Message from the TPC of Extrusion Division for ANTEC 2013

It is this time of the year again! From April 21st to April 24th, thousands of professionals from the plastics industry will gather in Cincinnati, Ohio to attend the Annual Technical Conference hosted by SPE (ANTEC). This is the premier networking event where ideas are cultivated, information is exchanged and friendships are formed. The Extrusion Division will have 9 excellent technical sessions in the areas of single screw extrusion, die design, twin screw compounding, nanocomposite processing, film and sheet extrusion, and a special session on hot melt extrusion (HME) and granulation. On Wednesday morning, there will also be a “Meet the Extrusion Experts” Tutorial session where attendees will hear presentations from industry experts in both single screw and twin screw extrusion. Attendees are also encouraged to bring questions from their own production lines for some interactive discussions.

We are excited to have many excellent speakers this year. We are honored to have Prof. Han Meijer of Eindhoven University of Technology to give us a plenary talk on “Fractal Structuring in Polymer Processing” on Monday morning. In addition, we have 3 keynote speakers as well. Dr. Gregory Campbell will educate us in the development of the screw rotation model for single screw extrusion on Monday morning; Mr. Tim Taylor who is the COO of Chevron Philips and also the 2013 Business Award winner, will be giving us a talk on sustainability on Monday afternoon; and Mr. Mark Wetzel of DuPont will be presenting his work in modeling the kinematics and thermodynamic interactions during the dispersion of layered silicates in polymer melts on Tuesday morning.

Don’t forget to join us on Tuesday afternoon, April 23rd, for the Extrusion Division Awards and Business Meeting right after session T28. We will be honoring scientists and engineers who have made significant contributions to the plastics industry in their respective fields. As an added bonus, hors d’oeuvres and refreshments are on us! Come on out to celebrate fellow colleagues’ successes, meet your Extrusion Division board members, and mingle with some old friends while making new ones over food and drinks! What could be better than that? We look forward to seeing you there!

Karen Xiao, Ph.D.
Technical Program Chair, Extrusion Division for ANTEC 2013

Celgard, LLC — A Polypore Company
Email: Karen.xiao@celgard.com
## ANTEC Program — Extrusion Division  
Monday — April 22, 2013

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- **The HME Process from Drug Discovery to HME-produced oral Pharmaceutical Products** — Chad Brown
  - Keynote: Gregory Campbell — Development of the Screw Rotation Model for Single Screw Extruders
  - A Study of Filled Volume in a Co-Rotating Twin-Screw Extruder Using Analysis of Residence Time Distribution — Babu Padmanabhan
  - Keynote: Tim Taylor (2013 Business Award Winner)

- **Pharmaceutical HME Viewed as a Compounding Polymer Processing Operation** — Costas Gogos
  - Influence of the Melting Zone on Compounding of Cellulose Fiber Reinforced Poly lactide — Tobias Koplin

- **Twin Screw Extrusion for Granulating of Pharmaceuticals** — Michael Thompson
  - The Influence of Design and Processing Parameters on the Mixing Performance of a Fluted Mixer — Pavel Kubik
  - An Expanded Residence Stress Distribution Study in a Twin-Screw Extruder: The Effect of Stress Bead Strength — Graeme Fukuda
  - Influence of Cooling Condition on Recycled PET Pellets — Kazushi Yamada

- **A Critical Review of Pharmaceutical Polymers for HME and Granulation** — Shaukat Ali
  - A Novel Method for the Evaluation of Particle Tracking Simulations of Mixing Processes — Thomas Erb
  - Residence Stress Distribution Study Using a Robust Design of Experiment Approach — David Bigio
  - Recycling of Polylactide for Packaging Applications — Sebastian Schippers

- **Twin Screw Equipment for Pharmaceutical HME and Granulation** — Charlie Martin
  - 3D-CFD-Simulation of Polymer Plastification in a Single-Screw Extruder Under High-Speed Conditions — Gregor Karrenberg
  - Effect of Process Parameters on Properties of Devulcanized Rubber Obtained from a Supercritical CO2 Assisted Devulcanization Process — Mohammad Meysami
  - Effect of Loading Level and Granulometry on PHB/Begetal Fiber Eco-Composites — Eduardo Canedo
  - Chain Extension of Virgin and Recycled Poly(Ethylene Terephthalate): Rapid Estimate of Molecular Weight Increase — Eduardo Canedo

- **Simulation of Distributive Mixing in a ZSK-90 Co-Rotating Twin-Screw Extruder** — Mahesh Gupta

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<td>Upgrading the Capacity of an Existing Extrusion System — Mark Spalding</td>
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Top 5 Reasons to Attend ANTEC

1. **Broaden Your Understanding of the Plastics Industry** - Attend sessions exploring the full spectrum of the plastics industry. ANTEC is the place to gain exposure to developments and people from throughout the entire industry.

