RDF STORAGE AND RETRIEVAL PROBLEMS
CAUSE - EFFECT - OPTIONS

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ABSTRACT

One of the more perplexing problems with the use of RDF (refuse derived fuel) as a fuel supplement has been, and continues to be, storage and retrieval of this product. Bridging, arching, ratholing, and even fires have plagued attempts to successfully store large volumes of this material in a single storage structure.

This paper recognizes the unique and difficult handling characteristics of shredded waste and the difficulty in producing a uniform product within exacting limits in any given processing facility. Regardless of the lack of uniformity, the RDF must be stored after processing and retrieved from storage for final disposal and/or use, and a reliable system must be developed. This paper attempts to explore the reasons for these problems and identify their underlying causes. It then offers some possible solutions, based on past experiences with raw refuse, that should reduce these problems to manageable proportions, if not eliminate them altogether.

INTRODUCTION

Much has been written and discussed about RDF storage and retrieval problems, both with air classified and unclassified material. Most of these discussions have centered around the wide variances in material size, shape, and density rather than possible solutions.

On the one hand, we have the systems designer who views the storage equipment as only a necessary part of the whole system, serving the needs of the system. On the other hand, we witness the storage equipment supplier suggesting that the whole system be subservient to the needs of the storage equipment. From a practical standpoint, the equipment manufacturer must be ready to supply reliable storage and retrieval systems to handle the RDF produced in a processing facility.

Many of the equipment items used in resource recovery operations are modified forms of equipment in successful operation in other industries. In some cases, excellent results have been obtained, while the performance of others has not been generally acceptable to date. And so it is with RDF storage and retrieval systems, as this paper will point out. This paper is not intended to offer finite solutions to the problems of refuse storage, but rather to offer a fresh approach with existing technology that can lead to reducing these problems to manageable proportions in the overall context of the resource recovery operation.

MATERIAL COMPACTION

To begin with, material compaction is the enemy of the materials handling engineer. The free flowing characteristic of any bulk material is inhibited by compaction, and because shredded municipal waste is not generally noted for its free flowing characteristics to begin with, the problem is compounded.
The engineer recognizes that the pressure against the bin walls is proportional to the amount of material compaction taking place within the bin. As wall pressure increases, the combination of material compaction and frictional forces against the wall can eventually overcome the gravitational forces acting upon the material, resulting in arching or bridging.

Suggestions have been made to reduce wall friction through the use of various materials that offer less resistance. The sloping of bin walls outwardly at the base is another example of attempting to reduce wall friction. Neither of these methods have been entirely successful with high compaction storage structures.

What we have not done thus far is address ourselves to the basic problem, which is material compaction. Aerating the material, which is common in bulk cement bins, is an effective way of reducing compaction, but it is probably not practical in storage bins of the size required for RDF. Other systems such as vertical screws have not demonstrated reasonable success with RDF.

Storage of RDF on an open concrete floor rather than within a confining structure is another approach. Here the material is reclaimed by front-end loaders for charging an apron conveyor which has some live storage capacity and is able to meter the material at the desired rate into the conveyor feed system.

This is the approach taken by Waste Management Inc. in their Pompano Beach ERDA project. However, this is a labor intensive operation, and the operating and maintenance costs associated with this type of operation may not be justifiable in a large facility. The ERDA project involves a rather small amount of shredded waste and is an experimental operation; thus, the long term economic affects were not the prime consideration for its implementation.

Changing the geometric configuration of the bin to reduce compaction is still another alterna-
tive. Decreasing the height of material stored in favor of increasing the bin's width and length to achieve the same capacity will lead to a reduction in material compaction.

Further, if the material can be kept in motion and not left to stand in static state for any length of time, we will not have to contend with breakaway shear forces of material on material, and material against the bin walls. These shear forces impede the movement of material and contribute to the bridging problems.

**THE LIVE BOTTOM BIN APPROACH**

These two factors - reduced headload and continuous material movement - are present in the open, live bottom bin approach advocated by Rexnord Inc. and shown pictorially in Fig. 1. Figure 2 is an enclosed version of the same system.

The live bottom bin would consist of a series of 12 ft (3.66 m) wide apron conveyors forming a live storage area across the bottom of the storage structure, with similar retrieval conveyors elevating the material from this structure opposite the loading point. The storage height would be limited to 25 ft (7.62 m), and the length dictated by the allowable working load of the conveyors. The structure width and the number of conveyors used would be dictated by the desired storage capacity.

We do not have sufficient data at this time to predict the exact geometric configuration in which bridging will not occur. In fact, it may be impossible to set exact standards given the wide variances in the material that we have to deal with, but one thing we can be certain of is that as we reduce the amount of material compaction, we will also reduce the tendency for bridging to occur.

While reducing the storage height by the use of the open live bottom bin does not guarantee that the bridging problem has been solved forever, it does allow the operator to do something about it if it does occur, no matter how infrequently. If you are an advocate of "Murphy's Law," as I am,
you know that if something can happen, it will happen.

