Shredder Practice for Preparation of Nonmetallic Concentrates and Potential for Particle Sorting of these Concentrates

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Outline

Shredder plant processes

Composition and size specifications for nonmetallic shredder residue (SR) concentrates

Practices and technologies for their production

Potential for sensor-based particle sorting of nonmetallic SR concentrates

Industrially applied sensors
Material recycling system

EU directives require recycling or “recovery” of recyclable materials from the EoL “old” items ELVs, EEE, appliances and other post-consumer durables are collected, de-polluted and stripped of re-usable parts at licensed de-pollution facilities (i.e. junkyards) Remaining hulks are flattened or baled for transport These bales meet commingled scrap from demolition at the steel shredder Steel shredder reduces scrap to fist-sized pieces in a matter of seconds Steel shredder input contains a mix of commingled metal and nonmetal scrap representing multiple manufacturers, industries, grades of each material
Material recycling system

UN conventions, EU directives, national regulations and implementation / US-EPA enforcement and component/material value

EoL items - vehicles, appliances, furniture, electronics etc. - collected, de-polluted and stripped of re-usable parts

Hulks flattened or baled for transport

Bales meet building demolition scrap at the steel shredder

Shredder input is a complex mix of commingled metal and nonmetal multiple manufacturers, industries, grades of each material
Dismantling and shredding

EoL items are dismantled for parts re-use or de-pollution

Stripped hulks are shredded for material recovery

Dismantling and shredding are complimentary:
- dismantled parts still need to be shredded for efficient material recovery
Steel, NMMC and SR

Hammer mills shred scrap
Drum magnets remove steel
Eddy-current rotors separate
  • nonmetals
  • nonmagnetic metal concentrate (NMMC)
Fines and nonmetallic light and dense fractions combine to make up shredder residue (SR)
Nonmagnetic metal concentrate
Preparation of nonmetallic concentrates

NMMC enables profitable shipment from the shredder to the metal sorter, and recovery of nonmagnetic metals.

Preparation of nonmetallic concentrates will be necessary to enable profitable shipment to:

- plastic and rubber recyclers
- producers of residue derived fuel (RDF) and of reducing agents for:
  - waste-to-energy incinerators
  - cement kilns
  - metal smelters.
Shredder product consistency

The main product of the shredding plant is a consistent quality steel shred.

Consistency is the key property for a marketable scrap product.

To achieve this consistency, it is a common practice to blend scrap from various sources in the input to the shredder.

Nonferrous metal and nonmetallic recyclables are a small fraction of the steel product volume.

Primary steel shredders rarely segregate the feed in order to improve the recovery of non-steel feed components.
Shredder product consistency

Main product = steel shred.

Key property = consistency

Common practice = blend input scrap from various sources

Nonferrous metal and nonmetallic recyclables – less important

No feed segregation for recovery of non-steel feed components.
Shredder plant processes

Dry
Moist
Wet
Shredding
Shredding

Liberates individual materials

Enables cost-efficient material separation for material recovery

Hammer mill 500 - 6000 HP
20~45 seconds per hulk
~4” exit product grate
Dry shredding process

Scrap is fed to the shredder without water addition

Extensive dust collection system controls air emissions:
- fluff sucked from the shredder, the shred discharge and from all the transfer points in the conveyor system.

Shredder light fraction (SLF)
- organic concentrate containing foam, textiles, plastic film and paper
- separated by and from the suction air stream
- processed by sizing and magnetic and eddy-current separation (ECS)

The material left over after magnetic-drum separation of steel is treated by sizing and ECS to split the residue into:
- fines
- nonmagnetic metal concentrate and
- a nonmetallic shredder dense fraction (SDF)

ECS separation may be done on two size fractions (>5<30 and >30<100 mm) to improve metal-nonmetal separation

Currently the SLF, SDF and the fines are usually combined for shipment to a landfill
**Dry shredding process**

No water addition to shredder

Extensive dust collection system

**Shredder light fraction (SLF)**

After magnetic-drum separation of steel residue split into:
- fines
- nonmagnetic metal concentrate (NMMC) and
- nonmetallic shredder dense fraction (SDF)

SLF, SDF and fines combined as SR for landfill
Dry steel shredding plant

- drum mag.
- baghouse
- hammer mill
- grapple
- infeed conv.
- overbelt magnet
- screens
- mag head pulley
- ECS
Dry steel shredding plant products

Infeed Scrap

Steel

Rubber

Irony

Irony

<30 mm NMMC

>30 mm NMMC

SDF

SLF

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Twin drum magnet system
Moist shredding process

A small amount of water is sprayed into the shredder to eliminate airborne dust emissions from the shredder and from the product transfer points.

