VIBRATING PROCESS EQUIPMENT FOR RESOURCE RECOVERY

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ABSTRACT

An overview of many waste streams and the manner in which technically advanced vibrating process equipment is used to assist in the recovery recyclable materials. Special equipment designs efficiently convey, separate and classify a wide range of materials for further processing while minimizing the volume of material destined for landfill.

TODAY'S CHALLENGE

Massive amounts of waste are produced daily throughout the United States, and some areas of the country have run out of places to put it. Many landfills have closed, and those remaining are rapidly reaching capacity. New facilities are difficult to establish because of environmental concerns and widespread public opposition. The days of our "throw-away" society have ended and the start of various types of recycling programs has led to the development of new, virtually unexplored applications for processing equipment.

The initial goal of most recycling programs is to reduce landfill volume; however, as programs have matured, a growing secondary market for recyclables has developed. Once the volume of these relatively easy to recover materials increases, the volume of residuals directed to landfill will be reduced. Today, vibrating equipment is playing an important part in speeding the recovery and enrichment of waste streams by reducing the need for manual separation and classification of valuable recyclable materials.

VIBRATING EQUIPMENT

Traditionally, vibration has had a negative connotation and been viewed as something that had to be eliminated; however, it is fortunate that a few inquisitive engineers saw vibration as a possible means of moving and processing bulk materials. Although various forms of vibrating conveying have been used in the United States for over a century, it has been only in the past few decades that the concepts of vibrating conveying and processing have achieved full industry acceptance. Recent advancements in high strength space-age materials and technological skills have fueled a development in the design of single, multipurpose vibrating machines which reduce material handling by combining various processes to increase productivity while reducing costs.

Current vibrating equipment designs, with very few exceptions, utilize the principle of natural frequency operation to minimize force input and reduce connected horsepower requirements, resulting in low energy demand.

Vibrating equipment has a long successful record in tough applications within the foundry, steel, coal, mining, and scrap industries where its ability to provide reliable, low-maintenance performance is highly regarded. The past few years have seen this same proven technology directed to development of special vibrating

machines within the expanding waste recovery and recycling industries.

Almost daily, new concepts for the processing of various selected waste streams seem to arrive on the scene and vibrating equipment designs have kept pace. Some current vibrating process equipment designs did not even exist less than a year ago.

Manufacturers of vibrating equipment have typically kept their engineering analysis and design techniques confidential and many of these newly developed machines are considered proprietary designs which have been patented or have patents pending.

BENEFITS OF VIBRATORY MOTION

Material on a vibrating conveyor is "live" and moves independently of the conveying medium, whereas on other types of conveyors, the material is static and the conveying medium moves. This important characteristic provides a solution to many difficult material handling and processing applications facing us in today's growing Solid Waste Processing Industry.

The proper combination of amplitude, the total movement of the material carrying deck, and frequency, the number of cycles of motion for a given time period, together with the angle in which the resulting force is applied, can provide an aggressive tossing action all the way down to a gentle sliding-type movement depending upon the motion needed to meet processing requirements. Abrasive wear is minimized, since the vertical accelerating force applied to the material reduces its effective pressure on the trough surface.

The ability to perform multiple supplemental functions such as screening or classifying, aligning, and turning material while conveying, along with provisions to discharge material at intermediate positions, provides a compact, economical solution to a variety of new processing demands.

INSTALLATION CONCERNS

The assumption that vibrating equipment requires massive foundations and/or support structures is no longer valid. Currently, a variety of balancing systems designs, with varying degrees of isolation efficiency, are available to reduce transmitted vibration. Some state-of-the-art designs even respond directly to changes in material loading thus assuring balanced operation at all times.

Steel support structures can now be designed based primarily upon static loading with only secondary consideration given to the degree of dynamic loading and the range of exciting frequencies involved.

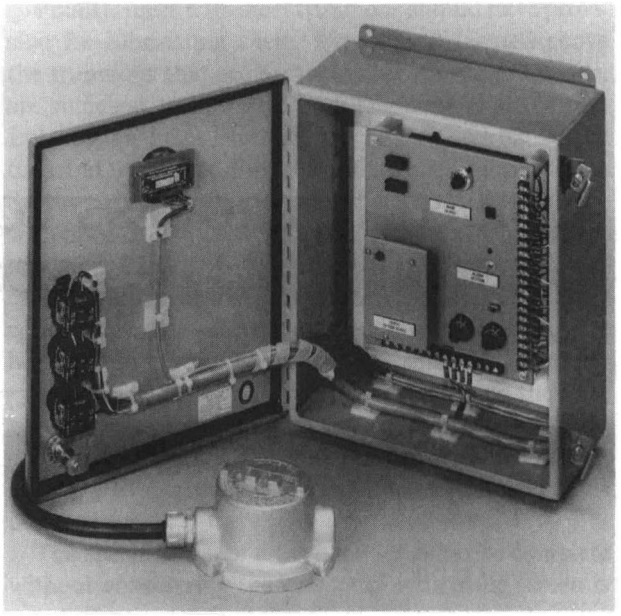


FIG. 1 ELECTRONIC STROKE MONITOR WITH VIBRATION SENSING TRANSDUCER PROVIDES REMOTE INDICATION OF VIBRATING UNIT'S OPERATION AND PROVIDES WARNING WHEN CONDITIONS CHANGE

PERFORMANCE MONITORING

A valuable accessory to complement any vibrating equipment installation is a digital feedback control which provides reliable and continuous monitoring of stroke amplitude. A typical unit is shown in Fig. 1. This device is ideal for monitoring the performance of vibrating units in inaccessible locations, especially those subjected to surge load conditions or those handling materials which may tend to build up on the trough surface. The monitor senses either an over or understroke condition so that immediate action can be taken to prevent equipment damage and loss of production.

A transducer mounted to the vibrating surface provides amplitude input sensing, a design adaptable to any vibrating machine.

