Technical Introduction to Scrap Steel Preheating System

Henan Quanshun Vibration Equipment Co., Ltd.

1. Technical Introduction

Scrap steel preheating is an effective method to increase the scrap steel ratio in converters. According to the material balance and heat balance calculations of converters, preheating scrap steel to a specified temperature can raise the scrap steel ratio in converters to 30-40%. To increase scrap steel consumption and steelmaking output in converters, domestic iron and steel enterprises have adopted various measures such as residual heat preheating, ladle heater baking, scrap steel hoppers, rotary kiln + briquetting, tunnel kilns, other kilns (shaft furnaces, etc.), and oxygen-fueled guns.

The tunnel kiln technology is improved by Henan Quanshun Vibration Equipment Co., Ltd. based on the scrap steel preheating of Consteel electric furnaces (Consteel furnace preheating mainly aims to utilize waste heat from electric furnaces for energy conservation, with no requirements for preheating temperature and output). It breaks through two key limitations:

1. Heating temperature limit: The average preheating temperature reaches 600°C.
2. Production capacity limit: The scrap steel addition amount reaches about 40%.

This technology matches the scrap steel supply with the converter production rhythm. During transportation, converter gas is burned to directly heat materials, improving thermal energy utilization and heating efficiency. Its application in converters with active control of production capacity and temperature is an industry first.

2. Economic Benefit Analysis

2.1 Heat Balance Calculation

Hot metal parameters: 1340°C, Si 0.5%, C 4.0%; End-point temperature guarantee: 1660°C, C 0.06%. The heat balance calculation results are shown in the table below:

Hot Metal Charge (t)	Unbaked Scrap (t)	Hot Metal Charge (t)	Baked Scrap (t)	Difference (Baked-Unbaked)
55	11.9	55	16.5	4.6
60	13.0	60	18.0	5.0
65	14.0	65	19.5	5.5
70	15.1	70	21.0	6.5

Under the premise of the same hot metal quantity, baking scrap steel to 600°C allows an additional 4.6-6.5 tons of scrap steel to be added. Based on an actual charge of 78±1 tons, baking scrap steel to 600°C enables adding 4 tons

more scrap steel while reducing hot metal by 5 tons, with no change in the blowing end point.

2.2 Benefit Calculation

(1) Cost of Using Baked Scrap Steel

Taking the smelting of HRB400 steel at a plant as an example, the scrap steel yield is converted to 88.9% based on the current water output rate of 92.22%. The content of alloy elements in hot metal and scrap steel accounts for 23.4kg/t.

- **Conventional Heat**: Scrap steel addition 14t, hot metal addition 65t. Tapping quantity: 65×0.92+14×0.889+(65×0.92+14×0.889)×23.4/1000=73.93t
- **Baked Scrap Heat**: Scrap steel addition 18t, hot metal addition 61t. Tapping quantity: 61×0.92+18×0.889+(61×0.92+18×0.889)×23.4/1000=73.81t

Data comparison:

Item	Hot Metal (t)	Scrap Steel (t)	Total Charge (t)	Tapping Quantity (t)	Hot Metal Consumption (kg/t)	Steel Material Consumption (kg/t)
Conventional	65	14	79	73.93	882.4	1068.5
Baked	61	18	79	73.81	830.4	1070.3
Difference	-4.0	+4.0	0.0	-0.2	-52.0	+1.8

- Steel material consumption cost increase: 1.8×2.4=4.32 yuan/t
- Baking cost: 15.84×18/73.81=3.86 yuan/t
- Total cost increase: 4.32+3.86=8.18 yuan/t

(2) Production Increase Benefit

Item	Hot Metal Quantity (t)	Hot Metal Consumption (kg/t)	Output (t)
Conventional	6500	882.4	7366
Baked	6500	830.4	7828
Difference	-	-	+461

Based on a daily hot metal quantity of 6500t, using baked scrap steel increases output by 461t with a melting cost increase of 8.18 yuan/t. If the profit margin of deformed steel bars reaches 400 yuan/t: Benefit=7828×(400-8.18)-7366×400=120766.96 yuan Benefit per ton of steel=120766.96/7828=15.42 yuan/t

2.3 Conclusion

1. Increasing scrap steel consumption and reducing the hot metal-steel ratio will be a key development strategy for China's iron and steel industry to grow from large to strong.
2. Increasing the scrap steel ratio in converters has received widespread attention from the international steel industry and has huge development potential.
3. The independently developed first domestic continuous scrap steel preheating system for converters significantly increases the scrap steel ratio by burning converter gas to preheat scrap steel.
4. With the same hot metal quantity, using preheated scrap steel in converters significantly increases steel output and reduces production costs per ton of steel.

