Continuous charging of scrap
Dissemination of
“Scrap continuous charging to EAF”

Contract No 7215-PP/027
1 July 1999 to 30 June 2002

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Background – Scrape selection

• Characteristics of scrap:
  • Density
  • Metallic Fe content
  • Gangue content,
  • Oil, grease
  • Non-metallic content
Background - Scrape pre-heating

- First initiated during the fifties to prevent explosion during melting from moisture and ice (more scrape drying)
- Early scrap pre-heating systems used independent heat sources
- Separated scrap preheating
  - Mostly for increased productivity, not for decreased energy consumption
  - Possible energy savings
    - Better utilisation of organic components in the scrap
    - Lower energy losses because of lower tap to tap time
  - Normal charging of cold scrap possible
- Efficiency
  - 35 % direct flow
  - 65 % recirculated flow
- Utilising energy in off-gas
Sankey diagram for melting scrape in an EAF

- Liquid steel: 380 kWh/ton
- Off-gas: 140 kWh/ton
- Miscellaneous: 10 kWh/ton
- Burners: 40 kWh/ton
- Slag: 50 kWh/ton
- Cooling water: 50 kWh/ton
- Chemical energy: 180 kWh/ton
- Total energy: 630 kWh/ton
- Electrical energy: 410 kWh/ton
- Off-gas: 140 kWh/ton

Swerea MEFOS
Background - Scrape pre-heating

- Off-gas approximately 25% of energy from the process
- Development towards
  - Continuous preheating
  - Higher pre-heating temperatures ~1000 °C possible
- Pre-heating closely related to scrape charging
Background – charging and pre-heating concepts

• Several different concepts are available today from different suppliers
• Establish concepts
• Bucket charging with pre-heating
  • With EAF off-gas or conventional burners
  • Drying / preheating up to 200 °C possible without need for dioxine treatment
  • Short power-on time is a problem
• Possible for all furnaces
• Energy savings 35 kWh/ton
Bucket charging with pre-heating

- Waste Gases
- Scrap Charge
- Charging Bucket
- Waste Gases to Bag House

EAF
Background – charging and pre-heating concepts

• Establish concepts with continuous or semi continuous charging

• Consteel
  • Develop by Intersteel Technology Inc i Charlotte, North Carolina (since 1994 a part of Techint, Tenova S.p.A.)
  • 45 installations 18 countries (Norway 2008, Celsa armeringstål, Mo i Rana)
  • Continuous scrap charging into flat bath

• Finger Shaft Furnace, FSF
  • Developed by Fuchs
  • Many installations ~30 since first installation at DDS Denmark 1988 (This installation was replaced by a conventional EAF 1992)
  • Semi continuous scrap charging into flat bath

• Several additional solutions are available
Consteel concept

Oxygen Injection

Connecting Car

Foamy Slag

Molten Steel

Preheater

Off-Gases

Scrap Charge

To Bag House
Consteel concept - Advantages

• Electrical energy savings
• Lower power requirement for the same level of production reduces kWh unit cost
• Decreased problems with flicker and other disturbances on the grid
• Lower electrode consumption and electrode breakage
• Cost reductions for logistics, manpower, maintenance and waste product management
• Lower use of oxygen and no burner fuel consumption in the furnace
• 1 - 2% increase in scrap yield
• Less dust is evacuated to the baghouse
Consteel concept - Drawbacks

- Burners needed in the preheating tunnel to cope with dioxins.
- Large energy losses to panels in the walls and roof due to the flat bath
- Increasing slag line wear if unstable slag foaming
- Burner can not be used effectively in the furnace
- Heavy scrap can not be handle through the pre-heater
- Inefficient heat transfer between gas and scrap during pre-heating.
Finger Shaft Furnace

d) Shaft hood

c) Funnel

a) Shaft panels

e) Hood Support

b) Finger System

f) Shaft base frame

g) Support steel structure
Finger Shaft Furnace

Melting cycle semi continues charging
Finger Shaft Furnace – double shaft
Finger Shaft Furnace - Advantages

• Less dust is evacuated to the baghouse, when some dust is caught up in the scrap
• Relatively many functional references furnaces
• Increasing the zinc concentration in the dust with up to 40%
• Electrical energy savings
• Improved steel yield
• High productivity especially for double shaft furnaces
Finger Shaft Furnace - Drawbacks

• Post combustion after the shaft is necessary to cope with dioxins
• Risk for recurring leaks in the shaft and fingers.
• Increased lining wear at the electrode 2 as scrap protection from radiation is lacking in this part of the furnace
• Heavy scrap can not be charged due to the risk of damaging fingers
• Close integration between melting and pre-heating presents a risk for production stop due to breakdown in the pre-heater
• Large water-cooled surfaces in the furnace, in the shaft and fingers require more cooling water.
• Requires high building height
Comparison Consteel vs. Finger shaft Furnace

