



## *Energy Conservation Techniques*



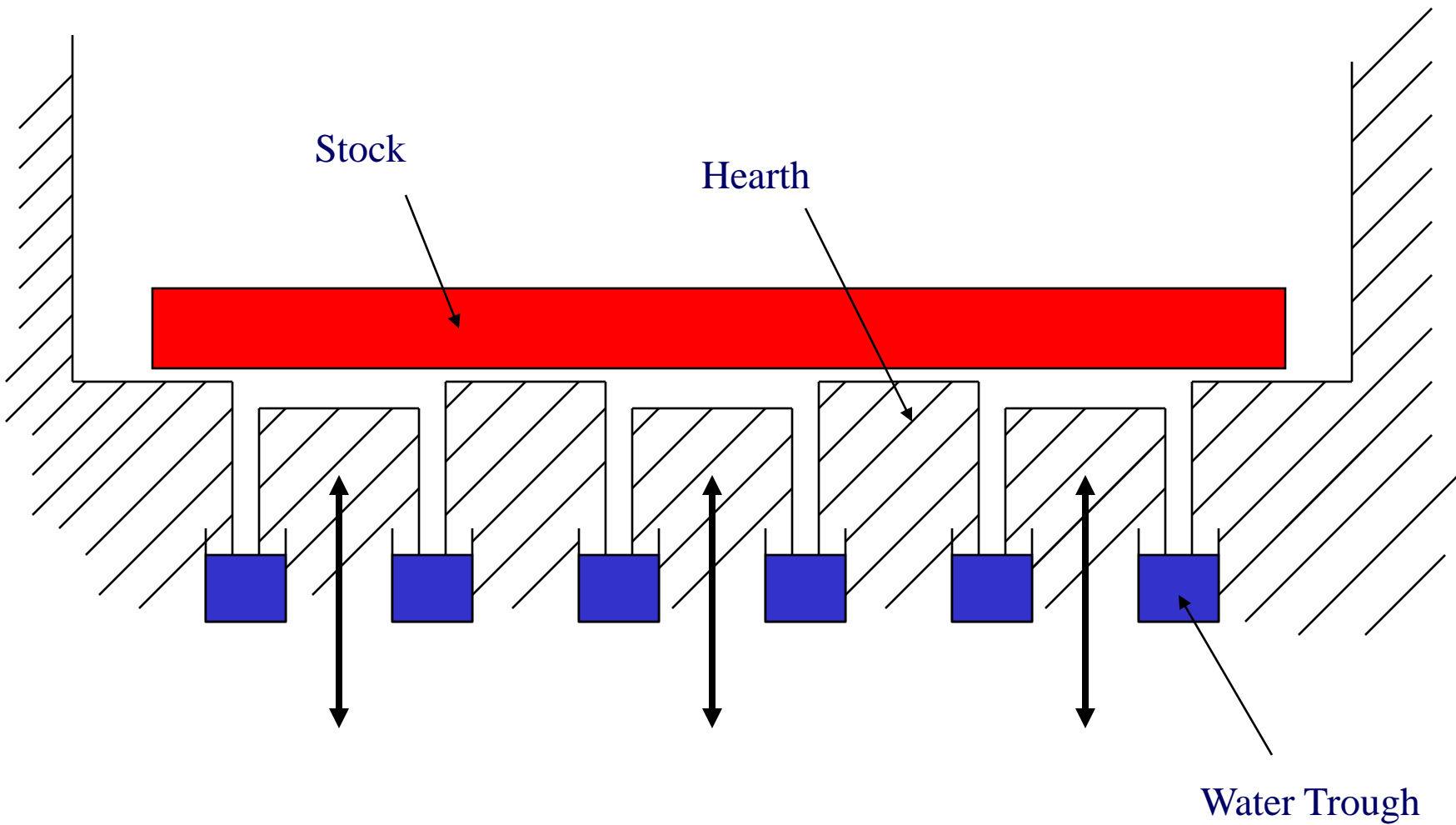
# Energy Conservation by

Reduction of Oil Consumption using Blast Furnace gas as well as Hot charging

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- Brief Description
- Case Study
- Action taken for improvement
- Energy conservation data
- Action proposed for further improvement
- Conclusion



Walking Hearth Furnace

# Technical Particulars of Existing Furnace

1. Type of Furnace : 45 TPH Walking Hearth Billet

## 2. Major Dimensions of the Furnace:

- Furnace outside length : 22500mm
- Furnace inside length : 21050mm
- Effective furnace length : 19320mm
- Furnace outside width : 10200mm
- Furnace effective width : 7630mm
- Hearth level : 985mm
- Hearth level when lifted : 1095mm

## Zone Length

- Soaking Zone : 4100mm
- Heating Zone : 4920mm
- Preheating Zone : 4466mm
- Recuperative Zone : 5834mm
- Center line of the Burner : 2128mm
- Width of walking hearth : 1400mm (2 NOS)
- Front clearance in walking hearth : 330mm

# Technical Particulars of Existing Furnace

## 3. Charge Details

- Billet cross section : 130 to 160 sq. mm billet of 2.7M to 7mtr. In single row
- Charging material : Low carbon steel, Alloy steel and S.S
- Reference billet weight : 160 sq X 7 mtr long, weighing 1400 kg
- Method of charging : Single row charging with the help of roller table and charging pusher outside.
- Method of Discharge : With the help of ejector.

## 4. Temperature Details:

- Charging temperature : Ambient 40 deg. Cen.
- Discharging Temperature : 1250 deg. Cen.
- Temperature uniformity : Top & Bottom 30 deg. Cen.
- Scale losses : 0.7% max during continuous operation at rated capacity utilization.

# Technical Particulars of Existing Furnace

## 5. Thermal Data:

- Fuel : Furnace oil containing 3 to 4% sulphur (HSD/LDO for flushing during start-up/shutdown). CV of Furnace oil being 10000 Kcal/kg.
- Specific heat consumption for discharge temp. of 1250 deg. Cen. At rated production of ref. : 288.9 Kcal/kg
- Billet 130160x7000mm length fuel connected load : 1700 Kg/hr.
- Temperature of flue gases : App. 700deg. Cen. At furnace exit & app. 300 deg. Cen. At base of stack.

