Energy Efficiency Intervention in the Rolling Mill Cluster in Bhavnagar (Gujarat), INDIA

DEBAJIT DAS

Sr. Program Officer

CLIMATE TECHNOLOGY INITIATIVE

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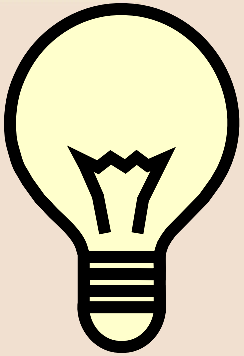
Mandate of the Intervention



Goal

- **Reduction of GHG emissions from Indian industrial sector leading to mitigation of global warming through implementation of Energy Conservation Measures**

Specific objectives

- **To Study existing Energy Consumption Pattern in the rolling mill cluster in Bhavnagar, Gujarat state of India**
- **To evolve energy conservation opportunities to upgrade existing inefficient system to an energy efficient, environmentally benign and economically viable system**
- **To upscale and diffuse the developed technology within the target cluster and to other clusters**

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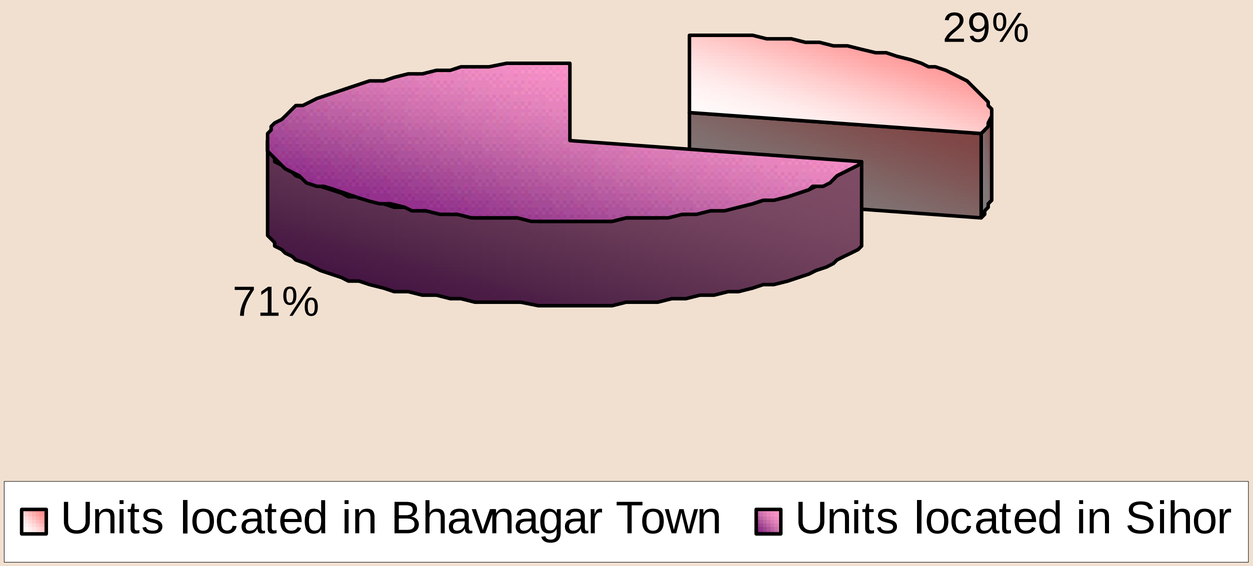
Distribution of rolling units between Bhavnagar and Sihor



Activities Undertaken

❖ **Inventorisation of units in the cluster**

Overview of Bhavnagar Rolling Mill Cluster

Range of operation (production, TPM)	45 TPM – 1500 TPM
Average production	534 TPM
Average Coal Consumption	60 TPM
Average Electricity Consumption	93 MWh / month
Average Specific Energy Consumption	0.71 MkCal/ tonne
	0.07 Mtoe / tonne

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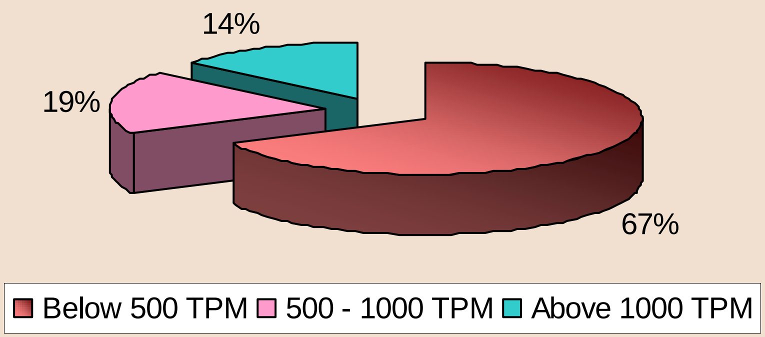
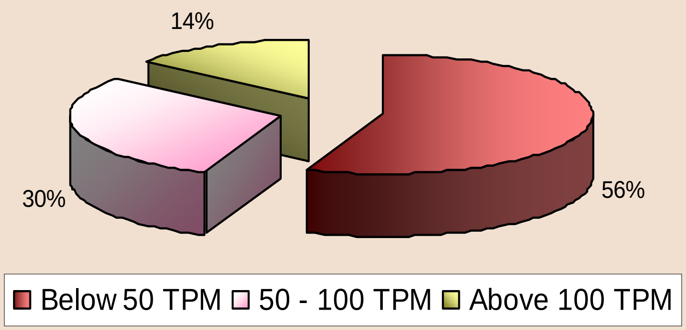
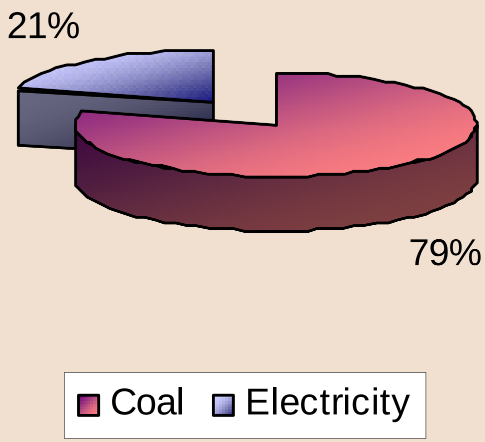
Activities Undertaken



Distribution based on average monthly production (TPM)



Distribution based on average monthly coal consumption (TPM)



Percentage contribution of coal and electricity in overall energy consumption

Activities Undertaken

- Identification of four units for energy and environment audit
  - Production capacity
  - Product mix
  - Fuel consumption pattern
  - Recommendation by respective association
  - Outlook towards energy conservation
  - Previous steps towards energy efficiency
  - Willingness and proactiveness of the entrepreneur

The selected demonstration units are:

- Steebars Re – Rollers
- Vijay Steel
- Triveni Iron & Steel Industries Pvt. Ltd.
- Garg Casteels Pvt. Ltd.

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Activities Undertaken

The overall audit is categorised into three separate audits as described below:

- **Thermal Energy Audit:**
  - Determination of efficiencies of generation, distribution & Utilisation of thermal energies. Furnace efficiency tests are carried out to determine heat generation to fuel ratio.
  - The energy saving areas normally identified are: Improvement in heat generation efficiency, operational practices, waste heat recovery, optimal choice of fuel, process optimization etc.

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Activities Undertaken

- **Electrical Energy Audit:**
  - Energy billing patterns.
  - Variation of electrical load and its consumption

- **Environmental Audit:**
  - To assess various sources of emission and concentaration of the same.
  - Suitable monitoring plan and locations were identified.
  - Coal sampling analysis.
  - Possibilitites of minimising the same impacts.