2. **Network** - Meet with fascinating, informed and creative colleagues from around the world to share insights from a broad range of disciplines and industries within plastics.

3. **Visit with Exhibitors** - Walk the tradeshow floor and talk with representatives from leading companies who offer solutions for your business.

4. **Understand the Impact of New Technology** - Confer with the plastics industry's leading experts to learn what new technologies and techniques are being developed today.

5. **Build New Skills** - ANTEC offers seminars, workshops and other forums for people of all levels within the plastics industry. Take advantage of one or more of our special sessions to enhance your skills and increase your knowledge.

The Extrusion Division launch of the first Extrusion Wiki in early 2009 has met with broad acceptance. Board of Directors Member Michelle Curenton was instrumental in developing the Wiki. The Extrusion Wiki will allow you to search a vast database of information concerning extrusion as well as being able to submit additional content.

Check it out by clicking [here](#)!
Extrusion Division
Awards Reception

Come network with your colleagues over food and drinks at the Extrusion Division Awards Reception on Tuesday afternoon, April 23!!

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<td>DEVELOPMENT OF SCREW ROTATION MODEL FOR SINGLE SCREW EXTRUDERS</td>
<td>Gregory Campbell, Castle Associates</td>
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<td>Monday 1:30 P.M.</td>
<td>SUSTAINABILITY</td>
<td>Tim Taylor, COO, Chevron Philips — 2013 Business Award Winner</td>
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<td>Tuesday 8:00 A.M.</td>
<td>MODELING THE KINEMATICS AND THERMODYNAMIC INTERACTIONS DURING THE DISPERSION OF LAYERED SILICATES IN POLYMER MELTS</td>
<td>Mark Wetzel, DuPont</td>
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<td>Wednesday All Morning</td>
<td>TUTORIAL SESSION — MEET THE EXTRUSION EXPERTS</td>
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**Plenary Speaker**

Prof. Meijer has developed a World Class laboratory for studying most aspects of polymer processing, including many operations that occur downstream from single-screw extruders. These operations include general fluid flow, extensional flow, elastic behavior, static mixers, coextrusion, and microlayer processing. He uses his lab to study experimentally the processes and then develops the numerical models. He has published numerous papers on these subjects. Han Meijer received his Ph.D degree from the University of Twente in 1980 with the late prof. J.F. Ingen Housz as his supervisor. He is currently a full professor in Polymer Technology.

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<td>Monday 11:15 a.m.</td>
<td>FRactal Structuring in Polymer Processing</td>
<td>Han Meijer, Professor, Eindhoven University of Technology</td>
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ACS Group is a leading manufacturer of auxiliary process equipment for plastic processing and other industrial applications. We manufacture a complete line of process cooling, temperature control, material handling and size reduction equipment.

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**K-Tron**

K-Tron is a global leader in the design, installation and maintenance of process feeders and pneumatic conveying systems for the handling of bulk solids. Specialized in high accuracy feeding and metering of powders and bulk materials, K-Tron develops, manufactures and oversees every aspect of its equipment, thus ensuring the greatest accuracy, consistency and long-term value.
Drying and Crystallizing Systems for Reclaim Extrusion
by
Jeff Courter
ACS-Walton/Stout

Abstract
Many reclaim lines require moisture removal from the regrind material, and a PET reclaim extrusion line will not operate properly if the drying and crystallizing system cannot supply the material into the feed throat at the desired moisture content, temperature and intrinsic viscosity (I.V.). A proper drying and crystallizing system can be the difference between quality product and junk, so it is worthwhile to consider some features of the new equipment for your system:

- Correct sizing and proper operation
- New filter systems for increased performance
- High-efficiency motors
- New user-friendly PLC-based control systems
- Heat recovery systems
- Gas-fired options
- Integration with extruder control system

The following equipment is crucial to any reclaim extrusion line:

- Hot air dryer (material dependent)
- Crystallizer (material dependent)
- Dust collection system
- Dryer and hopper sized for the application
- Loading system

Introduction
A properly configured crystallizing and drying system will help produce your product with higher quality, improved efficiency and lower cost if they are reviewed and specified in advance.

Auxiliary equipment sized to match downstream production needs
Many reclaim lines require moisture removal from regrind and reclaimed materials- with further processing required in the case of Polyethylene (PET); based on its chemical characteristics.