## 6. Combustion System :

- No. of heating zone : 3 nos
- Heating system : Side and End axial firing configuration.
- Burner Distribution : End Wall – 6 nos  
Side walls – 4 nos on each side,  
staggered mounting.

# Technical Particulars of Existing Furnace

- Burner Make : Vulcan Long flame  
Preheating – 150 kg/hr, Heating zone – 175 kg/hr, soaking zone – 75 kg/hr.
- Burner Turn Down ratio : 1:5
- Combustion blowers : Centrifugal Type, 21500 Nm<sup>3</sup>/hr, 3000 rpm, 75 HP Motor, 1200mmwc Pressure.
- Atomization Blower : 500Nm<sup>3</sup>/hr @ 7 kg/cm<sup>2</sup>
- Heating, Pumping and filtering unit : 3 set Zonal fuel oil pumping filtering unit
- Max. oil Preheat temp.& control : 110 deg. Cen. By Thermostat
- Service Tanks : 1 no. 35000 ltr. For FO with 27 Kw outflow heater, 2 nos. 165 LPM rotary gear pump, 1 no 5000 ltr LDO/HSD storage tank with 2 nos 65 LPM rotary gear pump.

# Technical Particulars of Existing Furnace

7. **Waste heat recovery system** : Multi tubular cross counter flow type
8. **Flue exhaust system** : Overhead flue exhaust duct from furnaces and later underground via flue channel to 72 mtr. High chimney. And 56 meter height
9. **Mechanical – Cross Transfer system** :
  - No of Fixed Hearth : 3
  - No of Walking Hearth : 2
  - Stroke Length : 280mm
  - Total Lift : 225mm
  - Type of Drive Mechanism : Hydraulic

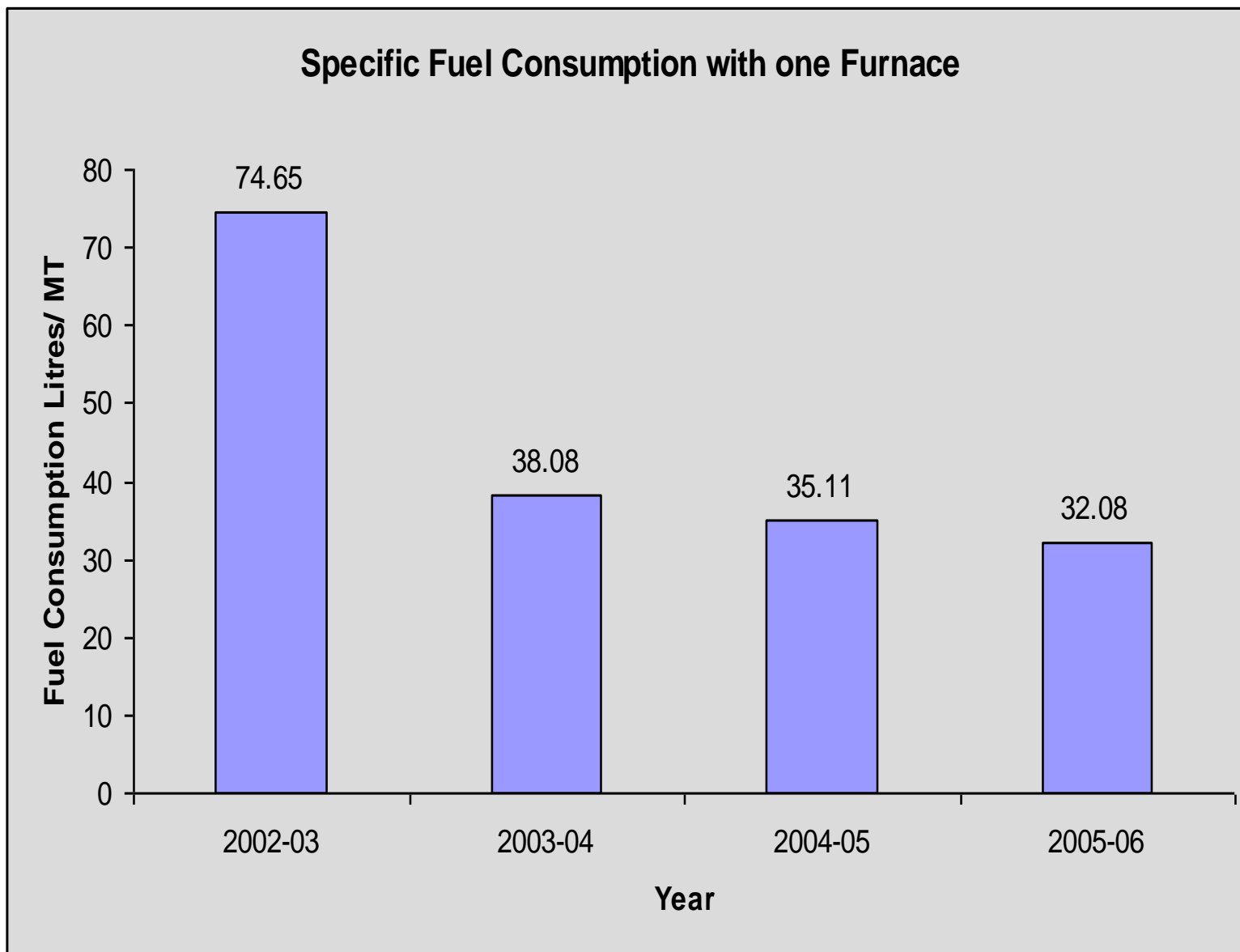
# Technical Particulars of Existing Furnace

## 10. Hydraulic System :

- Hydraulic Cylinder : Walking hearth forward/reverse  
- 1 No. Bore Dia = 125mm, Piston rod = 85mm, Stroke = 280mm
- Hydraulic Cylinder : Walking hearth lifting - 2 No.  
Bore Dia = 125mm, Piston rod = 85mm, Stroke = 280mm

## 11. Furnace Door Operation :

- Charging Side : Electromechanical
- Discharge Side : Pneumatically operated Air cylinder  
Bore = 160mm, Stroke = 400mm.