The solid state control has a bright LED readout showing actual operating stroke and dual push buttons to display preset high and low stroke parameters. These set points are fully adjustable allowing the monitor to be tuned to each specific application. Control output is in the form of a 4–20 ma analog signal with a separate signal indicating whether the deviation from normal

operation occurred in either the high or low stroke condition.

BIO-MASS FUELS

The recent slowdown in the forest products industry and the accompanying controversy over the Spotted Owl habitat, has resulted in a severe shortage of fuel for Bio-Mass fuel burning boilers. This has forced operators to search out new sources of acceptable fuel in order to stay on stream. Today, material never before considered as a viable source of fuel, old abandoned bark piles for example, can be enhanced by the removal of dirt, stones and other noncombustible contaminants.

In addition to providing an acceptable supply of fuel, reduced boiler service and slower clinker buildup are among the benefits provided by a hog fuel and woodyard waste, dry process, cleanup system. A dry system, besides being more economical, eliminates water handling, saturated bark and other problems associated with wet separation systems. Field experience shows a dramatic reduction in clinker buildup rate and substantially reduced ash contents when burning processed log yard or bark pile waste.

Undesirable fine material, which is mostly dirt, is removed from yard cleanup material by a vibrating finger screen design (Fig. 2), providing a cascading material flow across a series of self-relieving finger elements. Material which would hangup or catch in a conventional perforated or wire mesh screen is efficiently separated without difficulty. The "fines" passing through are an ideal mulching material.

A combination vibrating/pneumatic air-knife classifying unit identified as a De-Stoner (Fig. 3), separates and classifies the remaining fuel on the basis of density and particle size. A combination of vibration and high velocity air streams fluidize and stratify material prior to its being exposed to either single or dual air-knife curtains for thorough separation of unwanted material. The unit's vibrating action causes a natural separation where lighter material particles move upwards while heavier particles move to the bottom of the material bed. This initial separation is improved by blowing a high velocity stream of air through the bed of material just prior to exposing it to an air-knife angled in the direction of flow. An adjustable air current from the knife carries lighter particles across an adjustable drop-out gap, while heavier pieces fall into the gap and are discharged. The separator is virtually jam-proof, since there are no moving parts. Stones and other coarse "reject" material can be used as yard cover or directed to landfill.

The bio-mass fuel screening and classifying machines are energy efficient with a typical system using a total of less than 50 hp. Their balanced isolated designs eliminate the need for elaborate foundations and support structures, allowing simple, economical installation.

AUTO SHREDDER FLUFF (ASR)

Vibrating recovery equipment has recently been applied to the processing of automobile shredder residue (ASR) or "auto-fluff" as it is sometimes identified. Field experience has shown that this material, the remnants of shredded automobile bodies after magnetic separation and processing through various styles of reverse air-flows separators, may contain 5% or more of "heavies" of which up to 30% of this volume consists of additional ferrous and nonferrous material. The usual procedure is to magnetically separate shredded ferrous material from the shredder discharge flow and then process the remaining material through a gravity-style reverse air-flow separator to remove any ferrous material missed by the initial magnets plus nonferrous material which may be present. The residual "fluff" material is then disposed of in a landfill.

It is difficult to maintain separation efficiency on this type of air separator, since if the ratio of air-flow to material flow is too high, smaller pieces of metal scrap will be carried out with the light "fluff", plastics, etc. Should the air-flow ratio be too low, "fluff" material drops out with the heavier metal necessitating additional cleanup.

When a vibrating/pneumatic air-knife classifier is installed (Fig. 4), the reverse air-flow separator can be adjusted to provide maximum efficiency on the clean metal side and the metal contaminated "fluff" processed across the vibrating unit to remove all carryover ferrous and nonferrous material.

Field operation has shown the "fluff" processed across a vibrating air-knife to be virtually free of metal although upon occasion a piece of wire or aluminum trim will be caught in a "fluff ball" and carried out with it. Also, should a small piece of aluminum door trim enter the air stream in a specific attitude, it too may be carried out with the "lights".

A finger screen can be installed prior to the classifying unit to scalp off larger pieces of plastic, hose, insulation and sponge rubber to improve separation efficiency. Recent testing reveals that it may be possible to achieve additional high density separation from the processed light "fluff" stream.

