

Air Classification of Shredded Refuse: State-Of-The-Art

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Good morning fellow garbage men . . . er . . . uh . . . garbage persons!

My friend, . . . ASME's friend . . . everybody's friend . . . Joe Mullen of Combustion Engineering . . . recently critiqued for me our just-published first brochure on our ADS System. Among his comments was this:

"Garbage is a term that induces adverse reaction from the public. I prefer the terms municipal refuse, refuse, waste, municipal waste."

If you agree with Joe, from here on be my guest in substituting the synonym of your choice when I verbalize "garbage."

This division's committee, which recently deliberated on a name change, shied away from "Garbage Processing Division." Perhaps too unprofessional.

As television's white-suited Jonathon Winters does for Mobil's Husky trash bags, we could try to upgrade the image by popularizing use of "gar-*báge*."

But, to paraphrase the poet who wrote, "A rose by any other name smells as sweet," . . . garbage by any other name still smells!

And, right here, kindly indulge me in a moment's editorializing:

Those of us in the materials handling phase of garbage processing had better get out and smell it . . . get the feel of it . . . see it stand up straight and refuse to flow . . . see it compress and expand in remarkable fashion . . . see first hand, not in some technical report, the tremendous range of its constituents, of its

moisture contents, of its densities, and speculate on some others of its myriad variables. I recall once being exposed to a group of brilliant aerospace engineers. They tried to capture all the variables of garbage, to six decimal places, for a computer analysis on a solid waste disposal study. Talk about frustration . . . !

Burning refuse . . . for power generation or just incineration, really is no big problem. It does burn. Shredding garbage . . . for neater, cleaner, compacter landfills, or just better combustion . . . really is no big problem. It does shred. The big problem is in the materials handling of it . . . of the bulk junk to the shredder . . . of the shredded stuff to the classifier . . . of the several streams from classifier to storage, or to rail or truck or barge. That's a problem! Storage is a classic problem. How to get it out of storage?

We who are involved in materials handling of other stubborn, bulk products know and appreciate depth of the problems, and we may have answers to one or two of them. Not infrequently we find ourselves involved with people who, it seems just because they are quite knowledgeable and experienced with design of sewers, courthouses, bridges and air line terminals, automatically are expected, by their clients, to be equally adept at design of materials handling systems for such "wild" material as garbage in its many forms!

We think we see what could be some major mistakes being made at this moment, by otherwise qualified engineering people who don't face the fact

This talk was delivered September 5, 1974, at seminar of the Solid Waste Processing Division of ASME in New York City

there are more unknowns than knowns about garbage, its handling and its processing. You don't have to taste it . . . but do get out and see it . . . feel it . . . and you can't help but smell it!

Personally, I expect more intimate and daily contact with garbage constituents, because my last child is leaving the house for college now. I'll sure contemplate quantity while "materials handling" it from kitchen to garbage can!

It's worth contemplating, because it's big business. Disposal and resource recovery dollar volume is forecast to increase an average 33 percent a year from now to 1980. Frost and Sullivan, Inc., a New York City market research firm, reports that, and:

"Expenditures for construction of facilities related to solid waste management will reach \$1.5-billion by 1980."

I guess most of us here want a piece of that \$1.5-billion garbage pie . . . and that's one of the reasons we are here. Which brings us to the subject at hand, "Air Classification of Shredded Refuse—State of the Art." When he phoned the invitation for me to be here this morning Bill Robinson of Hammermills, Inc., suggested that title. I should have countered with, "Air Density Separation of Shredded Refuse," because we call our unit an "Air Density Separation System," or in this age of initial designators, "ADS."