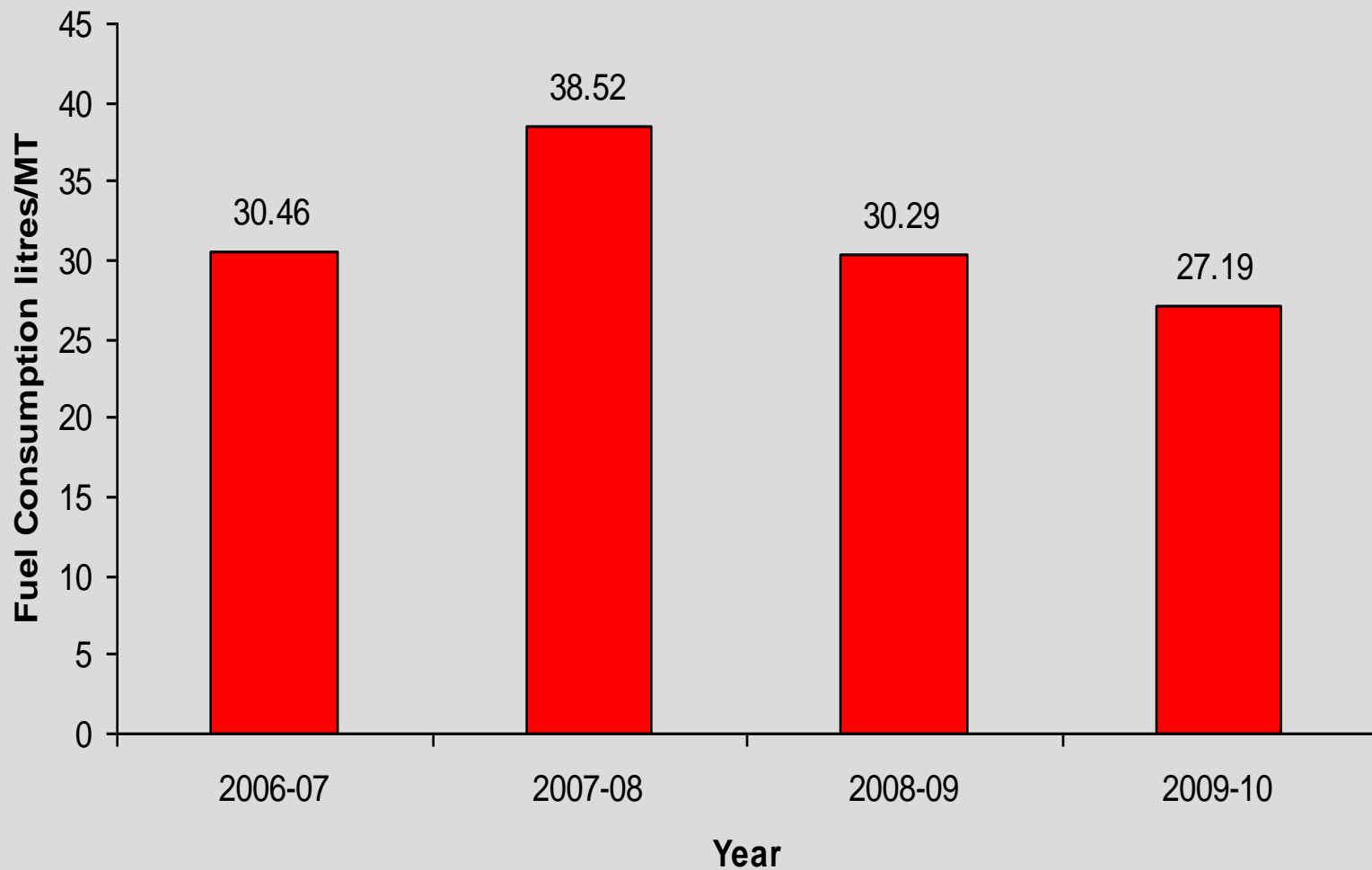
## REASONS FOR HIGH OIL CONSUMPTION WITH BRF 1

- IN 2002-03:
- MILL WAS UNDER COMMISSIONING
  
- IN 2003-04 & 2004-05:
- LOW PRODUCTION DUE TO LOW MILL AVAILABILITY
- DEVELOPMENT OF NEW PRODUCTS AND PRODUCT REALIZATION
  
- In 2005-06:
- MILL AVAILABILITY IS IMPROVED TO 59.45%
- AND ACCORDINGLY PRODUCTIVITY IS IMPROVED BY 44%

## INTRODUCTION OF II<sup>nd</sup> BRF 2

- IN 2006-07 :
- AS PER THE BUSSINESS PLAN TO INCREASE THE MILL PRODUCTION CAPACITY UP TO 35,000 MT / MONTH , WITH
- INSTALLATION OF TWIN CHANNEL SYSTEM
- INSTALLATION OF NTM MILL
- TO INCREASED THE PRODUCT RANGE
- II<sup>nd</sup> BILLET REHEATING FURNACE WAS COMMISSIONED IN SEP'06 IN VIEW TO MEET THE ENHANCED ROLLING MILL CAPACITY

### Specific Fuel Consumption with Two Furnaces



## PROBLEMS FACED WITH USE OF BOTH BRF 1 & BRF 2

- Furnace pressure increased from 0.5mm to 1.5mm WC
- Furnace cellar temp. was high
- Scale formation is more
- High heat losses from roof, side walls causing malfunctioning of control equipments
- High flue gas temperature from stake
- Lack of experience of using BF gas as a reheating furnace fuel
- It all leads to increase the fuel consumption and lower thermal efficiency of the BRF

## ROOT CAUSE ANALYSIS

- Day tank was not available
- In BRF 2 soaking zone dual fuel fired burners are not effective
- Both the BRF are connected to one chimney
- Dampers were not controlling the system due to frequent breakdown as it was installed before recuperator
- Bull nose failures frequently
- Cross sectional area of flue duct is more
- Filtration units were not installed at the unloading point from tanker to oil tank
- Only one pumping unit was installed to supply fuel for both BRF

# Action taken for Improvements

## In March-2007:

- One of the storage tank (45KL) is taken for use as a day tank

## In April-2007:

- In BRF-2 Consumption of BF gas is stopped in soaking zone.

## In March-2008:

- Bifurcation, installation and commissioning of separate chimney and flue tunnel line .

## In June-2008:

- Dampers positions is changed and installation of rotary type dampers.
- Replacement of bull nose with inclined flat roof.
- Old damaged recuperator replace with new one.

