Resource Efficiency Challenges in the Steel Industry

Resource Recovery from Waste Annual Conference
London, 16th January 2019

Peter Quinn, Head of Environmental Policy & Strategy, TSE
## Agenda

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## Agenda

1. **TSE - Overview**
2. Steel and Resource Efficiency
3. Integrated Steelmaking – Material Flows
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Tata Steel in the UK

8,500+ employees

£2 billion+ turnover

£136m UK investment in 2017-18
Tata Steel Operations in the UK

- **60%**
  - Sales to UK manufacturers

- **30%**
  - Sales to EU customers

- **4%**
  - Sales to USA-based customers
Our Steel in Use

Electric Nissan Leaf
Tata Steel's Zodiac Line at Llanwern supplies Nissan with coil that is used to produce exterior body panels for models such as the Qashqai and the electric Leaf.

The Royal Mint
Nearly all 1p, 2p, 5p and 10p UK coins in circulation originate from steel made in Port Talbot.

High performance packaging
Our unique Protact technology is a more sustainable, reliable and safe packaging material. It reduces water and energy use in canmaking, and is infinitely recyclable.

The Shard
As Western Europe's tallest building, the Shard has 87 floors with 1,000 tonnes of steel from Tata Steel's plant in Shotton, North Wales.
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2. **Steel and Resource Efficiency**
3. Integrated Steelmaking – Material Flows
4. Key Challenges / Barriers to Greater RE
5. Future Research / Policy Opportunities
Society is gearing up to a new economic operating model..

Steel is a uniquely sustainable material - once made, it can be used forever.

Source image: European Commission, Towards a circular economy (2014)
STEEL IN THE CIRCULAR ECONOMY A LIFE CYCLE PERSPECTIVE

WITH TODAY’S FINITE RESOURCES the world must move towards a circular economy in order to bring about a more sustainable world.

THE STEEL INDUSTRY IS AN INTEGRAL PART OF THE GLOBAL CIRCULAR ECONOMY DUE TO ITS ABILITY TO:

**REDUCE**
- TO IMPROVE FUEL EFFICIENCY
  - The increased strength of modern steel makes Sarah's new car lighter, safer and more fuel efficient

**REUSE**
- TO EXTEND ITS LIFE CYCLE
  - The beams in Hiro's new house were reused from an old factory

**REMANUFACTURE**
- TO RESTORE USED PRODUCTS TO LIKE-NEW CONDITION
  - Omar's wind turbines in Belgium were built by restoring disassembled wind turbines in Denmark

**RECYCLE**
- TO CONSERVE VALUABLE RESOURCES
  - Steel is magnetic, so it's easier for Maria to recycle and it can be recycled again and again without any loss of quality

THE REDUCTION, REUSE AND RECYCLING OF MATERIALS IS INTEGRAL TO THE GLOBAL CIRCULAR ECONOMY AND A FUNDAMENTAL ADVANTAGE OF USING STEEL.
The World Needs Steel: it is the ultimate sustainable material

The only truly cradle-to-cradle recycled material

Steel life cycle

Steel enables sustainability

- Never consumed – once made, it is used again and again without loss of strength
- The most recycled material in the world
- Long-term investment that does not go to waste
- Efficient – light yet strong

Source: worldsteel

Steel and Resource Efficiency

Higher strength steels..

.. produced with less material losses..

.. and using less energy

What will be the next step for steel?

1. Global steel industry, 2. UK steel industry
Source: Tata Steel, worldsteel, UK Steel, ISSB
Steel for a sustainable future

Premium steel grades that help make the difference

- Durability, efficiency and flexibility make steel the material of choice for the world’s most sustainable buildings
- Steel supports the future of energy generation and makes the generators more efficient too
- Steel is the essential material for sustainable vehicles and new grades make them even lighter, safer and more efficient
**Steel and Resource Efficiency**

**Tata Steel’s Substantial Contribution**

- Globally, it is now increasingly understood that there is a need to decouple economic growth from consumption; continuing to consume the resources of the world unsustainably is not the means by which we should tackle poverty and provide all the people of the world with a high standard of living.

- We need to create wealth through proper stewardship of energy and materials. There are a number of aspects to this:
  
  - Making products in clean, efficient processes, minimizing emissions and other waste.
  
  - Making products which deliver high levels of functionality with the minimum possible material.
  
  - Making products that, at the end of their useful life, are re-usable and recyclable.

- Steel in general, and Tata Steel in particular, have a great story to tell:
  
  - Steel products are durable, strong, flexible and infinitely recyclable.
  