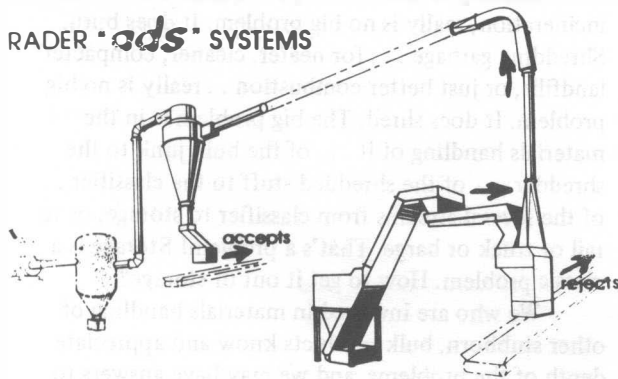


Fig. 1

My friends in our European operation, incidentally, advise that "Air Density Separation System" just cannot be translated properly into the several languages they use. Thus, because of their generous contribution to our balance of payments, we say "ADS" also means "Aero Dynamic Separation System," as you see. This, they say, can be translated, but I'll spare you that.

Speaking of names, I noted the program on this meeting, which I received in the mail, identified my company as "Radar" Pneumatics. A common mis-

take. I've seen six figure checks made out that way. And we chortle all the way to the bank with them. Equally as troublesome is "Pneumatics." There isn't one in twenty reservationists with Hertz or Holiday Inns who can spell it.

At the very beginning of Rader Pneumatics, about two decades ago, there really was a Rader . . . an affable, fullback-sized fellow aptly-named "Tiny" Rader. He left us his name to confuse those who followed, while he went up the ladder at Allen-Bradley . . . to president, now, I believe.

You now may run into people from various companies in the Rader family literally around the world. On this continent the other principal home bases are Portland, Oregon, Vancouver, B.C., and Montreal. But, the main thrust of Rader involvement in refuse has been from Memphis, Tennessee. However, the ADS System originally was developed by our Portland people at an installation in California. Now there are 31 units from coast-to-coast . . . and one in Iran . . . in various stages from customer's purchase orders, to fabrication, to field operation. Most of these systems are to separate foreign matter in flows of wood products particles—chips, shavings, sawdust, bark, hog fuel, etc. And, they are working well. Multiple, second-buy situations are common. Two California companies each have two units. Four are being installed in Oklahoma. A New Jersey firm has two on order—one for Illinois, one for Missouri. Rocks and metals can cause expensive downtime and can tear up costly equipment in pulp mills, roofing plants, and hardboard and particleboard manufacturing facilities. At one plant they just don't operate if the ADS System is down. Some of these wood products systems can process at rates up to 120 tons an hour.

There is only a single system processing shredded garbage. But the second one was purchased before the first was started up. There is one rather special system in operation with industrial refuse, and another on order. In sequence, St. Louis is running. Ames, Iowa is being fabricated and should be operational by Spring, I would guess. Eastman Kodak is in service and General Motors should be by Summer.

Now, speaking directly to the point of "State-of-the-Art," I gratefully and humbly say the state is "good" thank you . . . for Rader, at least. Last week it was announced Union Electric Co. of St. Louis had given us an order for in excess of \$4-million for 38 systems, including 11 ADS Systems.

So, we just gotta be doing something right!

I can't comment, of course, on "State-of-the-Art" for any of the other 18 firms I've recorded as

making—or saying they will make—air classifying systems for garbage.

As far as we know, our system in operation at the City of St. Louis refuse preparation facility is the world's largest—and really the world's first—production unit. Because it's all we have to “show and tell,” I'd like to picture it for you in some depth and detail. Here it is:



Fig. 2a

While you are finding your sunglasses to deal with that Rader blue, I should tell you a secret: The very first cubic foot of shredded garbage ever ADS'ed anywhere was processed on that rig, and it was when we punched buttons the first time at startup, mid-

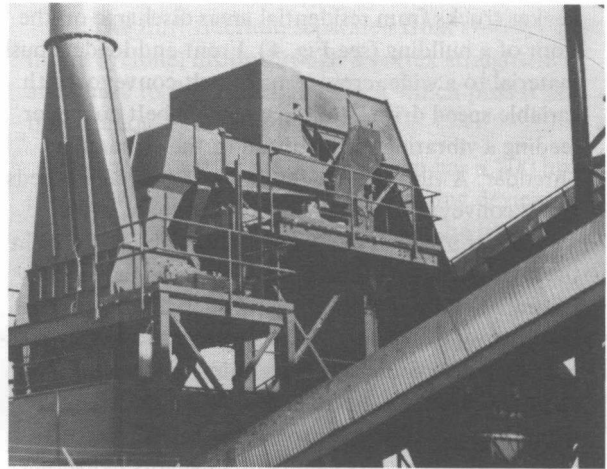


Fig. 2b

morning last November 9. In my lifetime to date, equal only to the thrill of becoming a father the first time—and the first breaking out of a low overcast to find the runway just where it ought to be—was the thrill of watching the cans, rubber heels and orange peels dropping out of the fuel fraction of that first garbage!