## In April-2009:

- Reduction of Flue Tunnel area in both BRF to enhance the positive pressure in the system

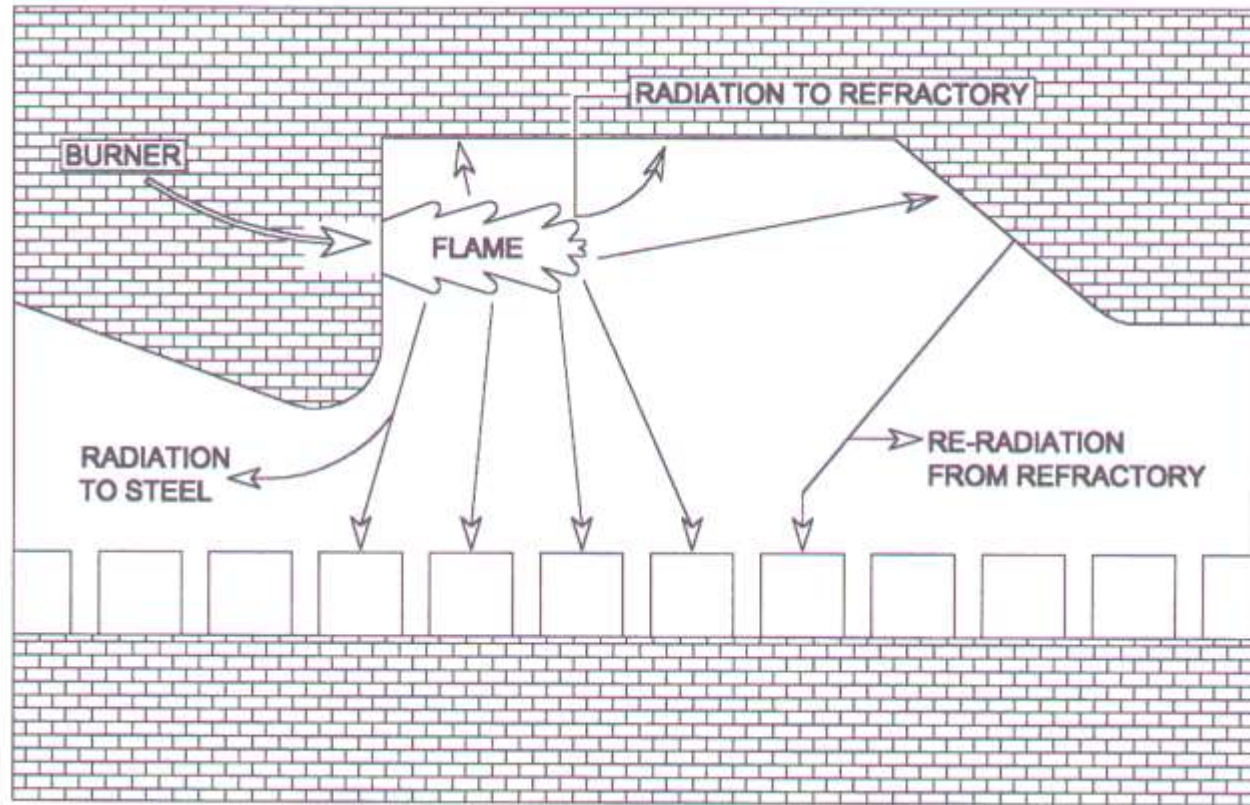
## In June-2009:

- Separate main pumping unit is installed
- Return line to day tank and Heat treating element installation and filtration unit added in furnace oil unloading and day tank filling line

## EFuel composition of B.F. Gas

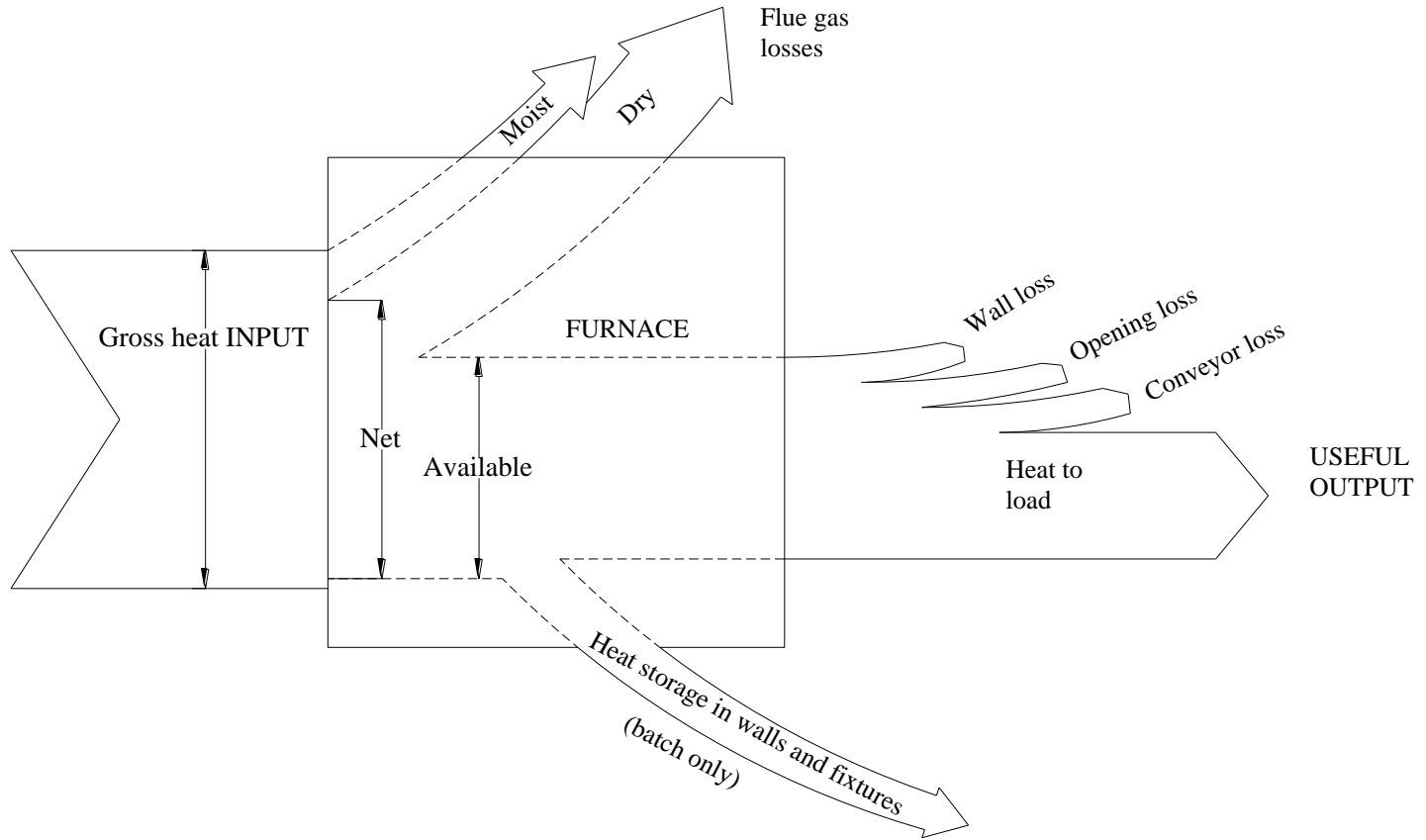
- Composition Of B.F. Gas is CO = 20-22%, N<sub>2</sub> = 53 – 55 %
- H<sub>2</sub> = 2 – 3 % , CO<sub>2</sub> = 16 – 19 % , O<sub>2</sub> = 0.5 – 1 %
- Temperature = 50<sup>0</sup>- 55<sup>0</sup>C
- C.V. / NM<sup>3</sup> = 690 K calorie