A PET reclaim extrusion line will not operate properly if the drying and crystallizing system cannot supply properly conditioned material to the feed throat at the desired moisture content, temperature and intrinsic viscosity (I.V.). A properly engineered drying and crystallizing system can mean the difference between having a quality product or an unusable finished good. It is well worth the time investment to consider multiple processing features of new equipment for your system:

Correct sizing of your upstream equipment relative to the desired throughput rates for recovery, as well as overall extrusion rates will be the first consideration for successful processing of reclaimed materials.

For example: many sheet producers – especially thermo-formers producing shapes with round configurations (i.e.: cups and lids) could easily have a 60% or greater scrap factor to consider. For PET sheet lines, this percentage of potential “loss” would quickly convert their business to a “non-profit” organization.

Considering typical reclaim percentages then becomes a relatively simple mathematical calculation. If a processor is running a thermoforming sheet line with a throughput rate of 1000 pounds per hour and has a maximum potential scrap factor of 60%, the recovery or reclaim rate desired should be sized to accommodate this potential, and will be equivalent to the needed rate of recovery at a reclaim rate of 600 pounds per hour.
Size Reduction

The first consideration for reclaiming materials for re-use would be for size reduction equipment to obtain reclaim characteristics that can be processed more similarly to the original virgin material. Screening of the material to a consistency that provides greater bulk-densities and good flow characteristics are always deliberate and essential for further downstream processes.

Granulators configured with accessories to accept materials as-processed by the extrusion line are also desirable to avoid undue intervention by an attendee for this portion of the process.

Crystallization Methodology

For PET processors, there are further considerations for the conditioning of reclaimed PET. In its natural state, PET is an opaque crystalline resin. Clear products can be produced by rapidly cooling the molten polymer to form an amorphous solid. In a process called “glass transition”, amorphous PET forms when its molecules are not given enough time to arrange themselves in an orderly fashion as the melt is cooled.

At room temperature these molecules are frozen in place, but if enough heat energy is put back into a controlled process, the molecular structure begins to migrate, allowing crystals to nucleate and grow. This procedure is known as solid-state crystallization.

Crystallization, or re-crystallization, has become an important process when considering potential losses of valuable petro-chemical “waste”. The massive amounts of post-consumer waste produced daily from food and beverage containers alone is staggering.

As mentioned previously, losses of in-house scrap-factors for large sheet producing facilities would accumulate startling amounts of waste in a just a matter of weeks – not to mention a stunning housekeeping problem.

Consider these statics for general reclaim of consumer products:

- Each year, 29 billion plastic water bottles are produced for use in the United States, according to the Earth Policy Institute, an environmental organization in Washington, D.C.
- Manufacturing them requires the equivalent of 17 million barrels of crude oil, so rising oil and natural gas prices have only exacerbated the high price of virgin plastic.
- Plastics News lists the price of PET virgin bottle resin pellets approaching $1.00 a pound, compared to 60 to 70 cents a pound for PET recycled pellets.

Selection of a properly sized crystallizer vessel is directly related to the bulk-density of the material, the size and shape of the particulates and the relative residence time or dwell time required to orient the molecular structure. Consistent agitation of the vessel is essential to disturb the tendency of the glass-transition phase to agglomerate. Thinner materials such as sheet or film will crystallize much more rapidly than more dense pellets, thicker sheets or blends of these materials.

Crystallization requires a heat source of forced-air through the column of material. A Hot-Air dryer is employed to control airflow with consistent temperature-controlled heating at the correct transition temperature to create an environment for molecular migration.

Special care in controlling the transition near the upper third of the vessel will have significant impact on successful crystallization.

Dust Removal

Re-processing of sheet and other regrinds, inherently produces a small percentage of nuisance dust from size reduction granulation. There are several methods of separating dust from the process, including; high-tech de-dusting equipment, cyclonic elutriation, central dust-collection systems, and/or simple cyclonic separators. All of these solutions have the ability to remove significant amounts of dust and fine particles post-granulator, or further downstream – with price variations to match the amount of dust removal desired.
Energy Conservation

Recent mandates for the use and distribution of energy-efficient motors have had an impact on the cost to operate machinery in the United States and abroad. Since the cost to operate generally rapidly outweighs the initial equipment investment, consumers and suppliers are always looking for ways to reduce, recoup and reuse energy – especially when heating and cooling are necessary processes involved in the manufacturing of finished goods. Engineers are always looking for ways to use otherwise lost energy sources and to return them to the process or use them in other localized process.

Off-the-shelf PLC Control Solutions and Controls Integration

Customers requiring feedback and historical data from their equipment have distanced themselves from simplified “relay-logic” control systems to avoid troubleshooting issues and to have nearly infinite control of their processes.