  - Tata Steel operates highly efficient steelworks, achieving high material yields by consuming residues arising in the processes, finding high-value uses in other sectors for its by-products and acting as a recycler for the residues of other sectors of the economy.
Steel and Resource Efficiency

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Integrated Steelmaking - Process overview

Primary steel making with BF-BOS

- Reduction of iron ore to iron takes place in the blast furnace, using carbon
- Iron ore has to be pre-processed in a sinter plant or pellet plant and coal generally has to be converted into coke in a coke plant
- The product of the blast furnace, hot metal, contains some carbon. This is removed in the BOS plant. Up to 20% of scrap can be added to the hot metal in the BOS process.
- Residual gases from coke production, BF and BOS processing are recovered as they have calorific value; then used for heating processes or for electricity production and are not wasted.
- For casting and rolling the steel into final products, some additional electricity and fuel might be necessary.
- A typical specific emission value for integrated steel production is 2.3 tonne CO$_2$ per tonne steel
Integrated Steelworks Schematic

- The main raw materials for integrated steelmaking are iron ore (fines, lump, pellets), steel scrap, coal / coke and fluxes such as limestone and dolomite.
- Typically, approximately two tonnes of raw materials are required for each tonne of cast steel.
- The cost of raw materials (including energy) dominates the cost base of the steel industry; competitiveness demands that resources be used efficiently.
- Integrated steelworks have thus developed around a model of recirculation of materials, energy and water across individual component parts of the system; an efficient case study in industrial symbiosis!
### Examples of Residue Utilisation within a Steelworks

<table>
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<tr>
<th>Residue</th>
<th>Process Step Producing Residue</th>
<th>Main Useful Constituents</th>
<th>Typical Recirculation Approach</th>
</tr>
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<tbody>
<tr>
<td>Steel scrap</td>
<td>BOS plant, casters, processing of steel, slag processing</td>
<td>Iron</td>
<td>Re-charged at BOS plant, BF or sinter plant</td>
</tr>
<tr>
<td>Sinter plant gas cleaning (ESP dust)</td>
<td>Sinter plant</td>
<td>Iron</td>
<td>Added back to sinter feed</td>
</tr>
<tr>
<td>Iron ore residues</td>
<td>Stock areas, conveyance, burden preparation</td>
<td>Iron</td>
<td>Added back to sinter feed</td>
</tr>
<tr>
<td>Coke oven gas</td>
<td>Coke ovens</td>
<td>$H_2, CH_4$</td>
<td>Refined in CO 'by-products' plant to separate fractions. Clean CO gas used as fuel across steelworks</td>
</tr>
<tr>
<td>Coke oven by-products</td>
<td>By-products plant</td>
<td>Tar, benzene, ammonia</td>
<td>Tar and benzene sold to chemicals sector for use in other sectors</td>
</tr>
<tr>
<td>BF gas</td>
<td>Blast furnace</td>
<td>Carbon monoxide</td>
<td>Cleaned through dry dust catcher and venturi scrubber and used as fuel across steelworks (inc. power generation)</td>
</tr>
<tr>
<td>BF gas cleaning slurry</td>
<td>Blast furnace</td>
<td>Iron</td>
<td>Hydrocyclone to segregate zinc etc. Underflow dried and added to sinter feed</td>
</tr>
<tr>
<td>BF flue dust</td>
<td>Blast furnace</td>
<td>Iron</td>
<td>Added to sinter plant feed</td>
</tr>
<tr>
<td>BF slag</td>
<td>Blast furnace</td>
<td>Calcium, silicon</td>
<td>Molten slag granulated and ground to cement OR air cooled and crushed to aggregate</td>
</tr>
<tr>
<td>BOS gas</td>
<td>BOS plant</td>
<td>Carbon monoxide</td>
<td>Cleaned in wet scrubber and used as fuel across steelworks</td>
</tr>
<tr>
<td>BOS plant gas cleaning slurry</td>
<td>BOS plant</td>
<td>Iron</td>
<td>Thickened, filter-pressed and added to sinter feed or briquetted and returned to BOS plant or BF</td>
</tr>
<tr>
<td>BOS slag</td>
<td>BOS plant</td>
<td>Calcium</td>
<td>Air cooled, metal fines recovery. Slag fines used as lime replacement at sinter plant, large fraction used as aggregate (mainly road construction) after weathering</td>
</tr>
<tr>
<td>Dry millscale</td>
<td>Rolling mills</td>
<td>Iron</td>
<td>Added to sinter plant feed</td>
</tr>
<tr>
<td>Oily millscale</td>
<td>Rolling mills</td>
<td>Iron / oil</td>
<td>Oil recovered with thermal desorption or centrifuge and dry residue added to sinter feed</td>
</tr>
<tr>
<td>Ferrous chloride solution</td>
<td>Cold mills (pickling)</td>
<td>Iron chloride</td>
<td>Sold to water treatment companies as flocculant</td>
</tr>
<tr>
<td>Waste oil</td>
<td>Rolling mills</td>
<td>Oil</td>
<td>Used as bulk density control and carbonised at coke ovens</td>
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Simplified Illustration of Material Flows in Integrated Steelmaking
As a proxy for overall resource management, the array of uses of process gases derived from coal and other carbon inputs serves to demonstrate how complex but effective resource efficiency has become in the steelworks system.

Illustrated another way, Tata Steel’s site at Port Talbot annually consumes ~7Mt of raw materials and landfills ~20kt – equivalent to a 99.7% RE rate.