The shred goes directly to drum-magnet separators that take out the iron.

The iron shred is separated from the lower-density magnetic contaminants in a Z-box air elutriator. The air stream transports the light fraction to a cyclone separator.

NMMC is produced from the nonmagnetic output of the drum magnets and from the cyclone solids by screening and magnetic and eddy-current separations.

Screened-out fines and ECS nonmetal products are then combined as the SR for landfill.
Moist shredding process

Small amount of water sprayed into the shredder

Drum-magnet separators that take out steel.

Air elutriator-cyclone removes lower-density contaminants from steel.

NMMC is produced from
- nonmagnetic output of the drum magnets
- cyclone solids
by screening, magnetic and eddy-current separations.

Screened-out fines and ECS nonmetal products are combined as the SR for landfill
Moist/Wet mill

Water

Shred discharge

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Moist steel shredding plant

Infeed scrap

grapple

Steel

cyclones

hammer mill

Z-box

drum mag

Mag head pulley

Irony

<30 mm NMMC

>30 mm NMMC

SR

ECS

Screen

Moist steel shredding plant

Infeed scrap

grapple

Steel

cyclones

hammer mill

Z-box

drum mag

Mag head pulley

Irony

<30 mm NMMC

>30 mm NMMC

SR

ECS

Screen
Moist process mega shredder

Texas Shredder
5,000 kW
360,000 T/year
Preparation of nonmetallic concentrates

Concentrates enable profitable shipment from the shredder to metal and plastic sorters.

NMMC enables recycling of nonmagnetic metals. Nonmetallic concentrates will enable:

- sorting of plastic and rubber
- production of residue-derived fuel (RDF) for:
  - waste-to-energy incinerators
  - cement kilns
- reducing agents for:
  - metal smelters.
Nonmetallic recyclable concentrates

Extended dry or moist processes to produce concentrates of recyclable nonmetallics

Separate >5<30 and >30<100 mm size fractions into:

- organic concentrates,
  - light (textile, foam, paper)
  - dense (wood, plastic and rubber)
- inorganic rock-brick-glass
- Nonmagnetic metals and stainless steel

by a combination of:

- high-intensity magnetic separator
- eddy-current sorters
- ballistic separators
- ECC sensor particle sorter
Suggested shredder residue recovery circuit

- Scrap
  - Basic shredder
    - Mill
      - Magnets
        - Air
          - Steel
        - Screen: 5/30/100
          - >100 mm
          - <5 mm
            - Ballistic
              - >30 mm
                - Heavy
                - St. steel
              - <30 mm
                - Light
                - Nonmetal
              - RE magnet
                - Magnetic
                - Nonmetal
                - ECS
              - ECC
                - Particle sort
                  - St. steel
                  - Irony
                  - Inorganic
              - Ballistic
                - Heavy
                - Metal
                - Wood
                - Light
                - Nonmetal
            - NMMC
  - Inorganic
  - Plastic
  - Rubber
  - Wood

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Ballistic separator

2~3 m/s monolayer

- Light
  - Foam
  - Textile
  - Foil
- Middling
  - Plastic
  - Rubber
  - Wood
- Heavy
  - Rock
  - Metal
  - Glass
Eddy-current separator

Nonmagnetic metal
& Nonmetal

Nonmagnetic metal
Nonmetal
Metal particle in the magnetic field of an eddy-current rotor (ECR)
Eddy-current separator

HVS MK V
ESR Int. wet shredding proposal

The thoroughly wet shredding, screening and sizing operations keep the dust in check.

Eddy-current separators replaced with sink-float dense-media drums.