3. Process Flow of Scrap Steel Preheating

The scrap steel preheating system consists of three sections: apron conveyor + grapple feeder section, scrap steel preheating vibrating conveyor section, and weighing system. Scrap steel is loaded onto the apron conveyor via an electromagnetic chuck, transported to the scrap steel preheating vibrating conveyor, heated, discharged into a weighing hopper as instructed, weighed, and then added to the converter.

The preheating vibrating conveyor section is equipped with a heat source, which uses converter gas. Burners are installed in the heating zone to supply heat. Thermal energy (especially radiant heat) is directly utilized to improve efficiency. Burners are mounted on top of the insulation hood with flames directed downward to rapidly heat scrap steel.

(Diagram: Dust Removal → Heat Exchanger → Electromagnetic Chuck → Conveyor → Weighing Hopper → Feeding → Converter; Apron Conveyor → Scrap Steel Preheating Vibrating Conveyor; Control System PLC; Converter Gas + Combustion Air)

4. Structural and Functional Description of Scrap Steel Preheating System

The scrap steel heating system comprises an apron conveyor, scrap steel preheating vibrating conveyor, scrap steel weighing hopper, feeding skirt, support platform, burners, exhaust system, and control system.

4.1 Apron Conveyor

The apron conveyor transports scrap steel from the yard to the heating furnace section. It consists of a frame, track plates, track chains, guide sprocket sets, drive sprocket sets, roller sets, and a drive platform assembly. It can load

over-wide and over-heavy materials, providing continuous feed for the heating furnace. It handles both shredded scrap and large objects, enabling simultaneous feeding at multiple loading points to ensure smooth feeding and match the crusher's processing capacity.

- **Frame**: Fabricated from integrally bent and welded steel plates, lined with wear-resistant plates. The inclined section has side walls ~0.8m high with an inclination angle of 12°.
- **Track Plates**: Rolled from 25MnB steel plates with convex claws, offering excellent wear resistance and lifting performance.
- **Track Chains & Rollers**: Heavy-duty chains and rollers for heavy load equipment, ensuring high load-bearing capacity.
- **Drive Platform Assembly**: Composed of a power platform, tower, variable frequency motor, and reducer. The variable frequency motor features fast, smooth start-up and good overload protection. It drives the drive sprocket set, which rotates the track chains and plates for continuous feeding.

Key Features:

- Track plates: Rolled manganese plates with high load-bearing and wear resistance.
- Feeding zone: Nylon support plates to absorb impact.
- Discharge zone: Horizontal section for long material transport.
- Track plate guides: Prevent deviation; edgeless lower rollers reduce local wear.

4.2 Scrap Steel Preheating Vibrating Conveyor

The scrap steel preheating vibrating conveyor consists of vibrators, feeding section, heating section, support devices, brackets, and material pressing devices.

Vibrator

- Four shafts housed in a single box, synchronized via gear drives. Motor speed controlled by a frequency converter in the MCC.
- Vibrator housing shaft holes machined in one operation for coaxiality. Tail vibrator uses large-clearance bearings for vibration machinery, lubricated by a centralized grease system (lithium-based grease) with a service life of 10,000 hours.
- Joints: Vibrator connection plates use reamed hole bolts; side plates, bottom plates, and beams use ring groove rivets to resist deformation from scrap steel impact.

Feeding Section

- Material chute: Bolted to side plates with intermediate top plates for impact buffering. Made of 16Mn steel, inner wall thickness 25mm.
- Hanger bolts: 42CrMo steel, quenched and tempered; lock nuts with a 2-year service life.
- Lateral damping device: Prevents lateral swing of the tail conveyor during vibration.
- Support devices: Brackets, convex/concave washers, high-strength double-headed bolts form a suspended oscillating system for reciprocating motion.

Heating Section

- Equipped with product observation and flame viewing holes, filled with aluminum silicate wool for full sealing and insulation to reduce heat loss.
- Temperature measurement and observation holes on the hood for maintenance convenience; thermocouple mounting holes staggered on the hood side for temperature monitoring.
- Material pressing device at the tail: Presses down excess scrap steel exceeding the required height.

