Organic Rankine Cycle
Waste Heat Recovery System
for Steel Rolling Mill Reheating Furnace

Mr Chua Hock Cheng, Vice President, (NatSteel Holdings Pte Ltd)
About NatSteel
Our Regional Footprint

- Part of Tata Steel – a global top 10 steel producer
- NatSteel has a combined steel capacity of over 2 million tonnes per annum, with over 2,500 staff
- Provides steel reinforcement solutions for the construction industry in the region and metal recycling services in Singapore
Our Steelmaking Operation in Singapore
From Metal Scrap to High Quality Steel Products

1. Radiation detection and sorting of metal scrap

2. Steel production using world’s most energy efficient Electric Arc Furnace

3. Rolling mill benchmarked against global standards

4. World’s largest Cut & Bend Centre producing 400k tonnes per year

5. Mesh Centre utilises state-of-the-art technology to manufacture high quality products

6. Caging Centre produces precages and bored piles according to customer needs
Our Vision
To be the World Steel Industry Benchmark for Value Creation and Corporate Citizenship

- The vision translates into a number of ambitious five year goals which are measurable and tangible
- A performance culture supports the vision and goals
Our Climate Change Policy
Adopting a Leadership Role in Climate Change Advocacy

Climate change policy for Tata companies

Tata companies will play a leadership role in climate change by being knowledgeable, responsive and trustworthy, and by adopting environment-friendly technologies, business practices and innovation, while pursuing their own growth aspirations and the enhancement of shareholder value.

Tata companies will measure their carbon footprint and will strive to:
- Be the benchmark in their segment of industry on the carbon footprint, for their plants and operations.
- Engage actively in climate change advocacy and the shaping of regulations in different business sectors.
- Incorporate ‘green’ perspective in all key organisational processes.

Ratan N Tata
Chairman, Tata Sons
Our Commitment to Energy Efficiency
Reviewing Energy Policy, Goals and Targets Periodically

• We are committed to utilize energy efficiently through technology and operational best practices

• We seek continual improvement through R & D, worker education and participation, periodic review to comply with relevant legal requirements & other requirements, while establishing and promoting internally best practices on the environment, occupational safety and health at the workplace

Our Goal is to be the World Steel Industry Benchmark for Energy Efficiency

We have set a target to achieve emission level at 0.4 tonne of CO2 per tonne of crude steel by year 2020
Steel Plant Equipment-Overall

Name: NatSteel Holdings Pte Ltd
Location: 22 Tanjong Kling Road, Singapore
Foundation Date: 16 Sep 1962
Number of Workers: 2,387 (CY 2013)

Equipment:
- 80 t DC Shaft Furnace,
- 80 t Ladle Furnace
- 4-strands, 9m radius hi-speed caster,
- Bar & Wire Rod Mill

Products:
- 150-160 mm sq. billet
- 10 to 50mm bar
- 5.5 to 16 mm wire

Source:
- 100% Scrap
- 0% DRI, pig iron & others

Annual Production: 750 ktpy
Operations – Energy Intensive

Meltshop

Rolling Mill

Molten steel

Billets

Wire rod
Steel Industry and Waste Gas

NatSteel initiated its Climate Change initiative in FY11 through one of its PerfEx committees – Clean, Green and Safe Committee. Key strategy was to optimize usage of energy, material resources and reduce its carbon footprint in achieving environmental sustainability (and possibly profitability) for a less carbon intensive economy.
Waste Heat Recovery – Basic Concept

Big Ticket

Recovered part of the Waste Heat’s Thermal Energy to drive
- Generator (electricity)
- Compressor (compressed air)

Process / Equipment releases hot gas into the atmosphere (RHF)

Off Gas (High Temp)
400 °C

Released to the air - Waste Heat

Off Gas (Low Temp)
150 °C

Released to the air - Waste Heat
Feasibility Study (2011)

• We engaged a metallurgical Process Specialist from USA to conduct a feasibility study to assess the potential, scope and magnitude of waste heat recovery opportunity in our Singapore plant.

• **ORC** (Organic Rankine Cycle) Waste Heat Recovery System was deemed to be the most suitable technology for our off gas condition (temperature, volume, flow rate, thermal dynamic).

• The challenge: ORC is a mature technology and is widely used in Bio-mass and Bio-gas industries. But we were not able to find any application of the ORC system in the steel mill industry.
Organic Rankine Cycle for Waste Heat Recovery System

- Hot Air from Furnace Recuperator
- Evaporator
- Turbine
- Power Generator
- Regenerator
- Condenser
- Waste Hot Air to Stack
- COOLING TOWER
- SUMP
The ORC Plant
We have selected **Pratt & Whitney-Turboden** ORC plant for our application. The ORC plant is *integrated* into the process flow of our reheating furnace at our rolling mill to recover waste heat from off gas which would otherwise be released to the atmosphere.

The plant is a **Direct Coupling Close Loop System**. The working fluid is vaporized, expanded in the turbine, condensed in a water cooled condenser and then pumped back to the heat exchanger/evaporator. The heat in the off gas from the reheating furnace *(about 400 C)* is captured via a heat exchanger in the ORC plant. The working fluid is an organic fluid - Power 2 (Dow Corning R200), chemical name Hexamethyldisiloxane. It has a high molecular weight which makes it suitable for high efficiency low thermal power and low temperatures application.

The off gas’s temperature is brought down to **about 130-150 C** before being released to the atmosphere through the stack.

The heated up **working fluid** changes into gaseous state and **expanded in a turbo-expander** directly connected to an Induction (asynchronous) **Generator** to produce electricity. The produced vapour that expanded in the turbine is about 9 bar abs and 200 C. The vapour exits the turbine at about 0.16 bars abs. i.e. it is under vacuum.
ORC System on Skid
ORC System Installed Next to RHF
Thank You