Dense media slurry up to 1.6 g/cm³ - fine silica sand from the feed.

- <1.6 g/cm³ density fraction (all organics)
- >1.6 g/cm³ density fraction (rock and nonmagnetic metals)
Wet steel shredding plant

- Infeed
- Scrap
- Water treatment
- Grapple
- Hammer mill
- Drum magnet
- Cyclones
- Ballistic
- Steel
- Storage
- Hydrocyclones
- Decanter centrifuge
- Media sand
- Filter cake
- Filter press
- Dense media drum
- Water treatment
- Settling
- Dewatering screens
- >1.6 NMMC
- <1.6 organics
- Infeed scrap

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Wet process - additional separation opportunities

Cyclone air-solid separation and bag-house dust control systems are replaced with a closed-circuit process water treatment system.

Rust ends up with the fines in the water treatment system, and could be separated cleanly with a wet magnet used industrially for iron ore concentration.

Fines can also be density sorted by hydrocyclones or by wet kinetic density separation into:

- organics
- inorganics
- denser metals plus lead sulfate

SR for disposal is reduced to treated inorganic fines and filter cake.
Wet shredder residue recovery process

Basic shredder

scrap → mill → magnets → air

light → steel

residue recovery

>100 mm → wet screens 5/30/100 mm

<30 mm

>30 mm

<1 mm sand

1.6 S.G. sink-float

metal + rock

NMMC

1.0 S.G. sink-float

plastic rubber wood

<1 g/cm³ float

<1.6 g/cm³

1.0 S.G.

water treatment

<5 mm metal

<5 mm organic

<5 mm inorganic

filter cake

residue recovery

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<table>
<thead>
<tr>
<th>Process Option:</th>
<th>Dry</th>
<th>Moist</th>
<th>Wet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredder plant output stream</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel &lt;100 mm</td>
<td>Product</td>
<td>Product</td>
<td>Product</td>
</tr>
<tr>
<td>Stainless steel &gt;5&lt;100</td>
<td>Product</td>
<td>Product</td>
<td>Product</td>
</tr>
<tr>
<td>Fines &lt; 5 mm</td>
<td>Residue</td>
<td>Residue</td>
<td>Residue</td>
</tr>
<tr>
<td>Baghouse dust</td>
<td>Residue</td>
<td>Residue</td>
<td></td>
</tr>
<tr>
<td>Iron oxide &lt; 5 mm</td>
<td></td>
<td></td>
<td>Product</td>
</tr>
<tr>
<td>Filter cake &lt; 1 mm</td>
<td></td>
<td></td>
<td>Residue</td>
</tr>
<tr>
<td>NMMC &gt;5&lt;30 mm</td>
<td>Concentrate</td>
<td>Concentrate</td>
<td>Concentrate</td>
</tr>
<tr>
<td>NMMC &gt;30&lt;100 mm</td>
<td>Concentrate</td>
<td>Concentrate</td>
<td>Concentrate</td>
</tr>
<tr>
<td>Inorganic &gt;5&lt;100 mm</td>
<td>Residue</td>
<td>Residue</td>
<td>Residue</td>
</tr>
<tr>
<td>Polyurethane (PUR) foam</td>
<td>Product</td>
<td>Product</td>
<td>Product</td>
</tr>
<tr>
<td>SLF &gt;5&lt;100 mm</td>
<td>RDF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDF organic &gt;5&lt;30 mm</td>
<td>Concentrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDF organic &gt;30&lt;100</td>
<td>Concentrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic &lt;5 mm</td>
<td></td>
<td>RDF</td>
<td></td>
</tr>
<tr>
<td>Organic &gt;5&lt;30 mm</td>
<td></td>
<td>Concentrate</td>
<td>Concentrate</td>
</tr>
<tr>
<td>Organic &gt;30&lt;100 mm</td>
<td></td>
<td>Concentrate</td>
<td>Concentrate</td>
</tr>
<tr>
<td>Magnetic attachments</td>
<td>Concentrate</td>
<td>Concentrate</td>
<td>Concentrate</td>
</tr>
</tbody>
</table>
Shredding plant process objectives

**Consistent quality** recycled material products with **minimum product purity** specifications.

**Minimum loss** of recyclables in **residues**,  
**Maximum yield** of recyclables in the sum of **all products + intermediates**,  
**Minimum yield** of non-recyclables in either **products or intermediates**,  
**Maximum yield** of recyclable in its **own concentrate**:  
- metal in the **metal concentrate** and  
- plastic + rubber in the **organic concentrate**.
Shredding plant process objectives

Provide consistent quality recycled material products satisfying the minimum product purity specifications.