Our people fully recognized the tremendous differences in characteristics of wood products, with which we felt comfortable, and shredded garbage with all its unknowns. But, we concluded we could translate our wood handling techniques and experience to garbage more accurately, and with less risk, than scaling upward from a small garbage model, and we could reach commercially acceptable performance and capacity. It appears we were right on.

For those who may not have visited the St. Louis installation—and thousands have—this schematic (Fig. 3) may help show you the material flow.

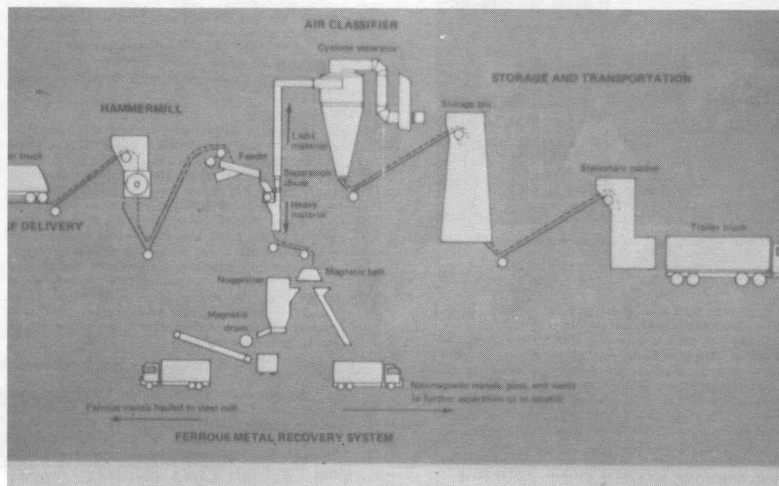


Fig. 3

Packer trucks from residential areas discharge on the floor of a building (see Fig. 4). Front-end loaders push material to a wide, cross-transfer belt conveyor with variable speed drive. It discharges to a belt conveyor feeding a vibrating feeder ahead of the Gruendler Shredder. A vibrating feeder under the shredder feeds a belt conveyor to the Rader ADS System, which we'll cover in detail in a moment. Dropping out from the ADS, the heavy fraction's ferrous is magnetically separated and fed an Eidal Mill which discharges to a belt conveyor (see Fig. 5) loading out trucks for transport to a steel company. Remaining nonferrous "heavies" are trucked to landfill. The light fraction from the ADS is belt-conveyed to the Miller Hoffft storage bin. Its augers feed belt conveyors delivering to a stationary packer loading out trailers for transport to the Meramec Station of Union Electric Company, some 20 miles away.

Back to the ADS System, schematically . . . flow of shredded garbage is from metering conveyor to vibrating feeder (see Fig. 2b), to infeed airlock, to separation zone. "Heavies" drop out. "Lights" are lifted through pipe and elbow for separation by cyclone and discharge through airlock.

The belt conveyor shown below in Fig. 5 really is broken—is two belts—first section dropping material from the shredder into the ADS System's triangular-shaped metering hopper with steeply-sloped, upward-rising, chain-flight conveyor. Flights are full-width—about 8' and lift material from the hopper. The



Fig. 4



Fig. 5

upward angle—about 60 degrees—allows most material above flight height to fall back into the bin. As the conveyor leaves the bin, there is a powered, reverse-rotating, leveling roll for positive assurance of a level, smooth bed of material being deposited on the full-width vibrating feeder.

It further levels and thins the material blanket. Some pulverized glass, sand and dirt are removed through holes in the punched plate's last 18", just before material slides down the chute to the infeed airlock. Subsequent models will have improved screening—punched plate over nearly the full surface, and a 'waterfall' half-way down the pan's length, so material atop the bed at the head end is up-ended and down to screen deck level.

