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Overview of Recycling Technology R&D

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May 22, 2009

Project ID # lm_28_daniels

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Overview: *Recycling Technology R&D*

- **Timeline**
  - Start: FY 2003
  - Finish: In progress
  - Percent Complete: 50%

- **Budget**
  - Total project funding
    - DOE, ~ $1500K/yr
    - Cost-share, ~ $1500K/yr
  - Funding received in FY ‘08 and ‘09
    - FY ‘08, $1515K
    - FY ’09, $2025K

- **Barriers Addressed**
  1) perception about recyclability
  2) cost of lightweighting materials
  3) use of recycled materials

- **Partners**
  - Interactions/Collaborations
    - USCAR, Vehicle Recycling Partnership
    - American Chemistry Council—Plastics Division
    - Institute of Scrap Recycling Industries
    - Automobile Recycling Association
    - Individual Shredder Operators
    - Midland Compounding, MBA Polymers, Troy Polymers
  - Project Lead
    - Argonne National Laboratory

Objectives: *"Economic use of advanced lightweight materials for automotive construction will be enhanced by both prompt recycling of scrap materials during manufacture, as well as recycling of end-of-life vehicles…"*

- Long Term Goals
  - Enable optimum recycling of all current and future automotive materials
  - Remove real or perceived barriers to use of advanced, lightweight materials
  - Continue to enable market driven vehicle recycling
- Intermediate goals
  - Benchmark automotive materials recycling state-of-the-art and disseminate information to stakeholders
  - Develop and demonstrate recycling process concepts for advanced materials (e.g. PMCs, aluminum, metal matrix composites)
  - Demonstrate technical and economic feasibility of processes for materials recovery from ELV and shredder residue
  - Facilitate transfer of technology to industrial practice

FY 2008 Milestones

Major Milestones	Planned Completion Date	Status
Complete engineering designs and economic analysis of the process based on pilot plant data	3rd Qtr	Done
Complete construction and shake down of the base recycling validation plant	4th Qtr	Planned completion 3rd Qtr of FY09
Complete design of the upgrade system for separation of wood and rubber from the recovered polyolefins for the validation plant	3rd Qtr	Done
Evaluation of recovered polymers from validation plant	4th Qtr	Begins in 4th Qtr of FY09

Additional Milestones	--	--
Complete evaluation of the Argonne process for removing the PCBs	4th Qtr	Done 1st Qtr of FY09
Determine physical properties of polymers cleaned by the Argonne process	4th Qtr	Done 1st Qtr of FY09

FY 2009 Milestones

Major Milestones	Planned Completion Date	Status
Complete validation plant equipment installation	2nd Qtr	Planned completion during the 3rd Qtr
Begin production	3rd Qtr	4th Qtr
Determine physical properties recovered by validation plant	4th Qtr	4th Qtr
Complete R&D plan for recycling lightweighting metals (aluminum, magnesium and titanium)	2nd Qtr	Done

Approach: *Recycling technology R&D portfolio evolved from three stakeholder workshops---2001,2005,2008*

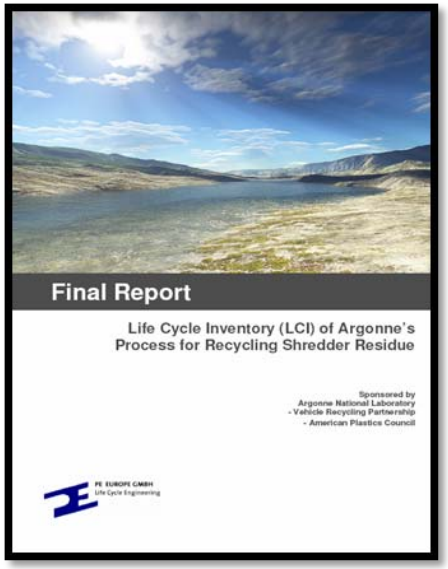
- The recyclability of ELVs is presently limited and several technical and economic barriers need to be overcome to increase recovery and recycling
  - Lack of commercially proven technology to cost-effectively separate, identify and sort materials
  - Lack of profitable post-use markets
  - Collection infrastructure exists
- Development of technology to recycle today's materials will provide the basis for recycling of future materials
- Industry-wide collaboration is needed
- Worldwide technology needs to be tracked and information disseminated to users

Approach: *Five projects initiated in FY 2003 to address priority stakeholder issues.*

- Recycling Assessments and Planning
  - Website development to facilitate information dissemination
- Baseline Assessment of Recycling Systems and Technology
- Post-shred Materials Recovery Technology Development and Demonstration
- Compatibilization/Compounding Evaluation of Recovered Polymers
- Development of Technology for Removal of Impurities and Substances of Concern