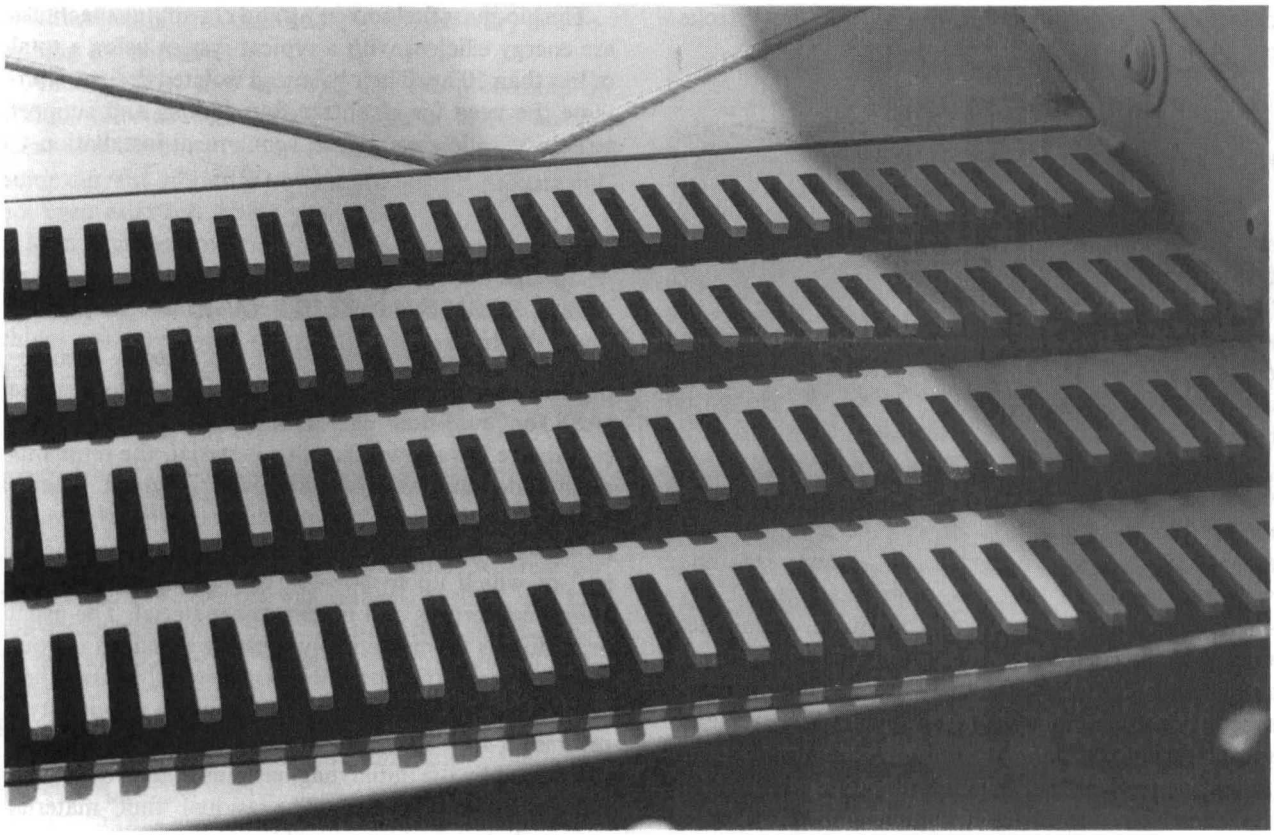


FIG. 2 TYPICAL FINGER SCREEN DECK WHERE MATERIAL CASCADES ACROSS SERIES OF OVERLAPPING TAPERED FINGERS. SIZE, NUMBER AND DESIGN OF FINGER SCREENS ARE DETERMINED BY APPLICATION REQUIREMENTS.

CONSTRUCTION/DEMOLITION (C/D) WASTE

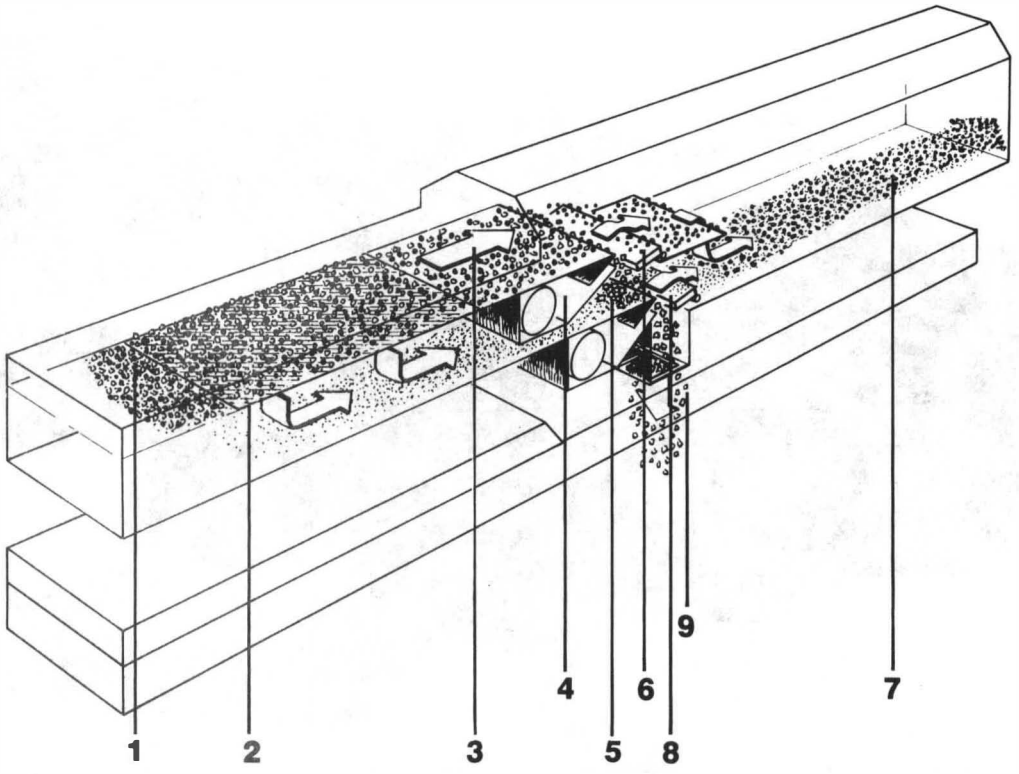
Efficient dry separation and classification of construction/demolition waste is now possible, allowing the reclamation of recyclables while concurrently reducing the volume of material destined for a landfill. Existing reclamation systems are handling material at rates up to 15,000 cu ft/hr.

In a typical system (Fig. 5), construction/demolition material on a tipping floor is moved within reach of pivoting grapple loader which moves bulky undesirable material like tires and storage batteries to a refuse container. Remaining material is placed on a crusher feeder which meters it into the crusher.

A vibrating feeder installed below the crusher, controls the feed of crushed material to an inclined belt conveyor which discharges to a conveyor incorporating a finger screen deck. The various size crushed materials which would otherwise catch in a conventional perforated or wire mesh screen, are efficiently separated by the vibrating cascading material flow over a series of self-relieving finger elements which remove minus 3/4 in. material for landfill cover. The deck may occasionally include a series of vertically spaced steps between screen sections to aid in the turnover of material as it drops onto the following section. Large bulky items and other undesirable materials, such as carpeting or tangled wire which bypass the crusher, are manually removed to containers.