# Mechanism of Heating Steel



**Heat Transfer by Radiation**

# ENERGY BALANCE IN A REHEATING FURNACE



## Energy Conservation - Data

- Rolling MS grade with one Reheat Heat Furnace (RHF) using cold charge
- Rolling MS grade with one RHF using hot charge
- Rolling MS grade with one RHF using hot charge & Blast Furnace (BF) gas
- Rolling MS grade with Two RHF using cold charge
- Rolling MS grade with Two RHF using hot charge
- Rolling MS grade with Two RHF using hot charge & BF gas
- Rolling alloys steel grade with Two RHF with cold charge
- Rolling alloys steel grade with Two RHF using cold charge & BF gas.

- Rolling MS grade with one Reheat Heat Furnace (RHF) using Cold charge

Maximum production /day- 1000 MT

Average production / day - 900 MT - 80% mill availability(MA)

Designed specific fuel consumption(SFC) - 29 lts / MT

Actual SFC - 30 lts/MT

- RRolling MS grade with one Reheat Heat Furnace (RHF)  
using  
hot charge

Hot charge billets temperature - 650 - 700 deg C

Maximum production /day - 1150 MT

Average production / day - 1050 MT - 80% MA

Actual SFC - 28 lts/MT

Difference in SFC - Cold Charge(CC) & hot charge(HC) -2lts/MT

Savings in Fuel calories:

2 lts / MT x 10000 K calorie (CV of FO) = **20000 K cal.**

- RRolling MS grade with one RHF using hot charge & BF gas

Hot charge billets temperature - 650 - 700 deg C

Maximum production /day - 1150 MT

Average production / day - 1050 MT - 80% MA

Actual SFC with HC - 28 lts/MT

Actual SFC with HC + BF Gas - 27 lts/MT

Difference in SFC -1 lts/MT

Savings in fuel calories:

1 lts / MT x 10000 calorie (CV of FO) = **10000 K cal./MT**

BF gas consumption / hr - **3000 NM<sup>3</sup>**

Calorie supplied by BF gas/MT - 3000NM<sup>3</sup> x 690 (BF CV) / 43.75MT  
(Average production per hr.) = **47314.3 K Cal. / MT**

The Effect of thermal efficiency of BF gas in RHF is 21 % (10000 / 47314.3 )

- RRolling MS grade with Two RHF using cold charge

Average production / day - 1800 MT - 80% MA

Actual SFC - 35 lts/MT (two furnaces and higher production)

- RRolling MS grade with two RHF using hot charge

Hot charge billets temperature : 650 - 700 deg C

Maximum production /day : 1800 MT

Actual SFC : 32 lts/MT

Difference in SFC - CC & HC : 3 lts/MT

Savings in fuel calories:

3 lts / MT x 10000 K calorie (CV of FO) = **30000 K cal.**

Furnace oil saving

1800 x 3 = 5400 Ltrs / Day

- RRolling MS grade with two RHF using hot charge & BF gas

Hot charge billets temperature : 650 - 700 deg C

Maximum production /day : 1800 MT

Actual SFC with HC : 32 lts/MT

Actual SFC with HC + BF Gas : 30 lts/MT

Difference in SFC : 2 lts/MT

Savings in fuel calories:

