant Components Affecting Residue Conveyor Design**

With the advent of stricter air pollution controls, the question of fly ash control equipment and methods of conveying fly ash becomes an important item in incinerator design. In some designs this is accomplished by placing drop-out chambers directly over residue conveyors, and in others by sluicing or mechanically conveying fly ash to the residue conveyor. When this is done, the effect of fly ash from both an abrasive standpoint as well as a corrosive standpoint must be considered. If large amounts of water, either intermittent or continuous, are used in sluicing, the conveyor trough must be designed accordingly.

Several factors may affect details of conveyor design. In some cases furnace design may indicate the need for wide conveyors. The type and size of residue removal trucks, or in some cases the use of container systems, may alter the discharge end of the conveyor. The amount of dewatering desired may also affect the design and possibly the length of inclined run. In quite a few recent plants, a rotary screen has been placed at the discharge of the residue conveyor. This tumbles the residue and separates ashes from the cans so that the cans and other metal can be sold.

In a few cases residue trucks have been eliminated completely. At one plant an adjacent quarry was available and the conveyor dumped directly into it. At another plant on the waterfront, the conveyors dumped directly into barges which transported the residue to the final disposal site. Another plant is under design where refuse will be barged in and residue barged out. These are unique applications but show the versatility of residue conveyors.

**Future Developments**

Other types of conveyors have been tried. Rubber belts are subject to tearing by metal incombustibles. With proper loading and when metal separation is practical, they may have a place. Apron conveyors are still subject to full scale test under high capacity operating conditions. Baling wire and similar metal objects may prove troublesome. The interlapping flights may deform under heavy service. All of these possibilities must be studied under operation before full acceptance can be achieved.

The utilization of incinerator residue for useful purposes may be forced upon us due to the lack of landfill area. This again will serve to increase the demand for more residue conveying equipment and undoubtedly additional types to meet the particular needs. By using the best materials obtainable, and designing the machinery for use with incinerator residue, residue conveyors today are a dependable part of an incinerator plant.

Charging gates for controlling the loading of refuse into top charging refuse furnaces have been a standard item for many years. Until about ten years ago they were always located under the charging floor and on top of the furnace. As there was considerable space available this was a logical place; particularly, as it did not require any change in the standard building designs. However, in an endeavor to reduce building costs, this space kept being reduced and plant operators found that working conditions were almost unbearable, due either to heat or low headroom. Along with decreased headroom, the higher furnace operating temperatures resulted in additional gate maintenance and more frequent lubrication. Thus ready access to the gates was a necessity.
The floor dump plants at Beverly Hills and Pomona, in California, were among the first plants built right after World War II to have the gates located in the floor and accessible when floor plates were removed. The first crane and bin plant using a charging hopper to have the gates at floor level was the Merrick plant of the Town of Hempstead. However, it was still found that the plant operators objected to removing floor plates to service the gates. Also the space between the gates and the top of the furnace left little access room.

In the early 1950's, the Babylon, L. I., plant was built. This plant had the first charging gates located entirely above the charging floor. Now the operators could observe and easily maintain the gates. A byproduct was less maintenance due to the gates being away from the heat of the furnace.

As mentioned previously, higher operating temperatures were also beginning to result in high maintenance costs. As an answer to this problem high alloy iron castings were used in the throat castings and on some jobs on the covers as well. Their higher initial cost was justified by their longer life, savings in maintenance labor, and less shut down time.

The installation shown in Fig. 8 shows a modern plant where the gate is located above the floor. The platform between the hoppers affords a ready means for an operator to remove any blockage in the chute below. The sloping plate extension of the hopper gives the crane operator a larger area to dump the bucket. This eliminates considerable spillage, and also can be used as a passage back of the hoppers and prevent workman from being struck by falling material or a bucket coming over the bin wall. In some cases the front of the hopper towards the pit is sloped and any material falling from the bucket merely slides back into the pit.

With the advent of the continuous burning furnace, it was felt that a charging gate was no longer needed. Many early plants used metal or asbestos covers to close off the top of the charging hopper when starting up or shutting down the furnace. However, metal covers were very heavy and required special building designs to enable the crane to move them into position, and also reach a suitable storage place, out of the way during normal plant operation. Asbestos covers were lighter but subject to damage from continual use. Therefore, a modification of the charging gate was developed to overcome this problem. As heat was not a normal problem, it was felt that the lined refractory cover casting could be left off and the steel plate cut off plate could be used as a seal when in the lowered position. The gates at the Valley Stream incinerator were the first to go into operation. They have performed very well.

Most of today's plants are using these charging Cut-Off gates by which name they have come to be known. As indicated in Figs. 6 and 7, they are located above the charging floor. Dual cylinders are used in many cases to save building room and thus the economies of using hydraulic operation can be achieved within the same space that in the past could only be achieved with individual motor operated gates.

From the foregoing it is readily apparent that existing equipment can be modified and changed to meet new operating requirements. Often times with an open mind these changes can result in less expensive overall plant costs.