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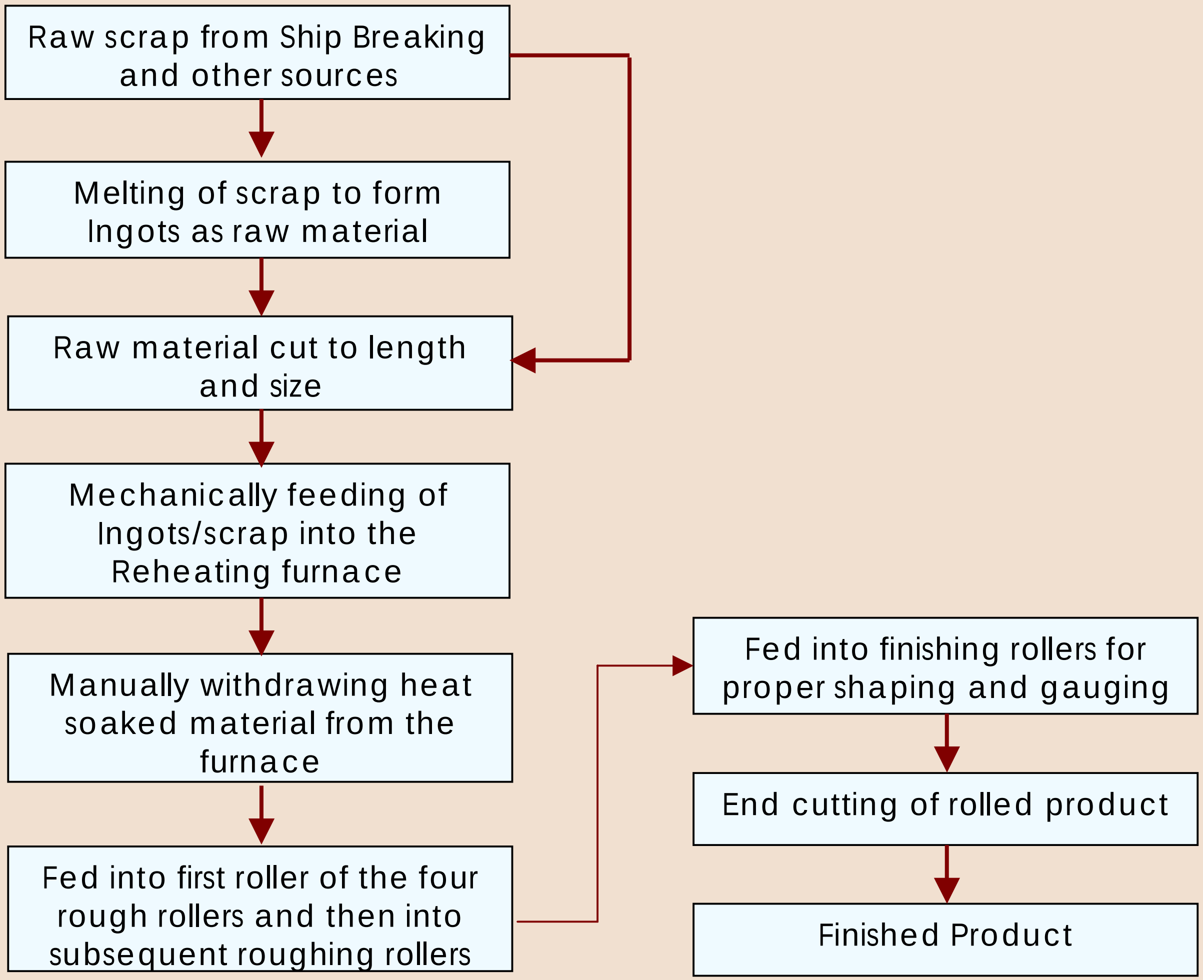
Production Process & Audit Methodology



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The key features of the four industrial units

Unit-A

- Unit- A manufacture special section products which vary from the regular sections in terms of complexity of shape with a production capacity of 40 TPD.

Unit- B

- Unit- B raw material in form of scrap steel sheets
- The production rate is quite high due to smaller section products, mostly 6 mm round bars.

Unit- C

- Unit- C use a raw material mix of scrap steel and ingots
- two automatic roller stands
- the furnace has a capacity of 40 TPD

Unit- D

- produces heavy section products and has two rolling mills, an integrated steel melting shop equipped with 2000 KVA induction furnace.
- Special composition ingots are cast in the melting shop which is fed into the reheating furnace for rolling.

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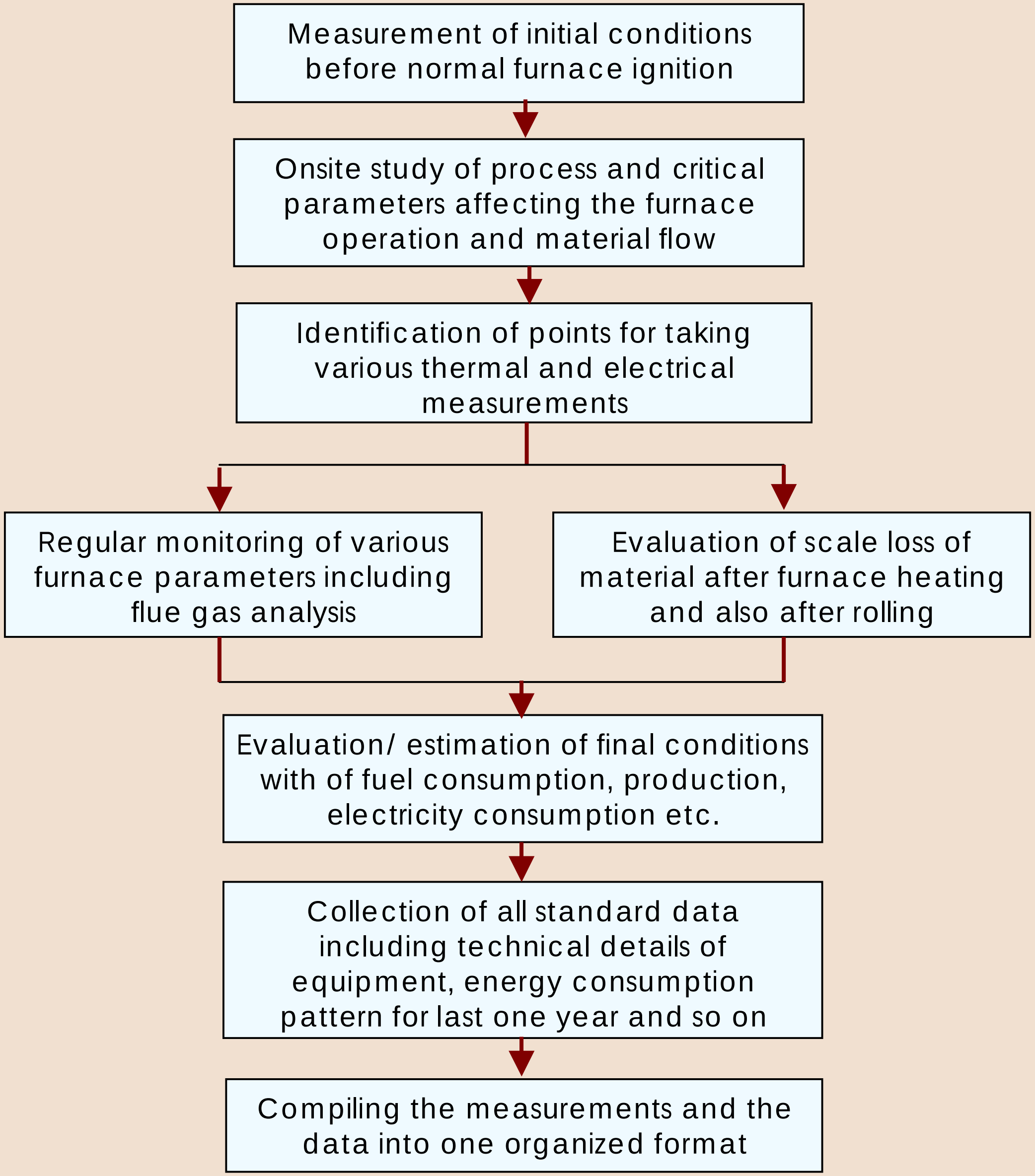
Energy Audit Methodology



Methodology for Scale loss study

Individually weigh 10 ingots and note down each ingot's weight separately.