Material remaining on finger deck passes below overhead in-line magnet, which discharges ferrous material into material container and allows the remaining material to discharge onto an innovative vibrating/pneumatic air-knife classifying unit, a De-Stoner, which separates and classifies mixed bulk materials on the basis of density and particle size.

Additional manual sorting can be accomplished on inlet portion of this unit, if desired. Material is fluidized and stratified by both vibration and high velocity air streams prior to being exposed to dual air-knife curtains



How it works

1. Material moves along conveyor by vibratory action with high density material settling to bottom of trough.

2. Pre-classifier conveyor section (optional) removes smaller particle sizes before reaching air fluidizer.

3. Air fluidizing section assists in stratifying material.

4. High velocity, low pressure air stream is directed through material flow.

5. Material conveys into air stream. Heavy material falls through air stream to secondary separator.

6. Marginal density material is caught on adjustable slope plate and falls back into secondary separator.

7. Acceptable material carries beyond plate and travels through conveyor to discharge.

8. Secondary separator continues separating process to assure thorough and complete classification.

9. High density refuse material is removed from conveyor through side discharge.

FIG. 3 MATERIAL FLOW IN DUAL AIR-KNIFE CLASSIFIER

for thorough separation. Paper, light plastics and remaining fines are carried by the airstream within the hood to a cyclone and dust control system. Heavy materials, brick, glass, tile, broken concrete, nonferrous metal, heavy plastic, etc. are side discharged to inclined vibrating conveyor. Lighter material, primarily wood products, is end discharged ready for further processing or use as ground cover or boiler fuel.

Inclined V-trough vibrating conveyor discharges heavy material from the classifying unit onto an elevated sorting conveyor, where an overhead cross belt magnet removes residual ferrous material. A final manual sorting operation recovers nonferrous and other recyclable materials.

Reduced volume of residue from this final sorting operation is directed to landfill.

WASTE-TO-ENERGY (WTE)

For many years, vibrating equipment has demonstrated outstanding reliability in demanding mass burn bottom ash applications. Despite corrosive atmospheres, variable load conditions, high impact, heat and moisture, specially designed vibrating conveyors keep material moving around the clock, day after day!

In a typical mass burn bottom ash handling system (Fig. 6), long balanced vibrating conveyors receive quenched ash from a series of dischargers. These conveyors have smooth, continuous, alloy steel replaceable decks entirely free of steps, ledges or other obstructions which could hinder material movement. The sectional design of the replaceable deck allows the use of thicker steel in areas of high impact loading. The units are

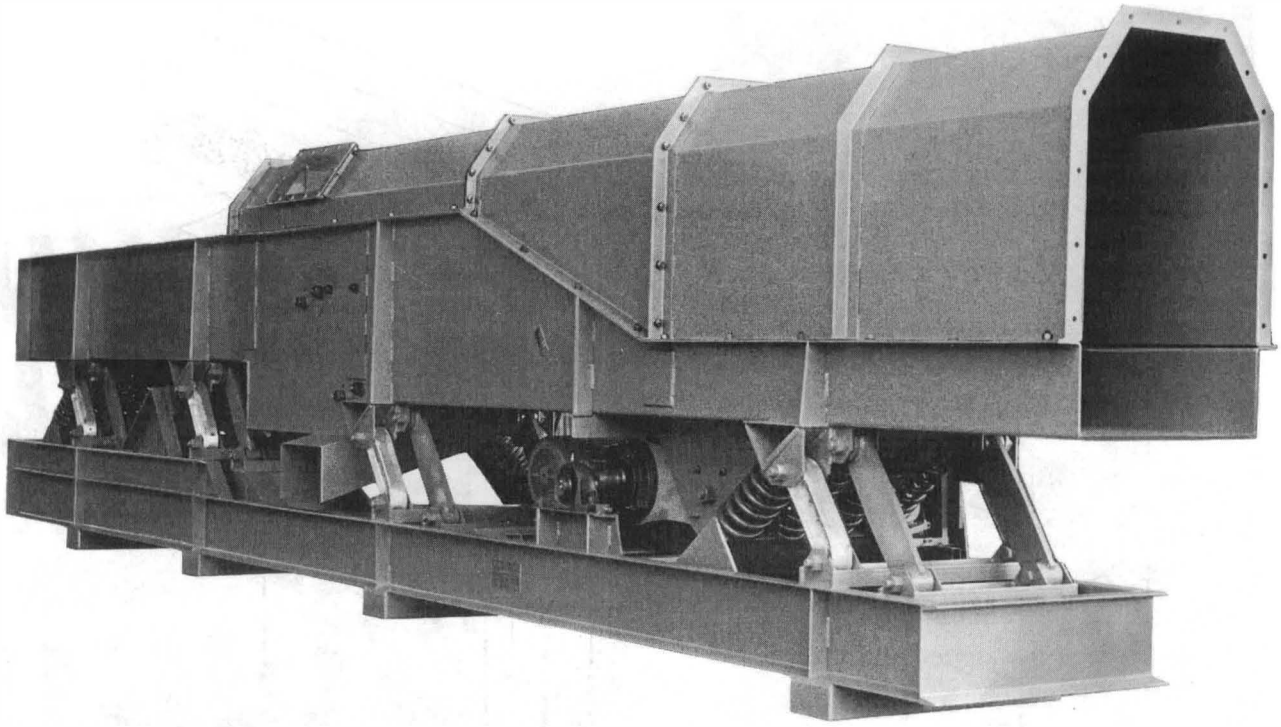


FIG. 4 VIBRATING/PNEUMATIC CLASSIFIER (Destoner) WITH DUAL KNIVES HAS A BALANCED DESIGN TO ELIMINATE FOUNDATION CONCERN. LARGE VOLUME HOOD WITH AIR TAKEOFF CONTROLS AIRBORNE PARTICLES.

capable of sequenced start/stop operation synchronized with operation of the ash dischargers.

