Frans Bijlhouver, Quality Consultants VOF/BONIJM

Wrought alloys from post-consumer scrap
Quality Consultants is a result oriented consultancy encompassing an integrated network of several professionals in business consulting and interim management for the global non-ferrous metals industry.

Our consultancy was established in 1999 aiming to supply independent and cost effective services to the non-ferrous metals industry.

Quality Consultants operates worldwide. We specialize in product, process and plant optimizing, process and plant design, operational and managerial issues, and quality improvement.

We work for organizations involved in the primary and secondary production of metal, casting, recycling, extrusion, rolling, forging and additional fabrication.
Quality Consultants has a wide experience in developing Client’s project ideas and definitions into a conceptual study, covering all aspects of the future project.

From there we carry out a full feasibility study or a full bankable feasibility study, that will lead to the fast realization of the Client’s project.

We have successfully carried out feasibility studies for billet and slab casting plants, extrusion plants, rolling mills, recycling operations, master alloy casting plants and wire rod plants.
We can offer in-house experience in plant lay-out design and engineering capabilities for the key equipment needed in the global aluminium industry. Along with the plant design, we are also able to fill in the project with a purchasing facility, offering capital equipment from approved global suppliers against the best conditions in the market.

We can supply quality melting furnaces, holding furnaces, degassing equipment, electro-magnetic and permanent magnetic stirrers, direct and indirect extrusion presses, tilting rotary furnaces, casting machines etc. from experienced companies with many reference projects.

Part of our service involves the execution of technical due diligence projects on cast houses and recycling plants, extrusion plants, rolling mills for the aluminium industry.
Quality Consultants, for all the steps between the Client's ideas and the fast realization of Client's aluminium industry project.

- Market intelligence
- New plant and new process design
- Existing plant expansion
- Conceptual studies and feasibility studies
- Quality improvement in process and/or organization
- Environmental services
- Consultancy services
- Operational services
- Interim management
- Project management
- Technical Due Diligence
- Supply of capital equipment and complete plants
- Turn-key projects for the aluminium industry
- Working with approved equipment suppliers

Our competitiveness is guaranteed by:

- Low overhead
- Being result oriented
- Expertise and experience
- Independent
- No ties with suppliers
- Network organization
- Confidentiality
- Results

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MASTER CLASS ALUMINIUM TECHNOLOGY
Dedicated training courses in aluminium application
Frans Bijlhouver, Quality Consultants VOF/BONIJM

Wrought alloys from post-consumer scrap
Why wrought alloys from post-consumer scrap?

- Present and future local availability of suitable scrap
- Increasing competition for clean scrap
- Price
- Good performance recycled aluminium products vs. primary based
- Not always needed tight tolerances on chemical composition
- Recycling based material can be used for >70% of today’s applications
Which wrought alloys from post-consumer scrap?

In first instance we tested the following:

- 6XXX series wrought alloys for extrusions (particular EN AW-6063)
- 3XXX series wrought alloys for FRP (particular EN AW-3005)

In a later stage we will test the following alloys:

- Other 6XXX series wrought alloys for extrusions
- 2XXX series wrought alloys for extrusions
- 1XXX series wrought alloys for FRP
Background

2008 – Alcastek Mumbai
Manufacturing of extrusion billets of scrap and swarf

2009 – Materials Technology
Why composition limits of popular extrusion alloys form an increasing obstacle for aluminum recycling

Request from a company to investigate the possibilities of using scrap based wrought alloys for extrusions. Reason is to increase margin without harming the integrity of the extrusion. The extrusions are not for anodizing purpose.

2nd phase
Investigate the possibilities to produce FRP from scrap-based wrought alloy. To be produced on a continuous casting machine.
Scrap processing flow chart
Scrap based material processing flow chart

Start

- Quality requirements
  - Melting and alloying scrap
  - Adding <10% master alloys
  - Filtering and degassing
    - Adding <10% primary ingots

DC casting billets

- Homogenizing billets
- Cutting and U.S. inspection
- Extrusion process incl. aging
- Alternative product

Continuos casting coil

- Inspection
- Cold rolling process incl. annealing
Scrap-based extrusion alloy
Shredded post-consumer profile scrap
Testing billet material at the Technical University Delft
Testing billet material at the Technical University Delft
Comparing the EN standard vs. scrap based material.  