But, this does not take full account of the overall efficiency of the process and doesn’t reveal the extent of opportunity that still exists to improve...
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Key Challenges / Barriers to Greater Resource Efficiency

End-of-life Recycling

• As described earlier, steelmakers are innovating in product development – recognizing the profoundly positive impact that steel can play in the circular economy. But this can come at a cost.

• Enhancing the durability of steel products to extend their service life reduces overall societal consumption,

• But advanced coatings and other product innovations can present operational challenges when those products are recycled at the steelworks:
  • Tin is difficult to remove during steelmaking and can accumulate within the steel pool, impacting on the potential for steelmakers in the future to use that steel in certain applications
  • Zinc can readily be removed from steel when galvanized scrap is recycled in the BOS plant but it accumulates in gas cleaning residues, limiting the volumes that can be recirculated back into the system
  • Whilst steel is extremely recyclable, scrap recovery systems are currently under-developed in terms of segregating certain high-alloy steels from plain carbon steels and potential therefore exists for down-cycling (e.g. Advanced, high-strength steels).
Key Challenges / Barriers to Greater Resource Efficiency
Trade-off between Resource Efficiency and Pollution Control

- Tightening controls / more prescriptive policy on industrial emissions to atmosphere have presented barriers to a number of traditional recovery and recycling routes:

  - Until 2010, the blast furnace at Redcar in Teesside (unfortunately now closed) used recovered fuel oil as a reducant, thereby displacing huge amounts of virgin fossil fuels such as coking coal (and its preparation in the coke ovens for use in the blast furnace). Revised Defra guidance on Waste Incineration Directive in 2011 effectively led to the end of this practice, with arguably no improvement whatsoever in terms of emissions.

  - Chlorides in blast furnace flue dust and sinter plant gas cleaning dust have been shown to have an impact on the efficiency of electrostatic precipitators (ESP), thereby limiting the volume with which these residues can be recovered on site.

  - Similarly, residuals of oil in millscale can have an adverse impact on ESP performance and also play a role in the formation of certain trace organic pollutants. As such, new routes have had to be found for such scales, some involving down-cycling, where the iron units are not recovered in a form that enables future production of steel products from them.
Key Challenges / Barriers to Greater Resource Efficiency
Difficulty in Measuring Resource Efficiency and ‘Circularity’

- A number of metrics have been used by steelmakers for decades to measure aspects of resource efficiency
  - Landfill rate
  - Through yield
  - Carbon intensity
  - Zinc applied per square meter of substrate
  - Tonnes of crude steel output per tonne of raw material used

- But given the complexity of material flows within the steelworks and the huge range of products that each tonne of crude steel can be turned into, it is remarkably difficult to define a truly holistic metric of resource efficiency, that accounts for the quality of and energy expended in recover/recycling, that accounts for product mix etc.

- We have used LCA extensively and, indeed, operate our own EPD programme. This is an excellent tool but does not lend itself to dynamic measurement of operational performance.
Key Challenges / Barriers to Greater Resource Efficiency
Other Policy Constraints

• Eco-design criteria and public procurement policy currently don’t provide sufficient incentive for component manufacturers to design for dis-mountability / separation of materials at end-of-life

• The intrinsic potential for steelworks to recover carbon, iron, calcium etc. from wastes arising in other industrial sectors and across wider society cannot be fully realized because of, for example, inflexible application of the co-incineration provisions within the EU’s Industrial Emissions Directive.

• The potential use of steel sector residues in non-steel applications is often restricted as a result of waste and chemicals policy:
  • Processed steel slag is an excellent aggregate but its use in certain aggregate applications remains restricted as a result of a highly conservative approach to risk assessment and a failure to account for the overall resource efficiency advantages of its use versus quarrying of virgin alternatives. The same problem constrains possible future uses of steel slag in mine remediation, sea defences, carbon sequestration etc.
  • Coal tar sales to the chemicals sector for refining and use in a wide number of applications – some of which are relevant within the steel sector (refractories, electrodes etc.) – are threatened by an impending authorization for CTPht under REACH
  • De-industrialization in the UK has constrained opportunities for industrial symbiosis, albeit that clustering approach is being taken forward for CCUS
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Future Research and Policy Opportunities

- **Policy opportunities:**
  - More holistic assessment of RE benefits from residue and by-product use in steelworks and wider society (rather than exclusive focus on leachate risks or prescriptive rules)
  - Greater use of product and public procurement policy to incentivize RE in product design

- **Technical opportunities:**
  - Enhanced scrap segregation systems to eliminate residuals, preserve high value alloys and prevent down-cycling / contamination of steel scrap supply.
  - Techniques for removal of zinc, chlorides, tin, oil etc. from end-of life steel products and/or steelworks arising residues (bio-electrochemical systems?)
  - Development of dynamic metrics for RE monitoring
  - (Assuming policy barriers can be addressed) pre-treatments for societal wastes to prepare them for use in steelworks processes (e.g. waste plastic in BF)
  - Carbon capture and use technologies
  - Novel applications for steel slag (e.g. carbon sequestration)
  - Novel techniques for recovery of valuable metals from slag and other residues (including landfill mining) – e.g. Vanadium
Thank you.
Any questions?

Together we make the difference