National Workshop on "Special Steel-Making, Processing, Quality Control & Application", Bokaro Steel City November 21, 2009

1. Sustenance of Growth In Steel Industry – Key Note Lecture (Dr S K Choudhury)
2. Modern Drives: The Key Enabler For Advances In Rolling Technology
3. Improvement In Quality of Annealed Coils At Continuous Annealing Line
4. Flatness Measurement In Cold Rolling Mill
5. Production of High Quality Hot Rolled Steel Strip Using Hot Skin-Pass Mills
6. R&D Efforts Towards Development of High Strength Linepipe HR Coils At BSL
7. Development & Commercialization of High Strength LPG At Bokaro Steel Plant
8. Productivity & Quality of Continously Cast Slabs At SMS-II, RSP
9. A Fundamental Approach To Optimise Calcium Treatment During Ladle Refining of Al Killed Steels At SMS II BSL
10. Special Steels For Automobile Sector
11. Improvement of Roll Life By Modified Cooling System At Roughing Stands Of HSM, BSL
12. Special Steel Making & Casting At Bokaro Steel Plant's SMS – II With 100% Customer Satisfaction
13. Innovative Approach For Effective Roll Bending At 4-Stand Tandem Mill of Bokaro Steel Plant
14. Siemens VAI Metals Technologies – Your Partner In Rolling Mills & Processing Lines

Sustenance of Growth

in

Steel Industry

Introduction

- **The surge in steel demand has its roots in the growing role of emerging economies like China, Brazil, India & Russia.**

- **Ecological degradation may become unbearable since one ton of steel made releases two tonnes of CO_2 in the atmosphere.**

- **Three major steel consuming areas are:**
  - **Infrastructure**
  - **Construction of production facilities**
  - **Urbanization**

- **Sustainable growth rate can be attained by**
  - **Recycling**
  - **Conservation**
  - **Adoption of best technology**

Hence, present day concept is to use high performance materials.

Status of Steel Industry

Global scenario

- At the end of 20th century steel production oscillated around 750 MT annually.
- Landscape changed abruptly with the advent of 21st century when demand & production capacity increased significantly, crossing one billion tonnes in 2004.

Global scenario

- **The production trend continued till Sept'08, when unprecedented global financial crisis witnessed sharp fall in steel demand and its price.**

- **In current year, production expected to be ~1230 MT of which 740 MT (60.1%) would be special steel, including alloy and stainless steel.**

Domestic Scenario

- **During 2008-09, total domestic consumption was 52.3 MT, includes 25.5 MT (48.8%) special steel (special mild steel: 23.0 MT, Alloy & Stainless steel: 2.5 MT). Percapita consumption: ~ 44 kg.**

- **Demand projection in 2009-10: 56.5 MT, includes 28.8 MT special steels (special mild steel: 26.0 MT & Alloy & stainless steel: 2.8 MT)**

- **The percapita consumption will increase to 54 kg by 2011-12.**

Domestic Scenario

- **During 2008-09, we have attained growth rate of 11% in special steel over 2007-08, touching a level of 30% (3.37 MT) of saleable steel.**

  In the current year our plan is to achieve special steel production up to 50% of saleable steel.

Business Strategies for Sustenance of Growth

- **Steel manufacturers responded present crisis by:**
  - **Development of new functional high value added products.**
  - **Renovation of product line by streamlining the process.**
  - **Adoption of cost control measures through improved process efficiency and alloy design.**
  - **Restructuring alliance among companies to mutually supplement their advantages to form more powerful competitive organization.**

New Functional Products

- During the last century, one of the major metallurgical achievement had been development of Microalloyed (MA) steels.

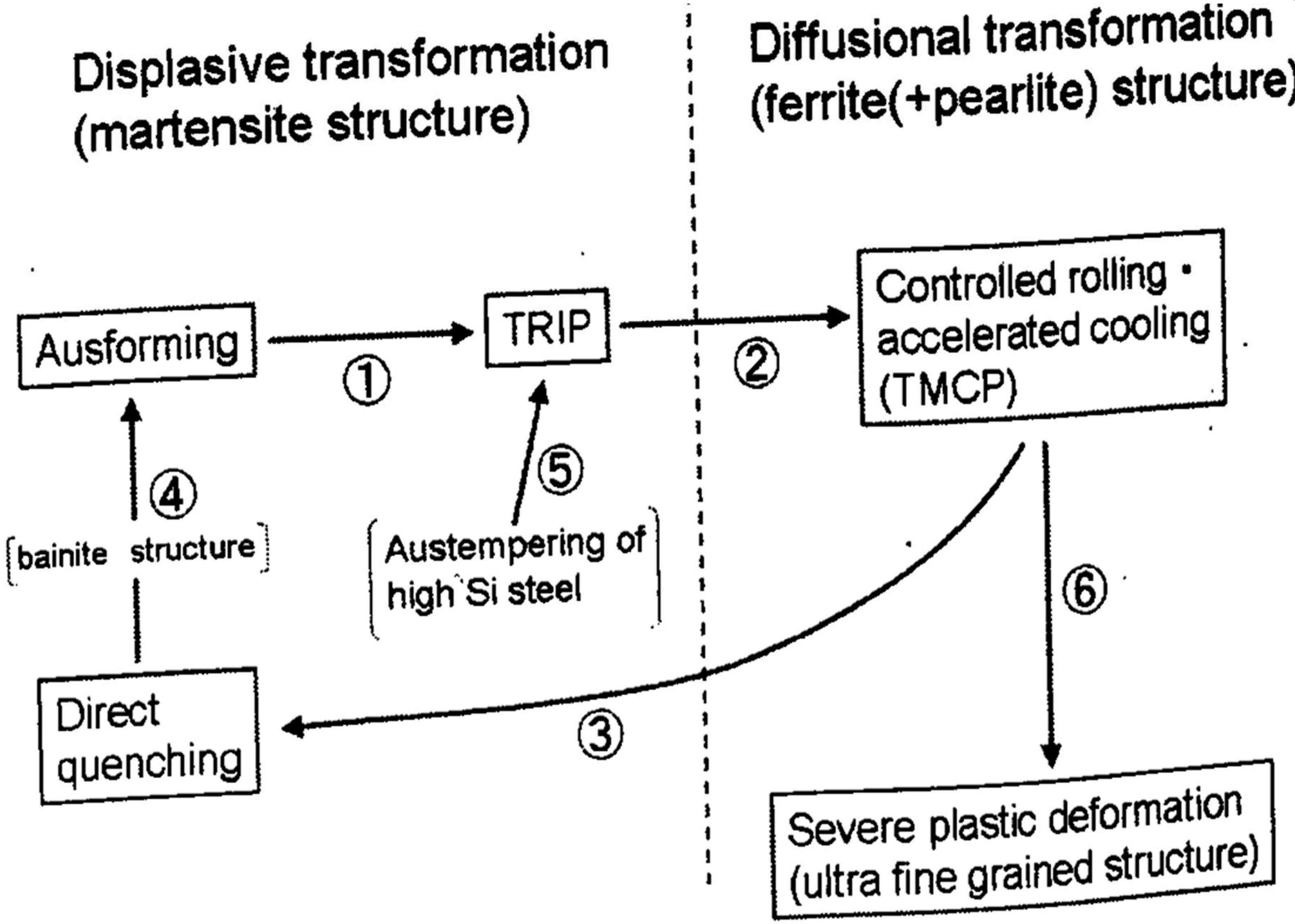
- MA steel – a cost effective product, since less than 1 kg MA elements (Nb, V, & Ti single or incombination) added per tonne (~4 to 6% of cost of the steel) to increase yield strength by two fold compared to structural carbon steel, contributing at least 25% weight saving.

- **The three microalloying elements are used for grain refinement and precipitation hardening.**
- **Fundamentally, these elements differ from each other in respect to:**

  - **Interaction with Nitrogen**
  - **Rolling practice**
  - **Recrystallization behaviour**
  - **Propensity of corner cracking during concasting**

Metallurgical Characteristics of Niobium & Vanadium

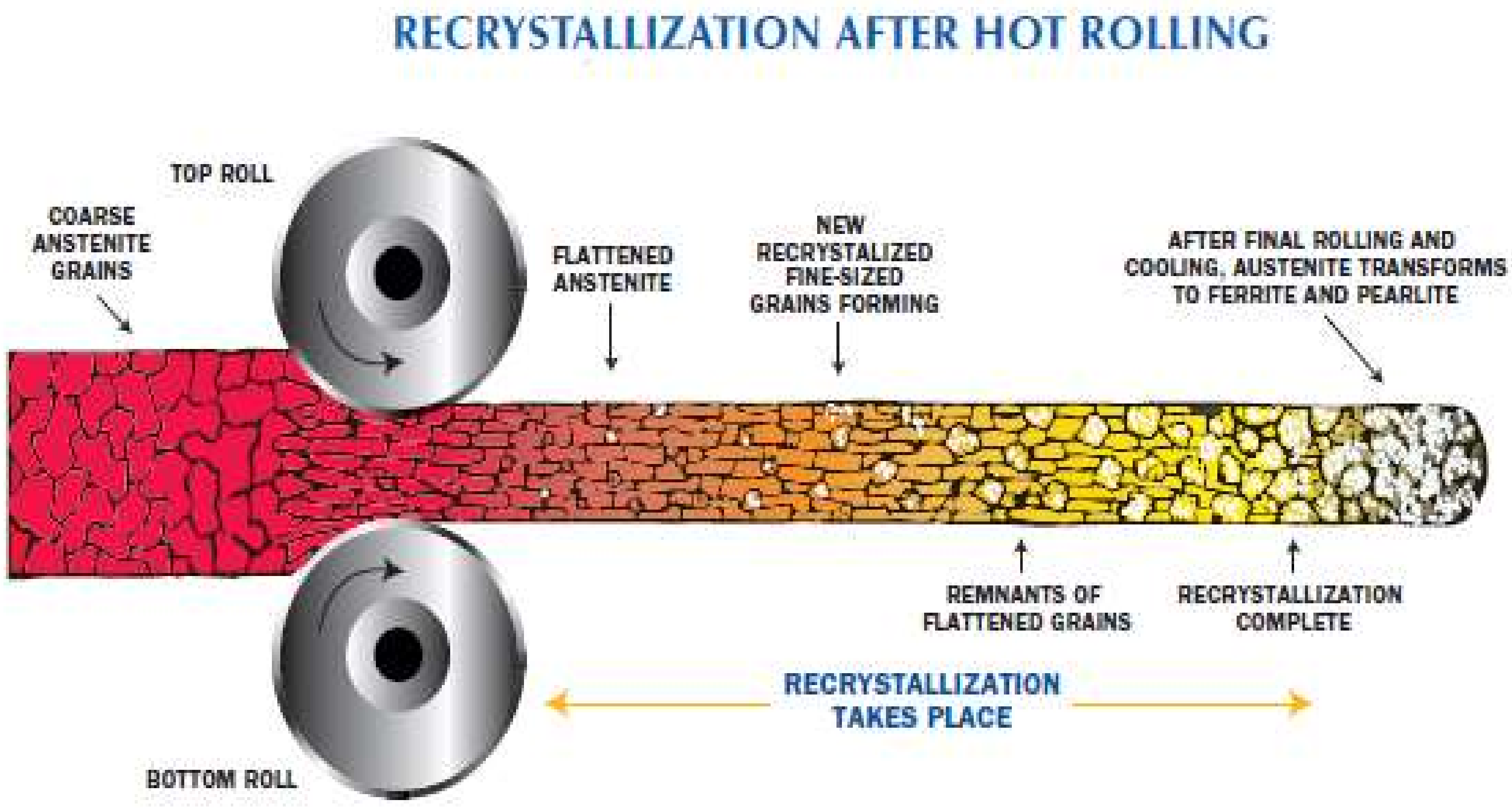
Factors influencing the alloy design	Niobium	Vanadium
Solubility of M(C,N) in Austenite	Low	High
Tendency for concast cracking	High	Low
Recrystallization stop temperature	High	Low
Ease of recrystallization	Low	High
Preferred rolling practice	CCR	RCR
Compatibility with nitrogen	Negative	Positive
Effect on grain refinement	Strong	Strong
Effect on pptn strengthening	Weak	Strong
Effect of N on pptn in austenite	Intensive	Limited
Effect of N on pptn in ferrite	Negligible	Positive
Nitrogen binding capacity	Weak	Strong



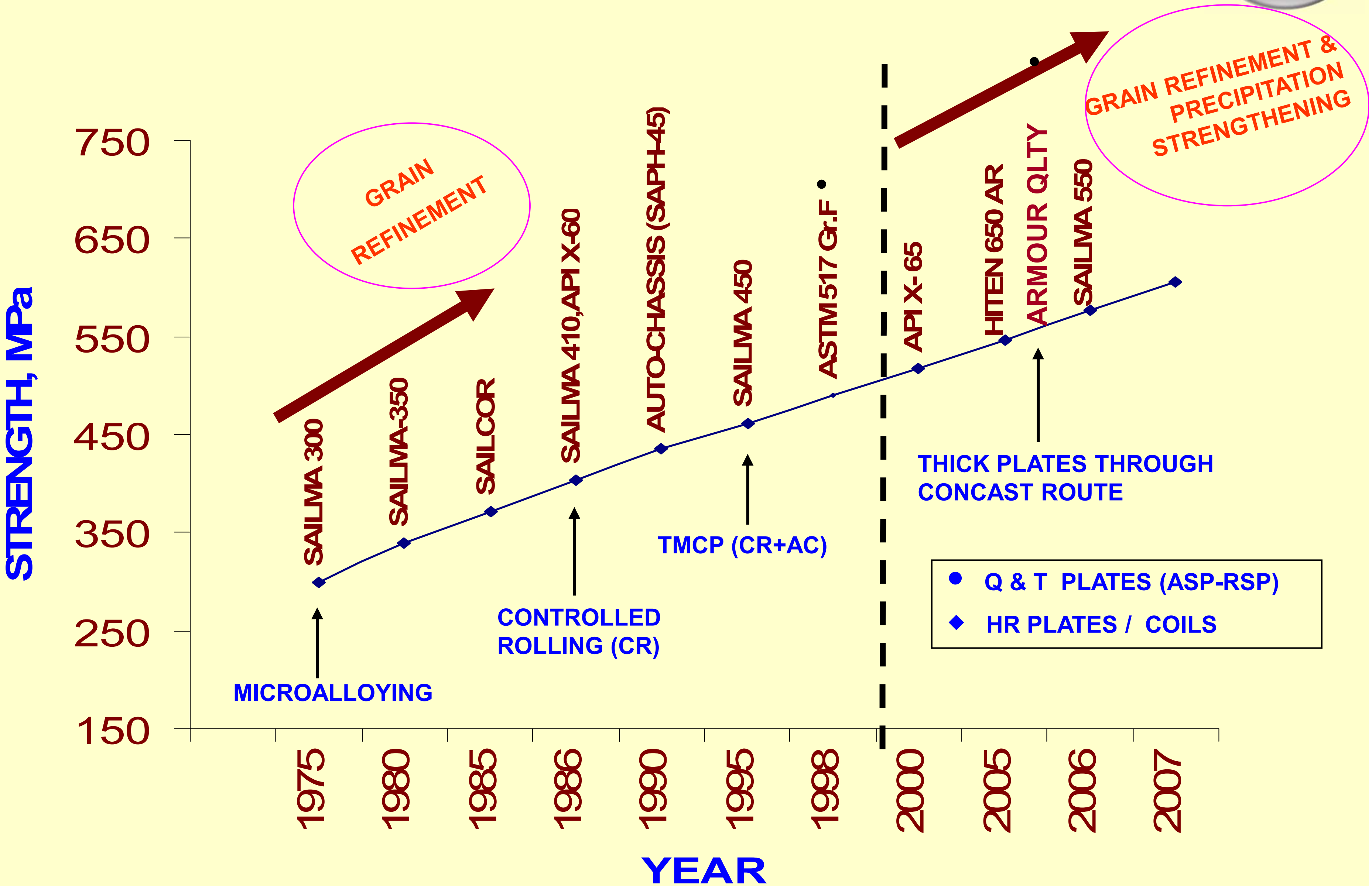
Displasive transformation
(martensite structure)
Diffusional transformation
(ferrite(+pearlite) structure)
Ausforming
①
TRIP
②
Controlled rolling ·
accelerated cooling
(TMCP)
④
bainite structure
⑤
Austempering of
high Si steel
⑥
Direct
quenching
③
Severe plastic deformation
(ultra fine grained structure)

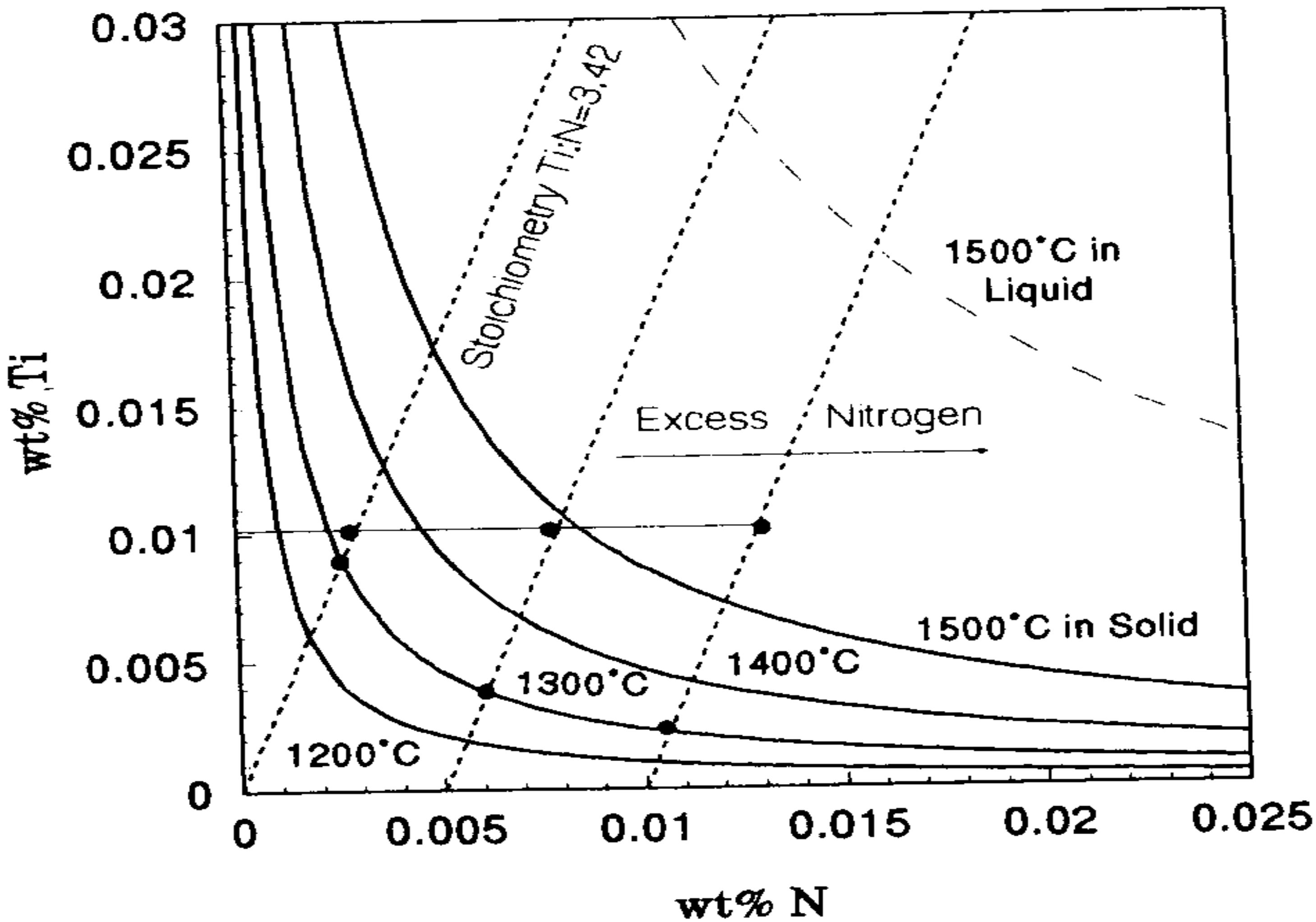
Microalloy Effects During Hot Rolling

Ti, Nb, and V all provide distinctly different responses



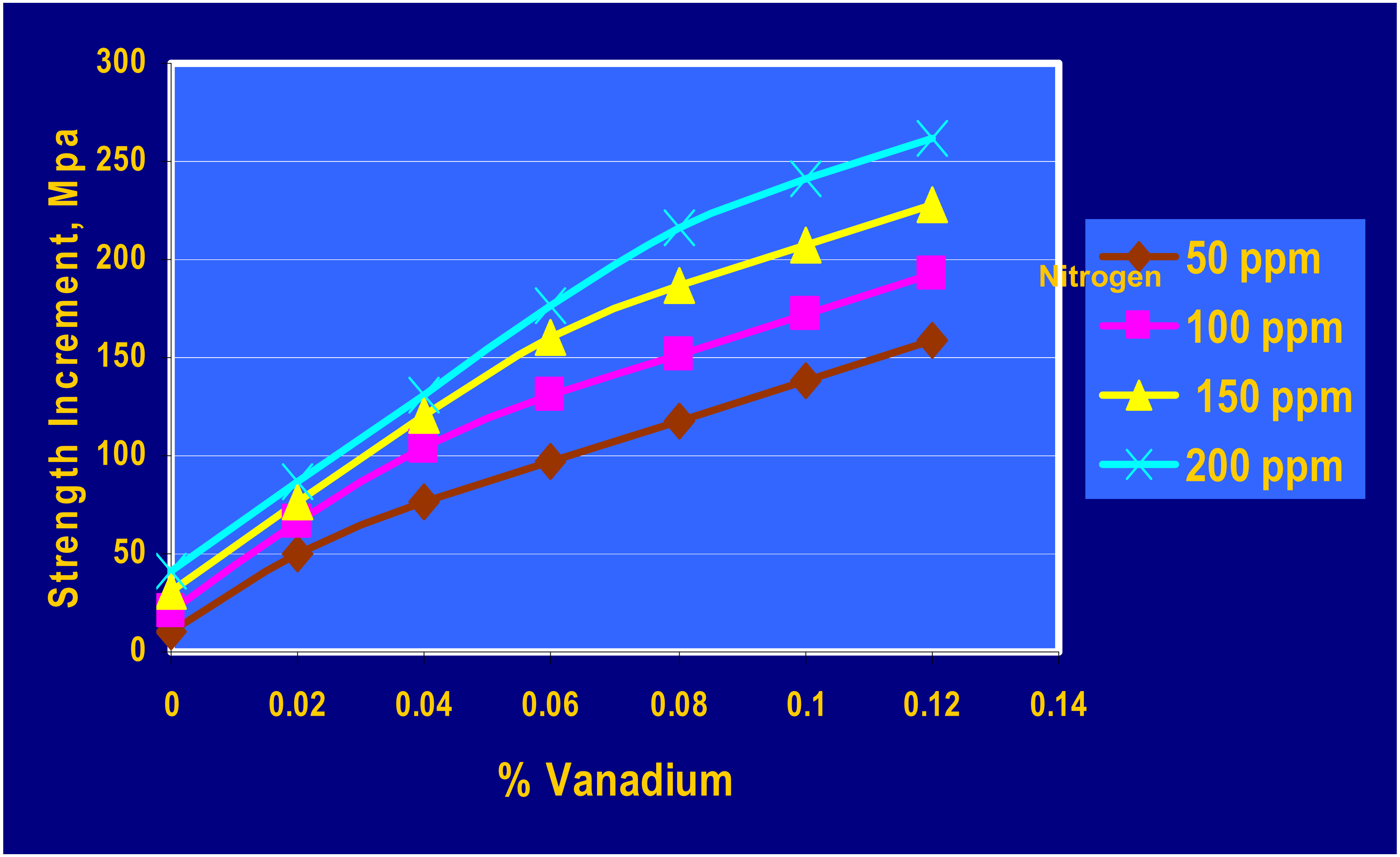
EVOLUTION OF HIGH STRENGTH STEELS THROUGH ADOPTION OF MAJOR TECHNOLOGIES



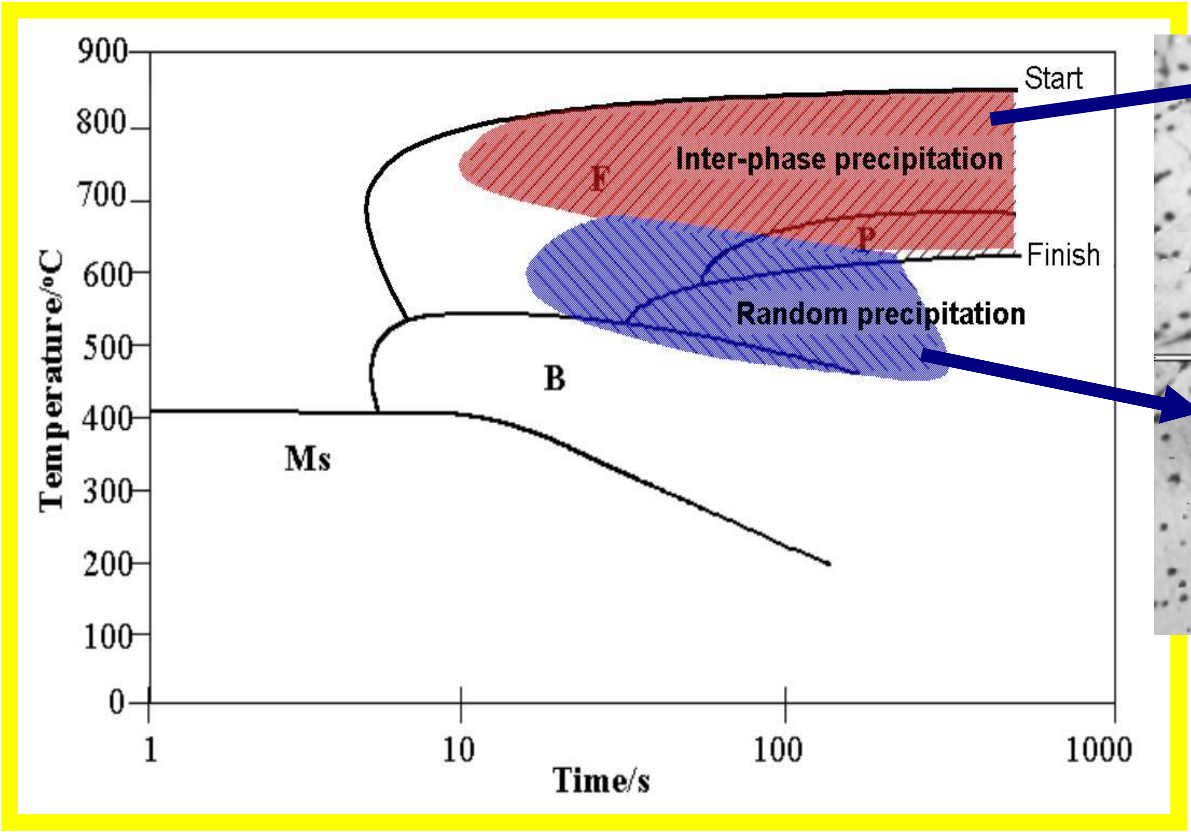


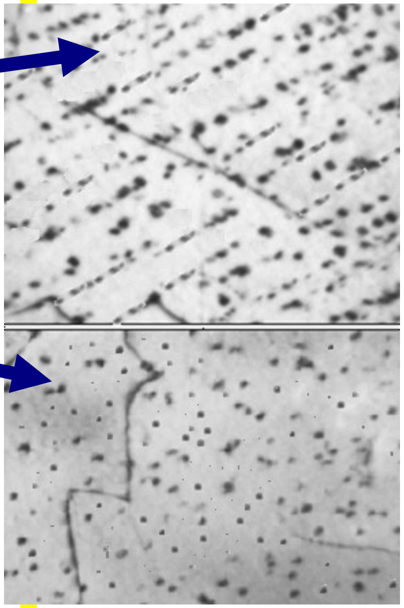
Effect of excess nitrogen on dissolved titanium

Vanadium-Nitrogen Strengthening



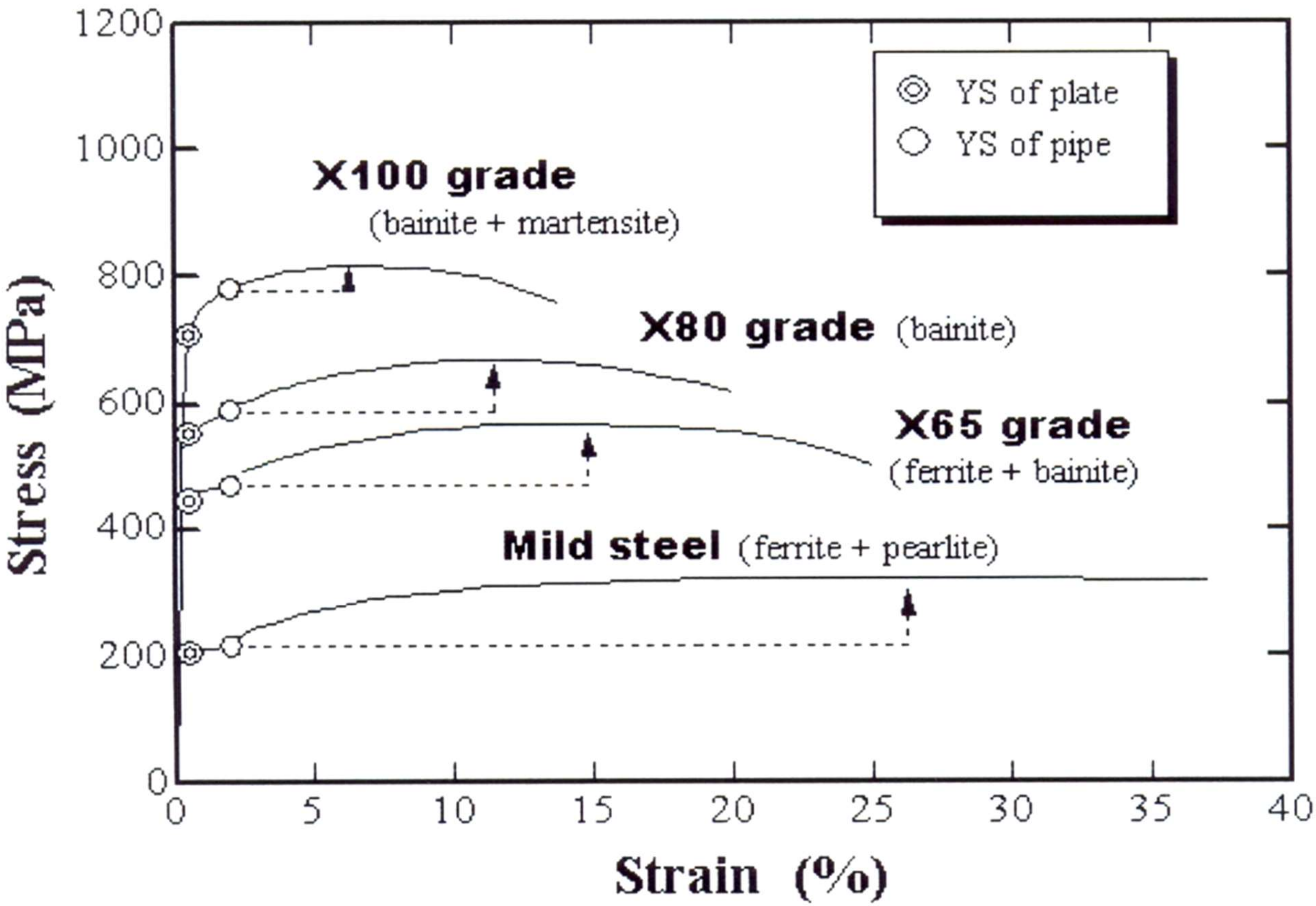
Precipitation of V(C, N) in Ferrite





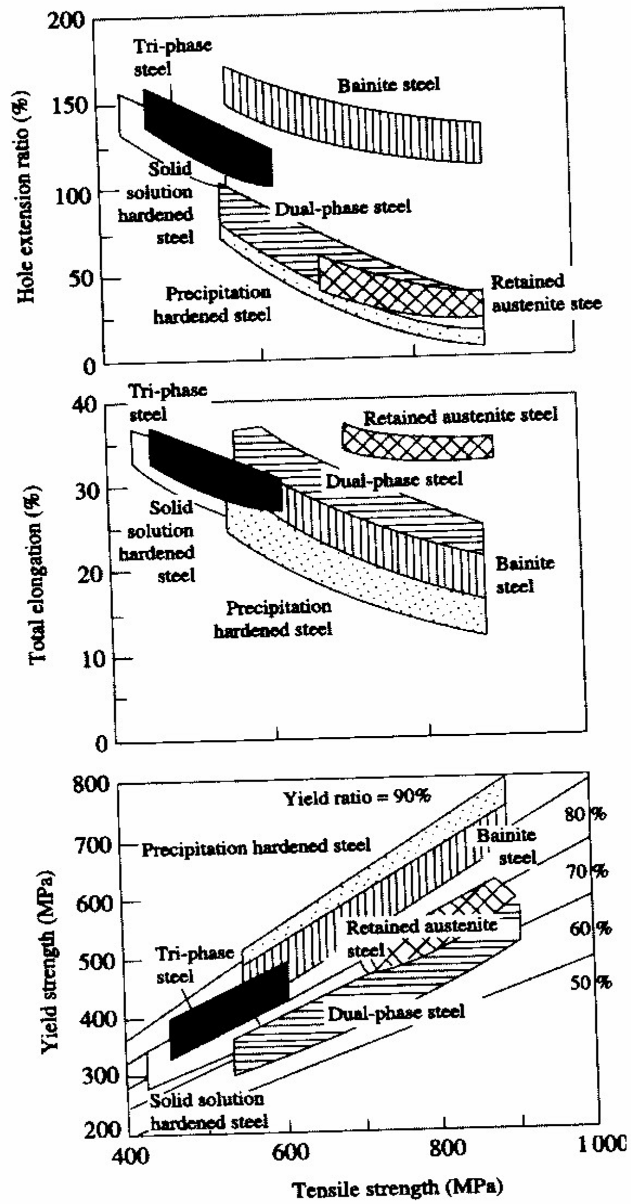
Major Formable Quality Products Developed

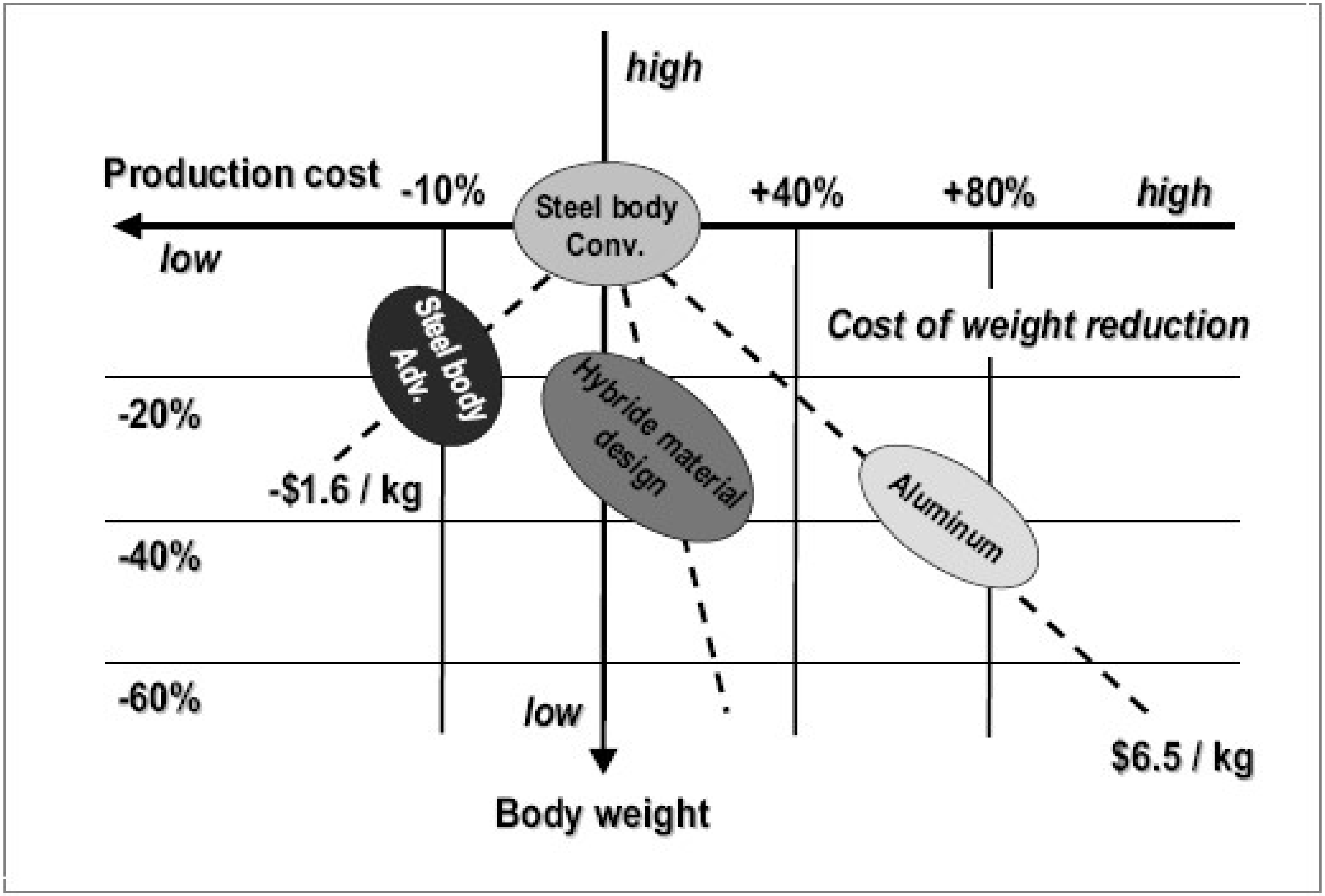
- Hot Rolled
  - Ti-bearing EDD steel
  - High strength fine grained steel (HSFG)
  - Boron treated low carbon steel
  - High strength LPG steels (YS: 255/265/295/ 310) for export
  - High strength Ti-bearing low carbon steel*
  - Up gradation of auto-chassis grade steels
- Cold Rolled
  - High strength cold rolled steel (HSCR)
  - Thin gauge weather resistant steels



YS of plate
YS of pipe
X100 grade
(bainite + martensite)
X80 grade (bainite)
X65 grade
(ferrite + bainite)
Mild steel (ferrite + pearlite)
Stress (MPa)
Strain (%)
0
200
400
600
800
1000
1200
0
5
10
15
20
25
30
35
40

Dependence of plate-to-pipe strength change on skelp Y/T ratio

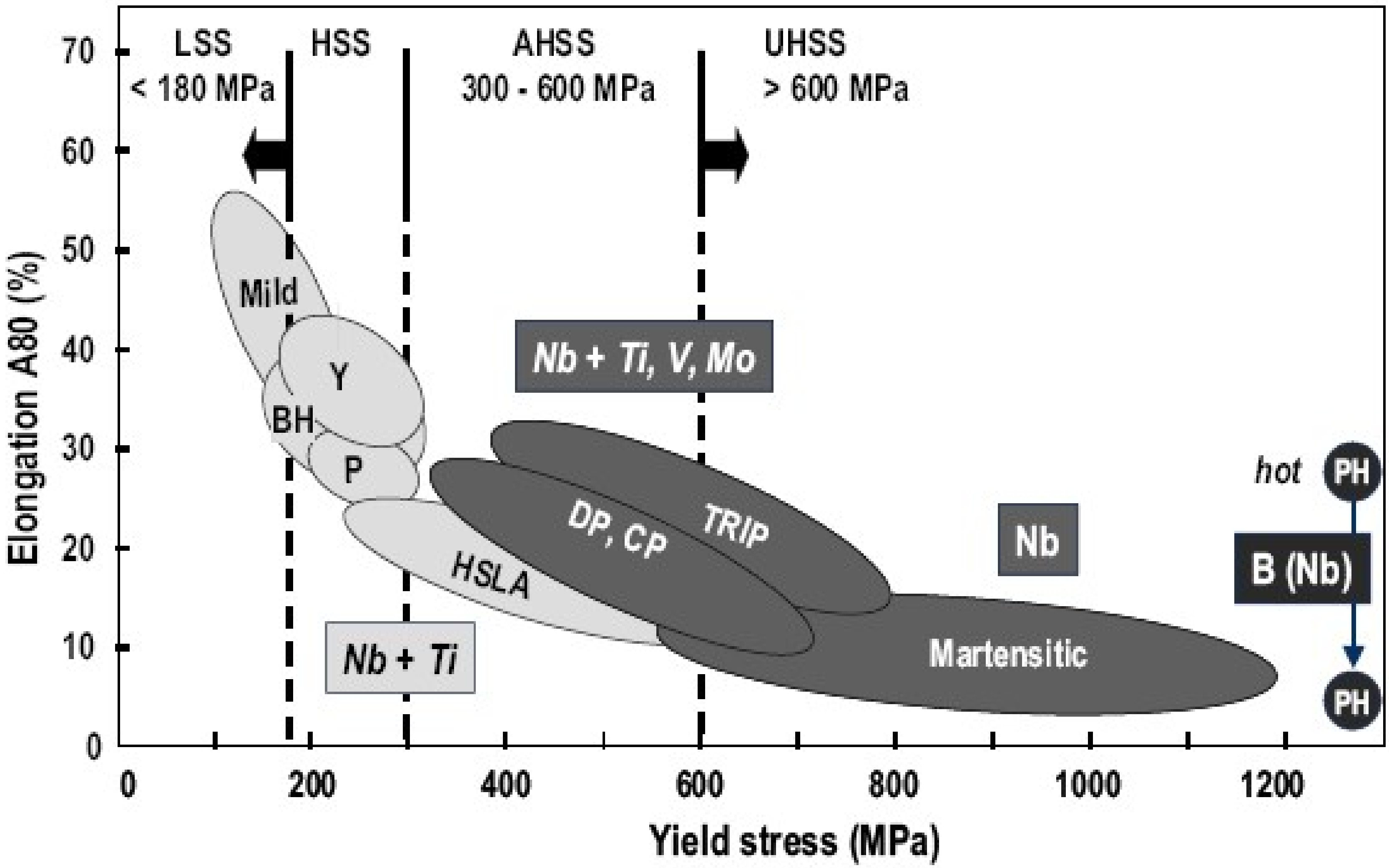

200
150
100
50
0
Hole extension ratio (%)
Tri-phase steel
Bainite steel
Solid solution hardened steel
Dual-phase steel
Precipitation hardened steel
Retained austenite stee
40
30
20
10
0
Total elongation (%)
Tri-phase steel
Retained austenite steel
Dual-phase steel
Solid solution hardened steel
Bainite steel
Precipitation hardened steel
800
700
600
500
400
300
200
Yield strength (MPa)
Yield ratio = 90%
80 %
70 %
60 %
50 %
Precipitation hardened steel
Bainite steel
Retained austenite steel
Tri-phase steel
Dual-phase steel
Solid solution hardened steel
400
600
800
1 000
Tensile strength (MPa)



Impact of material concepts on the weight and cost balance of a car body

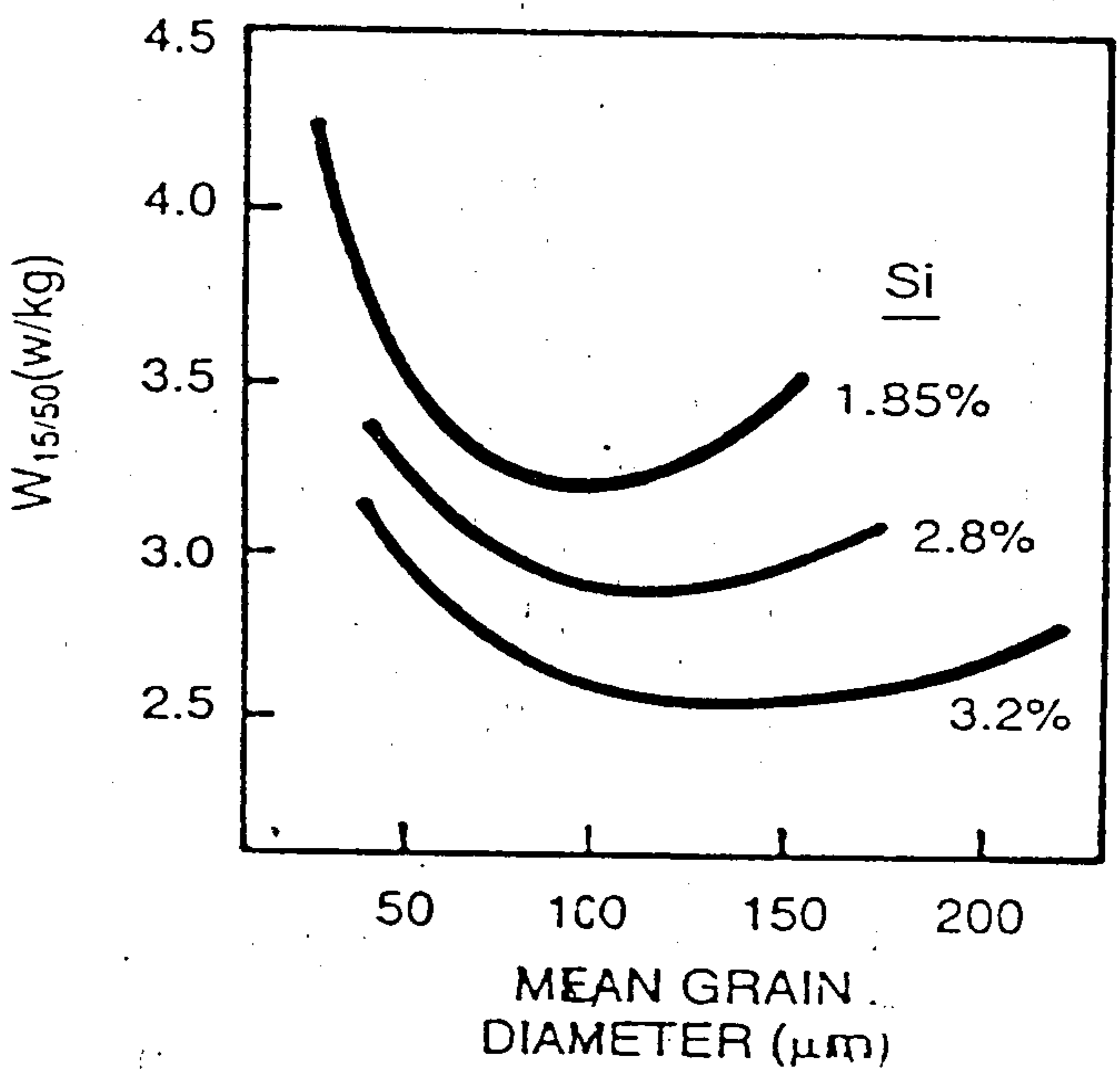
Parts	Main factors controlling thickness	
Panel	Panel stiffness Anti-dents	$E \cdot t^3$ $YS \cdot t^2$
Structure	Rigidity Impact strength	$E \cdot t$ $YS^{0.5} \cdot t^2$
Underbody	Rigidity Disk life	$E \cdot t$ $TS \cdot t^{2.6 \sim 3.6}$
Reinforcement	Impact strength	$YS^{0.5} \cdot t^2$

Main factors controlling the thickness of parts

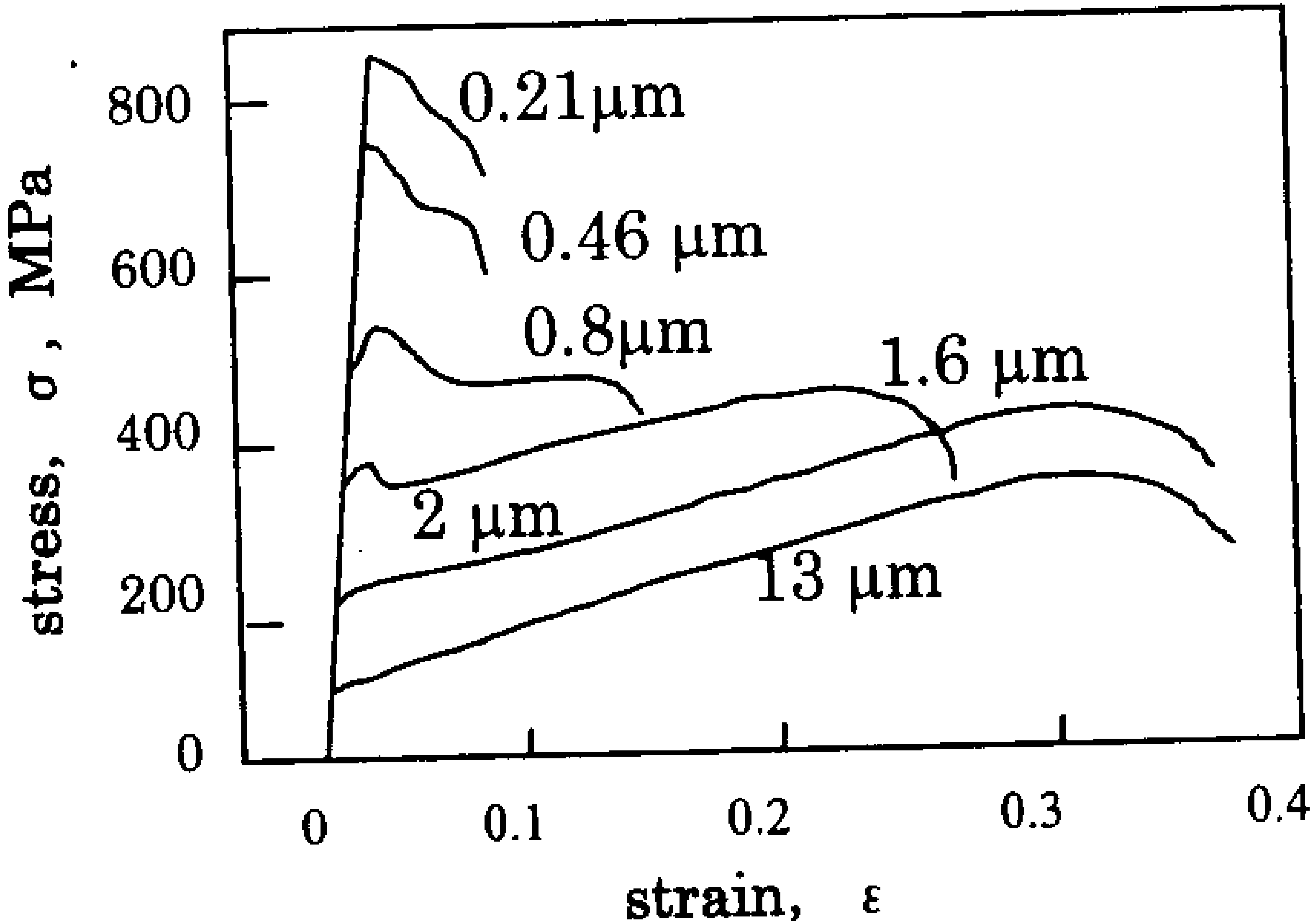

LSS
< 180 MPa
HSS
AHSS
300 - 600 MPa
UHSS
> 600 MPa
Mild
Y
BH
P
HSLA
DP, CP
TRIP
Martensitic
Nb + Ti, V, Mo
Nb + Ti
Nb
hot
PH
B (Nb)
PH
Elongation A80 (%)
Yield stress (MPa)
0
10
20
30
40
50
60
70
0
200
400
600
800
1000
1200

Year		1960	1970	1980	1990	2000
Changes surrounding automobiles		Motorization	Oil crises ESV plan	Anti-corrosion	Introduction of CAFE High grade	Crashworthiness Kyoto Agreement Restriction of CO_2 Recycling
TS MPa	300	· Low YS mild steel		· IF steel · BH steel		· Super formable steel
	400		· C-Mn steel	· P-added HSS	· IF HSS	
	600		· PPT hardened steel	· DP steel	· TRIP steel	
	800			· Bainite steel	· TRIP steel	
	≧1000			· 1000MPa ultra HSS		· 1500MPa ultra HSS
Process			BAF C.A.P.L.	RH/DH	CGL	

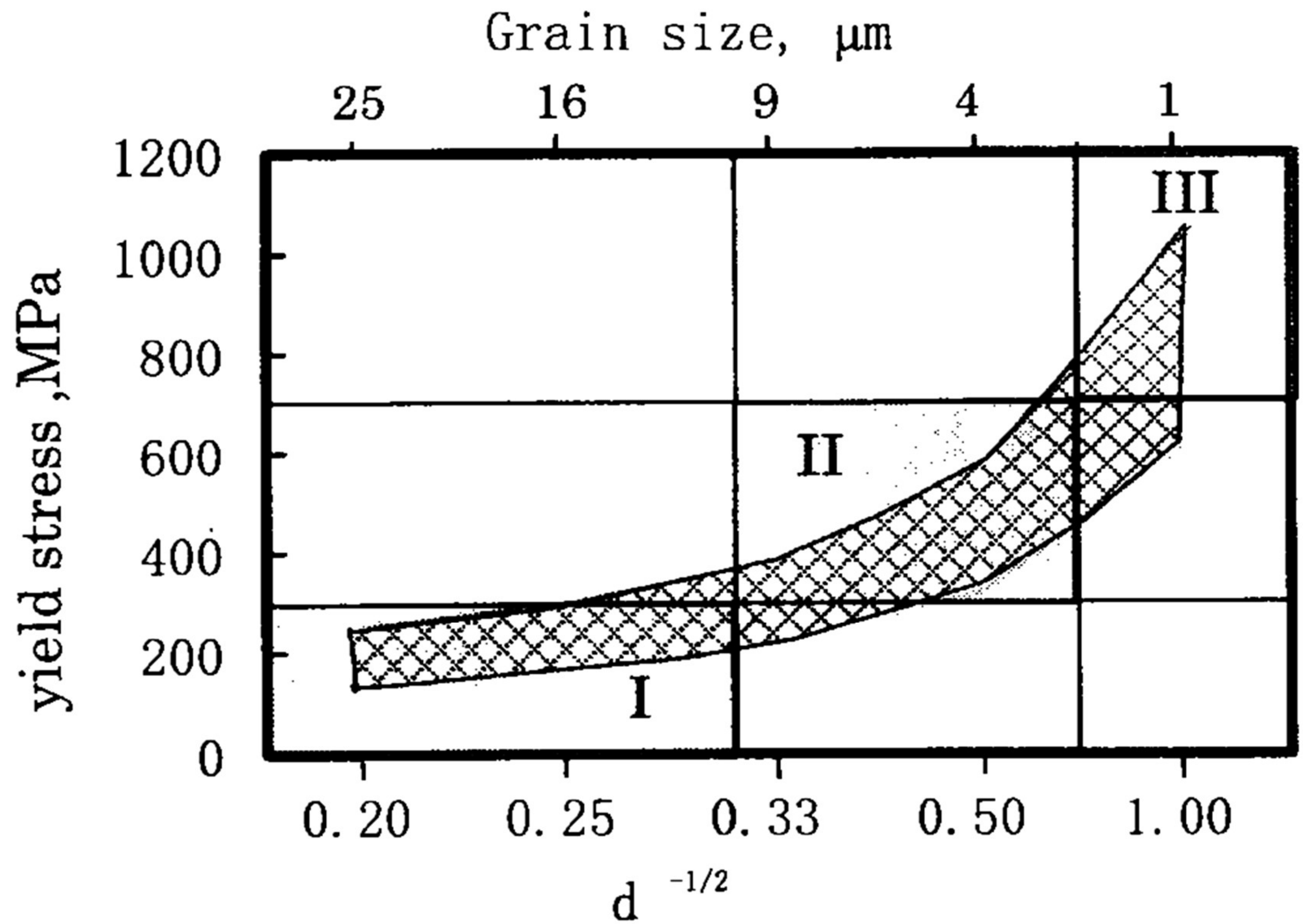
History of sheet steel development of rautomobiles in Japan



4.5
4.0
3.5
3.0
2.5
W15/50(w/kg)
Si
1.85%
2.8%
3.2%
50
100
150
200
MEAN GRAIN
DIAMETER (μm)



0.21μm
0.46 μm
0.8μm
1.6 μm
2 μm
13 μm
800
600
400
200
0
stress, σ, MPa
0
0.1
0.2
0.3
0.4
strain, ε

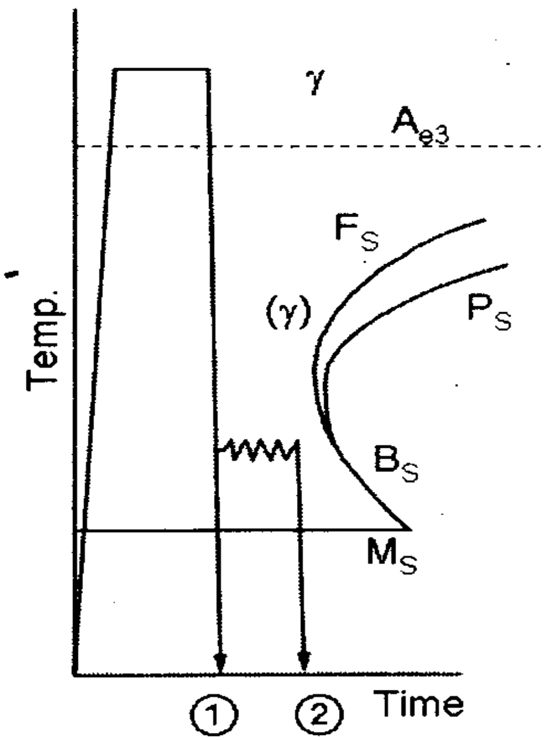


Grain size, μm
25
16
9
4
1
1200
1000
800
600
400
200
0
yield stress ,MPa
III
II
I
0.20
0.25
0.33
0.50
1.00
d -1/2

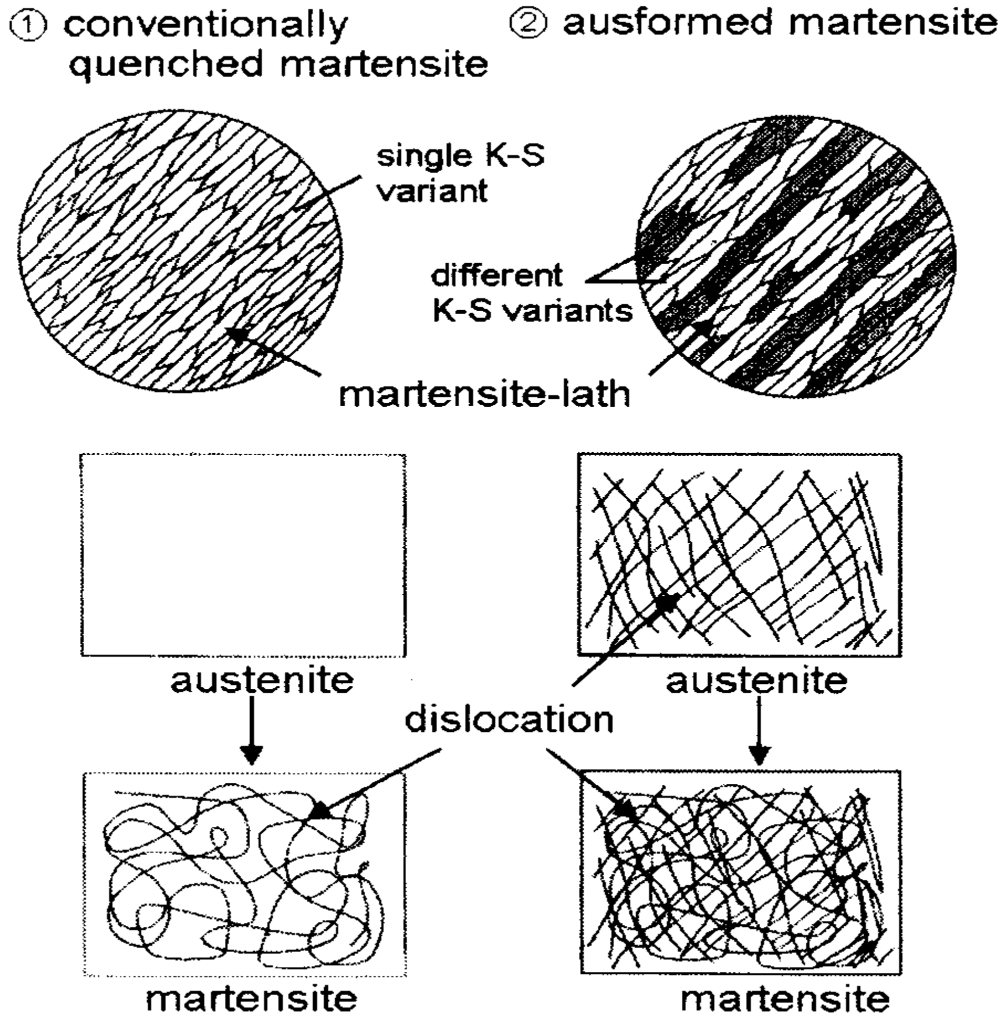
Conclusions

- **The surge in steel production and its sustenance will be dominated by the emerging economy driven by the rapid growth in the infrastructure, construction and urbanization.**
- **The profitability and competitiveness in the business will be guided by the volume of special steels produced by the company.**
- **Innovative market oriented product development for the present as well as in the future should be drawn up in line with the modernization of our plants and entering into collaboration with the leading special steel producers of the world for rapid implementation of technological knowhow.**

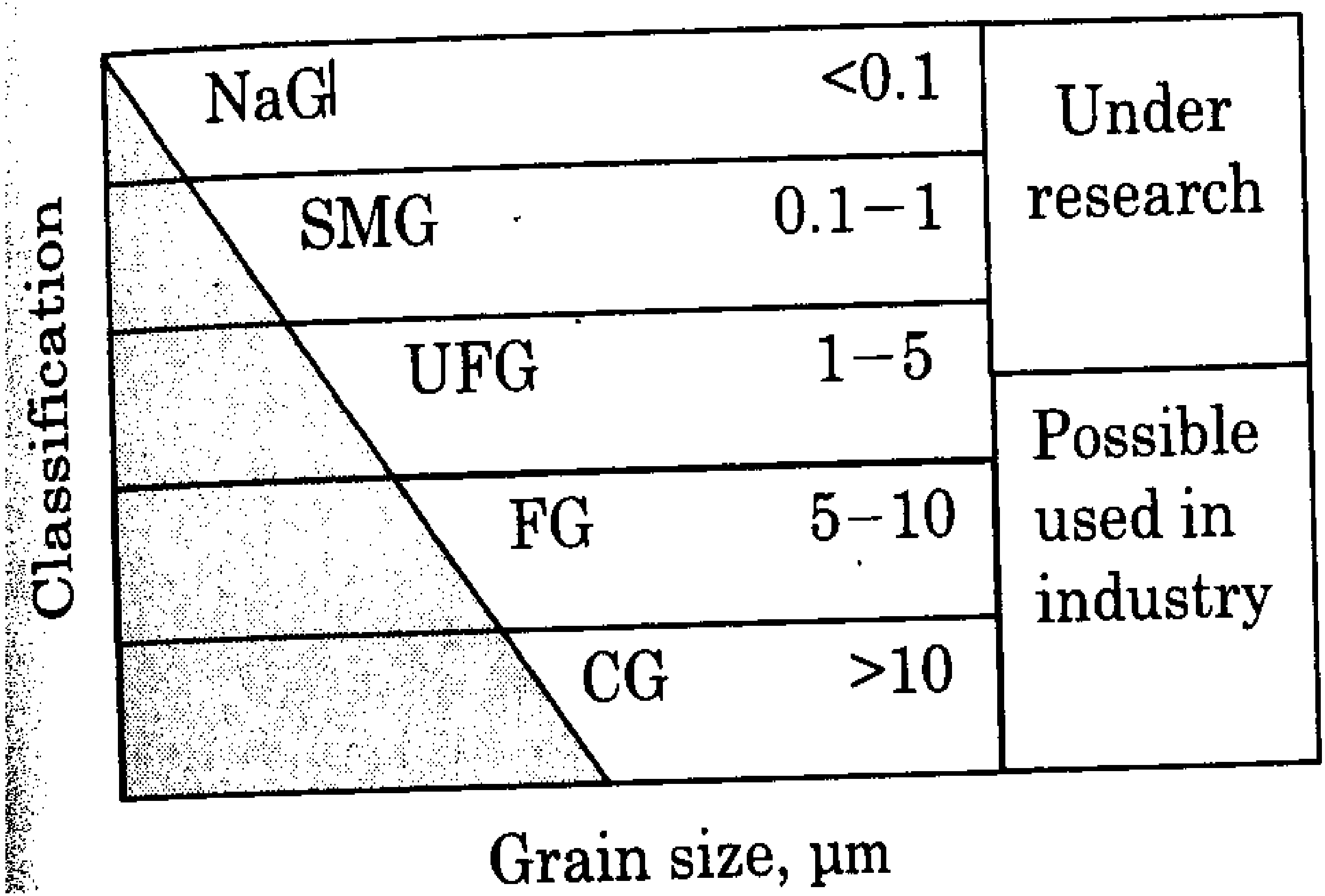
सेल SAIL

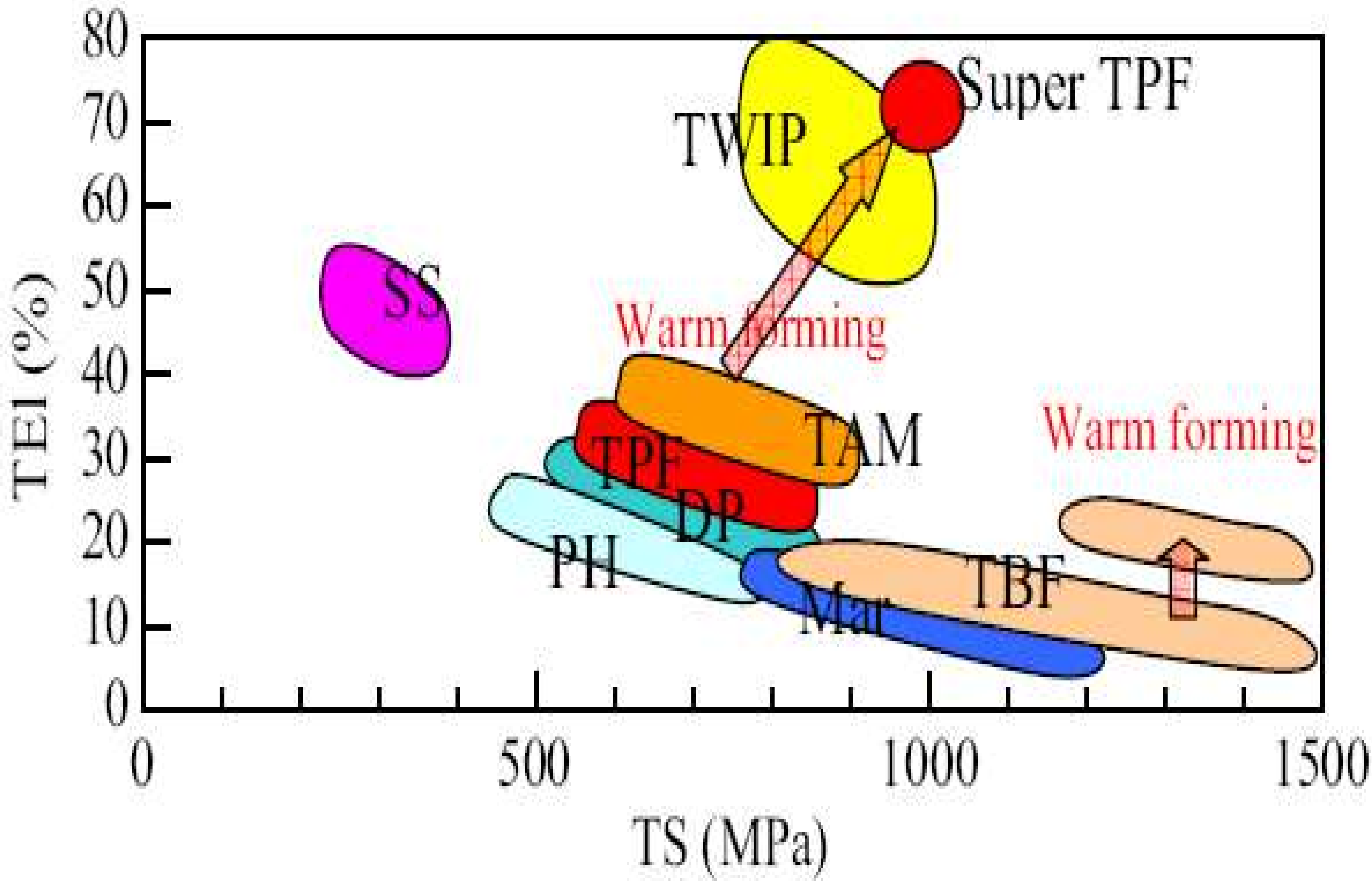


γ
A_{e3}
F_S
P_S
(γ)
B_S
M_S
Temp.
Time
①
②

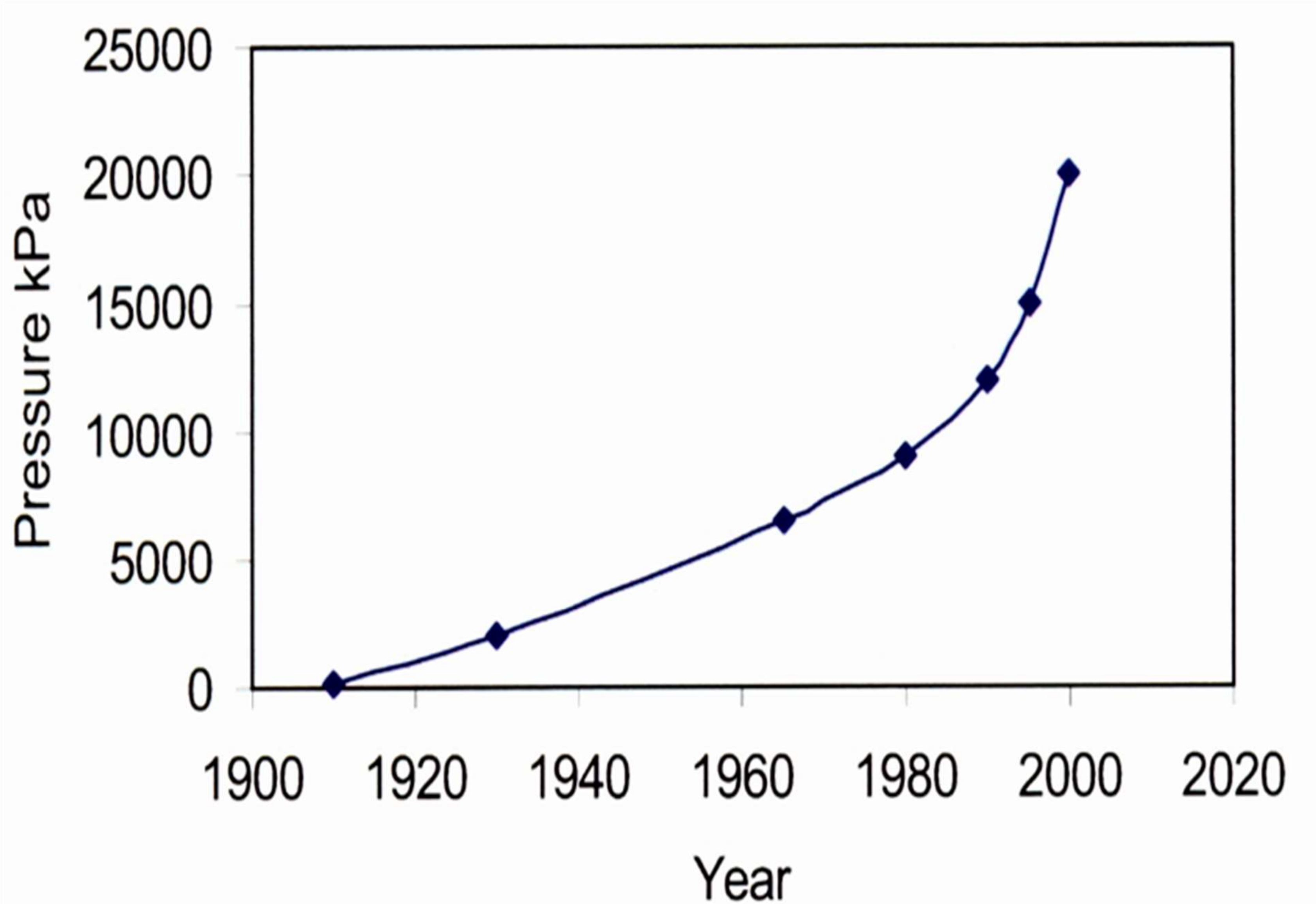


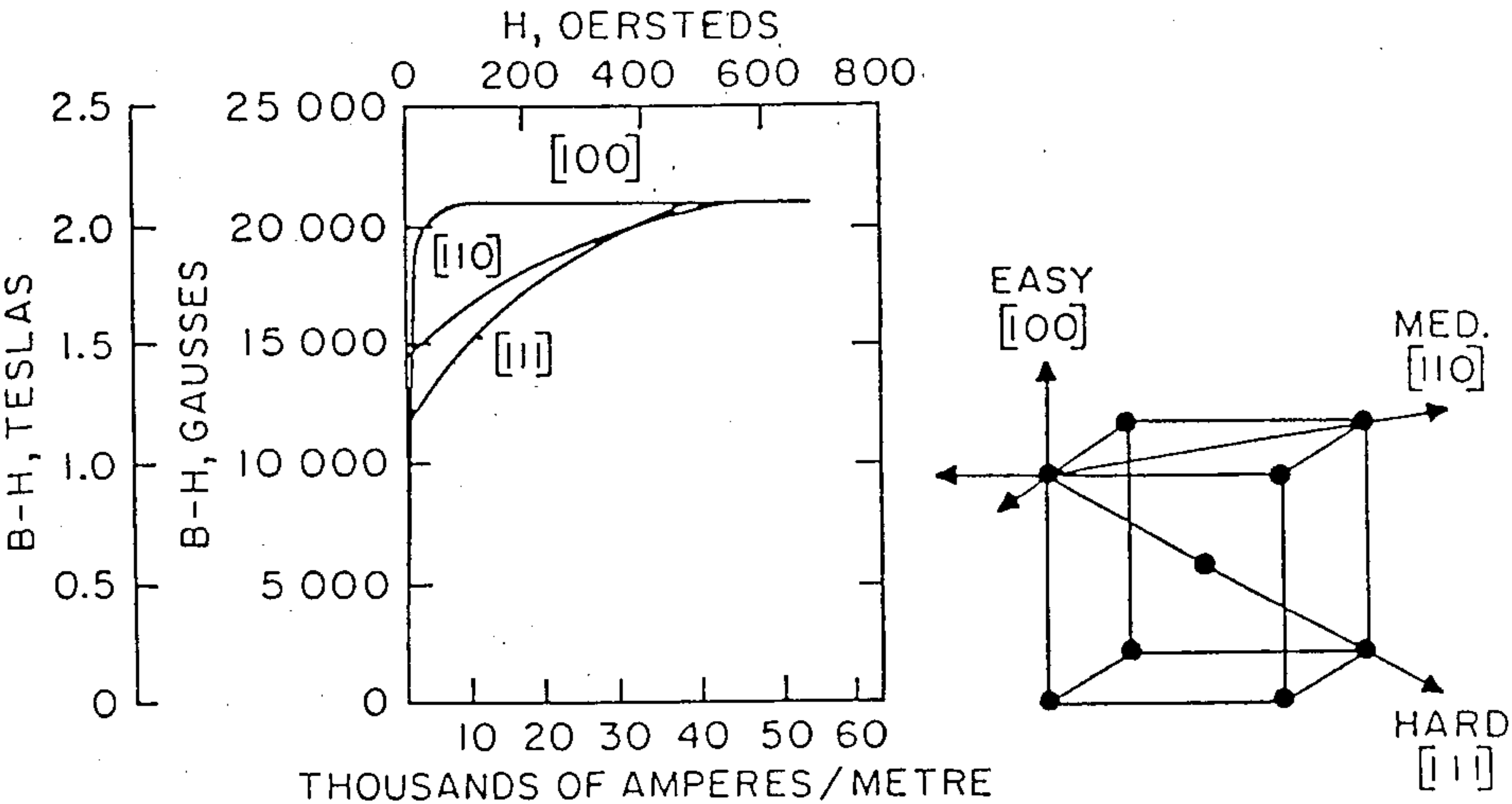
① conventionally quenched martensite
② ausformed martensite
single K-S variant
different K-S variants
martensite-lath
austenite
dislocation
austenite
martensite
martensite

