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Optimization of EAF Fe Feedstock as Related to Steelmaking and Decarburization

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Advances in EAF Technology

Further decarburization in the EAF is heavily dependent on:

- Renewable energy
- Higher quality raw materials

For greater amounts of renewable energy to be made available we need:

- Upgraded electrical grid
- More efficient power storage technology
- More efficient renewable energy technologies

As a result, hydrogen-based processes are unlikely to be implemented before 2035 except in regions that already have a lot of low C footprint energy available – Scandinavia, Canada

Scrap as a De-Carbonization Lever

- 100 % scrap-based operations utilizing EAF technology already have a very low CO_2 footprint
- Footprint can be lowered through improvements in efficiency and Fe yield
- Must understand the properties of scrap to optimize its' Value-in-use
- Increasing levels of scrap residuals (Cu, Sn, Ni, Mo) are a concern and will require varying amounts of ore-based metallics to allow recycle

Role of Steel Scrap in Decarburization

- Impossible to talk about decarburization without considering raw materials
- Single biggest cost for the EAF steelmaker is metallic charge
- The future of EAF steelmaking is about maintaining a sustainable balance between ore based metallics (OBMs) and recycled scrap
- The more we do to improve scrap quality, the less dependence we have on OBMs – leads to greater sustainability and improved circularity
- Maximum recycle of steel scrap can only be achieved by improving scrap quality

Scrap Challenges

- Steel scrap doesn't have a zero CO2 footprint
- CO2 footprint dependent on scrap quality
- CO2 taxes will drive us to deliver a higher quality scrap product

Raw Material – Double Standards?

- Steelmakers are always concerned with the quality of OBMs – gangue content, total Fe content, Fe metallization
- When it comes to scrap, why aren't we concerned with the same things?
  - Dirt
  - Extraneous non Fe bearing materials
  - Oxidation of scrap

Scrap Contamination

- **Residuals** – Cu, Ni, Mo, Sn – must be controlled to meet product specifications
- **Extraneous materials** – Plastics, non-ferrous metals, wood, oil, grease – greatest contributor to environmental issues in the EAF, also contribute to CO2 footprint
- **Dirt** – results in increased Flux requirements, increased energy consumption, yield losses, decreased productivity – 1 % dirt increases CO2 footprint by 43 kg/tls

Why We Need To Improve Scrap Quality?

	As-Is	Endpoint Improvement	Endpoint and Acid Load Improvement	Units
Charge Tonnes	150	150	150	tonne/ht
Average FeO%	39.3%	32.0%	32.0%	wt%
Acid Load	25	25	16	kg/tonne
Dolo Lime Usage	46	40	25	kg/tonne
HiCal Lime Usage	18	22	14	kg/tonne
Flux Consumption	64	62	39	kg/tonne
Slag Generation Rate	157	136	86	kg/tonne
Tap Tonnes	135.3	136.4	138.1	tonne/ht
Yield	90.2%	90.9%	92.0%	tap/chg
Flux and Scrap Costs per TLS	$429	$425	$415	$/tls
		($4)	($14)	$/tls

What Scrap Grades can be Upgraded?

- Scrap grades with the greatest amount of free copper are shredded, #1 HMS, #2 HMS
- Extraneous materials can be associated with almost all scrap grades but predominantly shredded, #1 HMS, #2 HMS
- Dirt associated with all scrap grades – predominantly shredded, #1 HMS, #2 HMS – some export scrap contains up to 7 % dirt

Technologies For Scrap Upgrading

The ScrapTuning® and HMS Cleaning Advanced tools pursue three main objectives:

a) Concentrating the metallic Fe.
b) Complete decontamination from inert materials, non-ferrous metals, non-metallic components, and composite materials,
c) Isolation and separation of steel scrap particles with high inherent residual content (Cu, Ni and Cr)

OBM Role to Achieve High Scrap Recycle Rate

- In North America, the short-term solution is dilution. This is evidenced by the high use of ore-based materials (pig iron, DRI and HBI) in the charge mix in order to dilute residual levels in the recycled steel. The added benefits of DRI and HBI on GHG emissions will also be a factor leading to increased use.
- Currently, the use of OBMs enables the recycling of high-residual obsolete scrap. **Without the OBMs, a significant amount of obsolete scrap would not be recycled but would be destined for the landfill.**
- The availability of "prime" scrap is shrinking in many of the mature economies as manufacturers become more efficient and generate lower quantities of scrap. In addition, as steel technology evolves (such as advanced high-strength steels), the quantity of steel being used is also shrinking.
- At the same time, several automakers are calling for high quality flat products made without pig iron – green steel.
- In North America, the steel industry has reacted to a PI scarcity by "upgrading" scrap quality

Better Separation of Free Copper

- US shredding operations - product with about 0.25–0.3 wt.% copper.
- The actual dissolved copper content of this scrap is 0.06–0.10 wt.%.
- “free” copper comes from electronics, wiring harness, battery, safety system, radio, computer, and within the starters and alternators.
- More copper can be removed by repeated shredding and magnetic separation, and by enhanced equipment maintenance.
- Recently Nucor and SDI producing shredd with 0.16 wt. % Cu.
- Electric vehicles - Cu is three times > conventional automobiles
- Much more thought - designing steel products to ensure that copper and other bulk residuals can be removed easily prior to recycling of these products at their end of life.
- Greater effort must be made to separate free copper

Steps to Upgrade Shredded

- Larger magnetic separators
- Adjust gap
- Aim for density > 80 pounds per cubic foot – corresponds to lower Cu content and 2 % Fe Yield improvement
- Install instrumentation to monitor copper level in product stream – use this to make set-up adjustments

HMS Upgrade Results

- Trials conducted by SICON in Europe. Processed HMS
  - Cu content was reduced by 0.15 wt. %
  - Ni contents was reduced by 0.04 wt. %
  - Cr content was reduced by 0.06 wt. %
  - Pb was reduced by 0.03 wt. %
  - P was reduced by 0.02 wt. %.
- CO_2 emissions would have been increased by ~ 200 kg/ton of scrap if the scrap was unprocessed
- Energy savings were projected at ~ 200 kWh/tonne of scrap

Scrap Upgrading At The Steel Plant

- Latest trend is to process scrap at the steel plant site
- Shredder and/or HMS processing
- Some facilities considering shredding of bushelling (densify)
- Dirt removal can provide significant savings
- Eventually want to push this processing back on the scrap supplier and/or reduce contamination through better design for EOL

Economics Of Scrap Upgrading

- One of the major obstacles to upgrading scrap quality is the argument that the costs will outweigh the benefits.
- CIX has resolved this conundrum through the development of a value-in-use model that allows for detailed evaluation of EAF feedstocks to track the benefits of higher quality raw materials.
- Coupled with equipment and operating costs supplied by equipment manufacturers, it is a relatively simple exercise to determine the cost benefits.
- Cost benefits greatly outweigh the costs – to reduce Cu from).35 to 0.16, the cost is about $4 – $5 per ton
- Higher density shredd typically corresponds to lower total Cu content

Conclusions

- Must drive towards a "cleaner" raw material input to steelmaking
- Steel scrap plays critical role - Can improve scrap VIU
- Upgrading costs are more than offset by reduction in CO2 footprint/EAF efficiency improvements/Reduced environmental concerns
- Equipment already available to upgrade scrap quality
- Need more involvement from scrap processors/manufacturers
- Need to design for EOL to achieve cleaner recycle streams
- OBMs enable greater scrap recycle and demand will remain high for the foreseeable future