This ability is not possible with a series of block timers and relays. In an effort to answer this need, equipment manufacturers looked to the electronics industry for inexpensive solutions, which were generally proprietary boards with no standardized features for generally accepted protocols.

As technologies rapidly advanced in processing speeds, many of these components quickly became obsolete, rendering entire lines useless for a lack of viable replacements. Initially, Programmable Logic Controllers (PLCs) were an expensive luxury that few could justify.

Now that robust PLCs have become quite affordable, many equipment producers have realized that the era of proprietary components has reached an end-of-life cycle, and are supplying PLCs with greater expansion capabilities, faster processing, and recoverable data that can be logged and tracked – also lending itself to nearly fool-proof troubleshooting of equipment – or entire systems.

PLC manufacturers, as well as governing institutions such as SPI have realized the need to integrate entire systems with a common communication standard generally referred to as “protocol”. These firmly established protocols allow users to have a common, standardized and regulated transmission of data between all equipment, computers and peripherals.

Gas-Fired Options

Natural Gas and Propane remain as efficient and viable options for processes requiring reliable heating. In some areas of the United States and abroad, natural gas supplies are prevalent and readily available. High consumption users have been awarded subsides and deep reductions from gas producers. For these consumers with equivalent thermal usages for gas, the use of this natural resource outweighs electric heating costs. Most equipment manufacturers have options available for gas-fired heater in lieu of electric heating elements.

Typical Reclaim Extrusion Line - Summary of Equipment

Focus on PET Granulation

- Select size-appropriate granulator for rates equivalent to the highest scrap-recovery rate.
- Select screen size for best bulk-density and flow characteristics.
- Evacuate granulator chamber with method best suited to dust separation and recovery of usable materials

Dust Collection

Several methods are generally employed – and best solved immediately following granulation
Crystallization

- Amorphous PET requires crystallization.
- Controlled heat and forced-air provide the methodology to initiate crystallization.
- Agitation is essential as the transition phase creates tacky agglomerates that must be broken apart to achieve optimal crystallization and to avoid “chunks” of agglomerates.

Blending

Once the amorphous material has been reduced in size for efficient handling; conveying and flow characteristics, it can blended with virgin material, colorants or other additives.

PET is a hydroscopic material and will readily bond with atmospheric moisture which must be removed prior to entry to the extruder or molding machine. The drying vessel is sized for the “worst-case” bulk-density that will be processed at any time, thus allowing for adequate dwell-time in the vessel for proper drying. This residence time is commonly 4-6 hours at ~350degF with 1CFM per pound, per hour airflow at the established temperature.

Loading Systems

Generally, sheet recovery conveying and handling (post-granulator with dust removed) can be accomplished with a common vacuum conveying system – with considerations for the bulk densities of the reclaim and rates desired.

Where simplified dust-removal systems are employed and removal is not accomplish 100%, and/or the processor can use the fine particulates, filtered-receivers can be installed to avoid undue maintenance of the rudimentary screen filter found with most standard receivers.

Poly-Lactic Acid (PLA) – “Going Green”

PLA, a plant-based polymer typically derived from corn nucleotides, has gained a foothold in the market as a viable replacement for petroleum-based products. This product group has been touted as the new “renewable resource” that is also a bio-degradable solution to off-set the fact that we have become a “throw-away nation.”

PLA is also a hydroscopic material as is PET. Although this material has similar characteristics to PET, it is significantly more “finicky” to process and needs preparation for extrusion.

The crystallization phase uses much lower (and tightly controlled) temperatures, becoming tackier during transition to the crystalline state. Once stabilized, it has more common “plastic” characteristics. A desiccant dryer is a bit more conventional, but also requires lower temperatures.

Newer Processing Technologies

Extruder designs

Several new technologies are being developed to help plastics processors to increase throughput rates, process lower quality regrinds and blends, and/or to eliminate conventional equipment such as dehumidifiers.

At least one manufacturer is working toward developing a new main screw and barrel design that utilizes a single main screw with peripheral “satellite” screws rotating in the opposite direction, driven by a ring gear in the main barrel. This design provides for more of internal exposure of the polymer and thus allowing for vapor or moisture removal at the machine. The drawback of these technologies today is the extreme cost for the initial investment, and the fact that most existing machines cannot be retro-fitted with the necessary components, necessitating the purchase of a new extruder or main extrusion components.
Infrared Processing

Infrared (IR) technology is being developed as a well-controlled heat source that generates IR “waves”. IR waves excite and heat materials from the inside out to assist in expediting the release of moisture from wet and hydroscopic materials. Heated materials can also be tumbled in IR equipment to assist in the crystallization of some polymers. IR has become an interesting and promising technology for some processing requirements.