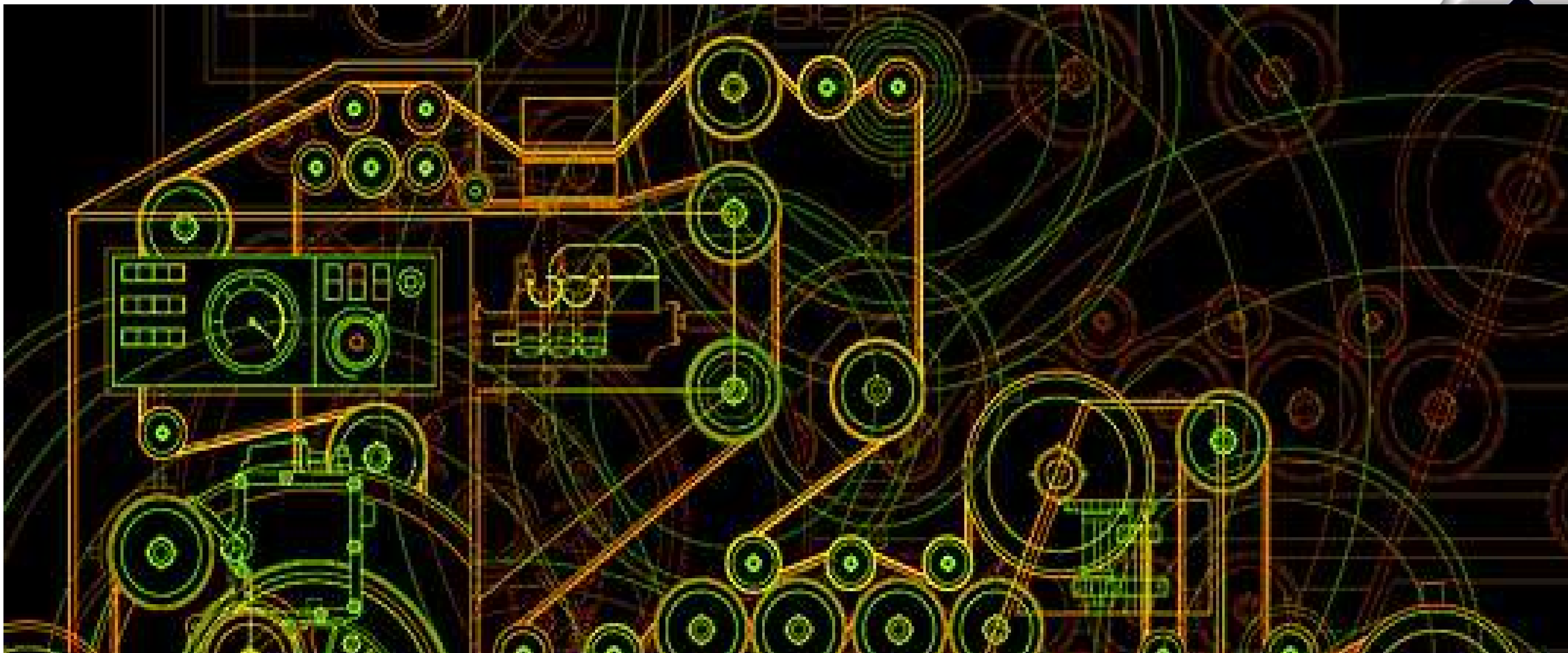

NaG
<0.1
SMG
0.1–1
UFG
1–5
FG
5–10
CG
>10
Under research
Possible used in industry
Classification
Grain size, µm



TEl (%)
TS (MPa)
0
10
20
30
40
50
60
70
80
0
500
1000
1500
Super TPF
TWIP
SS
Warm forming
TAM
Warm forming
TPF
DP
PH
TBF
Mar


25000
20000
15000
10000
5000
0
Pressure kPa
1900
1920
1940
1960
1980
2000
2020
Year


H, OERSTEDS
0
200
400
600
800
2.5
2.0
1.5
1.0
0.5
0
25 000
20 000
15 000
10 000
5 000
0
B-H, TESLAS
B-H, GAUSSES
[100]
[110]
[111]
10 20 30 40 50 60
THOUSANDS OF AMPERES/METRE
EASY
[100]
MED.
[110]
HARD
[111]



Esa Kolu / Large Drives and Machines, ABB BU Metals

Modern Drives: The key enabler for Advances in Rolling Technology

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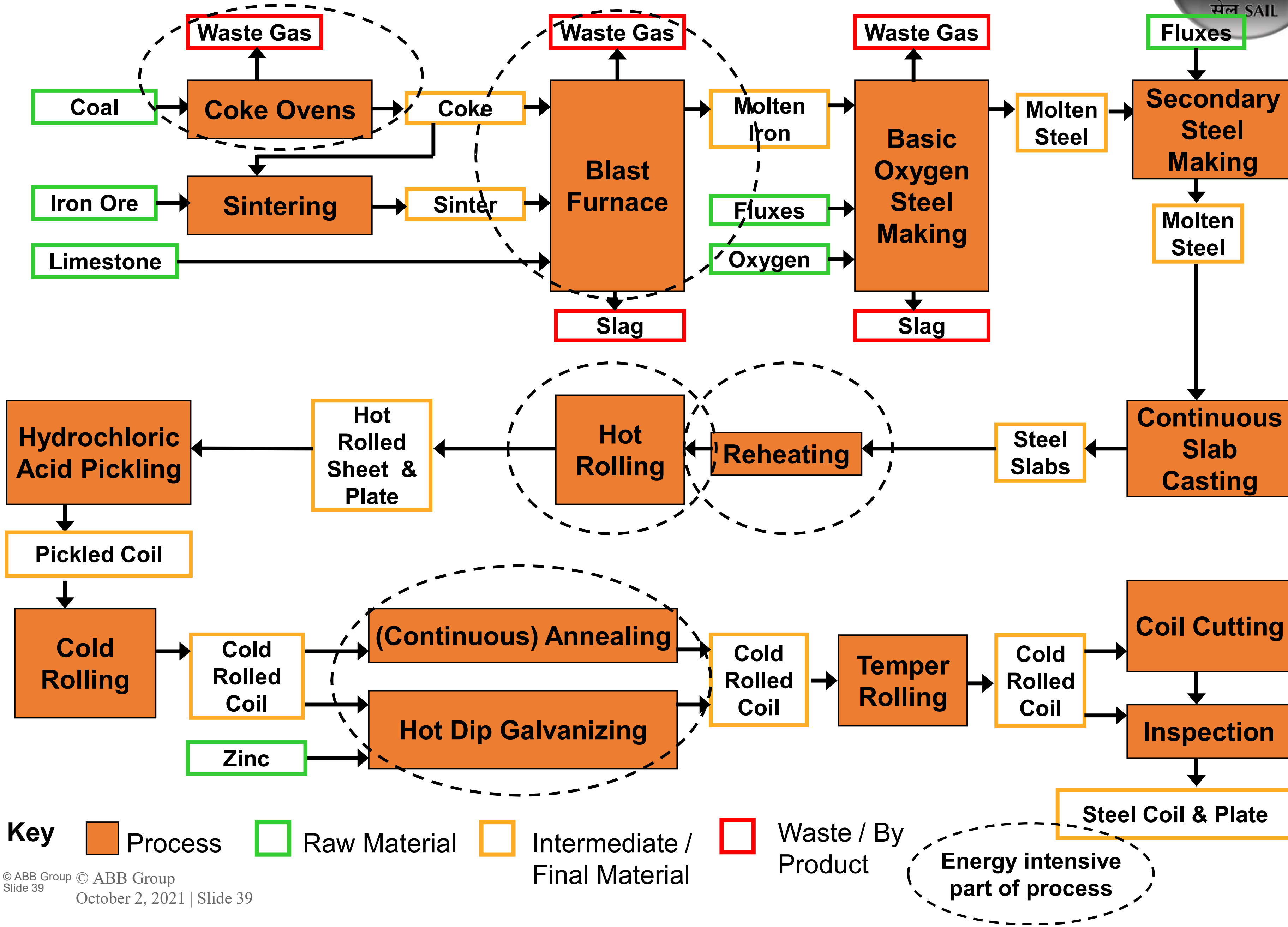
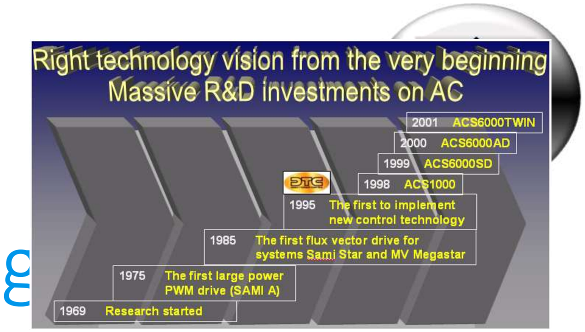
October 2, 2021 | Slide 37

Steel Making
Backround

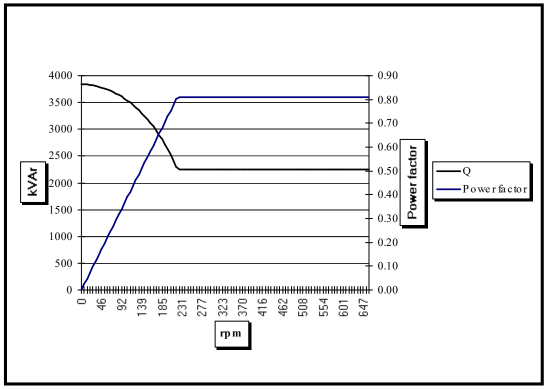
- Steel plants getting larger and more advanced
  - Greenfields
  - Brownfields
- Environmental issues with extra focus in all levels
  - Energy efficiency
  - Reduction of CO_2 emissions
- Advantages of drive systems should be considered in all parts of Steel production
  - Rolling Mills
  - Blowers (incl. traditional steam turbines)
  - Descaling pumps

Steel Making Process (energy intensive processes)

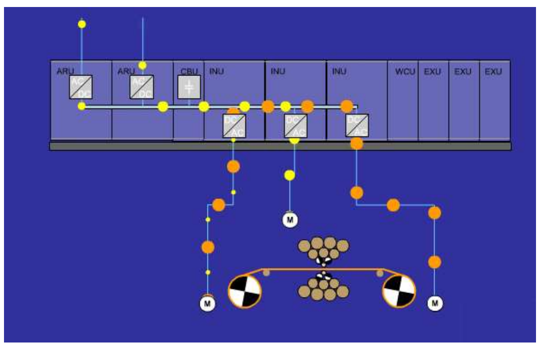


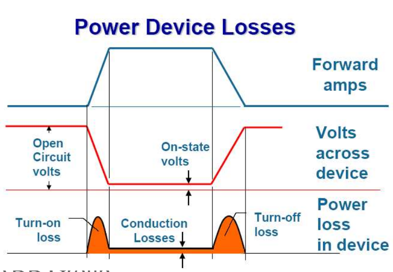


Drives in Rolling Mills
Step-change on Drives technolog



- Earlier Drives
  - Based on thyristors
  - Direct conversion from network to motor
    - Poor Power factor, harmonics content
- Recent developments
  - New MV semiconductors technology (IGCT)
  - Fully optimized performance
  - Improved total system efficiency
  - Improved reliability and maintainability

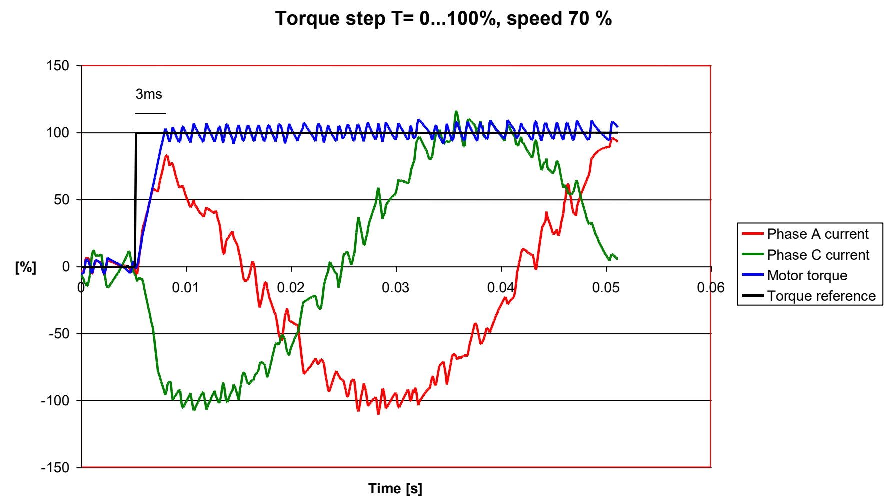


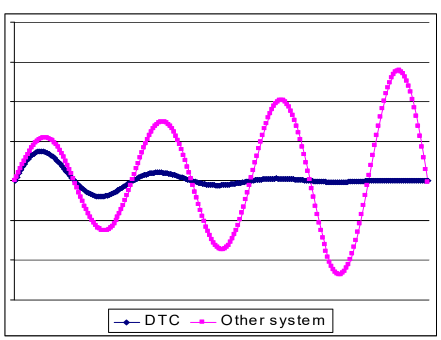


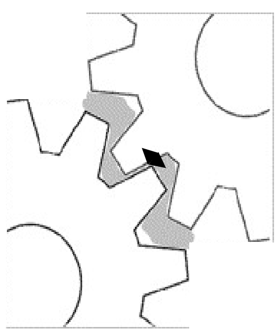
Drives in Rolling Mills

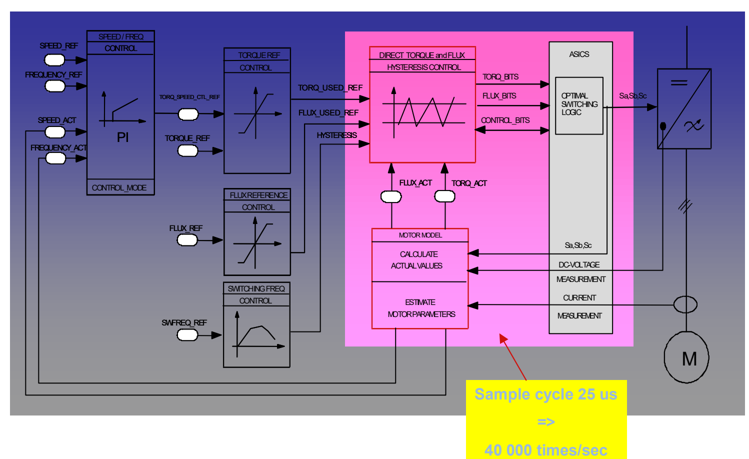
Enablers on Load side

- Latest Motor control techniques (DTC with RMD) enables:
  - Minimizing mechanical stress to heavy machinery and large fans by canceling possible torque overshoot and/or mechanical oscillation.
  - Maximizing product quality by optimal dynamic behavior of total Drive Train



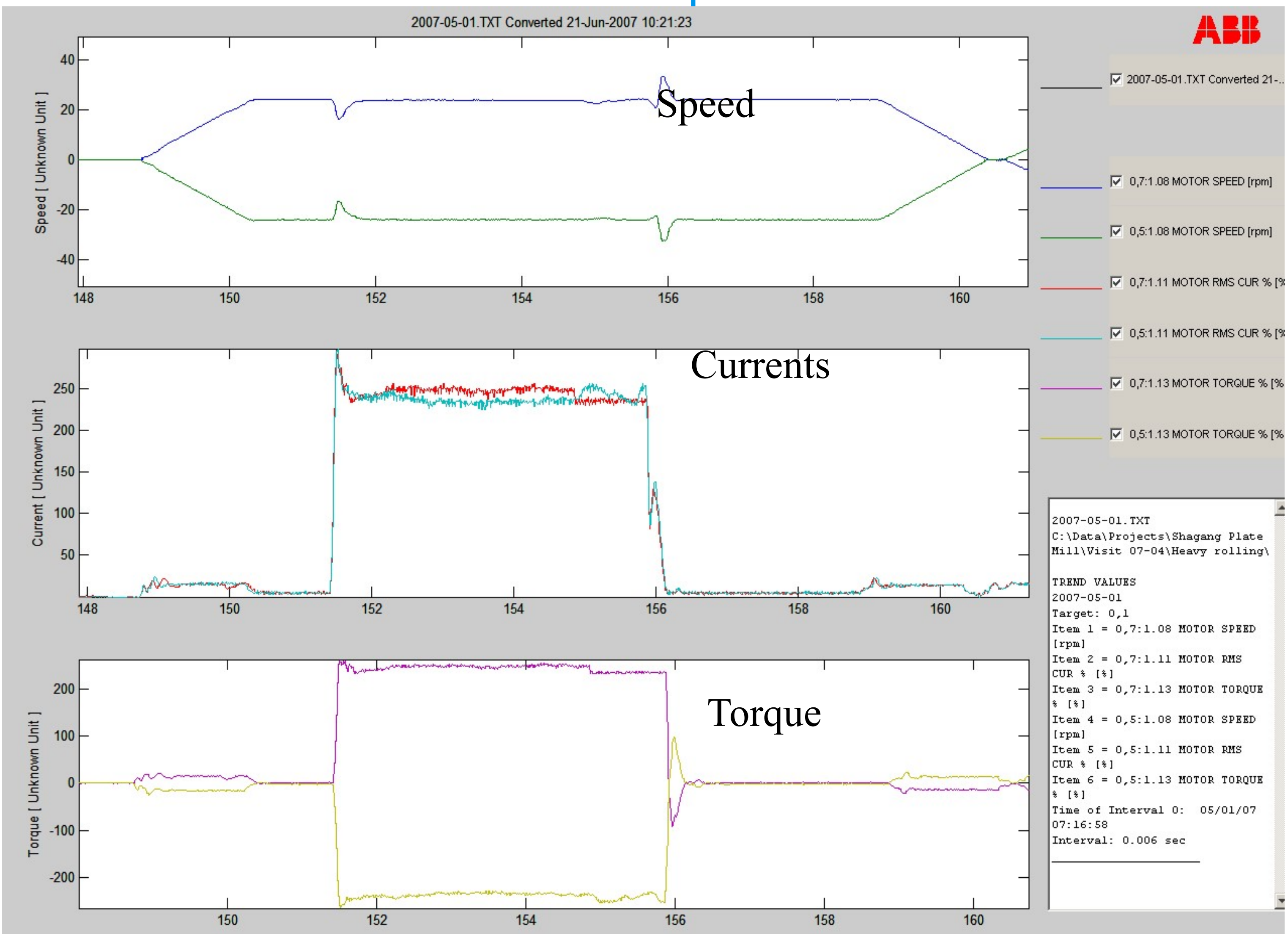






Drives in Rolling Mills

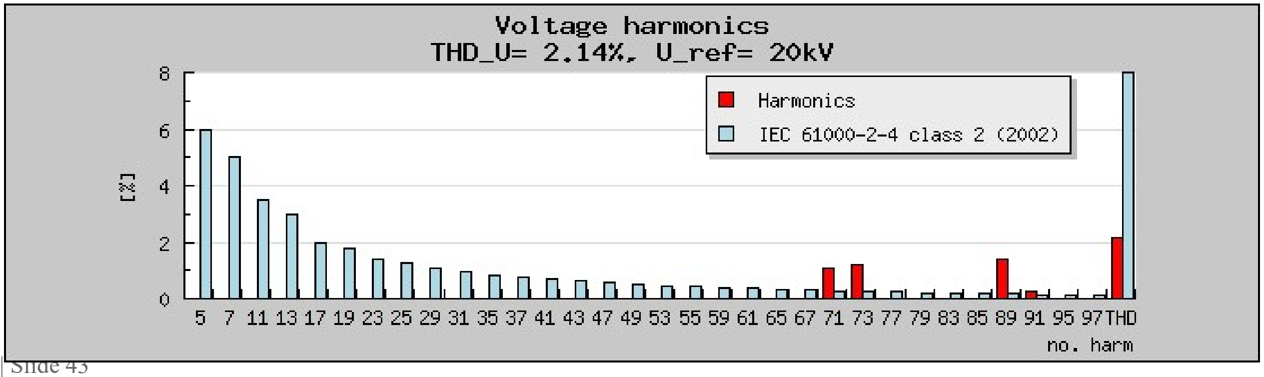
Enablers on Load side - performance



Drives in Rolling Mills

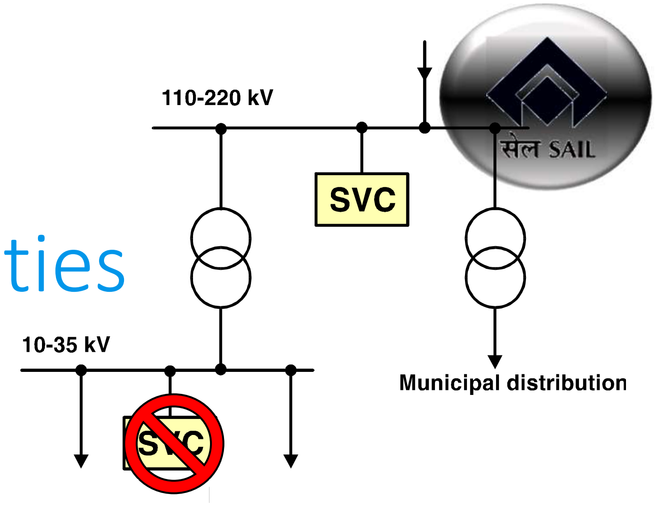
Enablers on Network side

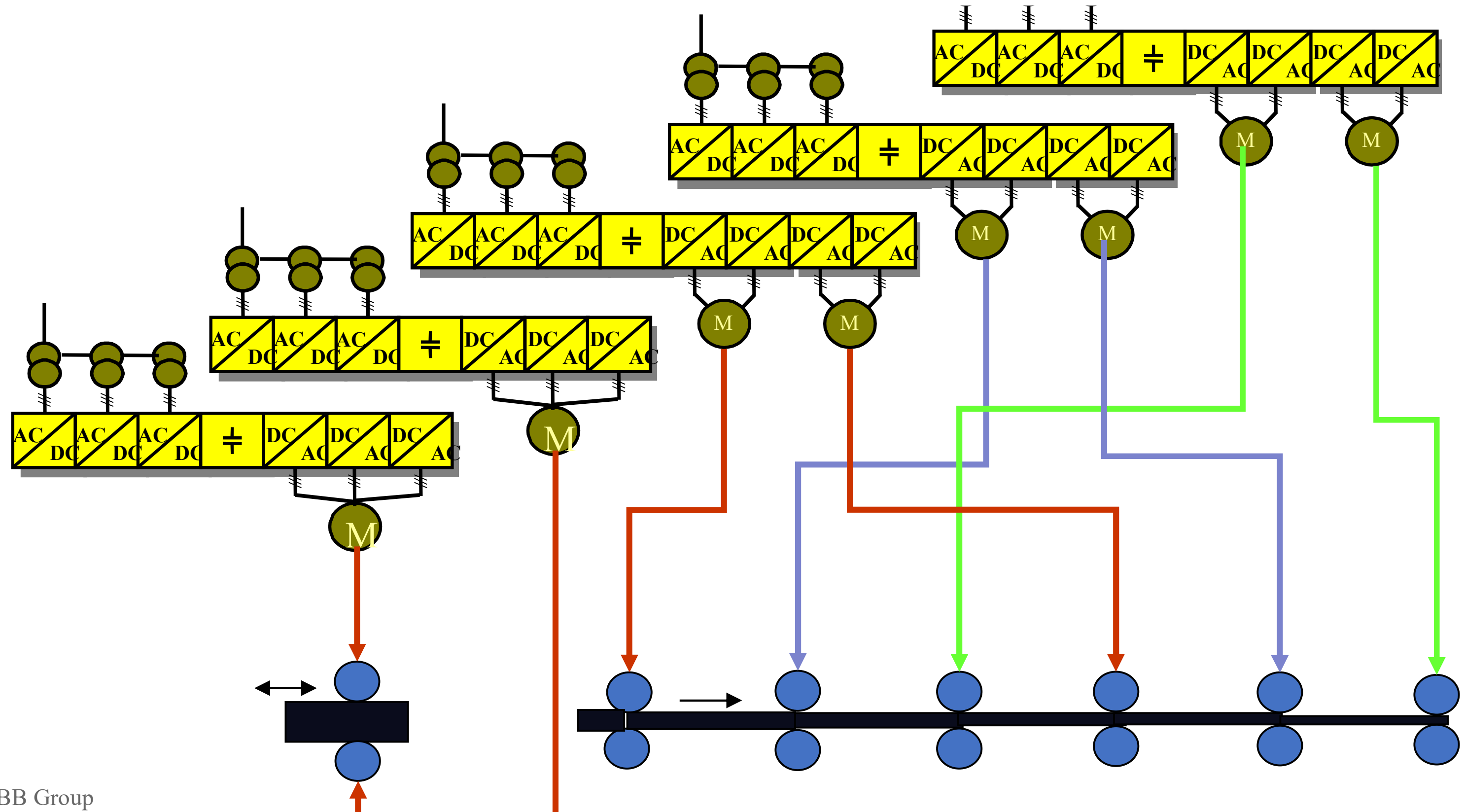
- Optimised
  - converter & transformer configurations
  - pulse patterns / harmonics
- Separate equipment for network quality recovery not needed
  - Securing power factor 1.0 at all load conditions
  - Minimizing harmonic content at source
- Common-DC configurations used to minimize power taking from network



Drives in Rolling Mills

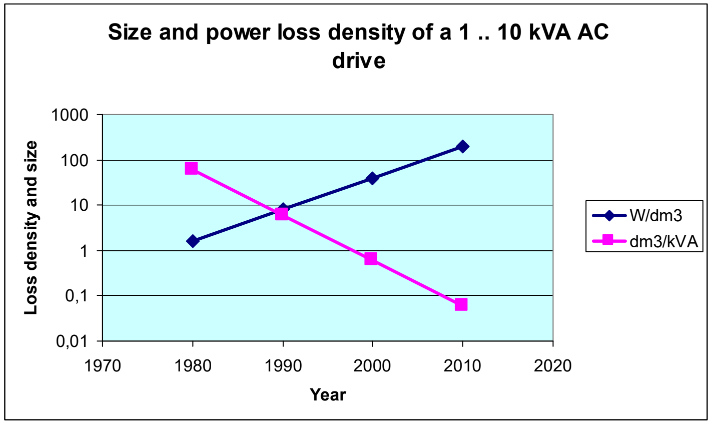
Enablers creates new possibilities





Drives in Rolling Mills
Furure Trends

- Next generation semiconductors
  - suitable for 6.6kV (for **high performance applications**) not available
  - technological steps needed
- 3kV / 3-level design is expected to dominate installations for some more years to come.
- Power densities of products are increasing continuously
  - Maintenability
- Future investments more dependent on
  - Environmental aspects
  - Product life cycle management
  - Total life cycle cost



Power and productivity
for a better world™

IMPROVEMENT IN QUALITY OF ANNEALED COILS AT CONTINUOUS ANNEALING LINE

AK MARIK
RDCIS
SAIL

QUALITY REQUIREMENTS

- Thinner Gauge
- Higher Strength
- Dimensional Accuracy
  - Gauge tolerance – (+/-) 0.05mm
  - Crown - < 30 µm
- Surface Defects
  - Free from any surface defects
- Surface Cleanliness
  - Reflectance > 90%
  - Carbon residue $< 7 mg/m^2$
  - Iron residue $< 20 mg/m^2$

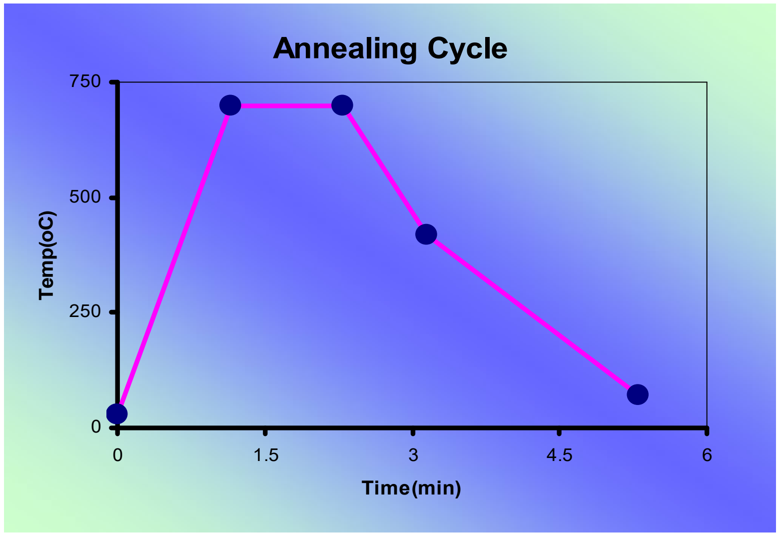
Surface Cleanliness is one of the Quality requirements of Cold Rolled Strip

ANNEALING

- Releasing internal stresses
- Grain refinement of elongated grain
- Improves mechanical properties

PROCESS

- Heating slightly above critical temperature(AC_1) in controlled atmosphere for recrystalisation
- Soaking at Annealing temp. for nucleation of new set of grains and grain growth
- Cooling at controlled rate for arresting grain growth



PROBLEMS

Lower Productivity

- Low thermal input and low line speed
- Inconsistent metallurgical properties

Poor Strip surface Quality

- Improper squeezing and rinsing

SCIENTIFIC APPROACH

Higher Productivity

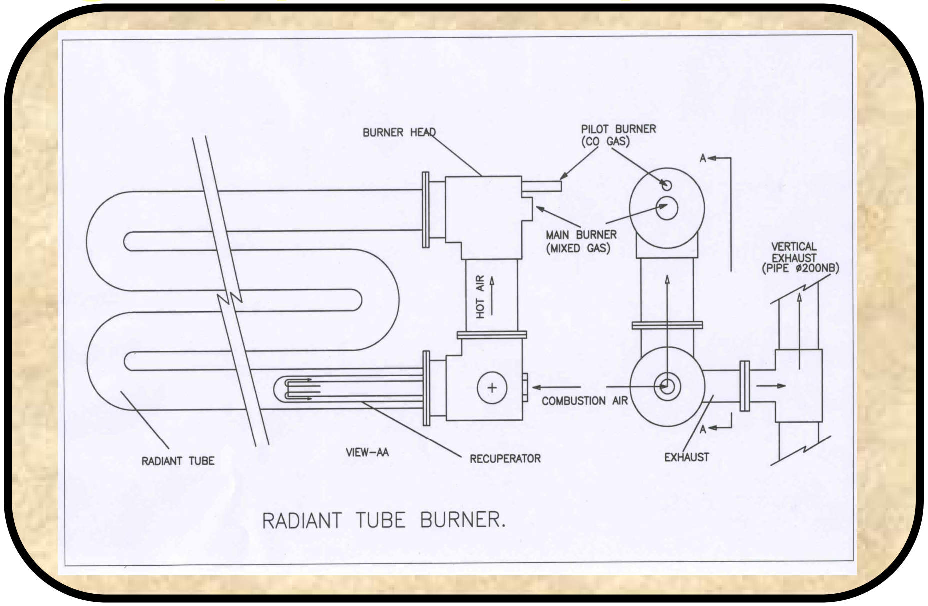
- Increasing thermal input
- Modification of Annealing Cycle

Improving Strip Cleanliness

- Hydraulic Roll Squeezing system
- High Pressure Rinsing system

IMPROVEMENT IN THERMAL INPUT

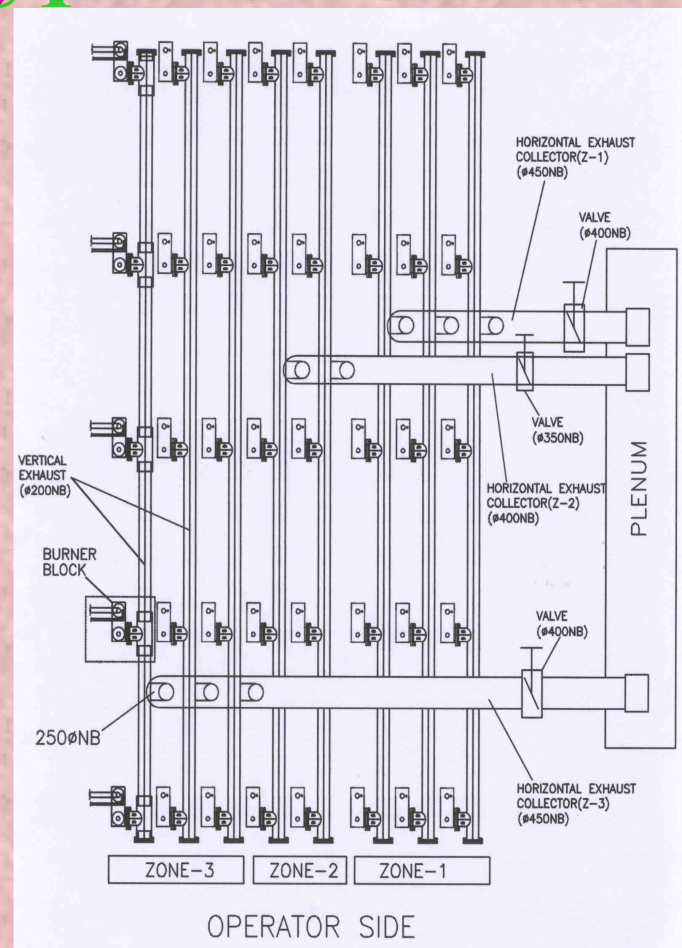
- Suction air pressure/velocity, exhaust gas temperature/pressure and flue gas analysed
- Suction air flow and velocity enhanced by additional opening of 50mm after recuperator
- Damaged/ choked exhaust gas pipe lines replaced
- Increased suction air pressure from 10mmWC to 40mmWC & increased suction air velocity from 4m/s to 12m/s



IMPROVEMENT IN THERMAL INPUT

- Increased gas flow by changing zonal gas flow control valves with pneumatic controls
- Increased mixed gas flow rate from 1500Nm^3/hr to

  2400Nm^3/hr
- Proper combustion of air-fuel mixture in burner
- Increased thermal input 740^{o}C~760^{o}C



ANNEALING CYCLE

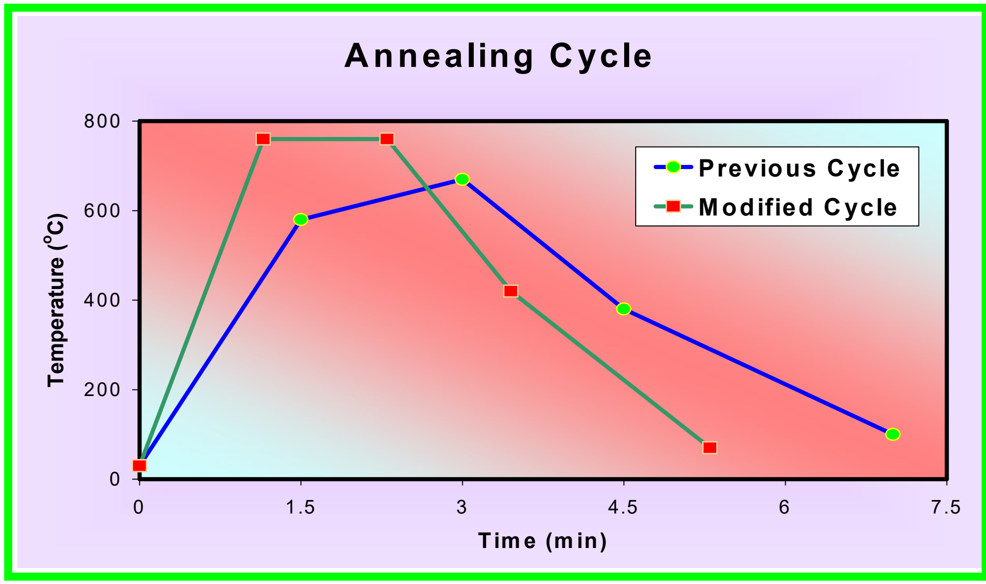
- Lab simulation of Annealing cycle in Thermo-Mechanical Simulator(Gleeble-3500) of diff. strip thickness and heating & cooling rate
- Optimized Annealing cycle for reduced strip hardness & uniform mechanical properties

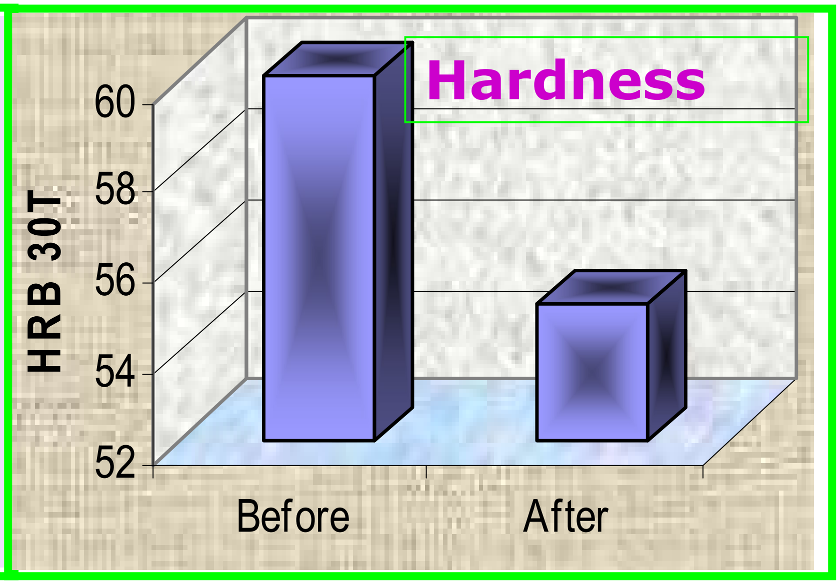
MODIFIED ANNEALING CYCLE

Gauge (mm)	Speed (mpm)	Heating Zone (°C)			Holding (°C)	Cooling (°C)	Exit Temp (°C)
		Z # 1	Z # 2	Z # 3	Z # 4 - 6	Z # 7 - 9	Z # 10
0.27–0.30	70 – 120	550 - 630	620 - 690	660 - 690	700 - 730	420 - 440	70 – 80
0.35- 0.40	60 - 80	570 - 650	640 - 680	680 - 700	720 - 750	420 - 440	80 - 90
0.45- 0.50	50 - 70	580 - 660	650 - 690	680 - 710	720 - 750	420 - 440	80 - 90
0.60- 0.63	40 - 60	580 - 660	650 - 690	680 - 710	720 - 750	420 - 440	80 - 90

ANNEALING CYCLE

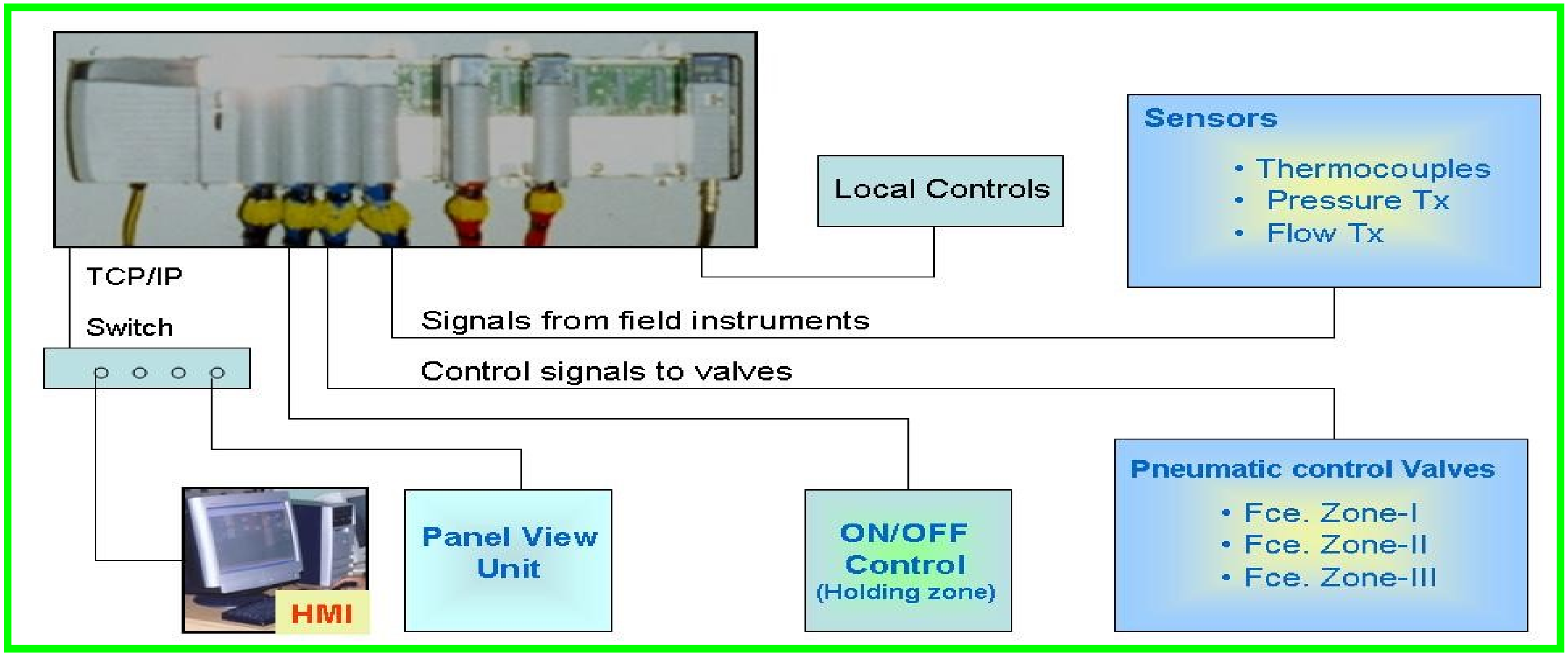
- Desired microstructure and grain size of annealed strip achieved
- Achieved uniform and reduced strip hardness <55 HR 30T with better mechanical properties





DATA ACQUISITION & CONTROL

- PLC based Data Acquisition system & Process Controller designed and installed
- Controlling and inter-locking of 32 nos. Process parameters from different field instruments
- Auto operation of Annealing Furnace



SOURCES OF CONTAMINANTS

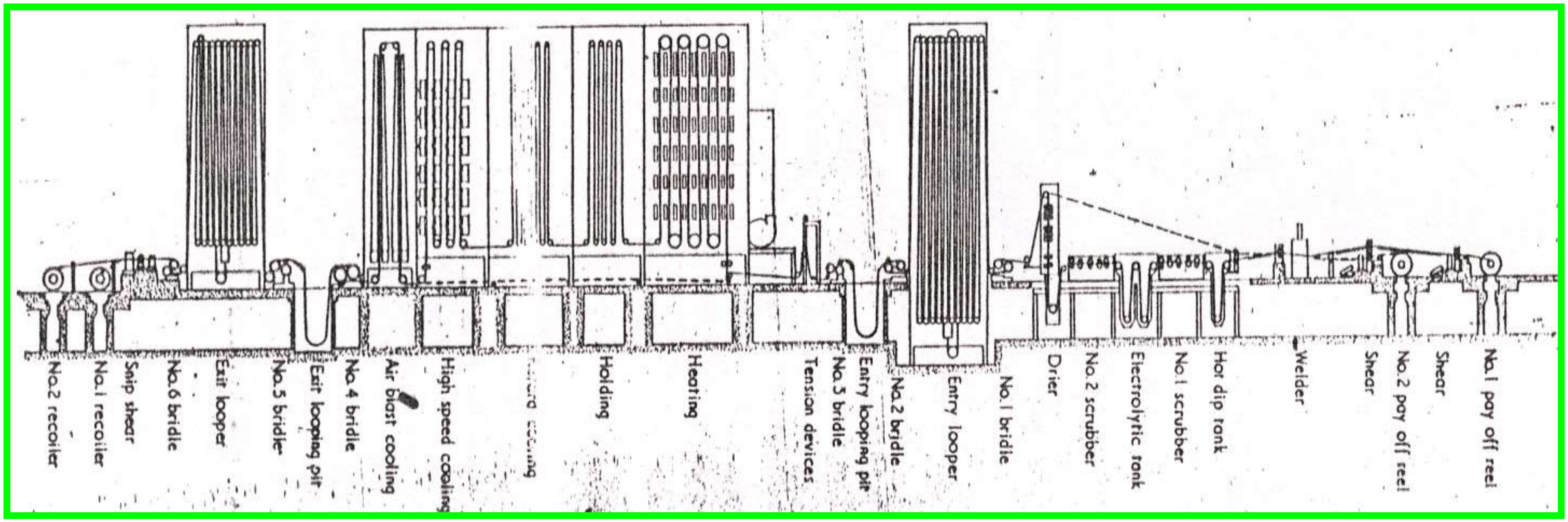
- Cold rolling emulsions
- Metal particles
- Iron fines
- Cracked hydrocarbons and hydraulic oils

Average values of residues after TCM on strip

- Emulsion oil 100-250 mg/m^2
- Iron fines 50-150 mg/m^2

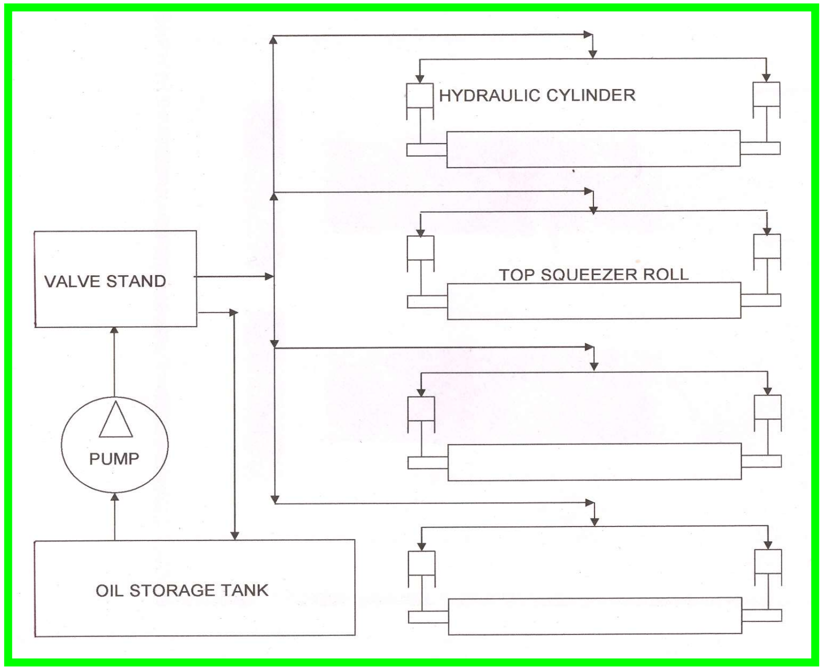
CLEANING SECTION AT CAL

- Alkali cleaning section
- Electrolytic cleaning section
- Scrubbing section
- Squeezing section
- Rinse section
- Hot Air Dryer



HYDRAULIC SQUEEZING SYSTEM

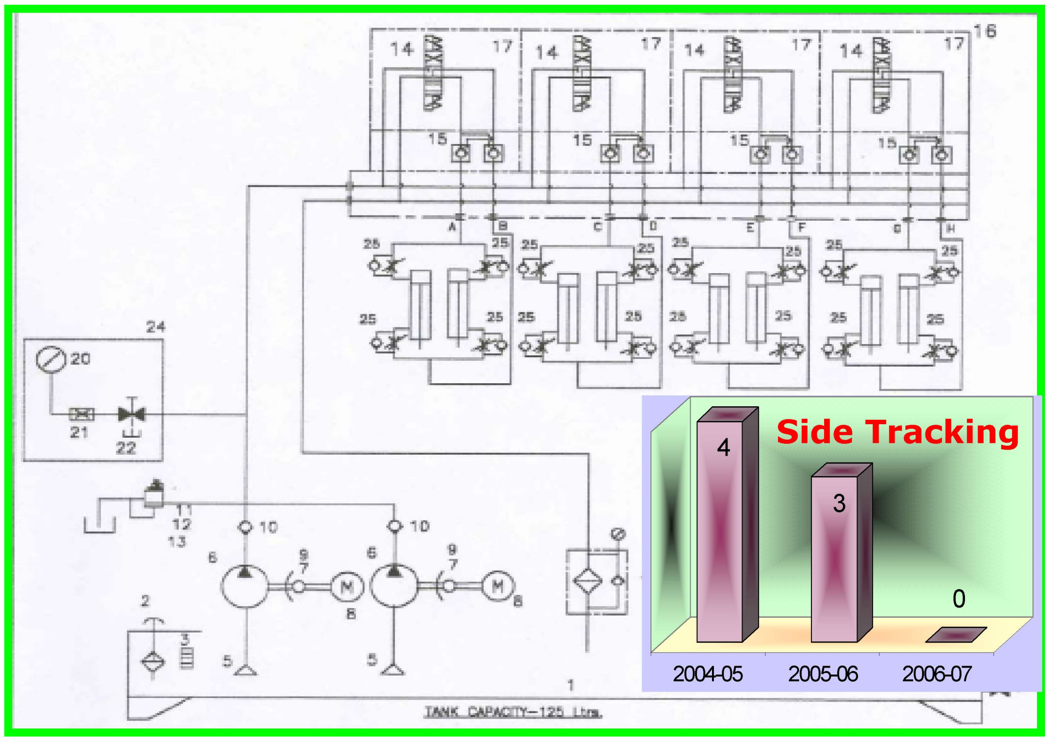
- Pneumatic cylinders are getting damaged due to contaminants like dust, moisture in industrial air led to non-uniform squeezing effect, strip side tracking and strip breakage



- Hydraulic power-pack with valve stand to each squeezer roll set for const. pressurized supply
- Metered movement of top squeezer roll & uniform squeezing pressure distribution across barrel

HYDRAULIC SQUEEZING SYSTEM

- Incorporation of pulsation dampener with throttle and check valves for meter-in flow hydraulic circuit
- Avoided strip side-tracking and strip breakage



- Effective squeezing effect and arresting carry-over residuals on strip surface
- Helped to improve strip cleanliness level and operating at higher line speed

HIGH PRESSURE RINSING SYSTEM

Quantity of Rinse water

L = D [Co / Ci] / N

L = rinse water consumption (lit / m^2 surface)

D = drag-out (lit / m^2 surface)

C_o = concn. of cleanser solution at exit of tank

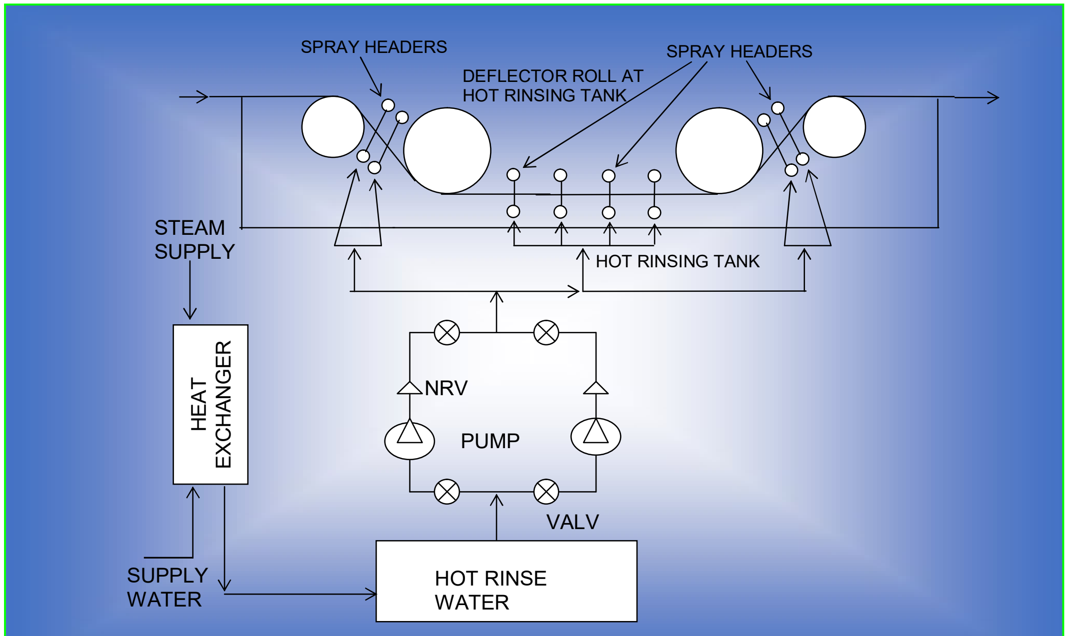
C_i = concn. of cleanser solution at entry of tank

N = number of spray headers

Optimized quantity of hot rinse water for effective degreasing of strip surface at higher line speed

HIGH PRESSURE RINSING SYSTEM

- Designing of High Pressure Rinsing system with higher capacity pump
- Tongue type spray nozzle for higher impact

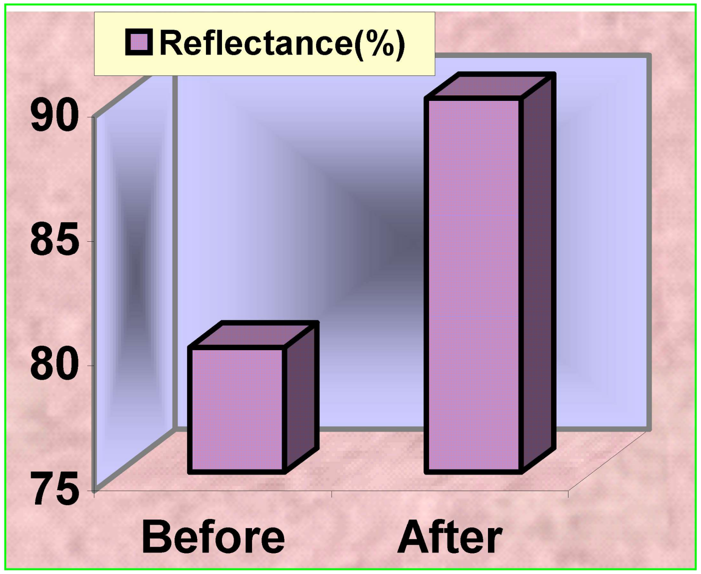


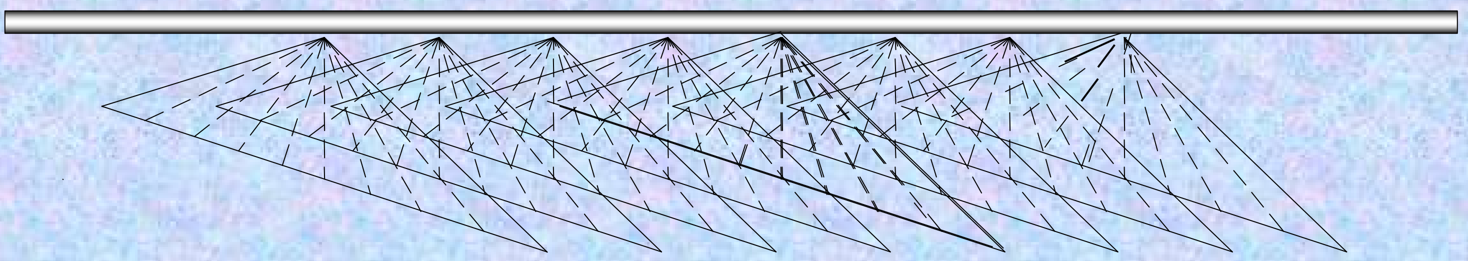
`SCHEMATIC DIAGRAM OF RINSING SPRAY ARRANGEMENT

- Higher impinging spray pressure
- Higher flow rate by reducing number of spray headers
- Easy maintenance and retrofitting to existing system

HIGH PRESSURE RINSING SYSTEM

- Uniform spray distribution across strip width with full coverage
- Herringbone spray pattern with proper overlap of spray
- Effective wash-off strip and improved strip reflectance

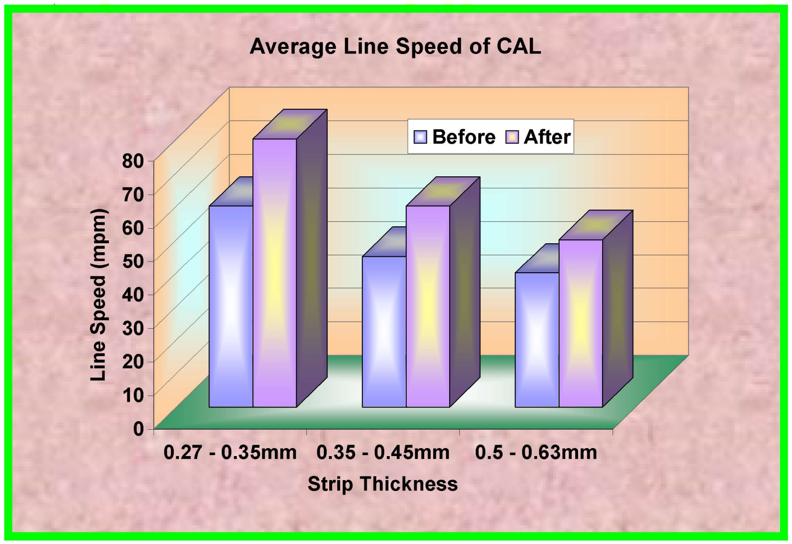


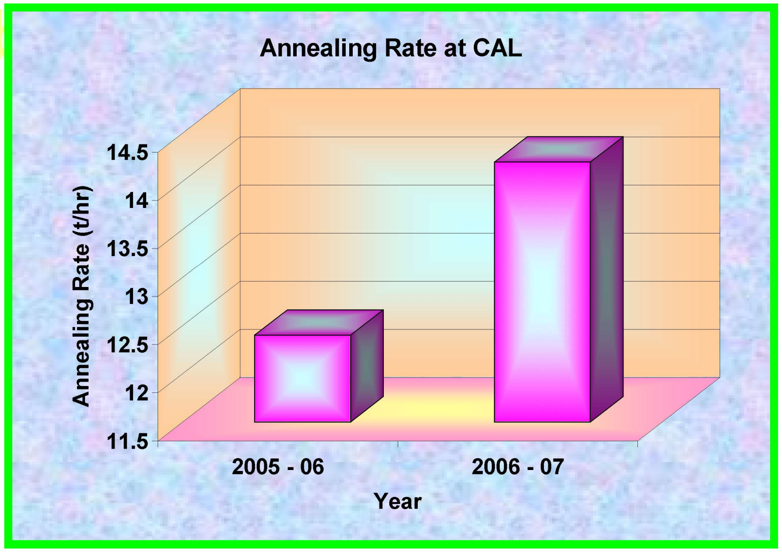


Herring-bone spray pattern

RESULTS

- Effective squeezing arrested carry-over residuals
- Hyd. squeezing eliminated side tracking of strip
- Effective wash-off of strip by high press. rinsing
- Improved strip surface reflectance >90%
- Achieved uniform strip hardness <55 HR 30T





CONCLUSIONS

Adaptation of Innovative technology

- **Improved heat capacity in Furnace**
- **Optimized Annealing cycle**
- **Hydraulic Roll Squeezing**
- **High pressure Strip Rinsing**
- Data Acquisition & Control system

Improved Productivity & Surface Quality

THANK YOU!

TOPIC

FLATNESS MEASUREMENT IN COLD ROLLING MILL

Alok Kumar Roy, DGM (CET)
Simon Peter Kachhap, AGM (CET)
Ajay Kumar, Manager (CET)

THE CHALLENGE

- **Rolled sheet metal is an important material in modern manufacturing & rolled products are found everywhere in our daily lives.**
- **The demands in regard to strip flatness in cold rolled products are ever increasing.**
- **The "Challenge" is to meet this quality demand.**

FLATNESS MEASUREMENT IN COLD ROLLING MILL

- In cold rolling, the first contact between material and machine determines the quality of the end product.
- If the roll gap profile has not been adapted exactly to the strip profile, a non-uniform pressure distribution across the strip width will be the result.
- This non-uniform pressure distribution leads to differences in elongation across the strip width, which we call flatness errors.