Massive size of components can be seen here. Pipe is 42" diameter. The man is on a platform alongside the infeed airlock. Separation zone is on floor below. (see Fig. 6)

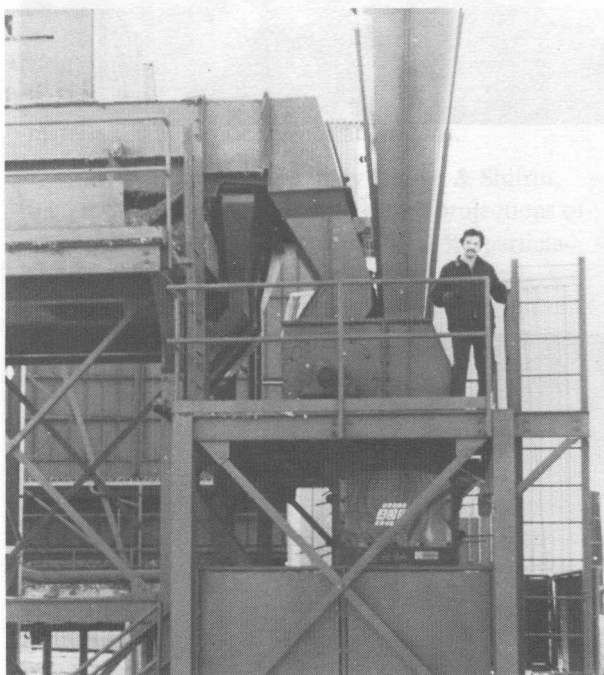


Fig. 6

Another visualization of system components size. Infeed airlock is nominally 8' wide—front to rear. (And this pipe is a little smaller.)

The light fraction is sucked through pipe and replaceable back elbow to cyclone. They haven't had to change out the elbow back yet. And, you're right . . . when they do, they'll need a crane or a helicopter!

The fluff fraction, separated from conveying air in the cyclone, drops through a vortex straightener and chute to the discharge airlock which puts it on the belt conveyor to storage bin.

The blower of the ADS System has a 200 hp motor. Were a filter, or other air cleaning device, required or desired, it most likely would be located between the cyclone and blower, but could be on the discharge side of the blower.

Well, that's the hardware making up a Rader ADS System for garbage. Now let's zero in a little closer on the actual separation of accepts and rejects.

For those of us without maids, or children at home . . . and with domineering wives . . . this is what we lug from kitchen to can, here dropped on the processing floor at St. Louis. We've observed its flow from shredder to separation zone of the ADS System.

Here comes the shredded material which we have meticulously massaged into a thin blanket, perhaps 6" high, full 8' wide and quite level. Particles continuously slide down the chute into opening pockets of the airlock rotor, turning clockwise in this view, and on into the separation zone. We have a level and metered volumetric flow of material. We'd like to have as uniform and small particles as economically practical. The first important control we must have is constant, even volume of material.

The upward rising air in the separation zone also is quite closely controlled. Desired air volume has been dialed into a control unit which maintains that volume consistent with density and constituent changes in the constant volume flow of material. Air velocity has been carefully adjusted by experimentation during system startup for the particular conditions of the installation.

Velocity control is by adjustment of moveable sections of zone walls. This unique zone design allows multiple zone shapes, and air velocities, in various sections of the zone. Air can be controlled, because with the infeed airlock, there is just a single source of air—from bottom of separation zone. So now, not only do we have control over material, we also have control of air.

What does this do for us?

Here we are looking upward toward the airlock, (Fig. 7) in the separation zone, from one side. This is where the action is. This is where all the variables of particle size, shape, density and flotation velocity are balanced out in the "moment of truth"—whether each particle rises or falls. If all material were same

particle size—and there were good control over both material and air flows—then density would be the deciding factor on whether each particle ended-up in a boiler, in a steel mill, or in a landfill.



Fig. 7

Mill—discharging from belt to truck (see Fig. 9). At last report this was worth \$58 a ton in St. Louis. That's up to about \$870 a day there. There's a couple of dollars worth of it here!