Minimize the loss of recyclable components in the residues destined for landfill.

Provide maximum recovery of the recyclable components in the sum of all the intermediate concentrates bound for further material recovery.

Minimize the recovery of the non-recyclable components in either products or intermediate concentrates.

Maximize the recovery of the recyclable component in its own concentrate: metal in metal concentrate and plastic + rubber in the organic concentrate.
<table>
<thead>
<tr>
<th>Process</th>
<th>Dry</th>
<th>Moist</th>
<th>Wet</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLF organic</td>
<td>&lt;5% inorganic</td>
<td>&lt;10% &lt;5 mm</td>
<td></td>
<td>RDF preparation</td>
</tr>
<tr>
<td>&gt;5&lt;100 mm</td>
<td>&lt;5% metal</td>
<td></td>
<td></td>
<td>PUR recycle</td>
</tr>
<tr>
<td></td>
<td>&lt;10% &lt;5 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDF organic</td>
<td>&lt;5% inorganic</td>
<td>&lt;10% &lt;5 mm</td>
<td></td>
<td>Dense-media plastic plant</td>
</tr>
<tr>
<td>&gt;5&lt;30 mm</td>
<td>&lt;10% metal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;10% &lt;5 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDF organic</td>
<td>&lt;5% inorganic</td>
<td>&lt;10% &lt;30 mm</td>
<td></td>
<td>Particle sorting plastics</td>
</tr>
<tr>
<td>&gt;30&lt;100 mm</td>
<td>&lt;10% metal</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>&lt;10% &lt;30 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>&lt;10% inorganic</td>
<td>&lt;5% metal</td>
<td>&lt;10% &lt;5 mm</td>
<td>Dense-media plastic plant</td>
</tr>
<tr>
<td>&gt;5&lt;30 mm</td>
<td>&lt;10% &lt;5 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>&lt;10% inorganic</td>
<td>&lt;5% metal</td>
<td>&lt;10% &lt;30 mm</td>
<td>Particle sorting plastics</td>
</tr>
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<td>&lt;10% &lt;5 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SR nonmetallic concentrates suitable as particle sorting plant feed

<table>
<thead>
<tr>
<th>Shredder plant process option</th>
<th>&gt;30&lt;br&gt;&lt;100 mm concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry process</td>
<td>organic (SDF)</td>
</tr>
<tr>
<td>Moist process</td>
<td>organic (ECS nonmetallic)</td>
</tr>
<tr>
<td>Wet process</td>
<td>organic (&lt;1.6 g/cm³)</td>
</tr>
</tbody>
</table>
Sensor signals useful for SR particle sorting

Non-contact sensors that identify at a point or image:

Light spectral line intensity over the hyperspectral range of:
- ultraviolet (UV: 150-400 nm)
- visible (VIS: 400-700 nm)
- near infrared (NIR: 700 nm - 5 µm)
- infrared (IR: 5-100 µm)

X-ray absorption in two selected energy bands

Disruption of the varying magnetic field amplitude and phase by the passage of the particle
Sensor-determined particle characteristics

The controlling computer can infer:

colour, shape, size, volume 
from the line scan image

average atomic number and thickness 
from X-ray absorption at two energy levels

metal/nonmetal and metal type 
from ECC magnetic field disturbance

polymer type 
from absorption/remission NIR or IR spectra

concentration of a particular element 
from UV-VIS emission line intensity
Particle sorter limitations

Throughput-particle size correlation
- Higher weight throughput for large particles

Blow valve cycle time
- 10 and 20 ms
- at 3 mm/ms 30-60 mm the minimum gap between particles

Statistics of particles placed randomly on a surface
- ~15% area loading

Particle velocity and aerodynamics
- 3 m/s is near the upper limit of a typical industrial sorter
Random and systematic particle sorting errors

Combination of errors:
- particle identification
- particle diversion

Random factors:
- particle shape
- random particle distribution on a belt
- particle aerodynamics
- sensor “noise”

Systematic factors:
- insufficient sensor signal content
- insufficient computation time to solve the inverse particle identification problem
- Sensor-sorter-blowbar misalignment

Industrial particle sorter at commercial throughput can never give a perfect sort
Sorting error reduction

Sort quality is defined by a combination of product composition and component recovery achieved at a commercial throughput.