Bulky oversize material in the bottom ash is removed by a grizzly scalper having tapered openings designed to prevent hangups. This separation can be accomplished as an integral part of the collecting conveyor or be done on a separate machine. A market is developing for these post combustion products. Following the removal of oversize items, the ash is processed across a vibrating finger screen to remove minus 1 in. for further utilization and/or stabilization.

More efficient magnetic recovery of ferrous material and eddy-current extraction of nonferrous material is achieved because of the reduced volume of cleaner, fines-free ash being processed.

The remaining reduced volume of processed ash is distributed across several storage bunkers in the ash load-out facility by a balanced vibrating conveyor equipped with a series of intermediate, air-operated bottom drop out gates.

Additional cleanup of both the recovered ferrous and nonferrous scrap can be accomplished by a special inclined vibrating unit equipped with a large volume water tank and spray nozzles. This unit washes residual ash from the reclaimed metals to further enhance their value.

Concern about foundation and support structures, as well as possible damage to surrounding equipment, is minimized since all the units have a balanced design utilizing the principle of natural frequency operation to fully compensate for varying material loads.

SCRAP PROCESSING

The heavy loading and abusive conditions encountered in most scrap recycling facilities are a natural for the inherent ruggedness of vibrating equipment. Currently, various design vibrating units are used to feed material to, and accept the discharge from, alligator and guillotine shears, convey processed scrap beneath magnets, through manual sorting operations, and withstand the severe impact below automobile shredders.

Vibrating decks are tailored to each specific application. A typical automobile shredder discharge conveyor (Fig. 7), for example, is positioned with minimum clearance between the shredder foundation side walls. It is

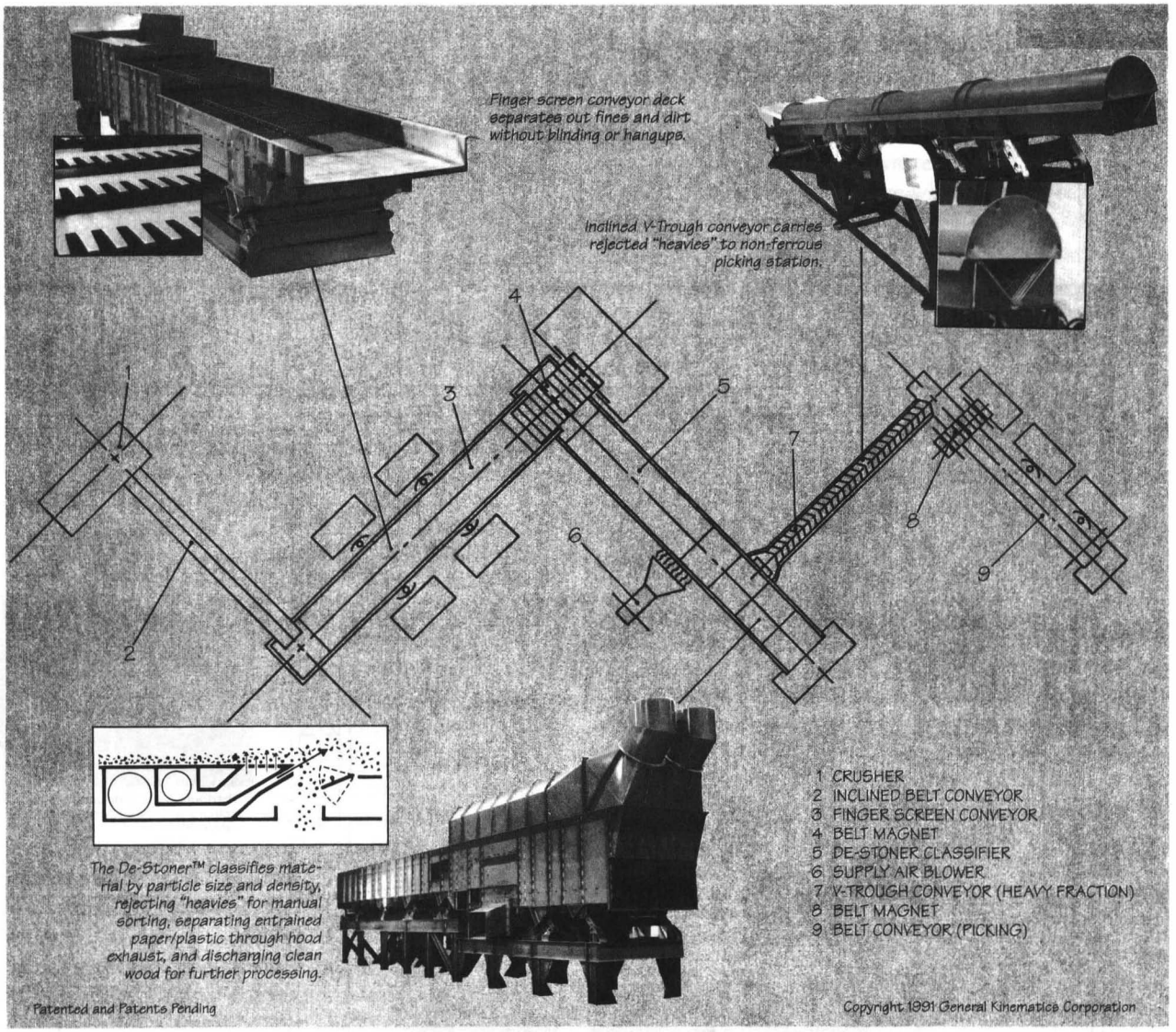


FIG. 5 TYPICAL SYSTEM FOR THE RECYCLING OF CONSTRUCTION/DEMOLITION WASTE

desirable to use as wide a deck as possible to eliminate leakage and improve shredder discharge chute angles, thus speeding material flow to prevent material from backing up into the shredder grate. The eccentric drive machinery and reactor system components are located on a base structure which is narrower than the deck in order to allow for easy access for maintenance. The material carrying deck is equipped with flared side walls to eliminate the possible wedging or jamming of irregular shaped pieces. To accommodate the abnormal force resulting from an occasional shredder explosion, rigid bumpers are designed to restrict deck movement and transfer this abnormal shock loading directly to the conveyor base and foundation.