Fig. 8

Yes, it's still garbage, but not the bulk junk we started with. Here it's been processed into a commodity good enough to replace coal in power generation in about a two-for-one ratio—a couple of pounds of this stuff saving about a pound of coal for the same quantity of electricity.

Back to the separation zone—"heavies" are dropping onto a belt conveyor, some for processing into thumb-sized steel "nuggets", the remainder—for now, at least—going to the dump. (see Fig. 8)

While this stuff now is bound for the dump, there are several processes for additional separation—and, we understand, also buyers for portions of these nonferrous rejects of the heavy fraction. Note that orange peels, aluminum can pieces, rubber heels, big pieces of wood—all of these, we know, will not be consumed in suspension-burning boilers. Its the job of the ADS to eliminate as much of this category as possible from the fraction going to the boilers.

Nuggetized steel—really beautiful material—after magnetic separation and action of a small Eidal



Fig. 9

From operating experience so far at St. Louis we've concluded one thing I'd appreciate your "trying on for size:" On balance, volume of garbage to be processed probably varies considerably less than does its weight. While there are some seasonal variations—and variations from neighborhood to neighborhood—number of packer trucks per day seems to be relatively constant. But, weight can change more radically.

Obviously, ingredients affect weight. Iron weighs more than paper, but, moisture content would appear to be the most prevalent variable. If it rained over the weekend, the Monday collection from the same neighborhood as last Monday . . . after a dry weekend . . . is going to weigh more. At St. Louis samples from each trailer going from preparation plant to generation station show a moisture content range from about 11% to about 66% with 30% the average.

Yet, most everyone wants to talk "tons of garbage" in discussing processing rate design. Certainly from shredder horsepower deliberations . . . from structural considerations, perhaps . . . from burning standpoints . . . weight is a criteria. We submit that volume is equally important, if not predominate, in materials handling design considerations.

In their preliminary study Horner & Shifrin, Inc., the St. Louis consultant, evolved projections of garbage density shredded to nominal 1-½" particle-size, a low of 4 pounds per cubic foot . . . high of 11 pounds . . . average of 7. According to our unscientific testing in the real world there, they were "right on."

What does all this mean to you and me—to our ADS System design?

Simply put, this Our ADS System must be engineered to handle a constant, fixed volume of material, not only at average density, but also at maximum density. The numbers at St. Louis are: 13,000 cubic feet per hour. At average density of 7 pounds per cubic foot the nominal tonnage capacity is 45 tons an hour. At maximum density, maximum tonnage capacity is 72 tons per hour. Should we call this a 45 or 72 ton unit?

Following a great burst of originality we call that St. Louis-sized, 13,000 cubic-foot-an-hour rig, our "Model 130".

O.K., Great. But, so what?

Just this: If you are working on a refuse preparation facility, and want to consider an ADS System,

you're going to have to tell me a lot more than merely you want to shred 50 tons an hour, or whatever. In our system design we must include metering conveyor and airlocks, for instance, for an agreed-upon constant volume . . . and then air and blower horsepower for that volume at what you say is maximum design density.

Now, returning again to this "State-of-the-Art" thing . . . Electrical World Magazine's May article on the St. Louis installation said,

"The single most important item that 'made things happen' . . . was installation of a Rader Pneumatics air classifier."

As already mentioned, Union Electric Company is including multiple ADS Systems in their plans for facilities to process all the refuse from St. Louis and seven surrounding counties . . . 8,000 tons a day, compared to the present 300 tons per day. When the utility, Horner & Shifrin and the City initially hatched-up the "trash to kilowatts" scheme air classification was not in the flow plan. At the time—and we were there and involved—no one really knew much about air classification—and it was not included. After the Spring 1972 startup some problems developed which, investigation revealed, air classification probably could help solve. These concerned excessive carry-through the boiler of oversize, unburned material . . . less than fully automatic operation of our pneumatic systems whose airlock feeders could be jammed by oversize, principally nonferrous, material . . . and a high rate of wear in pneumatic system elbows. We thought we could handle the first two—and not the third, elbow wear.