The limiting factors of IR processing:

These systems do not operate in the necessary closed-loop / low-dew-point environments needed for many popular polymers and thus require further heated, and closed-loop, low dew-point drying. Lamps and associated hardware can become overheated and require consistent air movement to keep the lamps and bases cool. The lamps cannot tolerate dusty environments and can become fouled easily when processing dusty materials, and regrinds. Complex zone controls and lots of moving parts are there for the internal tumbler beds.

Re-Pelletizing and Conditioning of Recovered and Recycled Materials

Several companies have worked closely with polymer chemists to provide innovative machinery to convert reclaimed plastics from granulated sheets, shapes and containers back to a uniform pellet that increases the bulk-density, provides for much better flow characteristics, and for controlling the process for a wide variety of polymers to “condition” these materials to nearly approach virgin specs in some cases.

Conclusion

A properly sized and configured crystallizing and drying system can provide the most economical and modular solution to produce a product with higher quality, improved efficiency and lower cost when reviewed and specified in advance.

New innovations by machinery manufacturers and polymer chemists will assist the industry to reclaim and reprocess otherwise lost resources.

References

1. Walton/Stout, Inc., New Berlin, WI
2. Cumberland Engineering, Inc., New Berlin, WI
3. AEC/HydReclaim, Inc., Schaumburg, IL
What’s New in Material Handling and Blending Systems for Reclaim Extrusion

by

Keith Larson

Colortronic North America, Inc. — An ACS Group Company

Abstract

Material handling systems are very important to the proper operation of any extrusion or molding process. An extrusion line is particularly vulnerable because the extruder can only process the material that is being supplied to the system. If the material fed into the feed throat is not blended properly, or at the right rate, the process rate and quality of the final product will suffer because the extruder can only process what goes in.

Manufacturers often spend considerable time on the extruder selection, but throw together pieces of existing or used equipment for a material handling and feeding system. This equipment can be the difference between making money and not, so it is worthwhile to consider what the correct equipment can do for your system:

- Maximum uptime making product
- Accurate feed rates with gravimetric feeders
- Inventory of materials actually used
- Variable speed AC and DC motor controls for improved control and efficiency
- User-friendly PLC-based control systems with color touch screen interfaces for clear communication of status and process data
- New feeders that can handle materials that are difficult to feed
- Gravimetric control of all components through a central interface

Integration with extruder control system for closed loop extrusion control and product weight

The following material handling equipment is crucial to any reclaim extrusion facility:

- Bulk storage of high volume materials
- Handling of sacks and gaylords of additive materials
- Material conveying systems
- Feeding and blending systems

Packaging and storage of finished product

This presentation will focus on the first four material handling issues leaving the last item for a separate discussion. Properly configured material handling systems will help produce your product with improved efficiency and lower cost if they are planned out before the system is installed.

Introduction

This paper will focus on the material handling, feeding and blending systems of a reclaim extrusion line, including:

- Material handling and bulk storage of the raw materials
- Material conveying system(s)
- Blending and feeding equipment
Bulk storage of raw material

Bulk storage equipment includes portable storage bins for small amounts of material, and larger surge bins that are generally secured to the floor in a central location. Portable bins are used to store smaller amounts of materials like low-usage virgin materials and additives. Surge bins are often used to moderate virgin material temperatures in colder climates, as well as provide a buffer of virgin and regrind materials inside a processing facility.

Larger amounts of material are stored in welded or bolted silos that can hold up to 250,000 lbs., or more, of material. This allows the processor to buy raw material in truckload or railcar quantities at a reduced price. Savings of $0.05 to $0.10/ lb. are typical, resulting in a strong payback for most large processors.

New features include ultrasonic and infrared level indication, as well as weighing systems to verify material usage.

Pneumatic material conveying systems

Pneumatic (vacuum or pressure) conveying systems are used to move raw materials into a facility, or distribute the virgin, regrind or blended material to molding machines or extruders within a facility.

Self-contained hopper loaders include an integral motor that generates the vacuum source. They are often used for lower throughputs of pelletized and clean regrind materials. Special models with extra filtration are also used for dusty regrind or some powder materials.

Central vacuum systems are the most common, but pressure systems are often used. These can be a single point-to-point system, like moving resin from a silo to a surge bin, or a from discharge bin on the end of a pelletizing line to the pack-out station. With the proper control system they can sequentially load multiple stations, like a six component blender over an extruder, or load multiple extrusion lines with a common pump.
Most vacuum receivers now use stainless steel mesh screens to keep the pellets or regrind in the vacuum receiver and prevent material carryover to the central filter. The screens will allow dust to carry over to a central filter protecting the vacuum pump. Most of the dust passes through the screen and is collected in the central filter, eliminating maintenance associated with cleaning individual cloth filters on each vacuum receiver.