Material carrying decks can be fabricated from non-magnetic stainless or manganese steel for use with electro or permanent magnets and thick abrasion resistant alloy steel liners can be provided for high wear areas. Units subjected to repeated heavy impact, such as shredder discharge or guillotine shear take away conveyors, for example, are fabricated with a deck having a grid or egg crate style understructure to maintain structural integrity.

TIRE RECYCLING

Used vehicle tires have always represented a disposal problem. Although they represent an excellent source

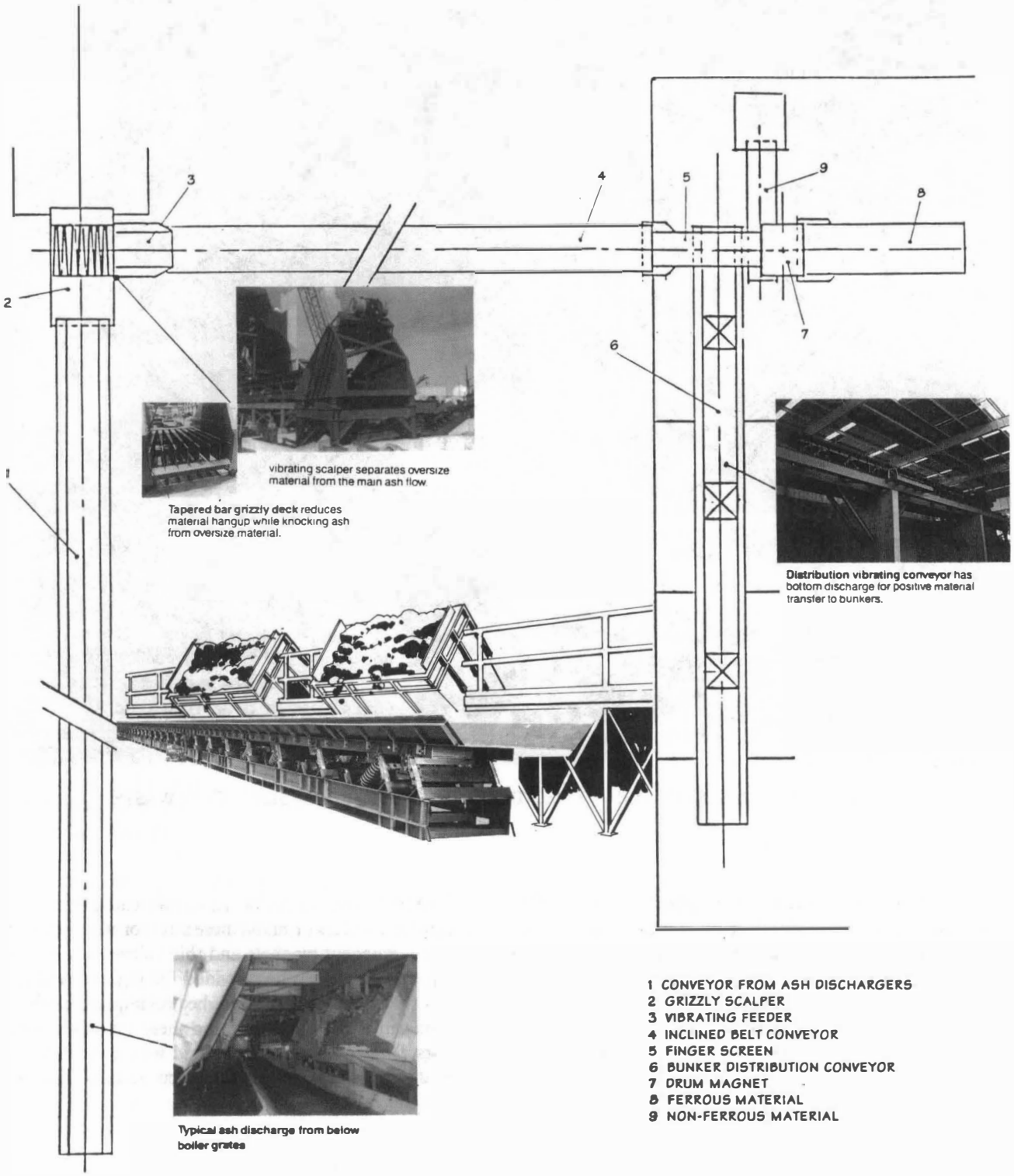


FIG. 6 TYPICAL WASTE-TO-ENERGY SYSTEM

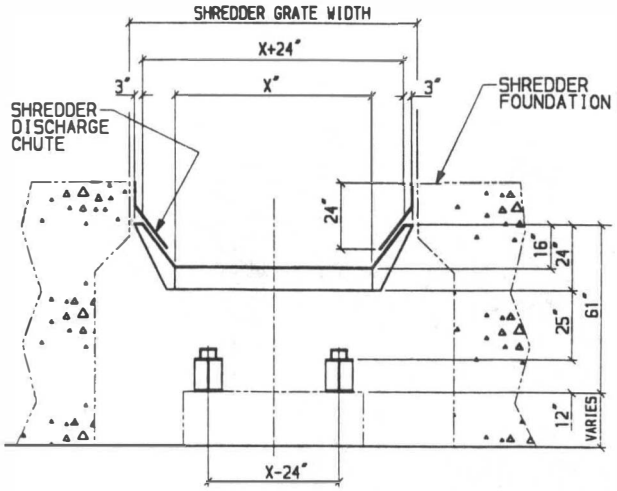


FIG. 7 SECTION OF VIBRATING CONVEYOR BELOW AUTO SHREDDER. WIDE FLARED TROUGH ELIMINATES MATERIAL JAMMING AND BACKUPS INTO SHREDDER GRATE. CONVEYOR MACHINERY BASE IS NARROWER THAN TROUGH, ALLOWING EASY ACCESS FOR MAINTENANCE.

of supplemental fuel for such applications as power plants or cement kilns, there has never been a strong incentive to produce a tire derived fuel (TDF). Today, however, new laws are being considered requiring all tires to be "chopped" or otherwise reduced before being placed in a landfill to reduce the fire hazard and eliminate mosquito breeding areas.