FLATNESS MEASUREMENT IN COLD ROLLING MILL

- **High strip tension during the rolling process may cover up this problem – at least until the strip is finished. That's when flatness deviations become visible as wavy edges, wavy center, quarter buckles and camber.**
- **Lack of flatness can have expensive consequences: lateral drift, buckling, or even tearing of the strip which slow the rolling speed and reduce mill productivity & quality.**
- **Thus a need of state of the art flatness measurement that can help in controlling the above potential problems related to cold rolled products is necessary.**

FLATNESS MEASUREMENT IN COLD ROLLING MILL

- **Flatness control ensures the best possible roll gap at all times based on reliable measurement of the tension distribution in the strip.**
- **The system measures true strip thickness unaffected by coolant, dirt, steam, air temperature variations, etc.**
- **Using the actual flatness deviation and the effectiveness of the actuators, an intelligent algorithm generates commands for tilting, bending, roll shifting, cooling and controlling all other functions of the rolling mill's actuators.**
- **Thus the flatness measurement and control system gives rolling mills continuous and precise online control of the flatness of cold rolled strip or sheet.**

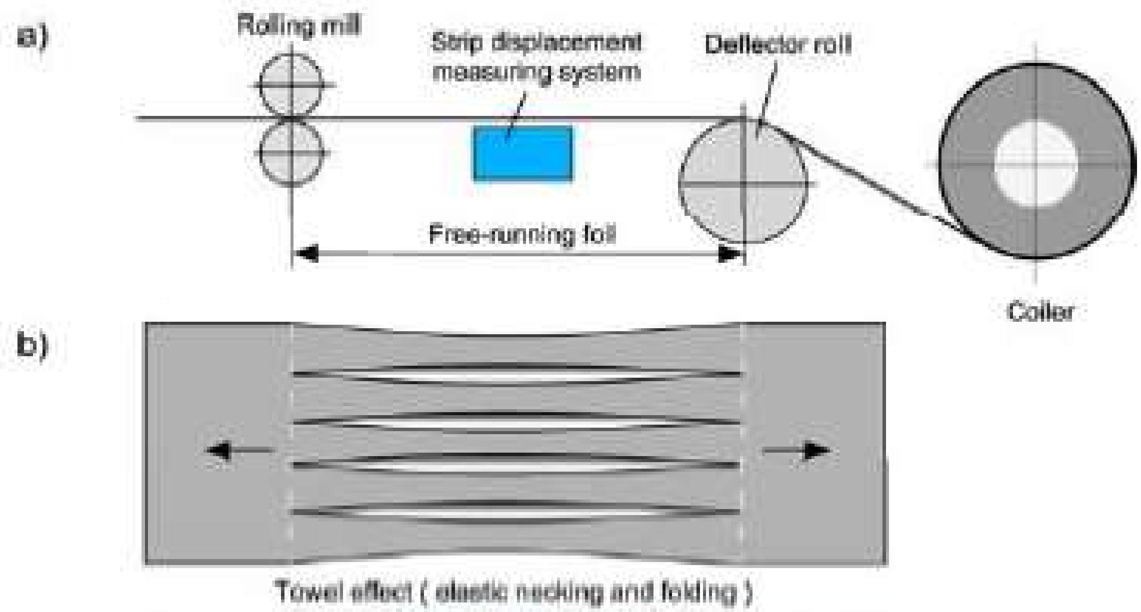
FLATNESS MEASUREMENT IN COLD ROLLING MILL

- **Strip flatness deviations can be measured by the tensile stress distribution which generally occurred in strip treatment lines in length wise distribution. There are many methods to determine this tensile stress distribution.**
- **When we apply external force to the strip it displaces. By measuring the local displacement due to the force applied we can determine strip tension distribution across the strip width.**

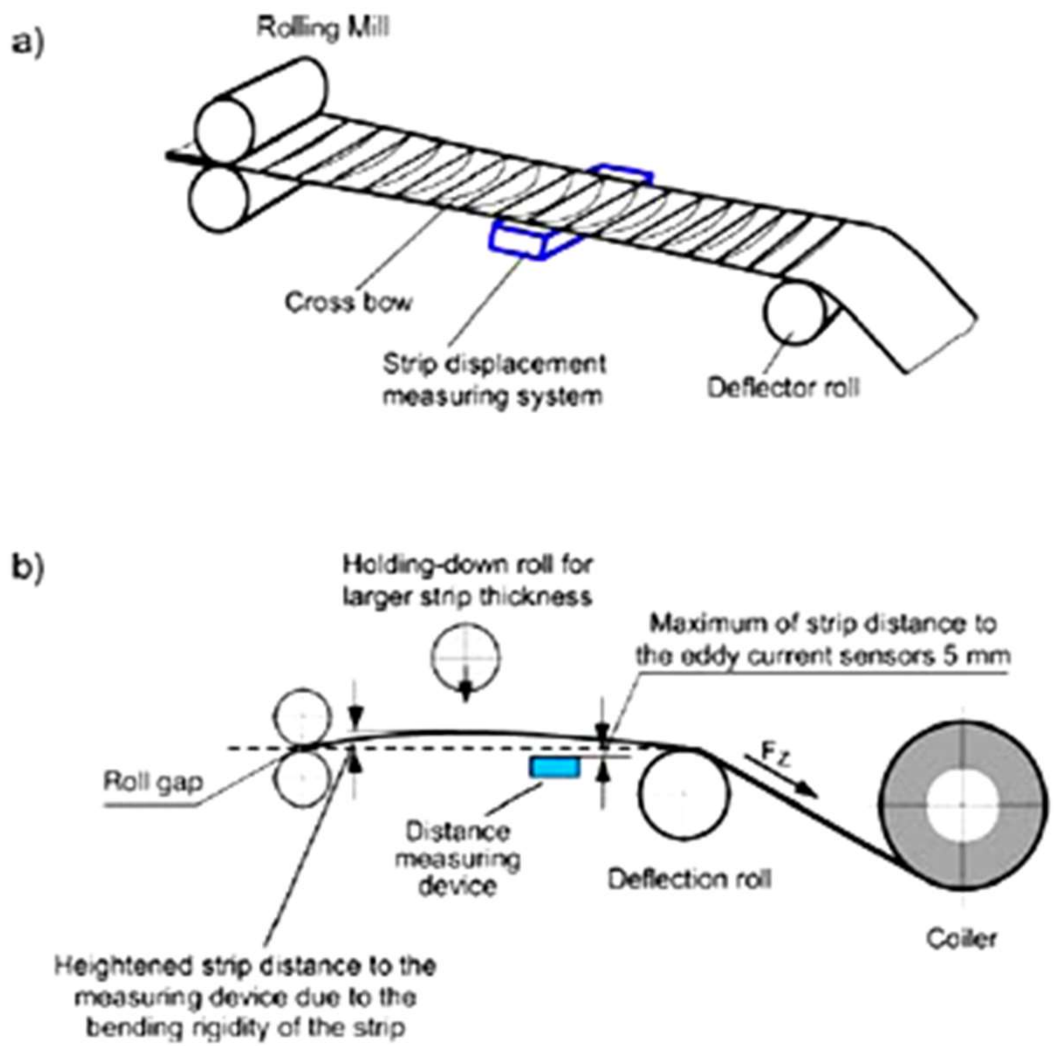
FLATNESS MEASUREMENT IN COLD ROLLING MILL

- **Measuring systems today can measure reliably and precisely irrespective of strip quality and dimensions.**
- **Earlier, Measuring Systems traditionally were non-contact type (ex: using light source/cameras, etc)**
- **However, Flatness measurement in present modern cold rolling mills and strip processing lines are carried out with measuring rolls designed to operate simultaneously as deflector rolls.**

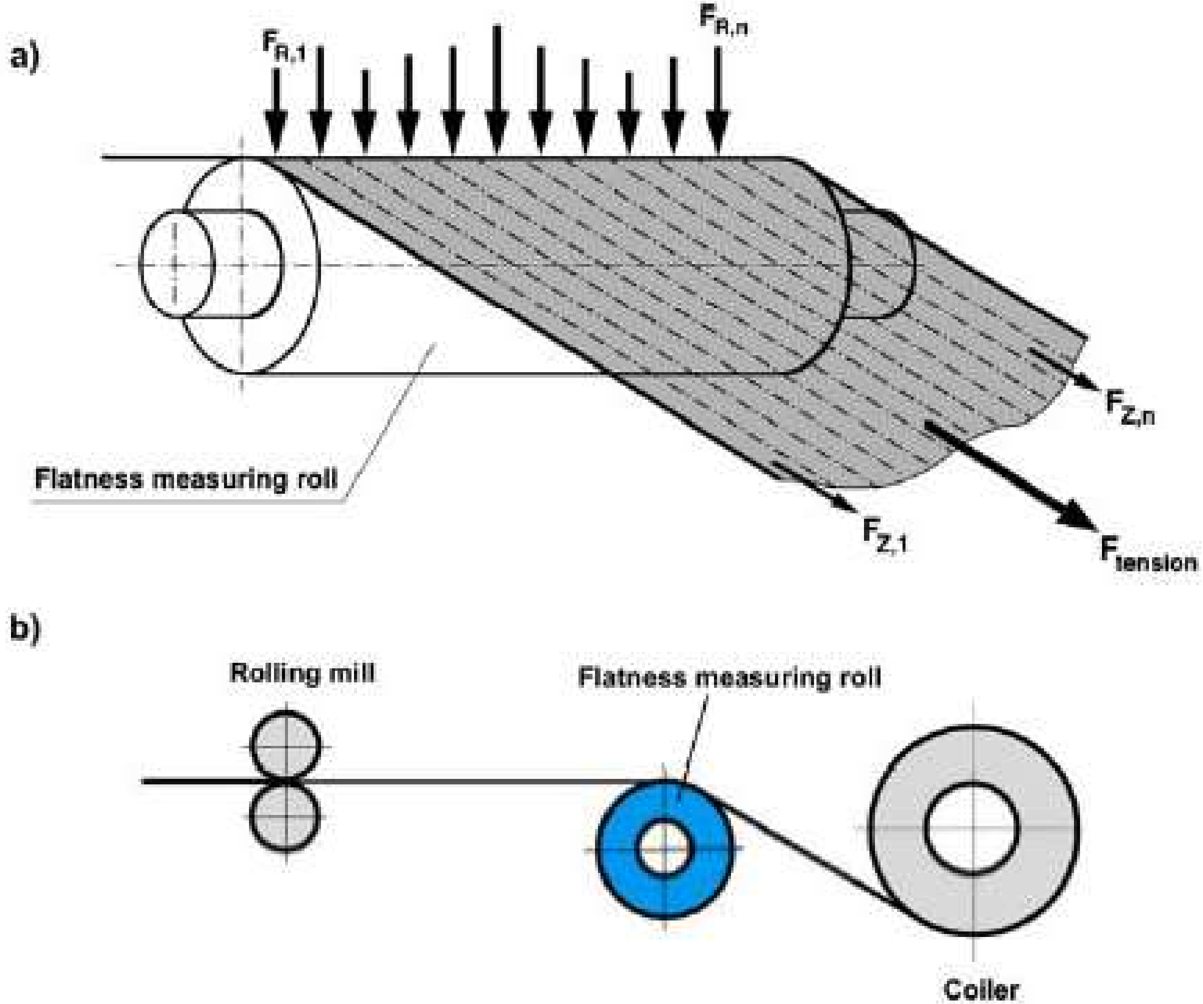
MEASURING ERROR DUE TO FORMATION OF FOLDS



MEASURING ERRORS CAUSED BY STRIP LENGTH BOW & CROSS BOW



MEASUREMENT OF LOCAL RADIAL FORCES BY DEFLECTOR ROLLS



MEASURING ROLLS

The measuring rolls vary between 160 and 700 mm in diameter and between 450 and 2400 mm cylinder width.

The surfaces of the measuring rolls may have the following characteristics:

- **hardness upto HRC 58,**
- **hardened and textured,**
- **hard chromium plated to HV 950,**
- **tungsten carbide plated,**
- **rubberized.**

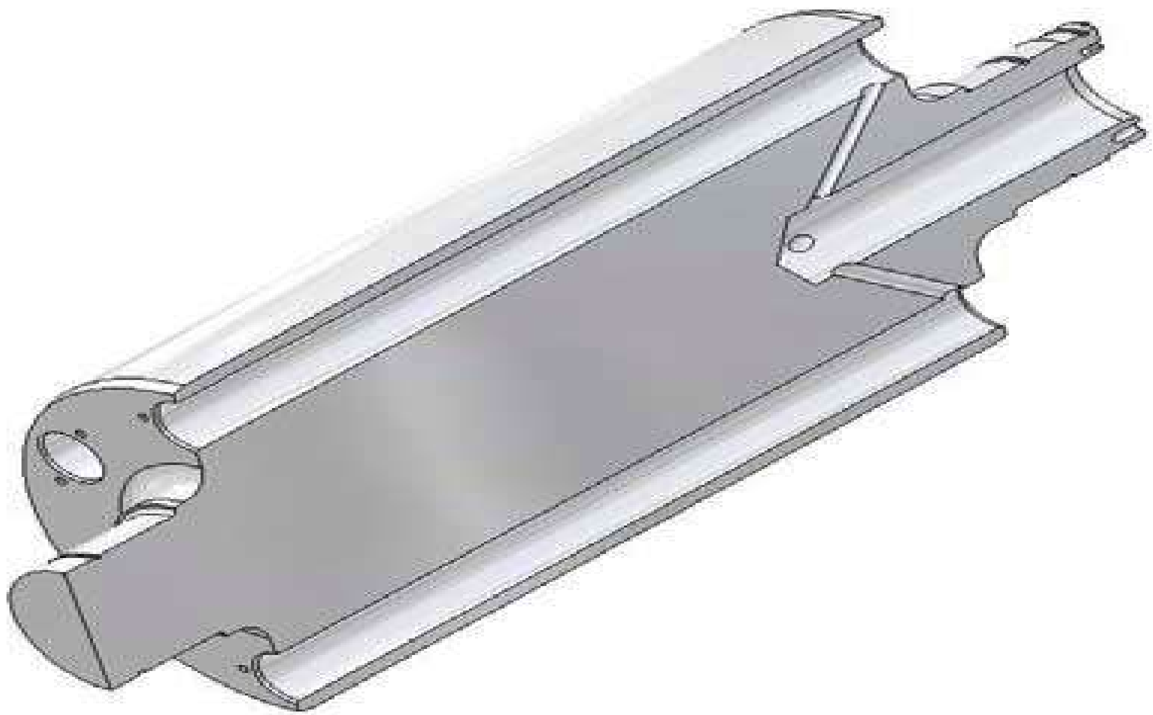
MEASURING ROLLS

- **In this design force sensors are mounted in axially parallel bores, which are executed as through-holes close to the shell surface of a solid roll body.**
- **This arrangement provides a robust design with a completely gap-free roll surface over the entire cylinder width.**
- **The high load capacity of the piezoelectric force sensors and the non-contacting optical signal transmission contribute to a fail-safe and nearly maintenance-free system.**

MEASURING ROLLS

- **The roll body is made of roll steel and consists of a solid roll body exhibiting an uninterrupted, smooth, gap-free and homogeneous roll surface over its entire cylinder width.**
- **To accommodate the force sensors, axially parallel bores are provided in the end faces of the roll body**

MEASURING ROLLS

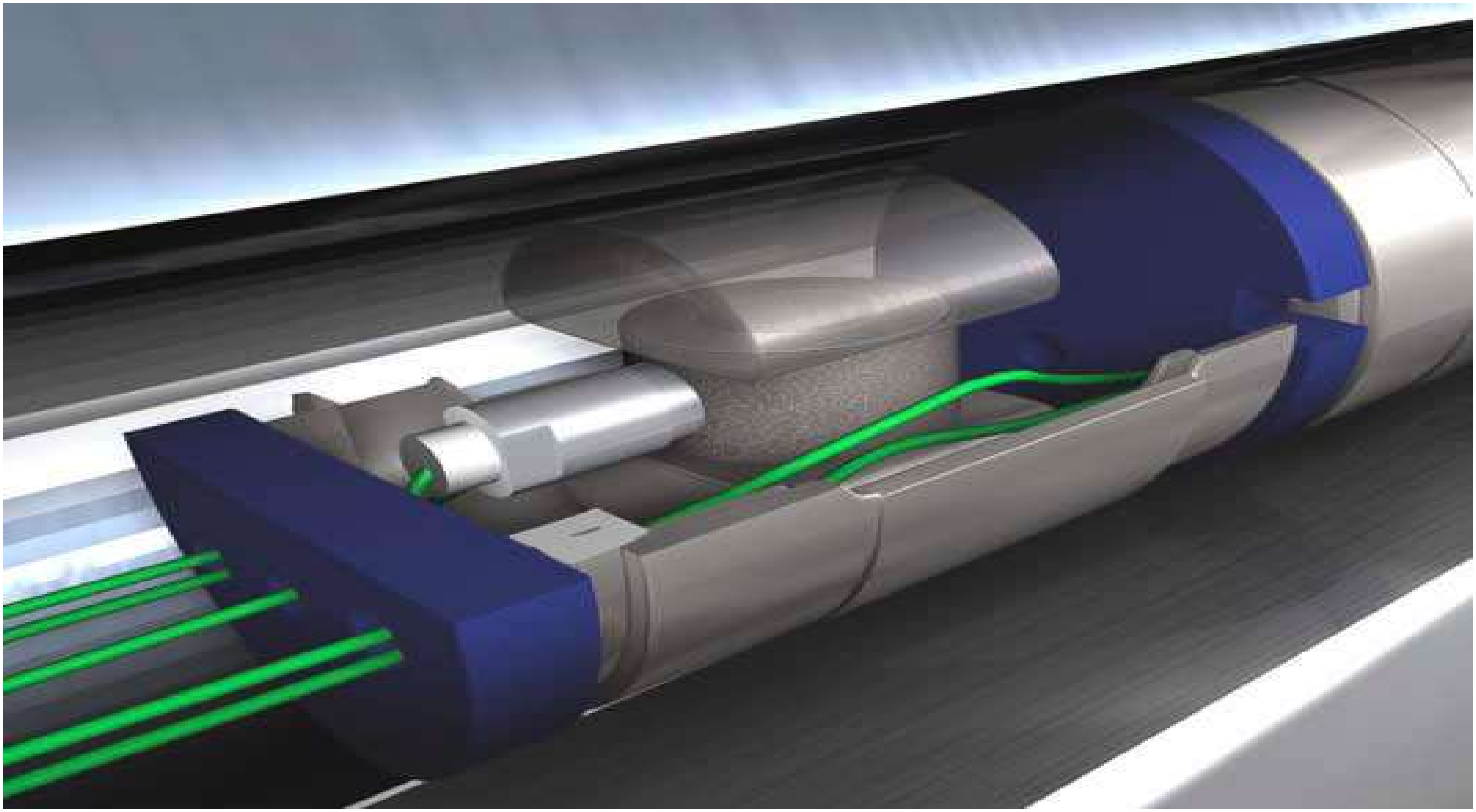


Measuring roll

MEASURING ROLLS

- **Arranged at a distance of 5 to 11 mm from the shell surface, these bores may be through-holes extending over the full cylinder width or be produced as blind holes.**
- **The diameter of the sensor mounting bores can be between 30 mm and 50 mm, depending on the force sensor type employed.**
- **2 and 6 such axial bores may be provided, depending on the desired number of force sensors and the wrap angle of the strip around the roll body when in service.**

MEASURING ROLLS



Axial bore with mounted

MEASURING ROLLS

- **Depending on the bore depth, up to 24 force sensors can be fitted in a single bore in this manner.**
- **By offsetting the sensors over the width of the measuring roll cylinder, the sensors can be axially positioned so that there will be one sensor every 10 mm from one bore to the next.**
- **This is beneficial for precise measurements in the strip edge area or where tensile stresses vary widely within narrow strip zones.**

MEASURING ROLLS

- **The new generation flatness measuring rolls use proven piezo-electric force sensor technology.**
- **These force sensors are very small yet can handle high loads at extremely low levels of elastic deflection.**
- **The action of mechanical pressure loads on the piezo quartz sensor produces a charge which is converted into a force-proportional voltage by the so-called charge amplifier.**
- **The piezoelectric sensors are passive force sensors requiring no electrical power supply.**

MEASURING ROLLS

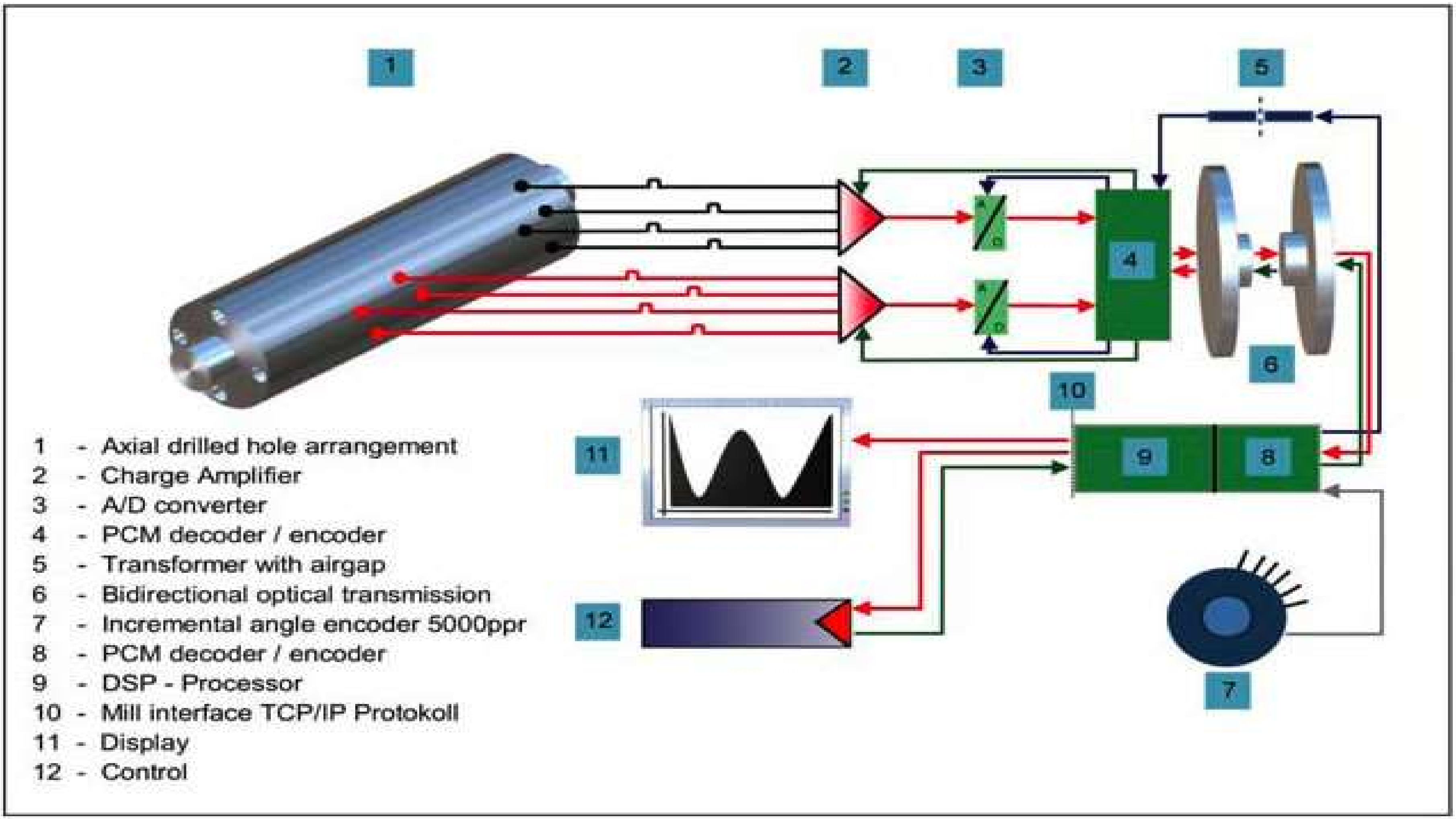
- **Since the measuring roll with its smooth, gap-free and entirely homogeneous surface is outwardly completely identical to a normal deflection roll, its behavior during the production process and its handling during maintenance operations, such as regrinding, is similar to that of any standard deflection roll normally used in its place.**

PIEZO FORCE SENSORS

PIEZO FORCE SENSORS

- **The force sensors in different bores are distributed at different angular positions over the circumference of the measuring roll, hence the staggered sensors are not exposed to strip loads simultaneously. So they can be connected in parallel to provide input to a common charge amplifier.**
- **In conjunction with this charge amplifier with “on-line” switchable gain, these force sensors can deliver readings of a constantly good resolution across different force ranges.**

DATA LOGGING, TRANSMISSION & PROCESSING



DATA LOGGING, TRANSMISSION & PROCESSING

- **For reliable transmission of force measuring signals from the flatness measuring roll to the measurement processing unit, the signals are digitized and encoded by pulse code modulation.**
- **The transfer of signals from the rotating measuring roll to the stator unit is achieved in a non-contact manner by means of infrared light.**
- **The charge amplifiers, encoders & transmission modules are integrated into one compact unit in a housing flanged to the measuring roll.**

CHARGE AMPLIFIER & TRANSMISSION UNIT

BENEFITS

- **By installing a flatness control system, higher rolling speed is achieved and, ultimately, increased production.**
- **Flatness control systems have helped Cold Rolling Mills to achieve productivity gains exceeding 15 percent and cost reductions of 20 percent.**

FLATNESS MEASUREMENT IN COLD ROLLING MILL

THANKS

FOR YOUR KIND ATTENTION

PRODUCTION OF HIGH QUALITY HOT ROLLED STEEL STRIP USING HOT SKIN-PASS MILLS

by

D K Joshi

National Workshop

Special Steel – Making, Processing, Quality Control & Application

SAIL – Bokaro Plant 21st November, 2009

HOT SKIN PASS MILLS

- CONTENTS:

  - **TECHNOLOGY OF THE PROCESS**
  - **DANIELI HOT SKIN PASS MILLS**

TECHNOLOGY OF THE PROCESS

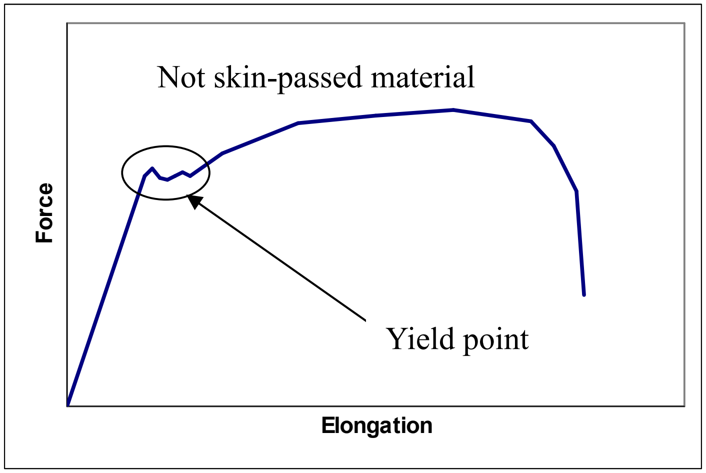
- Why hot rolled strip is processed in hot skin pass mill?

- 1. Appropriate mechanical properties developing
- 2. Strip flatness improving
- 3. Roughness transfer
- 4. Improving shape of coil winding
- 5. Coil recoiling and dividing

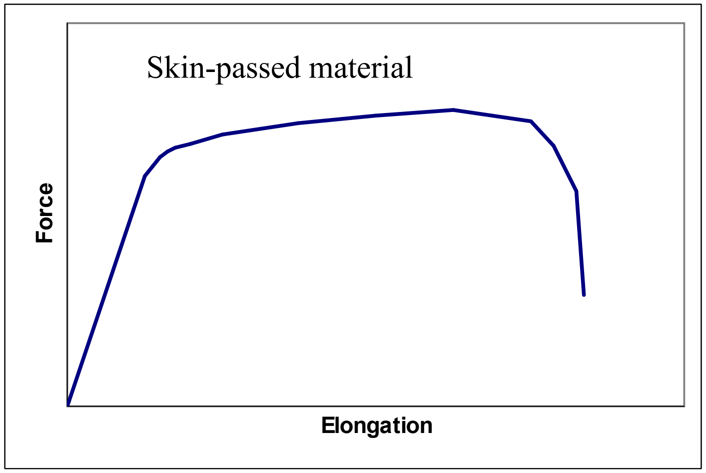
TECHNOLOGY OF THE PROCESS

1. Appropriate mechanical properties developing

- 1a. Yield point suppression



Due to the elongation, the free atoms of carbon and nitrogen leave the dislocations inside the grain structure. Dislocations are free to move and further deformation (i.e. stamping) is more uniform.



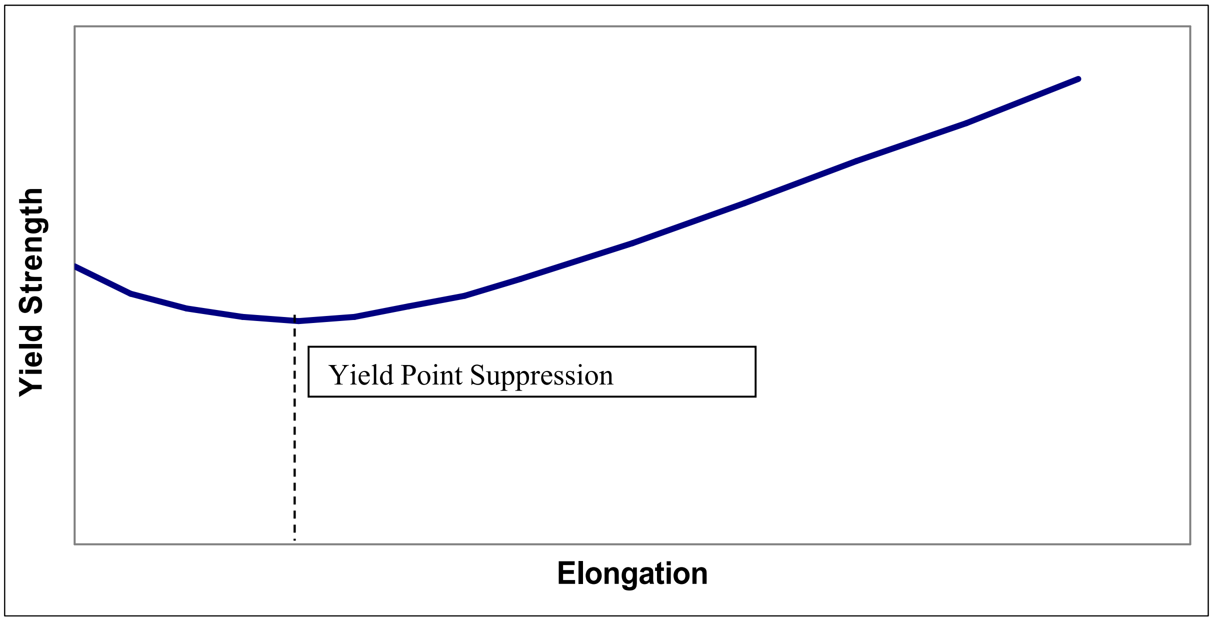
Luders lines are not generated in stamped strip which was previously skin-passed.

- ***Improvement is given by strip elongation.***
- ***With the increased material yield strength and thickness the increased elongation has to be applied (0,5 % – 3,0 %).***

TECHNOLOGY OF THE PROCESS

1. Appropriate mechanical properties developing

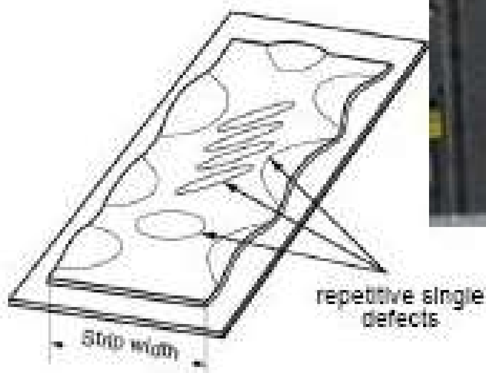
1b. Yield strength increasing



- The yield strength decreases with elongation till yield point suppression is reached, after that it starts increasing due to material hardening.

TECHNOLOGY OF THE PROCESS

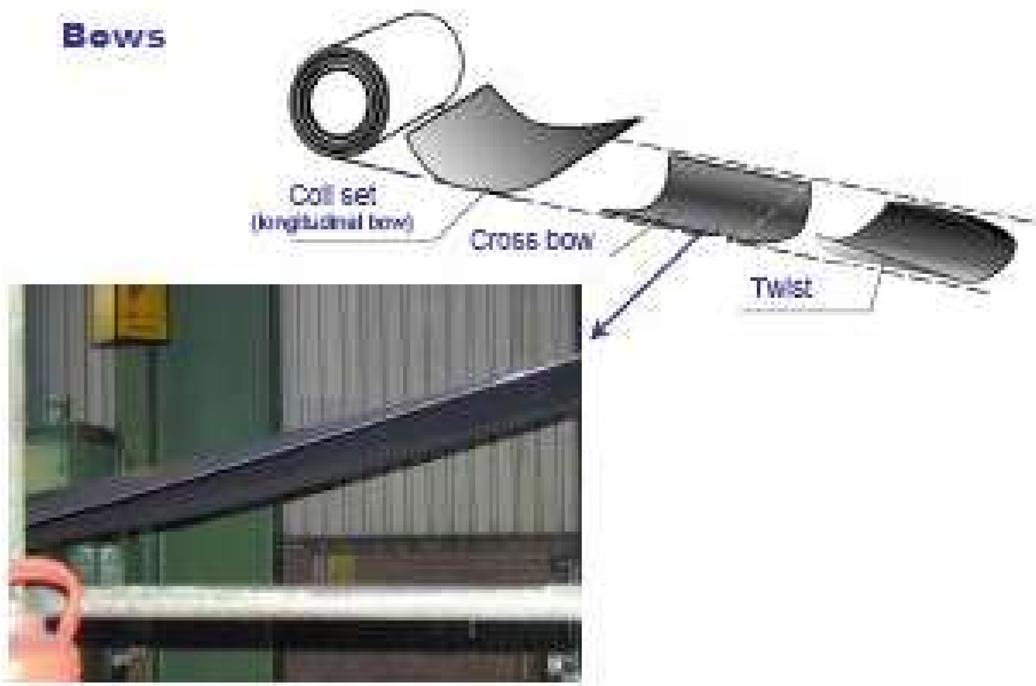
- 2. Strip flatness improving
- Correction of the strip shape is another aim of skinpassing.



Waves defects can be corrected using positive and negative bending and suitable work roll crown.

TECHNOLOGY OF THE PROCESS

Bows defects can be avoided by the anti cross-bow roll and anti crimping installed in the skin-passing mill stand.

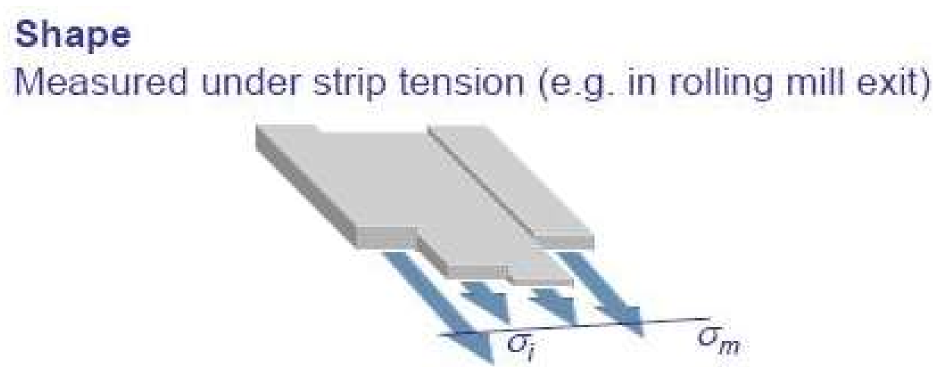


TECHNOLOGY OF THE PROCESS

- 3. Roughness transfer
- During skinpassing the work rolls transfer roughness to the strip .
- Average transferred roughness is around 50% of that of the work roll.
- The higher is the rolling load, the higher is the roughness transfer.

TECHNOLOGY OF THE PROCESS

- 4 - 5. Improving shape of Coil Winding /
- Coil recoiling and dividing
- During skin-passing the coils are unwound and rewound under tension control of pay-off reel and tension reel. Strip Centre Position Control (CPC) and/or Edge Position Control (EPC) reduce coil telescopicity.



TECHNOLOGY OF THE PROCESS

The good coiling accuracy is facilitated by the suitable strip tension, proper work roll gap levelling (tilting) and work roll roughness.

During the process coils can also be divided.

TECHNOLOGY OF THE PROCESS

- Which conditions are important for the process?
- 1. Strip temperature
- 2. Steel aging after skinpassing

TECHNOLOGY OF THE PROCESS

- 1. Strip temperature
- Special care to be observed concerning the temperature.
- Strip temperature must be lower than 50°C.
- Should the strip temperature of the coil be greater than 50°C, the same elongation would give an harder material and benefit of the yield point suppression would be lost.
-

TECHNOLOGY OF THE PROCESS

- 2. Steel aging after skinpassing
- Free nitrogen and carbon atoms slowly return to the grain boundary producing again a more significant yield point.
- Skinpassed coils have to go to the following forming process before a period of 10 to 50 days.
- Aging is faster with higher environment temperature.
- Aluminium killed steels do not have distinct yield point and do not generate Luders lines. They are skinpassed for flatness improving.
-

TECHNOLOGY OF THE PROCESS

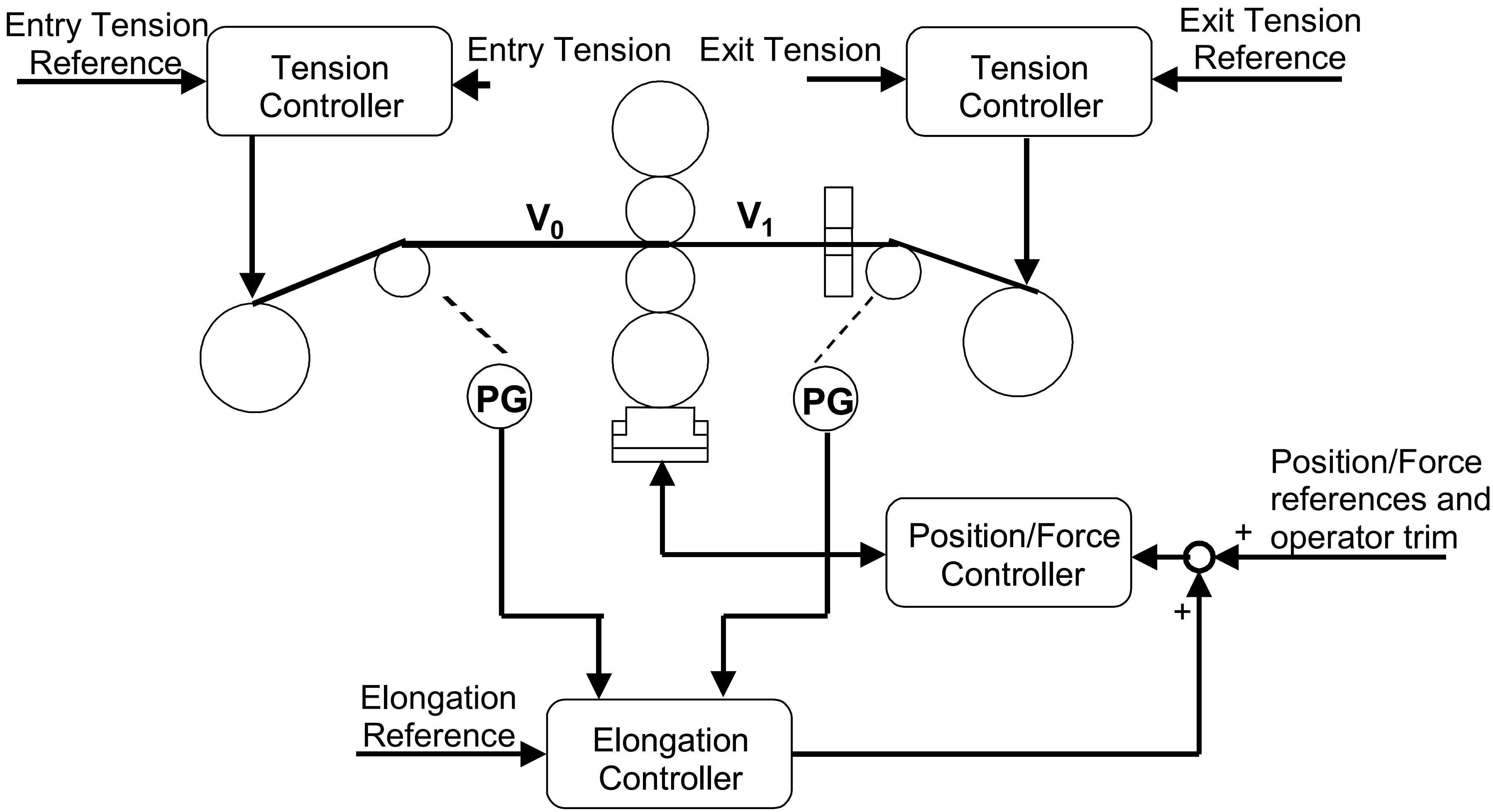
- What are the operating modes of skin-passing?

1. Elongation control mode for constant mechanical properties along the strip length.
2. Roll force control mode for strip shape (waviness) correction and roughness transfer.

TECHNOLOGY OF THE PROCESS

1. Elongation control mode

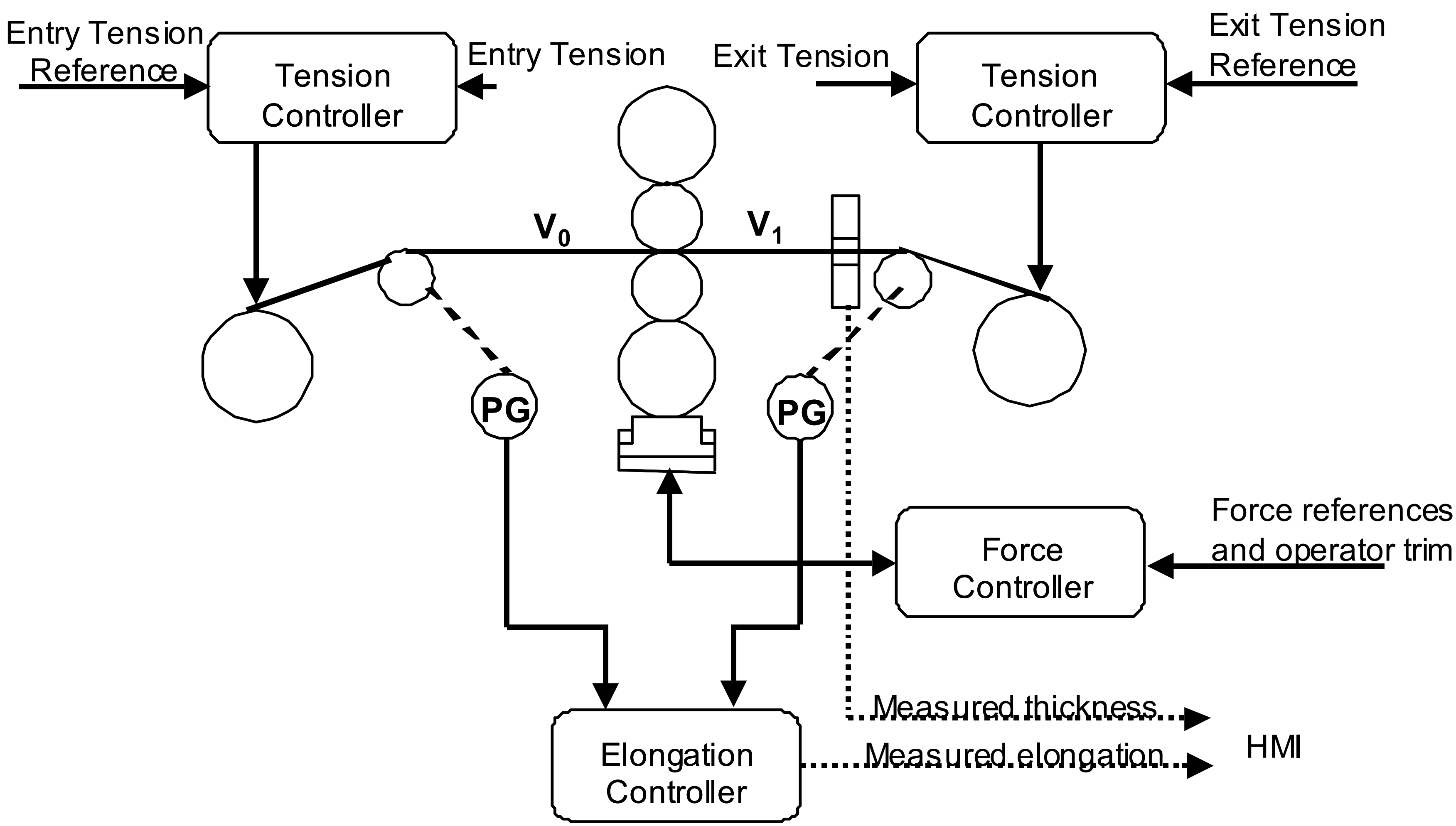
Strip elongation and strip tension are controlled, roll force is "free"



TECHNOLOGY OF THE PROCESS

2. Roll force control mode

Roll force and strip tension are controlled, strip elongation is “free”

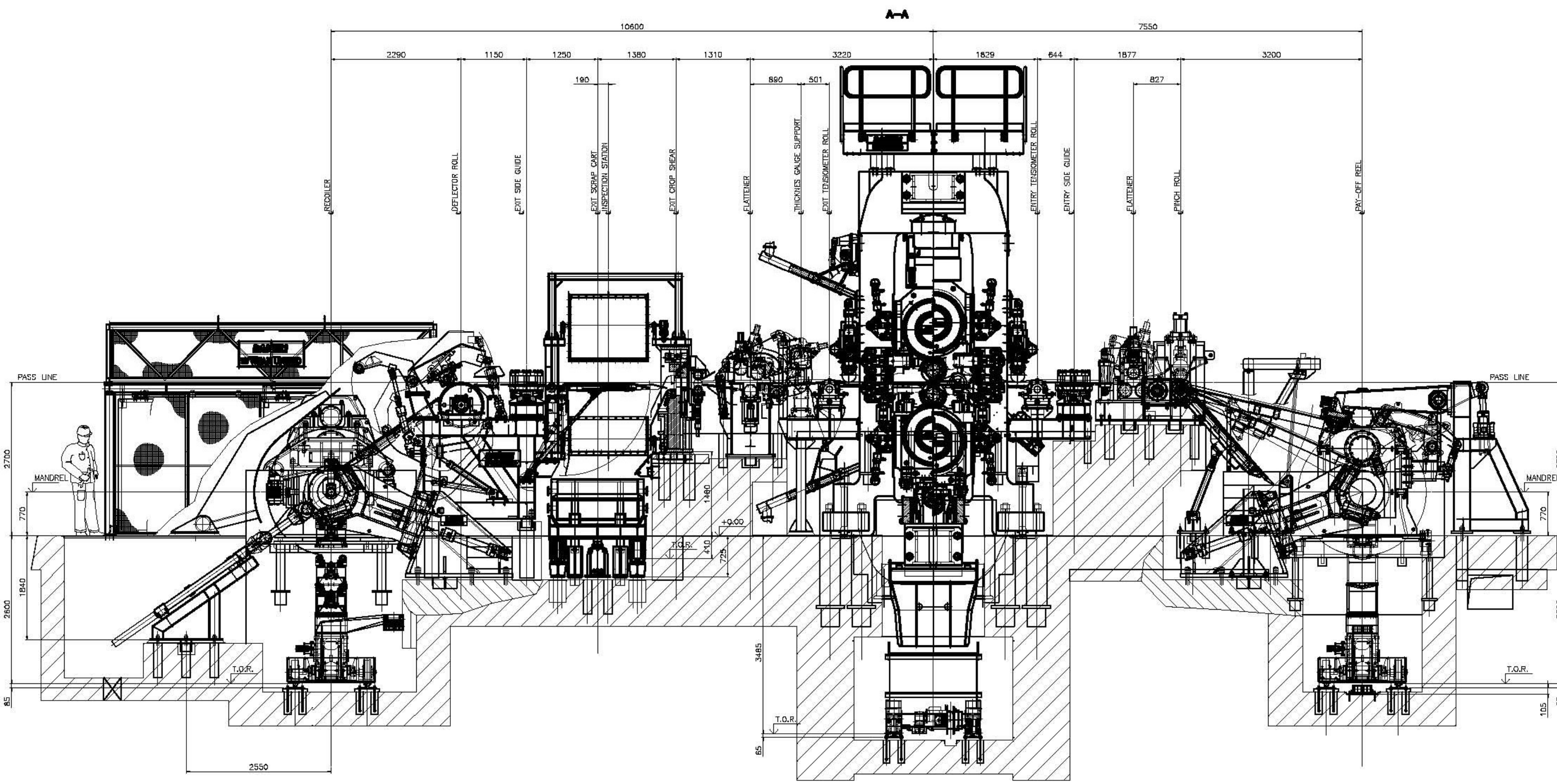


DANIELI HOT SKIN PASS MILLS

- Reference Layout

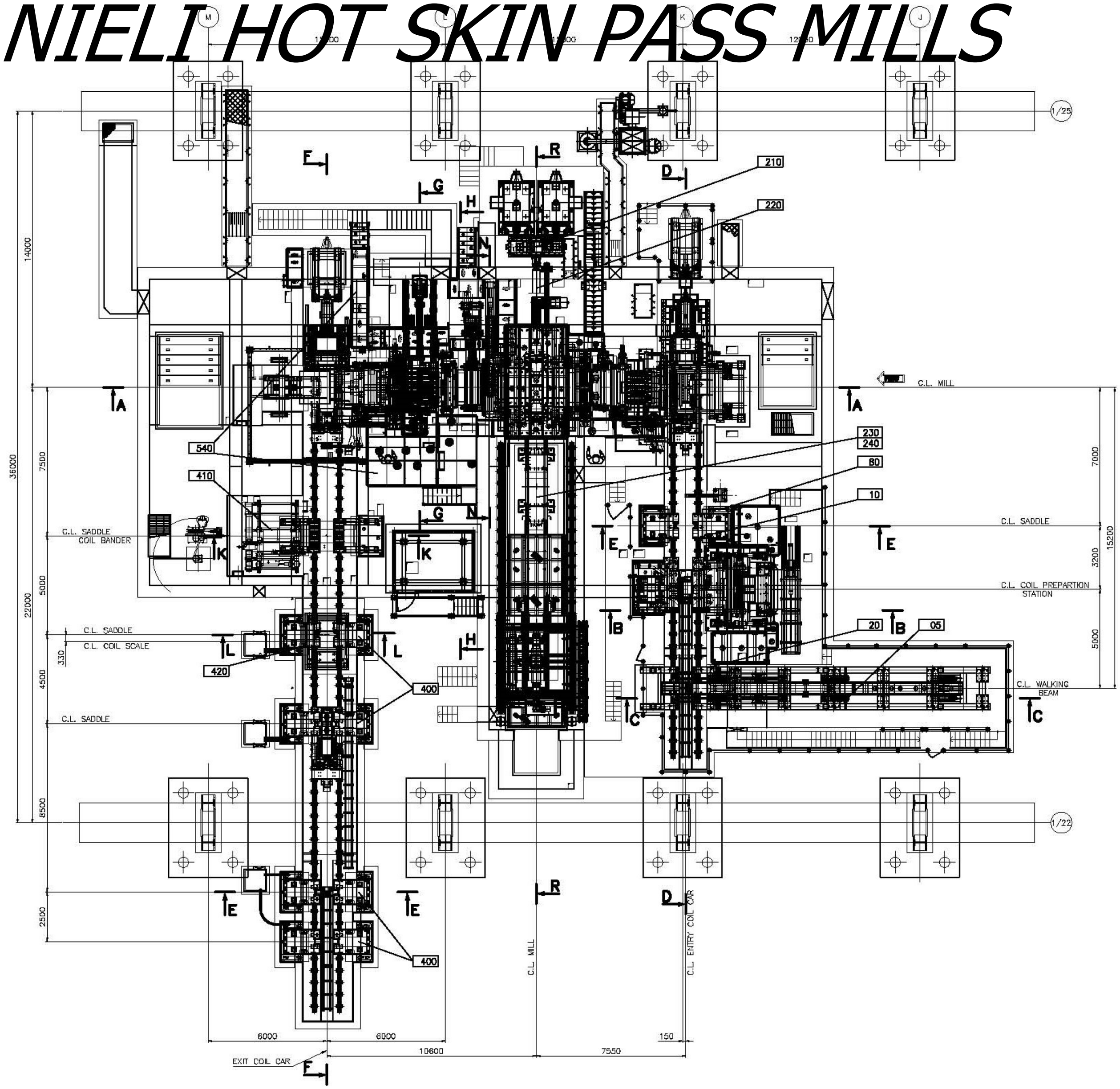
- The next slides show a typical layout (section and plant view) and a description of the plant highlights.
-
- After this section will be provided a complete list of the latest Danieli&C. reference plants with a short main data description for each one.

DANIELI HOT SKIN PASS MILLS



Section View

DANIELI HOT SKIN PASS MILLS

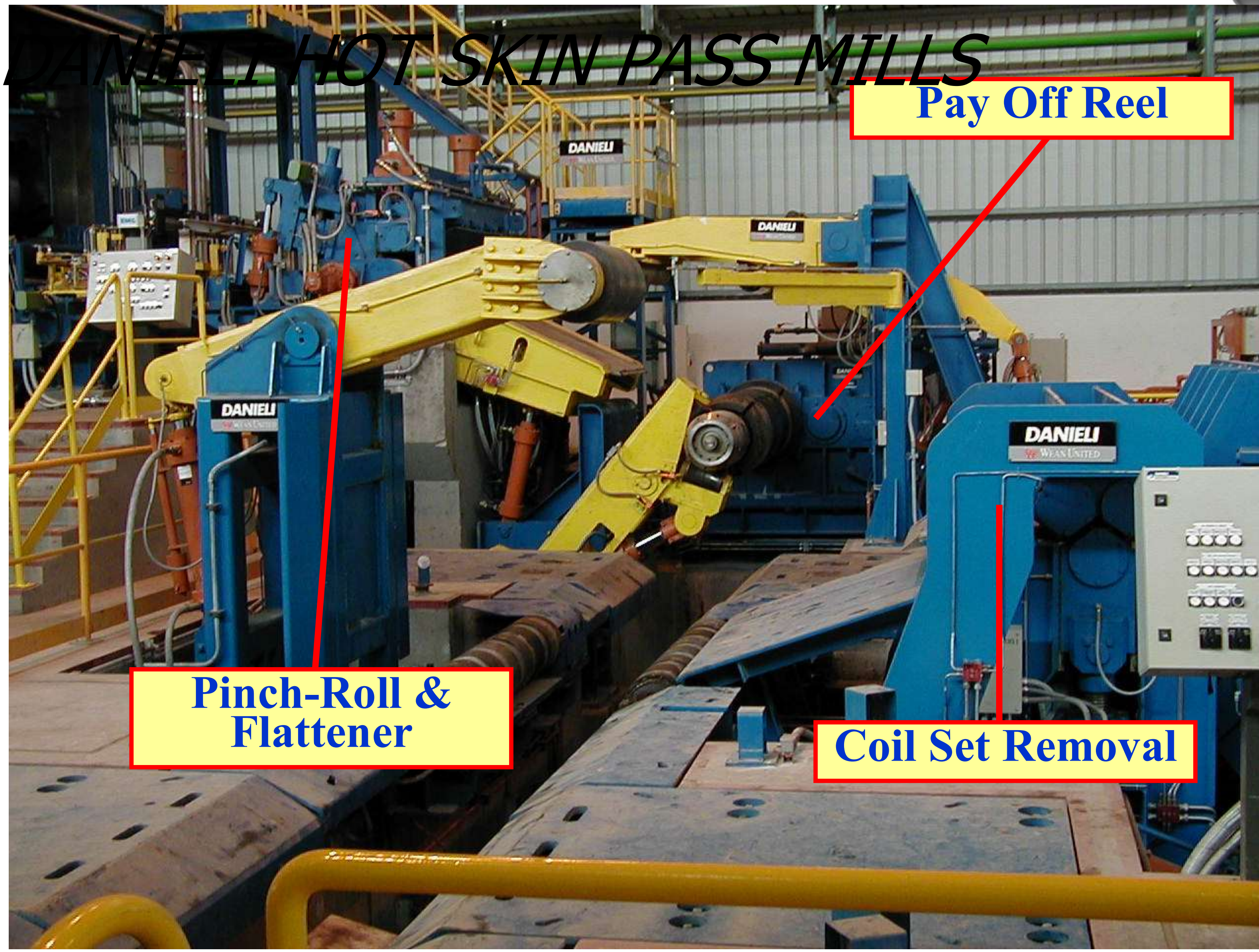


Plant View

DANIELI HOT SKIN PASS MILLS

Overall View of Hot Skin-pass Mill

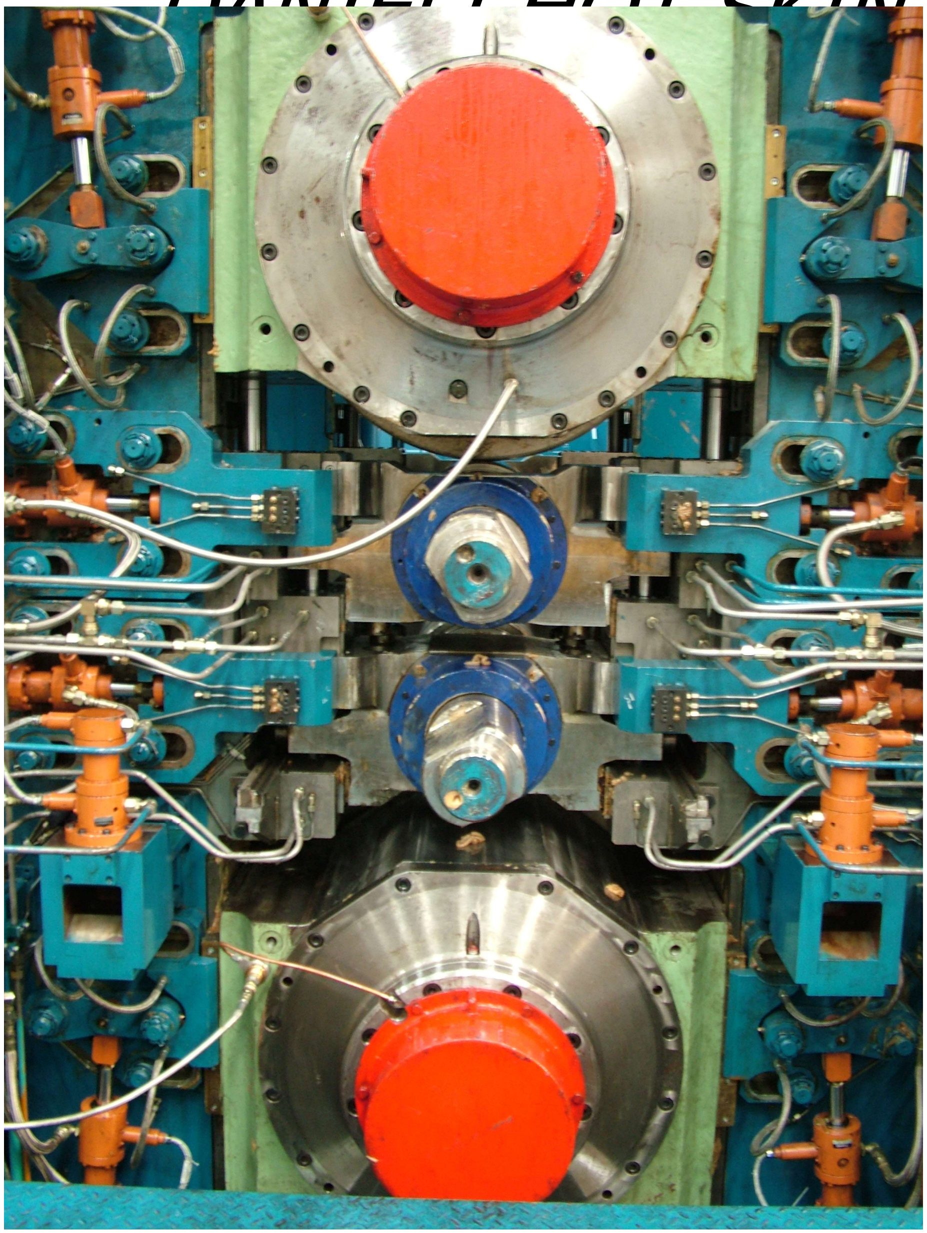
DANIELI HOT SKIN PASS MILLS



Overall View of the Entry Section

DANIELI HOT SKIN PASS MILLS

View of the 4hi mill stand

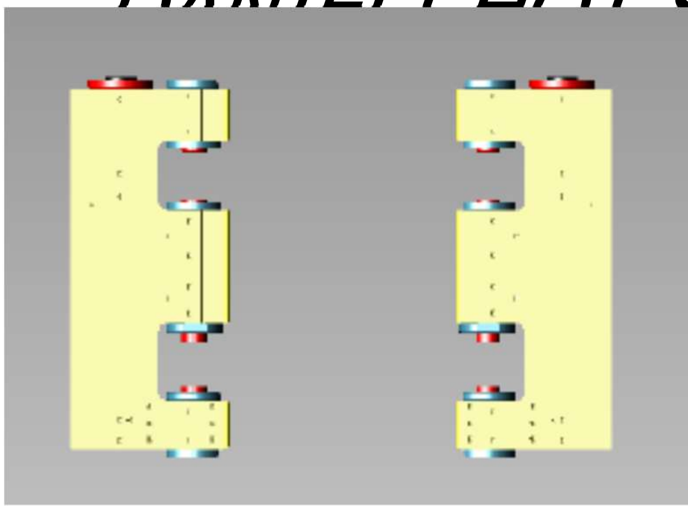


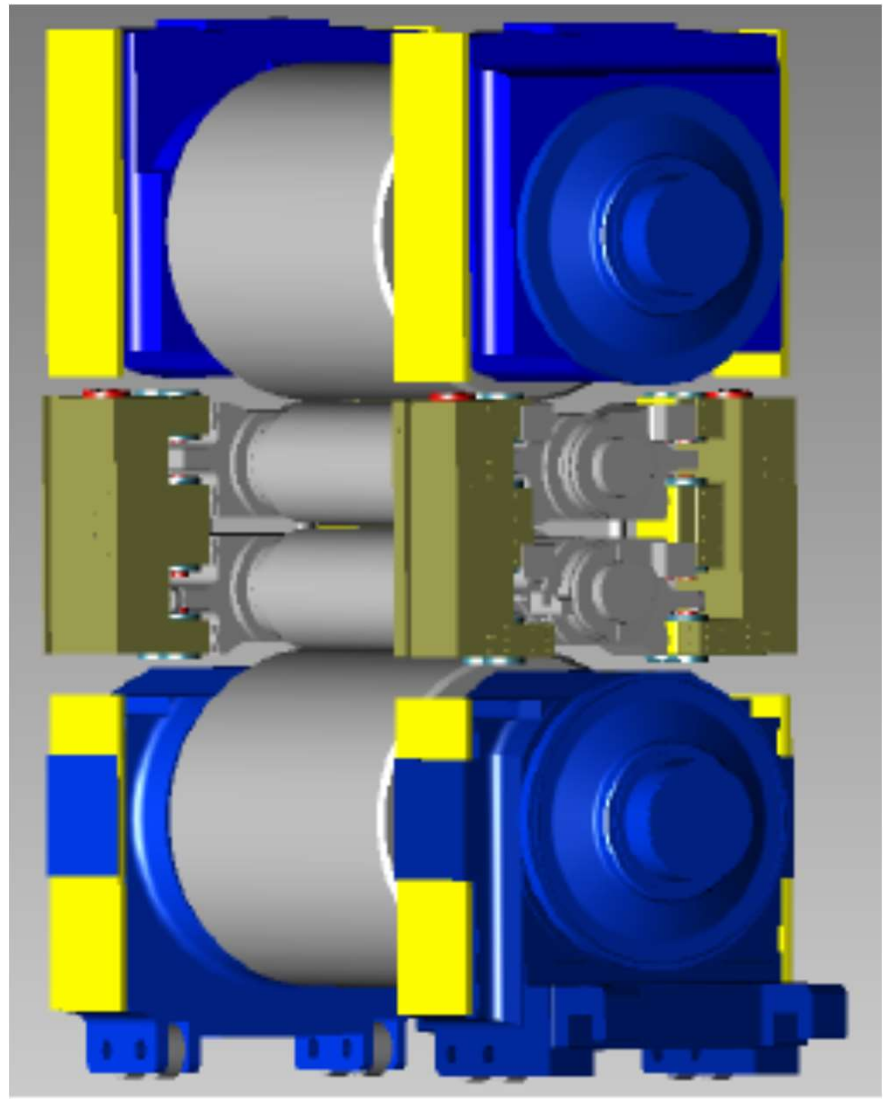
4hi Mill Stand with the here below listed main features:

- E-Blocks for positive and negative bending of Work Rolls;
- BUR balancing integrated in the E-Blocks;
- Work rolls chocks without hydraulic high-pressure intake for bending;
- Automatic clamps for BUR and WR chocks;
- WR quick change in 270s.

DANIELI HOT SKIN PASS MILLS

View of the 4hi mill stand

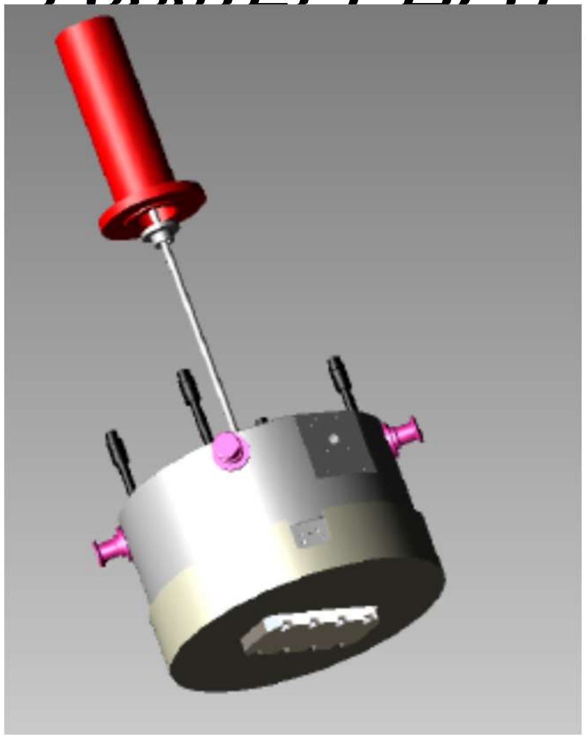




Complete assembly of the WR and BUR with their chocks and liners for the BUR chocks.

On the top picture there's the view of the E-Blocks with the actuators for positive and negative bending. On the top of the blocks are visible the actuators for the top BUR chocks balancing.

DANIELI HOT SKIN PASS MILLS

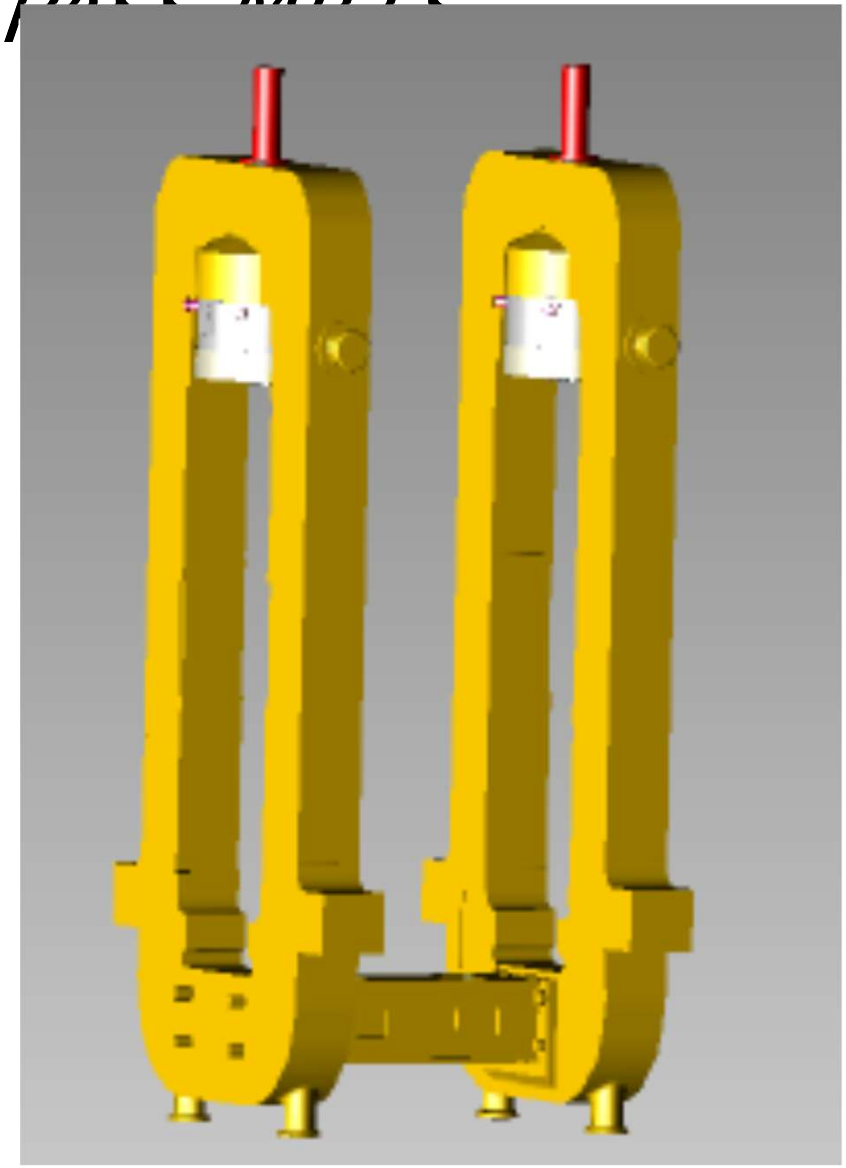


Hydraulic AGC for gap adjustment, installed on the top side of the hot-skinpass mill.

The HAGC will be provided with one centre absolute position sensor.