Note the total weights of each set and mark the sets as Set I and Set II

Make two sets of 5 ingots each and add up the weights of individual ingots to determine total weight of each set.

Put suitable mark on the ingots so as to identify them among other similar ingots and then feed into the furnace

Withdraw Set I from the furnace one by one and allow it to cool down naturally

Withdraw Set II from the furnace one by one and send it for the rolling process. Allow rolled products to cool down naturally.

Weigh the unrolled ingots and note down the total weight of the set.

Weigh the rolled out product and note down the total weight of the set.

Compare with the initial weight of each set. The difference gives the scale loss in each step of the process.

Results of Energy Study at four selected units

Energy Consumption Pattern

Total production and coal consumption

Year	Total Production (Tonnes)	Coal Consumption (Tonnes)
Unit- A		
2005	7850	905
2006	8300	998
2007	8020	995
Unit- B		
2005	2290	
2006	1170	
2007	2343	

Year	Total Production (Tonnes)	Coal Consumption (Tonnes)
Unit- C		
2005	8480	975
2006	8300	996
2007	8820	1110
Unit- D		
2005	14068	1780
2006	13742	996
2007	12612	1550

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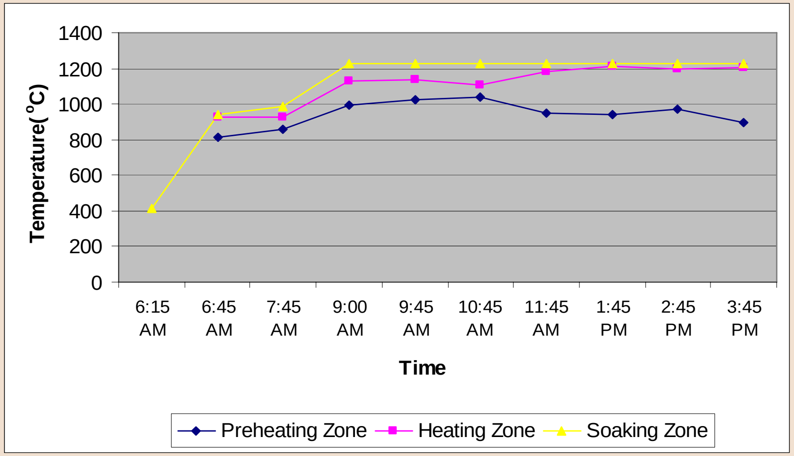
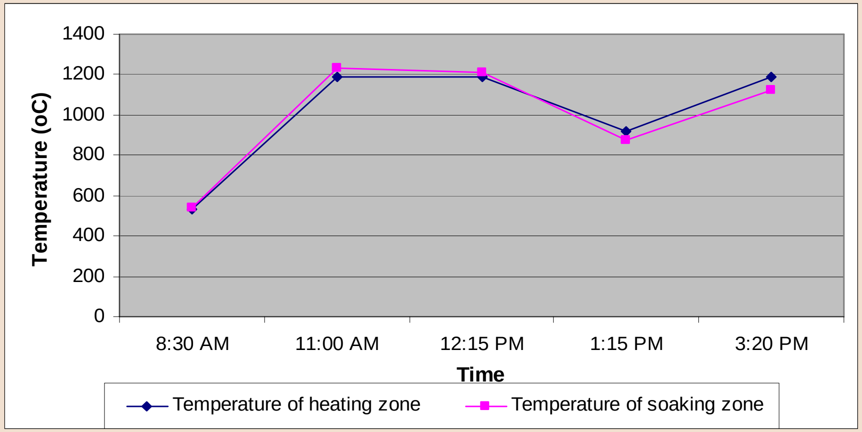
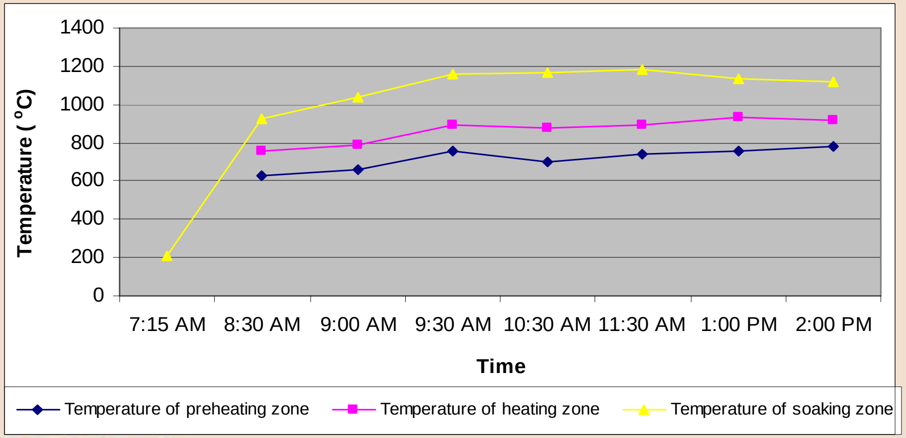
- **Furnace Heat Balance**