Reduction of both systematic and random sort errors can improve the sort quality.

Systematic errors can be minimized by process development:
- selection and tuning of appropriate combination of sensors
- sensor, blowbar and sorter alignment
- calibration and training of the sort algorithm on a sample representative of feed components

Random errors can be addressed by:
- narrowly sizing and pre-sorting the particles by shape and density
- limiting the particle velocity
- limiting the belt area loading with particles, and
- passing the material through the sorter more than once
- passing the material through a system of more than one sorter
Particle sorting unit operation

Multiple sorters to improve product grade and component recovery
Practical and economic applications of particle sorting

Very high-value ores:
  • diamonds, precious metals and coins

Individually diverted large particles:
  • metal scrap, plastic bottles, fruit and vegetables

Product cleanup:
  • removal of a low fraction of contaminants from a small particle-size stream
  • contaminant particle is diverted with a number of surrounding particles
    • plastic flake, crushed glass, rice and grain

Product inspection:
  • particles are not diverted and the sensor is used for quality-control inspection of the product
Industrial applications of particle sorters for old scrap

Particle sorters can certainly have the performance required for sorting scrap, and are already industrially applied to sorting:

$/tonne of sorted product

- Glass by colour, transparency and DE X-ray $60
- Plastic bottles by polymer resin type $200-$300
- Stainless steel by the ECC magnetic field signature $2,000
- Nonmagnetic metals by colour, size and shape $1,000-4,000
- Metals and Al alloys by elemental concentration $2,000
Preparation of SR organic concentrates for particle sorting

For the complex unknown mixture of polymers in SR further pre-grouping is necessary. (Inverse problem)

Re-size >30 mm organic feed on a secondary shredder
Wash and wet screen to >30<75-80 mm
Sink-float separate at various media densities:

- \(<1.0 \text{ g/cm}^3\) polyolefins
- \(1.0 < 1.15-1.20 \text{ g/cm}^3\) low-density sink plastics
- \(1.15-1.20 < 1.6 \text{ g/cm}^3\) dense plastics, filled or reinforced or containing fire retardants
- \(>1.6 \text{ g/cm}^3\) inorganics and metals

Hydrodynamically separate high-aspect-ratio particles
Particle sorter inputs from SR and target products

Three particle sorter feed streams
- low-aspect-ratio particles (thick sheet/plate and chunks)

1. **Polyolefins with low-density rubber contamination** for separation of:
   - contaminants
   - PE from PP

2. **Low-density sink plastics** for separation of:
   - filled PP
   - ABS
   - HIPS

3. **Dense and filled organics** composite materials with significant volume fractions of fillers and reinforcements, plus dense additives containing high atomic weight chlorine and bromine atoms. Separation of:
   - inorganic contaminants
   - PVC and particles with BFRs
Plastic particle sorting plant

Plasticsort

Secondary shredder

Screen 20/75 mm

>20<75 mm

Colour

Shape ECC

NIR

mix

mix

NIR

mix

mix

NIR

NIR

mix

n resins

resin n

mix

>75 mm

Cleaning

Turbo wash

<20 plastic rubber wood

Sizing

>30<100 plastic rubber wood

<20 plastic rubber wood

Wood

Metal

Black

Colour sort

light

dark

other

>30<100 plastic rubber wood

<20 plastic rubber wood

Wood

Rubber

Wood

Resin

Mix resins

Mix dark

Mix light

Mix

Plastic sort

Resin

Resin n

Mix
Persistent organic pollutants (POPs)

Key organic **Substances of Concern (SOCs)** are the POPs that are:
- acutely toxic, or
- teratogenic, or
- mutagenic, or
- carcinogenic, and
- are transported in the biosphere, and
- bioaccumulate in the food chain.