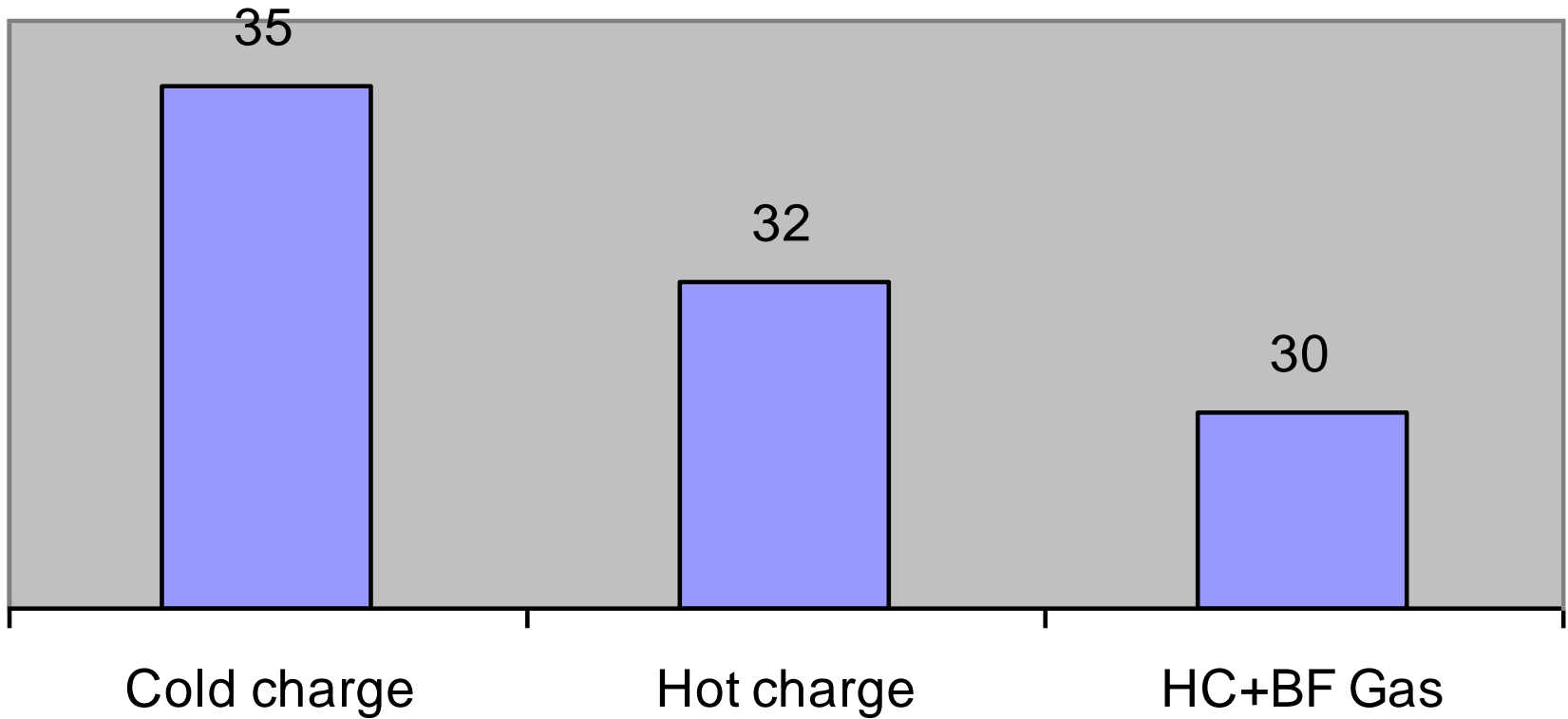
2 lts / MT x 10000 calorie (CV of FO) = **20000 K cal./MT**

BF gas consumption / hr : **10000 NM<sup>3</sup> (RHF1 -3500 , RHF2 - 6500)**

Calorie supplied by BF gas/MT - 10000NM<sup>3</sup> x 690 (BF CV) / 93.75MT  
(Average production per hr.) = **73600 K Cal. / MT**

The Effect of thermal efficiency of BF gas in RHF is 27.17 % (20000 / 73600 )

# FURNACE OIL CONSUMPTION IN LITERS / MT WITH RHF-1&2



- RRolling alloys steel grade with Two RHF with cold charge
- Average production / day : 1050MT
- Actual SFC : 32 lts/MT
- The production is low due to Rolling rate is low in comparison to MS rolling rate
- Free cutting steel rolling and different grades rolling also down production rate
- On line handling system also affect the rate of production

- RRolling alloys steel grade with Two RHF using cold charge and BF gas

- The following steps are taken during Rolling of Alloy steels to control the SFC
- The charging order of different grades are classified on the basis of low carbon & high carbon alloy steel , free cutting and Boron steels etc.for the better furnace temp. control
- RHF is to be charge of 60- 62% of its design capacity it helps to lower the residing time inside RHF and hence lower the scale loss
- PHZ ( pre heating zone to be put off )
- Use of BF gas **4000NM3** in Brf 1 and **6000NM3** in BRF 2

- RRolling alloys steel grade with Two RHF using cold charge and BF gas

Avg. production /day :1050 MT

Actual SFC with out B.F. : 32 lts/MT

Actual SFC with cold chng.+ BF Gas : 27 lts/MT

Difference in SFC : 5 lts/MT

Savings in fuel calories:

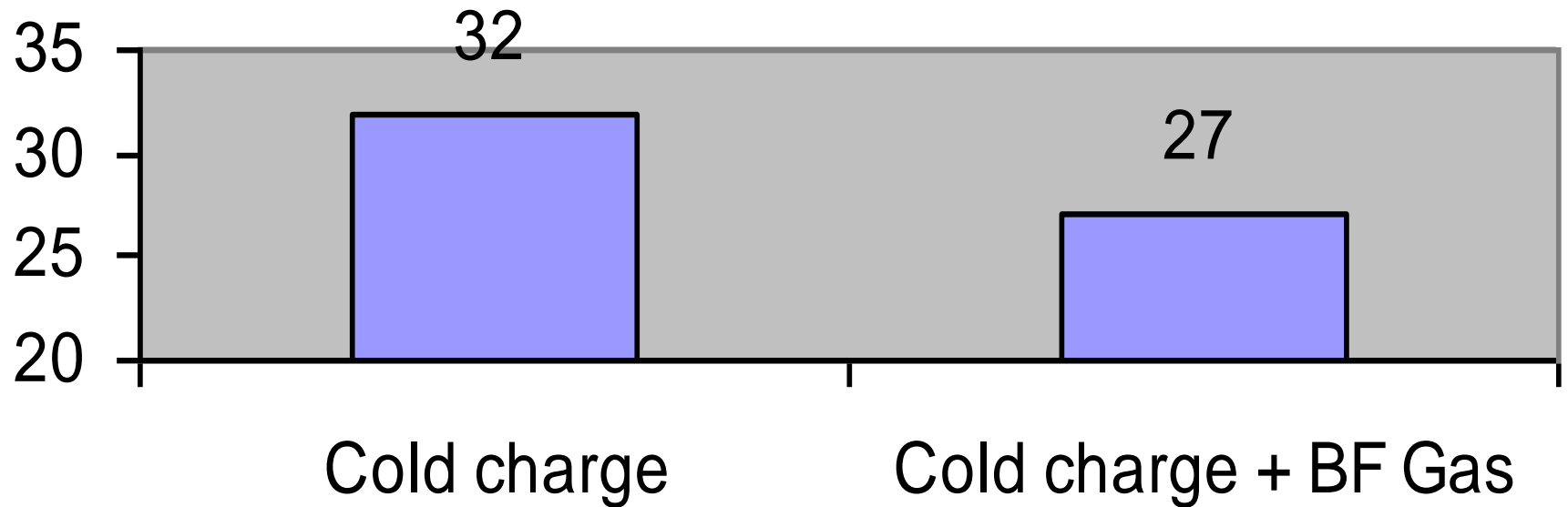
5 lts / MT x 10000 calorie (CV of FO) = **50000 K cal./MT**