Powder conveying systems utilize better filtration on the receiver itself, keeping the dust and fines in the process. Various methods like “implosion” and compressed air blowback are used to keep the filter cartridges or bags clean, and the system operating at its maximum performance. A simple cartridge style safety filter is usually provided before the inlet on the vacuum pump with these systems. This protects the pump in case a bag in the main filter rips or wears out.

Most conveying systems today use a programmable relay controller (PRC) or a programmable logic controller (PLC) to control the vacuum pumps, sequencing and filter cleaning. The PRC systems are more limited in capability and are usually used for control of one or two pumps and up to 8 loading stations. The PLC systems can handle up to 24 vacuum pumps and 128 stations, and generally include a color touch screen interface with system graphic capabilities. Support documentation, spare parts information, alarm logs and troubleshooting help are often built in.

Some systems integrate multiple systems, like conveying, drying and blending, into one system. While this puts everything in one display, if the controller has a problem, the whole system is down.

Local I/O includes traditional system field wiring and the system must be powered down to add stations or make changes. Distributed I/O technology uses two cables that run through your entire plant, and the modules can be “hot swapped” to add a station of replace a defective one. Installation is much less expensive since conduit is not required – the cables are usually just tie-wrapped to the vacuum line.

Vacuum and pressure power units can be combined into one system to convey high rates of material long distances, like in a railcar unloading system. The vacuum side pulls the material out of a railcar and discharges it into a cyclone or filter receiver above a rotary valve. A pressure system then blows the material into the storage silo(s).
How to Size a Central Vacuum Conveying System

Extrusion

Maximum process rate of all extruders, plus 50% safety factor

Calculate Actual Conveying Rate:

Machine mount blender @ 1,000 lbs./hr.
1,000 x 1 = 1,000 lbs./hr. x 1.5 = 1,500 lbs./hr.

Floor mount blender, then up to extruder
1,000 x 2 = 2,000 lbs./hr. x 1.5 = 3,000 lbs./hr.

Floor mount blender and drying system, then convey up to extruder
1,000 x 3 = 3,000 lbs./hr. x 1.5 = 4,500 lbs./hr.

Add the rate each time the material is conveyed!
Don’t forget the safety factor!

Calculate Equivalent Conveying Distance:

One horizontal foot = one equivalent foot
One vertical foot = two equivalent feet
Long radius elbow = 20 equivalent feet
One foot flex hose = four equivalent feet

Equivalent Feet Conveying Distance Example

100 horizontal feet = 100
20 vertical feet = 40
(4) L R elbows = 80
20 feet of flex hose = 80
TOTAL 300 equivalent feet

It is important to take all of these factors into account and remember the system runs the best when everything is new. As things wear, filters get dirty and connections come loose and leak, the system capacity will decline, so additional capacity up front is a great idea!

Blending and feeding equipment

Blending in the plastics industry meant many things in the past, including pitch forks, shovels, buckets, cement mixers, grain augers and even rolling drums full of material across a plant floor. Volumetric blenders were developed to feed a variety of materials at the same time, and were a leap forward in technology.

Volumetric feeders are still used today, but typically to add only one or two minor ingredients into a process. Many processing facilities use additive feeders to introduce additives into their process. Volumetric and gravimetric feeders are available, with volumetric being the most common.

Volumetric and gravimetric blending systems are available for multiple components, with gravimetric being the most common. Gain-in-weight batch blenders are usually used in injection molding and simple extrusion applications, while continuous loss-in-weight systems are used for high-end extrusion and compounding lines.
Additive Feeders

*Volumetric* feeders are used to add one or two components to a process and are usually the most economical additive feeder you can buy. However, they are strictly a feeder, and even though certain designs are very accurate feeders, none of them can accurately track actual material usage.

*Gravimetric* feeders utilize a weighing device to measure the actual throughput that the feeder dispenses, giving the processor an actual measure of the amount of material used. The feeding device may not be as accurate, but the material usage value is, as long as it is properly calibrated to a known weight.

Gravimetric blenders have come down in price so much that volumetric blenders are almost a thing of the past. Gravimetric blenders provide many advantages, including:

- Improved accuracy
- Compensation for variations in bulk density
- Documentation of correct blending process
- Inventory control of all blended materials

Virtually all of the gravimetric systems available today offer significant advantages over the volumetric systems. The chart below compares blending processes.
However, there is a lot of confusion about “gravimetric” blending systems, and they are not all the same. In fact, each type works very differently, and has its own advantages and associated costs.

