Discussion on Reduction on CO_2

The focus is on reducing CO_2 emissions per ton of liquid steel produced through the Direct Reduced Iron (DRI) route, which is currently around 2.5 tons of CO_2 per ton of sponge iron for standalone plants. The target is to reduce this to 2.2 tons of CO_2.

1. CO_2 Emissions Breakdown:

CO_2 emissions in a coal-based DRI plant primarily come from:

Coal combustion (60-70% of total emissions),

Reduction reactions using coal-based reductants (20-25%),

Electricity generation (10-15%) if not sourced from renewable sources. The typical CO_2 intensity in these plants ranges from 2.5 to 3.5 tons of CO_2 per ton of DRI produced, depending on plant efficiency, coal quality, and the production process.

2. Calculation Adjustments: Volatile Matter (VM) in coal, which generates CO_2 during combustion, should be factored into emissions calculations. - A more refined calculation shows that for every 90 tons of coal (50% Fixed Carbon) used, around 1.54 tons of CO_2 is generated per ton of DRI, assuming no credit for waste heat power generation. - CO_2 Credit for Power Generation: If the DRI plant generates power from waste heat (e.g., a 2 MW plant for a 100 TPD DRI plant), it can reduce the net CO_2 emissions by offsetting some emissions from external power sources.

3. Technological and Operational Adjustments:

Optimization of Production Economics: The key to survival in the face of increasing regulatory pressures is optimizing production economics, but this must be done with careful consideration of long-term operational stability. The solution must be cost-effective and compatible with continuous operations.

Hydrogen Integration: One proposed solution is the partial replacement of carbon (whether from coal or methane) with hydrogen in the Rotary Kiln process. This would require modifications to the gas recirculation system, similar to the setup used in Vertical Kilns. By using a combination of hydrogen and solid carbon, it is believed that CO_2 emissions could be kept within permissible limits, potentially allowing RK operations to continue beyond 2050.

4. CO_2 Intensity of Steel Production:

The International Energy Agency (IEA) reports that global steel production currently emits an average of 1.8-2.0 tons of CO_2 per ton of steel produced, with the highest emissions coming from the Blast Furnace-Basic Oxygen Furnace (BF-BOF) route (2.0-

2.5 tons of CO_2/ton steel) and lower emissions from Electric Arc Furnace (EAF) processes.

Rotary Kiln Emissions: Professor P.K. Sen's research into RK CO_2 emissions, factoring in the power generation from flue gases used to produce steel, is part of efforts to quantify and potentially reduce emissions in the DRI process.

5. Coal Consumption and Efficiency Improvements:

Over the past few decades, significant improvements have been made in reducing coal consumption, directly lowering CO_2 emissions. For instance:

Imported Coal: The consumption of imported coal has reduced from 1.3 tons to 0.9 tons per ton of sponge iron, resulting in better product consistency.

Blended Coal: The use of a blend of imported and Indian coal has resulted in an intermediate coal consumption of 1.2 tons.

The Perform, Achieve, and Trade (PAT) scheme under the Bureau of Energy Efficiency (BEE) has helped DRI units collect valuable data on coal consumption and emissions reduction.

6. Gas Injection and Carbon Capture:

A technical solution to reduce coal consumption is the injection of combustible gases from the discharge end of the Rotary Kiln, which could reduce the need for injection coal by 10-15%.

There is also a need for further exploration of Carbon Capture and Storage (CCS) technologies to reduce CO_2 emissions in the long term. This could be a key part of the strategy for meeting stringent emission standards.

7. Way Forward:

Innovation and "Out-of-the-Box" Thinking: While it's important to think creatively (even "wild"), the solutions need to be grounded in basic engineering principles to ensure they are practical and scalable.

Continued Coal Efficiency Improvements: Continuing efforts to optimize coal usage, improve energy efficiency, and incorporate cleaner fuels like hydrogen or gas from the discharge end burner will be essential in reducing emissions.

Exploring Alternative Kiln Designs: While modifications to Rotary Kilns are a potential solution, the cost and feasibility of converting or replacing them with smaller Vertical Kilns using gas should also be considered, especially if they offer lower CO_2 emissions and better efficiency.

Conclusion: To ensure the sustainability of Rotary Kiln operations beyond 2050, the industry must focus on reducing CO_2 emissions, optimizing production processes, and exploring innovative technologies like hydrogen use and carbon capture. At the same time, improvements in coal efficiency and the continued use of cleaner fuels will help reduce the carbon footprint of the DRI route in steel production. The balance between engineering feasibility, cost-effectiveness, and environmental compliance will be key to the future viability of Rotary Kiln operations.

Summary of the Discussion on CO2 Emissions and Solutions for DRI Plants

The conversation centers on the challenges of reducing CO2 emissions in coal-based Direct Reduced Iron (DRI) plants and the need for innovative solutions to meet increasingly stringent environmental regulations.