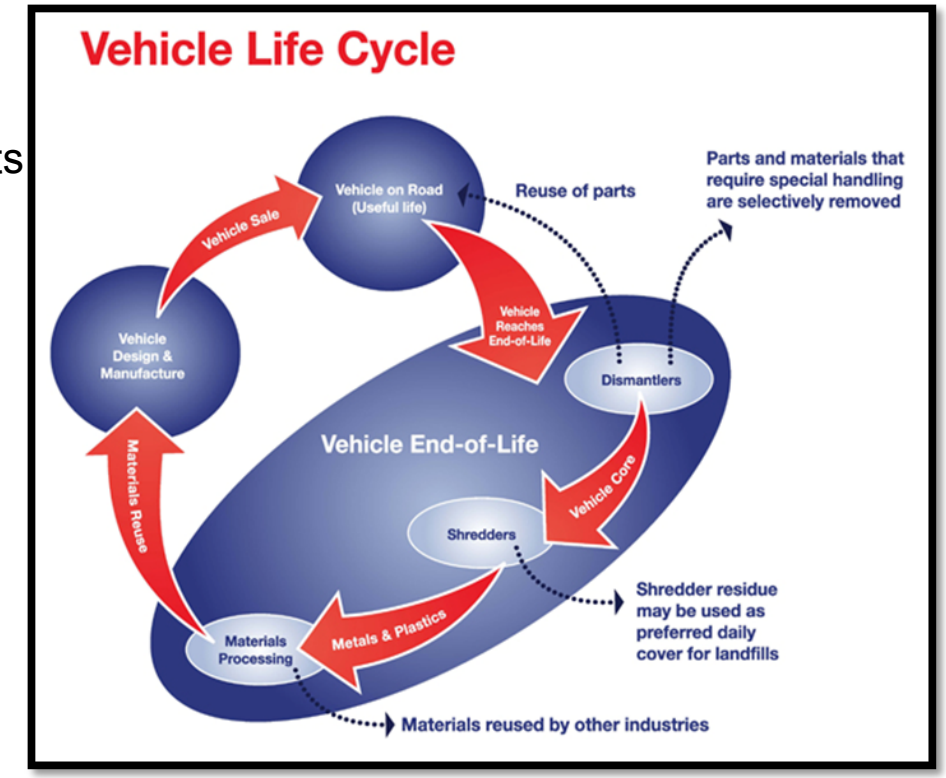
Accomplishments: *Planning and Information*

- Recycling Assessments and Planning
  - Launched and maintained a website to facilitate dissemination of information about recycling automotive materials
  - Updated ELV Recycle Roadmap
  - Held a workshop in 2008 and identified R&D needs for recycling lightweighting metals
- Baseline Assessment of Recycling Systems and Technology
  - Conducted literature review of recycling technologies
  - Published an extensive annotated bibliography
  - Prepared technology review document
  - Conducted life-cycle studies of “post-shred” technologies



Accomplishments: *Website facilitates information dissemination*

- Website has been launched and updated. Last update was in Nov 2008. (http://www.es.anl.gov/Energy_Systems/CRADA_Team_Link/Index.html)
- Information on the website includes:
  - Overview of research activities
  - Publications including progress reports and brochures
  - Recycle bibliography
  - Technology review document
  - Related news and media events
  - Links to related sites



Accomplishments: *Post-shred R&D---Argonne's pilot-plant provides a focal point and requisite large-scale experimental facilities*

- Physical separation produces material concentrates from bulk shredder residue
  - Foam
  - Ferrous and Non-ferrous
  - Polymer Concentrate

- Plastics recovery process is a 6-stage wet (froth flotation) system for recovery of plastics from the polymer concentrate
  - Polyolefins
  - ABS
  - Nylons
  - Other