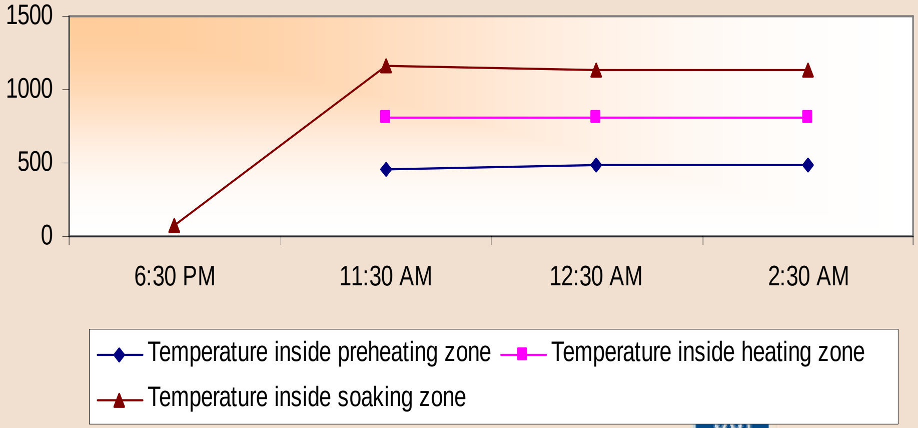
Unit- A



Unit- B



Unit- C



Unit- D

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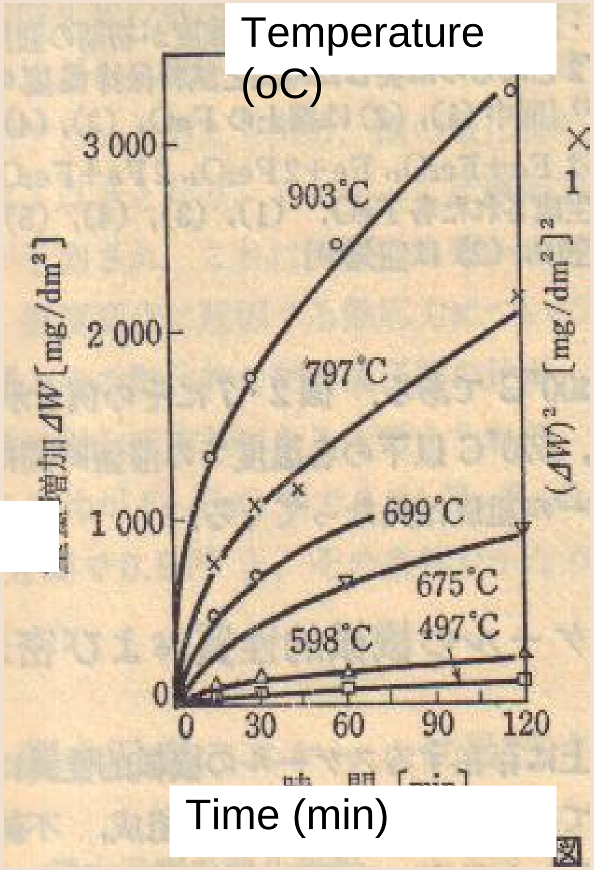
Scale Generation

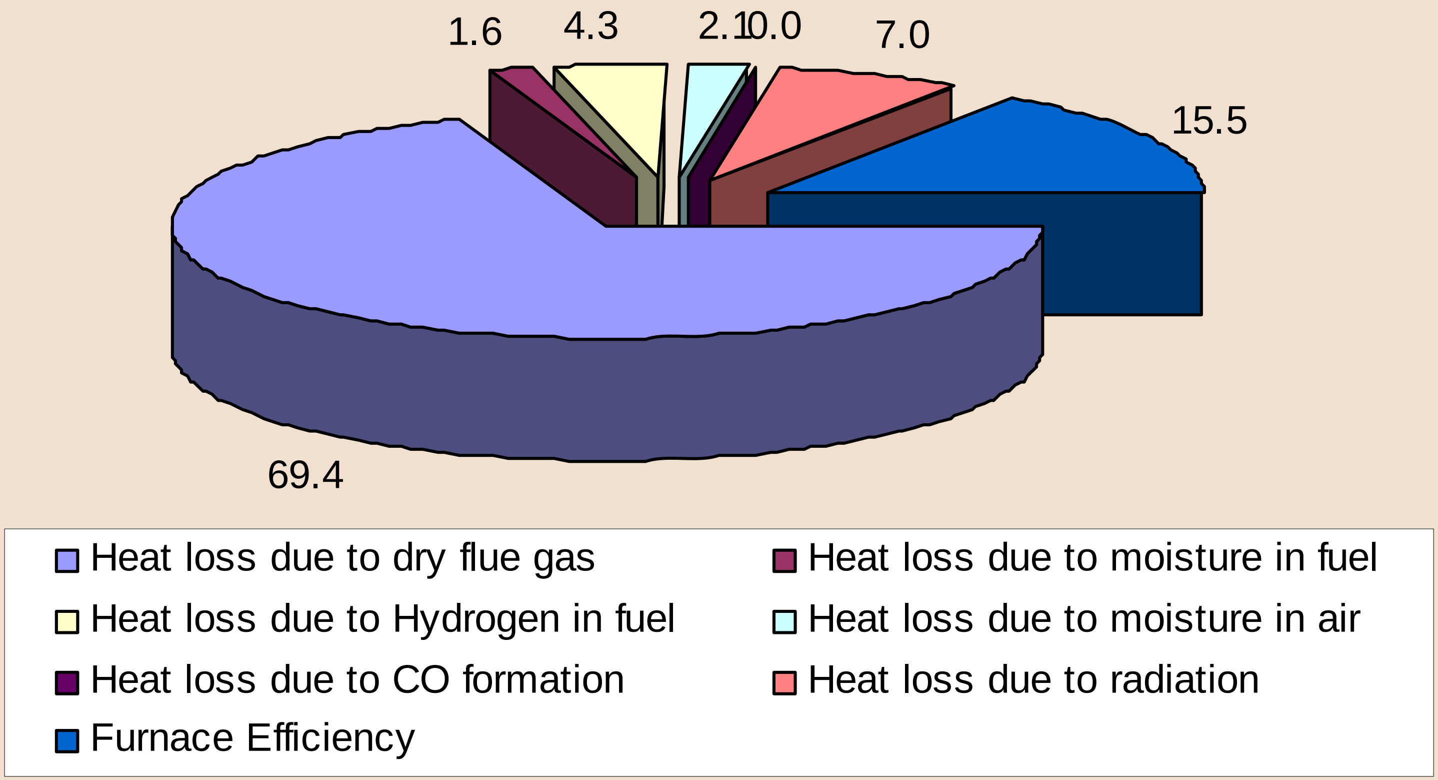


- **Scale Loss Study**

	Unit- A		*Unit- B*		*Unit- C*		*Unit- D*	
	Furnace heated Product	**Rolled out Product**	**Furnace heated Product**	**Rolled out Product**	**Furnace heated Product**	**Rolled out Product**	**Furnace heated Product**	**Rolled out Product**
Total Initial Weight* (kg)	469	469.4	37.8	34.2	34.8	44.5	416.1	427.4
Total Final Weight* (kg)	462.5	454.5	35.8	31.1	32.2	40.95	408.6	409.4
Difference (kg)	6.5	14.9	2.0	3.1	2.6	3.55	7.5	18
Difference (%)	1.4	3.2	4.02	9.06	7.47	7.97	1.8	4.2

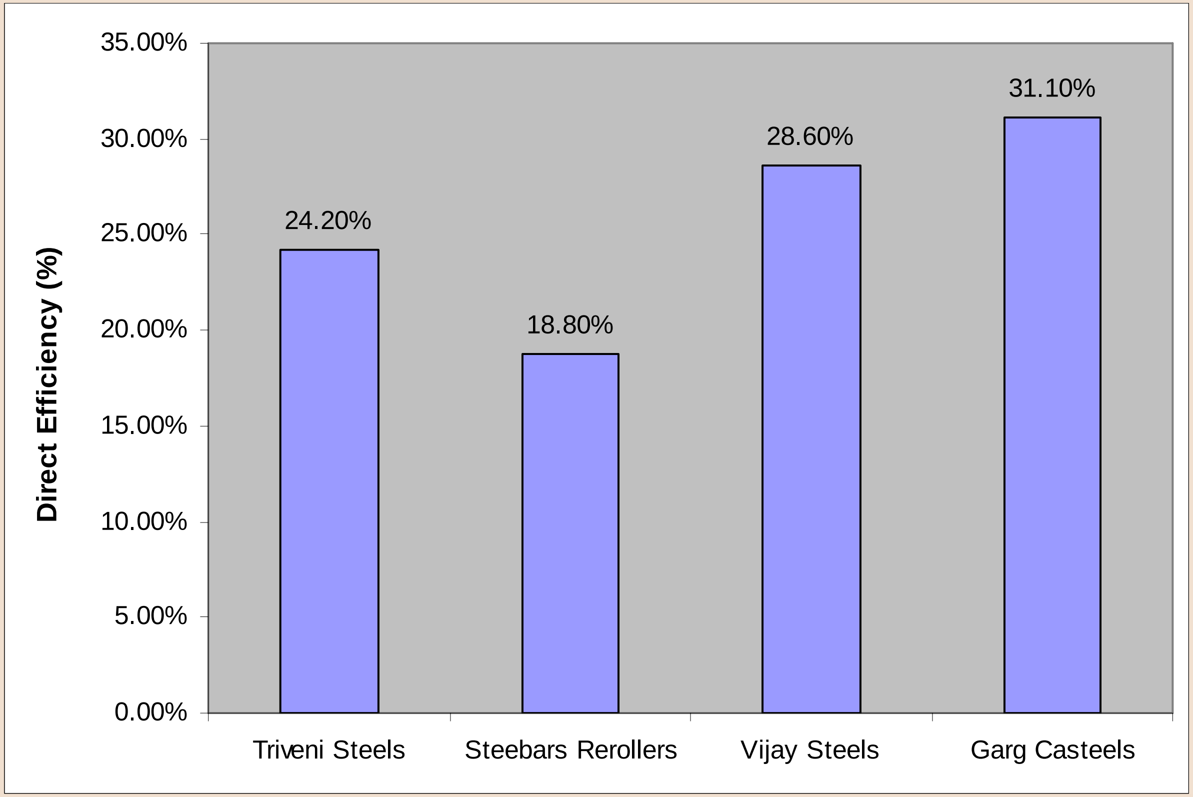
** Total weight of all sample ingots/bars.*