POPs of concern include a structurally related family of halogen-(Cl and Br) substituted aromatic hydrocarbon compounds:

- PCB and PBB: poly-halogenated-biphenyl dielectric oil additives
- PCDE and PBDE: poly-halogenated-diphenyl-ether fire retardant additives
- PCDD and PBDD: poly-halogenated-dibenzo-dioxin combustion products
- PCDF and PBDF: poly-halogenated-dibenzo-furan combustion products
Poly X Biphenyl

Poly X Diphenyl Ether

Poly X Dibenzo Furan

Poly X Dibenzo-p-Dioxin

# = H or X, X = Halogen: Cl or Br
United Nations Stockholm Convention on POPs

Specifically targets man-made POP chemicals for:

- elimination: PCBs on the list, pentaBDE is to be added
- prevention of unintended production: PCBs, PCDDs and PCDFs

Requires:

- best available techniques and environmental practices for elimination of unintended production of POPs.
- disposal in such a way that the POP content is destroyed or irreversibly transformed

Prohibits:

- recovery, recycling, reclamation, direct reuse or alternative uses of POPs.

Once ratified, regulations will:

- either eliminate recycling of most plastics from SR, or
- justify removal of halogenated plastic particles from SR-sourced recycled products
- more aggressive cleaning for removal of PCBs
Fire retardant and impurity sort

DE X-ray

BFRs + impurities

BFR / PVC

Organic BFR / PVC Metal BFR & PVC (can you see it?)
SOCs in SR fines

SOCs, including mercury, basic lead sulphate, and PCB-containing oils, remain in the SR fines.

Although sensor-based particle sorting has no role in processing SR fines, unless the disposal of residue fines is adequately and economically addressed, it will make no economic sense to recover plastic and rubber concentrates from SR as feed to downstream sensor-based sorters.

Sensor-based output stream inspection can demonstrate compliance with environmental regulations.

- LIBS has been successfully applied to monitoring elemental concentrations of heavy metals, arsenic and other toxic elements in liquid effluents
- Raman and IR spectroscopic sensors can monitor concentrations of organic SOC molecules
Summary and conclusions - SR

The organic fraction of SR (plastics and rubbers) is among the most challenging of post-consumer materials sources for recycling.

Distributed worldwide among nearly 1,000 shredding plants, this SR fraction contains a mixture of materials from vehicles and demolition and consumer durables, making it a very complex mixture of unknown compositions that is contaminated with SOCs from various industries.

It is the SOCs and their environmentally responsible handling that will dictate which products can utilize recycled plastics, and which processes and technologies will produce them.
Summary and conclusions – SR organic concentrates

Individual shredding plants are usually too small and do not have adequate technical sophistication to invest in sorting systems. They should produce SR organic concentrates.

Downstream processors are better equipped than shredding plants to recover the recyclables.

There is a tradeoff between plastic and rubber recovery from the residue at the shredder, and transportation, waste-disposal and sorting costs at the downstream processor.

Shredder operators and downstream processors need to collaborate to develop the organic SR concentrates specifications and recycling, decontamination and recovery systems.
Summary – Sensor-based sorting of SR

Sensors are likely to find use in automated inspection of:
- recycled plastic particles
- compounded plastics with recycled content

Particle sorters can be economically used on large particle size fraction to produce value-added plastic products:
- PP, ABS, HIPS…

For high-value-added applications of SR-sourced recycled plastics, sensor-based sorters will remove contaminants.

If destruction of BFRs is mandated by regulations, sensor-based sorting of BFR-containing particles would be economically justified to reduce BFR treatment costs.
Summary and conclusions – Particle sorters for SR

The SR market and potential profit from recycling of SR plastics and rubber is not sufficient to justify independent development of sensors and particle sorters for this application.

Sensors and sorters developed for metal scrap, glass, ores, coal and plastic packaging are being adopted and modified for SR sorting.
Thank you

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Discussions with
Ed Daniels and Bassam Jody
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