Physical Separation Pilot-Plant

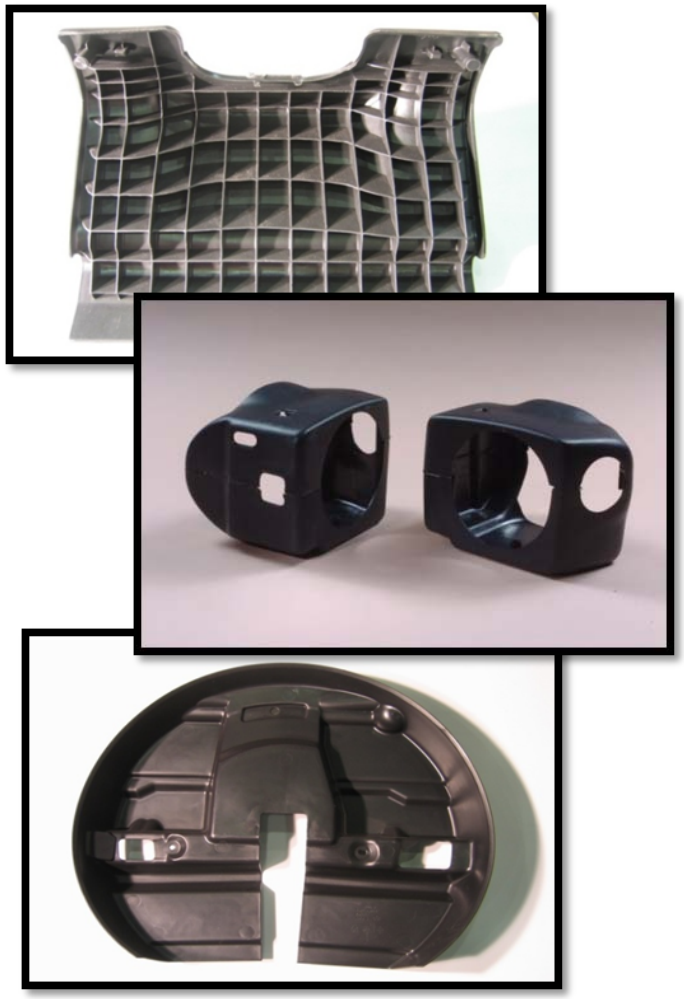
Plastics Recovery Facility

Accomplishments: *Post-shred technology is being validated at commercial-scale*

- Post-shred materials recovery technology development and demonstration
  - Benchmarked and evaluated domestic and international recycling technologies
  - Developed a process for materials recovery from shredder residue
  - Confirmed the technical feasibility of recovering polymers and residual metals in a 2 ton/hr pilot plant
  - Developed designs for a 20 ton/hr validation plant
  - **A 20 ton/hr validation plant is now under construction at a shredder site**

Accomplishments: *Mold trials confirmed the technical feasibility of re-use of recovered polymers*

- Confirmed the technical feasibility of using polymeric fractions recovered from shredder residue for making auto parts
  - Determined physical properties of polymers recovered by the Argonne process as well as by other processes
  - Confirmed that the recovered polyolefins can be blended with other regrind and pelletized
  - Conducted mold trials where recovered polyolefins were used to make auto parts
  - Confirmed that the recovered styrenics can be blended with virgin ABS



Accomplishments: *Options identified for dealing with residual PCBs*

- Benchmarked many PCB removal processes. None achieved removal of PCBs to < 2 ppm under practical operating conditions
  - Developed a two-stage process for PCB removal and tested the process at 5 pounds per batch and achieved < 2 ppm
  - For a 2000 pound per hour design capacity
    - Equipment cost is $2.75 million
    - Operating Cost $0.05/lb
  - Economic viability depends on relative product prices

- Controlled shredder trials indicate feed control can decrease residual PCBs

Accomplishments: *3rd stakeholder workshop held to develop lightweighting metals R&D needs*

- **Workshop held Sept 24, 2008 – USCAR headquarters**
  - 35 material subject experts participated (facilitated by John Green)
- **Scope:**
  - Aluminum, magnesium, titanium, metal matrix composites
    - *Technology that would enhance lightweighting metal recycling*
      - Leading to increased lightweighting in automotive industry
    - *Technology, without which would threaten use of lightweighting metals in automotive industry*
- **Outcomes:**
  - Identification of technology gaps and prioritized R&D needs
  - Summary of workshop report published in Light Metals Age
  - Workshop document being prepared as Argonne Report
    - *"Automotive Lightweighting Metals Recycling Technology Workshop Report" – expected issue date March 2009*

Accomplishments: *ALM Recycling Technology Workshop identified eight priority needs*

- Improved removal of Fe impurity from non-ferrous fraction
  - Removal from re-melted molten aluminum
  - Improved physical and magnetic separation of shredded scrap
- Improved separation and sorting of non-ferrous shredded scrap
  - High Fe vs. low Fe
  - Wrought alloys vs. cast alloys
- Improved removal of Mg from non-ferrous fraction
  - Removal from re-melted aluminum (alternative to chlorine fluxing)
  - Improved shredding, sorting to generate Mg stream
- Develop recycling compatible alloy (urge designers to use fewer alloys)
- Adopt LCA to quantify cost/benefit for recycling
- Improve recovery of recycled aluminum (minimize oxidation losses)
  - Improved furnace designs
  - Improved de-coating and de-lacquering processes
  - Develop rapid submergence technology (to minimize oxidation)
  - Develop improved fluxing practice
- Improved process for handling by-products (salt cake)
  - Develop closed-loop recycling technology
- Improved, more-energy-efficient transport/delivery of molten metal

Future Work

- Update Web site, as necessary
- Establish least-cost strategy for control of residual PCBs
- Complete construction, shake-down and start-up of the validation plant
  - Confirm costs and performance---yields, recoveries, quality and markets
- Develop R&D operating plan for lightweighting metals recycle effort

Summary

- Development of cost-effective recycle strategies and technologies supports the deployment of advanced lightweighting materials---increased recycling reduces the cost of these materials.

- Increased use of recycled materials is one of the three technology specific materials goals for 2010.

- Recovery and reuse of lightweighting materials will
  1. Increase materials supply options and decrease costs for lightweighting materials; directly reducing the cost barrier to broader use of these materials in automotive applications
  2. Decrease the carbon footprint of lightweighting materials over product life-cycle
  3. Conserve the embodied energy of these materials which further reduces energy use beyond that which results from weight reduction during vehicle use.