Heat loss break up



Energy Conservation Measures

Energy Efficiency of the furnaces



Short term low investment options

Installation of temperature controllers inside the furnace

- **Proper temperature measuring devices be installed at all relevant points in the furnace like different zones, flue gas duct, etc.**
- **this will not only help the furnace operator to correctly judge the temperature, but will also lead to reduction in heat loss and scale loss.**
- **It is estimated that such a measure will lead to a minimum energy saving of 3 – 4 %.**

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Saving by installing temperature control system

Saving on account of heating the stock		
Existing average working temperature of furnace	1230	ºC
Working temperature of furnace after installing controller	1100	ºC
Average production per day	37120	kg/day
Saving in energy by reduced operating temperature	579066	kcal/day
Average boiler operation	300	days/annum
Annual saving in fuel	30638	kg/annum
Saving on account of reduced flue gas loss		
Average fuel firing rate	324.3	kg/hr.
Total air used for combustion @ 20% excess air	9.5	kg/kg of fuel
Mass of air supplied for combustion	3089	kg/hr.
Heat content of flue gases at existing condition	1093172	kcal/hr.
Heat content of flue gases after installing controllers	974883	kcal/hr.
Equivalent saving in energy	118289	kcal/hr.
Annual saving in fuel	75104	kg/annum
Total fuel saving	105742	kg/annum
Percentage fuel saving	9.06	%
Cost of fuel	6.00	Rs./kg
Annual monetary saving	6.34	Lac Rs.
Investment		
Cost of control system	2	Lac Rs.
Payback period	4	Months

Short term low investment option

Controlling excess air inside the furnace

- To ensure complete combustion of fuel a certain amount of air excess to stoichiometric amount is needed.
- Flue gas studies carried out at Unit- A and Unit- C showed high quantity of oxygen in flue gas composition.
- Needs to interlink air flow and coal feeding rate controls at pre-decided air-fuel ratio.
- Online flue gas analyzer to check the composition and temperature of the gas stream.

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Short term Low investment option

- **The following table presents the analysis of savings achieved by implementing this measure, calculated typically for Unit- A.**

Excess air being used for combustion	171	%
Corresponding dry flue gas loss	69.4	%
Optimum desired excess air level (max)	20	%
Corresponding oxygen level in flue gas	3.50	%
Corresponding dry flue gas loss	11.13	%
Reduction in dry flue gas loss	8.87	%
Hence saving in fuel consumption	8.87	%
Annual fuel consumption	1167	TPA
Fuel saved per annum	104	TPA
Percentage fuel saving	8.9	%
Cost of fuel	6.00	Rs./kg
Annual monetary saving	6.21	Lac Rs.
Investment (for combustion control system & combustion analyzer)	4	Lac Rs.
Payback period	8	Months

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Short term Low investment option

Elongation of Skid Rail Transfer Tool to Material Charging point

- **The existing rail carrying tool is useful to carry the hot rail from the discharged position to the material charging position safely and quickly. But the too is little far from charging position. The rail carrying tool is necessary to be elongated to the position over charging position to decrease radiation heat loss from hot skid rail**

Medium investment option

Provision of waste heat recovery system

- Waste heat refers to the quantity of heat carried away by the hot flue gases escaping out of the furnace. These gases are generally in the range of 500 – 600 ^{o}C for typical reheating furnaces as installed in the four rolling units.
- Waste heat recovery systems (WHRS) are specialized according to type of use, and therefore, a detailed design for such a system needs to be worked out for this type of furnace.

Medium investment option

Using a general estimate, the following saving calculations have been worked out for this option.

Energy Saving by Installing Waste Heat Recovery System in furnace		
Average exit flue gas temperature	589	oC
Temp. of supply air for combustion in existing condition	29	oC
Temp. of supply air for combustion after installation of WHRS	200	oC
Rise in supply air temperature	171	oC
Total air used for combustion @ 20% excess air	9.5	kg/kg of fuel
Fuel firing rate	324.3	kg/hr.
Mass of air supplied for combustion	3089	kg/hr.
Heat recovered from flue gas	155595	kcal/hr.
Corresponding saving in fuel consumption	27.44	kg/hr.
Percentage saving in fuel consumption	8.46	%
Average furnace operation	12	hrs/day
Annual saving in fuel	98791	kg/annum
Cost of fuel	6.00	Rs./kg
Annual monetary saving	5.93	Lac Rs.
Investment on installation	6.00*	Lac Rs.
Payback period	12	Months

Medium investment option

Installing proper capacity and proper design combustion system

- **The combustion system as seen in most of the units consists of burners made of simple pipes. Special burners available for firing pulverized coal need to be installed at all units.**

- **The following table shows the savings calculation for this option. The savings have been typically calculated for Unit- A.**

Savings by installing proper combustion system		
Average savings estimated by installing proper burners	5	%
Present fuel consumption rate	324	kg/hr
Heat input to the furnace	1838497.5	kCal/hr
Reduction in heat input to the furnace	91925	kCal/hr
Average reduction in coal consumption per hour	16.21	kg/hr
Average reduction in coal consumption per year	58365.00	kg/year
Annual monetary savings	3.50	Lac Rs.