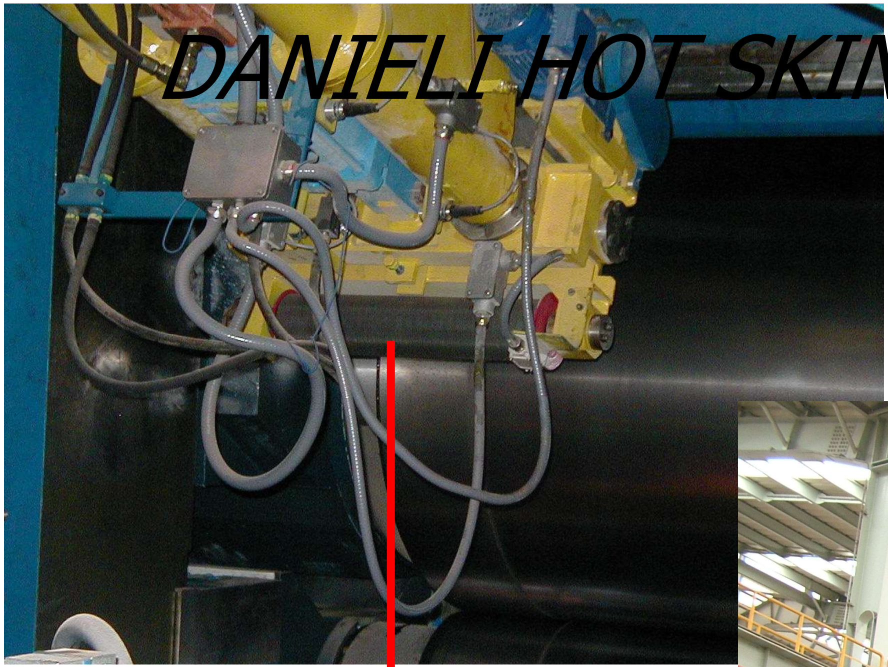
High pressure valve stand will be accomodated on the top side of the mill, in order to minimize the response time of the HAGC (1.5ms approx)

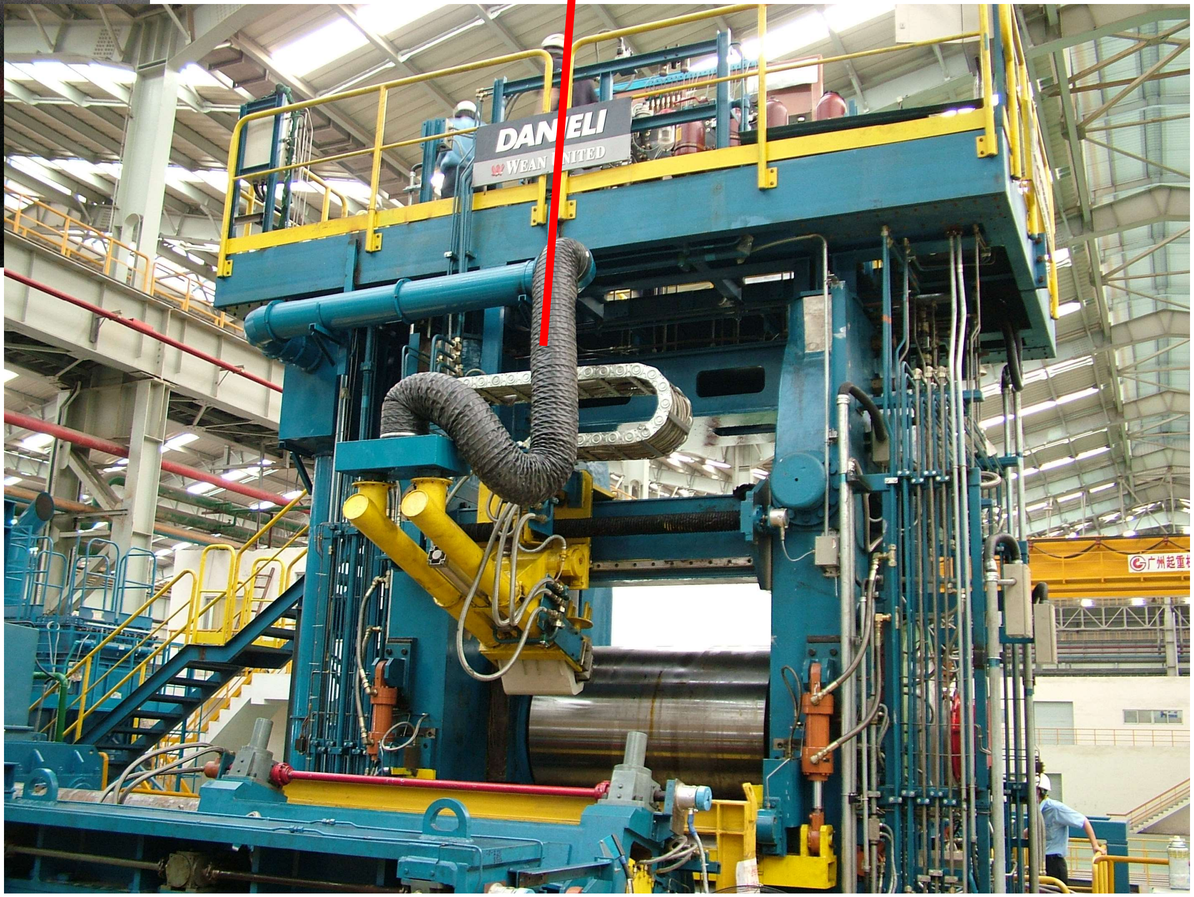
View of the 4hi mill stand



DANIELI HOT SKIN PASS MILLS

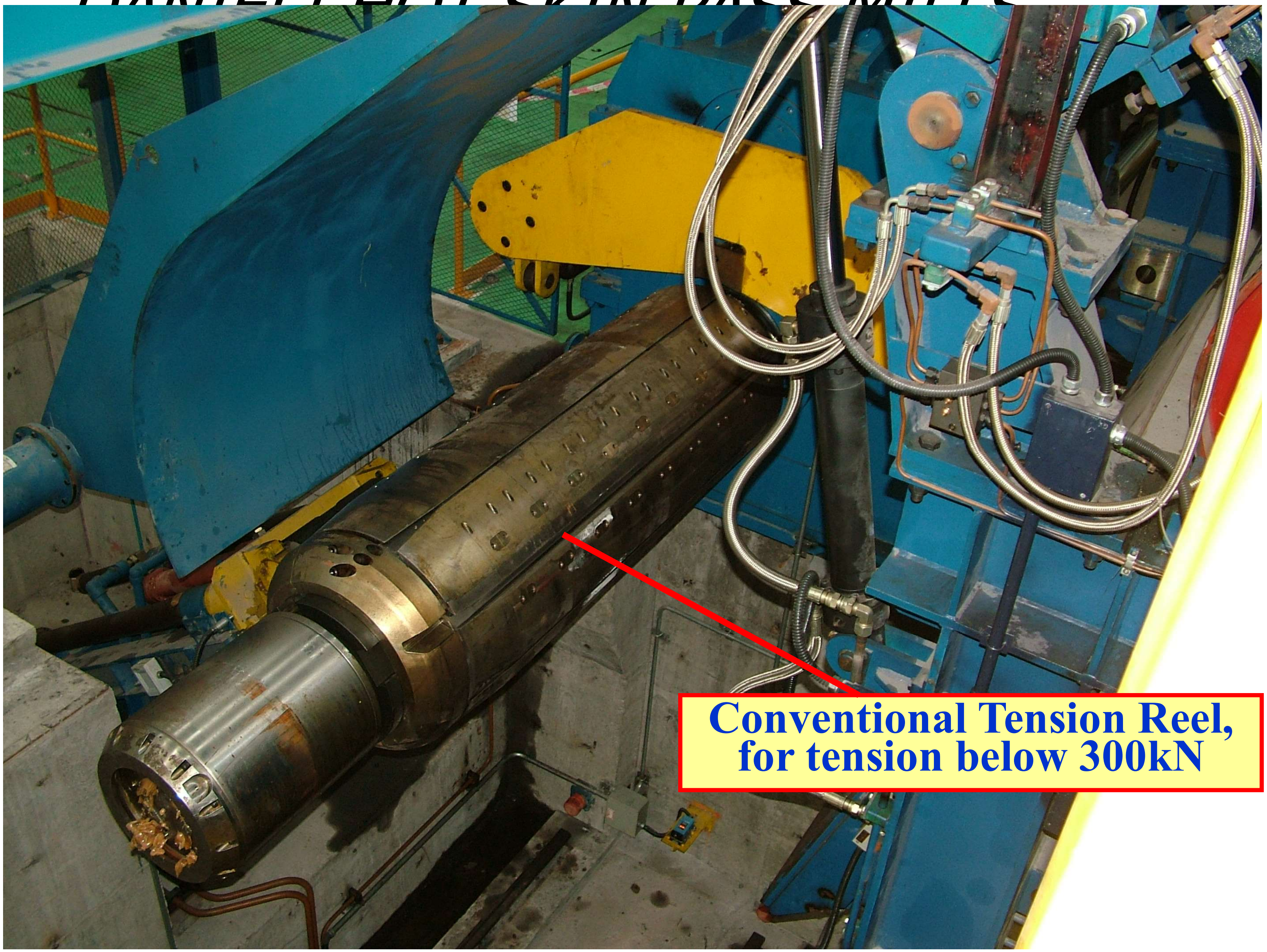
View of the Backup Roll Brush





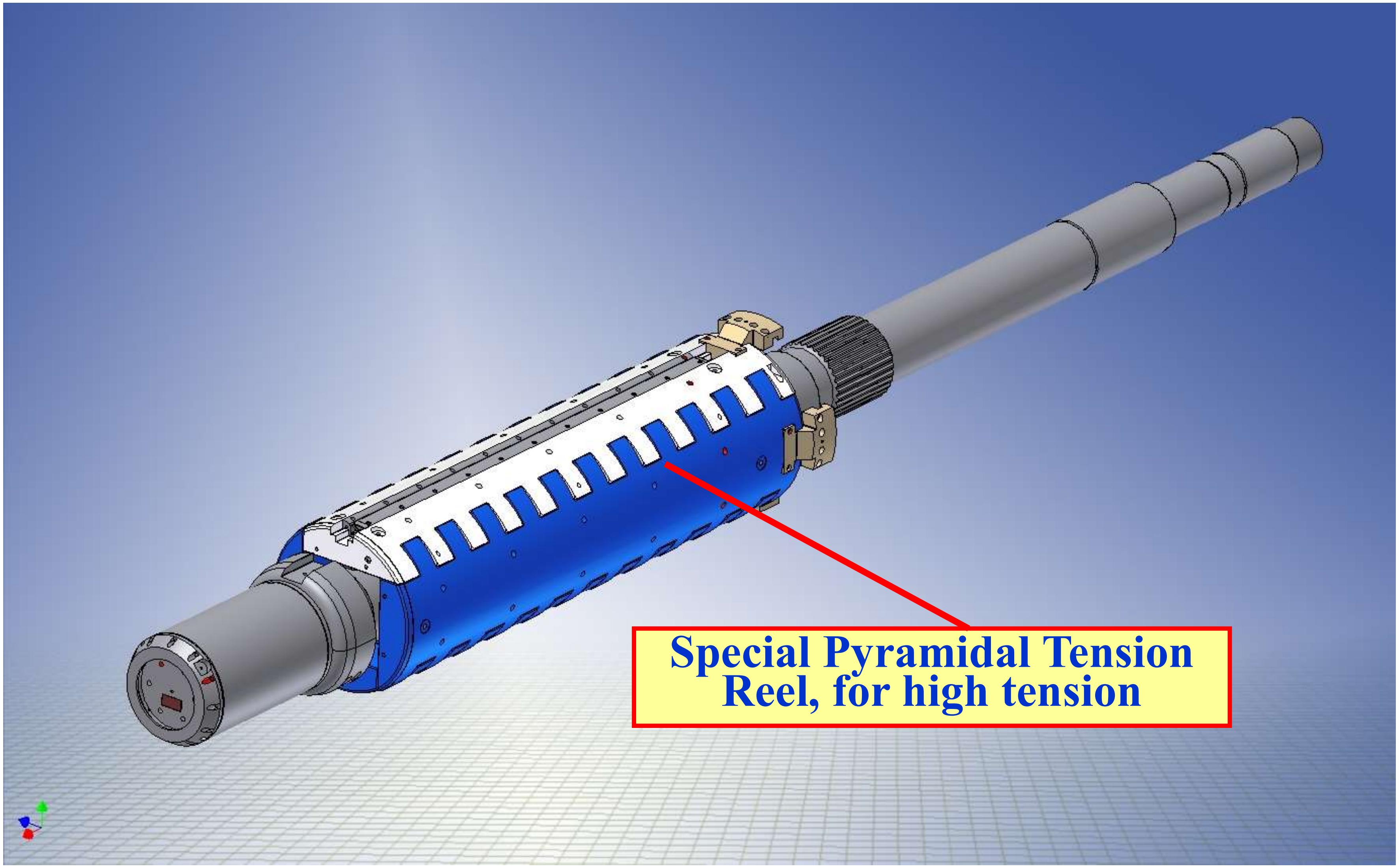
DANIELI HOT SKIN PASS MILLS

View of the Tension Reel



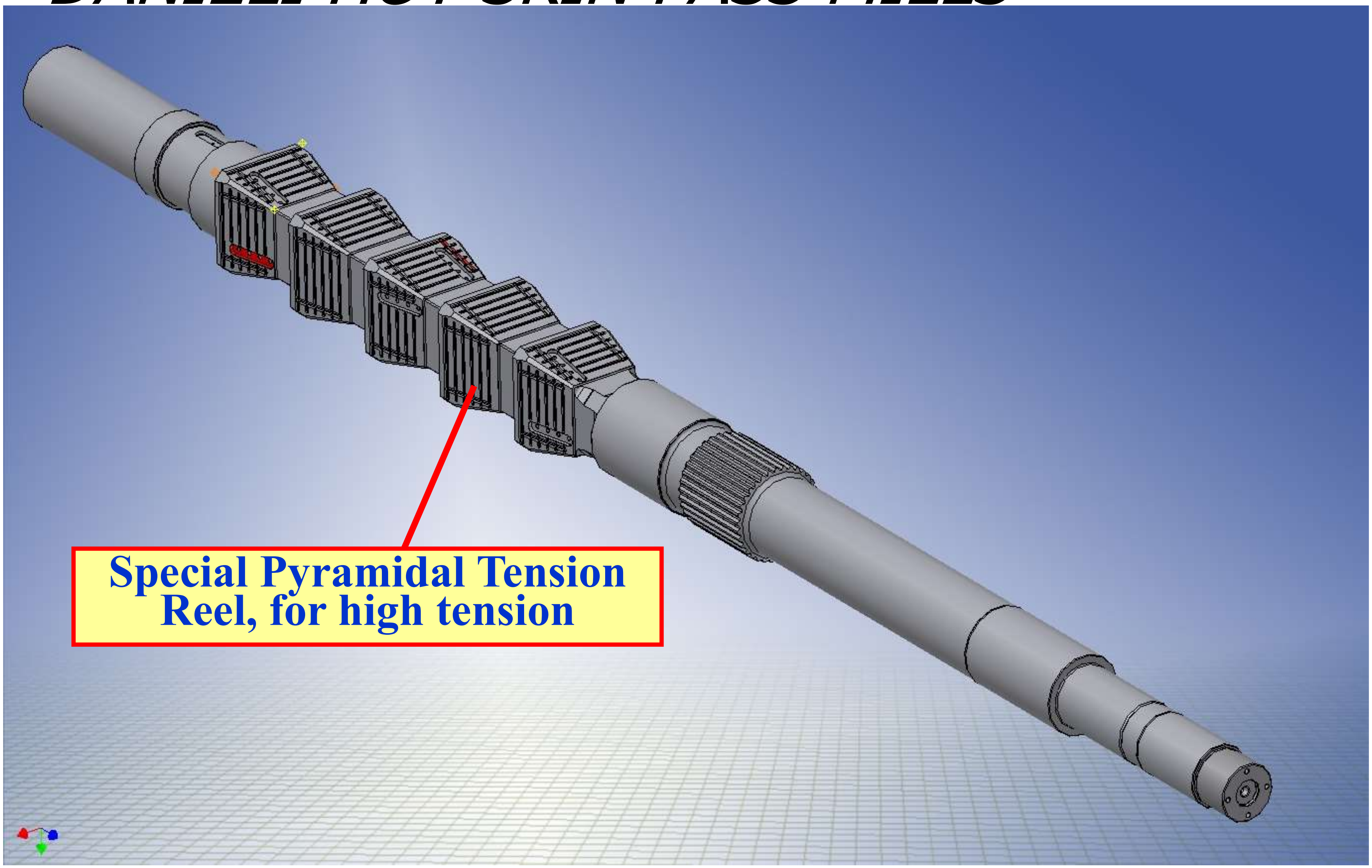
DANIELI HOT SKIN PASS MILLS

View of the Tension Reel

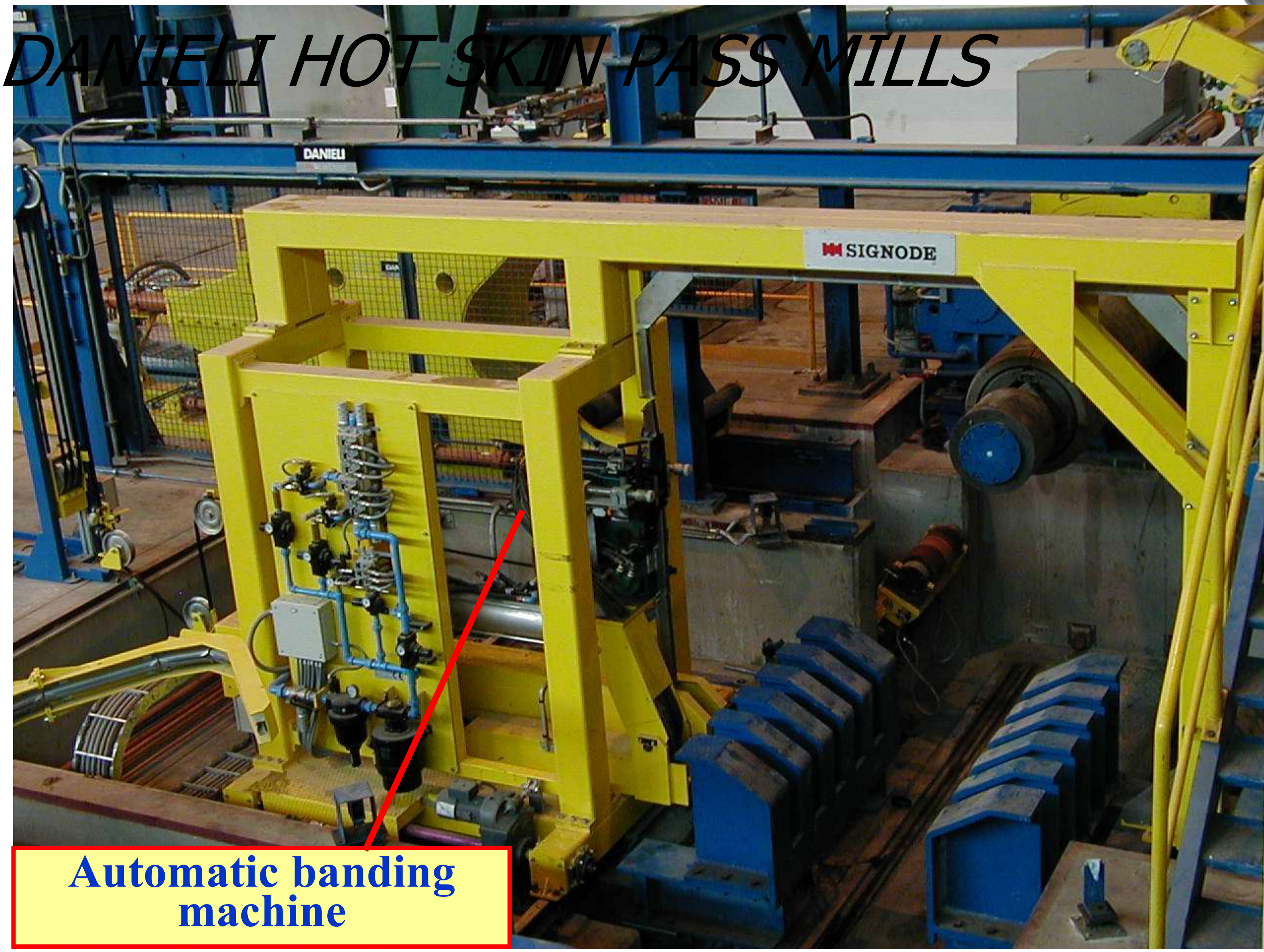


DANIELI HOT SKIN PASS MILLS

View of the Tension Reel



DANIELI HOT SKIN PASS MILLS



Overall View of the Exit Section

Some qualifying references for

DANIELI

The Reliable And Innovative Team In The Metals Industry

HOT SKINPASS MILLS

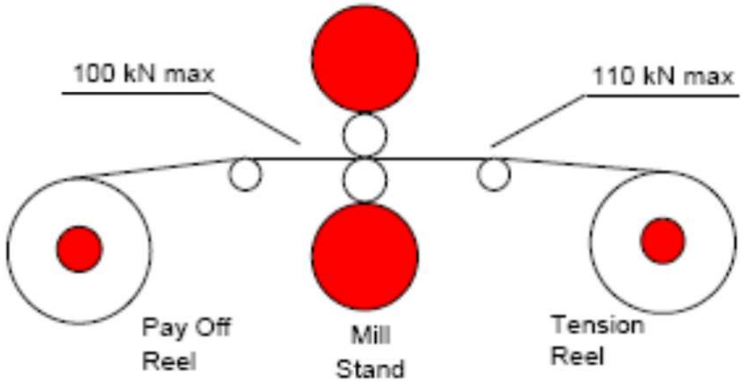
DANIELI HOT SKIN PASS MILLS

Year	Customer	Country	Strip Width	Type
2002	AL EZZ	EGYPT	1,560 mm	4-High Hot Skin-pass Mill
2005	LISCO (YUSCO)	P.R. CHINA	1,600 mm	4-High Hot Skin-pass Mill
2006	TANGSHAN GUOFENG	P.R. CHINA	1,300 mm	4-High Hot Skin-pass Mill
2007	HANDAN	P.R. CHINA	2,130 mm	4-High Hot Skin-pass Mill
2007	TOKYO STEEL	JAPAN	1,630 mm	4-High Hot Skin-pass Mill
2007	DRAGON STEEL	TAIWAN	1,880 mm	4-High Hot Skin-pass Mill
2008	DRAGON STEEL	TAIWAN	1,880 mm	4-High Hot Skin-pass Mill
2008	COSIPA-USIMINAS	BRASIL	2,050mm	4-High Hot Skin-pass Mill
2008	COSIPA-USIMINAS	BRASIL	2,050mm	Recoiling line

Ezz Hot Skinpass

BUR - Driven

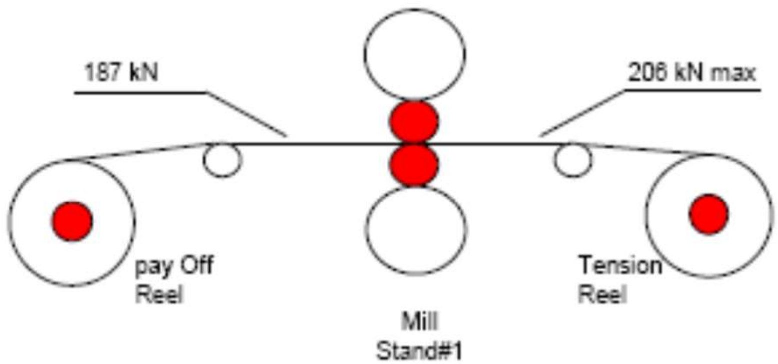
Stand Capacity: 1000 ton - Max Speed: 600 mpm



Specifications		
Maximum Entry Strip Thickness	5,0	mm
Minimum Entry Strip Thickness	1,00	mm
Maximum Strip Width	1600,0	mm
Minimum Strip Width	800,0	mm
Maximum Exit Strip Thickness	5,0	mm
Minimum Exit Strip Thickness	1	mm
Entry I.D.	762	mm
Entry Max. O.D.	2000	mm
Exit I.D.	610	mm
Exit Max. O.D.	1900	mm
Maximum Coil Weight	25	t

Specifications	Pay Off Reel	Mill Stand	Tension Reel
Nominal Total Power (kW)	750	1000	1050
Nominal Motor Torque(kN*m)	9,6	19,1	13,4
Maximum Overload	1,50	1,50	1,50
Gear Ratio (-)	8,660	6,607	7,021
Motor Base Speed(rpm)	750,0	500,0	750,0
Nom. Total Torque at Exit Gear Box (KN*m)	82,7	126,2	93,9
Motor Max Speed (rpm)	2250,0	1500,0	2250,0
Torq. at max speed at Exit Gear Box (kN*m)	27,6	42,1	31,3
Minimum Diameter (mm) Back Up Rolls/Mandrel	762,0	900,0	610,0
Maximum Speed at min Diameter (mpm)	622	642	614
Maximum Diameter Back Up Roll/Coil O.D. (mm)	2000	1000	1900
Maximum Speed at max Diameter (mpm)		713	

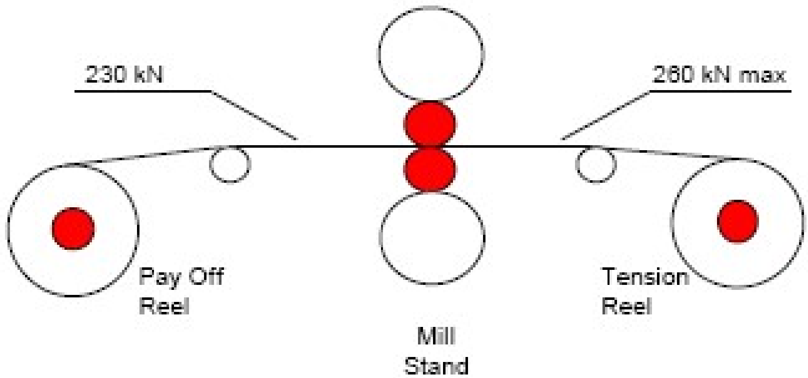
Lisco
Hot Skinpass



Specifications		
Maximum Entry Strip Thickness	6,5	mm
Minimum Entry Strip Thickness	1,20	mm
Maximum Strip Width	1600,0	mm
Minimum Strip Width	800,0	mm
Entry I.D.	762	mm
Entry Max. O.D.	2100	mm
Exit I.D.	762	mm
Exit Max. O.D.	2100	mm
Maximum Coil Weight	30	t

Specifications		**Pay Off Reel**		**Mill Stand#1**	**Tension Reel**	
Nominal Total Power (kW)		1000		2000	1000	
Nominal Motor Torque(kN*m)		19,1		38,2	19,1	
Gear Ratio (-)		5,00	10,00	3,10	5,00	10,00
Motor Base Speed(rpm)		500		500	500	
Nom. Torque at Exit Gear Box (KN*m)		95,5	191,0	118,4	95,5	191,0
Motor Max Speed (rpm)		1500		1500	1500	
(kN*m)		31,8	63,7	39,5	31,8	63,7
Minimum Diameter(mm) Work Rolls/Mandrel		762	762	400	762	762
Maximum Speed at min Diameter (mpm)		718	359	608	718	359
Maximum Diameter Work Roll/Coil O.D. (mm)		2100	2100	450	2100	2100
Maximum Speed at max Diameter (mpm)				684		

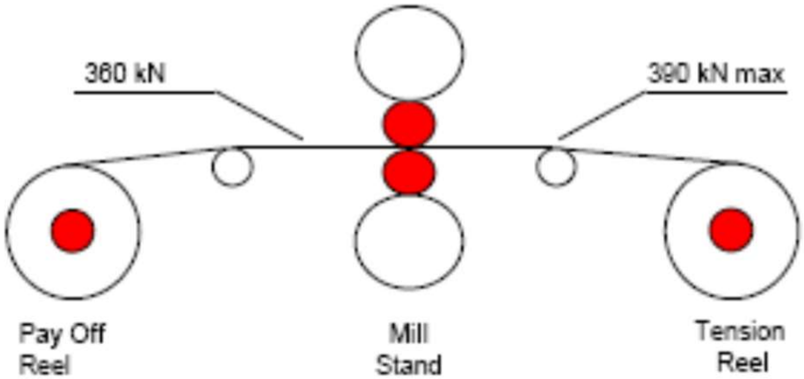
Tangshan Guofeng
Hot Skinpass



Specifications		
Maximum Entry Strip Thickness	12,7	mm
Minimum Entry Strip Thickness	1,20	mm
Maximum Strip Width	1300,0	mm
Minimum Strip Width	600,0	mm
Entry I.D.	762	mm
Entry Max. O.D.	1850	mm
Exit I.D.	762	mm
Exit Max. O.D.	1850	mm
Maximum Coil Weight	21	t

Specifications		Pay Off Reel		Mill Stand#1	Tension Reel	
Nominal Total Power (kW)		1000		2000	1000	
Nominal Motor Torque(kN*m)		19,1		38,2	19,1	
Gear Ratio (-)		7,50	15,00	4,00	7,50	15,00
Motor Base Speed(rpm)		500		500	500	
Nom. Torque at Exit Gear Box (KN*m)		143,3	286,5	152,8	143,3	286,5
Motor Max Speed (rpm)		1500		1500	1500	
(kN*m)		47,8	95,5	50,9	47,8	95,5
Minimum Diameter(mm) Work Rolls/Mandrel		762	762	400	762	762
Maximum Speed at min Diameter (mpm)		479	239	471	479	239
Maximum Diameter Work Roll/Coil O.D. (mm)		1850	1850	450	1850	1850
Maximum Speed at max Diameter (mpm)				530		

HANDAN
Hot Skinpass
Stand capacity: 1500 ton



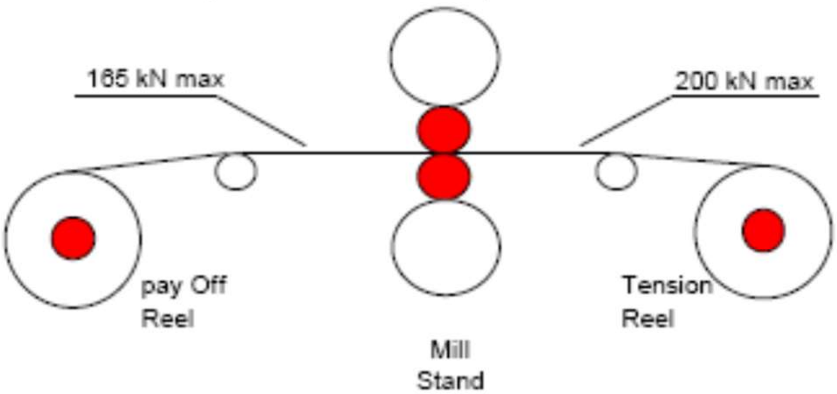
Specifications		
Maximum Entry Strip Thickness	12,7	mm
Minimum Entry Strip Thickness	1,20	mm
Maximum Strip Width	2130,0	mm
Entry I.D.	762	mm
Entry Max. O.D.	2200	mm
Exit I.D.	762	mm
Exit Max. O.D.	2150	mm
Maximum Coil Weight	40	t

Specifications	**Pay Off Reel**		**Mill Stand**	**Tension Reel**	
Nominal Total Power (kW)	1600		2500	2100	
Nominal Motor Torque(kN*m)	30,6		31,8	40,1	
Gear Ratio (-)	6,55	11,20	3,40	6,55	11,20
Motor Base Speed(rpm)	500		750	500	
Nom. Torque at Exit Gear Box (KN*m)	200,2	342,3	108,2	262,8	449,3
Motor Max Speed (rpm)	1500	1500	1500	1500	1500
(kN*m)	66,7	114,1	54,1	87,6	149,8
Minimum Diameter(mm) Work Roll/Mandrel	762		400	762	
Maximum Speed at min Diameter (mpm)	548	321	554	548	321
Maximum Diameter Work Roll/Coil O.D. (mm)	2150	2150	450	2150	2150
Maximum Speed at max Diameter (mpm)			624		

Tokyo Steel - Hot Skinpass

Capacity 1500 ton

Option: Stand motor power 1600kW



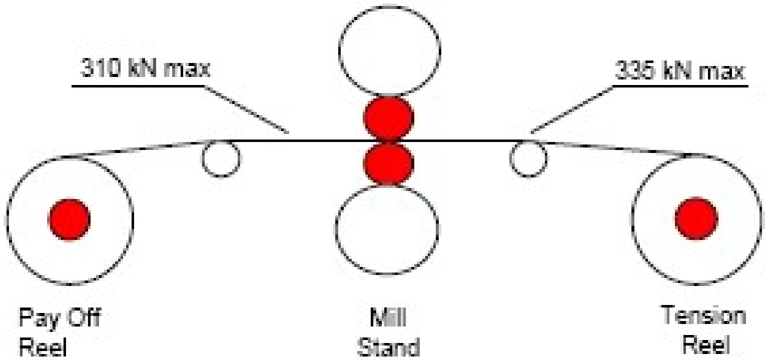
Specifications		
Maximum Entry Strip Thickness	6,00	mm
Minimum Entry Strip Thickness	1,50	mm
Maximum Strip Width	1630	mm
Minimum Strip Width	780	mm
Entry I.D.	762	mm
Entry Max. O.D.	2050	mm
Exit I.D.	762	mm
Exit Max. O.D.	2050	mm
Maximum Coil Weight	30	t

Specifications		Pay Off Reel		Mill Stand#1	Tension Reel	
Nominal Total Power (kW)		800		1600	1150	
Nominal Motor Torque(kN*m)		15,3		30,6	22,0	
Gear Ratio (-)		7,10	10,80	3,75	7,10	10,80
Motor Base Speed(rpm)		500		500	500	
Nom. Torque at Exit Gear Box (KN*m)		108,5	165,0	114,6	156,0	237,2
Motor Max Speed (rpm)		1500		1500	1500	
(kN*m)		36,2	55,0	38,2	52,0	79,1
Minimum Diameter(mm) Work Rolls/Mandrel		762	762	400	762	762
Maximum Speed at min Diameter (mpm)		506	332	503	506	332
Maximum Diameter Work Roll/Coil O.D. (mm)		1900	1900	450	1900	1900
Maximum Speed at max Diameter (mpm)				565		

Dragon Steel

Hot Skinpass No. 1 and 2

Stand Capacity: 1500ton - WR Driven



Specifications		
Maximum Entry Strip Thickness	12,7	mm
Minimum Entry Strip Thickness	1,20	mm
Maximum Strip Width	1880,0	mm
Entry I.D.	762	mm
Entry Max. O.D.	2250	mm
Exit I.D.	762	mm
Exit Max. O.D.	2200	mm
Maximum Coil Weight	35	t

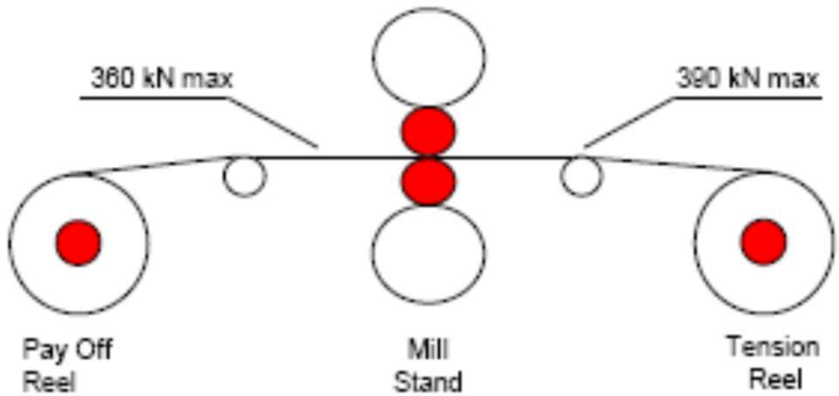
Specifications	**Pay Off Reel**		**Mill Stand#1**	**Tension Reel**	
Nominal Total Power (kW)	1300		1500 (2X750)	1750	
Nominal Motor Torque(kN*m)	20,7		23,9	27,9	
Gear Ratio (-)	7,50	11,70	3,54	7,50	11,70
Motor Base Speed(rpm)	600		600	600	
Nom. Torque at Exit Gear Box (KN*m)	155,2	242,1	84,5	208,9	325,9
Motor Max Speed (rpm)	1800		1800	1800	
(kN*m)	51,7	80,7	28,2	69,6	108,6
Minimum Diameter(mm) WR/Mandrel	762		400	762	
Maximum Speed at min Diameter (mpm)	575	368	639	575	368
Maximum Diameter WR/Coil O.D. (mm)	2250		450	2200	
Maximum Speed at max Diameter (mpm)			719		

NOTE: mill motors: 2 x 750 kW

COSIPA

Hot Skinpass

Stand capacity:1500 ton



Specifications		
Maximum Entry Strip Thickness	12,7	mm
Maximum Entry Strip Th. (for Skinpassing)	6,5	mm
Minimum Entry Strip Thickness	1,2	mm
Maximum Strip Width	2050	mm
Entry I.D.	762/610	mm
Entry Max. O.D.	2100	mm
Exit I.D.	762/610	mm
Exit Max. O.D.	2100	mm
Maximum Coil Weight	35	t

Specifications	Pay Off Reel		Mill Stand	Tension Reel	
Nominal Total Power (kW)	1500		2300	2100	
Nominal Motor Torque(kN*m)	28,7		29,3	40,1	
Gear Ratio (-)	5,40	10,80	3,40	5,40	10,80
Motor Base Speed(rpm)	500		750	500	
Nom. Torque at Exit Gear Box (KN*m)	154,7	309,5	99,6	216,6	433,2
Motor Max Speed (rpm)	1500	1500	1500	1500	1500
(kN*m)	51,6	103,2	49,8	72,2	144,4
Minimum Diameter(mm) Work Roll/Mandrel	610		400	610	
Maximum Speed at min Diameter (mpm)	532	266	554	532	266
Maximum Diameter Work Roll/Coil O.D. (mm)	2100	2100	450	2100	2100
Maximum Speed at max Diameter (mpm)			624		

DANIELI

The Reliable And Innovative
Team In The Metals Industry

THANK YOU FOR YOUR KIND ATTENTION

R&D efforts towards development of high strength linepipe HR coils at BSL

Santosh Kumar*, B.K. Jha*, V. Kumar*, S. De*,
S. Mukhopadhyaya*, S.K. Chaudhuri*,
A.K. Singh**, Amarendu Prakash**, Alok Verma**, S.K. Sinha**,
S. Mallik**, R. Datta**, K.N. Changder** & S.N. Prasad**

सेल SAIL

* R&DCentre for Iron & Steel
** Bokaro Steel Limited
Steel Authority of India Ltd.
e-mail : santosh-kumar@sail-rdcis.com

Our Special Thanks goes to
Dr. MMS Sodhi, Mr. BL Chopra, Mr. Jayant Kumar, Prof RDK Misra & Dr. Fulvio Sisiliano

Driver for Development

Continuing need to reduce cost of construction of pipelines

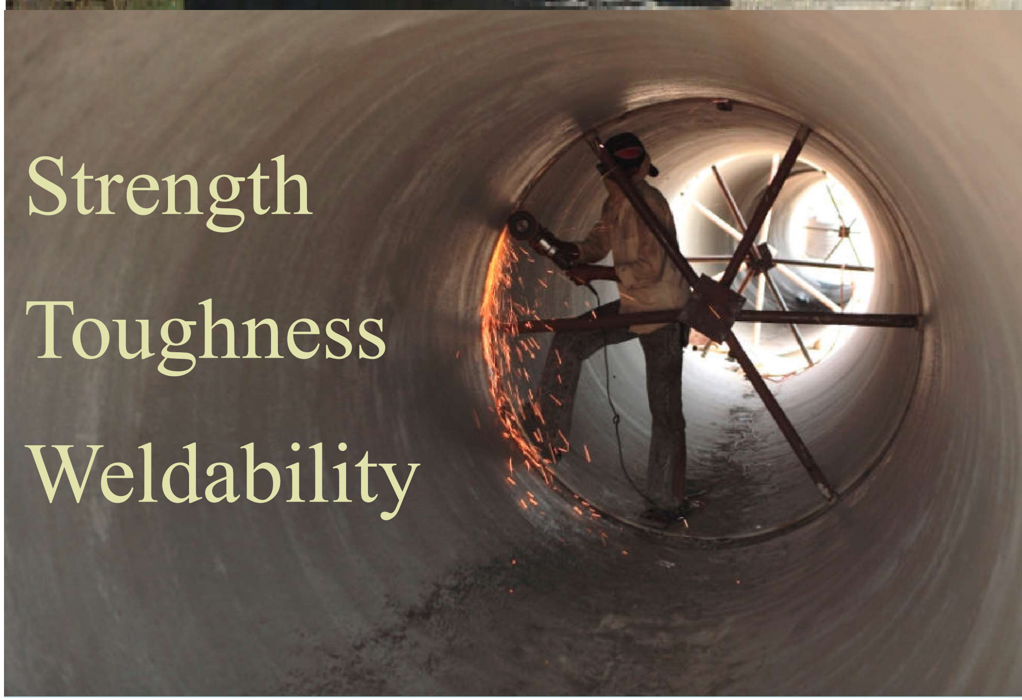
Diameter and wall thickness dictates the material and field welding costs

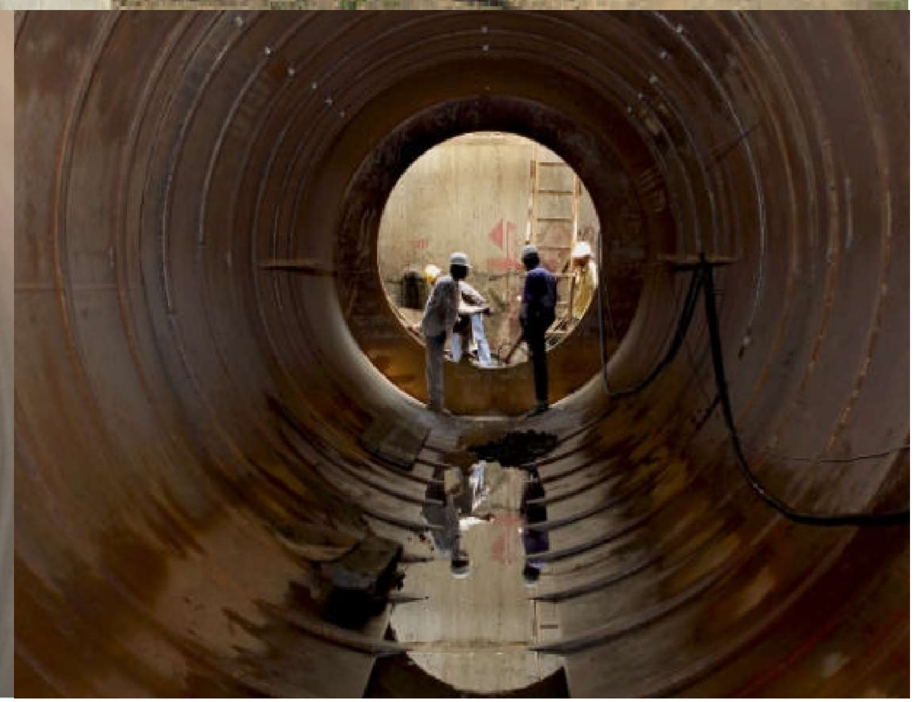
- Reduce wall thickness of the pipe
- Reduce the diameter
- Operate at higher pressure

one attractive avenue

Increase the strength to reduce cost

For steel producers, this drive towards higher strength presents **a challenge in meeting** the combined demands of **higher strength, good toughness & excellent weldability**, both for longitudinal welding of the seam in welded pipe and also, particularly, for field welding


Strength
Toughness
Weldability



Approach

Key Concerns for process control

- ❑ **Alloy Strategy**
- ❑ **Casting Conditions**
- ❑ **Rolling Schedule**
- ❑ **Dynamic Cooling**

→

- ❑ Strength
- ❑ YS / UTS ratio < 0.9
- ❑ Fracture toughness at lower temperatures
- ❑ Weldability
- ❑ Corrosion Resistance

Mechanical Properties

	Aim	Worst	API X – 70
YS	540 MPa	500 MPa	483 – 621 MPa
UTS	640 MPa	580 MPa	565 – 758 MPa
% El	> 30	30	
CIE(J) – 0°C	>100	100	

Metallurgical Considerations

for Alloy Design & processing parameters

- More Mn beneficial owing to solid Solution Strengthening, however, cap on upper limit due to its segregating tendency
- Adjust limits of S, P & N in accordance with process capabilities
- Avoid peritectic reaction (Restrict C $\leq$ 0.08%)
- Ti ties up free N in steel & improves hot ductility
- Vanadium contributes to precipitation hardening without increasing the mill load,
- Ensure Mn / S & Mn / Si ratios above critical values
- Ensure dissolution of precipitates of Nb & V during soaking.
- More than 67% reduction below T_{nr} in finishing strand
- Selection of lower FRT & CT

Chemistry of API X – 70

Steel Comp^{n}	Aim Chemistry	Actual Comp^{n}
C	0.06 – 0.08	0.074
Mn	1.40 – 1.50	1.43
Si	0.20 – 0.30	0.291
Al	0.02 min.	0.056
S	0.01 max	0.002
P	0.02 max.	0.018
V	0.04 – 0.05	0.05
Nb	0.05 – 0.06	0.06
Ti	0.01 – 0.02	0.014
N	60 ppm max	56 ppm
CE	0.35 max.	0.322

CBT i.e. Combined Blowing Technology used for making of API X – 70 grade

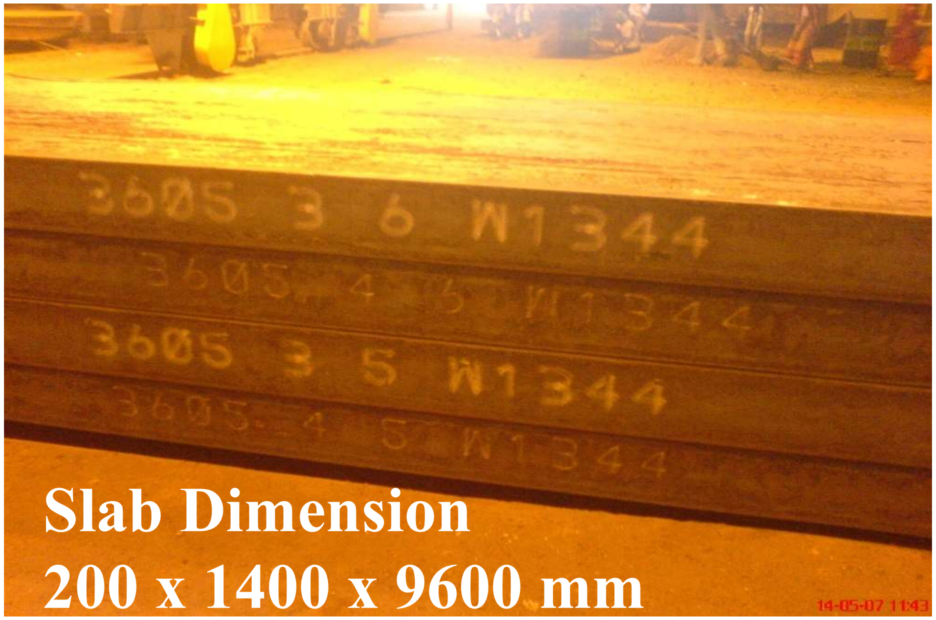
Continuous Casting of API X- 70

Casting Parameters

Parameter	Aimed	Actual Achieved
Speed :	1.2 M/min.	1.1 - 1.2 M/min.
Tundish Temperature :	1545 °C Max	1535 – 1542 °C
ΔT :	25 °C Max.	14 – 21 °C
Primary Cooling :	-	9320 – 9440 lpm
Secondary Cooling :	Soft	Soft
Stack cooled :	-	60 hours

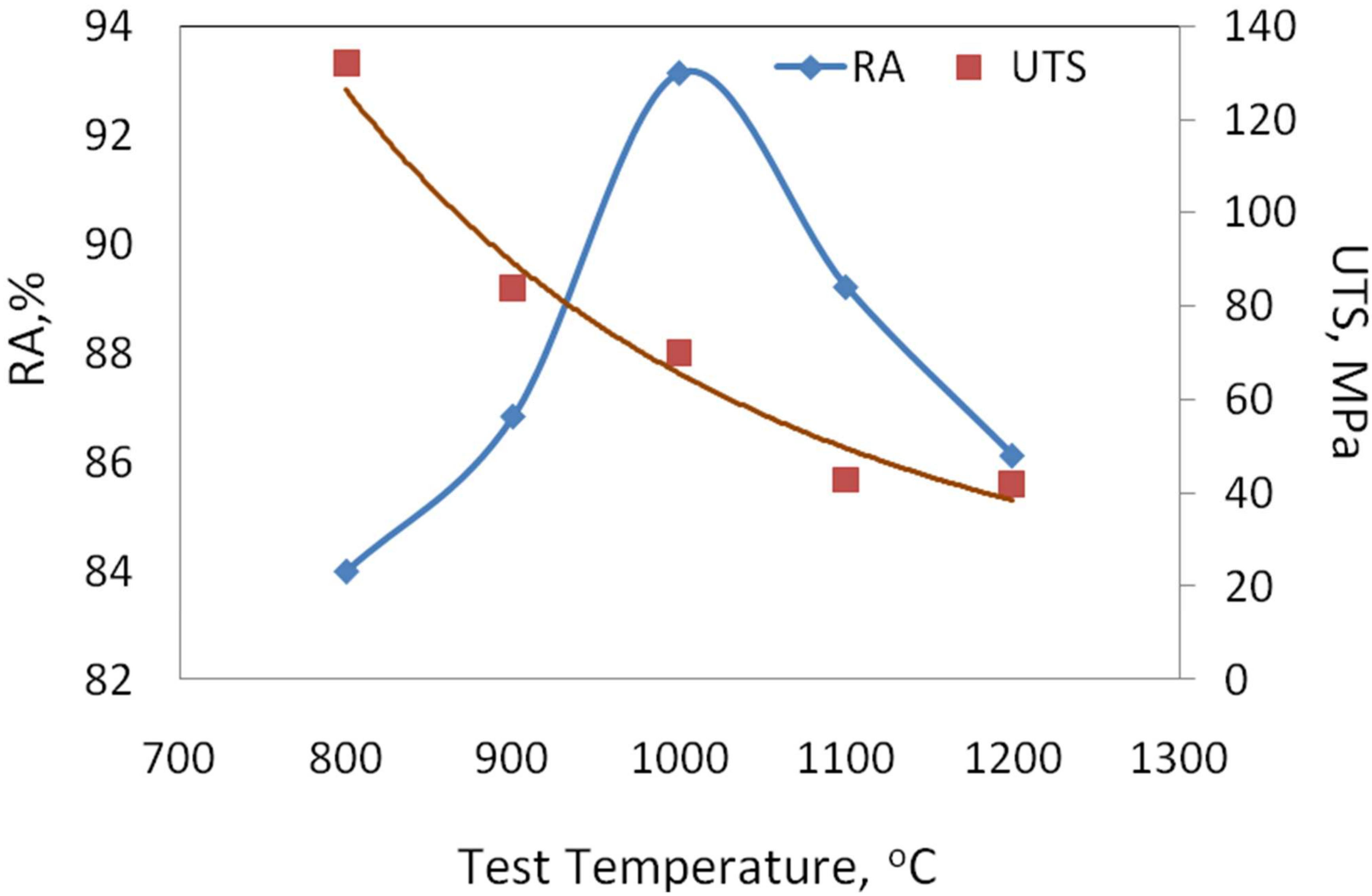
Liquidus = 1536.6 – 76.0 C
– 5 Mn – 8 Si – 25 S
– 30 P – 1.5 Cr – 4 Ni
– 2 Mo – 5 Cu

Liquidus 1520.9 C



Slab Dimension
200 x 1400 x 9600 mm

Hot Ductility

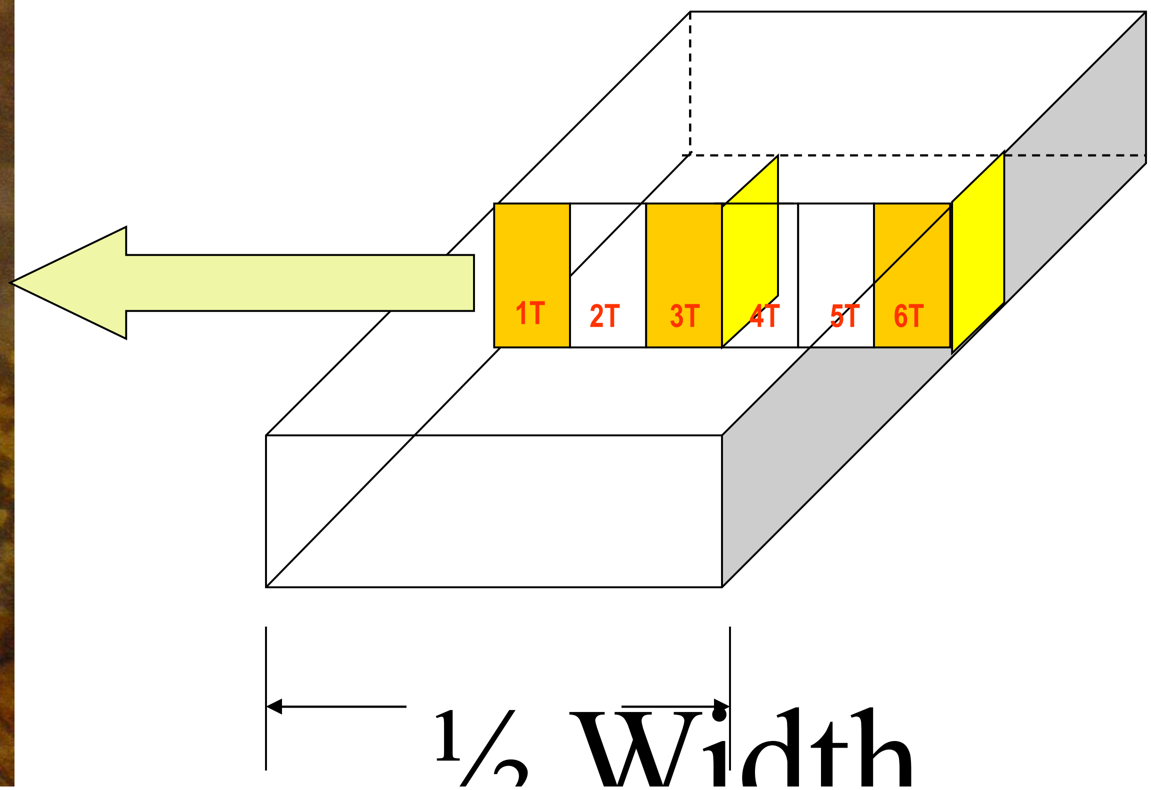


Visual Inspection

No surface cracks
No corner cracks
No abnormality

Macro of Transverse Section near the Edge

No sub-surface cracks
No off-corner cracks
No triple point crack

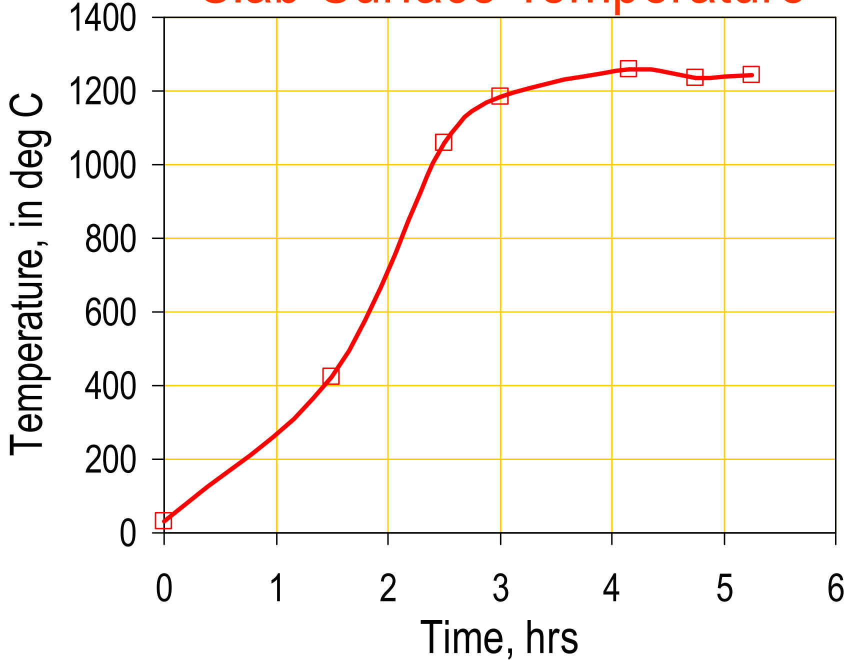


Reheating

Irvine:

log[Nb][C+12/14N] = -6770/T+2.16

Slab Surface Temperature



Sol. Temperature for Nb (CN) = 1203 C

Slab Discharge Temperatures

Coil No.	Top	Middle	Bott
995054	1247	1254	1232

Slabs were soaked for more than 2 hrs at 1250 C as per standard practice (1 hr per 100 mm thickness of the slab)

Slabs were well soaked

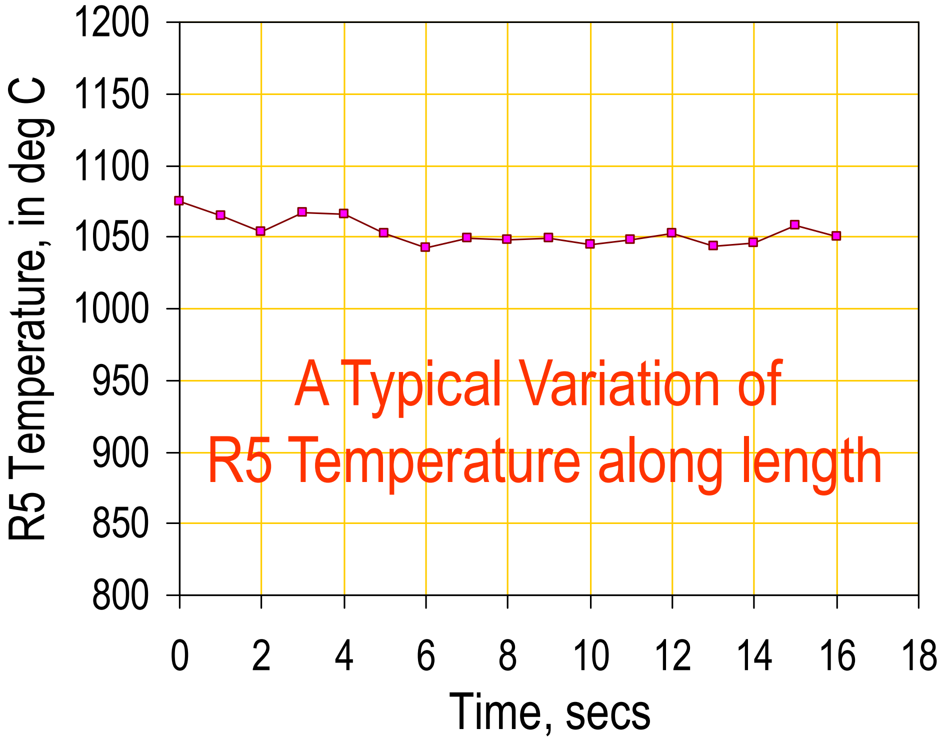
Hot Rolling

200mm →(R1, 25.0) 150 →(R2, 26.7) 110 →(R3, 30.4) 80 →(R4, 31.2) 55 →(R5, 24) 38mm

	Thickness,mm			Temp., C		(in KN)	(in Amp)
Strand	Ho	Hf	% Red^n	Head	Tail	Roll-Force	CurrentLoad
F6	38.07	29.04	23.72	996	939	18220	4901
F7	29.04	22.49	22.56	975	930	20901	4233
F8	22.49	18.23	18.94	951	918	16791	4710
F9	18.23	15.65	14.15	929	905	15317	3662
F10	15.65	13.84	11.57	912	896	14084	4396
F11	13.84	12.65	8.60	894	885	11176	3226
F12	12.65	12.15	3.95	876	877	6342	2434

*30000 KN

Hot Rolling



Theoretical
Calculations

Tnr : 1064 C
Ar3 : 774 C

Thickness, mm
Temperatu

Coil No. H_{R5}

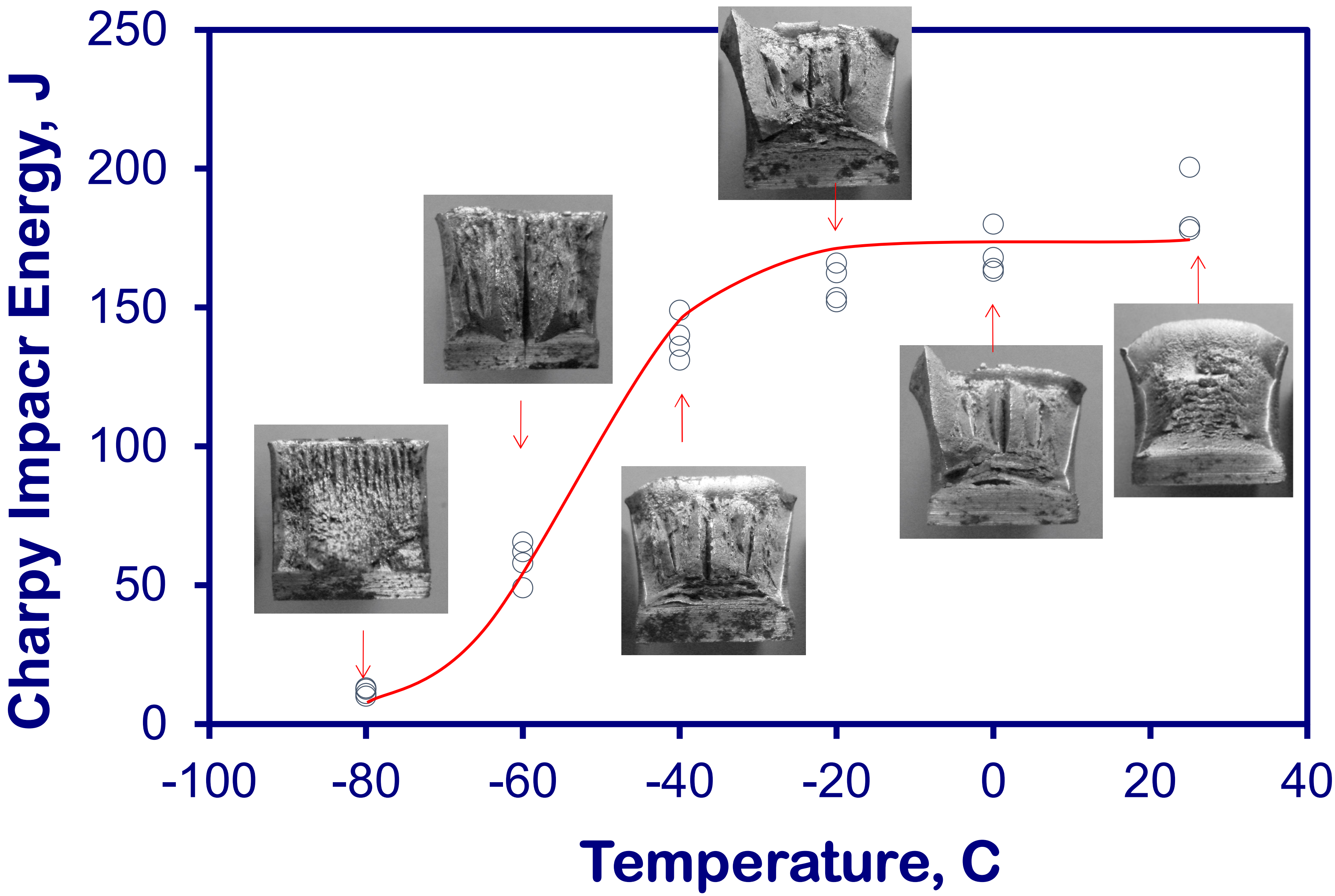
H_{FRT} R5 FRT

Mechanical Properties

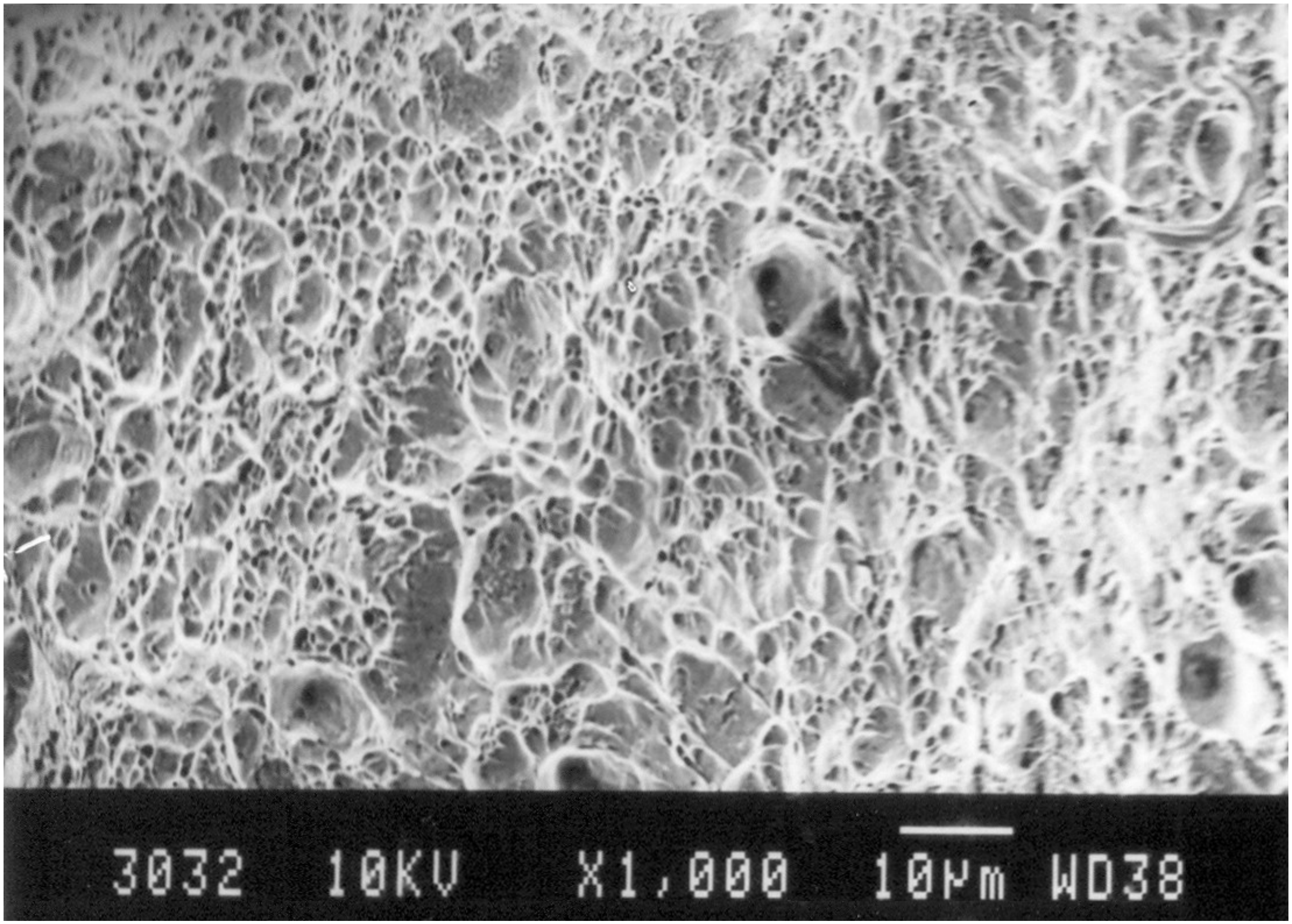
Properties	Specified	Aimed	Worst	Achieved
YS, MPa	483 – 621	540	500	535 – 557
UTS, MPa	565 – 758	640	580	616 – 645
YS / UTS	–	< 0.9	0.9	0.86 – 0.88
El., %(50GL)	–	> 30	30	33 – 50
CIE, J at -20°C	–	> 100	100	> 172