4.3 Support Platform

Fixed to the foundation, the support platform supports the insulation hood of the heating section. It is constructed from I-beams, channel steel, steel plates, and railings.

4.4 Feeding Skirt

A structural steel skirt at the upper feeding section of the conveyor guides material during loading.

4.5 Burner

Burners heat scrap steel in the furnace, comprising a combustion chamber, air chamber, gas chamber, cyclone, ignition torch, high-energy electronic igniter, and flame monitor. They enable automatic ignition, vaporization, thorough mixing, stable combustion, and complete burning.

(1) Working Principle and Characteristics of Gas Burners

- **Working Principle**: Gas from pipelines passes through quick-cut valves/electric regulating valves and distribution headers to the combustion chamber. Intense axial, radial, and cyclonic collision creates a mixture, ignited by a high-energy electronic igniter to form a stable flame. Secondary mixing with combustion air in the furnace enables semi-internal and semi-diffusion combustion. Air-gas ratio is proportionally adjusted for complete combustion. A photosensitive element monitors flames; misfire triggers immediate gas valve closure, alarm, and furnace purging.

- **Key Characteristics**: Small-load ignition prevents furnace explosion; large turndown ratio (30-110%) for flexible heat load adjustment; automatic air-gas ratio control for complete combustion (efficiency ≥98%); no flammable gas emissions, eco-friendly.

(2) Burner Body Features

Custom-designed for user conditions and process requirements. Flame tubes made of high-temperature resistant 1Cr18Ni9Ti stainless steel with multi-stage swirl and multi-path mixing. Sewage outlets and viewing/cleaning holes for poor-quality gas; UV flame monitors for high sensitivity and reliability.

(3) Ignition System

High-power igniter, gas-specific ignition solenoid valve, and manual valve for automatic ignition.

(4) Gas Supply System

Composed of low-pressure protection switches, diaphragm pressure gauges, electric regulating valves, quick-cut valves, intelligent meters, and filters. Temperature/pressure signals control valve opening and combustion air volume.

(5) Combustion Air System

Composed of combustion air fans and dampers, linked to gas valves via a linkage mechanism for air volume adjustment.

(6) Combustion Control System

Workflow: Startup → Fan activation → Timed furnace purging → Ignition sequence start → Air valve close → Igniter activation → Ignition solenoid valve open → UV monitoring → Main gas valve + air valve open (normal combustion) → Automatic adjustment via temperature/pressure setpoints → Misfire (alarm + gas cut-off) → Post-purging → Shutdown.

Equipped with automatic/manual modes, fault safety protections (gas high/low pressure, misfire alarm, quick fuel cut-off).

4.6 Exhaust System

Composed of exhaust pipes, exhaust fans, and heat exchangers.

(1) Exhaust Pipes

Furnace pressure control butterfly valve on the main exhaust pipe for automatic pressure regulation. Pipes made of carbon steel, insulated with aluminum silicate wool. Flue gas discharged to the dust removal main pipe via outlets, branches, main pipe, and exhaust fan.

(2) Heat Exchanger

Installed at the furnace outlet to recover flue gas waste heat for combustion air preheating, reducing energy consumption and exhaust temperature.

High-temperature section: heat-resistant steel; low-temperature section: aluminized pipes.

(3) Fan & Pipe Insulation

Hot air pipes and fans insulated with wool blankets, asbestos cloth, and 0.3mm aluminum sheets. Waste heat recovery valves installed; excess flue gas discharged via a chimney 3m above the workshop roof.

4.7 Control System

(1) Siemens PLC S7-300 Industrial Control System

A typical three-tier computer management control system:

- **Fieldbus Level**: High-speed Profibus fieldbus for easy expansion.
- **Process Level**: 100M TCP/IP industrial Ethernet, supporting multiple operation stations and upper network interconnection.
- **Master Station**: High-performance S7-300 PLC controls apron conveyor, vibrating conveyor, temperature/pressure, combustion, and power automation.

Configuration:

- Upper host: Advantech industrial computer.
- PLC: Siemens S7-300 series with CE/UT/CSA certified DI/DO and AI/AO isolation modules.

Software Functions:

- Upper monitoring software: Temperature curve setting, production data logging, real-time monitoring, alarm records, report generation, parameter modification, historical data viewing, curve recording, system operation logging.
- Lower control software: Analog signal acquisition, PID control, module communication, operation monitoring.