Increasing the length of preheating zone of the furnace

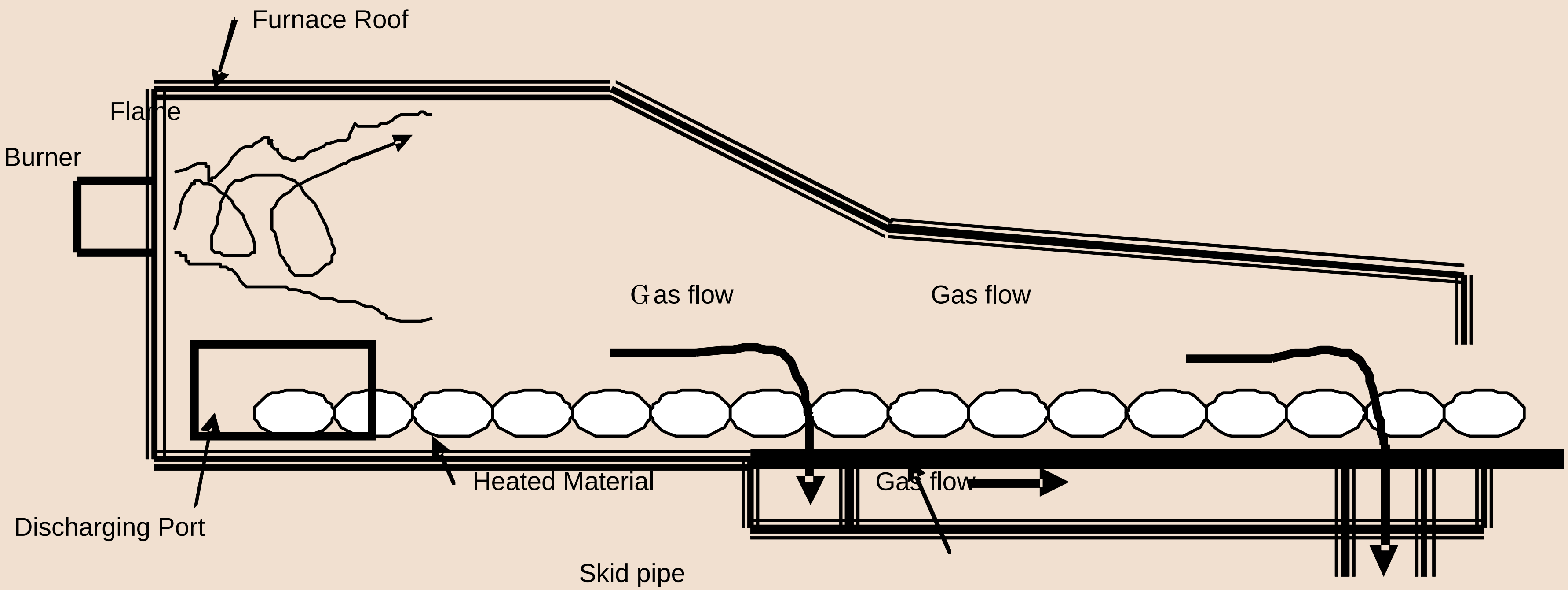
- **The following table shows the savings in fuel consumption that can be achieved by attaining a preheat temperature of 150^{o}C of the material.**

Temperature of material before feeding into the furnace	30	oC
Specific heat of the material (MS)	0.12	kCal/kg-C
Temperature achieved by Preheating the material	150	oC
Material feeding rate	3093.3	kg/hr
Heat input to the material	44543.52	kCal/hr
Fuel Savings per hour	7.856	kg/hr
Fuel saving per year	28281.6	kg/year
Monetary saving	1.70	Lac Rs.
Estimated Investment	6	Lac Rs.
Simple Payback period	3.5	years

Long term high investment option

- **Redesigning of the furnace and associated systems**

Conceptual Drawing of New Furnace



Long term high investment option

Installation of Coal Gasifying System

- Gas burns with more efficiency and cleaner flame as compared to coal.
- SO_2 emissions will be much lower.
- With better mixing of air & gas in gas burners, the CO is expected to be within acceptable limits.
- CO_2 emissions to the atmosphere are reduced as the producer gas combustion has drastic reduction in net CO_2 emissions.

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Long term high investment option

Centralised Gasification Facility for a Cluster Of Roliing Mills

- **Based on their closeness & scatter in an industrial area**
- **Cumulative pulverized coal consumption profile of the selected cluster with respect to time to determine peak, average and minimum consumption data**
  - Selection of gasification technology and sizing of the suitable equipment
  - Piping layout, gas metering, gas quality monitoring, etc.
  - Pricing, management, ownership, logistics, etc.
  - Environmental and safety related issues

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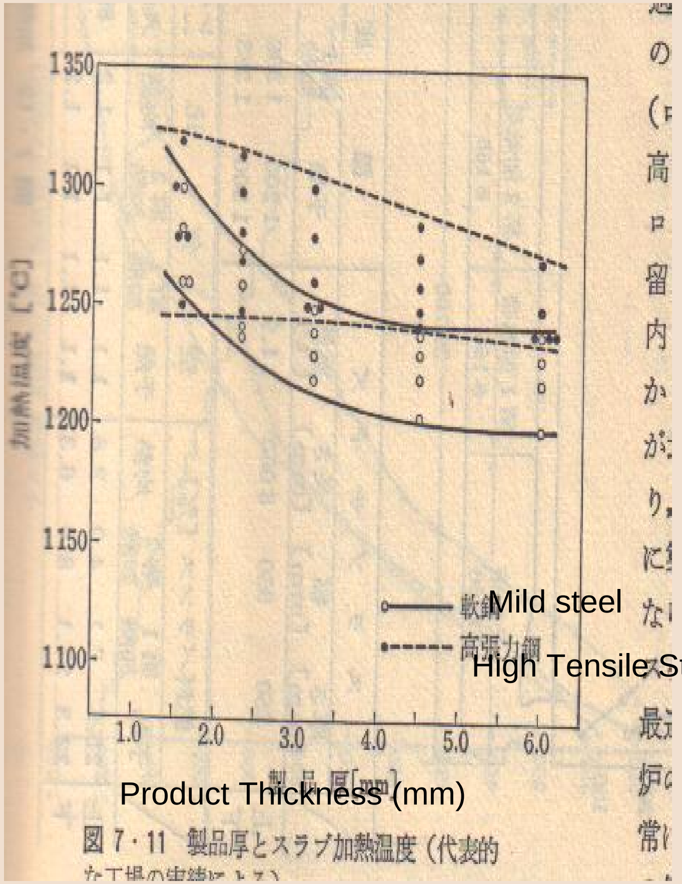
Long term high investment option

Benefits of Centralised Gasification Facility for a Cluster Of Roliing Mills

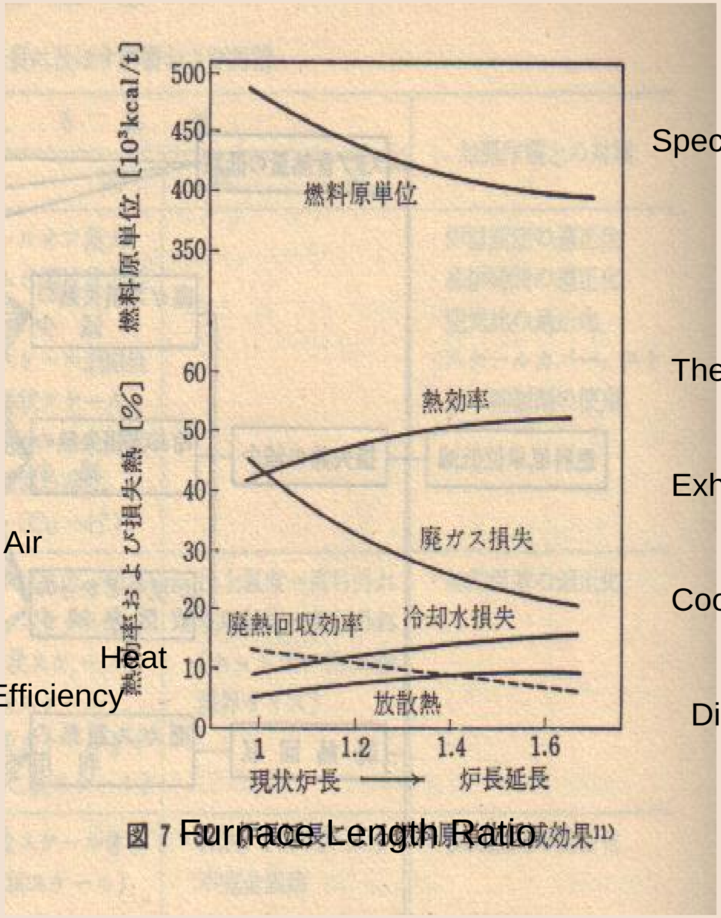
- **The individual rolling mills are spared from additional physical and financial efforts**
- **The gas generation utilities could come up as co-operative ventures or separate business entities.**
- **Opportunity for substitution of pulverized coal in reheating furnaces of rolling mills by producer gas**
- **Substantial financial savings with associated environmental benefits for the society.**