A vibrating unit with a special deck design can convey and singulate a mixed batch of tires prior to discharging them at a controlled rate into a shredder or granulator. Vibrating conveyors accept the material discharged from the shredder and expose it for magnetic separation. Once the pieces of steel belting have been removed, the remaining material is ready for use as fuel or available for additional processing in preparation for alternate use as a binder ingredient in asphalt, for example.

Recent developments involve the use of pyrolysis to recover such by-products as oil, gas, carbon and metal from scrap tires. Presently, recovered gas is fueling power plants and there is a developing market for the recovered carbon and metal wire. Vibrating conveyors are used to accept the tire residue from the pyrolysis chambers and separate metal wire from the carbonaceous material.

MUNICIPAL SOLID WASTE (MSW)/REFUSE DEPRIVED FUEL (RDF)

Vibrating conveying, screening and classification equipment has allowed Municipal Solid Waste (MSW) to be separated into various selected process streams depending upon the specific resource targeted for recovery. Existing facilities are recovering virtually all plastic bottles, steel and aluminum cans, scrap metal and newspaper from the waste stream. Local market conditions usually determine whether glass recovery is economically feasible.

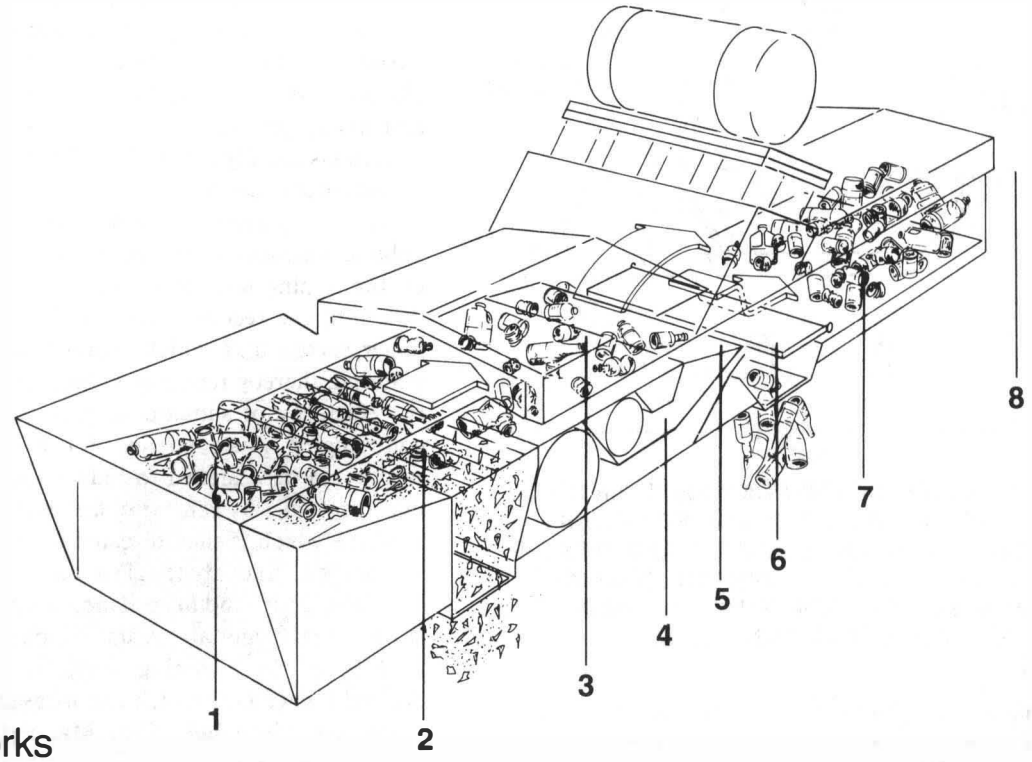
At the very beginning of the recovery process, a large volume open-tub style vibrating conveyor-feeder is used on the tipping floor to collect and meter the material flow into the recovery system. This is followed by a finger screen unit which removes a specified size of material, thereby reducing volume in order to increase the efficiency of subsequent process equipment. In a commingled waste stream, for example, the finger screen can be designed to reduce the load on the primary trommel by removing fine material below a certain size which is then directed to composting.

Once the fines, both glass and plastic containers, cans, aluminum and miscellaneous metals are removed, the residual material stream, which can approach up to 45% of the incoming waste, is essentially refuse derived fuel (RDF) which can be used in its raw form or processed into fuel pellets. Material suitable for pelletizing is obtained by installing a vibrating/pneumatic air-knife classifier (Fig. 8), near the end of the recovery system prior to a pelletizing system. The classifier includes a primary screening section to remove compostable fine material and remaining heavies such as can lids, broken glass, etc. drop out through the air-knife gap. The separating air current carries light material across the gap and into the pelletizing system. The air-knife can be adjusted to snag any large pieces of torn plastic bags which would be detrimental to the pelletizing process.

COMPOST

Composting is probably considered as the best method of solid waste disposal other than landfilling or incineration which explains the significant growth in new composting facilities. The design of new compost facilities throughout the country varies greatly because of the differing characteristics of infeed material. Flow rates fluctuate, and properties of the material may vary seasonally, hourly and even between truckloads. Vibrating conveying, screening and classifying equipment is used to regulate the flow and condense the varying infeed material into one with acceptable content and relatively common size.