Ferrite Grain Size : ASTM No. 9 – 11

Ductile Brittle Transition

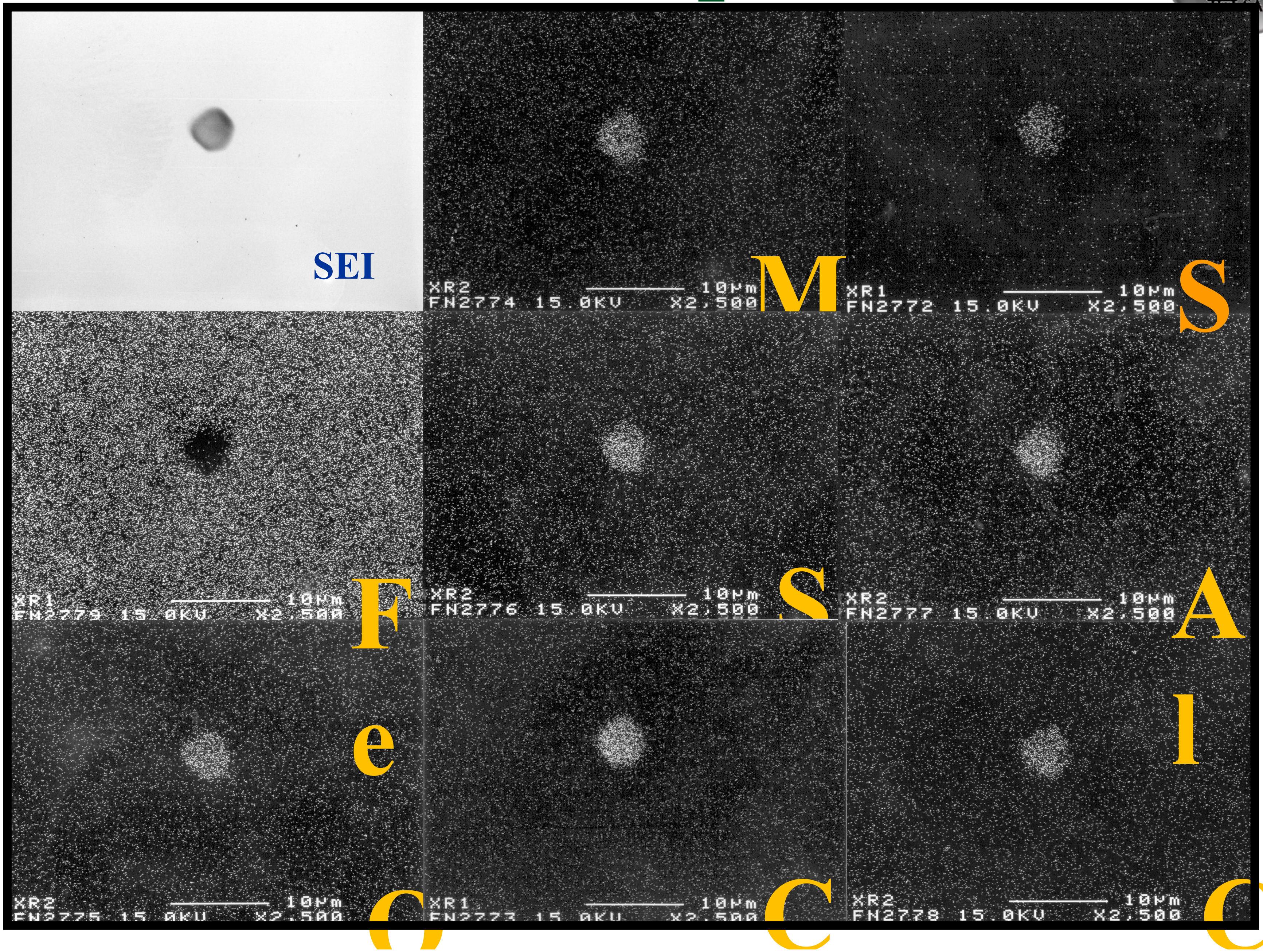


Fractograph

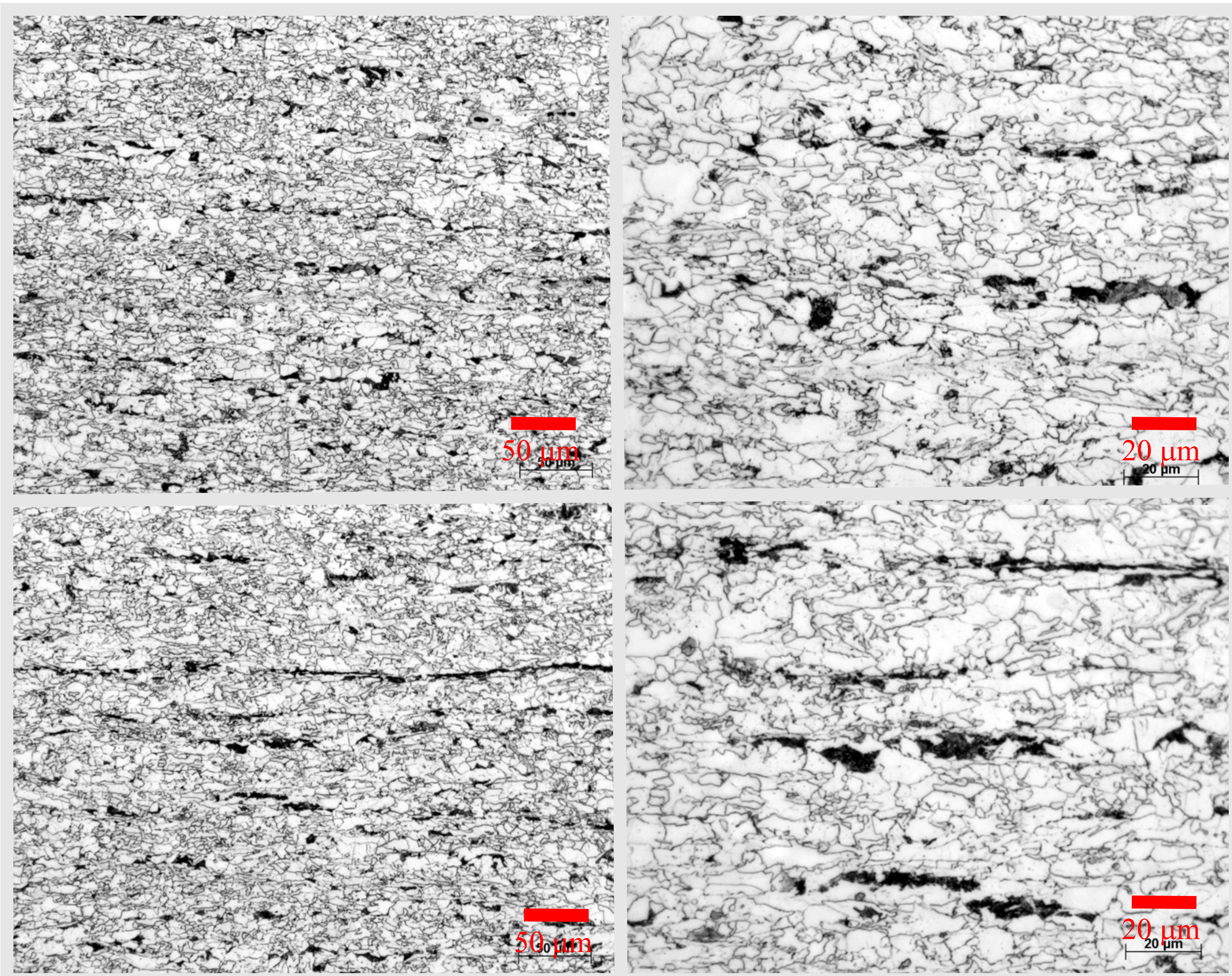


Test temperature : – 20 C

Inclusion Shape Control



Typical Microstructure



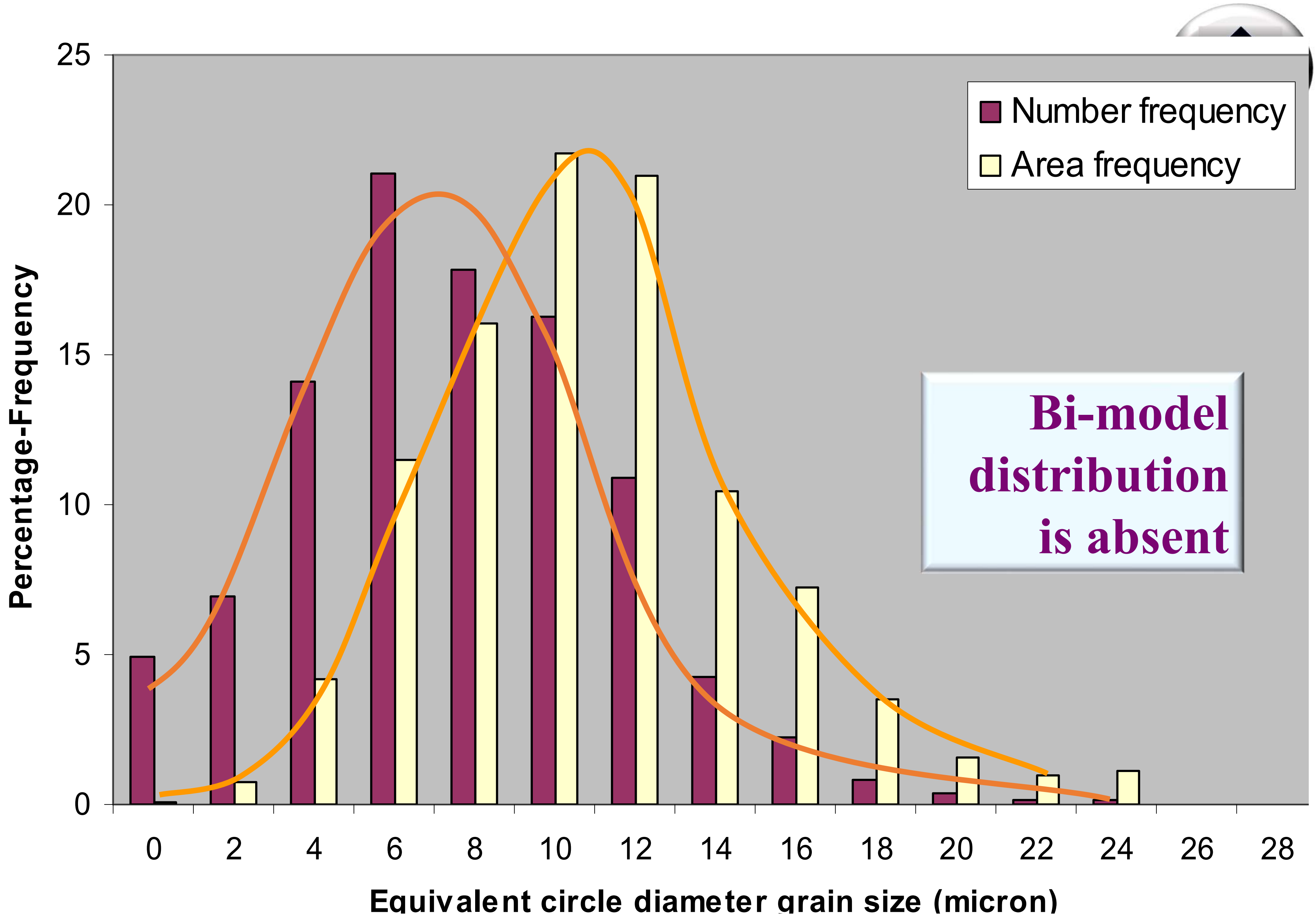
Near

Ferrite Size : ~ 9.4 μm

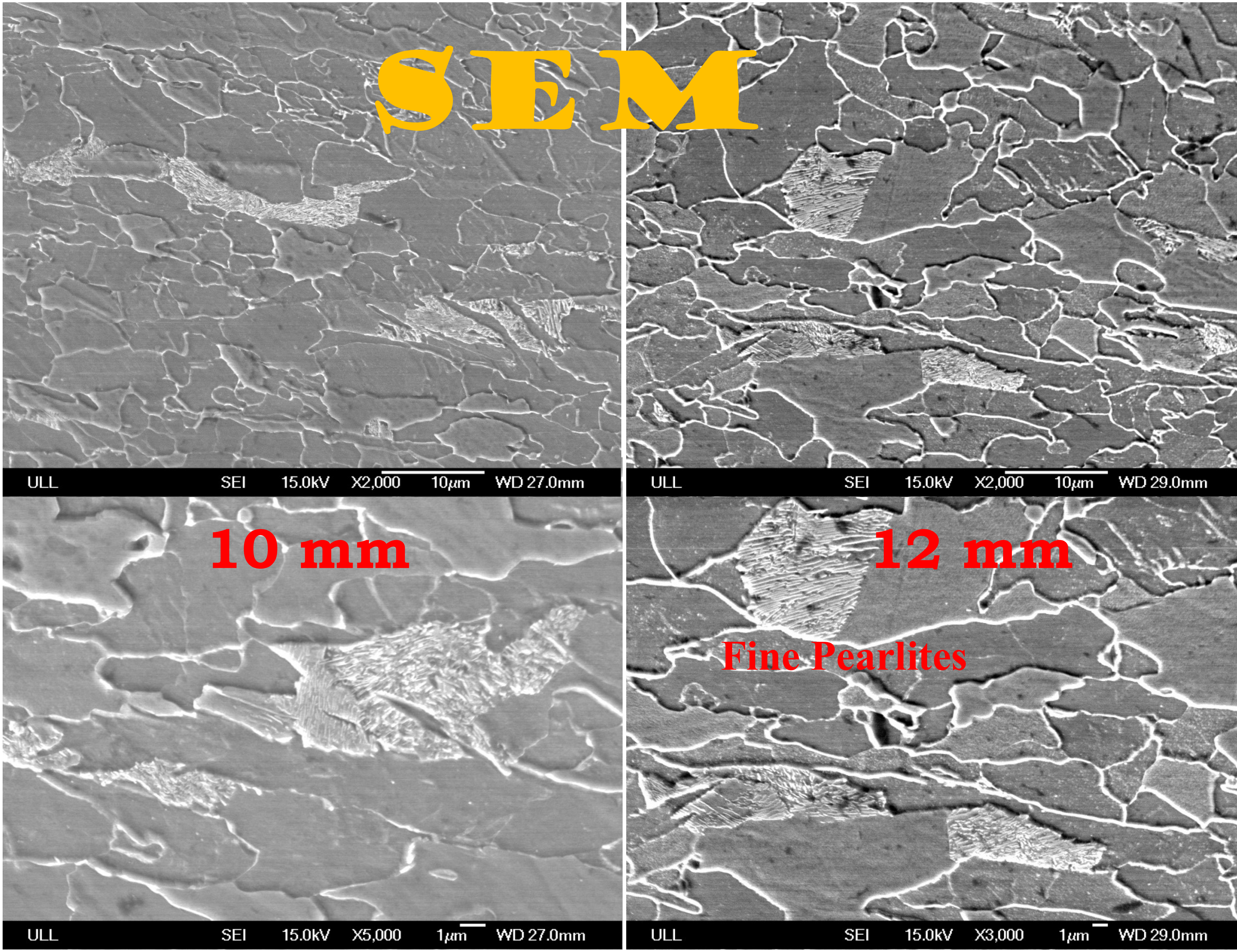
20 μm

Cent

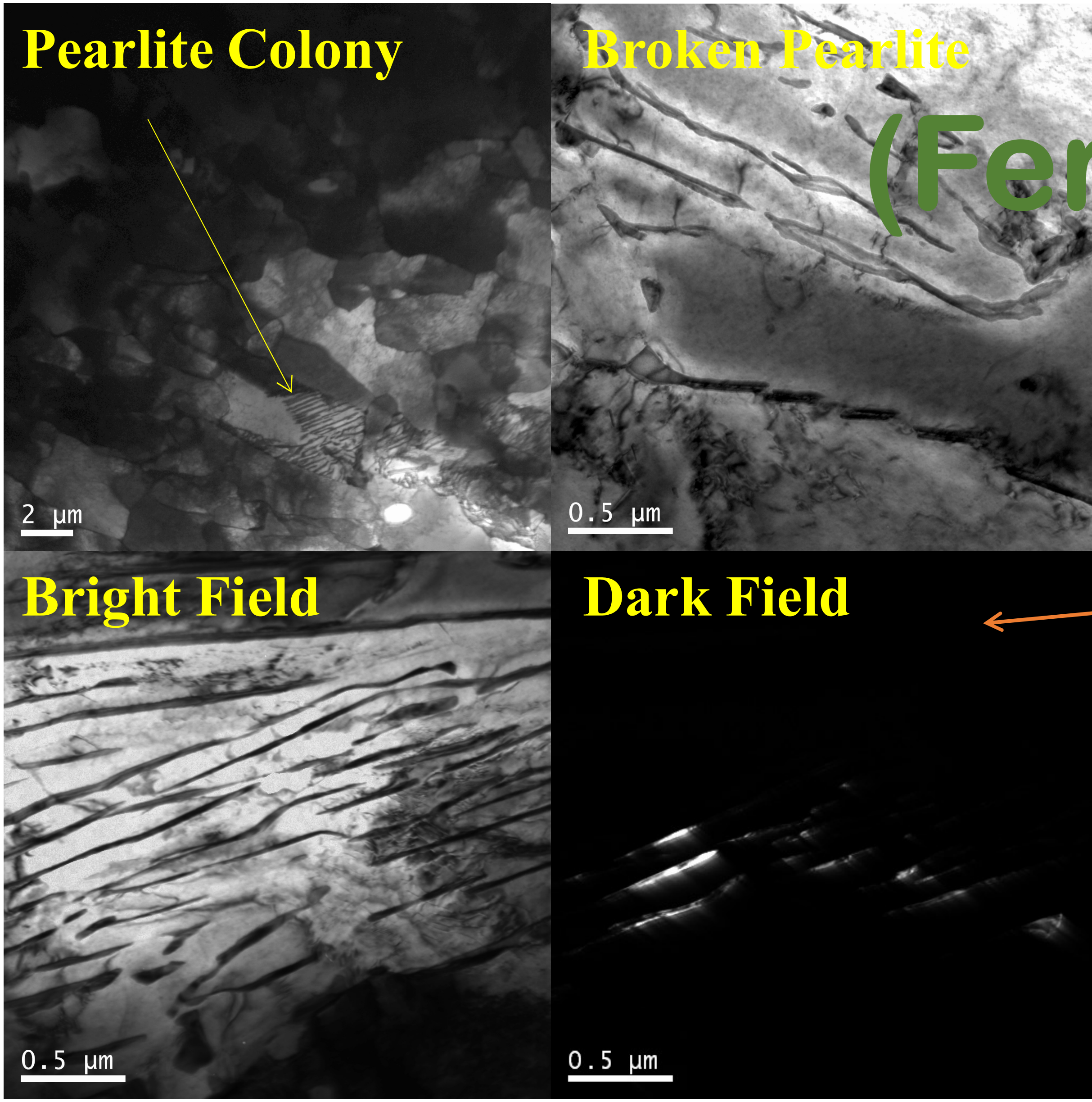
Ferrite Size : ~ 9.7 μm



Number frequency
Area frequency
Bi-model distribution is absent
Percentage-Frequency
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Equivalent circle diameter grain size (micron)

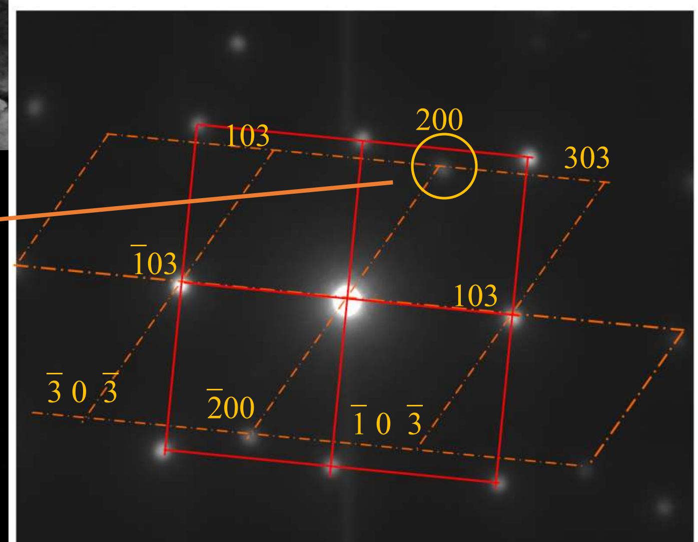

SEM
10 mm
12 mm
Fine Pearlites
ULL SEI 15.0kV X2,000 10μm WD 27.0mm
ULL SEI 15.0kV X2,000 10μm WD 29.0mm
ULL SEI 15.0kV X5,000 1μm WD 27.0mm
ULL SEI 15.0kV X3,000 1μm WD 29.0mm

Transmission Electron Micrographs



Microstructure

(Ferrite – Peal

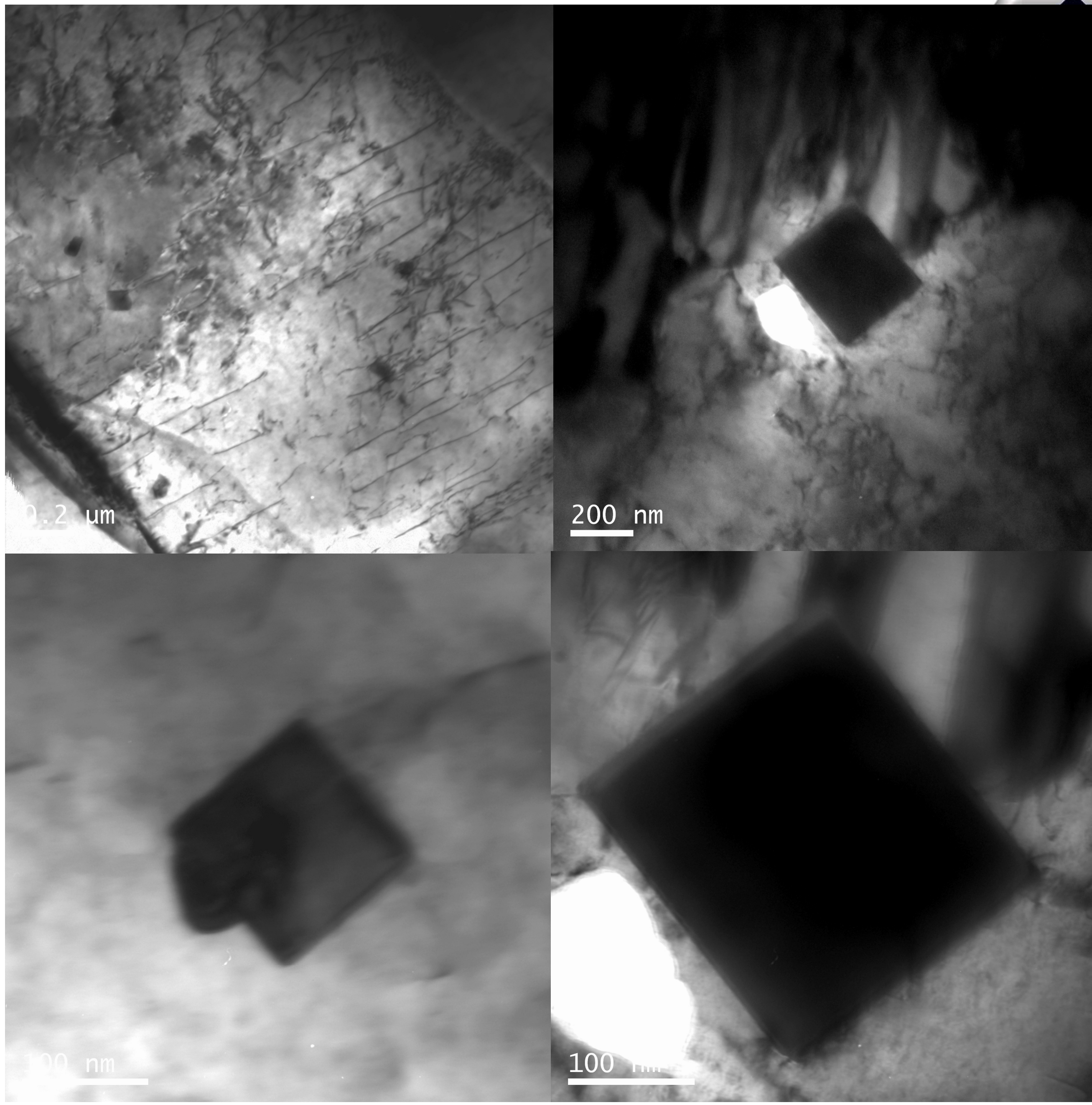


Selected Areas Diffraction
Ferrite & Cementite

(Ti,Nb,V)N

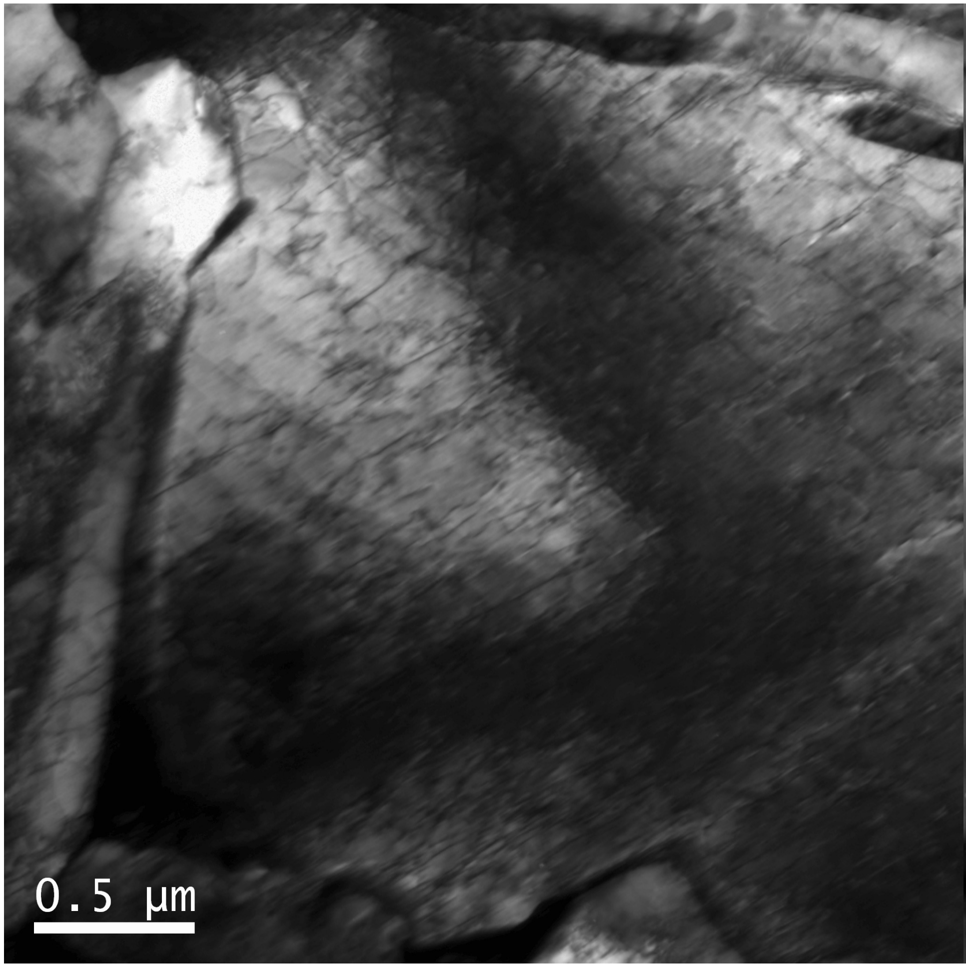
Precipitate size :
250 – 300 nm

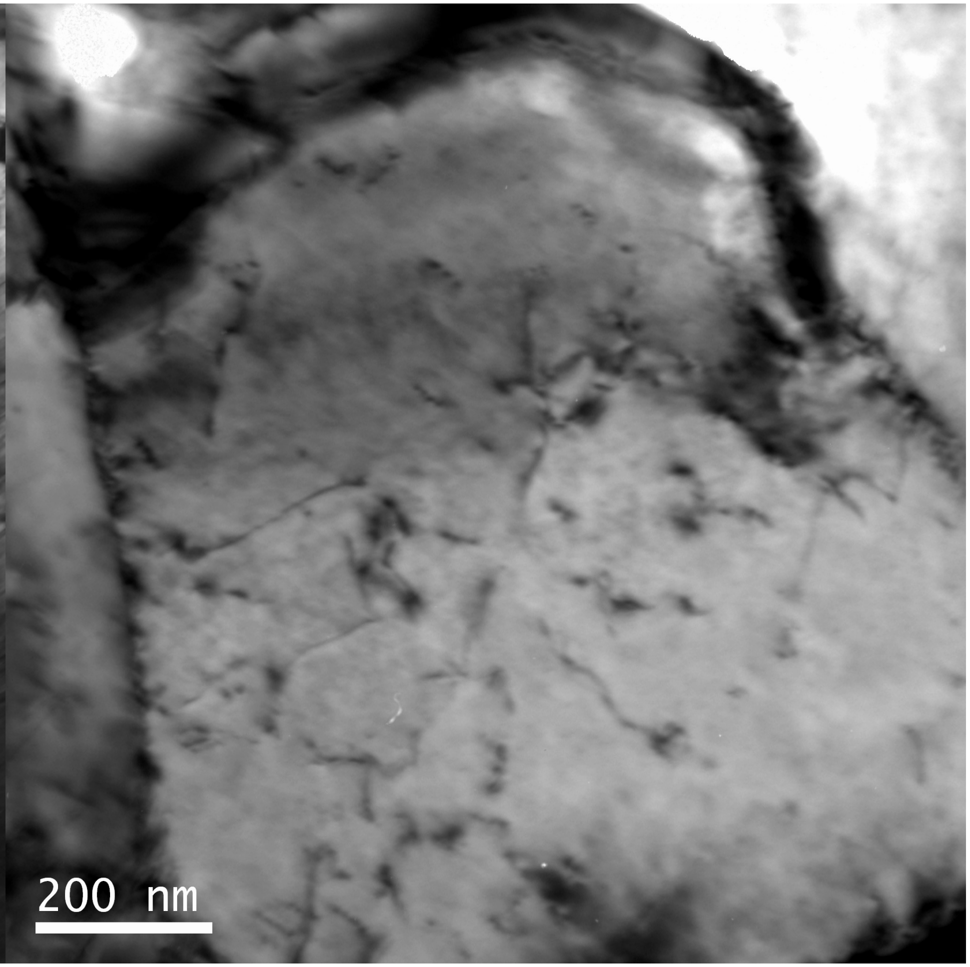
Core : Triplex (Ti, Nb, V)
Shell : Duplex (Nb, V)



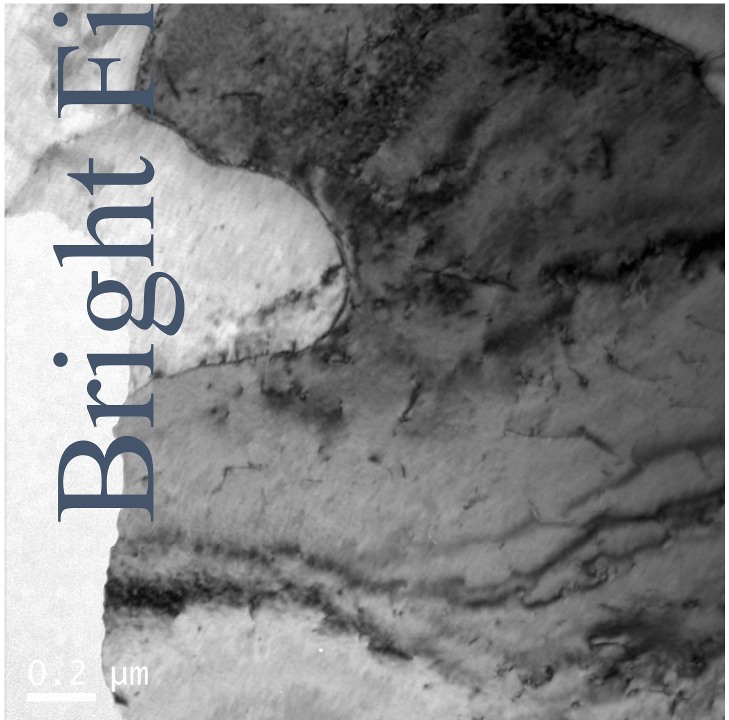
Core – shell Precipitate

Dislocations' Jungle & Dislocation Pinning

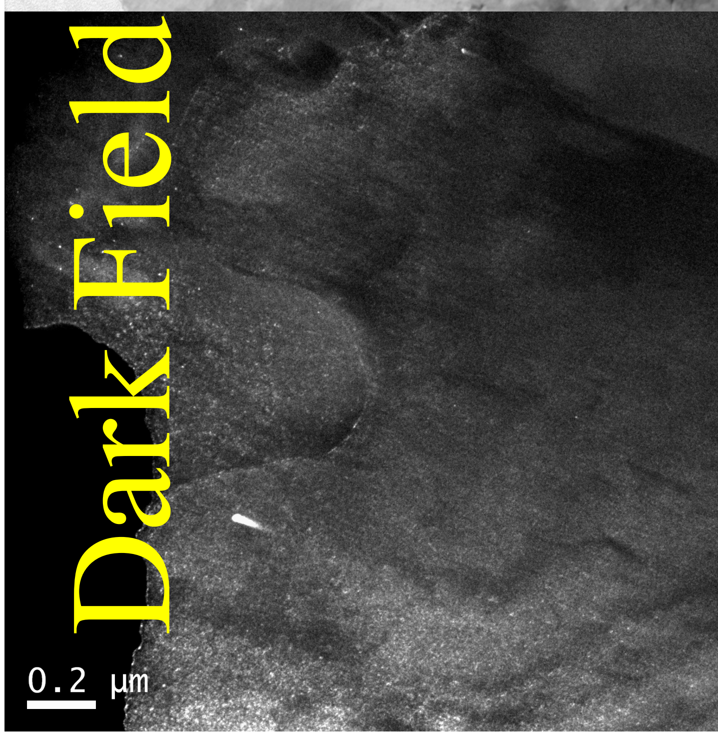


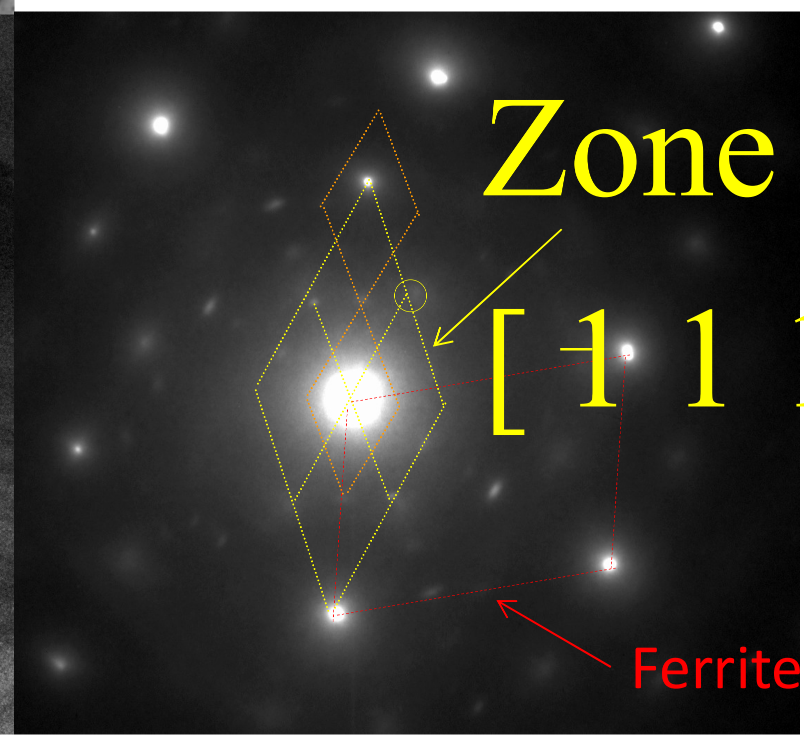


Precipitate Characterisation



M_4C_3





Edge trimming of API X – 70 HR Coil

API X – 70 HR Coil
1410 X 10 mm

↓

Uncoiled

↓

Slitting

~ 20 mm Trimmings ← Slitting → ~ 140 mm Trimmings

↓

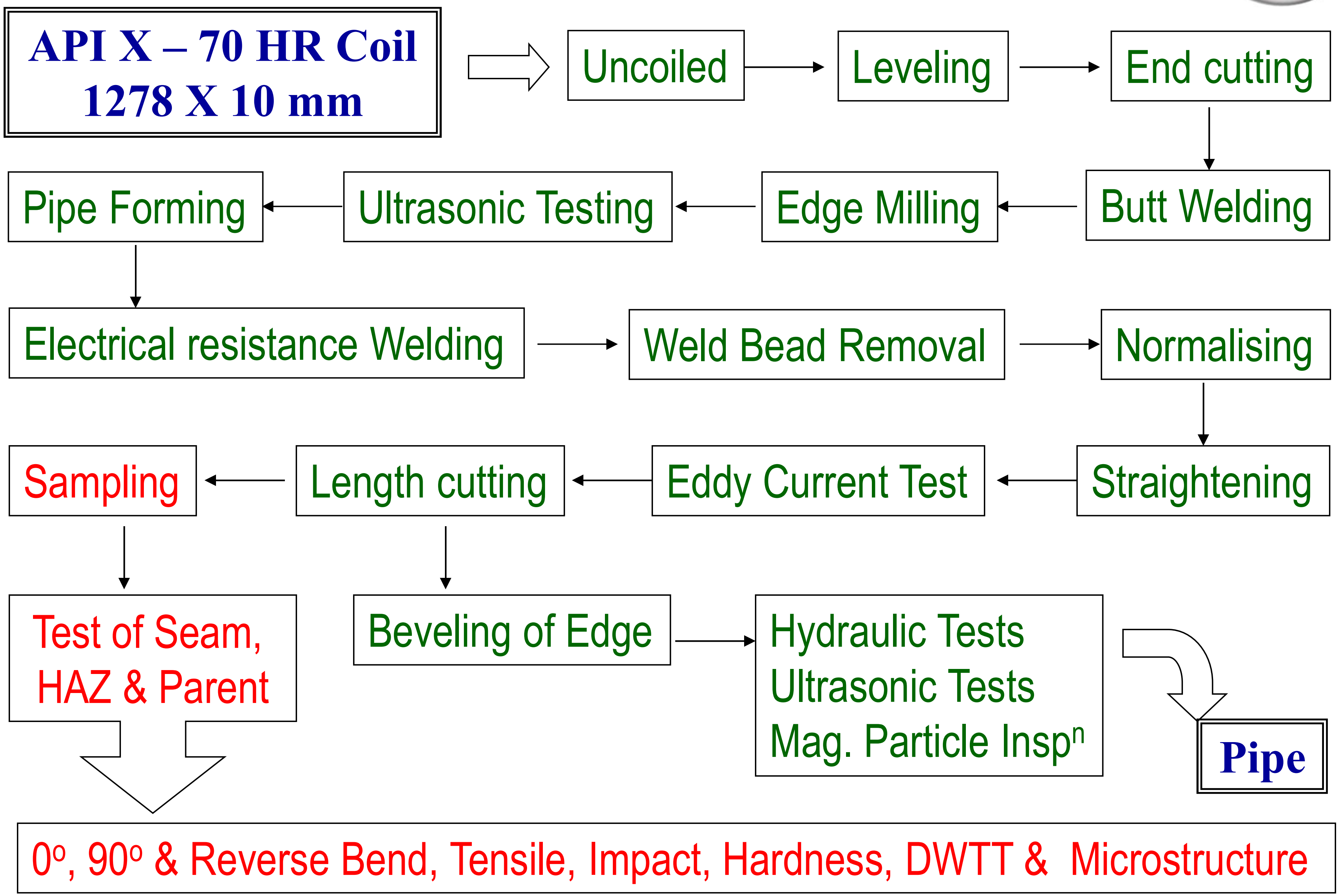
Coiled

↓

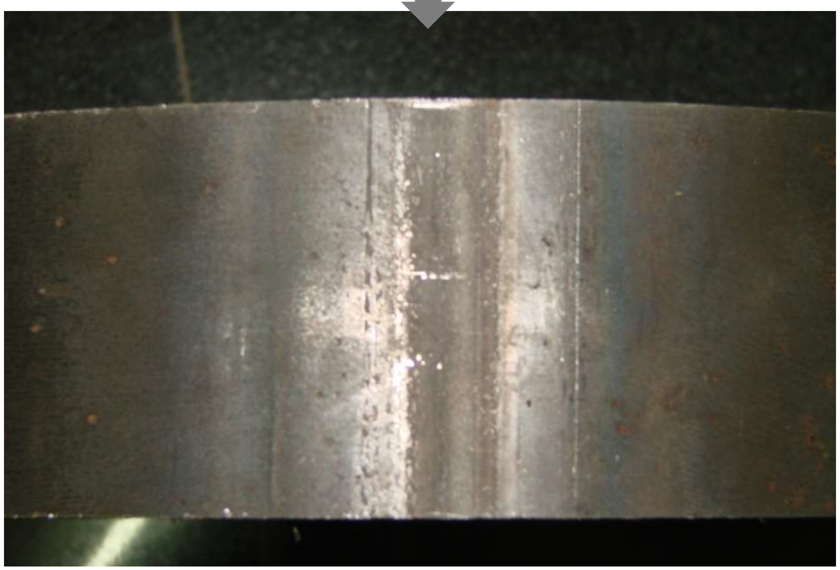
API X – 70 HR Coil
1278 X 10 mm

No lamination in hot rolled coil

Steps in Pipe Making



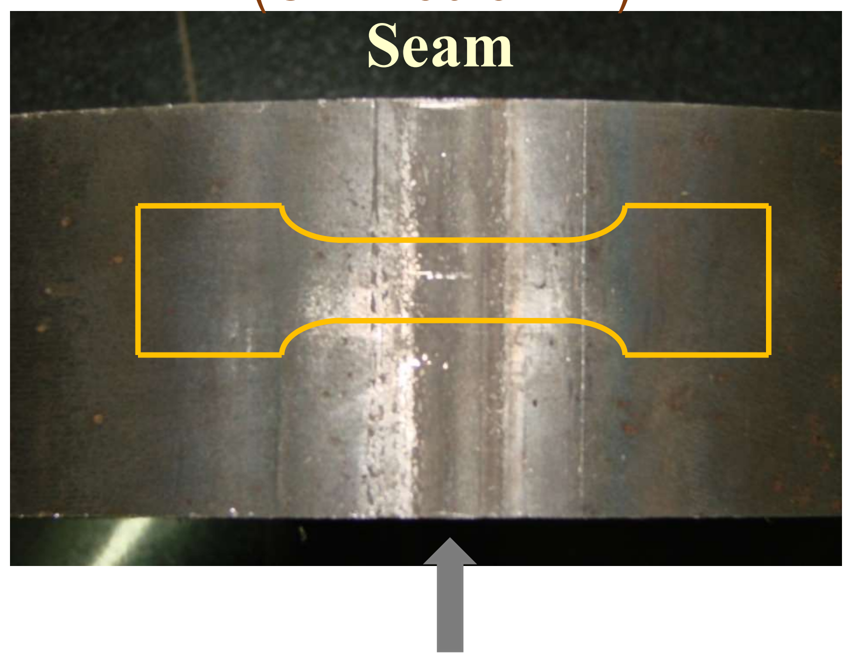
Sampling from Pipe



Mechanical Properties

Cutting & Flattening of Seam Region

Tensile Sample
(GL — 50.8 mm)



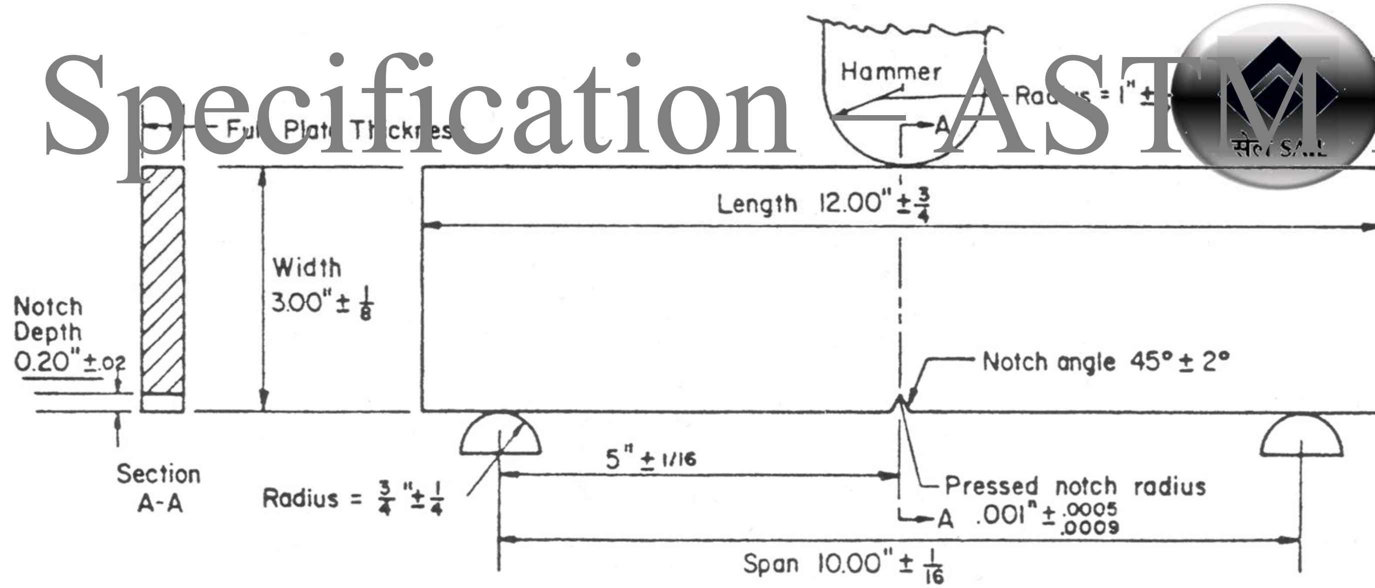
Tensile Properties

YS(MPa)	UTS(MPa)	El.(%)	YS/UTS	UTS-W(MPa)
521	614	33.6	0.85	590
528	626	33.5	0.84	664
516	630	36.8	0.82	634
544	630	36.0	HR Coil	
528	620	30	TC	

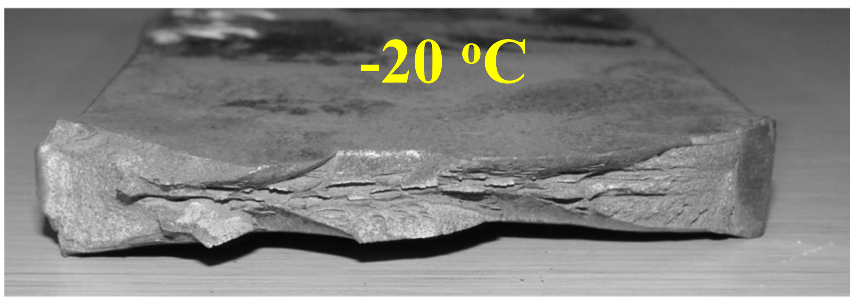
Bauschinger effect :
Drop of **25 – 30 MPa** in YS

Specification – ASTM

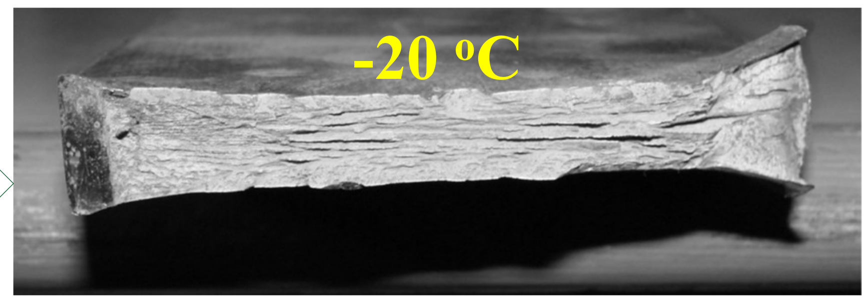
DWTT



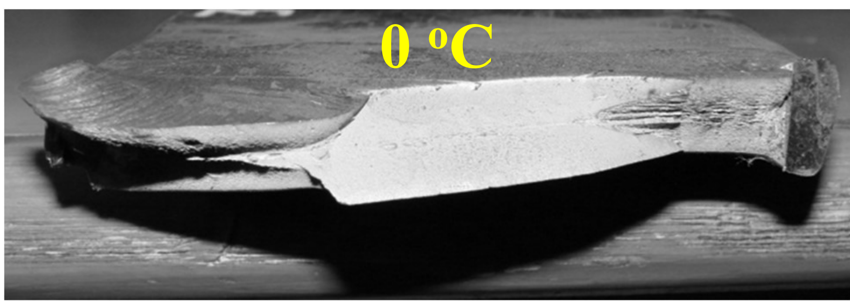
Shear Area



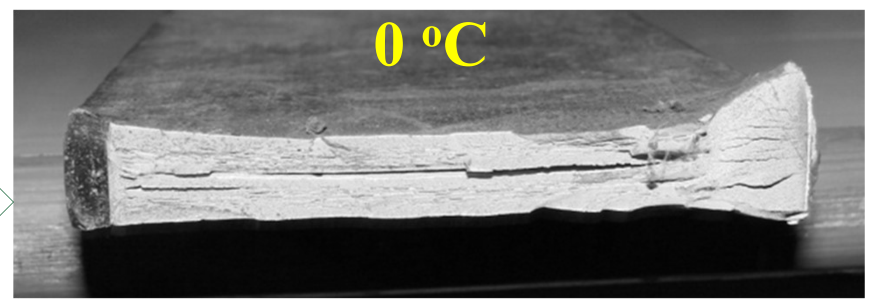
87%



86%



100%



86%

Conclusions

- Slabs of API X70 grade made at BSL have been free from defects (subsurface, triple point or off corner cracks).
- Dispersion of fine (2 – 5 nm) precipitate of desirable M_4C_3 type is observed. Hot rolled coils of API X – 70 grade at BSL has desirable microstructure both at optical and TEM levels.
- Tensile properties obtained for the developed API X -70 were close to the aimed YS & UTS values. With typical values of >33% and 172 J at 0 ^{o}C, elongation and Charpy impact values exceeded the aimed values.
- DBTT is below -40 ^{o}C.
- DWTT results are satisfactory with > 85% shear area.

Conclusions

- Result of ultrasonography testified absence of lamination or any internal defect within the material. The pipes successfully passed various types of NDT tests.
- Metallographic evaluation and mechanical properties including tensile, impact, hardness and DWTT evaluated for both pipe material and HAZ met the specification of API X-70.
- A drop of 20-25 MPa in YS is due to Bauschinger effect. UTS has remained unaffected.
- **The process technology for API X 70 grade HR coils has been developed successfully at BSL. Product is ready for commercial production.**

Thanks

DEVELOPMENT & COMMERCIALIZATION OF

HIGH STRENGTH LPG AT

BOKARO STEEL PLANT

S K De, A Deva, S Mukhopadhyay, B Mishra, A K Singh, S Mallik, B K Jha

LPG STEEL FROM BSL, BOKARO

- **Bokaro Steel Plant is an established manufacturer of IS 6240 LPG steel in India**

- **IS 6240 grade of LPG steel is essentially for domestic market**

- **Market demand of export grade LPG steels estimated at 20,000 T/Year**

- **Developmental work taken up to cater to the needs of this prestigious market segment**

HS LPG FROM BSL

Critical Quality Requirements

- Guaranteed mechanical properties after normalizing of formed cylinders
- Laboratory studies showed considerable drop in properties during normalization
- To overcome above problems, suitable alloy design & optimized process parameters were employed

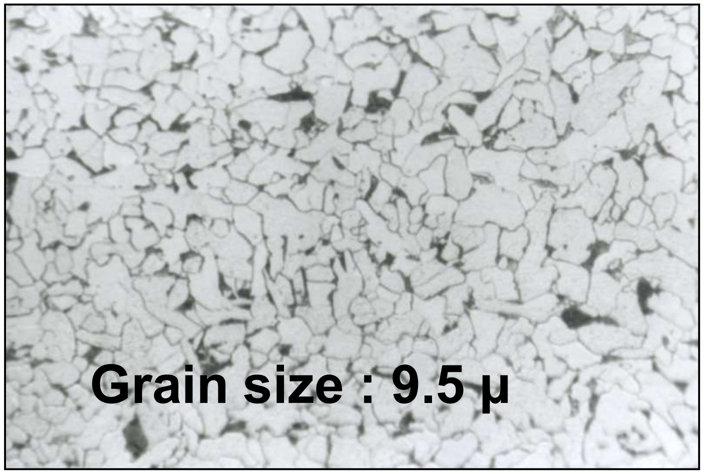
HS LPG FROM BSL

Production Trial

- First heat of JISG 3116 SG 295 with micro alloying
- HR coils size 2.4 X 1270 mm
- First consignment of 1000T successfully formed to export grade LPG cylinders
- Subsequently non-microalloyed & customized composition heats also developed

HS LPG FROM BSL

EN 10120 P 265



% C : 0.12

% Mn : 0.97

% Si : 0.070

% Nb : NIL

HR properties

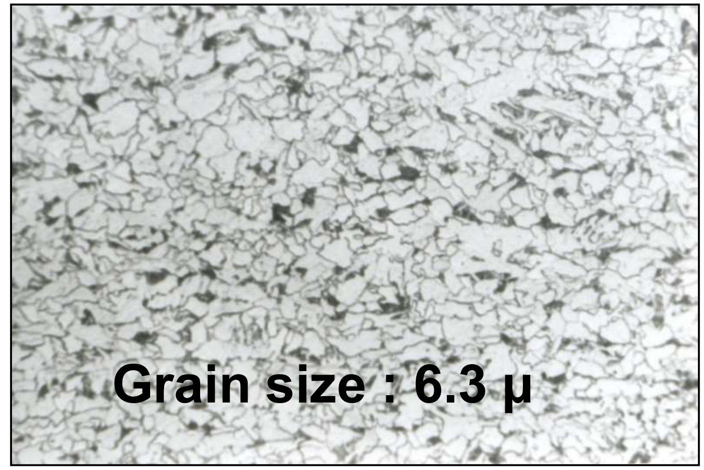
YS : 320-340 MPa

UTS : 420-460 MPa

% El : 37-39

FRT & CT : 840-860^{0}C & 600-620^{0}C

JISG 3116 SG 295



% C : 0.13

% Mn : 0.94

% Si : 0.072

% Nb: 0.008

HR properties

YS : 410-420 MPa

UTS : 500-530 MPa

% El : 32-34

FRT & CT : 850-870^{0}C & 620-640^{0}C

EXPORT QUALITY CYLINDERS (HIGH STRENGTH LPG) FROM BSL, BOKARO

GRADES:

EN 10120 NB series

JISG 3116 SG series

SIZES:

(2.2 to 3.6 mm X 1070 to 1250 mm)

DIFFERENT TYPES OF CYLINDERS

CHEMICAL COMPOSITION (HS LPG)

EN 10120	C (max)	Mn (min)	P (max)	S (max)	Si (max)
P245	0.16	0.3	0.025	0.015	0.25
P265	0.19	0.4			0.25
P310	0.20	0.7			0.50
P355*	0.20	0.7			0.50

JISG 3116	C (max)	Mn	P (max)	S (max)	Si (max)
SG 255	0.20	0.3 min	0.040	0.040	-
SG 295		1.0 max			0.35
SG 325*		1.5 max			0.55

** Yet to be developed*

MECHANICAL PROPERTIES (HS LPG)

Grade	YS MPa (min)	UTS MPa	%El min		Normalising Temp
			<3mm GL:80 mm	>3mm GL: 5.65 $\sqrt{A_0}$mm	^{0}C
P245	245	360-450	26	34	900-940
P265	265	410-500	24	32	890-930
P310	310	460-550	21	28	890-930
P355	355	510-620	19	24	880-920
SG 255	255	400	28		-
SG 295	295	440	26		-
SG 325	325	490	22		-

WHAT NEXT?

DEVELOPMENT OF HIGH STRENGTH LPG GRADES

JISG 3116 SG 325

EN 10120 P 355 NB

SUMMING UP……….

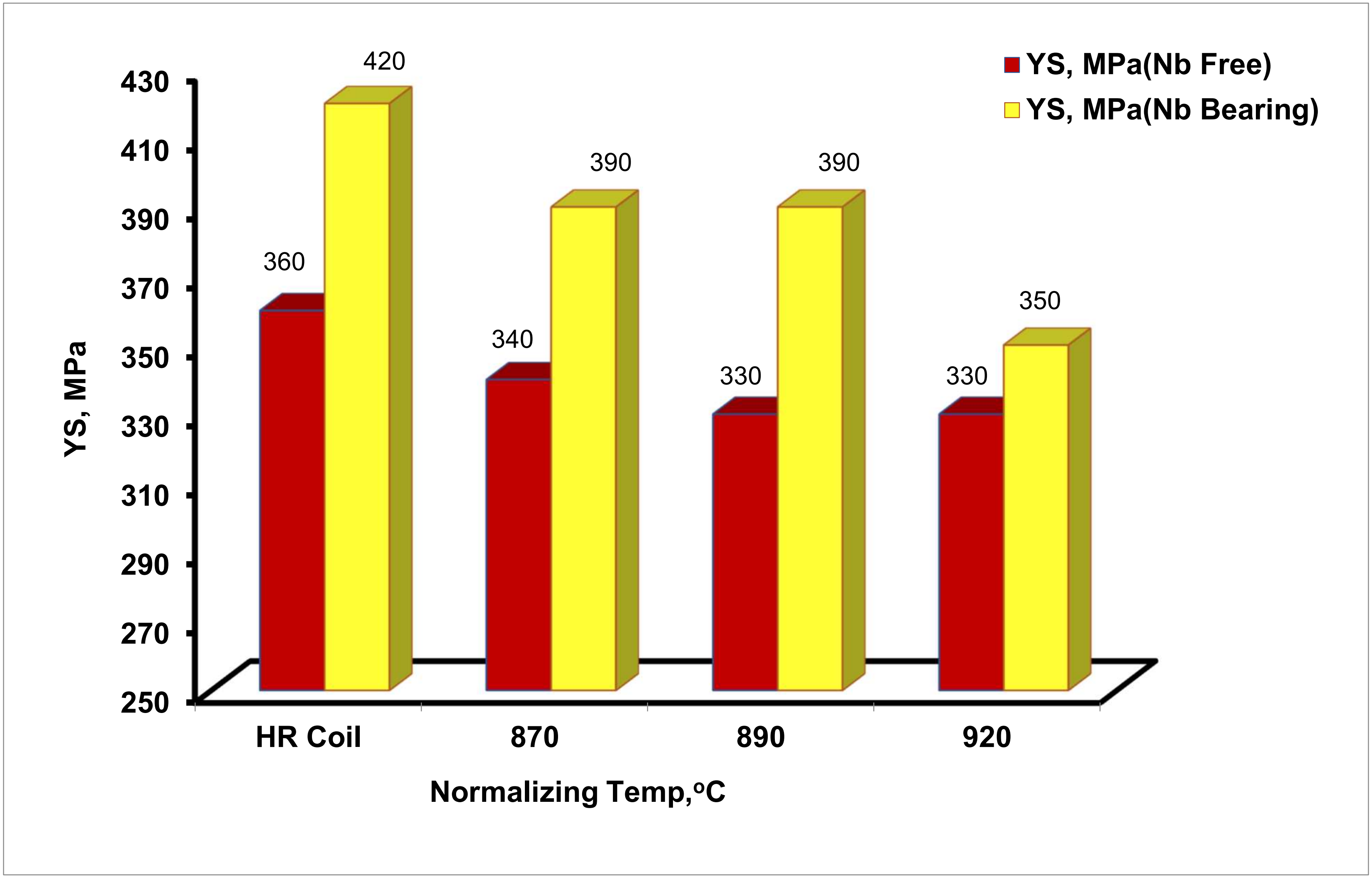
- High strength LPG steel successfully developed for export quality cylinders for the first time in SAIL
- HR properties were optimized to achieve minimum specified properties in formed cylinders
- For the first time in SAIL, thinner gauge HS LPG (2.2 mm) of EN 10120 P310 grade hot rolled successfully
- More than 25,000T of high strength export grade LPG made so far
- On behalf of BIS, RDCIS is preparing specification for these grades in India


Thank You!

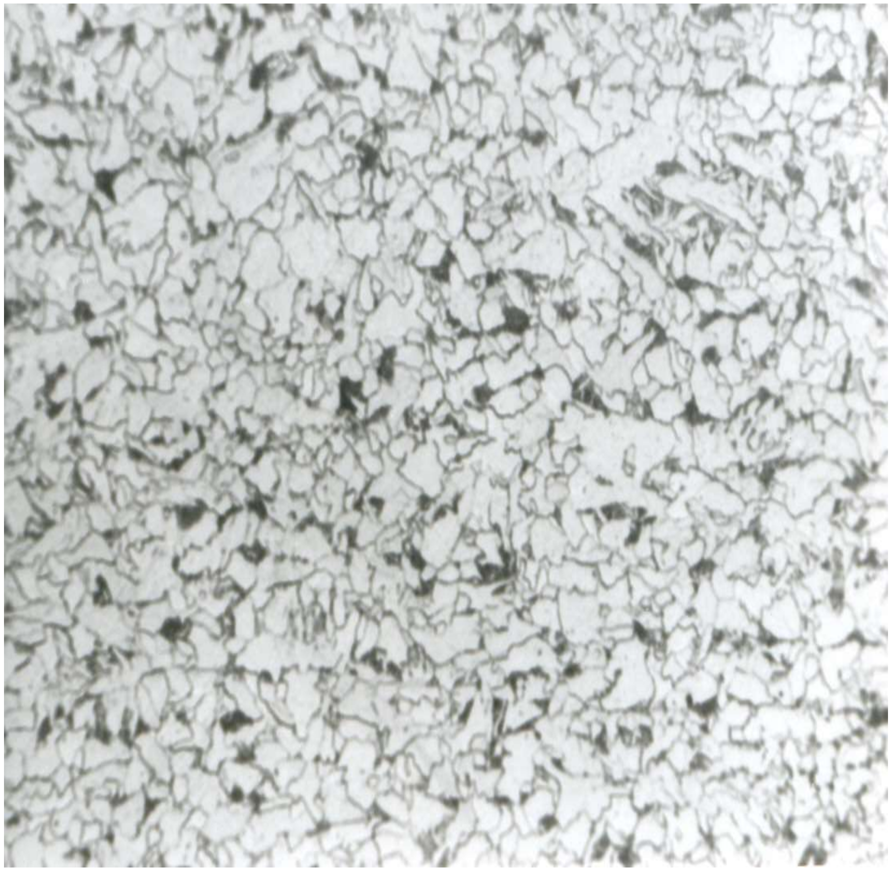
NORMALIZING OPERATION

HS LPG cylinders (JISG 3116 SG 295) during normalization

DROP IN YS DURING NORMALISING



EFFECT OF NORMALIZING TEMP ON MICROSTRUCTURE (WITH Nb)



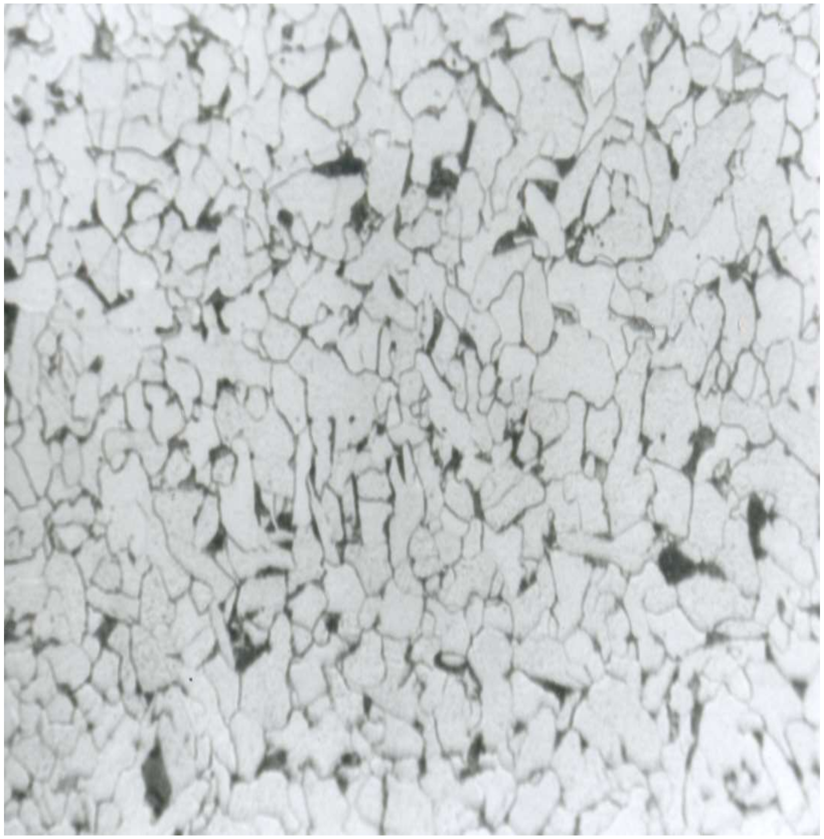
Grain size : 5.5 μ

As rolled HR coil

Grain size : 8.3 μ

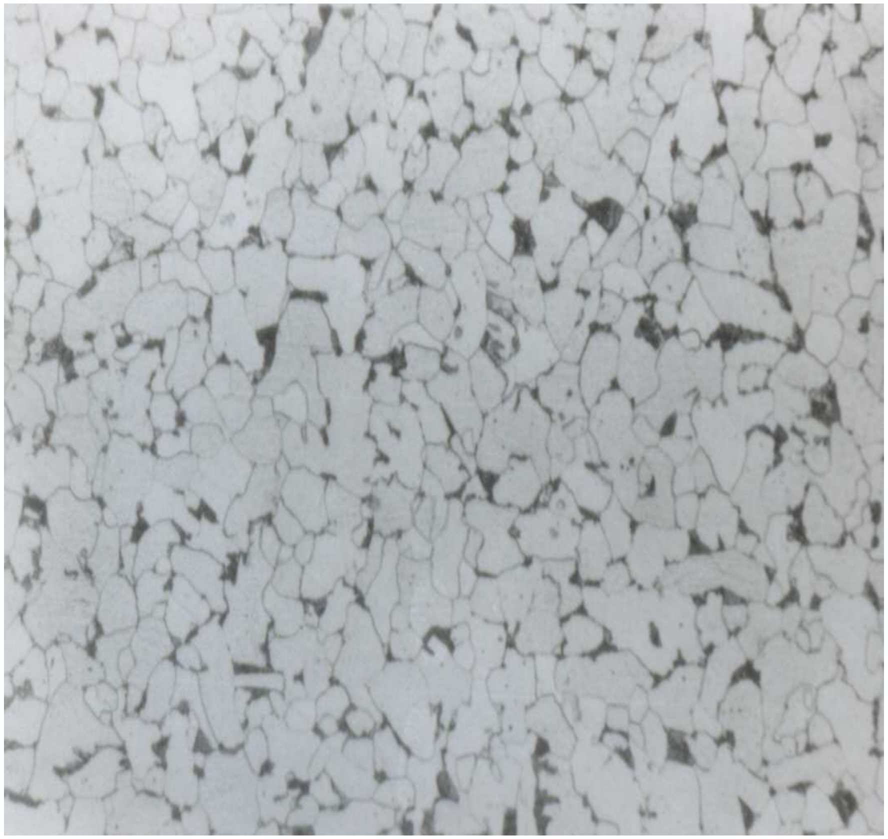
After normalizing at 920 ^{0}C

EFFECT OF NORMALIZING TEMP ON MICROSTRUCTURE(WITHOUT Nb)



Grain size : 9.6 μ

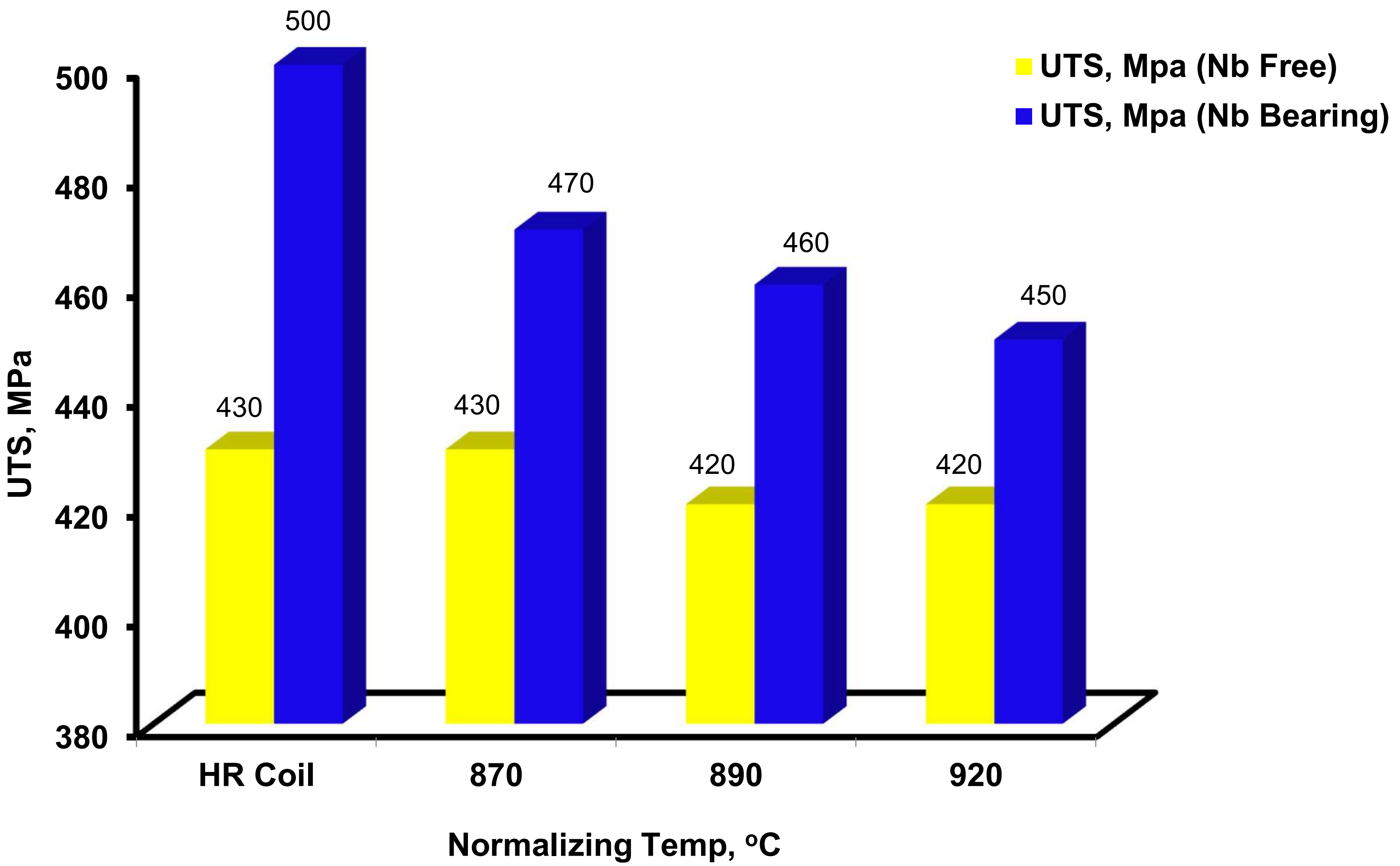
As rolled HR coil



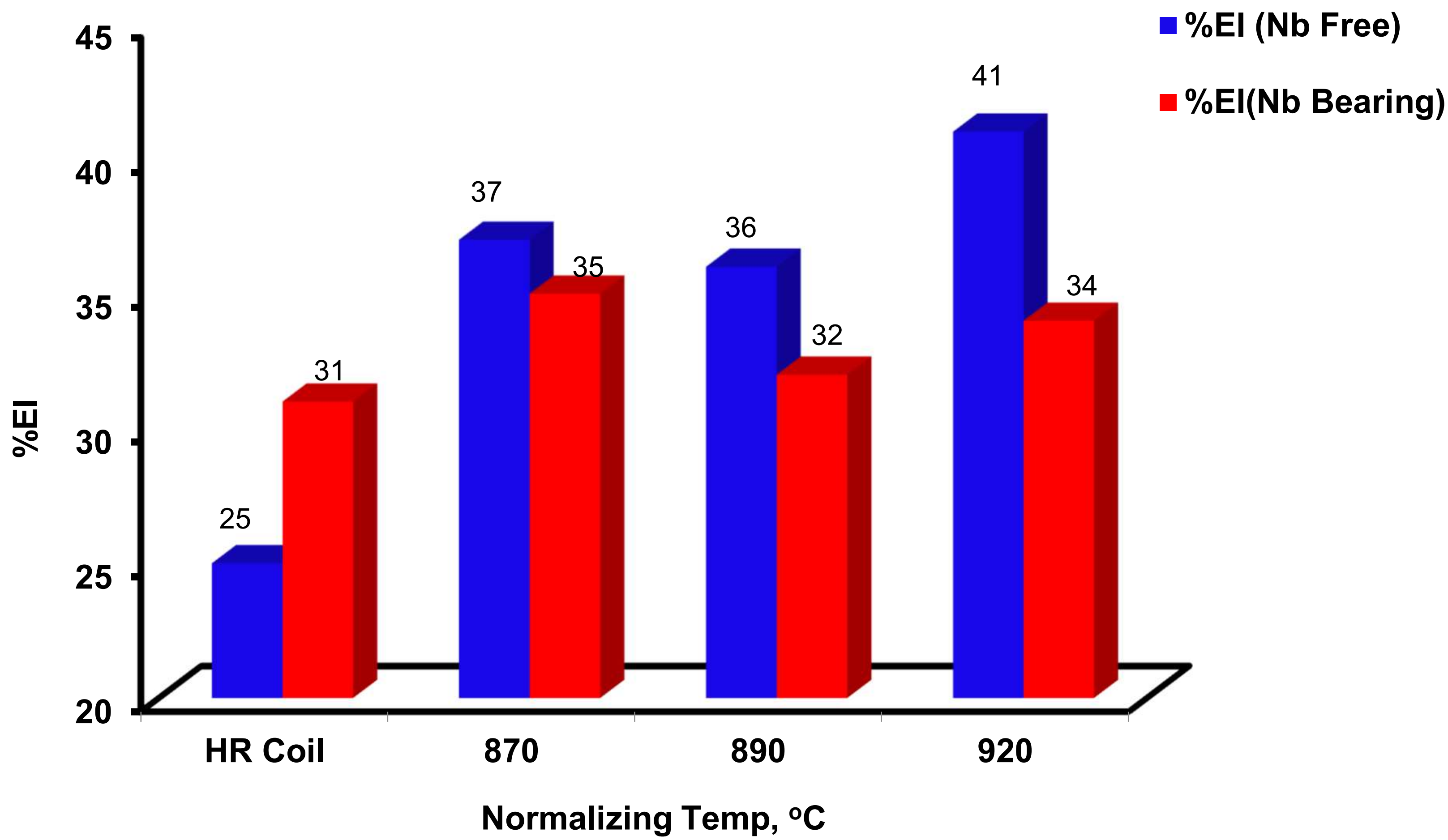
Grain size : 9.2 μ

After normalizing at 920 ^{0}C

DROP IN UTS DURING NORMALISING



INCREASE IN %El DURING NORMALISING



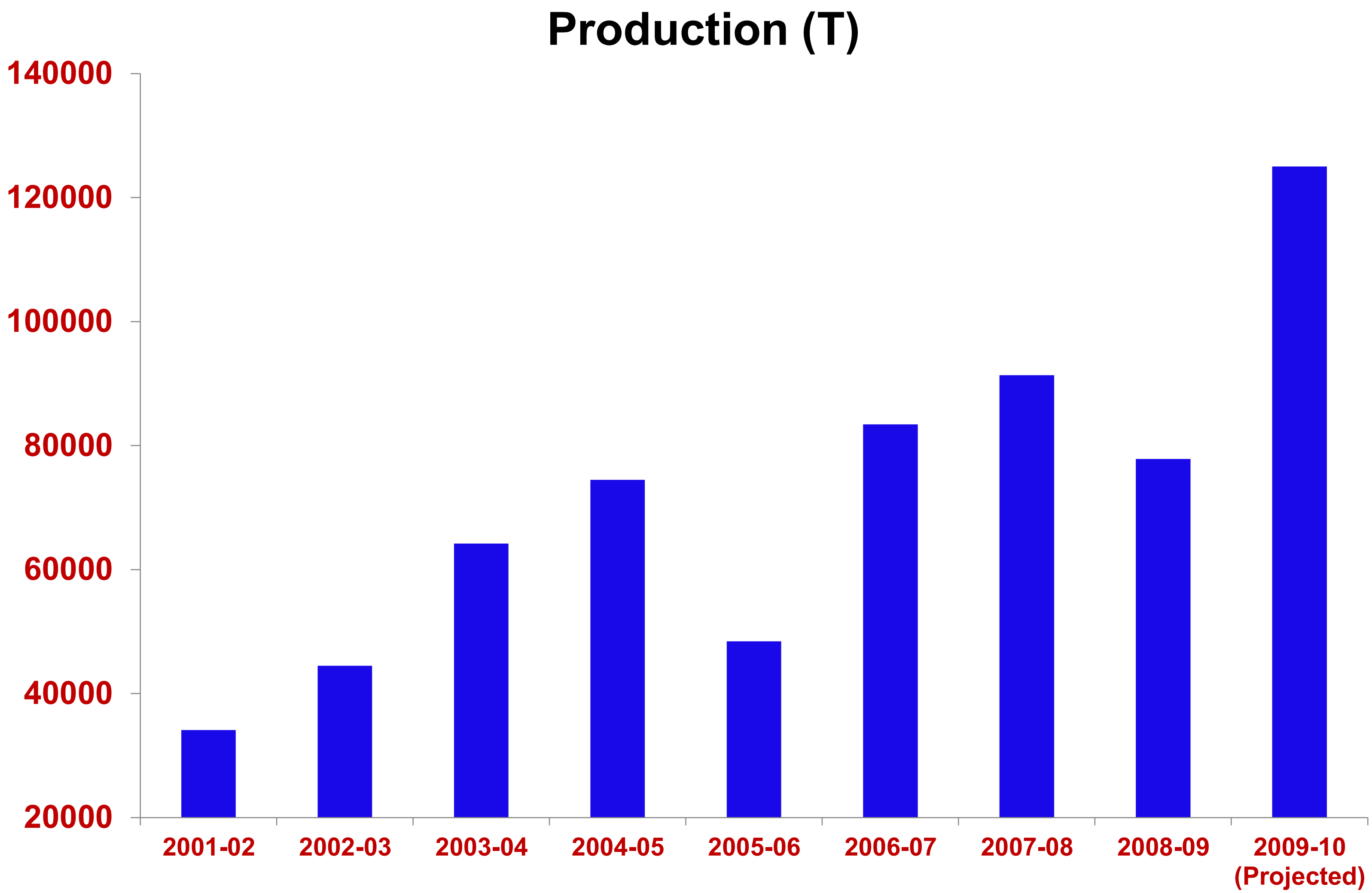
HS LPG FROM BSL

Effect of normalizing on properties of microalloyed JISG 3116 SG 295

Parameter	At HR coil stage	After normalising at 920^0C	Drop in properties
YS (MPa)	410-420	330-360	70
UTS (MPa)	500-530	460-490	40
%El	32-34	30-34	-

* For C-Mn variety, the drop in properties is minimal

PRODUCTION OF LPG OVER THE YEARS (BSL)



ROURKELA STEEL PLANT
SMS-II

PRODUCTIVITY & QUALITY OF CONTINOUSLY CAST SLABS AT SMS-II, RSP

AUTHORS NAME
M.K.PRADHAN, AGM, R&C LAB
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P.LENKA, AGM,SMS-II(O)
SK PRASAD DGM I/c (O) SMS II

PRESENTED BY

M.K.PRADHAN, AGM, R&C LAB

ROURKELA STEEL PLANT- SMS-II

EXISTING FACILITIES OF THE SHOP

- **2 X 150T LD CONVERTER – 1 RUNNING**
- **2 X 220 MM THICK, 850-1550 MM WIDTH) SINGLE STRAND SLAB CASTER**
- **1 X150T LHF**
- **1X150T ARS (OFF LINE)**

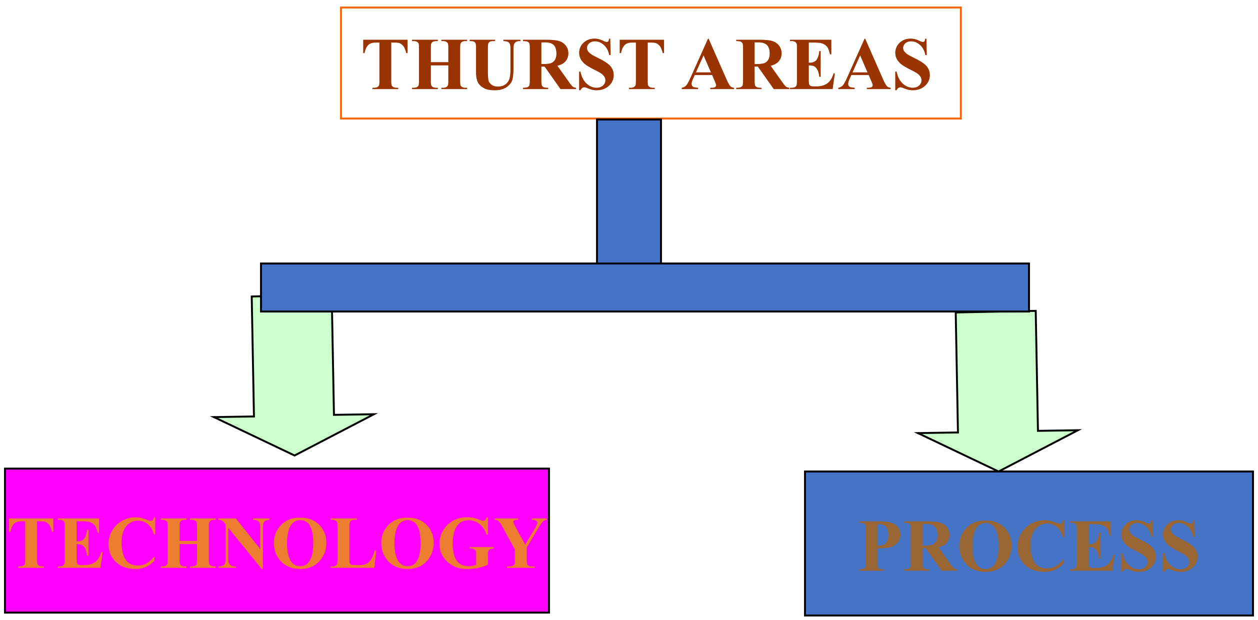
ROURKELA STEEL PLANT- SMS-II

PRODUCTION STATISTICS

PARAMETERS	BEFORE 2005	AFTER 2005
Average Blows/ Day	23.5	30.5
Cast/Day	23.3	30.0
YIELD (%)	97.2	98.3
Ladle Skull(%)	0.40	0.25
Tundish Skull(%)	1.3	0.81
Return Steel(%)	2.2	1.6

ROURKELA STEEL PLANT- SMS-II

Two major areas were identified as thrust areas for improvement in productivity and quality .