Skipping over a few thousand words of really interesting history of what followed, our ADS System was cranked-up just 19 months after the first garbage was blown into the boiler. While not all problems were eliminated, jamming of pneumatic system airlocks was ended . . . boiler carryover reduced . . . and elbow abrasion "put into perspective." On balance, the ADS changed the technological and economic evaluation from "no" to "go," as evidenced by the Union Electric commitment of \$70 million dollars to "Garbage Power."

"State-of-the-Art?" When you say that, you imply the state is fluid and changing . . . and it is. Rader is looking ahead toward improving the state.

Perhaps this, too, will contribute to cleaner fuel. About a hundred "Scrap Trap" Tees are in service now, taking rocks and metals out of wood chip

flows in Rader high pressure pneumatic conveying systems. Depicted is the airlock feeder of a pneumatic transport system. The “tee injector”—the pipe connection under the feeder where conveying air and material are mixed—is modified. A drop-out pocket is provided for dense materials . . . before they can become airborne.

On one of the Union Electric boiler charging systems an experimental “Scrap Trap” tee worked so well we had to remove it! Sand and glass were dropped out at such an alarming rate we now are back on the drawing board working out an automatic clean-out device!

Compared to the artist’s sketch, here’s the real thing. Note the manual clean-out door at the bottom of the drop-out of the tee injector. We are trying for a continuous, automatic ejection device with minimum additional vertical height and without disruption of system conveying capability.

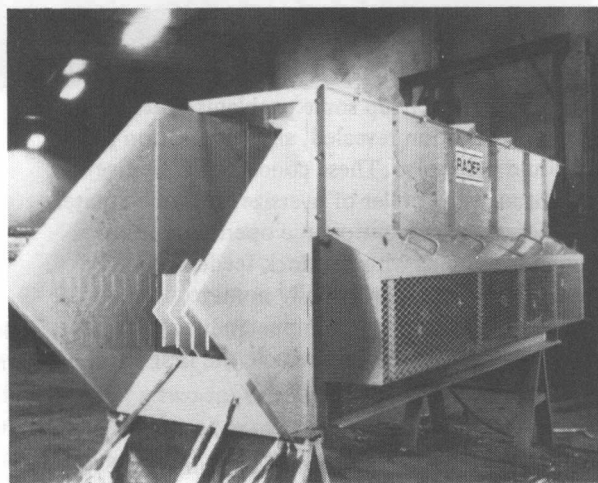


Fig. 10

Perhaps the RDS, also, will contribute to an improved “State-of-the-Art,” although a mechanical, rather than air, classifier. It’s simple, but unique . . . and thrillingly promising! We call it “Rader Disc Screen” . . . or RDS. (see Fig. 10) We project two possible applications in refuse processing:

1. Between shredders in a two-stage line, “accepting” that surprisingly high percentage of material which already is down to required small size, and sending on to the second stage only that which needs further reduction.

2. And, a separate unit to screen-out pulverized glass, sand and dirt from the accepts light, fuel fraction.

The RDS consists of parallel shafts containing multiple star-shaped discs. Material is introduced at one end. It is moved forward by the rotating discs. Discharged at the far end are big pieces. Dropping through clearances between discs, and between disc points and shafts, are smaller pieces. Clear openings are adjustable. Material constantly is being agitated—clumps broken up—and sifted. Volumetric capacity is quite high. (See Fig. 11)

In addition to screening the RDS is also a much-needed positive conveyor, and a leveler, for this difficult-to-handle material. We see it also, possibly, as an improvement on, and substitute for, the vibrating feeder in our ADS System flow. Several RDS units are running with wood products. Tests with refuse are encouraging, to put it mildly. We hope to have a refuse installation operating for production evaluation by the first of the year.



Fig. 11

Now, thank you for your kind attention and patience in listening to this nonengineer, nonartist . . . comment on “State of the Art” in Air Density

Separation of shredded refuse, municipal waste, or whatever synonym by now you've selected. I also appreciated the opportunity to acquaint you with some of the new technology with which we are involved. I would hope some of you might contribute to it. We

would be happy to have your thoughts.

I hope too, it might be possible, in a year or so, again to comment on the "State-of-the-Art." Who knows, by then it might even be scientific! or, at least, more so than now.