BF gas consumption / hr - **10000 NM<sup>3</sup> (RHF1 -3500 , RHF2 - 6500)**

Calorie supplied by BF gas/MT - 10000NM<sup>3</sup> x 690 (BF CV) / 43.75MT  
(Average production per hr.) = **157714.28 K Cal. / MT**

The Effect of thermal efficiency of BF gas in RHF is 31.7 % (50000 / 157714 )

# Furnace oil consumption in ltrs for Alloy steel with RHF 1 & 2

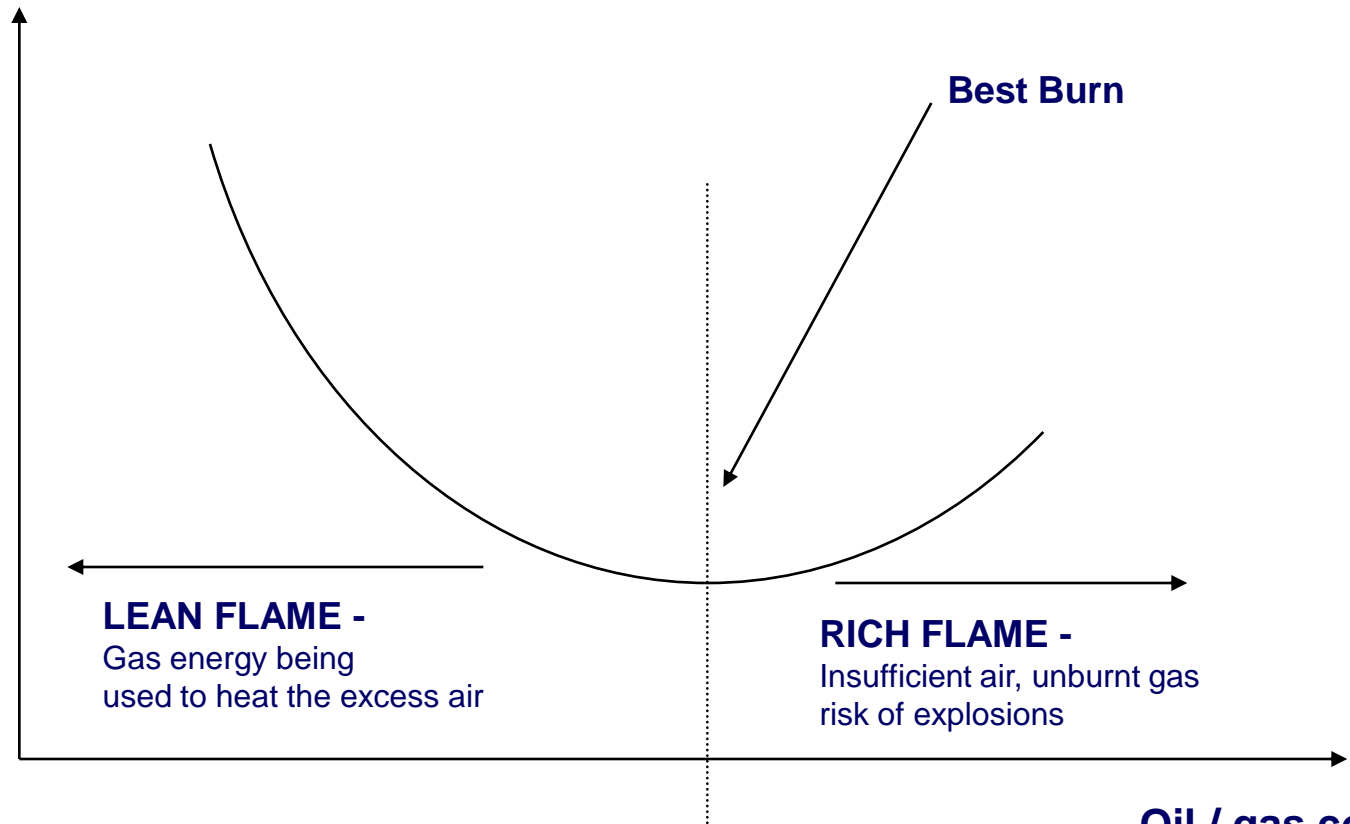


## Action Plan For Improvements in SFC Ahead

- Bifurcation of soaking zone control system in soaking zone-1 & soaking zone-2.
- Replacing of BRF-2 soaking zone dual fuel fired burners with oil fuel fired burners, Vulcan Make.
- Average rolling rate of alloy steel will be improve by installing on line compactor machine( Morgan Make) by 100-150Mt and in turn SFC will be improved.