TECHNOLOGY

ROURKELA STEEL PLANT- SMS-II

TECHNOLOGY:

a. Use of co-injection for HM desulphurisation

b. Introduction of Slag arrestor (DART type)

c. Introduction of high dimensional cored wire of reactive aluminium (in the process of adoption)

d. Adoption of online purging during tapping

e. Changeover from 9mm to 12 mm dia Al wire at LHF

f. Adoption of Tundish flow modifier

g. Changeover to continuous temperature measurement in tundish (Being regularised)

h. In house modification of slab thickness (210-220)

i. Modification of secondary cooling

j. Machine cooling parameter monitoring

TUNDISH FLOW MODIFIER

Earlier Design

- Impact pad & wear dam system

Short comings of earlier system

- Temperature drop across the tundish
- Turbulent flow
- Red eye formation
- Less residence time(Low inclusion floatation)
- High inclusion level in slab
- Damage of tundish cover due to initial splashing
- Bigger tundish skull
- Metal splashing during initial ladle opening

ROURKELA STEEL PLANT- SMS-II

Benefits after implementation of TFM TFM.htm

- No initial metal splashing
- Improved life of tundish covers
- Laminar flow of metal
- Elimination of red eye formation
- Less temp drop across the tundish
- Reduction of dead zone
- Improved inclusion floatation
- Improved productivity
- Improved slab quality
- Smaller tundish skull Table-3.htm

ROURKELA STEEL PLANT- SMS-II

CONTINUOUS TEMPERATURE MEASUREMENT

Earlier method & short comings

- Immersion temperature measurement
- Interval of 10 to 15 minutes
- Long interval of temperature measurement
- Timely speed ramping not possible
- Exposure of steel to atmosphere during every measurement

ROURKELA STEEL PLANT- SMS-II

Benefits with continuous measurementcontitherm.htm

- **Improvement in caster throughput T**
- **Improved speed regulation**
- **Reduction in tundish skull**
- **Reduction of failures due to low temp operation.**
- **Improved yieldYIELD.htm**
- **Improved quality of slabs**

CONTINUOUS TEMPERATURE MEASUREMENT

Proposed usage of CAST TEMP (Continuous Measurement)

In addition to the above benefits two more advantages are

- **Elimination of tundish rejection due to improper preheating.**
- **Exact temp near MBS is indicated.**

ROURKELA STEEL PLANT- SMS-II

ADOPTION OF ONLINE PURGING

Earlier : Steel tapped to ladle without purging

Modified : Provision of Argon purging during taping and deoxidation introduced

BENEFITS

- Elimination of bottom purging failure.
- Homogenisation of steel before reaching LHF
- Better deoxidation
- Pre modification of slag during tapping
- Reduced treatment time at LHF
- Increase in productivity & quality

ROURKELA STEEL PLANT- SMS-II

INTRODUCTION OF SLAG ARRESTOR

Earlier: No slag arresting arrangement or during tapping

Shortcomings : High slag carry over and associated problems

BENEFITS of Slag arrestor

- Reduction of slag carry over (from 14 to 7 Kg / TCS)
- Better recovery of FeAlloys
- Increase in slag zone life of ladles
- Reduction in deoxidiser consumption
- Reduction of treatment time
- Cleaner steel SLABDEFECT.htm
- Reduction of treatment cost

PROCESS

PROCESS

a. Improvement in charge balance
b. Reduction in reblown heatREBLOW.htm
c. Tap hole maintenance (4 minutes)
d. Change in deoxidation practice
e. Slag modification at LF (FeO+MnO>20% to < 3%)
f. Inclusion floatation before dispatch to caster
g. Dispatch at correct superheat
h. Changeover to granular mould flux
i. Effective argon shrouding
j. Remarkable improvement in ladle free opening.
k. Reduction in caster breakouts/failures

ROURKELA STEEL PLANT- SMS-II

Change in deoxidation practice

Earlier

- **Pet coke was added during tapping along with FeAlloys**

Existing

- **Pet coke is added in the ladle before tapping. Al & FeAlloys during tapping.**

Benefit:

- **FeAlloy recovery is better**
- **LHF opening O2 is comparatively less**
- **Better homogeneity**

ROURKELA STEEL PLANT- SMS-II

Slag modification at LF SLAG MOD.htm

Earlier

- Oxide content (FeO+MnO) in the dispatch steel was 10-15%

Existing

- Oxide content (FeO+MnO) is <3%

Benefit:

- Reduction of Sulphur
- Better Al recovery
- Reduction in Al feeding at caster
- Reduction in SEN clogging
- Increase in sequence length

Mould flux changeover

Earlier

- Casting powder was being used

Benefits of changeover:

- Good spread ability
- Better lubrication
- Uniform heat transfer
- Less slag entrapment
- Less consumption
- Improved surface quality of slabs
- Reduction in breakouts BREAKOUT.htm
- Improved productivity

THANK YOU

Figure-1

Yield of slabs with respect to last six years

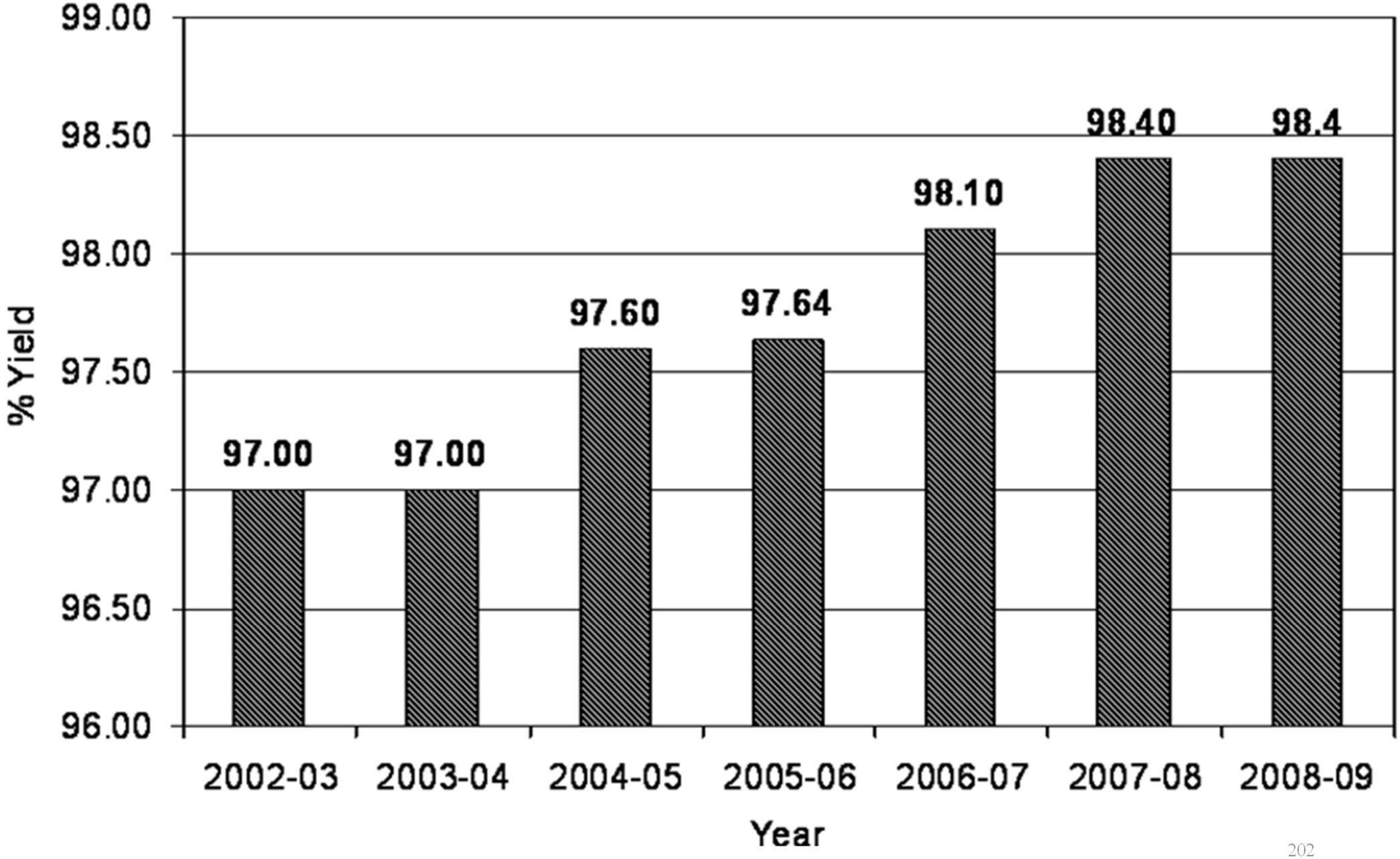


Figure-2

Improvement of Productivity vs Years

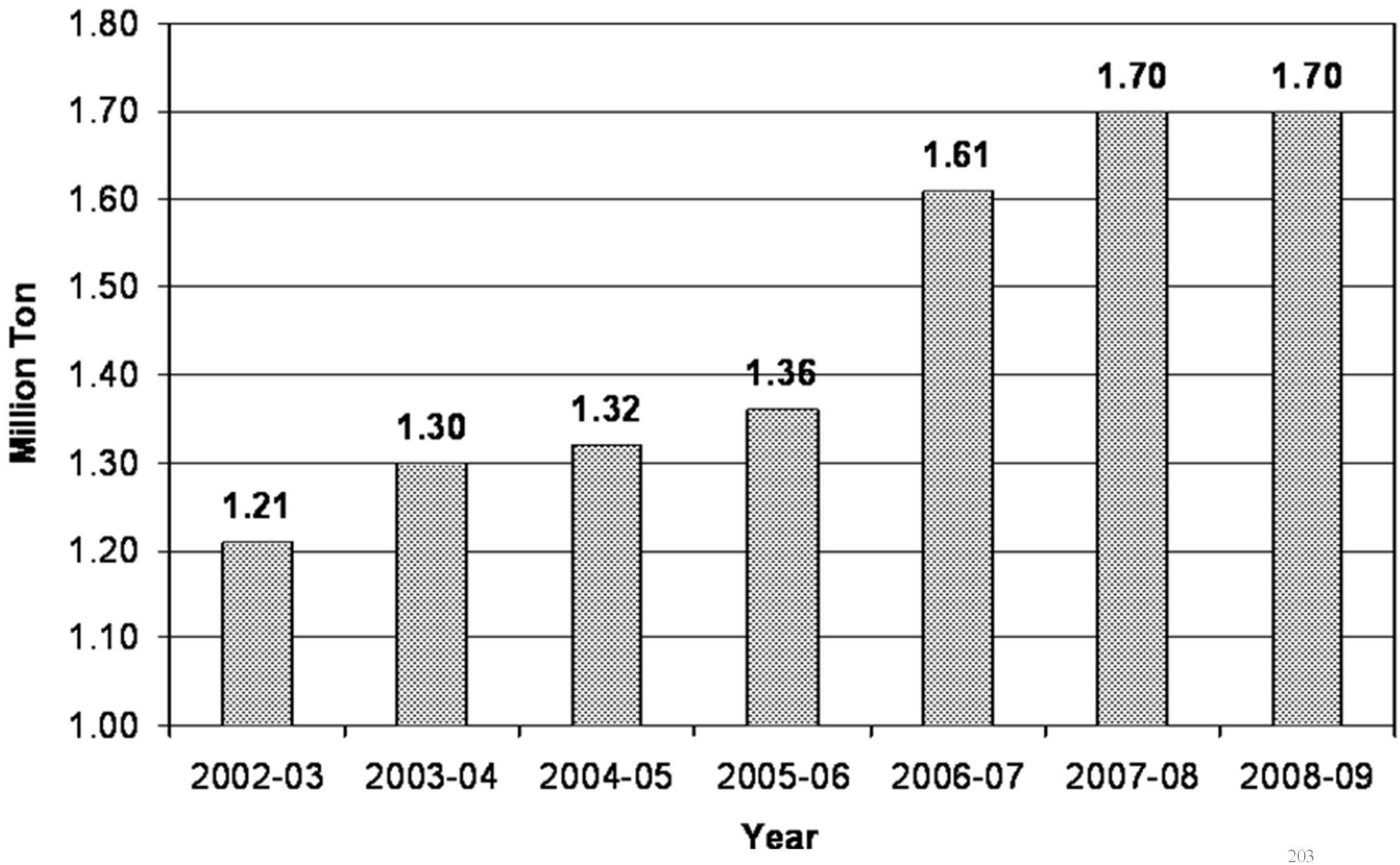


Figure-3

% Defects Slabs vs Years

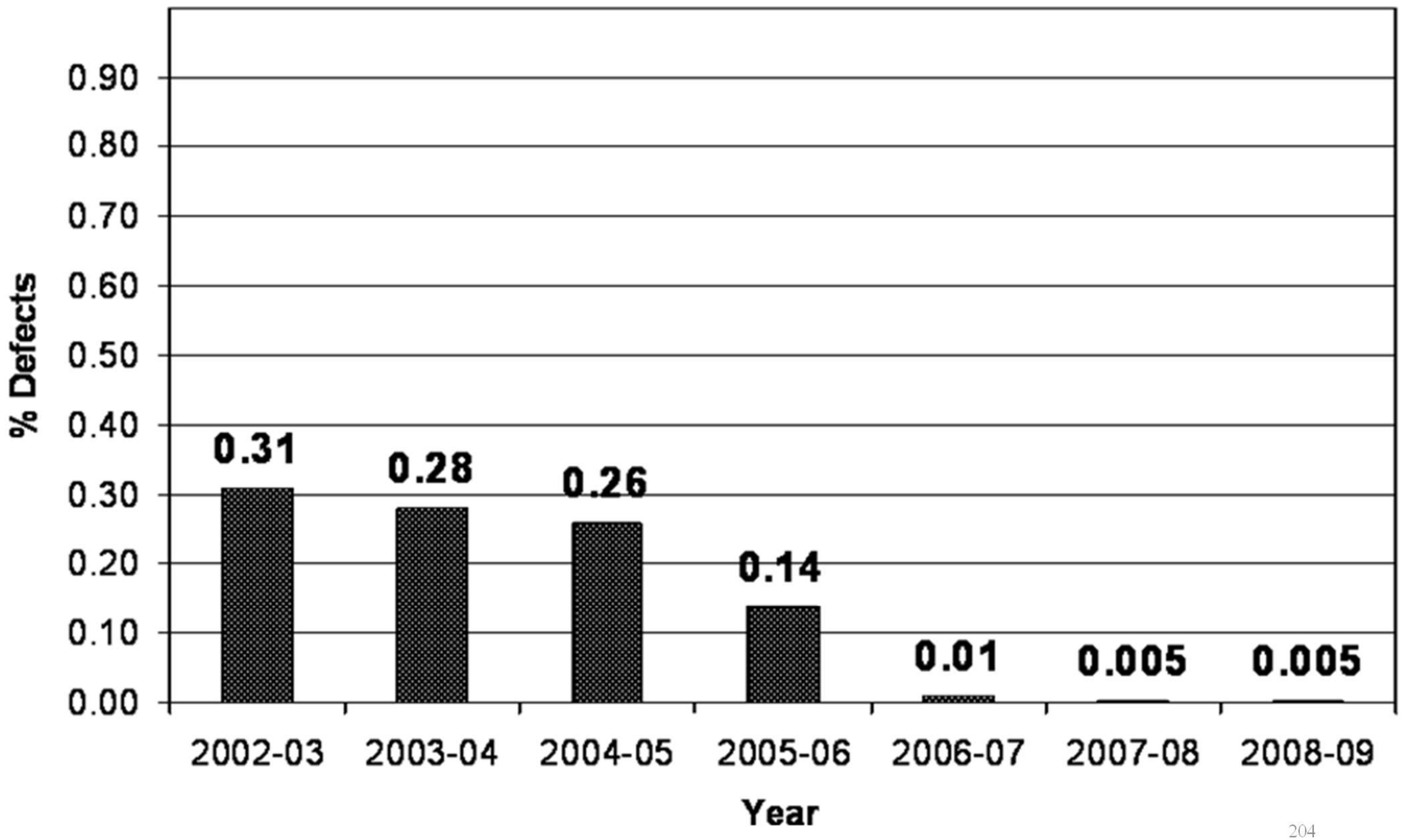


Figure-4

Super Heat Casting >30ºC above Liquids Temperature

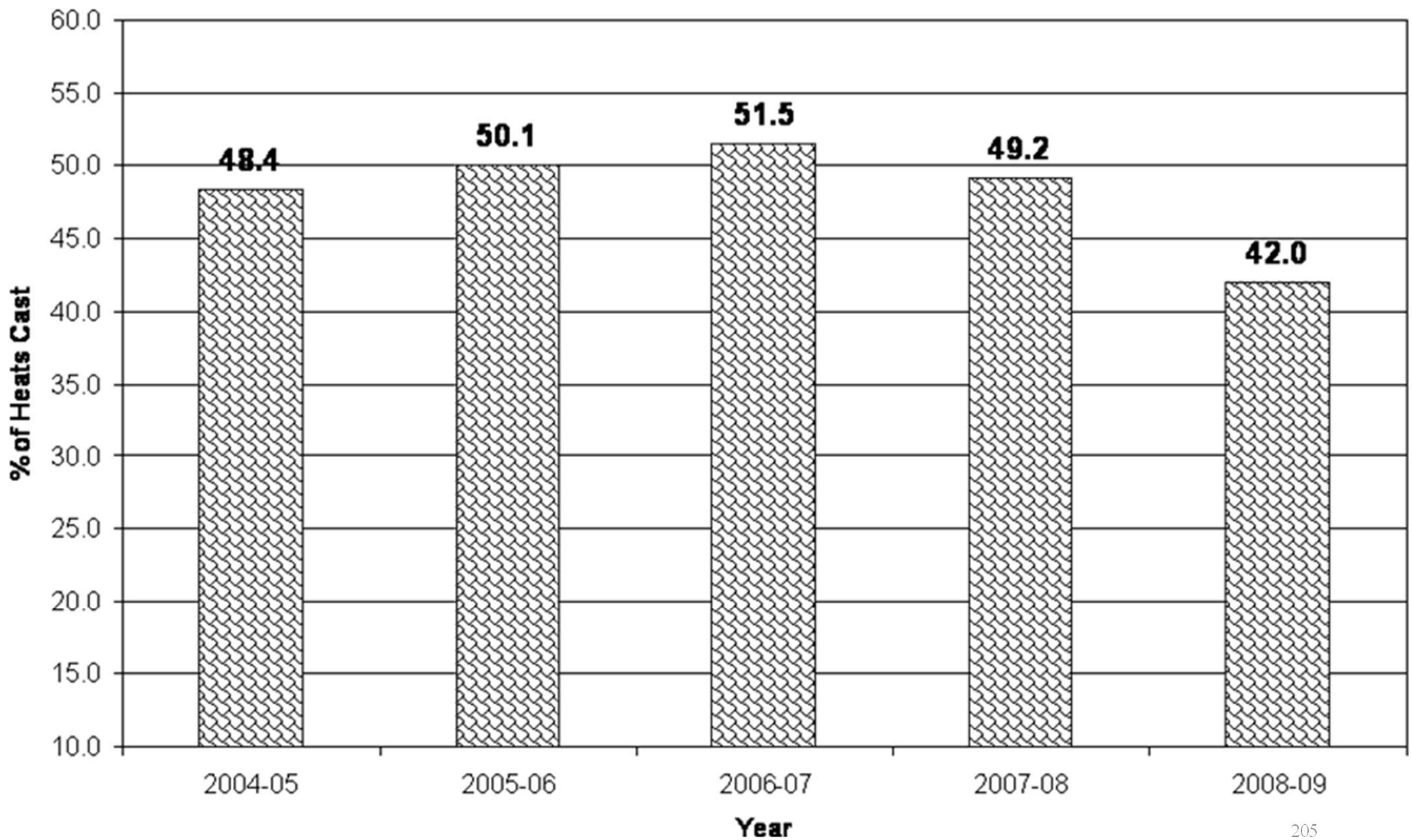


Figure-5

Through Put of Caster vs Year

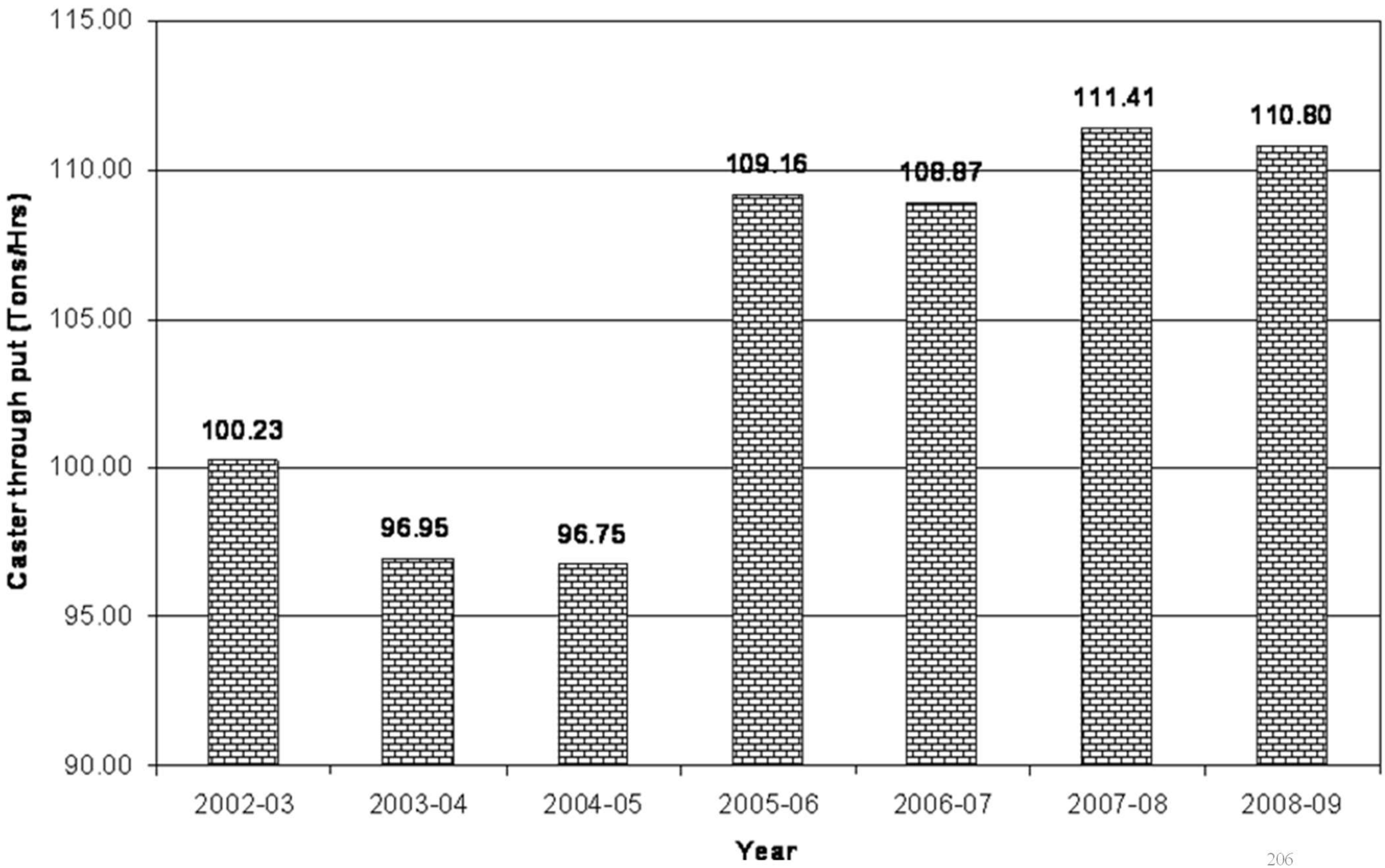


Table-1

Tapping Duration & Reblown Heats vs Year

Year	T.D < 4 Minutes	R.B Heats
	% Heats	
2002-2003	19	14.4
2003-2004	21	10.9
2004-2005	09	7.8
2005-2006	09	3.8
2006-2007	11	3.1
2007-2008	09	2.6
2008 - 2009	07	3.4

<u>Table-4</u>

Comparison of old and Modified Water Plan for Low Grade

Loop No.	Flow for 0.6 mts (Liter / Min)		Flow for 1.0 mts (Liter / Min)		Flow for 1.5 mts (Liter / Min)	
	Old (Plan-1)	Modify (Plan-3)	Old (Plan-1)	Modify (Plan-3)	Old (Plan-1)	Modify (Plan-3)
1	126	135	210	225	325	349
2	36	40	60	68	93	103
3	108	115	180	192	279	297
4	108	115	180	192	279	297
5	81	81	135	135	209	209
6	81	81	135	135	209	209
7	72	72	120	120	186	186
8	78	78	130	130	201	201
9	48	48	80	80	124	124
10	60	60	100	100	155	155
11	24	24	40	60	62	93
12	36	36	60	60	93	93
13	21	21	35	55	54	85
14	23	33	55	55	85	85
15	21	25	35	55	54	85
16	39	42	65	70	101	109
17	21	25	35	75	54	116
18	39	42	65	75	101	116

Table-5

Comparison of Old & Modified water plan for high grade

Loop No.	Flow for 0.6 mts (Lit/min)		Flow for 1.0 mts (Lit/min)		Flow for 1.5 mts (Lit/min)	
	Old (Plan-2)	*Modify (Plan-4)*	*Old (Plan-2)*	*Modify (Plan-4)*	*Old (Plan-2)*	*Modify (Plan-4)*
1	90	100	150	165	233	256
2	30	35	50	60	78	93
3	84	90	140	150	217	233
4	84	90	140	150	217	233
5	66	66	110	110	171	171
6	60	66	110	110	171	171
7	54	54	90	90	140	140
8	60	60	100	110	155	155
9	36	36	60	60	93	93
10	48	48	80	80	124	124
11	24	24	40	55	62	85
12	36	36	60	60	93	93
13	24	24	40	55	62	85
14	36	36	60	60	93	93
15	1	21	1	55	1	85
16	36	36	60	60	93	98
17	1	21	1	55	1	85
18	1	25	1	42	1	65

A Fundamental Approach to Optimise Calcium Treatment During Ladle Refining Of Aluminium Killed Steels at SMS II BSL

M.K.Sardar, S Mallick, S.Mukhopadhyay, S.Verma, U.K.Bandopadhyay**, S.Rai*

- R & D Centre for Iron & Steel & Bokaro Steel Limited
  Steel Authority of India Limited

Extremes in casting of Low Carbon Aluminium Killed (LCAK) Steels

- One inclusion out of every 1500 if deposited on SEN inner wall under typical casting conditions may cause nozzle blockage

- Sequence of 10,000 tons / 68 heats through a single tundish without nozzle clogging could be cast by controlling aluminium & Al_2O_3 related inclusions

Calcium addition- Why

Calcium addition in aluminium killed steel modifies solid Al_2O_3 inclusions to liquid calcium-aluminate inclusions

Calcium addition needs Optimisation:

To produce liquid CaO-Al_2O_3 inclusions avoiding formation of intermediate phases like CA_6, CA_2 and CaS for effective alleviation of nozzle clogging phenomenon

Expected Benefits

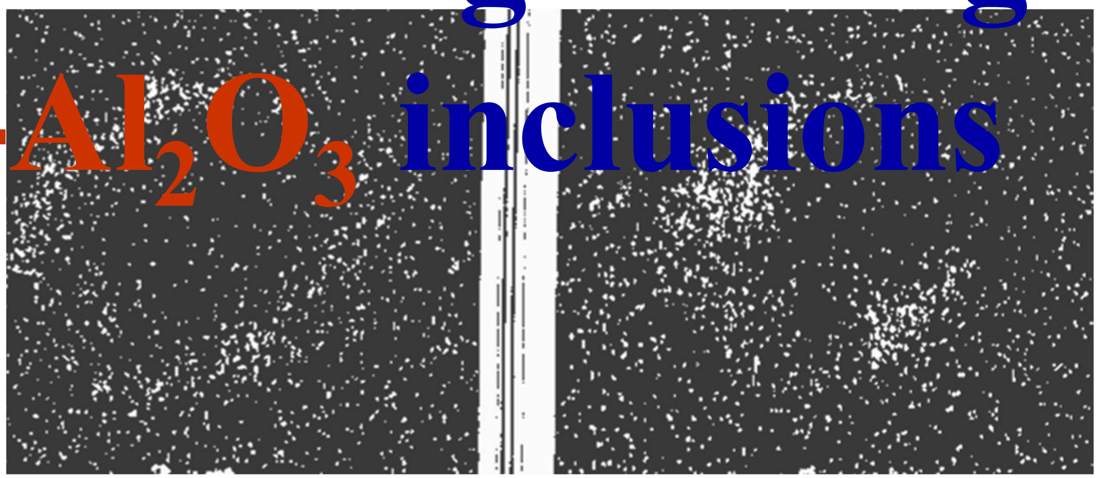
Longer sequence length **Increased productivity**

Reduced cost **Cleaner steel**

Clog causing inclusions

- Alumina (Al_2O_3)
- Spinel ($MgO.Al_2O_3$)
- Calcium sulphide (CaS)
- high melting point $CaO-Al_2O_3$ inclusions

EPMA of clog causing $CaO-Al_2O_3$ inclusions



Sulphur X ray Calcium X ray

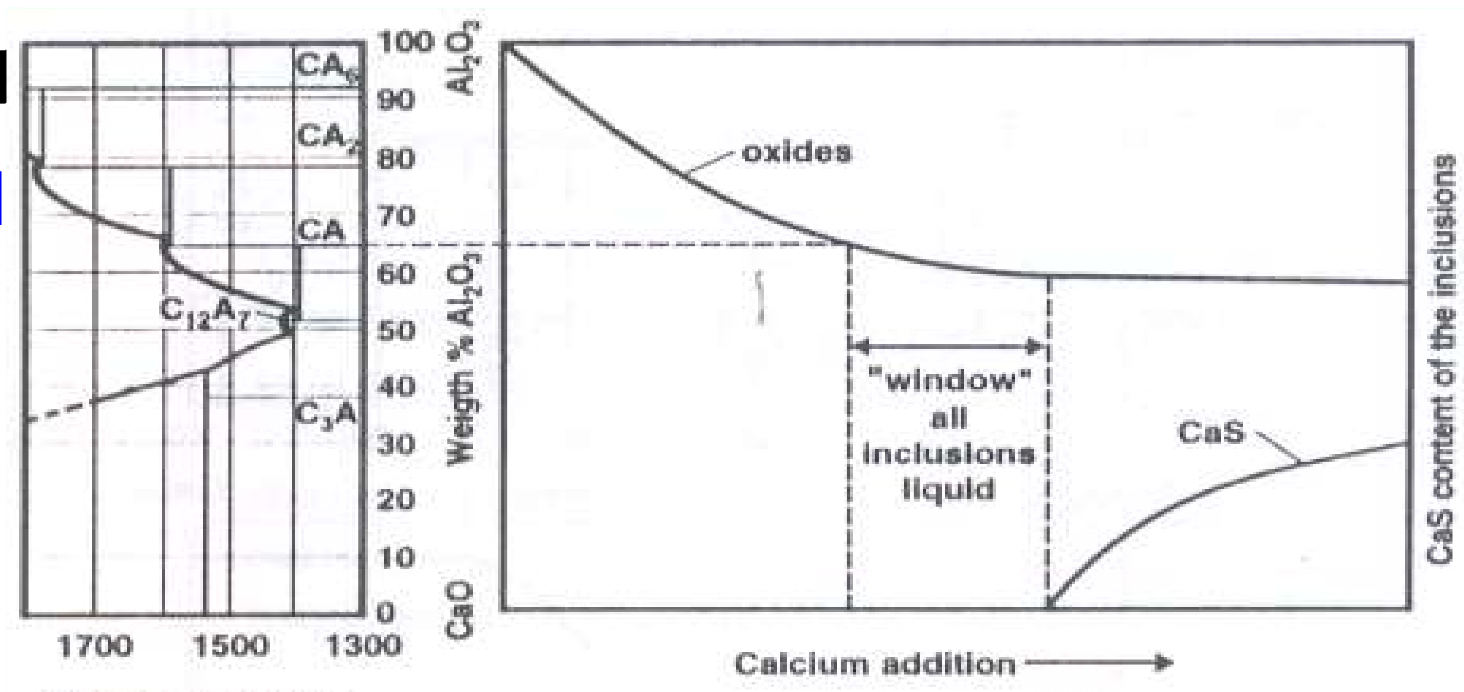
Nozzle Clogging - two situations

Deficient addition of Ca result in formation of intermediate & solid phases of $CaO-Al_2O_3$ or partially convert Al_2O_3

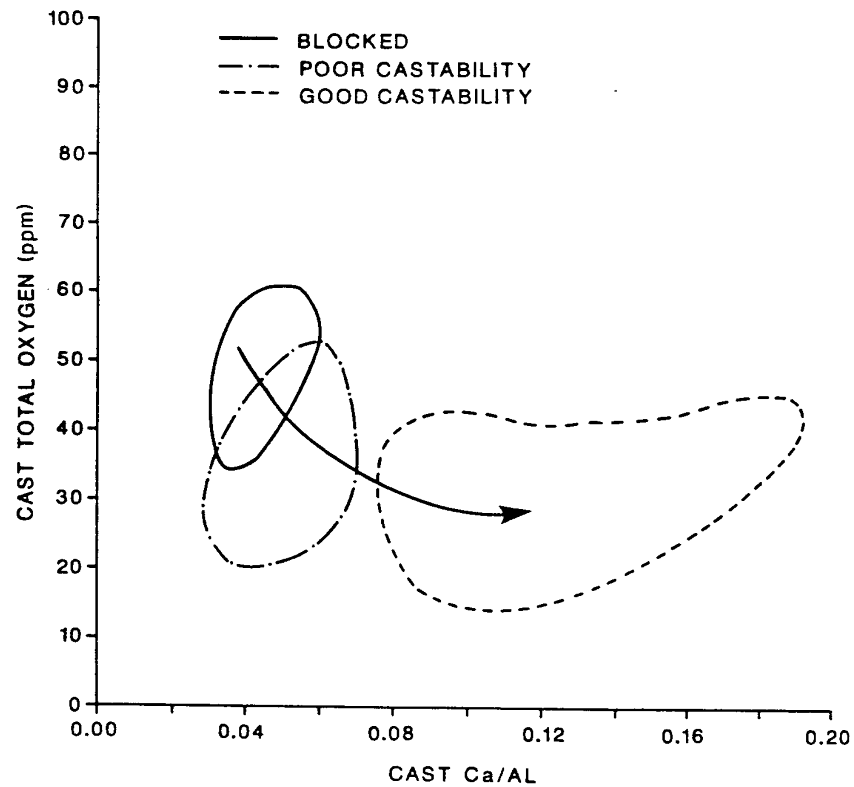
Excess addition of Calcium result in CaS generation

Thus tl

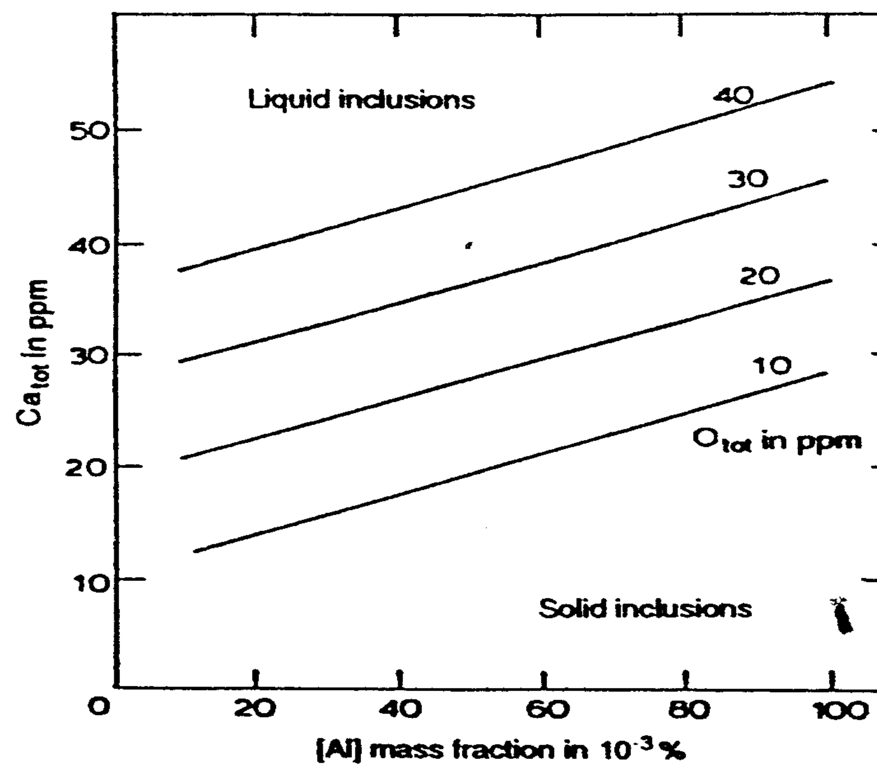
“LIQUI



Influence of Ca/Al ratio on total oxygen



Influence of Ca and Al content on total oxygen



Shape & Size of Liquid Window-Parameters

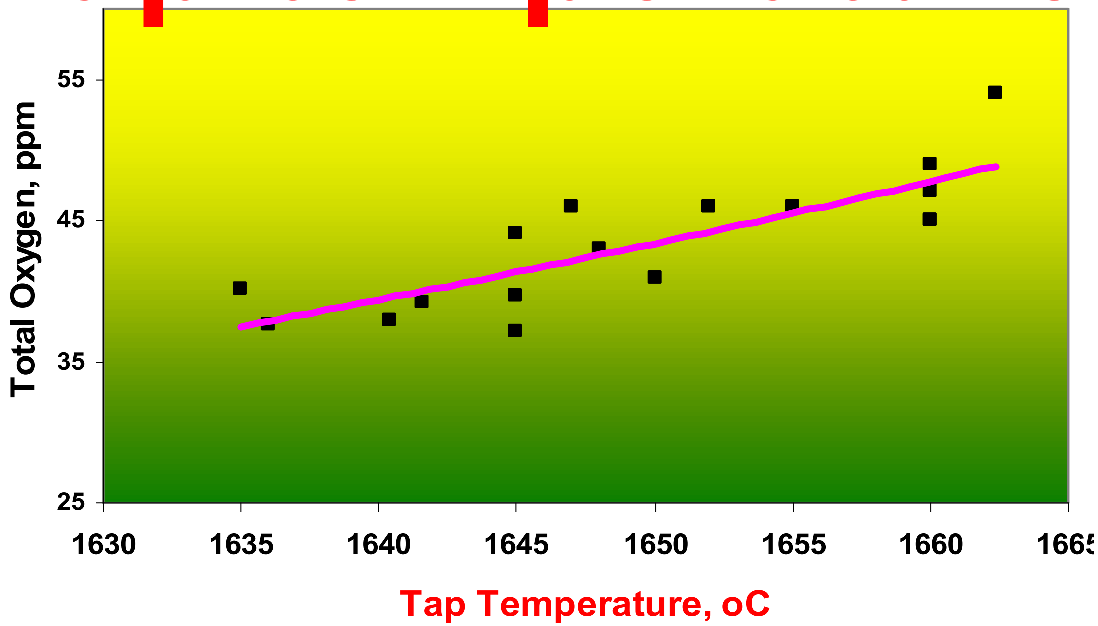
- Total Oxygen content
- Sulphur content / activity
- Casting Temperature

Approach to optimise Calcium treatment

- Improve steel cleanliness w.r.t. total O & S
- Compositional adjustment to lower Al content in steel
- Restrict Re-oxidation

Control of Total Oxygen

Tap temperature

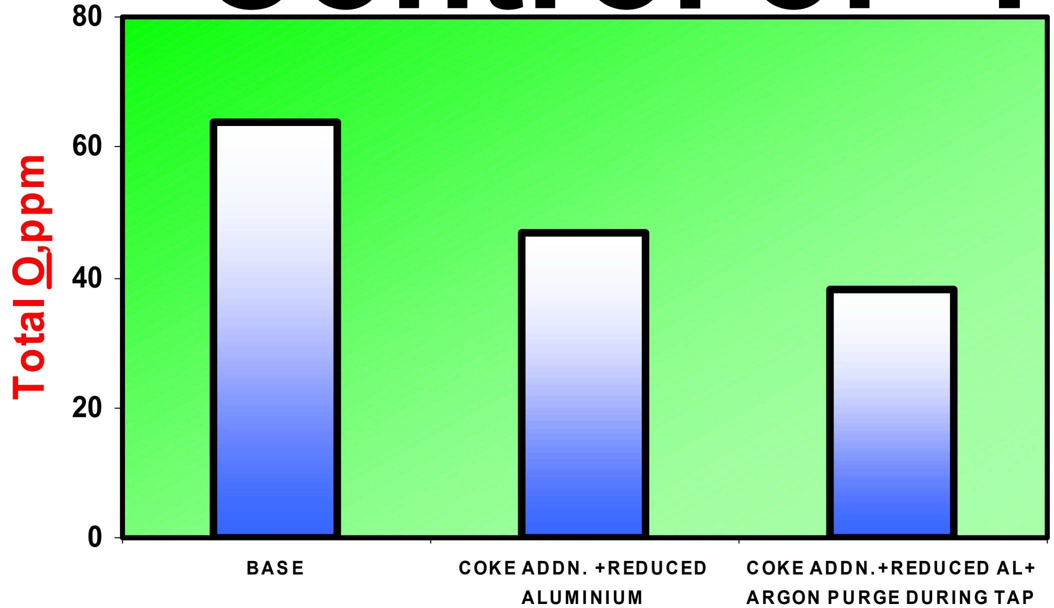


Reduction in Tap temperature has an effect on the Tot O of LCAK steels

Control in Slag Carry Over

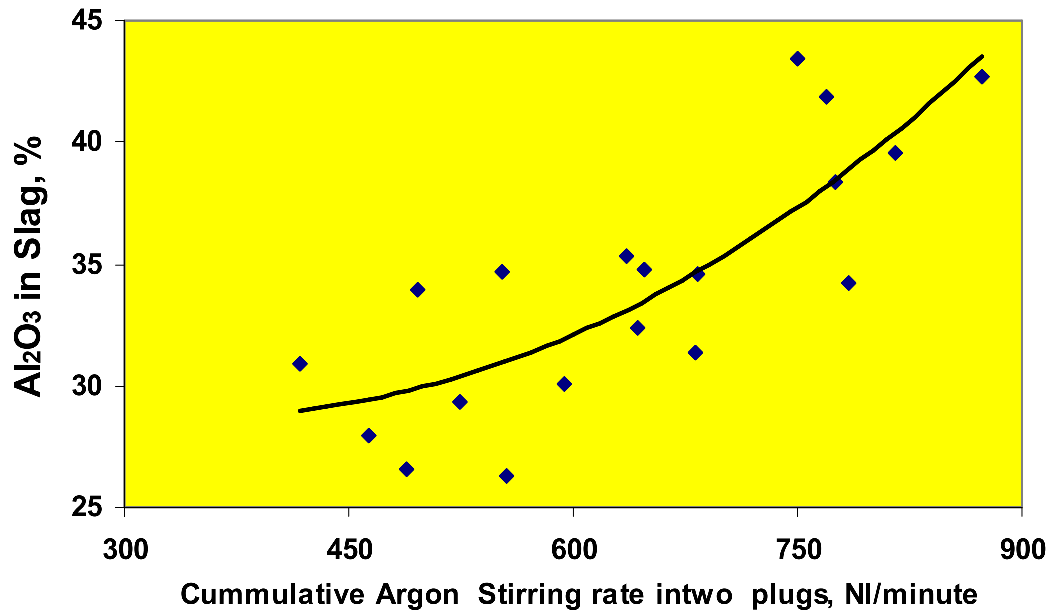
- With DART > 10 kg / ton
- With DART +RAM TREE < 7 kg / ton

Control of Total Oxygen

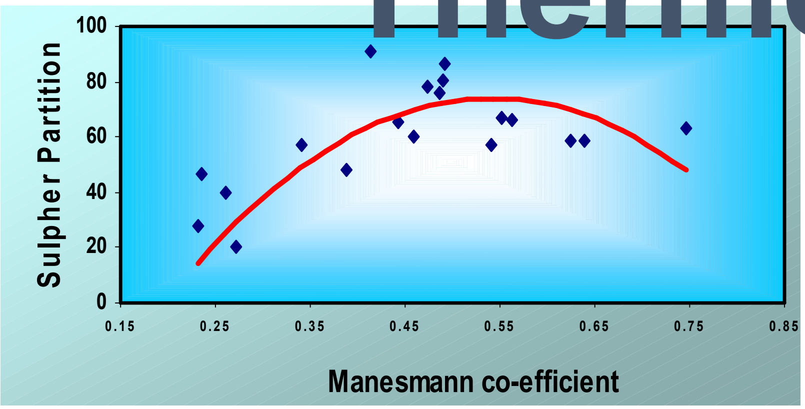


Substitution of primary De-oxidant Aluminium by coke & OLAP

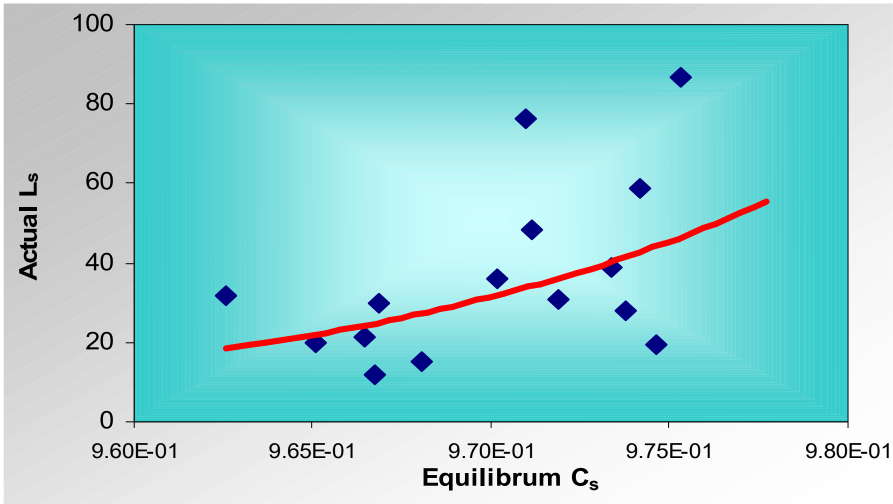
Control of Stirring intensity in ladle furnace



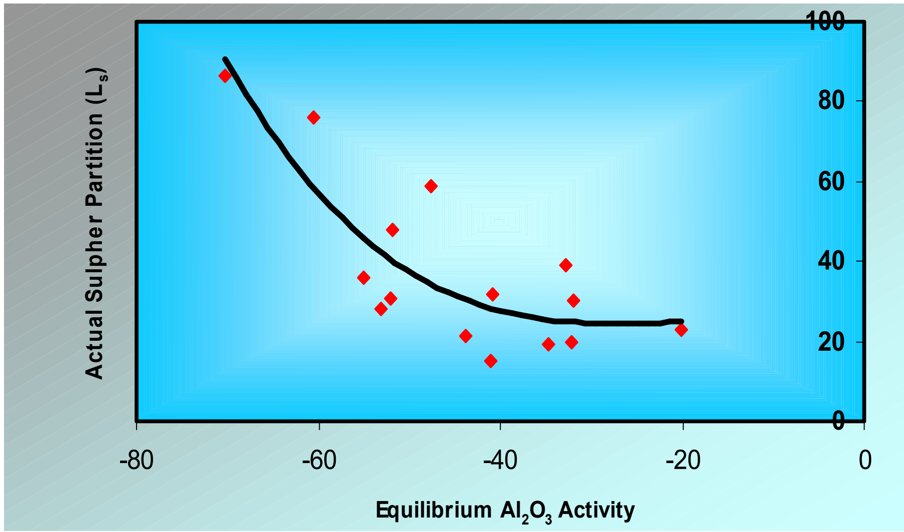
Thermodynamic Contro



Mannesmann Co-efficient controlled between 0.4 - 0.5

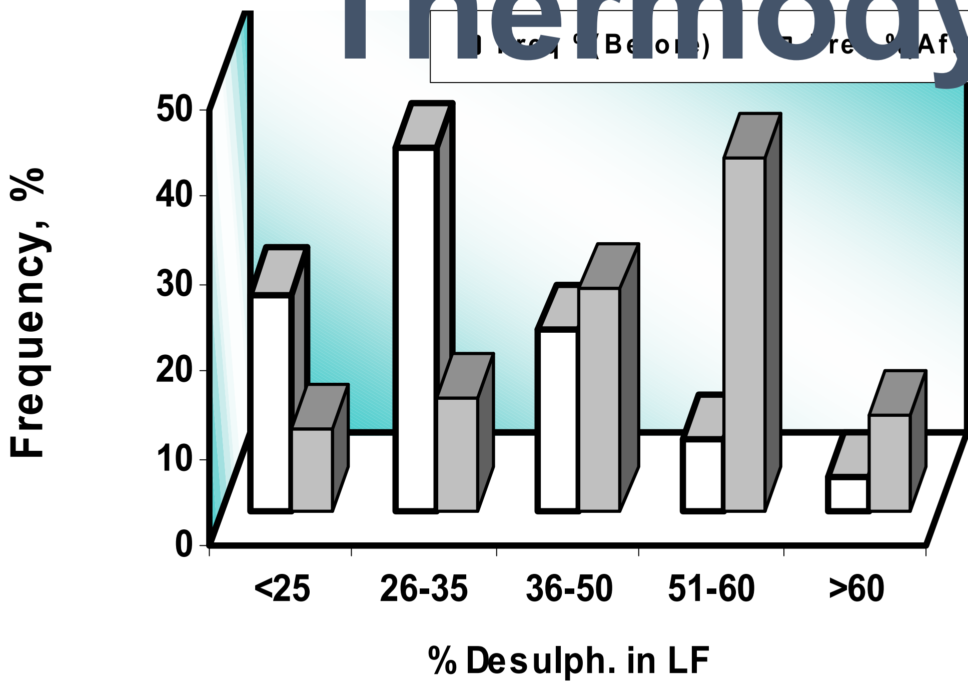


- Eqm. C_s calculated as per Young
- Highest C_s at lime saturation
- L_s partition directly varies with C_s



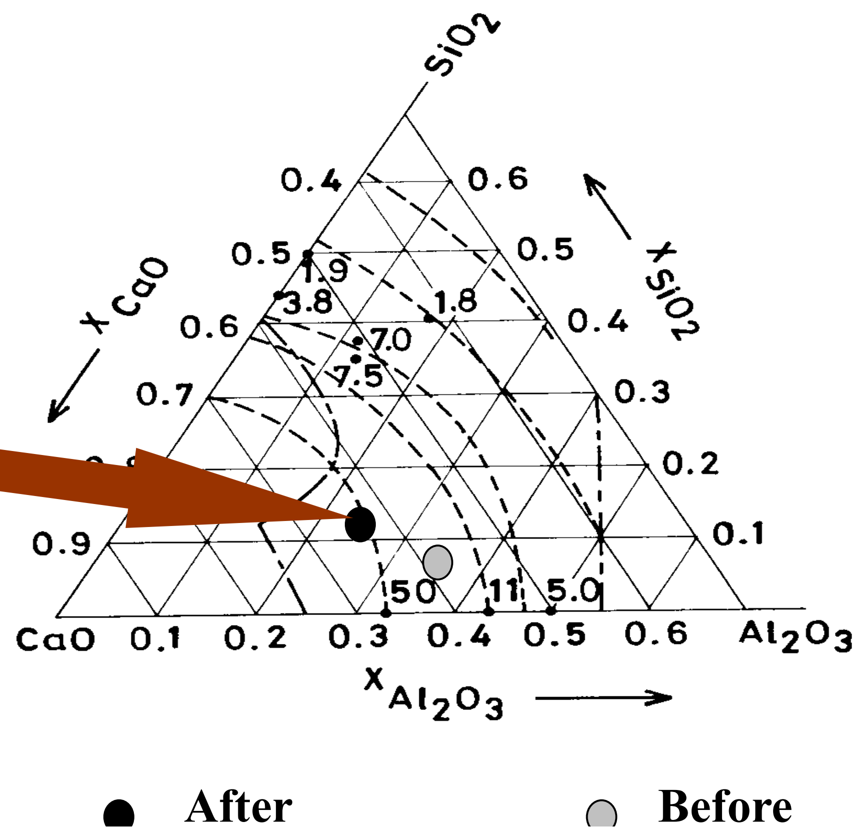
Eqm. Al_2O_3 activity equivalent to 30-32% Al_2O_3 in slag

Thermodynamic Contr

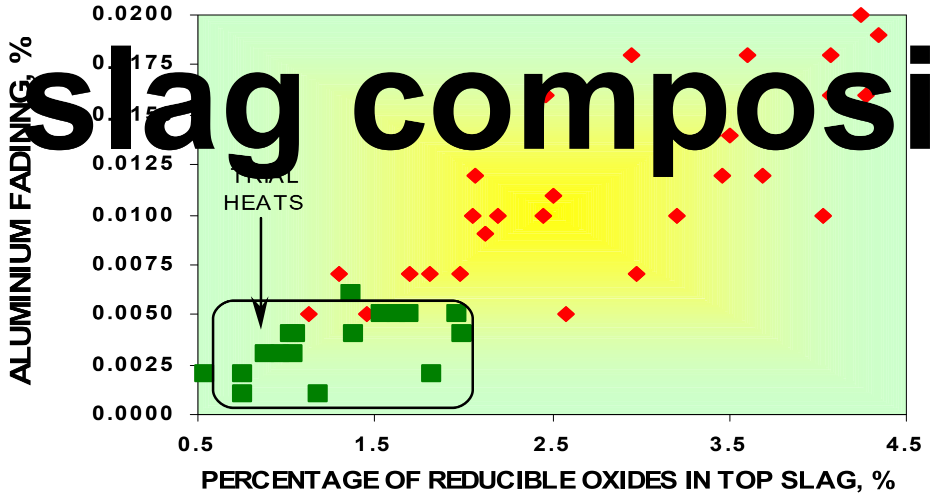


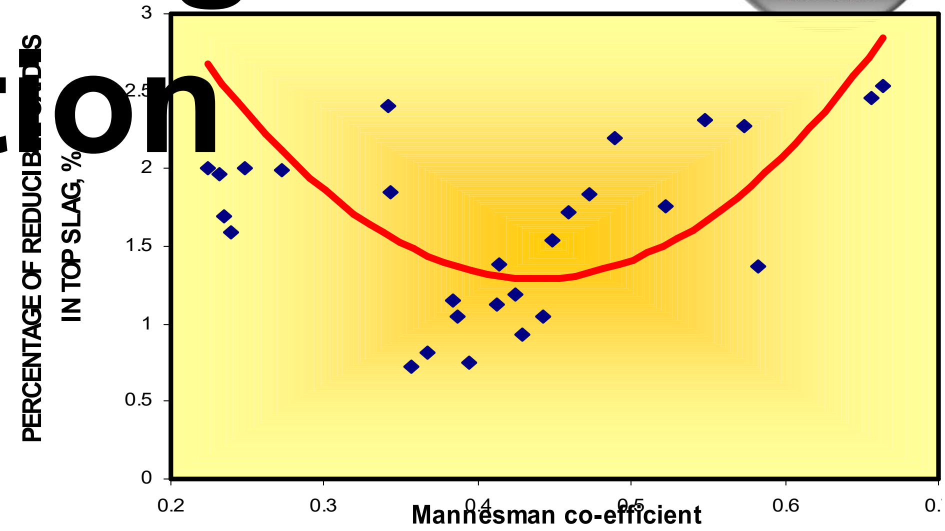
60 % Desulphurisation & [S] content <0.01% achieved in 70% heats

Typical Slag Composition of high Sulphide capacity



Aluminium fading Control-slag composition

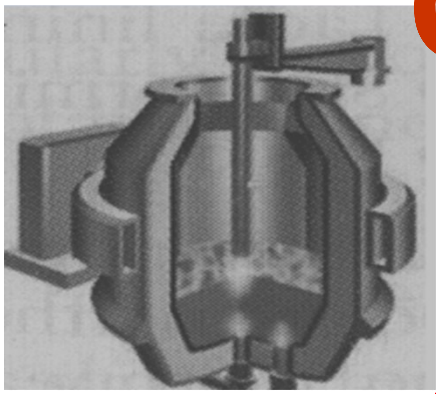




- Reducible Oxide content of top slag : FeO+MnO ≤ 2.0%
- Mannesmann Co-efficient controlled ~ 0.4
- Enhanced gas and refractory shrouding system
- Basic ladle lining

Controlled Aluminium fading ≤50 ppm between LF &CC

Clean Steel Practice at



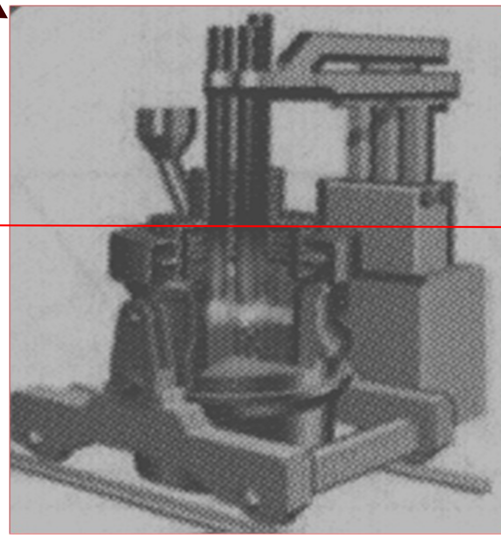
- CO slag stopping: DART+Ram tree < 7kg/t
- On line argon purging: 3-4Nl/ second / plug

Tapping additions :

Coke (nomogram based) Fe-Mn (HC) Aluminum

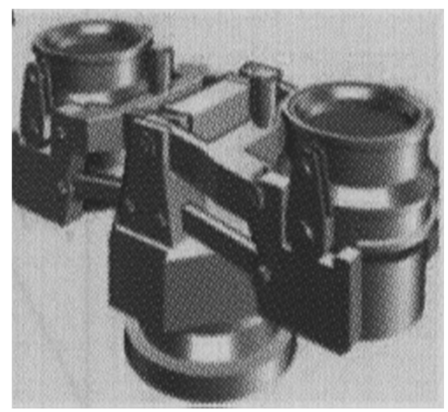
Ca-Si/Ca-Fe Addition

Heating & Slag formation



Medium / Soft purging

Cleansing purging

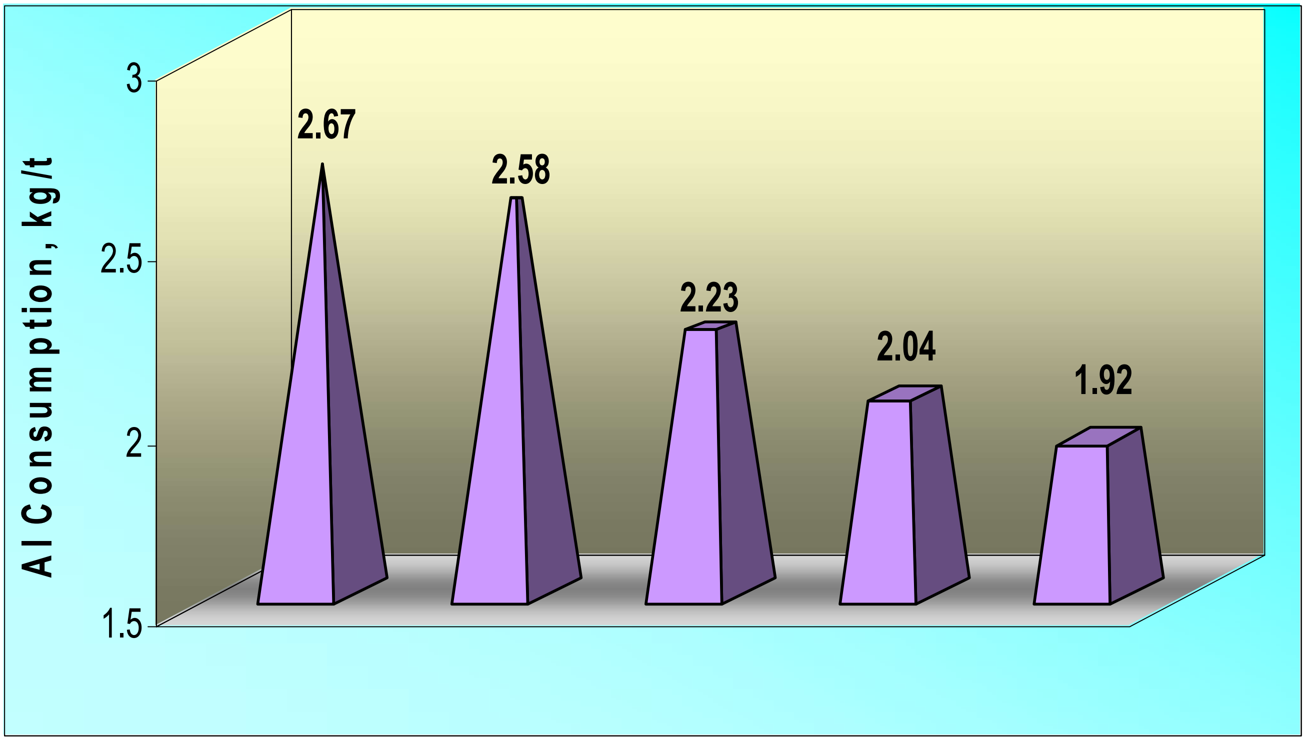


Slag : FeO+MnO~1.5%

Basic ladle refractory

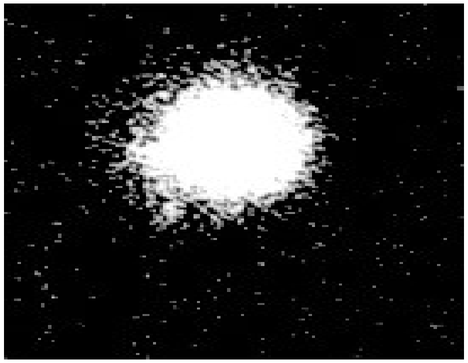
Shroud: Gas + Ceramic

Conclusions

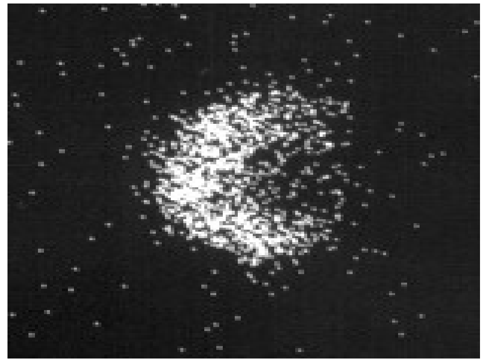


Aluminium consumption reduced from 2.7 to 1.92 kg/t

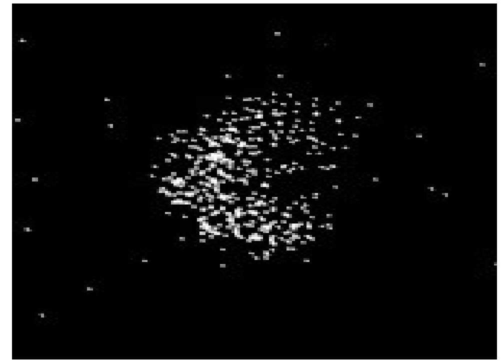
Before Clean steel practice



Aluminium

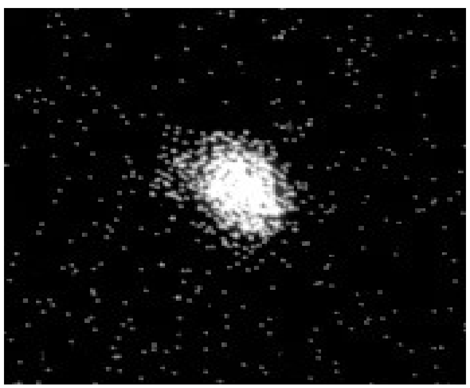


Calcium

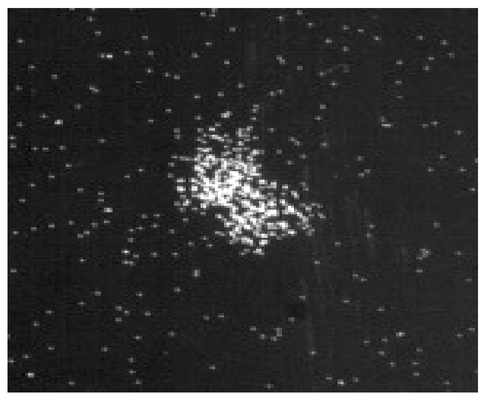


Sulphur

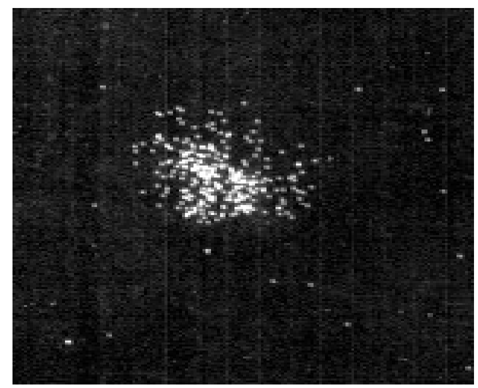
After Clean steel practice



Aluminium



Calcium



Sulphur

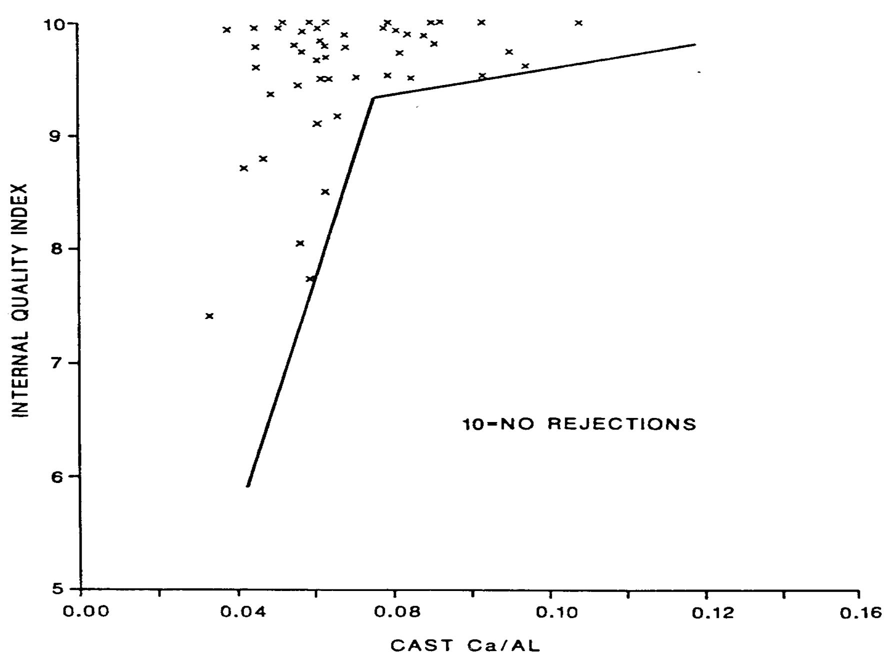
EPMA Absence of Calcium-Sulphide ring

- **Optimum Consumption of Ca-Si & Ca-Fe wire**
  Reduced to < 0.43 kg/t from 0.74 kg/t with improved inclusion structure and without any SEN clogging

- **Consistent & Improved Clean Steel Output**

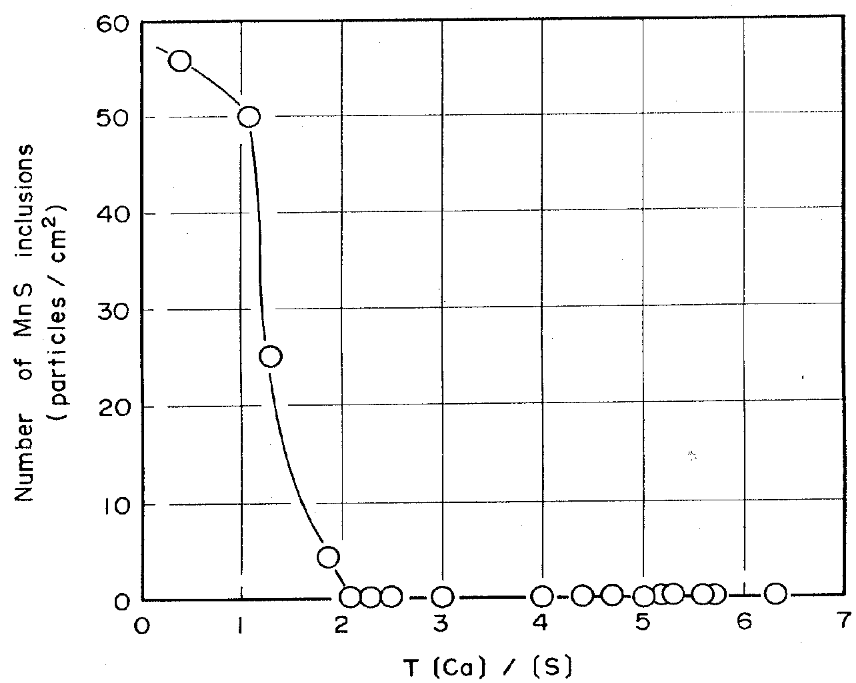
Total O	**< 42 ppm**
'S'value	**<120 ppm**
Al-content	**~0.03%**

THANK YOU



Influence of Ca/Al ratio on quality index

Effect of [Ca]/[S] ratio on number of MnS inclusions



SPECIAL STEELS FOR AUTOMOBILE SECTOR

Presented by

Sangeeta Sethy

Asst. Design Engineer

SMS section MECON Limited, Ranchi

Requirement of properties of steels for automotive Sector

- High Strength
- Light Weight
- Good formability
- Dent Resistance
- Impact resistance
- Cost Effectiveness

Classification of Automotive Steels

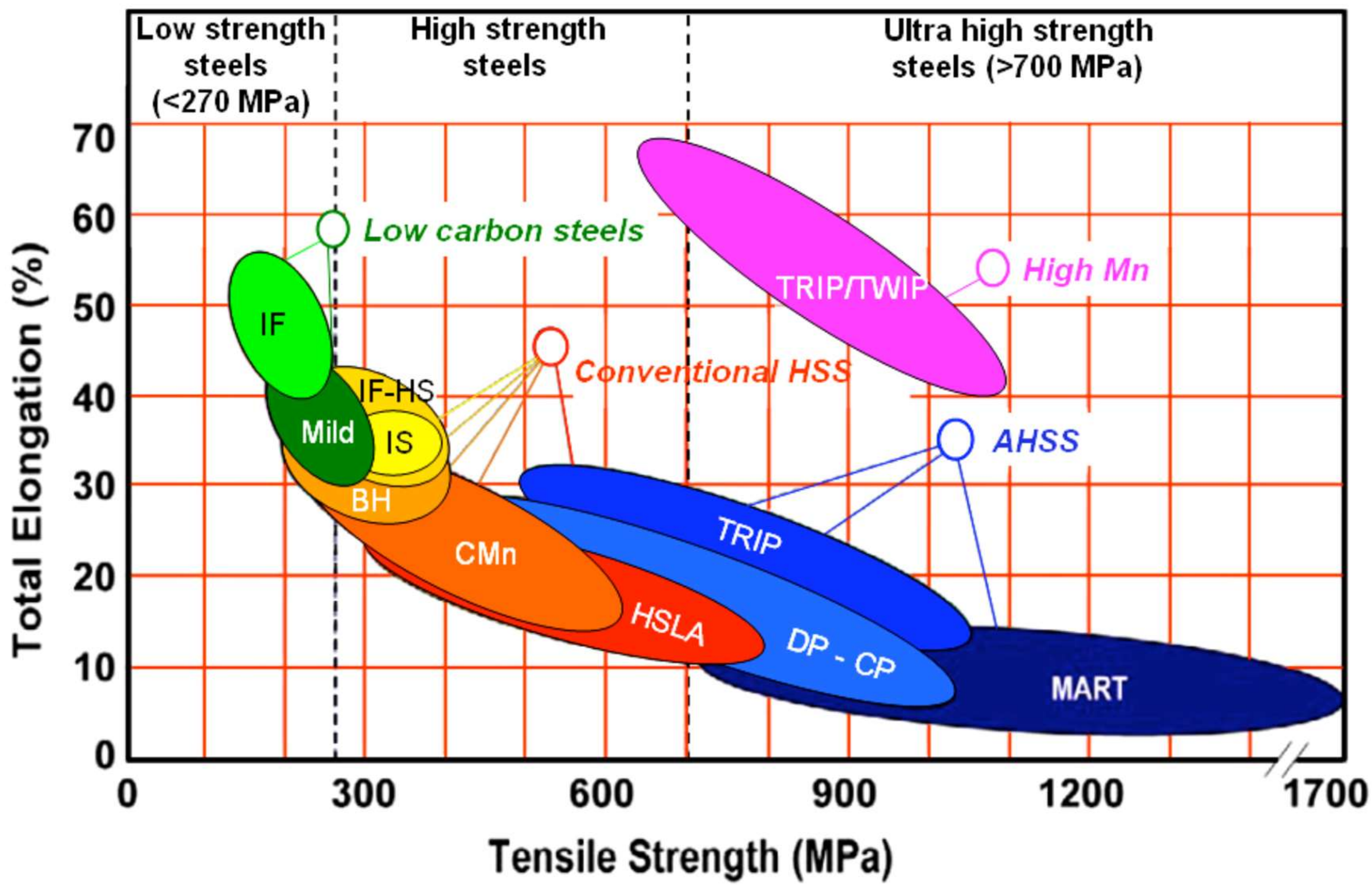
- Low Strength Steels

  Interstitial free steel, Mild Steel, etc.