Furnace Temperature necessary to roll certain Product Dimension

Furnace Temperature Necessary to roll (oC)



Furnace Length vs. Specific Fuel Consumption



Specific Fuel Consumption

Thermal Efficiency

Exhaust gas Loss

Combustion Air

Cooling Water Loss

Exhaust Heat Recovery Efficiency

Dissipation Heat Loss

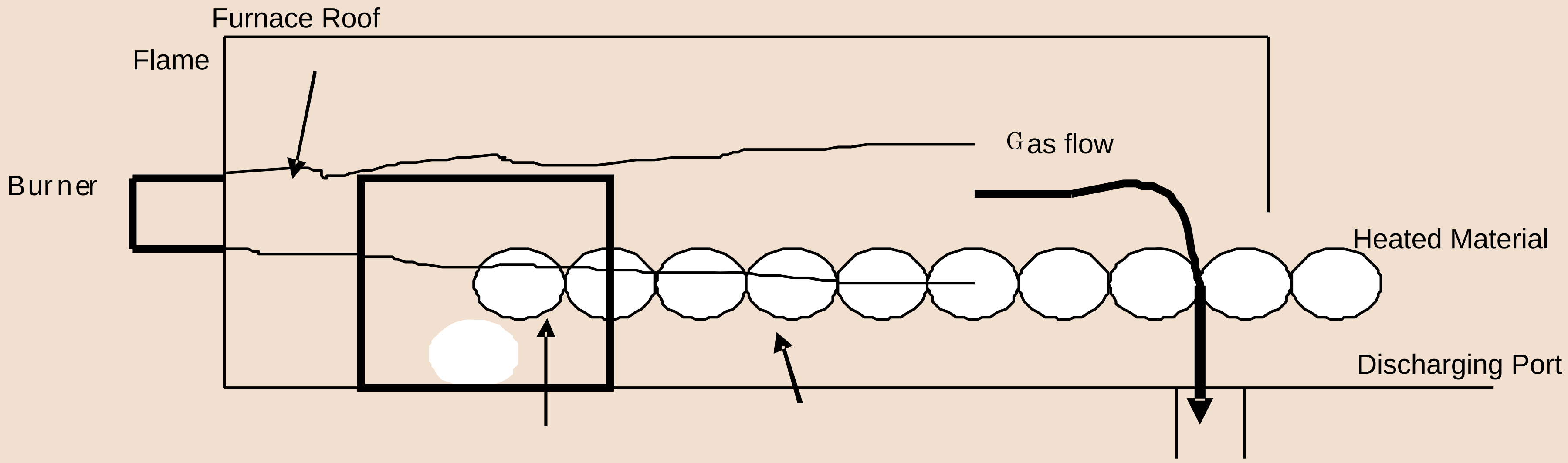
General Problems of Existing Furnaces

- **Low Furnace Height** (Insufficient volumetric heating capacity)
- **Low Burner Position**
- **Thick Material Layer** (Washing by combustion gas over material layer)
- **Straight Flame Burner without Swirl** (Long flame with much non-burnt carbon)
- **Lack of Thermal Insulation** (Much radiation heat loss from furnace surface)

General Problems of Existing Furnaces (continued)…

- Short Furnace Length (High temperature exhaust gas)
- Narrow Furnace width for Space of Down Take to Flue (Insufficient draft to chimney)
- Large Discharging Port always open (much entrained air into furnace)
- Only one side heating (Long time to heat)
- Both ends over heated but middle length under-heated due to radiation from side walls (Non-uniform temperature profile in material)