Consteel
• Preheating temperature 600 °C
• Energy saving 65 kWh/ton
• Energy and costs for dioxine removal not included
• High off-gas temperature

Finger shaft Furnace
• Preheating temperature
  • 750 °C for single shaft
  • Higher for double shaft
• Energy saving
  • 70 kWh/ton single shaft
  • 100 kWh/ton double shaft
• Energy and cost for dioxine removal not included
• Maintenance problems
• Concept has ”peaked”???
Dissemination of “Scrap continuous charging to EAF”

- Contract No 7215-PP/027
- 1 July 1999 to 30 June 2002
- Project focus on the Consteel concept
  - The project was carried out to optimise the Consteel concept and to demonstrate the benefits of this technology
- Partner consortium
  - ORI Martin (project co-ordinator)
  - Centro Sviluppo Materiali (CSM) (research partner)
  - Techint (engineering partner)
Dissemination of “Scrap continuous charging to EAF”

- Objectives of project
  - Design and apply optimised operating practices to minimise electrical energy consumption for different amount of coal additions
  - Identify and solve the environmental problems resulting from the scrap heating process

- Ways and means
  - Development of mathematical models of scrap temperature distribution in the tunnel and of EAF steelmaking process
  - Experimental trials with extensive measurements of process parameters
  - Model simulations to design optimised operating conditions with respect to consumption of coal (chemical energy source)
  - Development of new measuring sensors, temperature and gas composition
“Scrap continuous charging to EAF”
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- Electric Arc Furnace
  - Furnace type AC/EBT
  - Water cooled panels and roof
  - Interchangeable shell
  - Shell diameter 5.4 m
  - Tapping capacity 75 ton
  - Liquid heel 40 ton
  - Total capacity 115 ton
  - Operating power supply 35 MW
  - Minimum tap to tap time 52 min
  - Equipped with oxygen and coal injection lance.
“Scrap continuous charging to EAF”

- Consteel
  - Total length 48.5 m
  - Tunnel length 24.0 m
  - Tunnel width 2.0 m
  - Tunnel height: 3.0 m
  - number of injectors installed in the tunnel roof 6
Schematic representation of current Consteel
Results of temperature measurements
Results of temperature measurements

Distance from the entrance of the scrap in the tunnel [m] vs. temperature [°C]

- Surface
- 10 cm depth
- 30 cm depth
Results on effect distribution

Case 1 – before optimisation
Case 2 – after tunnel optimisation but no CO post combustion in EAF
Case 3 – after tunnel optimisation and partial post CO combustion in EAF
Results

- Stable process conditions were maintained even if a minimum set of on-line continuous measurements was adopted
- Maximum recover of energy from scrap pre-heating was achieved
- Reduction of electrical consumption was obtained
- Low values of concentration of polluting emission was measured
What methods comes in future?

Some examples

- Former SIMETAL EAF **Quantum** - now Primetals EAF **Quantum**
  - Electrical energy consumption 280 kWh/ton
  - 3 basket practice
  - Large hot heel, nearly 100 % flat bath operation
  - 33 min tap to tap time
  - No instillations at the moment
  - Planned installation during the of 2016 at Acciaieria Arvedi S.p.A. in Cremona, Italy.
Quantum
What methods comes in future?
Some examples

Shaft Furnaces with Pushers
- COSS scrape pre-heater FUCHS Technology
  - Flat bath operation
  - Reduced electrical energy consumption by scrap preheating
    (scrap temp. approx. 400°C - 800°C)
  - Reduced electrode consumption of approx. 10%
  - Decreased Tap-to-Tap-Time leads to higher productivity
  - Independence of bucket charging from melting process:
    - Charging causes no power-off time
    - Reduction of dust amount
    - Constant high energy input, lowest flicker generation and less noise generation
  - 4 installations
COSS scrape pre-heater FUCHS Technology

last push and first basket of the next heat charged

Off Gas Exit

after tapping: pusher retracted
COSS scrape pre-heater FUCHS Technology
What methods comes in future?
Some examples

• Telescope EAF FUCHS Technology
  • Innovative EAF concept for single bucket application, even with scrap density down to 0.5 t/m³
  • Telescope principle for gantry & roof lifting minimized electrode length
  • Minimized power-off time
  • High electrical & chemical energy input leads to shortest power-on time
  • High Productivity
  • Highest Operational Safety
  • Electrical energy consumption 342 kWh/ton
  • One installation 2010
Telescope EAF FUCHS Technology
What methods comes in future?

• There are many more process concepts
  • THE DANARC PLUS M2 CONCEPT
    • Electrical energy consumption 280 kWh/ton
    • One installation
    • EPC® System
    • JP Plantech/ ECOARC
    • BBS – Brusa Rotar Kiln Preheater
    • IHI Shaft Furnace
    • ESC – System
    • Twin Shell Furnace
EPC System EAF
Thank you for your attention!
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