In addition to ferrous separating equipment, all municipal solid waste (MSW) composting facilities require



How it works

1. Vibratory action moves material, with high density material settling to bottom of trough.

2. Fines drop out section (optional) removes smaller particle sizes of broken glass and dirt before reaching air fluidizer.

3. Air fluidizing section assists in stratifying material.

4. High velocity, low pressure air stream is directed through material flow.

5. Material conveys into air stream. Heavy material such as glass and metal falls through air stream to discharge chute.

6. Marginal density material is caught on adjustable slope plate and falls back into discharge chute.

7. Acceptable material such as aluminum and plastic carries beyond plate and travels to product discharge.

8. Light material, paper and plastic film is removed through air exhaust on stationery hood over discharge.

FIG. 8 MATERIAL FLOW IN SINGLE AIR-KNIFE CLASSIFIER

some form of coarse screening. Whether the material is raw MSW or preprocessed material, it is necessary to remove a specific size of unwanted oversize items. These can be further reduced in size for re-entry into the process system or otherwise disposed of. The jam free, nonblinding, cascading flow action of a vibrating finger screen unit is ideal for screening mixed materials having different sizes and physical characteristics.

At some point in the composting process, it is sometimes desirable to "fine" screen the fermenting compost in order to enhance the final product. Again, the efficient performance of a vibrating finger screen is ideal.

A vibrating/pneumatic air-knife classifier is also used to remove undesirable material, such as glass shards, plastics and nonferrous metallics, from the mature compost.

MATERIAL RECYCLING FACILITY (MRF)

Vibrating equipment is being applied to many new applications within the emerging resource recovery industry, especially as recyclers search for more cost effective ways to develop selected waste streams using minimum manpower.

Vibrating process machines are easily adapted for this service and their design varies from one facility to the next because of their intended purpose in the operation and the many possible variations in the incoming material flow. The infeed material may consist of source separated, dirty or relatively clean commingled mixed containers and paper stock, construction/demolition or even metal scrap!

The ability of a single-knife vibrating/pneumatic classifier (Fig. 9), to separate glass from aluminum and

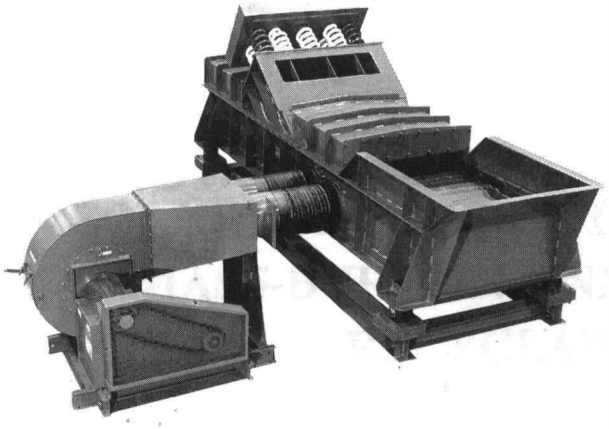


FIG. 9 VIBRATING/PNEUMATIC CLASSIFIER (Destoner) WITH SINGLE AIR-KNIFE HAS FINGER SCREEN SECTION FOR "FINES" REMOVAL. AIR VOLUME THROUGH DECK IS CONTROLLED BY MANUAL BLAST AND ADJUSTABLE INLET DAMPER ON BLOWER.

various plastic containers after ferrous separation, results in two concentrated streams. One, the glass stream, provides an easier positive pick of glass by color whereas the other allows plastics to be manually selected by type, PET, HDPE and PVC. The residual aluminum can be removed by eddy current separation.

Selected waste paper streams can be processed across a finger screen unit to produce a negative pick condition; for example, larger pieces of corrugated cardboard can be separated from boxboard, newspaper and other paper waste prior to a baler. Undesireable fines are removed without "fluffing" the remaining material. Efficient separation is possible because of the nonblinding, cascading material flow characteristic of the finger screen design.

There are many situations where manual picking or sorting operations are necessary to achieve a specific goal. The action of a vibrating conveyor causes material to spread out across the deck in a thin bed allowing faster visual identification resulting in easier, more efficient sorting. The path of a picking/sorting conveyor can be linear, circular, horizontal, inclined or any combination thereof. Vibrating units can be furnished with special deck designs which allow workers to actually lean against the sides of the unit without danger of injury. Double or triple decks and troughs having multiple lanes can be provided for special applications where it may be desireable to handle different products at the same time without cross contamination.

SUMMARY

Vibrating process equipment no longer carries the image of a self destructive piece of troublesome equipment which will shake apart both itself and the facility where it is installed.

Advanced technology, together with innovative design techniques, have resulted in reliable, low maintenance, energy efficient multi-purpose process machines with various balanced designs. The size of units has kept pace and it is not uncommon to see single vibrating units with decks as wide as 96 in. and as long as 200 ft.

The unique "live action" of material on a vibrating machine allows it to be processed in many ways while being conveyed thus permitting a single piece of equipment take the place of multiple units.

New applications are being uncovered every day by inquisitive people who having a specific need in mind for their process, approach a vibrating supplier asking if there is a machine available that can handle a special application. Today, chances are that one is available; but if not, there will be soon!

REFERENCES

Since the application of vibrating equipment technology directed specifically to various phases of resource recovery has only occurred over the past few years, very little published material exists.

The innovative air classifying equipment discussed in this paper is covered by U.S. Patents 4,624,370; 4,715,950; 4,844,235 with others patents pending on the cascading finger screen.

A highly competitive situation among the few major manufacturers of this type of equipment has also resulted in details of specific developments and installations being considered proprietary knowledge which is kept confidential.