- Conventional HSS Carbon Mn Steel, Bake Hardenable, IF-HS, HSLA

- AHSS Dual Phase, Complex Phase, TRIP, Martensitic Steel

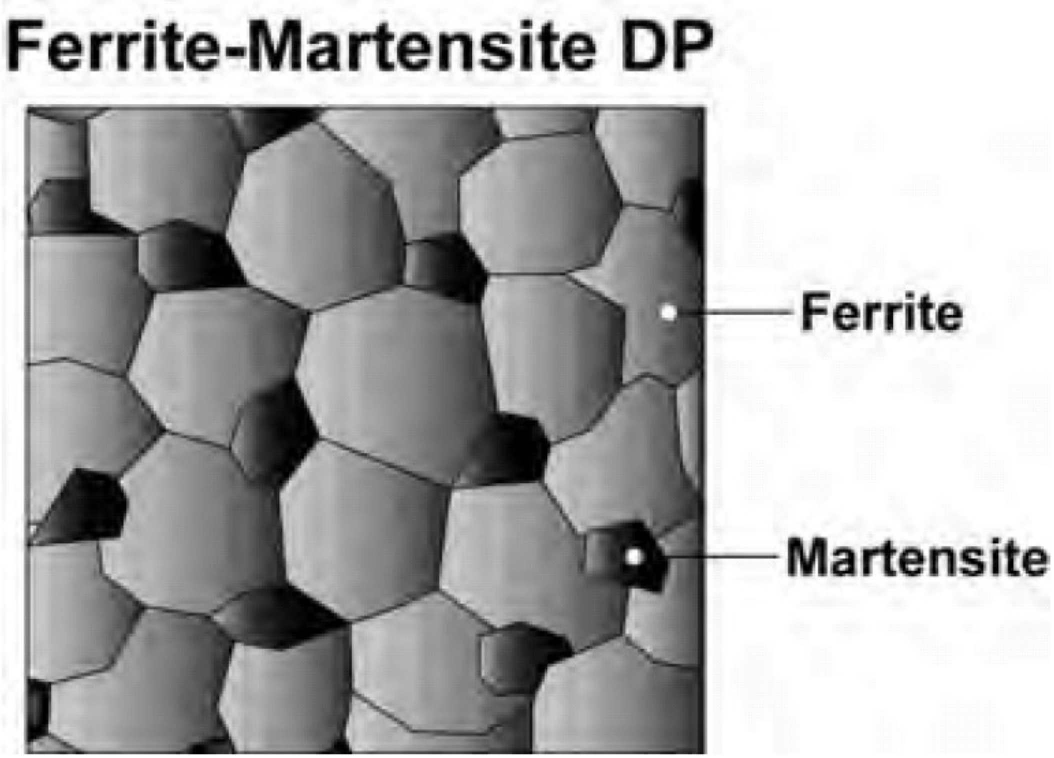
- UHSS Twinning-induced plasticity, nano, hot-formed, and post-forming heat treated steels



Low strength steels (<270 MPa)
High strength steels
Ultra high strength steels (>700 MPa)
Low carbon steels
High Mn
Conventional HSS
AHSS
IF
IF-HS
Mild
IS
BH
CMn
HSLA
TRIP/TWIP
TRIP
DP - CP
MART
Total Elongation (%)
Tensile Strength (MPa)
0
10
20
30
40
50
60
70
0
300
600
900
1200
1700

DUAL PHASE STEEL
(DP STEEL)

Microstructure of Dual Phase Steel

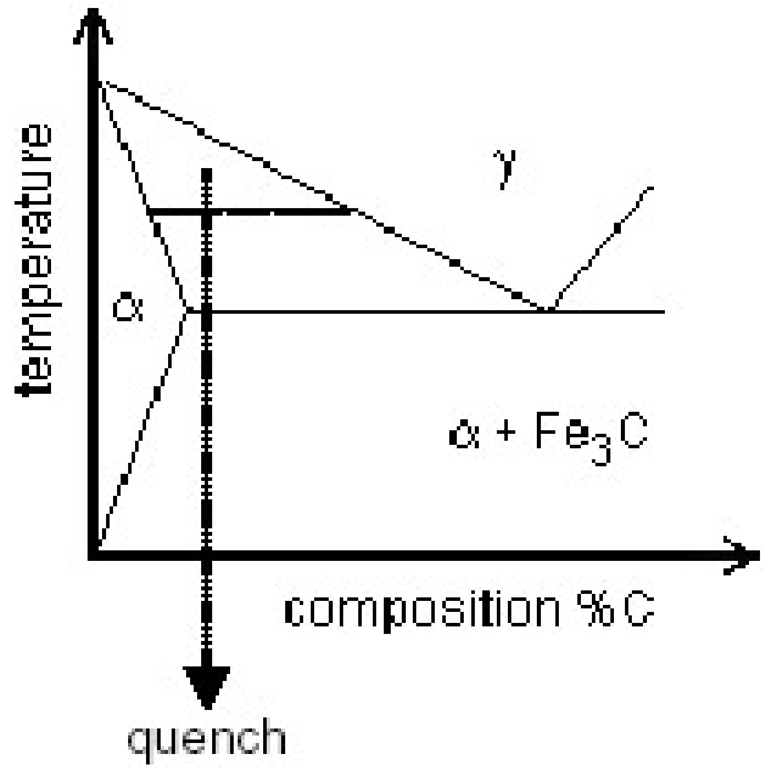


Typical composition

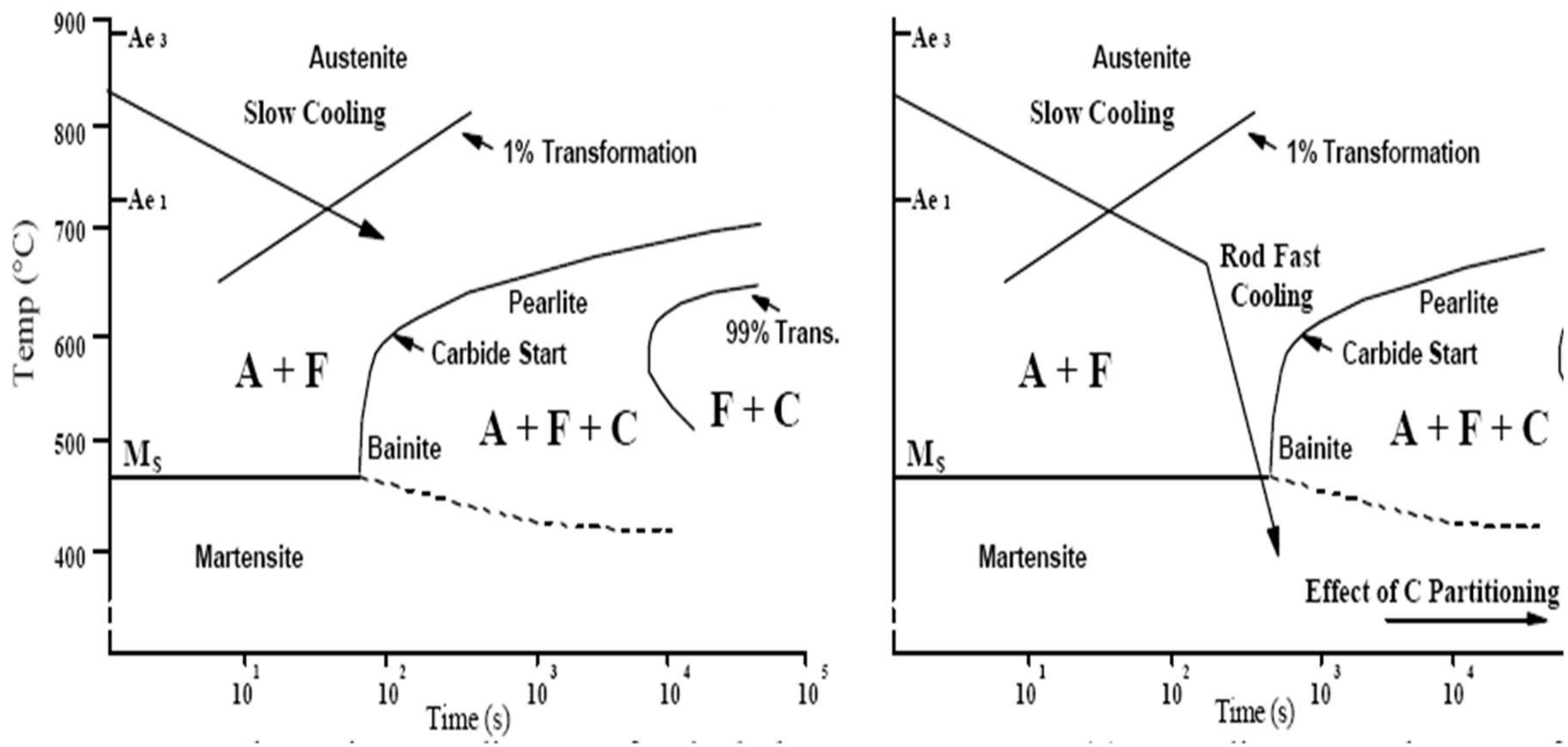
C	Mn	Si	P	S	Cr	V	Ti	Al	Mo
0.05	1.2	0.6	min.	min.	0.5	nr	nr	0.05	0.2

DP Steel - Principle

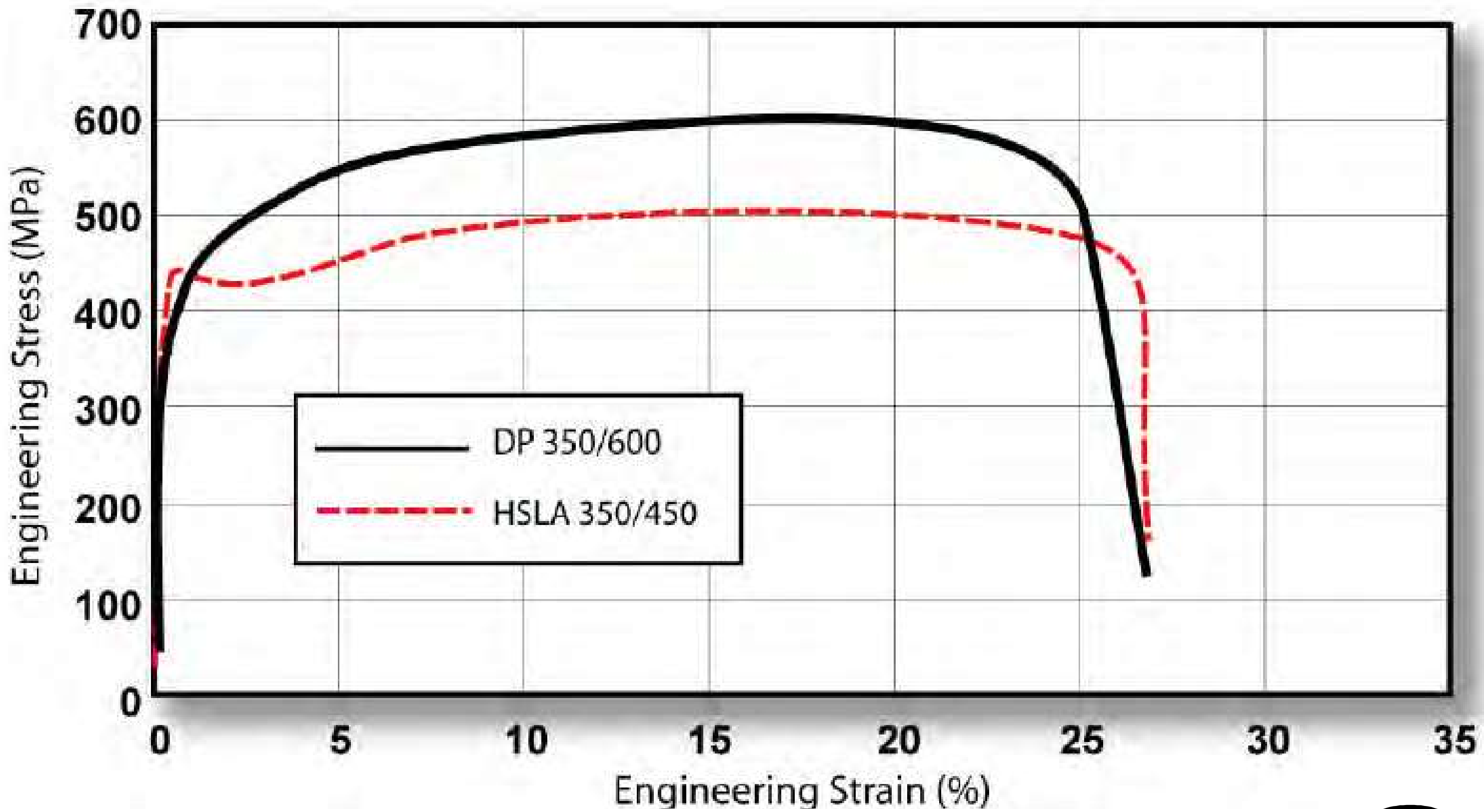
- Intercritical cooling from austenite
- Partial transformation: austenite to ferrite
- Fast cooling: Transformation of the remaining austenite to martensite



Transformation phases for DP steel



DP350/600 with greater UTS than HSLA 350/450

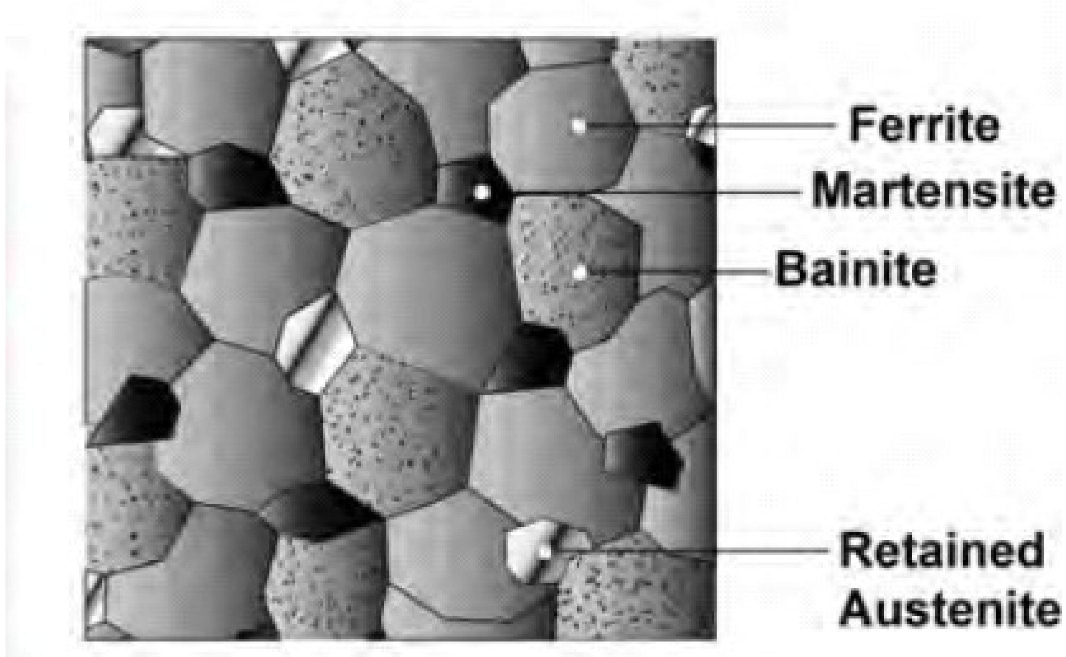


Use of DP steels in autobody

- Crash boxes
- Support components
- A, B and C pillars
- Box girders for chassis
- Wheels
- Bumpers
- Rails

TRANSFORMATION INDUCED PLASTICITY(TRIP) STEELS

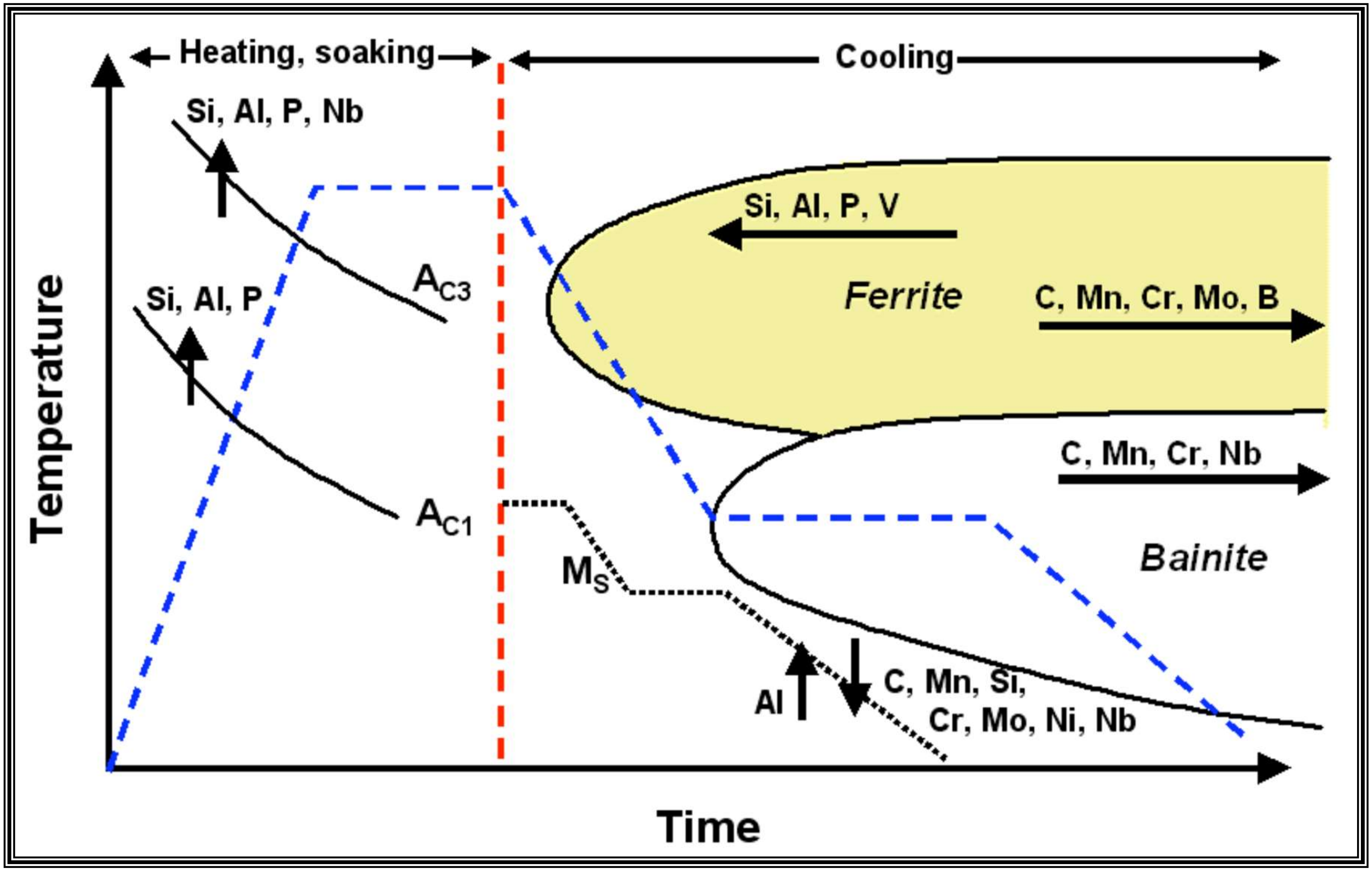
Microstructure of TRIP Steel



Typical composition

C	Mn	Si	P	S	Cr	Ni	Cu	Al	Nb
0.19	1.45	1.9	0.02	0.02	0.07	0.02	0.04	0.02	0.003

Heat treatment of TRIP Steel



Use of TRIP steel in autobody

- Front door panels
- Bumpers
- Ancillary parts
- Body structures
- Longitudinal members

Conclusion

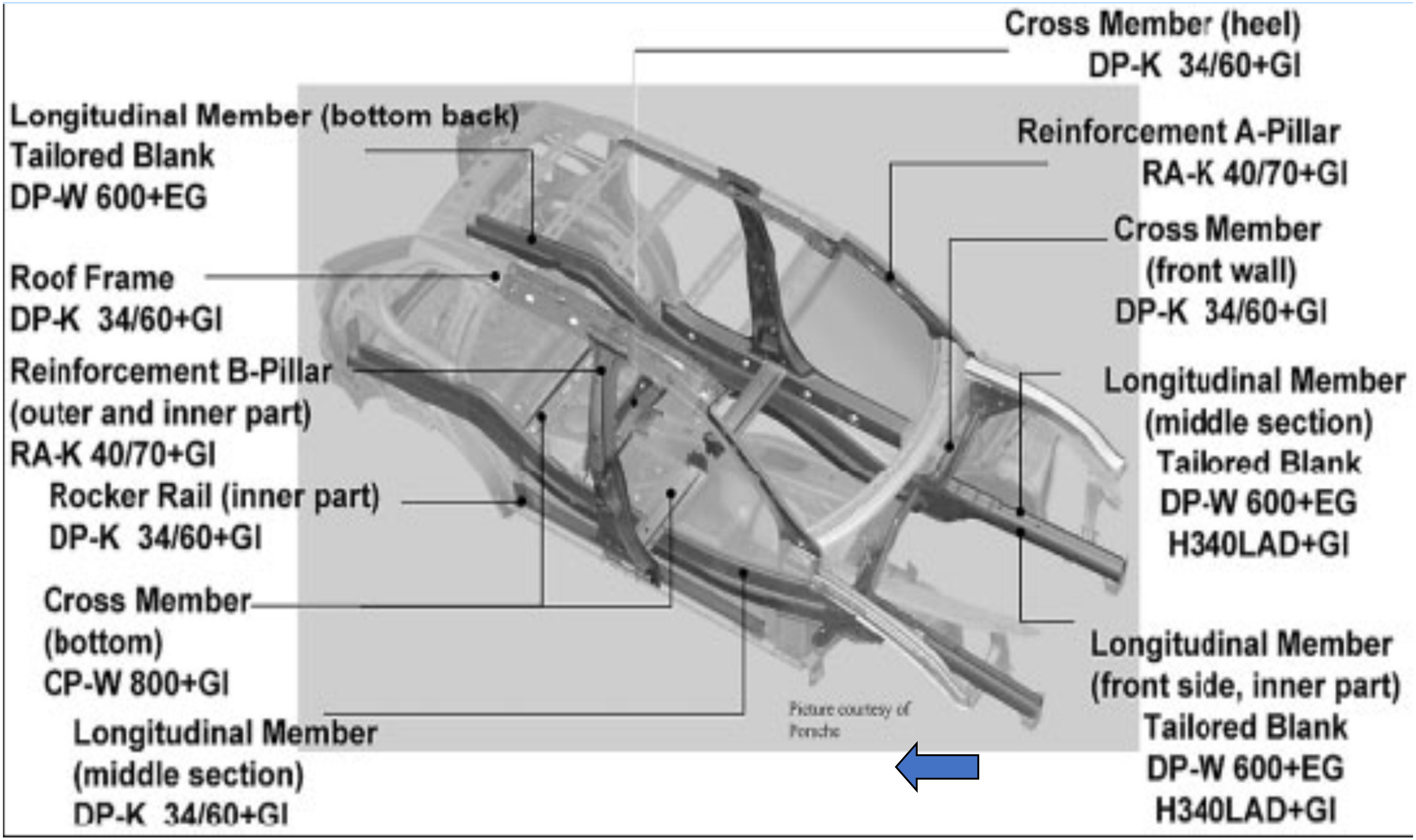
- Both DP and TRIP steels have superior properties required for automotive applications compare to conventional steels

- There is potential market for these steels

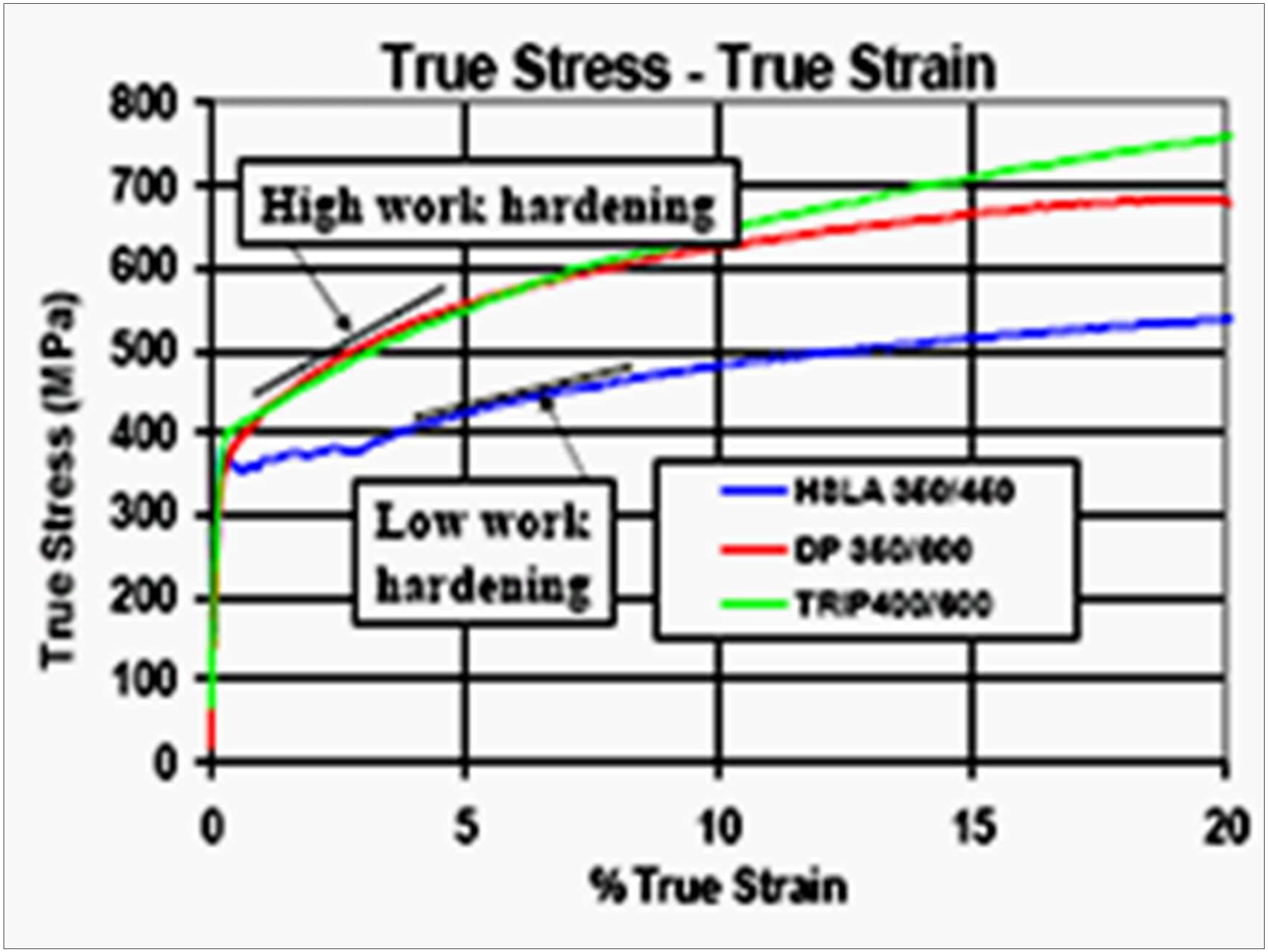
- Use of such latest grades of steel will not only increase fuel efficiency and safety of vehicles but it will also provide a competitive edge apart from meeting the stringent environmental and road safety regulations to come in force in recent future

THANK YOU

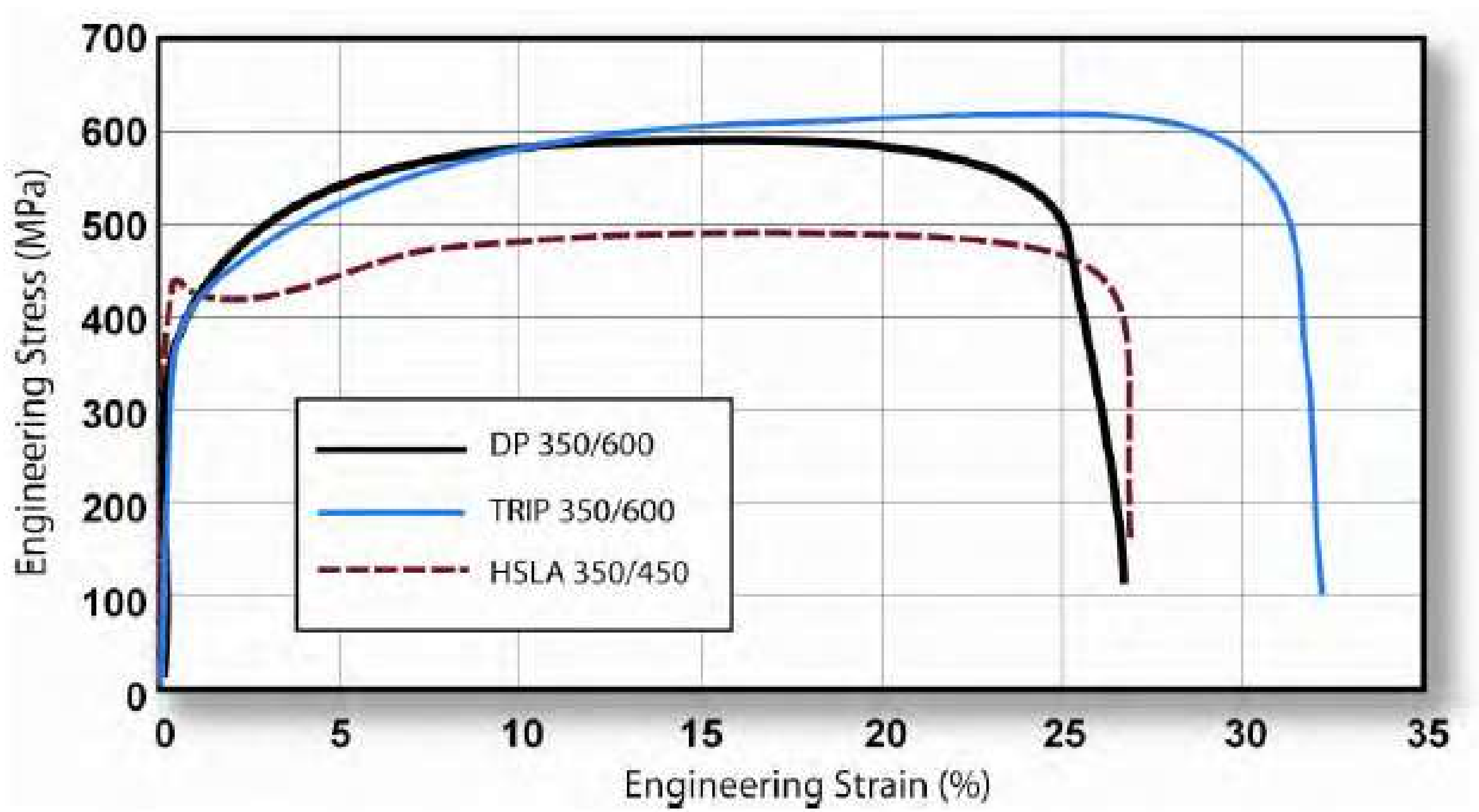
Applications of DP Steels



Conclusion



True Stress - True Strain
800
700
600
500
400
300
200
100
0
True Stress (MPa)
0
5
10
15
20
% True Strain
High work hardening
Low work hardening
HSLA 350/450
DP 350/600
TRIP400/600

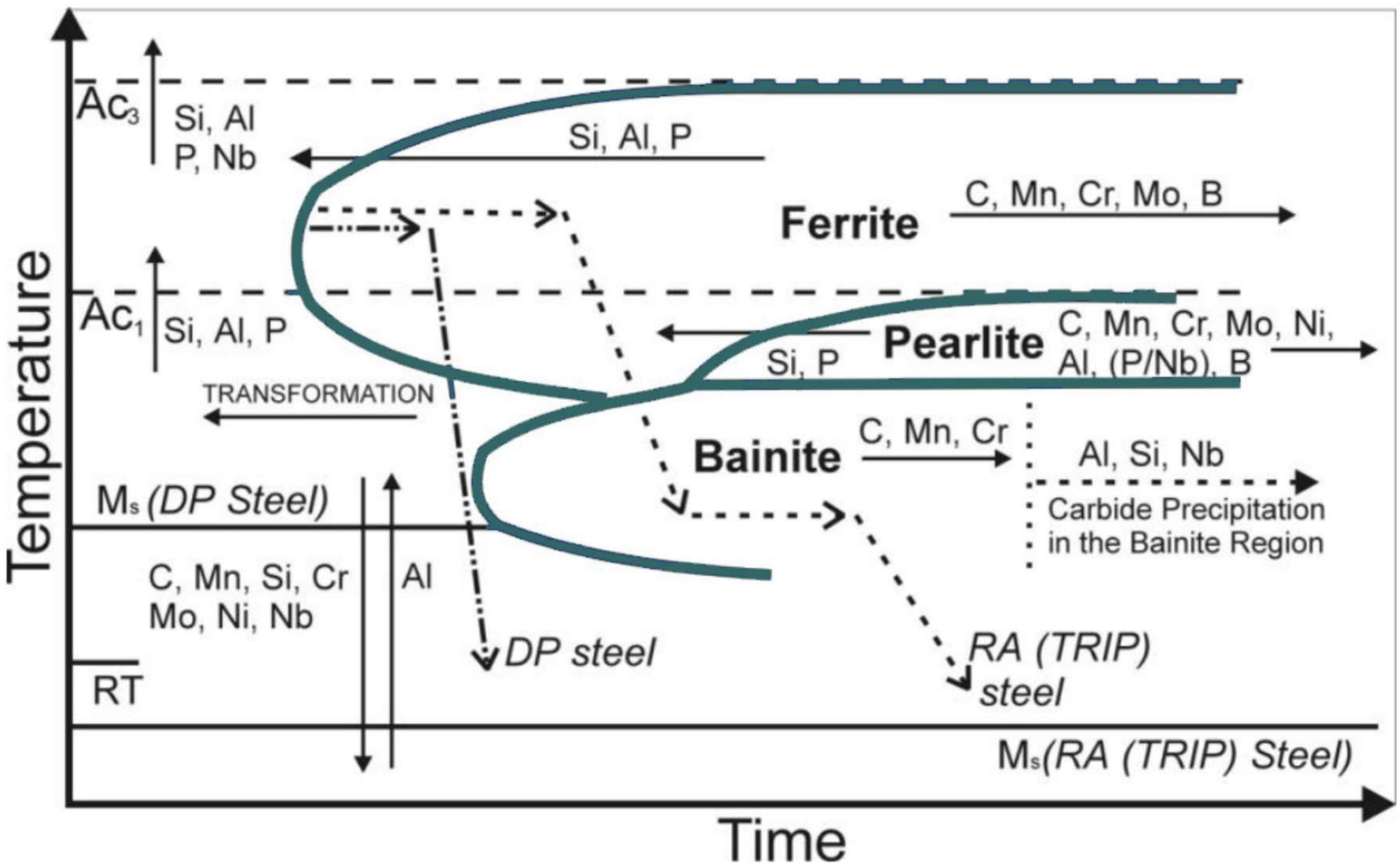


Engineering Stress (MPa)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
Engineering Strain (%)
DP 350/600
TRIP 350/600
HSLA 350/450

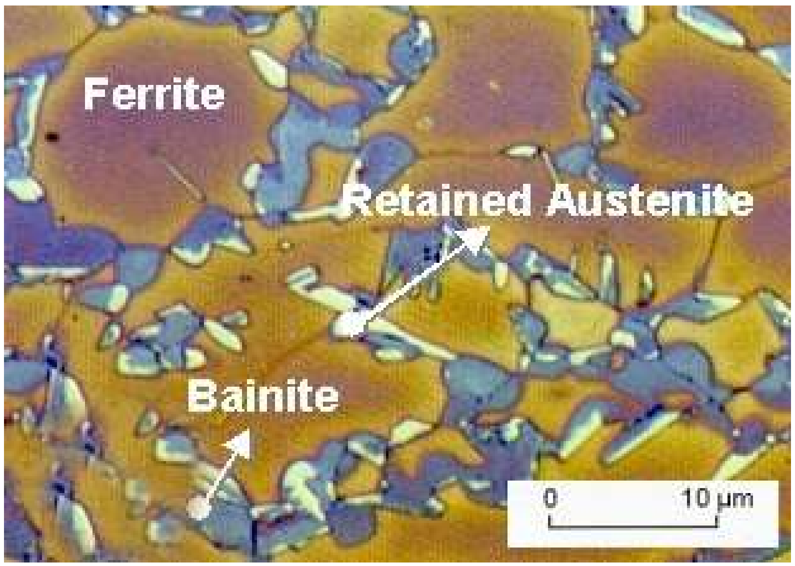
Steels utilized in ULSAB-AVC

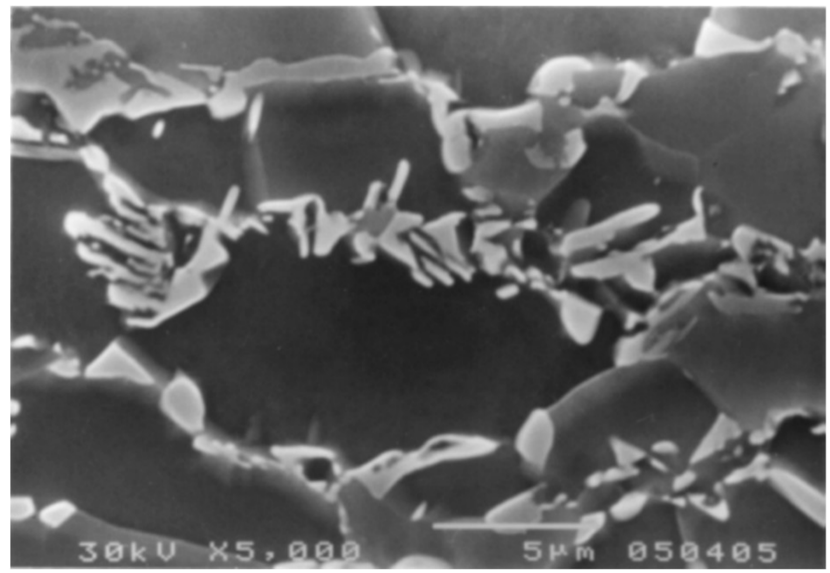
	C class			PNGV class	
Body structure	grade	Weight/kg	Proportion/ %	Weight/kg	Proportion/ %
	HSLA350/450	2.68	1.33	2.68	1.23
	IF 300/420	5.77	2.86	4.18	9.11
	BH 210/340	6.64	3.29	8.69	3.98
	BH 260/370	16.77	8.31	12.69	5.82
	DP 280/600	7.84	3.89	15.02	6.89
	DP 300/500	18.14	8.99	17.4	7.98
	DP 350/600	6.58	3.26	6.02	2.76
	DP 400/700	9.14	4.53	9.14	4.19
	DP 500/800	47.71	23.64	49.21	22.56
	DP700/1000	59.32	29.40	65.47	30.02
	Trip 450/800	8.44	4.18	8.92	4.09
	CP 700/800	1.13	0.56	1.13	0.52
	Mart 950/1200	6.09	3.02	5.83	2.61
	Mart1250/1520	1.77	0.88	1.77	0.81
Closure	IF 260/410	2.52	6	5.72	10
	DP 350/600	18.17	46	26.92	45
	DP 500/800	5.31	13	7.22	12

Influence Of Alloying Elements on TTT Behaviour

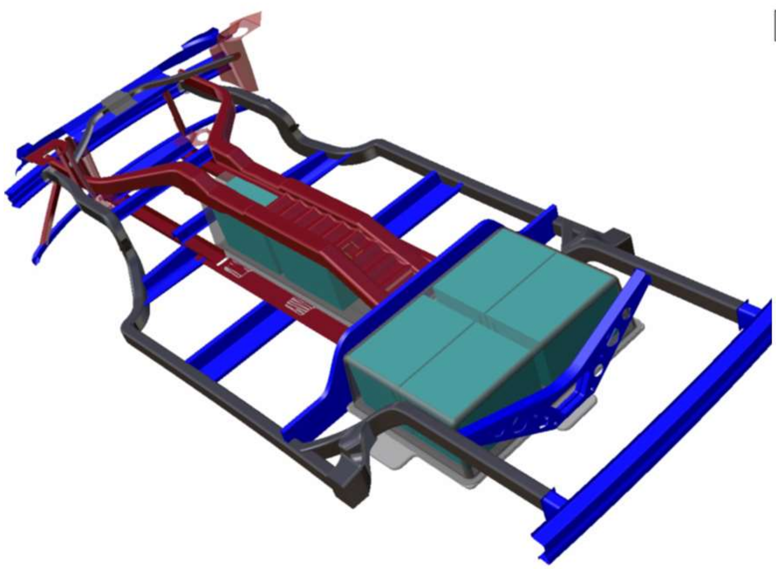


Microstructure of TRIP Steel

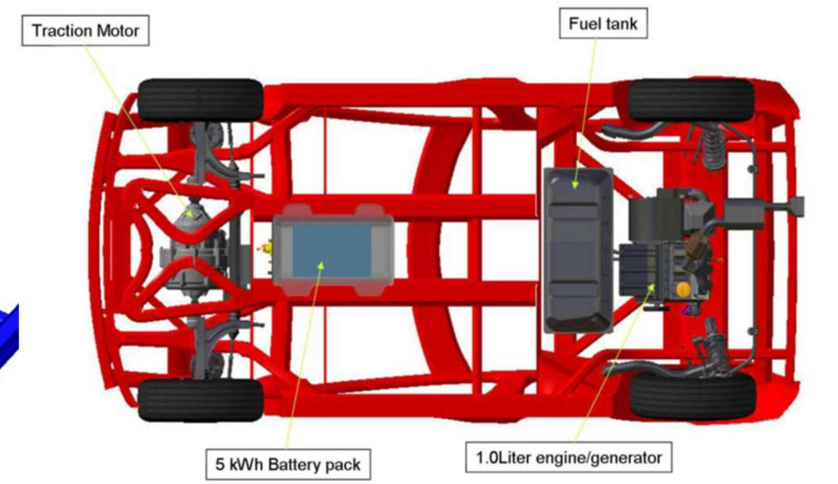




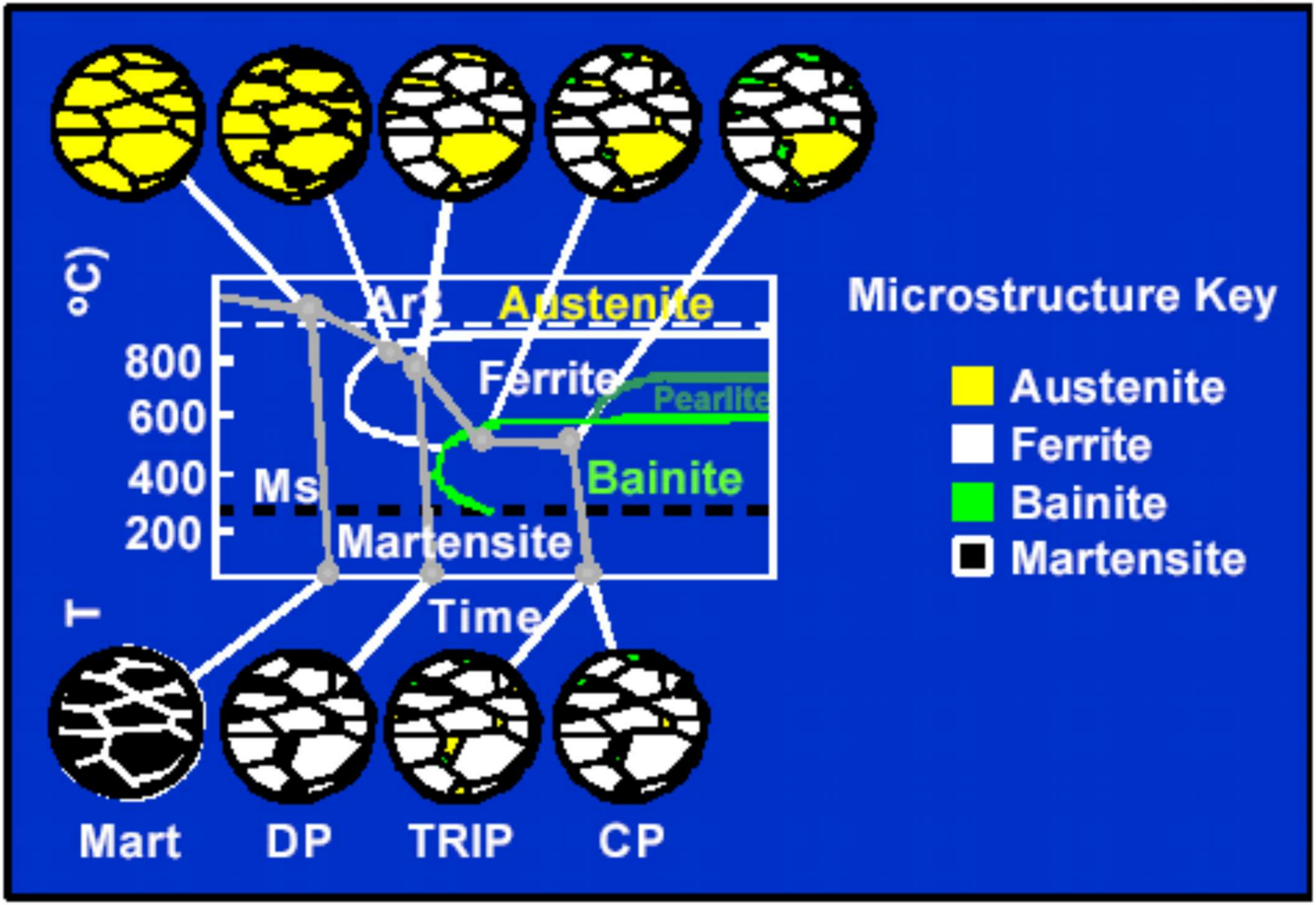
Future Steel Vehicle



BEV Underbody

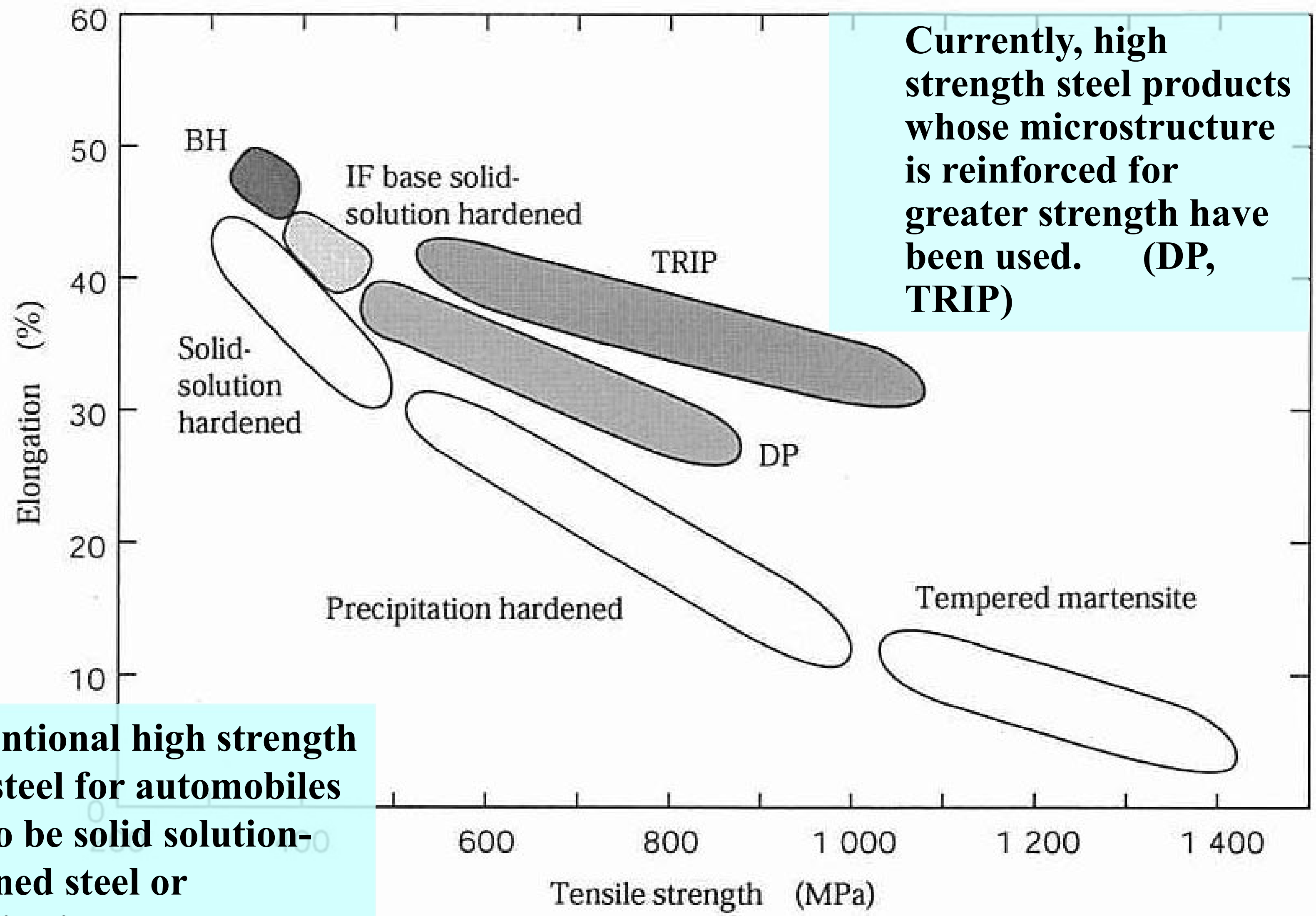


PHEV20 Powertrain Layout



T (°C)
800
600
400
200
Ms
Ar3
Austenite
Ferrite
Pearlite
Bainite
Martensite
Time
Mart
DP
TRIP
CP
Microstructure Key
Austenite
Ferrite
Bainite
Martensite

Relation Between Tensile Strength And Elongation



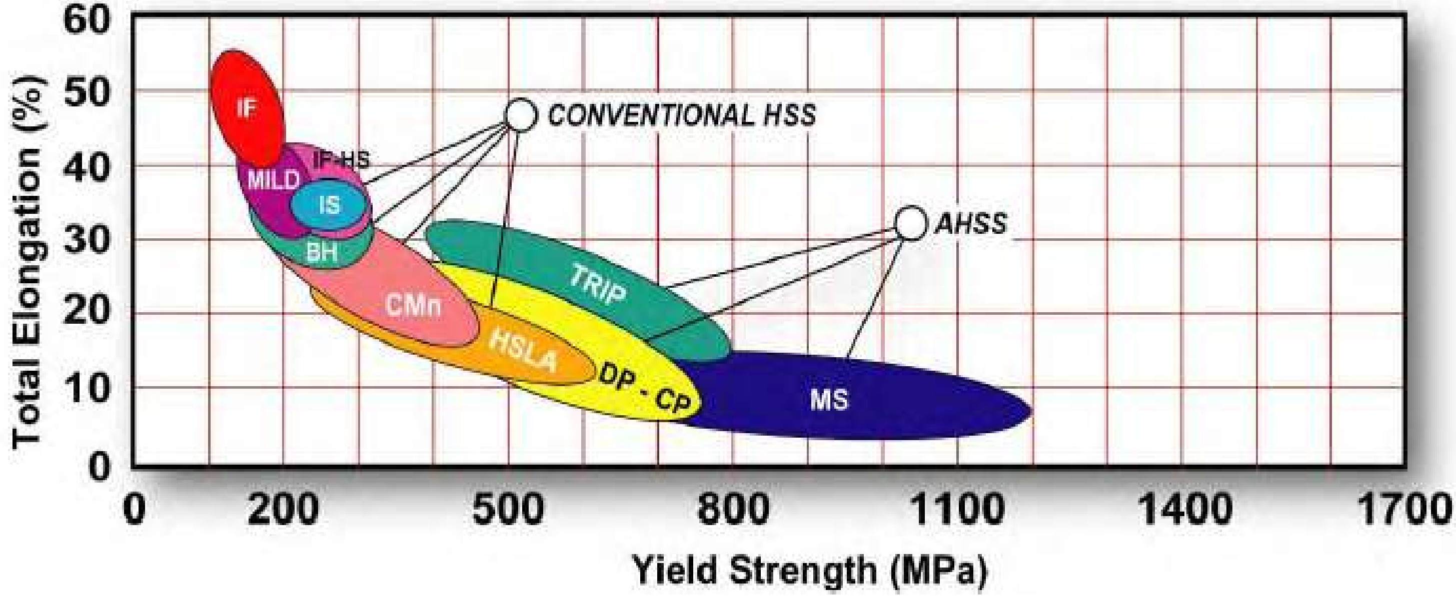
Currently, high strength steel products whose microstructure is reinforced for greater strength have been used. (DP, TRIP)

Conventional high strength sheet steel for automobiles used to be solid solution-hardened steel or precipitation-hardened steel with alloy added.

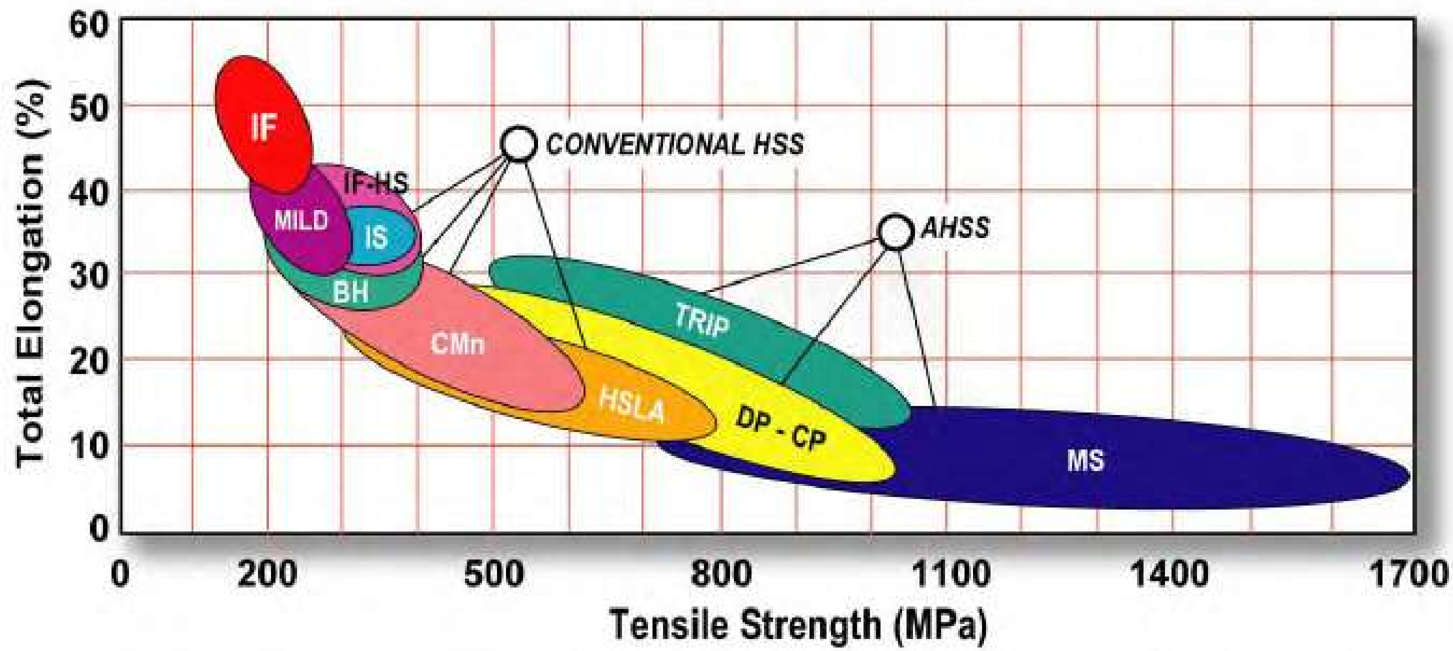
Steel Grade Properties From ULSAB-AVC

Steel Grade	YS (MPa)	UTS (MPa)	Tot. EL (%)
HSLA 350/450	350	450	23-27
DP 300/500	300	500	30-34
DP 350/600	350	600	24-30
TRIP 450/800	450	800	26-32
DP 500/800	500	800	14-20
CP 700/800	700	800	10-15
DP 700/1000	700	1000	12-17
MS 1250/1520	1250	1520	4-6

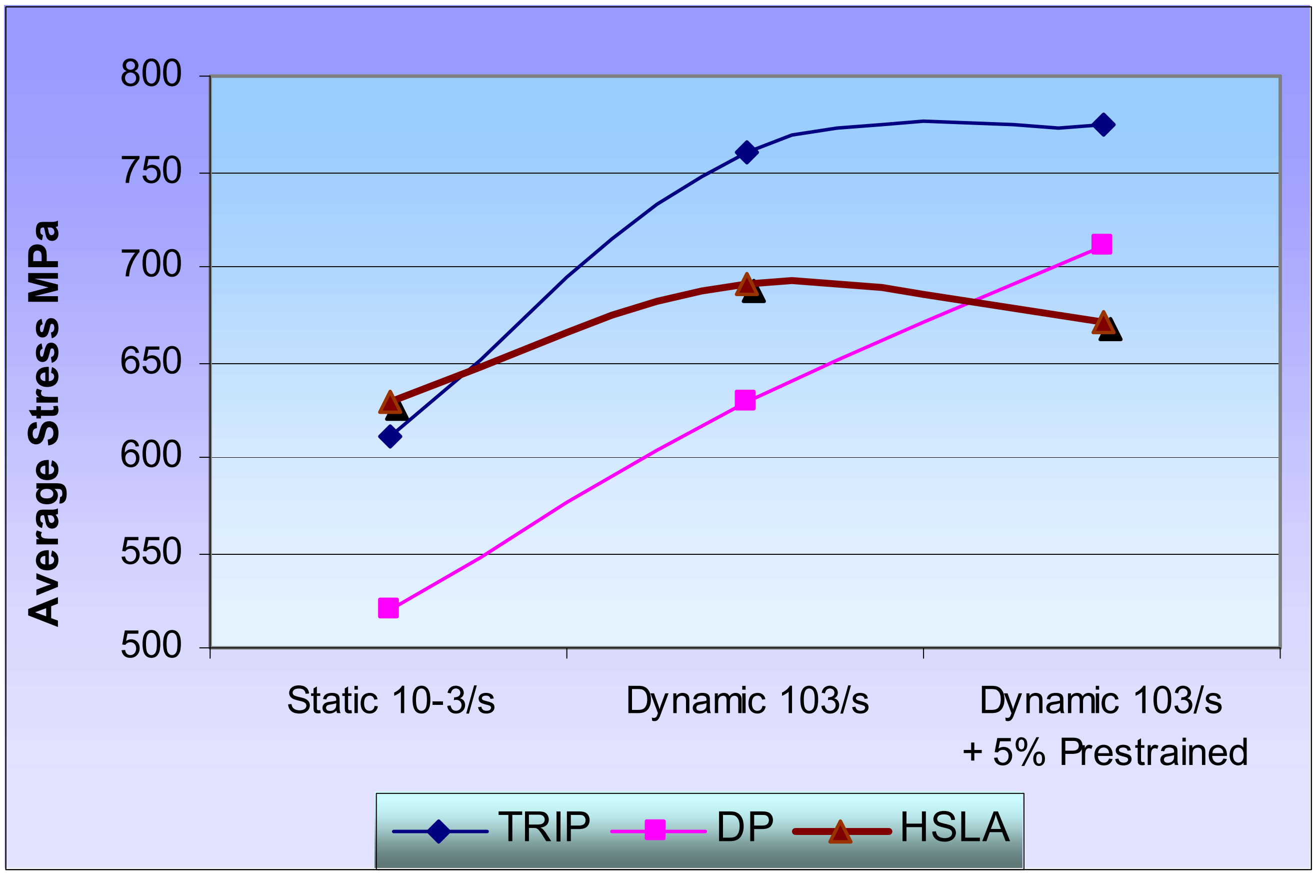
YS and UTS are minimum values



Total Elongation (%)
60
50
40
30
20
10
0
IF
MILD
IF-HS
IS
BH
CMn
CONVENTIONAL HSS
AHSS
TRIP
HSLA
DP - CP
MS
0
200
500
800
1100
1400
1700
Yield Strength (MPa)

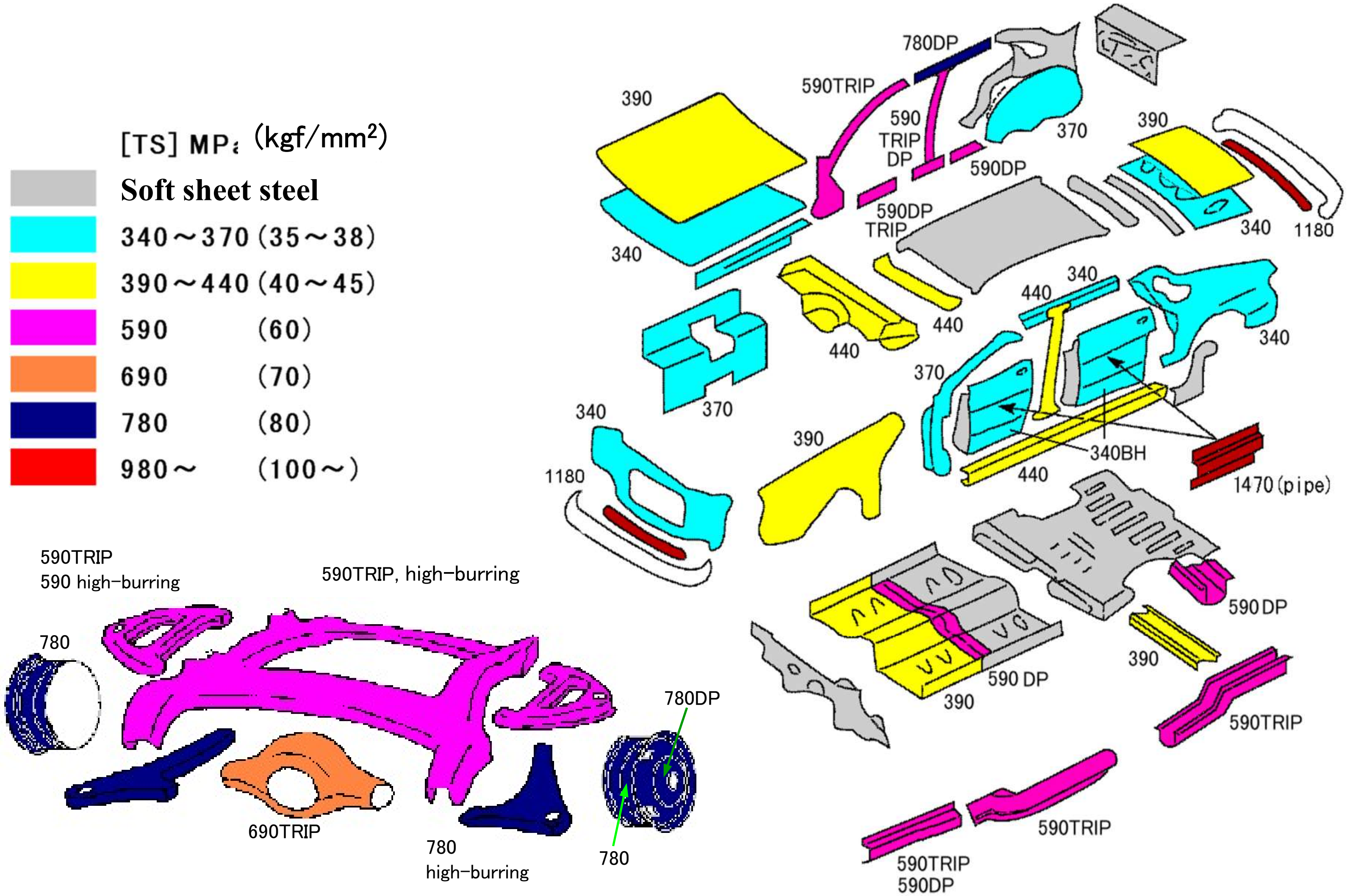


Total Elongation (%)
60
50
40
30
20
10
0
IF
IF-HS
MILD
IS
BH
CMn
CONVENTIONAL HSS
AHSS
TRIP
HSLA
DP - CP
MS
0
200
500
800
1100
1400
1700
Tensile Strength (MPa)