(2) Scrap Steel Preheating System Control Methods

- **Temperature Control**: Proportional gas-air mixing for burners; single actuator control for precise temperature and energy efficiency. Variable frequency combustion air fans stabilize air pressure.
- **Feeding Control**: Variable frequency drive for apron conveyor with PLC automatic speed regulation.
- **Furnace Pressure Control**: PLC-controlled high-temperature butterfly valve for automatic pressure stabilization.
- **Safety Interlocks**: High/low pressure switches, solenoid cut-off valves, flow meters, pressure gauges for gas overpressure/underpressure protection; alarms for pressure/temperature deviation, motor overload, and transmission faults.

(3) Main Software System Functions

1. Real-time monitoring of the entire heating system.
2. Automatic control of thermocouple temperatures.
3. Graphical display of thermocouple temperatures.
4. Automatic control of furnace pressure.
5. Real-time monitoring of all automatic control valves.
6. Temperature/pressure over-limit and equipment fault alarms with logging.
7. Report and graphical output.
8. Control parameter modification.
9. Monitoring and control of all electromechanical equipment.
10. Historical data query.
11. Temperature curve setting, recording, and trend analysis.
12. System operation logging (power outages, equipment start/stop, communication faults).
13. Simulation control of furnace status.

5. Equipment Quality Assurance

5.1 Equipment Quality Assurance

1. The supplier guarantees all goods are new, unused, and fully compliant with contract quality, specifications, and performance requirements.
2. The supplier guarantees reliable operation of goods throughout their service life with proper installation, operation, and maintenance.
3. The supplier is liable for defects or failures caused by design, process, or material issues during the warranty period.
4. Equipment design, material selection, manufacturing, inspection, and acceptance comply with national standards.
5. Stable operation of electrical control, instrumentation, water cooling, mechanical, and hydraulic systems; all spare parts meet working conditions.
6. **Warranty Period**: 12 months from installation and commissioning completion or 18 months from delivery (whichever comes first).

5.2 Equipment Performance Guarantee Values

1. Feeding capacity: ≥5t/min
2. Scrap steel hopper inlet temperature: ~600°C
3. Preheating section hood service life: ≥10,000 heats
4. Material chute service life: ≥10,000 heats
5. Vibrator service life: ≥10,000 heats

Items 1 and 2 are basic performance requirements; items 3-5 are normal service life (components to be replaced after expiration).

6. Technical Services

6.1 Installation and Commissioning

1. The supplier provides on-site installation guidance and commissioning, resolving design/manufacturing quality issues during trial operation.
2. The supplier assists the buyer in hot testing and operation.
3. On-site service personnel quantity and expertise adjusted based on project progress.
4. The supplier is responsible for the safety of on-site installation personnel.
5. The buyer provides on-site installation and assembly space.
6. The buyer provides free workshop hoisting equipment (external crane costs borne by the supplier if needed).
7. The buyer provides free installation power supply.
8. The buyer provides construction auxiliary materials (cutting gas, welding rods/wire).

6.2 After-sales Service Commitment

1. The supplier responds within 2 hours upon receiving a fault notice and dispatches on-site personnel within 48 hours if necessary.
2. The supplier provides long-term preferential prices for spare parts.

7. Project Schedule

Within 6 months of contract signing, complete civil engineering design, equipment design, manufacturing, and delivery.

8. Enterprise Profile

Henan Quanshun Vibration Equipment Co., Ltd. (formerly Henan Taihang Vibration Machinery Co., Ltd.) covers an area of 30,000 ㎡ with 10,000 ㎡ of production buildings and over 500 production/testing equipment sets, including Korean HB-150/1 machining center, Japanese Toshiba BTD-200QF machining center, and Austrian large welding robot.

Business Scope: Vibration machinery and environmental protection equipment design, R&D, production, sales; import/export of goods and technology.

Patents: Multiple patents, including national invention patents for "Continuous Feeding and Preheating Vibrating Conveyor for Converters" (Patent Nos.: 201810867433.5, ZL 2018 2 1232655.1, ZL 2019 2 0116316.5, ZL 2019 2 0116249.7, ZL 2019 2 0436866.5, 201911324219.6).

Application: The first domestic continuous scrap steel preheating vibrating conveyor for converters was put into operation at HBIS Tangsteel No.2 Steelmaking Plant in November 2018.

Corporate Philosophy: "Honesty in conduct, integrity in business, continuous innovation". Committed to customer satisfaction and dedicated service.