## Stoichiometric Burn

Air content



**LEAN FLAME -**  
Gas energy being  
used to heat the excess air

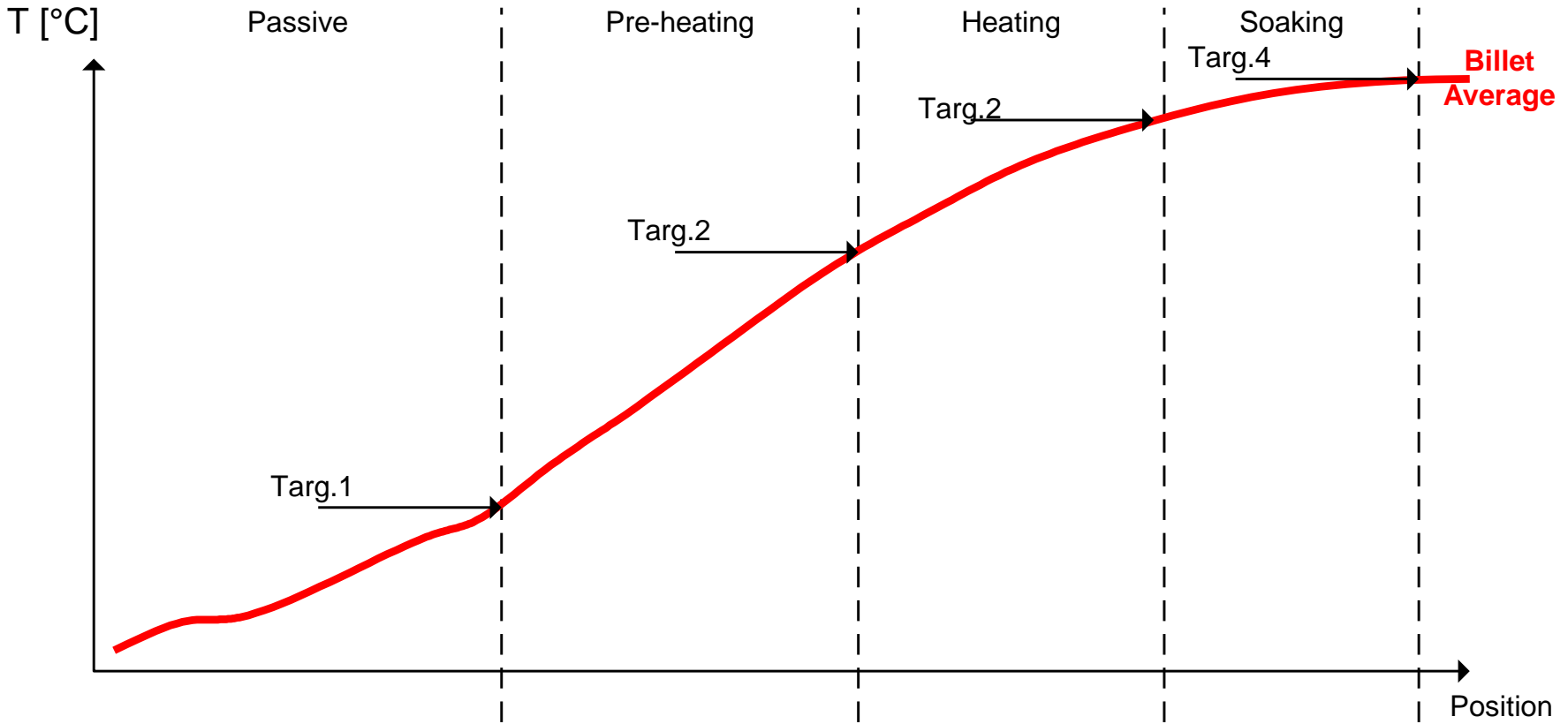
**RICH FLAME -**  
Insufficient air, unburnt gas  
risk of explosions

Oil / gas content

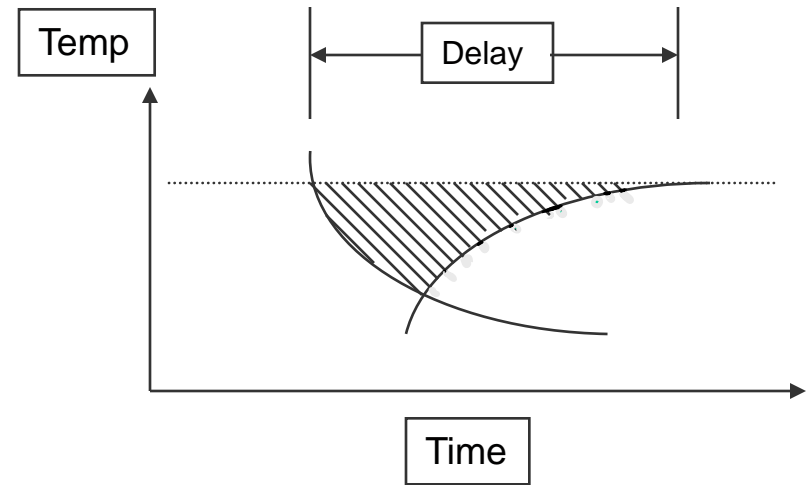
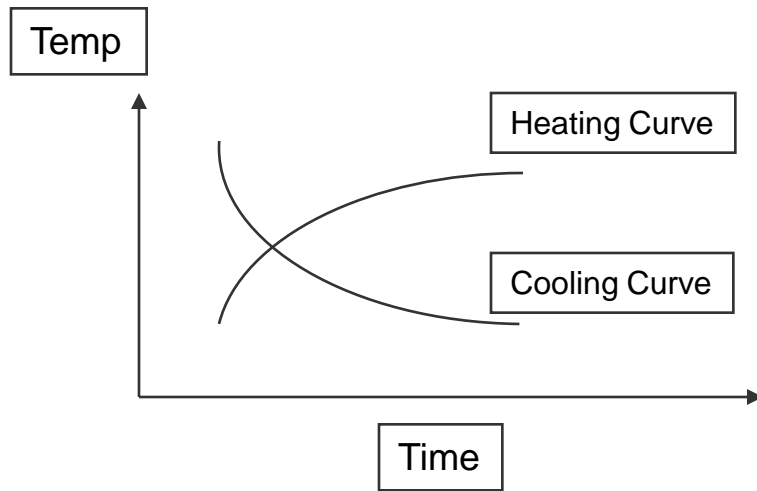
## Heating Quality

- The furnace operator should understand the term “heating Quality”. With steel the quality consists of
  1. Nominal temperature level
  2. Temperature uniformity
  3. Surface quality

# Target Temperatures



# FURNACE DELAY STRATEGIES



## 7 ways to minimize scale formation

1. **Heating practice:** heat as late as possible, minimize the soaking zone time.
2. **Fire on ratio:** operate to low level of free O<sub>2</sub> for minimum scale formation.
3. **Furnace pressure:** maintain a positive furnace pressure to reduce O<sub>2</sub>.
4. **Balance burners:** avoid localized over/underheating.
5. **Close doors:** keep furnace doors closed, to reduce O<sub>2</sub>.
6. **Delays:** respond to delays by cutting back the furnace temperatures.
7. **Communication:** the mill rolling personnel must keep furnace operator informed on estimated length of delays, expected stoppage time, and start-up times.

The amount of carbon, which goes in or out of steel mainly depends on 3 factors :

1. **Temperature:** as temperature increases, the rate of decarburization increases  
decarburization does not take place under 800 C.
2. **Time:** the amount of decarburization increases with time. The duration that the steel surface is exposed to a set of decarburization hot occurs.
3. **Atmosphere:** a major influence on decarburization is the atmosphere to which the steel is exposed.

## Conclusions

To conclude, let's repeat the basic rules of furnace operation:

Heat steel as late as possible

Know the Air/Fuel Ratio

Do not overheat – heat uniformly

Use damper to control furnace pressure

Know your mill operation – have a delay strategy.

Keep doors close

Know the furnace controls

Check cooling water system

Maintain the furnace system