As an example, the distance between each conveyor line is sealed off by a triangular divider structure. The space between will be minimal, allowing only sufficient space for conveyor accessibility. This structure will be tapered in the direction of conveyor travel with the distance between them greater at the conveyor headend than at the back to reduce the frictional resistance that impedes material movement. Yet, we cannot predict with any degree of certainty that bridging will never occur at this point.

ACCESSIBILITY

One of the most important advantages of the open live bottom bin concept, however, is its accessibility. For the stored material is readily accessible from above to collapse arching and to combat fires should they occur. It may be impractical to make a storage system absolutely foolproof, but it can and should be made accessible.

While material accessibility is important, access to the operating equipment at all times is equally as important. Equipment failure, when buried under several tons of shredded waste, can be extremely painful to the operator. The replacement part is often insignificant compared to the downtime and labor costs to make the replacement.

The live bottom storage bin concept allows for complete accessibility to the operating equipment. The stored material is confined within the storage bin itself, while the conveyor components are outside the bin, making accessibility along the full length of each unit possible. Figure 3 is a photograph of an existing facility showing the access to the conveyor components for maintenance and repair.

RETRIEVAL MECHANISM

Since uniformity is not one of the virtues of classified shredded waste, problems have resulted from retrieval mechanisms that employ a scraping or dragging action. This type of equipment is exposed to material contamination. That is to say, whatever stringy material, such as rags, wire, etc., that is present in the waste eventually becomes
entangled in the mechanism, reducing its effectiveness and, in some cases, plugging the system.

Some amounts of highly abrasive material, such as sand and glass, are present even in air classified refuse. This abrasive material would cause excessive wear on drag type conveyors. If an attempt were made to completely remove this material, a significant reduction in the amount of recoverable light fraction would result. This, of course, would be highly undesirable if the production of RDF is one of the major objectives of the process.

A retrieval system incorporating a carrying surface, such as an apron or pan conveyor, is more suitable for handling wide variances in material size and abrasiveness, since these factors are not as critical to their operation. These conveyors would consist of 7 ga. formed steel pans having sufficient beam strength to support the imposed load and mounted on two strands of 12 in. (0.3 m) pitch steel chain with support rollers located outboard at mid-pitch of each link on removable stubshafts, for ease of maintenance and replacement when necessary.

Drag systems are one of the more inefficient means for bulk material movement. They demand higher power consumption and are generally more expensive to operate and maintain. Some industries continue to use them, however, because they are able to perform a function that is not available by any other means. However, other than for these specific requirements, it is difficult to justify their use as a long term solution to a materials handling problem, and apron or pan conveyors should be used for RDF live bottom bins.

**SYSTEM OPERATION**

The horizontal conveyors in the live bottom bin can receive the RDF directly from transfer trailers. This is an advantage, because auxiliary unloading equipment is not required. Each conveyor would be independently powered, employing hydraulic drives that can provide infinite speed variation within the speed range with full output torque. This allows for conveyor operation at creeping speeds of less than one 1 ft/min.

The incline or retrieval conveyors would be
similarly designed. The speed range, however, would be considerably higher, as the intent of these units is to peel from the face of the moving pile the desired retrieval rate. The angle at which these units would exit from the bin would be approximately 50-55 deg. in order to insure rollback of undesirable surge loads. Each of the retrieval conveyors would discharge onto a common conveyor belt which would discharge to the inclined transport conveyor. Figure 4 is an illustration of this system. Should it ever become necessary to remove the stored RDF from the system, reversing the common or gathering belt would deliver this material to waiting transfer trailers.

The common conveyor belt may incorporate an electronic belt scale. As the RDF material is conveyed across this scale, the scale would continuously weigh the material and convert the electronic weigh signal to a rate signal. The scale will compare this rate with the desired rate set by the operator. Any variances from the desired rate will be automatically corrected by an electronic feedback signal, adjusting the drives on the retrieval conveyors.

In most cases, a continuous, predetermined retrieval rate will be required while the delivery of RDF will occur in daily surges. If the bin is to be loaded along the back wall that is opposite the retrieval end, then each conveyor system used for distributing the load across the bin length must be loaded in succession in order to insure an uninterrupted retrieval rate. Thus, the initial charges will provide the surge for RDF retrieval, while succeeding charges continue to fill the bin through successive use of the live storage conveyors. At the end of a 24-hr period, the last charge will be in the process of being retrieved while the repeated sequence of bin loading takes place.

SUMMARY

This paper has pointed out several advantages of the live bottom storage bin concept and, while no predictions can be made as to its success in eliminating all of the current problems in RDF storage and retrieval systems, it does offer exceptional promise in alleviating these problems. Certainly the use of apron conveyors as a storage and retrieval media would be less sensitive to the wide variances in material size, shape and density, and the reduced storage height will certainly improve the compaction problem.

Key Words: Compaction, Materials Handling, Pits, Refuse Derived Fuel, Storage
Discussion by

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In discussing Mr. Lisiecki's paper on RDF storage and retrieval, I am in close agreement with his objective of developing a reliable system. It is on the means of implementing this objective that I wish to raise some questions and make some suggestions.