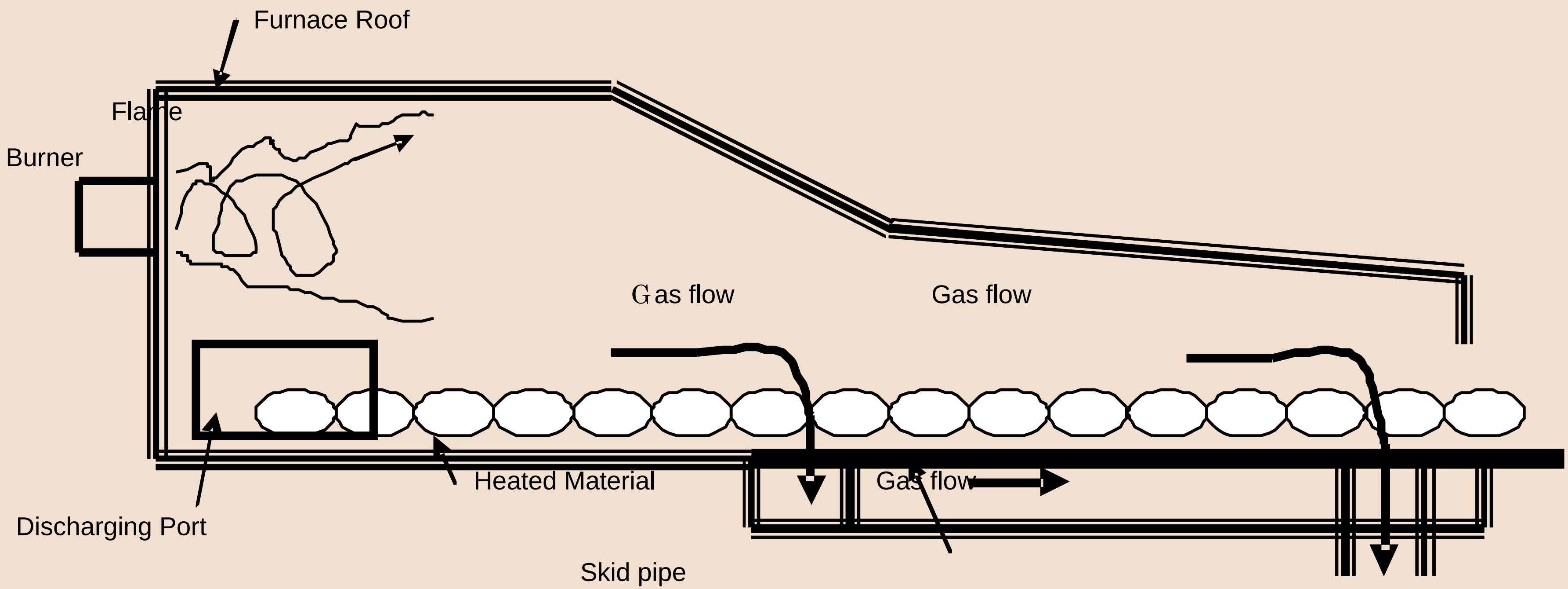
Model of Existing Furnace



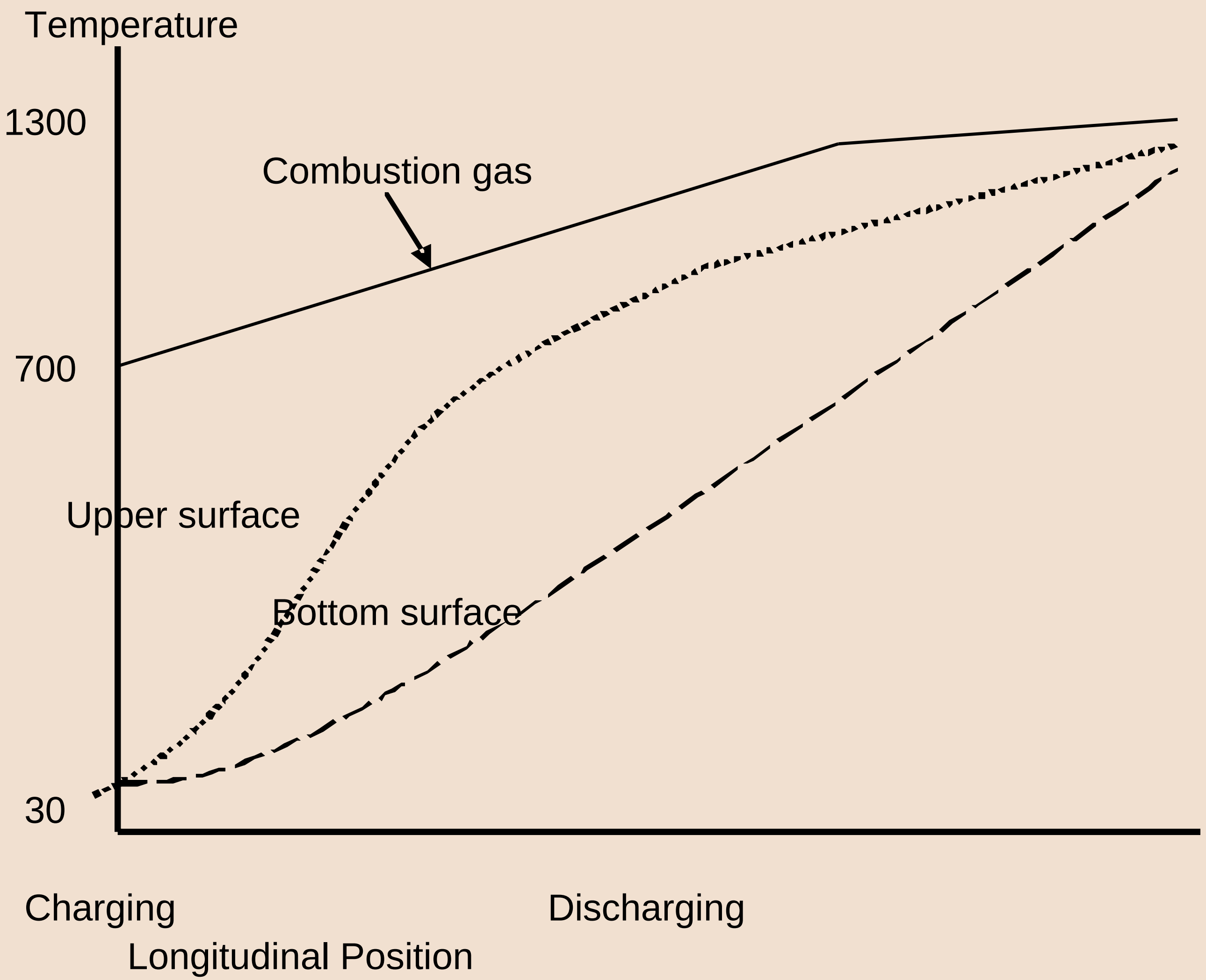
Features of New Furnace

- High Furnace Roof at Soaking Zone and Low Roof at Pre-heating Zone
- High Burner Position
- Thin Material Layer
- Mixing Flame Burner with Swirl
- Enough Thermal Insulation
- Long Furnace Length
- Wide Furnace width for Space of Down Take to Flue
- Small Discharging Port with Mechanical discharging
- High skid pipe at Preheating & Heating zones
- Both side heating with upper & lower gas flow, and heating middle part of length

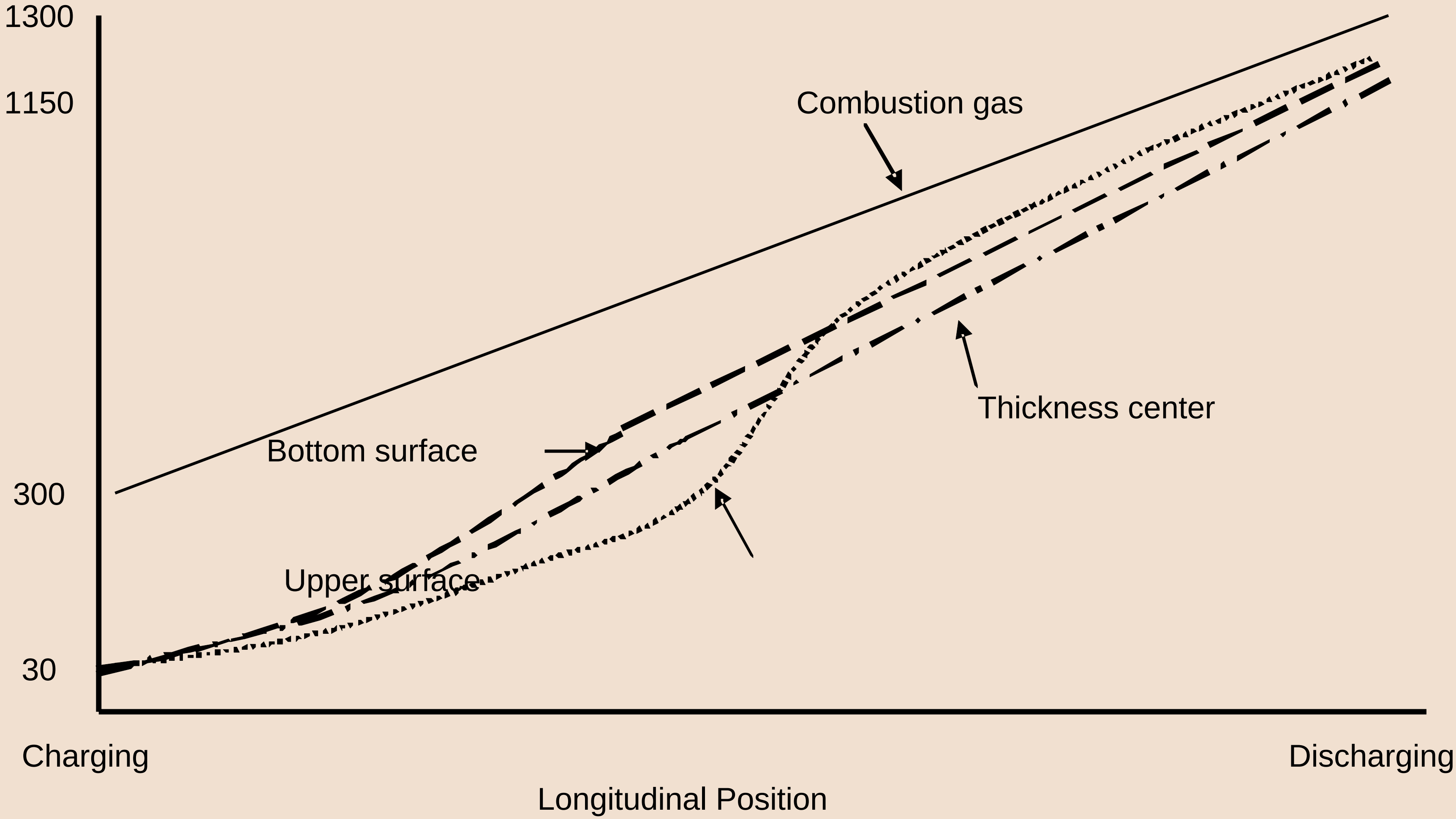
Conceptual Drawing of New Furnace



Heat Pattern in Existing Furnace



Heat Pattern of New Furnace



GHG emission reduction

(expected from each unit under implementation)

Measures	Emissions reduction *(t of CO_2 / annum)*
Installation of temperature controllers	190
Installation of waste heat recovery	177
Installation of proper combustion system	105
Increasing in length of preheating zone of the furnace	509
Redesign of furnace (long term option)	982

From 50 operational units expected reduction = 49100 tCO2 per year

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Thank You