Nr. of samples: 125

<table>
<thead>
<tr>
<th>EN AW-6063</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.20-0.60</td>
<td>&lt;0.35</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>0.45-0.90</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scrap based 6063</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg.</td>
<td>0.75</td>
<td>0.35</td>
<td>0.18</td>
<td>0.20</td>
<td>0.64</td>
<td>0.05</td>
<td>0.10</td>
</tr>
</tbody>
</table>

The scrap-based material is high in some elements, but this does not directly disqualify the material.
Comparing standard material vs. scrap based

<table>
<thead>
<tr>
<th></th>
<th>UTS Rm MPa</th>
<th>YS Rp 0.2 MPa</th>
<th>Elongation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN AW-6063 T6</td>
<td>190-215</td>
<td>160-170</td>
<td>10%</td>
</tr>
<tr>
<td>Scrap based 6063 T6</td>
<td>AVG</td>
<td>230</td>
<td>180</td>
</tr>
</tbody>
</table>

It reflects in some mechanical properties, but the elongation is still within tolerance.
To be limited. Reduces press efficiency. Increases ductility up till 0.3%.

Needed for reaching the mech. properties by precipitation.

Reduces mech. properties. Improves Mg$_2$Si precipitate. Increases ductility. Use 0.25 to 0.35%.

Increases mech. properties.

Use half of tolerance.

Use half of tolerance.
Alloy profile of AW 6063

%Mg %Si %Mn %Fe %Cu %Zn %Cr

Level scrap-based alloy
Conclusion on AW 6063 scrap based alloy

It is very well possible to produce an extrusion alloy from shredded post-consumer profile scrap that is available on the scrap market. The material should be shredded and sorted in a modern sorting line. The measurements on the chemical composition slightly exceed the EN standard.

No primary metal has been added, just grain refiner. The results are satisfying and the mechanical properties are within limits. This scrap based alloy is not for anodizing. There are no other restrictions.
Technical advantages and restrictions for extrusion

- Similar or better mechanical properties including elongation
- Can not be used for anodised surfaces (less than 25% of the market share)
- Can sometimes replace higher alloyed material like EN AW-6005A or 6082 for a far better price
- Guaranteed 100% recycled content
- Incidental higher extrusion prices for lower extrusion productivity
Cost price advantages for this scrap-based extrusion alloy

Primary material for extrusion

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market price:</td>
<td>LME (October 2012) 1550 EUR/tonne</td>
</tr>
<tr>
<td>Billlet premium:</td>
<td>200 EUR/tonne</td>
</tr>
<tr>
<td>Processing (extrusion)</td>
<td>EUR 1000/tonne</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>EUR 2750/tonne</strong></td>
</tr>
</tbody>
</table>

Scrap-based material for extrusion

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market price:</td>
<td>LME-25% (October 2012) 1163 EUR/tonne</td>
</tr>
<tr>
<td>Billlet premium:</td>
<td>100-125 EUR/tonne (less alloying elements)</td>
</tr>
<tr>
<td>Processing (extrusion)</td>
<td>EUR 1000/tonne</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>EUR 2263/tonne</strong></td>
</tr>
</tbody>
</table>
Scrap-based FRP alloy
Shredded old rolled baled scrap (Taint/Tabor)
Processing scrap-based material on CC line
Comparing the EN standard vs. scrap based material.  
Nr. of samples: 63

<table>
<thead>
<tr>
<th></th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EN AW-3005</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;0,60</td>
<td>&lt;0,70</td>
<td>&lt;0,30</td>
<td>1,0-1,5</td>
<td>0,20-0,60</td>
<td>-</td>
<td>&lt;0,25</td>
</tr>
<tr>
<td><strong>Scrap based 3005</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg.</td>
<td>0,30</td>
<td>0,35</td>
<td>0,12</td>
<td>0,35</td>
<td>0,70</td>
<td>0,10</td>
<td></td>
</tr>
</tbody>
</table>
Comparing standard material vs. scrap based

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<tr>
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<th>UTS Rm MPa</th>
<th>YS Rp 0,2 MPa</th>
<th>Elongation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN AW-3005 O/H111</td>
<td>115-165</td>
<td>&gt;45</td>
<td>&gt;12%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>UTS</th>
<th>YS</th>
<th>Elongation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrap based 3005 O/H111 AVG</td>
<td>175</td>
<td>60</td>
<td>12%</td>
</tr>
</tbody>
</table>

Scrap based 3005 O/H111
Scrap based version 3005. Need addition of Mn and Mg
Conclusion of FRP

Also the production of a wrought alloy for sheet is very well possible by using the right scrap material from the market and process it in a modern sorting line. The measurements on the chemical composition slightly exceed the EN standard.

At present we do not have enough statistical data to come to a final conclusion, but the results are promising.
Conclusion

The composition limits as laid down in the EN standards and Teal Sheets are a obstacle in recycling. The defined alloys are based on primary metal.

The industry needs alloys definitions that are based on scrap input and especially post-consumer scrap.

Then there is no need to dilute the melt with primary metal to reach unrealistic composition limits.

The tests show that the direct recycling of properly sorted metal can provide a reliable extrusion alloy with even better mechanical properties in comparison with the original.