Gravimetric means “to weigh”, but that is where the similarity ends – not all gravimetric systems work the same way, or offer the same advantages. The following types of gravimetric systems are readily available to the processor today:

- **Gain-in-weight batch**
- **Loss-in-weight batch**

*Continuous loss-in-weight*

**Gain-in-weight batch** blenders weigh one ingredient at a time into a common weigh hopper, mounted on one or two load cells. The batches are dumped into a mix chamber that distributes the components into a homogenous mix. These blenders are very economical, but are not the best choice for low percentage ingredients (< 2%), or materials that vary greatly in particle shape and density, especially powder additives (particles can separate during mixing). These are the most common gravimetric blending systems in use today, are available in up to eight component models and are available from many reliable suppliers.
Gain-in-weight Batch Blending Cycle:

The materials are metered one at a time into a common weigh hopper, and each batch is dumped into the mix chamber. The metering cycle repeats, while the mixing continues, until the high level in the mix chamber is reached, and the process stops. Metering will start again when the processing machine draws material from the mix chamber and the level drops below the high level switch.

*Loss-in-weight batch* blenders meter all ingredients at the same time into a common collection hopper. Each feeder is equipped with its own load cell so the output of each feeder is constantly controlled. The load cells are sized to each feeder, so the smallest ingredients do not have to be weighed with large load cells, resulting in much better accuracy. These feeding systems are more expensive, but are the best choice for low percentage ingredients (0.25 to 2%), or materials that vary greatly in particle shape and density (particles can separate during mixing).

*Continuous loss-in-weight* blenders meter all ingredients at the same time directly into the throat of a starve feeder or extruder. Each feeder is also equipped with its own load cell. This type of system delivers the most homogeneous mix because all of the components are metered simultaneously, and dropped straight into the throat of the extruder (or starve feeder). The load cells are also sized to each feeder, so the smallest ingredients do not have to be weighed with oversize load cells, resulting in much better accuracy. These systems are the best choice for:
- Starve feeding an extrusion process
- Feeding low percentage ingredients (0.25 to 2%)
- Material that is not free-flowing
- Materials that vary greatly in particle shape or density (especially powder additives).

These systems can feed up to twelve components, and are available from several suppliers, but look for the system with the most modular, integrated design and user-friendly control system.
Continuous Loss-in-weight Blending Process:

All materials are metered simultaneously directly into the extruder throat. (Drawing also shows film regrind being fed into the process.) Metering continues as long as the extruder is running.

Feeders and Metering Devices

All of the systems described above can use a variety of metering devices to feed material into the gravimetric process, and each has its advantages. The most common are:

- **Pneumatic slide gates** – economical and reliable
- **Augers, or screws** – well known, but are inconsistent and inaccurate at low speeds
- **Pinch valves** – another twist on a slide gate, but a potential wear point
- **Dosing disc** – the most *consistent* feeder, especially at low rates (as low as 20 grams/hour)
- **Vibratory feeder** – works well with some materials
- **Bulk solids pump** – similar to a dosing disc feeder, but mounted vertically
- **Rotary scalpel feeders** – similar to a dosing disc feeder, but mounted vertically
<table>
<thead>
<tr>
<th>Feeder Type</th>
<th>Applications</th>
<th>Strengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Screw Feeder w/o agitator</td>
<td>Free flowing granules and regrinds</td>
<td>Low cost, simple</td>
</tr>
<tr>
<td>Single screw with agitator</td>
<td>Poor flowing regrinds and medium flowing powders</td>
<td>Wide material range</td>
</tr>
<tr>
<td>Twin screw feeder with agitator</td>
<td>Non-free flowing and floodable powders</td>
<td>High accuracy, able to handle difficult materials</td>
</tr>
<tr>
<td>Disc feeder</td>
<td>Low rate applications for pellets</td>
<td>High accuracy, quick exchange feature</td>
</tr>
<tr>
<td>Flexible hopper screw feeder</td>
<td>Good flowing to non-free flowing materials</td>
<td>Wide application range, no influence with agitator</td>
</tr>
<tr>
<td>Vibratory feeder</td>
<td>Glass fibres, friable materials</td>
<td>Able to handle long fibers without damage</td>
</tr>
<tr>
<td>Belt feeder</td>
<td>Free flowing and non-sticky materials</td>
<td>High throughputs, friction sensitive materials</td>
</tr>
</tbody>
</table>

Keep in mind that many materials are not free-flowing and will not feed consistently. Most gain-in-weight systems rely on controlled metering time to feed the given weight, and check the weight over time. If material does not feed consistently, which many don’t if you start and stop the flow every batch, the control system keeps adjusting the feed rate and can wind up chasing its tail. Continuous gravimetric systems keep the material moving all the time, and when used in conjunction with the proper agitation

### Extrusion Control

Continuous loss-in-weight feeding can also be taken to the next level for even better process control. By connecting the starve feeder or extruder screw speed to the gravimetric hopper, material can be fed at a consistent, precise rate. You enter the rate you require and the extrusion control unit adjusts the screw speed to maintain that throughput.