Experience has shown that the more simple and uncomplicated a design can be, the more reliable it becomes. We have some experience with storage of refuse both shredded and unshredded which can give us guidance in design. With regard to compaction, if walls cause trouble it might be logical not to use a bin to contain the RDF but to let it assume a free standing pile. This is mentioned as an alternative in this paper; perhaps it should be the primary method.

Experience with moving refuse from a pile on top of a conveyor has been something less than satisfactory. This causes one to question the live bottom bin approach advocated by the author. He suggests that the depth of refuse (RDF) should be limited to twenty five feet, but considering the poor shearing and separating characteristics of even shredded refuse, I feel this is much too deep. The most successful conveying of refuse has been done when the belt is loaded directly or from a very shallow pile.

The wide bin filled with RDF is described as being emptied by several inclined conveyors which are fed by a similar number of horizontal conveyors. It is not at all certain that the RDF will submit to variable speed movement on the horizontal conveyors, nor separate onto the inclined conveyors for emptying. Where this has been tried, in some cases bridging has resulted.

In regard to the unloading transfer trailers loaded with RDF, a variable speed for the horizontal conveyors is suggested which will move the incoming material into the bin at the same rate as it is emptied from the truck. Again, the lack of shearing ability of the waste seems to present a formidable problem, since one conveyor would be expected to move refuse past the others which requires that the refuse separate (shear) easily, which is not characteristic of refuse. The trucks would be expected to be able to empty 75 cu yards in a matter of minutes, which means very rapid movement by the live bottom conveyor. The dust generated by emptying these trucks into the suggested 25 ft deep pit will be somewhat of an environmental problem as well.

Reliability and accessibility are stressed in the paper. Access is gained underneath the bin. But once something is dropped into the bin and the conveyors are not able to function due to weight or bridging, there is no way to empty the bin short of bringing in auxiliary equipment. Reduced manpower is indicated, but no consideration is given for the manpower needed for the maintenance of the various bearings and wearing surfaces plus replacement of conveyor sections, etc.

To return to the original concept of simplicity and reliability, is it necessary to drop RDF into a pit in order to put it on a conveyor? A flat slab can serve as a storage surface while a front end loader loads the transfer conveyor at what ever rate is needed and with the added advantage of selectivity. There must be ample space for maneuvering and emptying trucks and the loader will have to be manned 24 hr/day if refuse is to be supplied continuously. However, this is no different in the end than if a front end loader is needed to push RDF into a pit after bridging over the live bottom conveyors has made it clear that they are unable to function otherwise.

AUTHOR'S REPLY

To Eugene A. Glysson

Mr. Glysson states that moving refuse from a pile on top of a conveyor has been something less than satisfactory.

Rexnord's experience with a live bottom receiving pit of the magnitude proposed for RDF storage is limited to the SWARU facility. The results have not been generally acceptable to date, since only a third of the pit capacity is usable. Perhaps this is what Mr. Glysson has reference to.

The basic problem with SWARU is that the conveyor drives are not adequate for starting under a fully loaded pit. This condition is a result of mass movement with compaction occurring at the retrieval end that was not considered in the design calculations.

As this paper indicated, the subject of SWARU was treated in a very comprehensive paper presented at an ASME meeting in New York and, subse-
quently, published in *Waste Age* (March 1976). The conclusions reached in that paper were that it was a workable concept providing certain design changes were made that would consider the mass movement of refuse and compaction.

There are four parallel conveyor lines at SWARU. Each conveyor is independently controlled. Frequently, the individual conveyors are run at different speeds, since each is controlled by the shredder it feeds. Often one or more lines will be at rest while the others continue to feed. There has been no problem: in this regard as Mr. Glysson suggests will happen with RDF. The fact that raw refuse moves en masse indicates a very high shear factor. In this regard, it is similar to RDF.

In the concept that this paper proposes, material shear (providing it is properly accounted for in the drive calculations) is not a factor. All of the retrieval conveyors will operate simultaneously. Control will come from the gathering belt scale. It doesn’t make any difference, therefore, how much material each conveyor is delivering, since it is the sum total of all units that is being controlled.

A storage pit 25 ft deep with a 12 ft wide conveyor will hold 75 cu yard in less than 2 3/4 ft of conveyor length. The conveyor movement would be less than 5 ft/min to accommodate the 75 cu yard trailers, hardly the rapid movement suggested by Mr. Glysson for trailer unloading.

In terms of reliability, we again draw upon the experiences of SWARU. Since its inception in 1971, only one chain link and one conveyor pan has had to be replaced because of damage. Approximately six roller assemblies were replaced, which is a minor problem, as they can be replaced in less than 5 min with or without refuse in the system. When we consider that this system incorporates over 1,200 ft of chain and roller assemblies, the durability is somewhat remarkable.

Mr. Glysson suggests that slab storage with frontend loaders moving RDF into a conveyor feed system — also considered in this paper — is the answer. The paper points out, however, that this is a labor intensive operation. When added to the operating and maintenance costs of the frontend loaders, the annual costs can very easily dilute the value of RDF so as to make the entire venture questionable.

The growth of energy recovery from municipal waste will be dictated by economics. Our efforts to improve on the processing technique must include a reduction in operating costs as well. In this regard, the live bottom storage system shows promise of fulfilling that need.