You can also tie the unit into an encoder riding on your final product and control weight-per-length of the end product. Products with specific thicknesses, like tubing, pipe or sheet, can also use a gauging system tied to the extrusion control unit and maintain precise thickness of the final product. Versions of these systems are also used for gauging layer thickness in multi-layer products like film or sheet.

The benefits of this type of closed loop system are:
- Improved process control
- Improved product quality
- Material savings through the reduction of over feeding
- Inventory control
Film scrap reclaim

Film scrap can be recycled whether its edge trim scrap or defective rolls of film. The film re-feed systems can grind the scrap into “fluff” and re-feed it into the throat of your extruder in proportion to the pelletized material being extruded. These systems can re-feed the “fluff” up to 40% of the extruder output – some facilities are re-feeding at higher rates with certain materials.

In general, these systems can be used on any extruder that is not equipped with a grooved feed throat.

Communications

All of these systems can be connected to a data collection system that will allow the units to be controlled, and the data collected, from a central location, i.e. the plant manager’s office. Remote communication is available over Ethernet TCP/IP and Profibus networks, and most control systems feature internal diagnostics and user-friendly menu-based screens for easy operation. Wireless systems are also available, but have been problematic with all the electrical noise in a plant environment. These software packages are a very useful tool for consolidating control and reporting functions in a facility, or across multiple facilities.

Processors can save money, increasing the profitability of their operation, by:
- Improving the feed accuracy to their extruders
- Adding their own colorant and additives
- Using their own regrind in the products they are manufacturing
- Using post-consumer regrind (PCR) in the product by taking advantage of gravimetric control to achieve a more consistent product

In summary, many very good gravimetric blending systems are available to the processor today. Be sure to consider the types of material you are using, and what is important to your process. The key is selecting the system that is the most cost effective solution for your operation, but also the most modular one to accommodate your future needs!
Crystallizing and drying systems

Some materials require crystallizing and/or drying to remove moisture prior to:

- Compounding
- Packaging of pellets for post-processing
- Processing into the final product

*Non-hygroscopic* materials require heated ambient air (typically 140°F to 180°F) to remove moisture, since the water is on the surface of the pellets and can be easily removed.

Other materials are *hygroscopic*, which means that moisture is absorbed inside the pellet. A dehumidifying dryer, supplying hot air at -40°F dew point, or lower, is required to extract the moisture from the material and eliminate the defects in the finished product. These materials are also usually dried at higher temperatures (typically 110°F to 350°F).

PET and PLA regrind must also be crystallized before it can be dried. Traditional systems use heated ambient air, while some new technology uses infrared energy to crystallize the regrind.

Size reduction systems

Most plastic processing facilities and all reclaim operations utilize some form of size reduction equipment.

*Shredders* are used to reduce large parts and purgings to smaller chunks (0.75 to 2 in.) that can be further reduced depending on the actual process.
Granulators reduce the shredded material, as well as scrap product, into regrind (0.125 to 0.625 in.) that can be easily melted and re-used in the process machine.

Pulverizers can be used to reduce certain virgin and regrind materials into powder (20 to 100 mesh) to ensure they are fully melted in the final process.

Crystallizing, drying and size reduction systems will be covered in other sessions and will not be detailed in this paper. They are only mentioned because they are an integral part of the entire material handling, process.

Conclusion

There are many opportunities available to improve the efficiency of your operation, and most equipment suppliers can help you exceed your specific requirements. With rising energy costs and tighter profit margins, everyone should be looking at ways to maximize the efficiency of their reclaim operations.

A properly designed feeding and blending system, in conjunction with the other peripheral equipment, is as important to the productivity of the plant as the extrusion technology itself. The analogy that “a chain is as strong as its weakest link” applies to reclaim extrusion as well. You don’t want a million dollar extrusion line sitting idle because you saved $5,000 when you bought your feeding system! You also don’t want to spend any more money than necessary to re-process your material, so an energy-efficient system should be in your future plans!

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