Nippon Steel

Components and Steel Grades



Range of steels available for future vehicles

Product	YS (MPa)*	UTS (MPa)*	Total EL (%)*	n-value (5-15%), if applicable	r-bar*	Application Code
Mild 140/270	140	270	38-44	0.23	1.8	A,C,F
BH 210/340	210	340	34-39	0.18	1.8	B
BH 260/370	260	370	29-34	0.13	1.6	B
IF 260/410	260	410	34-38	0.20	1.7	C
DP 280/600	280	600	30-34	0.21	1.0	B
IF 300/420	300	420	29-36	0.20	1.6	B
DP 300/500	300	500	30-34	0.16	1.0	B
HSLA 350/450	350	450	23-27	0.22	1.0	A,B,S
DP 350/600	350	600	24-30	0.14	1.1	A,B,C,W,S
DP 400/700	400	700	19-25	0.14	1.0	A,B
TRIP 450/800	450	800	26-32	0.24	0.9	A,B
HSLA 490/600	490	600	21-26	0.13	1.0	W
DP 500/800	500	800	14-20	0.14	1.0	A,B,C,W
SF 570/640	570	640	20-24	0.08	1.0	S
CP 700/800	700	800	10-15	0.13	1.0	B
DP 700/1000	700	1000	12-17	0.09	0.9	B
Mart 950/1200	950	1200	5-7	0.07	0.9	A,B
MnB**	1200	1600	4-5	na	na	S
Mart 1250/1520	1250	1520	4-6	0.07	0.9	A

Application Code: A = Ancillary Parts, B = Body Structure, C = Closures, F = Fuel Tank, S = Suspension/Chassis, W = Wheels

IMPROVEMENT OF ROLL LIFE BY MODIFIED COOLING SYSTEM AT ROUGHING STANDS OF HSM, BSL

N Mondal, A K Marik, P Pathak, D Chowdhury, S Kumar, P Raj, R Datta & K N Changder

BACKGROUND

INTRODUCTION

- ❖Capacity of Hot strip mill of BSL- 3.955 MT
- ❖ Modernization of HSM done in 1998
- ❖ No major technological improvements done in roughing zone after modernization

BACKGROUND

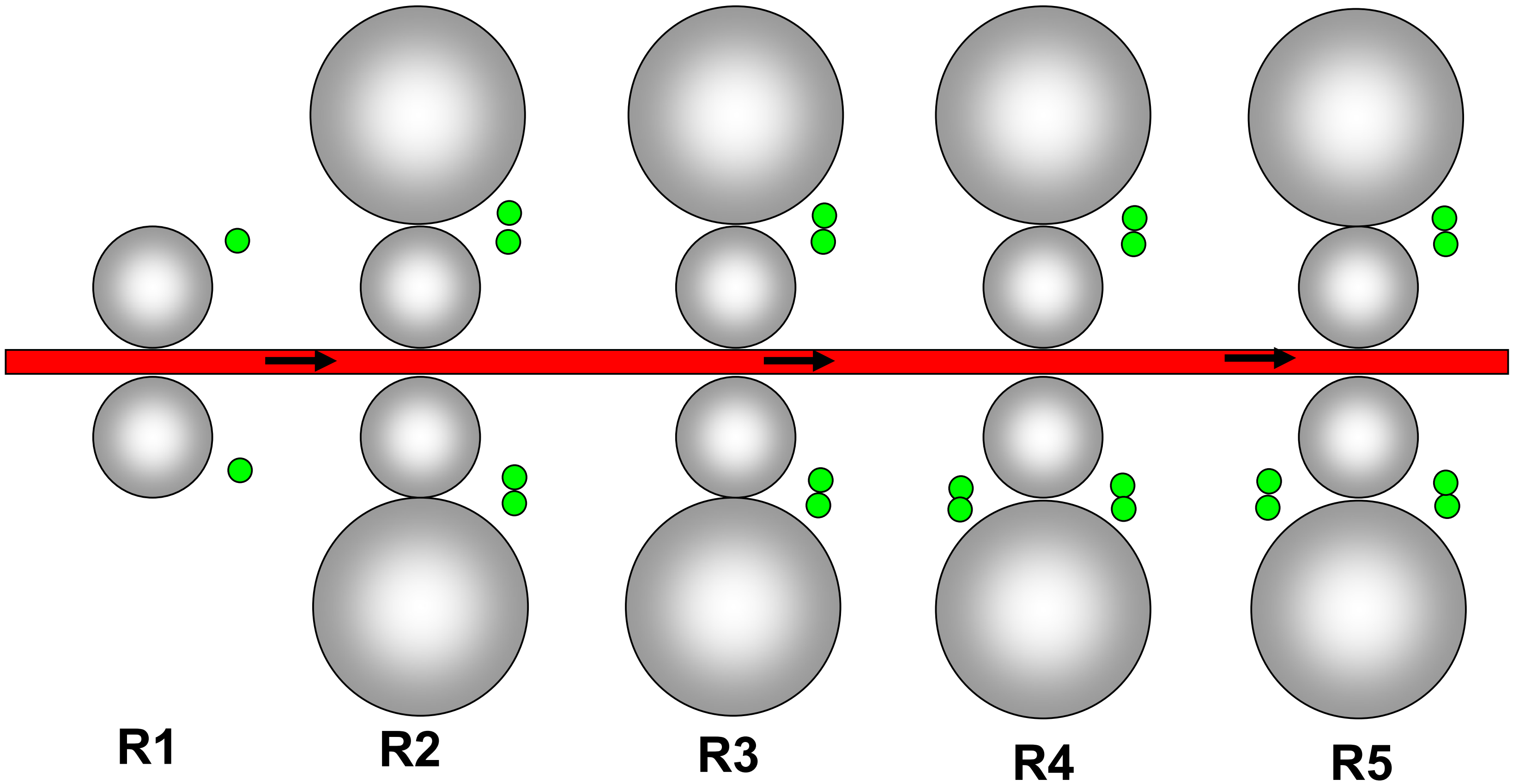
PROBLEMS FACED

- Primitive roll cooling system
- Inadequate coolant flow rate and non-uniform flow density across the roll
- Spray headers with 2 rows of 6mm Ø drill hole
- Location of spray towards WR and BUR bite
- Poor HTC due to low impinging force & pressure
- Higher roll wear, grinding off-take and higher specific roll consumption

APPROACH

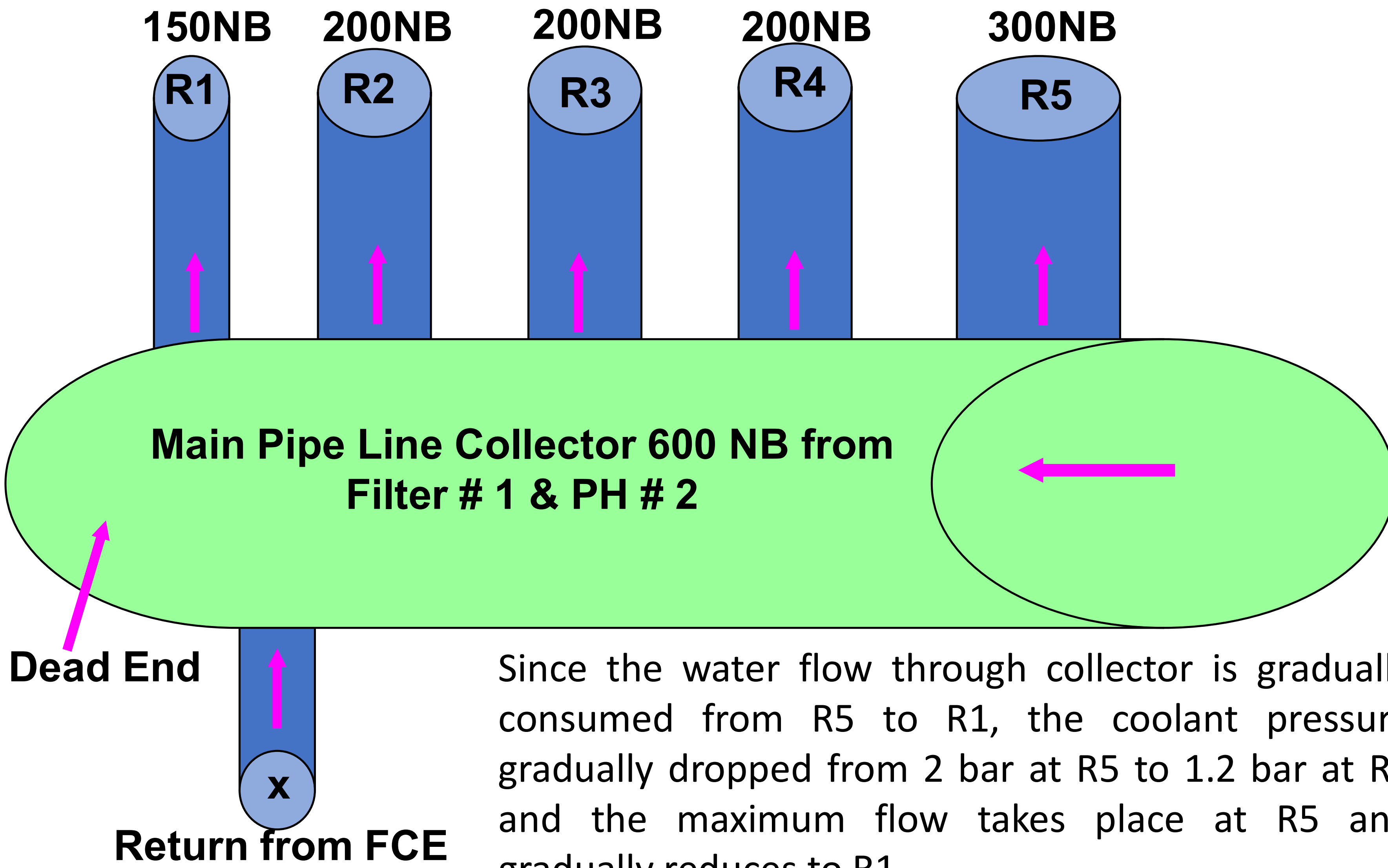
- Study & analysis of existing roll cooling system
- Designing of modified spray header with flushing arrangement
- Fabrication of roll coolant spray headers
- Installation & Commissioning of modified roll cooling system at R # 1,2,3, 4 and 5
- Performance evaluation of modified cooling system

EXISTING SPRAY HEADER LOCATION



3500 lpm @ 1.2 bar	5000 lpm @ 1.2 bar	6500 lpm @ 1.5 bar	9000 lpm @ 1.8 bar	10000 lpm @ 2.0 bar

WATER SUPPLY TO ROUGHING STAND

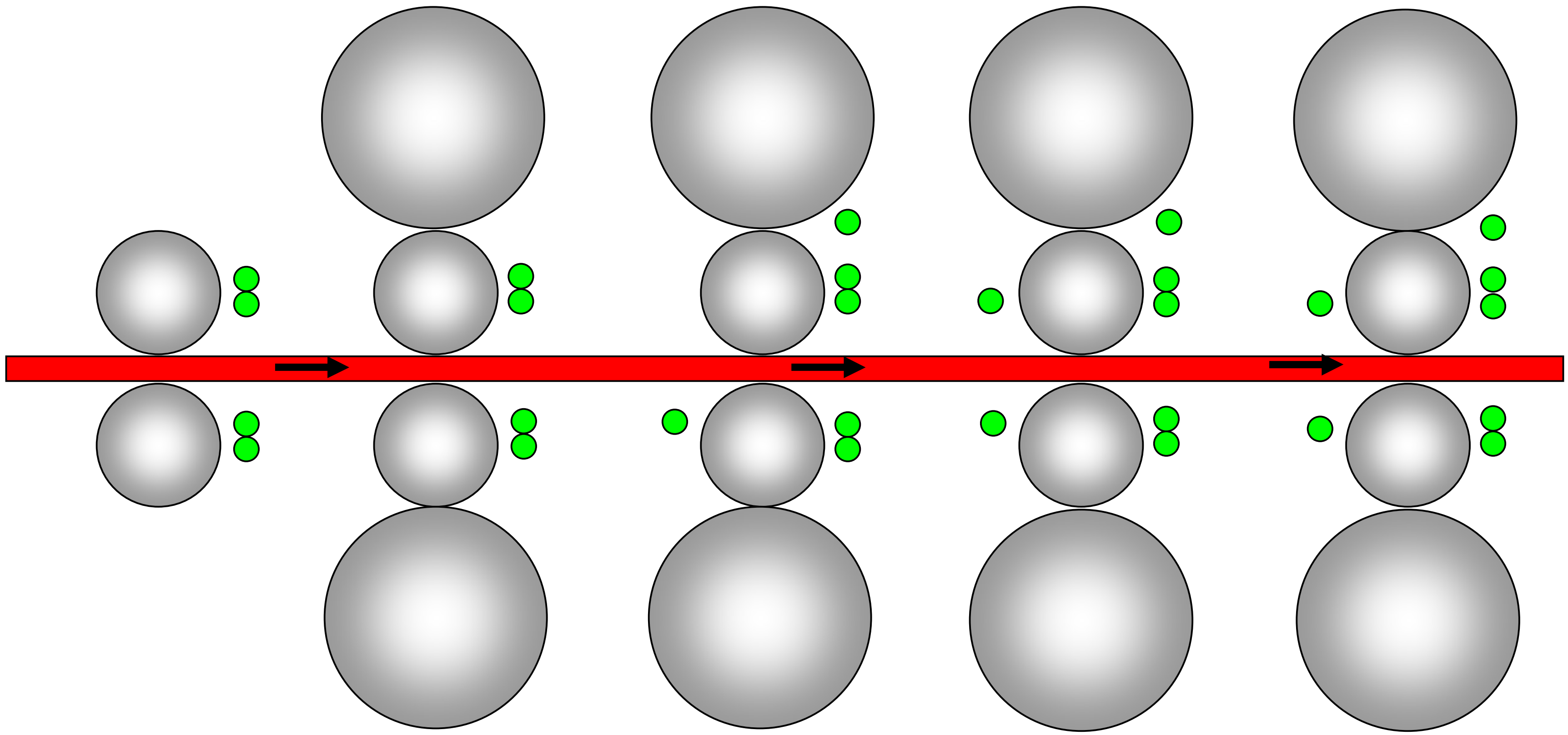


Since the water flow through collector is gradually consumed from R5 to R1, the coolant pressure gradually dropped from 2 bar at R5 to 1.2 bar at R1 and the maximum flow takes place at R5 and gradually reduces to R1

DESIGN CRITERION

- Introduction of flat jet nozzle
- Relocation of spray headers
- Intense cooling of work roll at exit
- Increase in impinging coolant pressure
- Increasing coolant volume by higher flow rate nozzle
- Variable coolant flow distribution

MODIFIED SPRAY HEADER LOCATION



R1	R2	R3	R4	R5
5000 lpm @ 3.0 bar	6100 lpm @ 3.0 bar	8260 lpm @ 3.0 bar	9940 lpm @ 3.0 bar	11410 lpm @ 3.0 bar

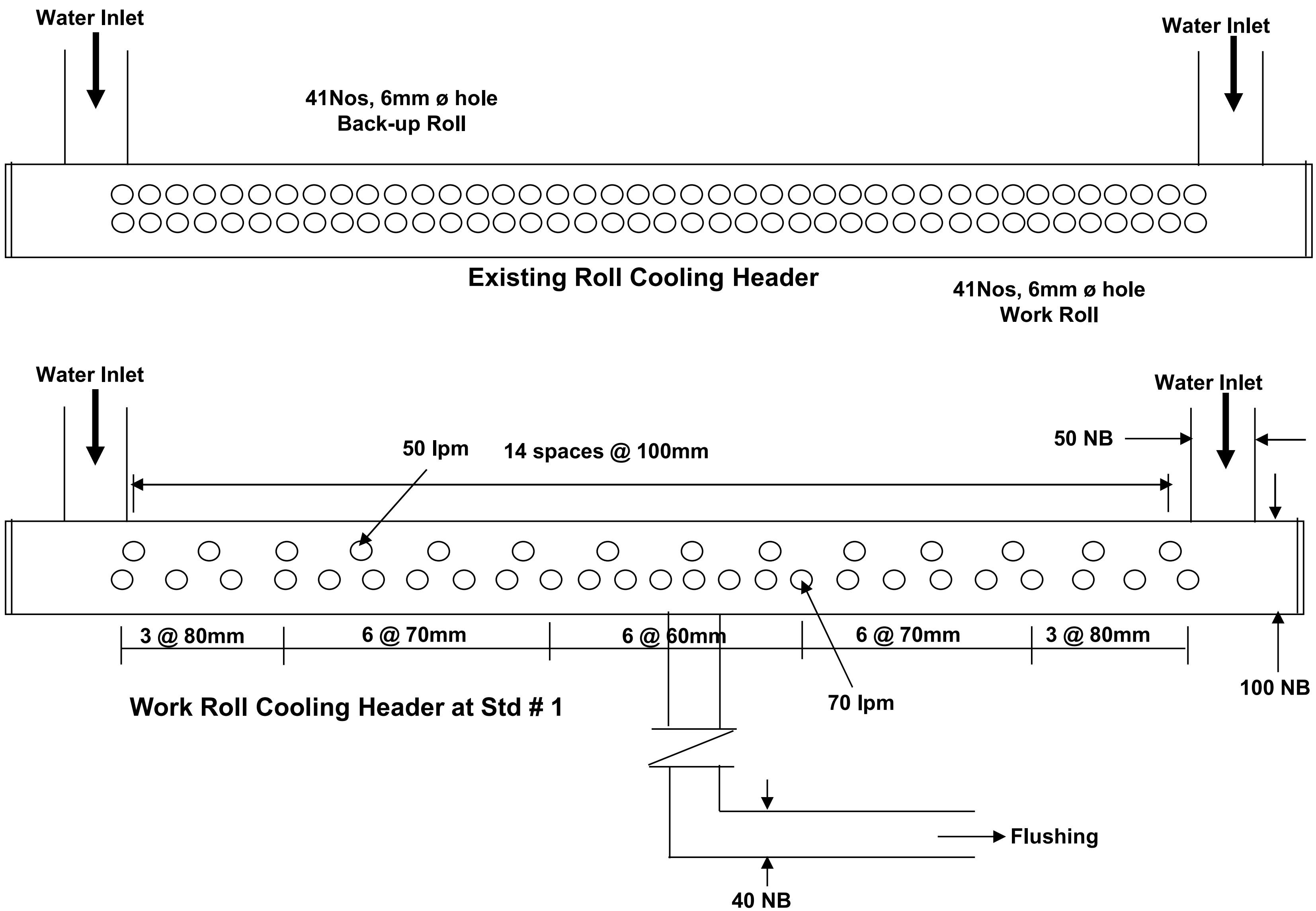
DESIGN OF SPRAY HEADER OF ALL STD

	Std # 1	Std # 2	Std # 3		Std # 4		Std # 5	
	Exit	Exit	Entry	Exit	Entry	Exit	Entry	Exit
TBUR				Single 21		Single 21		Single 21
TWR	Double 25 + 15	Double 29 + 21		Double 29 + 21	Single 21	Double 29 + 21	Single 21	Double 29 + 21
BWR	Double 25 + 15	Double 29 + 21	Single 21	Double 29 + 21	Single 21	Double 29 + 21	Single 21	Double 29 + 21
Flow (lpm)	5000 @ 3 bar	6100 @ 3 bar	8260 @ 3 bar		9940 @ 3 bar		11410 @ 3 bar	
Present Flow	3500 @1.2bar	5000 @1.2bar	6500 @ 1.5 bar		8500 @ 2.0 bar		10000 @ 2.0 bar	
(kw)	6000	7000	10000		12000		13000	
% kw	0.83	0.88	0.83		0.83		0.88	

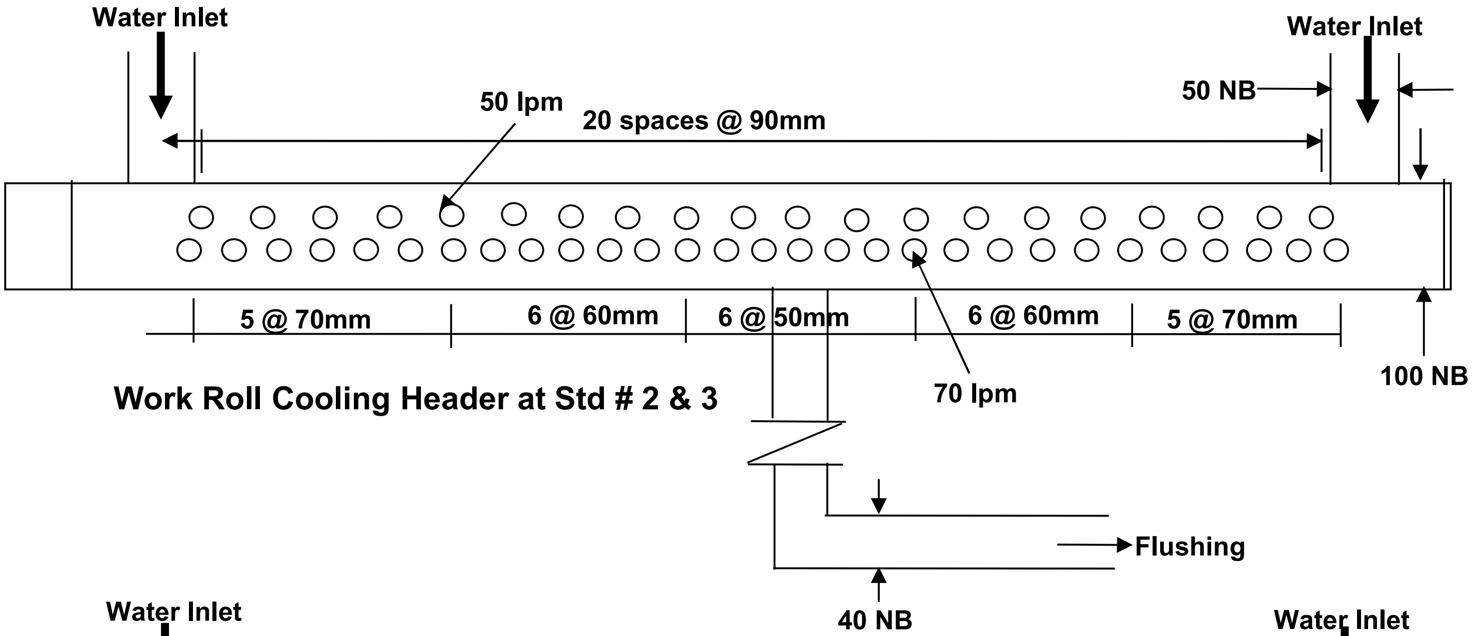
Nozzle (3-pc Dove-tail Flat jet)– 70 lpm @ 3 bar, Bore-10mmø,Spray Angle-45^{o}, Width-300mm

Nozzle (3-pc Dove-tail Flat jet) - 50 lpm @ 3 bar, Bore- 8mm ø,Spray Angle-45^{o}, Width-300mm

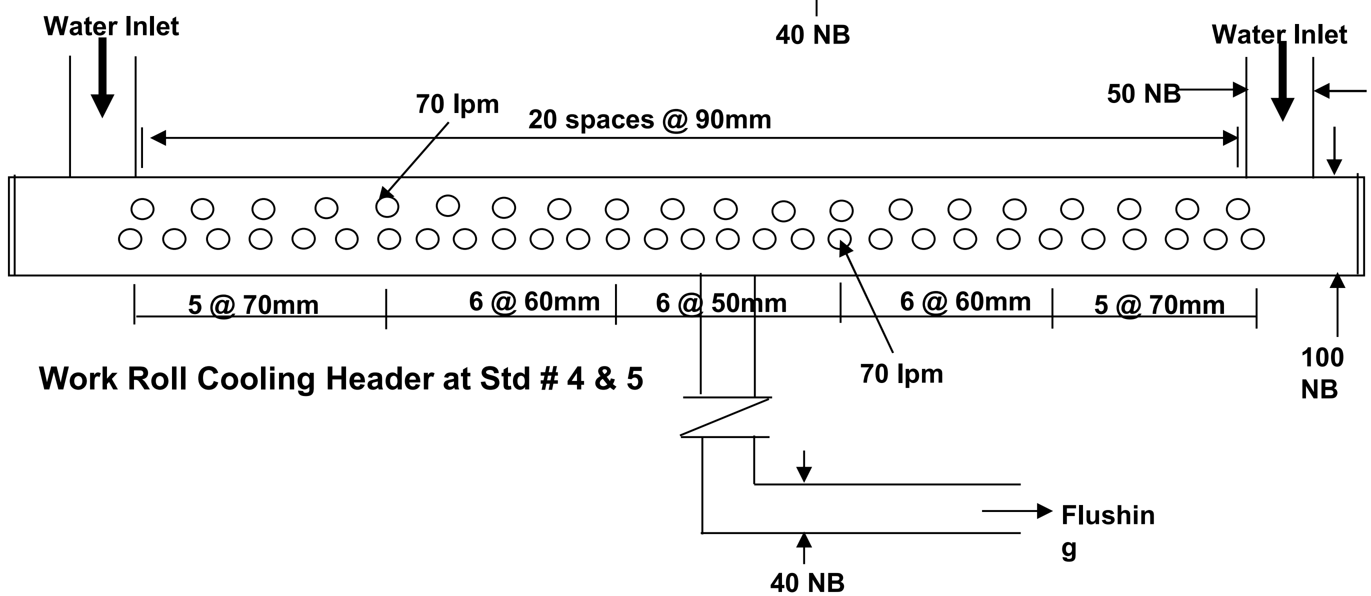
SPRAY HEADER DESIGN



MODIFIED SPRAY HEADER DESIGN



Work Roll Cooling Header at Std # 2 & 3



Work Roll Cooling Header at Std # 4 & 5

WORK CARRIED OUT

- Modified system installed in R-1,R-2,R-3,R-4 & R-5

- Spray headers fabricated with flat-jet dove-tail type nozzles to ensure aligned spray pattern on roll surface

- Nozzles welded to spray headers with an off-set angle of 20^0 to avoid more over-lapping with adjacent spray

WORK CARRIED OUT

- Spray over-lap maintained at 50-60% to avoid dry spotting of the roll surface

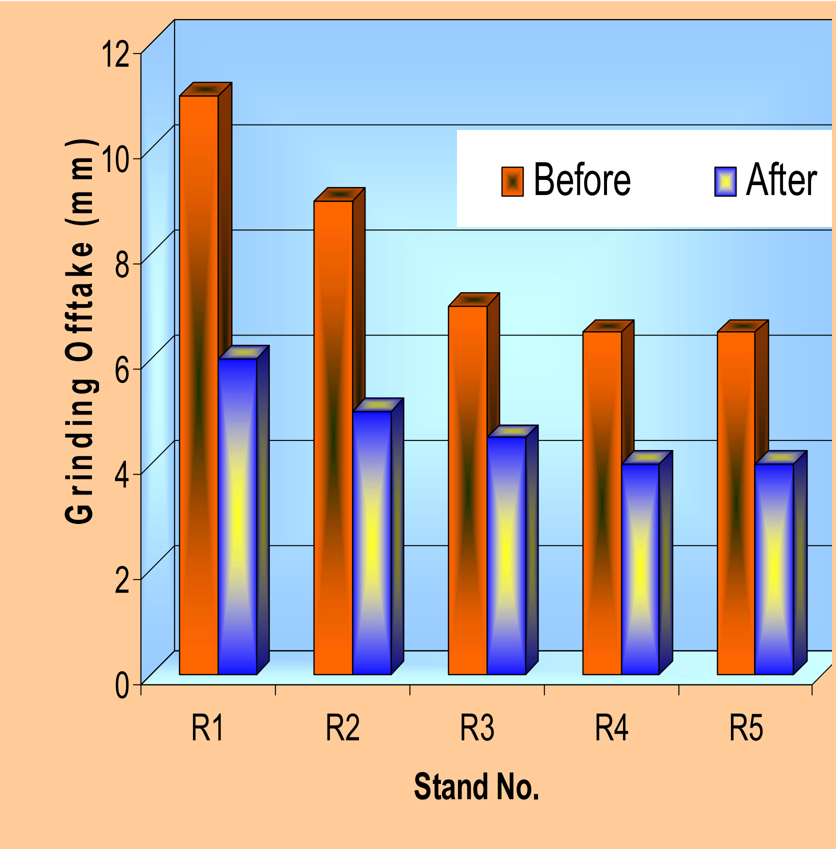
- Number of nozzles are more in the central area of the headers than the edges with different spacing

- Water inlet connection given at both sides to maintain constant water flow

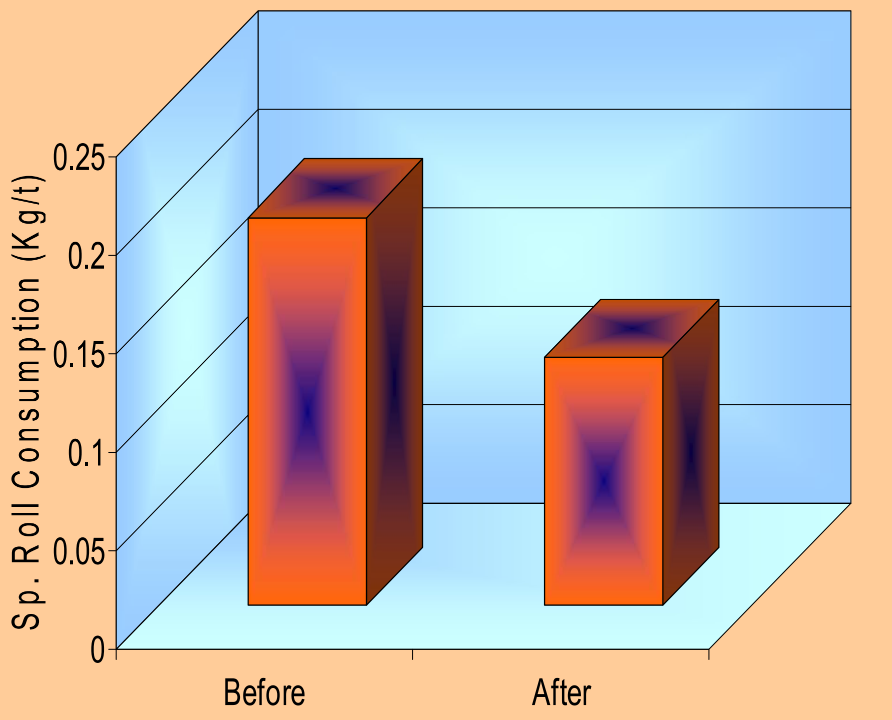
RESULTS

- Flattened roll profile with reduced surface temperature and improved thermal profile
- Roll wear reduced due to improved HTC
- Campaign life increased by 10%
- Grinding off-take reduced by 15~40%
- Roll consumption reduced by 30%
- Higher Benefit to Cost ratio 25 : 1
- Estimated Annual Financial Benefit around Rs 5.0 crores

RESULTS



Grinding Off-take



Sp. Roll Consumption


Thank You!

SPECIAL STEEL MAKING & CASTING

AT BOKARO STEEL PLANT'S SMS – II

WITH 100% CUSTOMER SATISFACTION

NP Sachan, B Mishra and S Mallik
Bokaro Steel Plant

Introduction

sector, Defence sector,

Oipeline sector, Saw

& Cycle Industries, LPG

SAILMA 350 HI (10 – 14 mm)

- Chemistry modified with addition of V~0.02% and reducing Nb from 0.02% min to 0.01% min

SAILMA 350 HI (10 – 14 mm)

C %	Mn %	S %	P %	Si %	Al %	V %	Nb %
0.11-0.13	0.90-1.20	0.015 max	0.020 max	0.10-0.15	0.03 min	0.015-0.020	0.010-0.015

peritectic range (>0.08%)

DMR 249A Plate gauge

- Secondary cooling – Soft
- Vanished cracks on slab surface

DMR 249A Plate gauge

C %	Mn %	S %	P %	Si %	Al %	Nb %	Ti %	Ni %	V%
0.080-0.0.85	1.15-1.20	0.010 max	0.015 max	0.25-0.35	0.030-0.050	0.025-0.035	0.010-0.015	0.65-0.70	0.035-0.045

EN 10120 P 310 High Strength LPG

maintaining good caster

conditions

C %	Mn %	S %	P %	Si %	Al %	Nb %	Ti%
0.10-0.13	1.1-1.3	0.010 max	0.020 max	0.10-0.15	0.03 min	0.010-0.015	0.010-0.015

more than desired limits

EN 10120 P 310 High Strength LPG

E46-SS4012A

YS slightly reduced

•V added 0.030% - hot ductility & formability

E46-SS4012A

C %	Mn %	S %	P %	Si %	Al %	Nb %	V%
0.06-0.08	0.85-0.95	0.010 max	0.020 max	0.040 max	0.025-0.050	0.035-0.045	0.030-0.035

Air Hardening Strapping Steel

Austenite to Bainite used

•So additional treatment required and problem of high UTS (1000 MPa) &

Air Hardening Strapping Steel

C %	Mn %	S %	P %	Si %	Al %
0.40-0.42	1.50-1.60	0.015 max	0.030 max	0.50-0.60	0.025 min

Corrosion Resistant Low Alloy Steel (CRLA)

- Nb for increasing YS
- Cu for corrosion

C %	Mn %	S %	P %	Si %	Al %	Nb %	Ti%	Cu%
0.07-0.09	0.75-0.85	0.010 max	0.030 max	0.25-0.30	0.02-0.04	0.010 min	0.010 min	0.20-0.25

- All mechanical properties

Corrosion Resistant Low Alloy Steel (CRLA)

High Strength Formable Quality steel (HSFQ)

Si (Nb: 0.035-0.045% &

Si: 0.25-0.30%) gave

YS/UTS ratio ~ 0.86 –

C %	Mn %	S %	P %	Si %	Al %	Nb %	Ti%
0.06-0.08	1.0-1.2	0.010 max	0.020 max	0.25-0.30	0.02 min	0.035-0.045	0.005-0.010

•Medium Carbon steels

WTCR+B

B :- Excellent Hardenability, best suited for shovels, blades, knives etc

WTCR+B

Properties	YS, MPa	UTS, MPa	% El	Hardness, HR_B	SAI	Grain size, mm	$\bar{r}$	Thickness Redn. %
WTCR + B	243-250	328-335	43-45	44-48	10-12	20-22	1.4-1.7	>92
WTCR	260-265	357-362	40-42	47-54	16-20	16-18	1.2-1.5	85-88

C %	Mn %	S %	P %	Si %	Al %	B ppm	N ppm
0.06 max	0.25 max	0.025 max	0.025 max	0.040 max	0.025-0.060	10 min	30-50

- Secondary reducers were

lamination removed by

optimising casting speed

(1.0-1.2 m/min) and

BOKARO IS QUALITY

FOLLOW FOR EQUALITY

THANK YOU

शीत बेलन शाला

IIM 2009 -10

Presentation

BOKARO STEEL PLANT

STEEL AUTHORITY OF INDIA LTD.

सेल SAIL

पी सी भौमिक, उप महाप्रबन्धक यांत्रिक

today's deliberation

INNOVATIVE APPROACH FOR EFFECTIVE ROLL BENDIND AT 4-STAND TANDEM MILL OF BOKARO STEEL PLANT

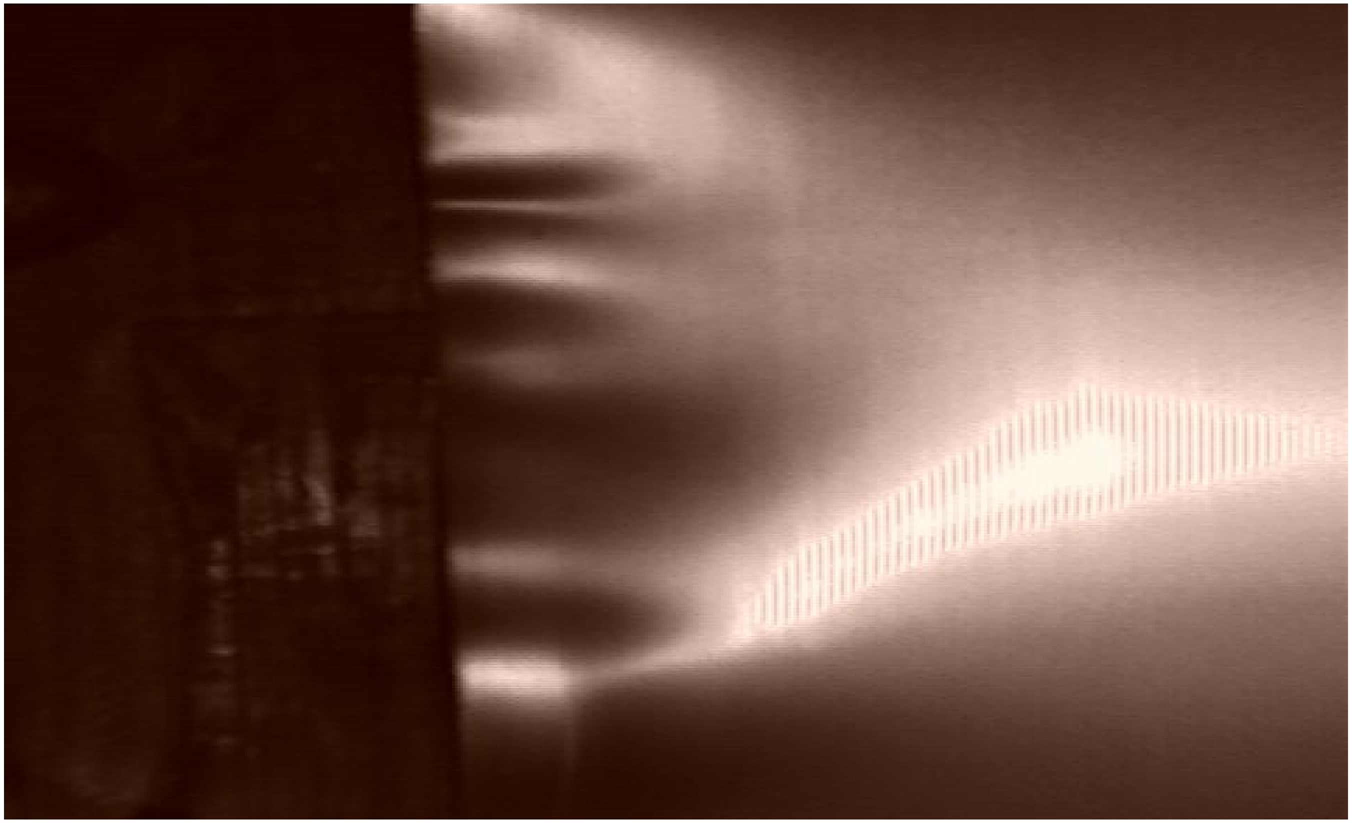
Defects generated at cold mill

Defects	Potential origin
Symmetric shape defects (long edges, center buckling, long bow, cross bow, etc on the strip)	• Incorrect roll bending, • No continuous variable crown (CVC) • Improper roll balancing, • Error in ground profile of W/roll, • Horizontal bending of W/rolls, • Plane containing Work roll not perpendicular to the plane of strip
Friction mark/ heat scratches on surface	• Low oil content, • Inefficient cooling • Insufficient lubrication
High load	• Emulsion instability • high friction.
High roll temp	• Poor HTC

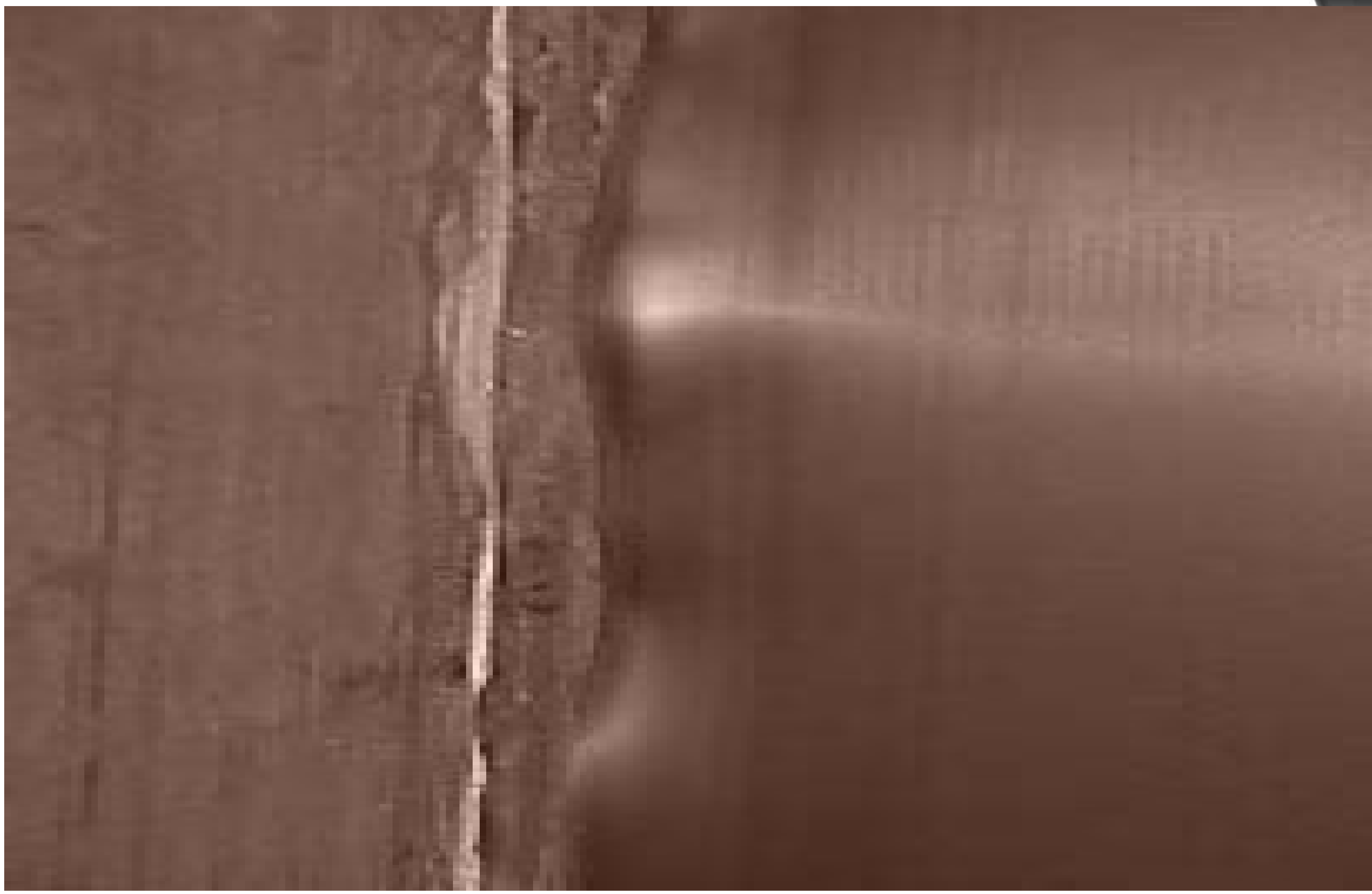
Defects generated at cold mill

Defects	Potential origin
Asymmetric shape defects - herringbone, quarter buckle, etc on the strip	• An increase in W/roll thermal camber • Localized variation in roll bite friction • Variation of temperature across the strip width • Improper roll cooling sprays
Dirty strip	• Less emulsion flow and high temp. • Low spray pr, • Incorrect oil ratio,
Flatness defects	•Temp. variation along the strip width, • Different friction conditions along two areas of contact
Differential temp along roll width and high roll surface temperature	•Poor heat transfer •High emulsion temperature •Less coolant spray pressure

Defect



Cross ripples/undulations of varying magnitude appear along the long direction either at the edge or middle of the strip/sheet.



Buckle Height: Mostly upto **9 mm** for precision levelled material.

Centre buckles are located at the middle of strip, while edge waves appear at the edges.

Possible Causes:

•Mismatch of roll gap with in-comming strip crown leads to differencial elongation along the rolling direction both at Hot & Cold rolling stage.

•Incorrect profile or positioning of support rollers.

•Contact with edge guides.

Remedial Measures:

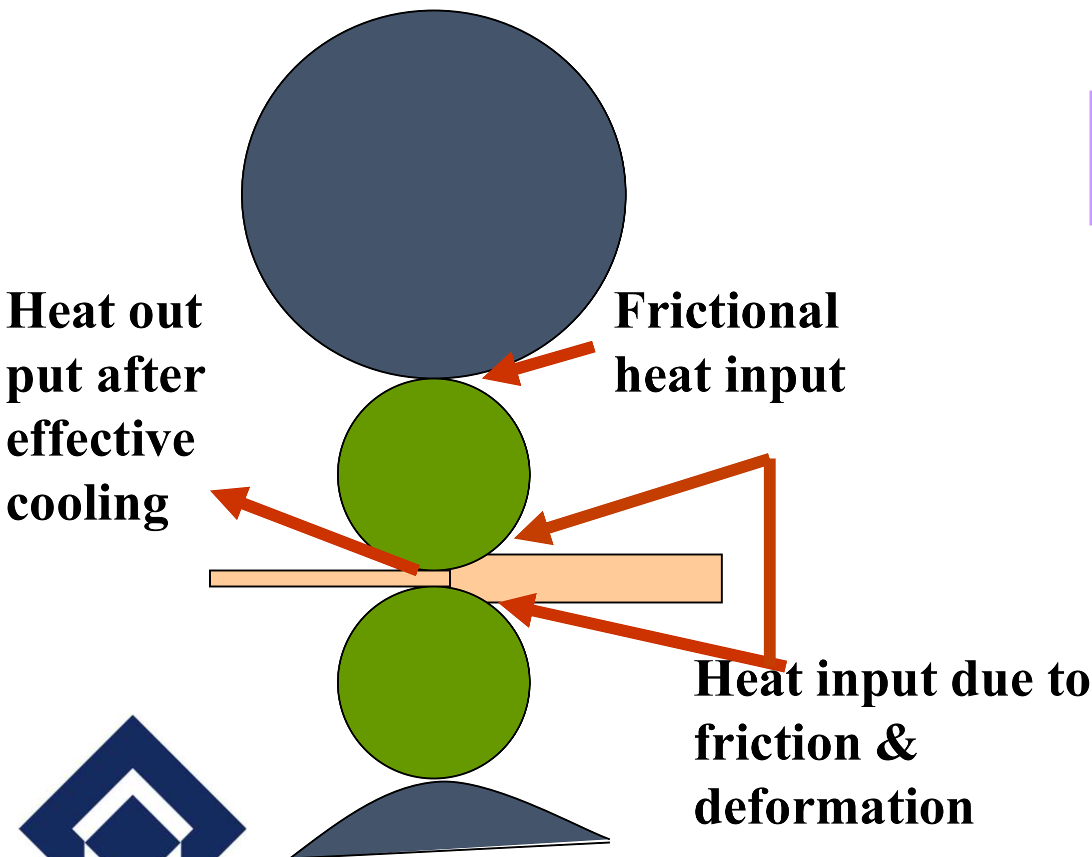
- Control of waviness at both HSM and CRM by **work roll bending** and selective cooling.

- Reduction of waviness through precision leveller or stretch leveller.

PROJECT :

TO IMPROVE SHAPE AND FLATNESS OF THE COLD ROLLED STRIP BY ADJUST -ING THE ROLLS' CROWN ACCORDING TO THE INCOMING STRIP

HEAT FLOW PATTERN IN COLD MILL

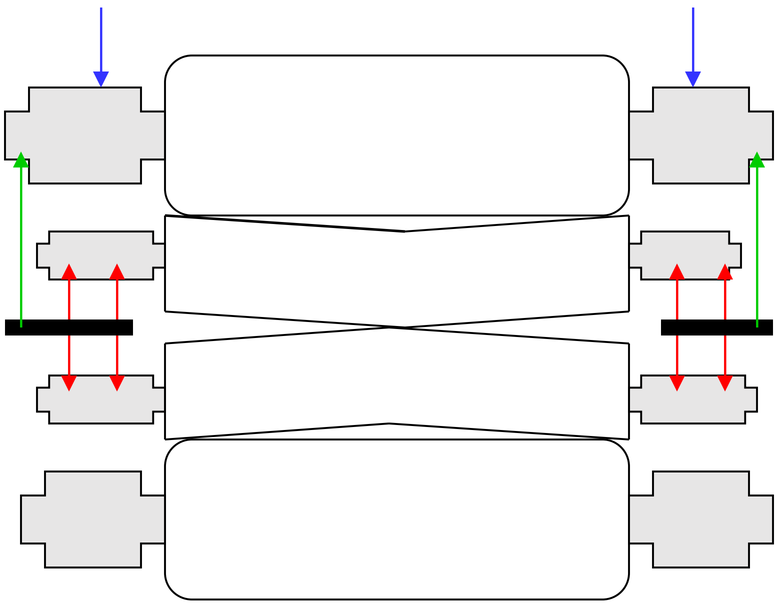


Non-zero flattening

Less thermal camber

More thermal camber bending

Bending and balancing systems of mill



for Bending system

- Crown in Cylinders - 04 no
- Screw down(electro-mech)- 02 no
- Back up balance Cylinder - 01 no

total cylinders for bending
and balancing = 05 no

WORK CARRIED OUT :

Hydraulic shaping consists of supplementing mechanical and thermal crowning by applying hydraulic forces on the work roll chocks. The system consists of four hydraulic cylinders located in the top of each bottom work roll chock. These cylinders are actuated with the variable plunger stroke subjected to hydraulic force developed on each chock. These roll separating force will deflect the top work roll upward and the bottom work roll downward to create the desired work roll bending crown for ensuing proper profile of the strip at the roll gap.

WORK CARRIED OUT :

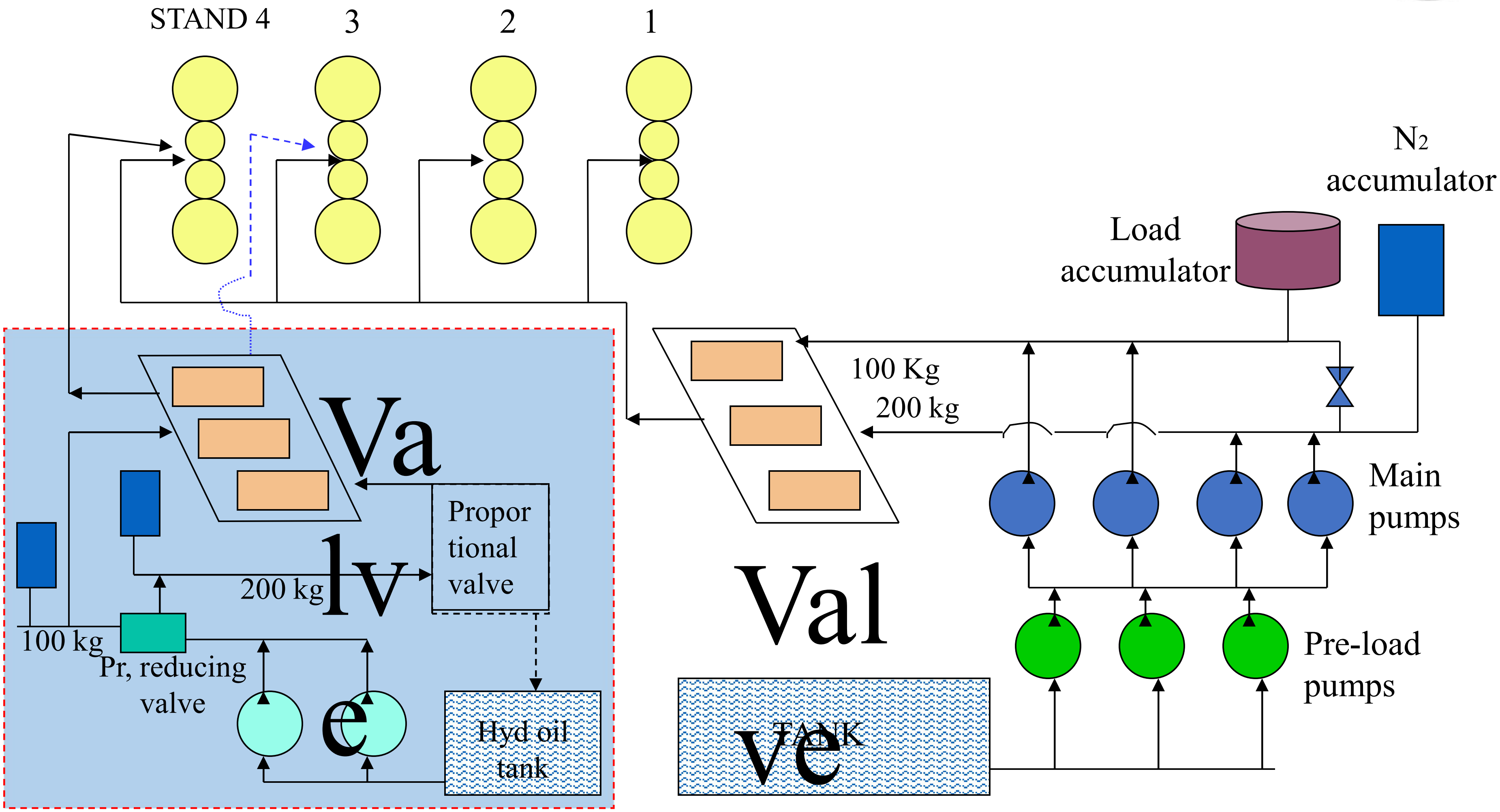
The system consists of

- variable volume pump controlled by a pressure compensator. The delivery pressure of the pump ranges from 0 to 320 bar.
- The pump suction is connected to a 3.0 M3 oil tank.
- A duplex type pressure filter is fitted in the discharge end of the pump ensuing 5μ filtration level of hydraulic oil to the valves.
- The system is protected by a pressure relief valve set at 100 bar with on/off solenoid valve.

WORK CARRIED OUT :

- The directional control valve and a proportionate pressure reducing relief valve is also incorporated for ensuing variable pressure from 0bar to 100bar to the hydraulic cylinders in the work roll chock.

- The hydraulic pressure is being controlled through potentiometer located at the operator’s control desk as per desired shape correction of the strip through visual observation.



SCHEMATIC OF

RESULTS:

The modified system has resulted in

- correcting the edge waviness and center buckles on the strip.
- improved strip flatness by 20% and shape / profile of the strip.
- minimized roll crown provisions
- improved customer services by reduced customer complaints by 15%.

RESULTS:

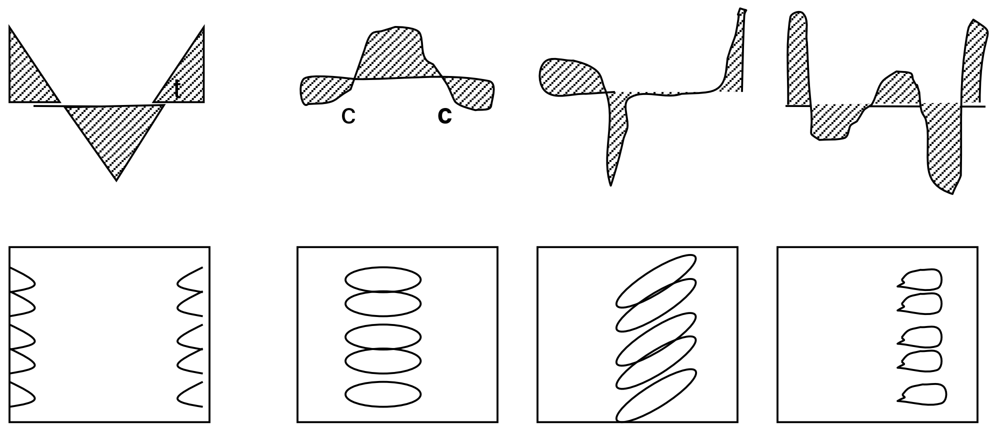
- Provision for positive roll bending as per the requirement i.e. Step less control.
- Removal of heat, generated at contact zone.
- Elimination of adverse factors like high fluid pressure, high temperature etc. Minimize the destruction of oil film.
- Optimization of surface roughness (0.17micron to 0.24 micron

CONCLUSION :

- This modified system is one of the easy ways to control the shape defects.
- The system has helped to correct the edge waviness and center buckles on the strip.
- It has helped to improve strip flatness by 20%.
- The system is easy to operate and retro-fitted to existing system.

CONCLUSION :

- It has minimized roll crown provisions
- It has improved the shape and profile of the strip.
- It has also improved customer services by reducing complaints.
- The system is easy to maintain and less expensive.



Long edge | Long middle | herringbone | Quarter buckle

(t = tensile stress c = compressive stress)

next generation metals

SIEMENS
VAI

National Workshop on Special Steel-making, Processing, Quality Control & Application,

on 21st November 2009 at Bokaro

Siemens VAI Metals Technologies

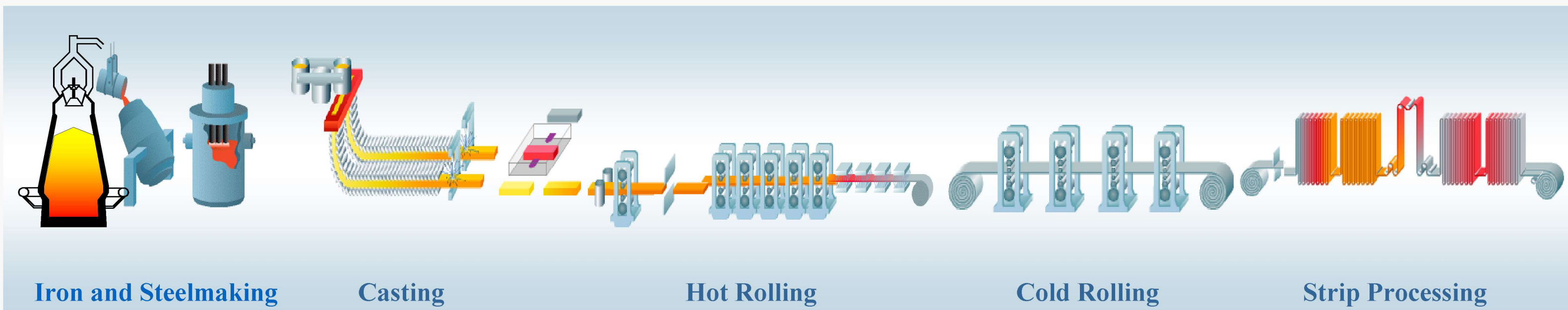
YOUR PARTNER IN ROLLING MILLS & PROCESSING LINES

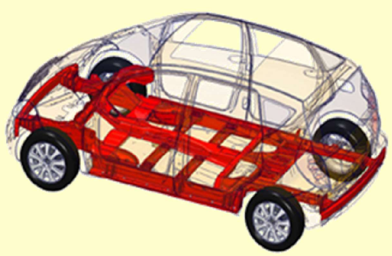
Wide Range of Steel Grades
Siemens VAI fulfills your Market Requirements

Pipeline steels

Structural steel

Ship building steels





Automotive steels

Electrical steels

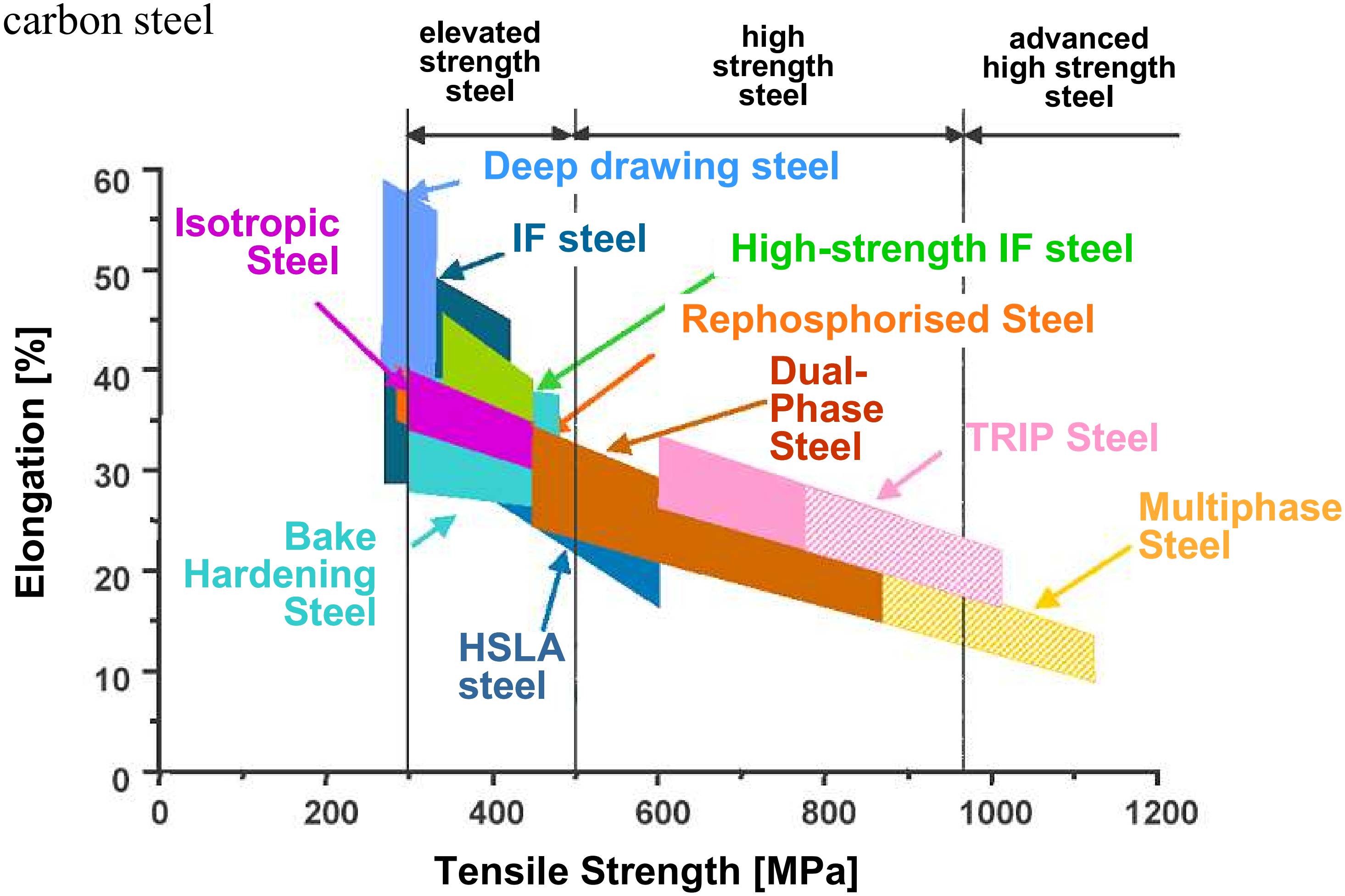
Deep drawing steels

High strength steels

Market requirements of your customers may change,
your plant must be capable of adaptation !

Wide Range of Steel Grades
New Steel Grades

Overview on important steel grades in the area of hot-rolled carbon steel



Siemens VAI MT RP - Our Strategy

Focused on our SIROLL^{CIS} * products, we generate value for our

Setting the **trends -** Taking **the lead - **Generating **profit**

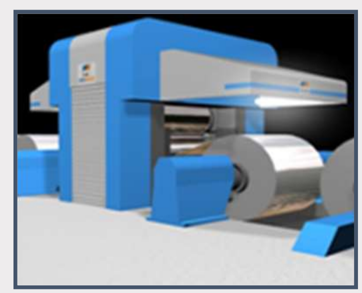
Siemens VAI MT RP - Our Portfolio

Providing total plant and special equipment for the global iron & steel flat products industry in the fields of:

- Hot Strip Mills / Steckel Mills
- Plate Mills
- Cold Rolling Mills (PLTCM – TCM – CCM – RCM – SPM …)
- Processing Lines (PL – CGL – ECL – CAL – CCL – ETL…)
- Strip Finishing Lines (TLL – IRL – SL – CTL – CPL…)





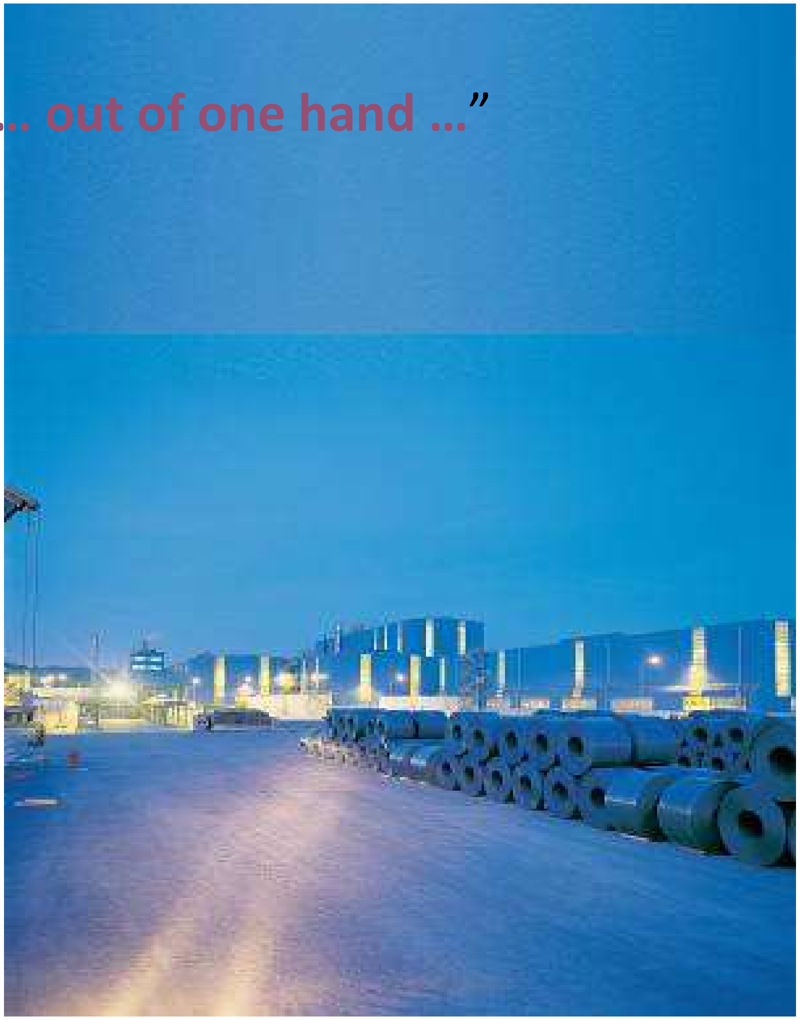


Your Technology Supplier with Single Responsibility

•A Completely Integrated Solution

"… out of one hand …"

- Process Know-How
- Layout planning and optimization
- Plant engineering competence
- Production Planning / MES
- Throughput optimization
- Process models
- Technological controls
- Automation
- Drives & Motors
- Energy Distribution & Transformers
- Process Equipment



Hot Strip Mill, Arcelor Mittal, Poland

Roughing Mill with Edger

Strip Width 2200mm (max)

Reheating Furnace

Encopanel

Finishing Mill

Hot Strip Mill, Arcelor Mittal, Poland

Laminar Cooling Section

Strip thickness 25mm (max)

Hot Strip

Crop Shear

Down Coiler

Cold Mill Products

Learning from Experience!

REFERENCES

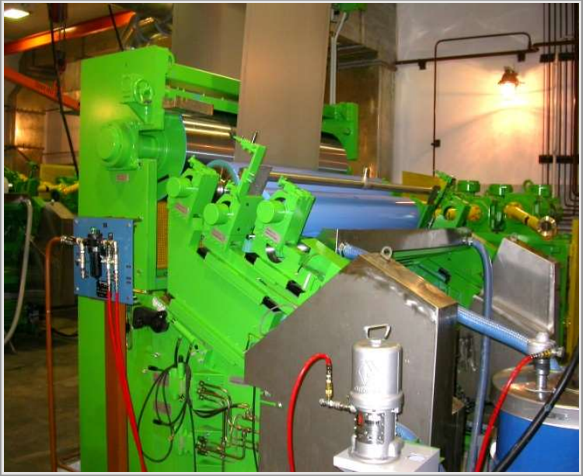
8 **Cold-Rolling Mill Complexes**
152 **Cold-Rolling Mills**
60 **Single-Stand and 2-Stand Reversing Mills**
92 **Cold-Rolling Tandem Mills**
15 **Linked Pickling and Cold-Rolling Tandem Mills**
147 **Single-Stand and 2-Stand Skin-Pass Mills**

MT RP – SIROLL^{CIS} PL
Processing Lines for Carbon Steel Products Portfolio

- **CPL** - Continuous Pickling Line
- **PPPL** - Push Pull Pickling Line
- **CGL** - Continuous Galvanizing Line
- ECL – Electrolytic Cleaning Line
- **CAL** - Continuous Annealing Line
- **CCL** - Colour Coating Line
- **ETL** - Electrolytical Tinning Line
- **TLL & SPTLL** – Tension Levelling Line & Skin Pass and Tension Levelling Line

MT RP - SIROLL^{CIS} PL
Special Equipment for Processing Lines
Products Portfolio

- **Welders (Mash Lap, Flash Butt, Laser)**
- **Skin Pass Mills, Tension Levellers, Scale Breakers**
- **DAK® Air Knives**
- **Roll Coaters**



Pickling section
Continuous & Push Pull Pickling line

Last 3 years Main References

Siemens VAI is one of the leading suppliers of pickling lines. In POSCO, Siemens VAI is the leading supplier for low carbon steel pickling. Our high turbulent side jet pickling section is recognized as the most efficient technology in terms of flexibility and operating cost.

New Lines

- Posco P2 C , Korea
- Posco POL 3, Korea
- Posco K1C , Korea
- ACB, Spain
- Gonvarri, Spain
- Voest Alpine, Austria

Modernizations:

- Corus, England
- Mittal Steel, Rumania
- Gonvarri, Spain
- Wisco, China

Hot Dip Galvanizing Lines

Siemens VAI is the leading supplier in the field of hot dip galvanizing lines (more than 30 references over the last ten years).
The installation of advanced high quality line technologies and the supply of CLECIM™ key process equipment such as in-line Skin Pass mill, Tension leveler, Welders, Air knives, and Roll coaters are key for success of our Customers in the field of CGL.

Latest *References*

- Corus, Holland
- Borcelik, Turkey
- Benxi,China
- Bluescope Steel, Thailand & Indonesia
- Galvasid, Mexico
- Tangshan,China
- China Steel,Taiwan
- Voest Alpine, Austria
- Handan, China
- Tata BlueScope Steel, Jamshedpur, India
- Panzhihua, China
- Wuhan, China
- Rautaruukki, Finland
- LTV,USA
- Ilva Taranto,Italy
- Bokaro Steel, India

Cleaning Sections and Cleaning lines

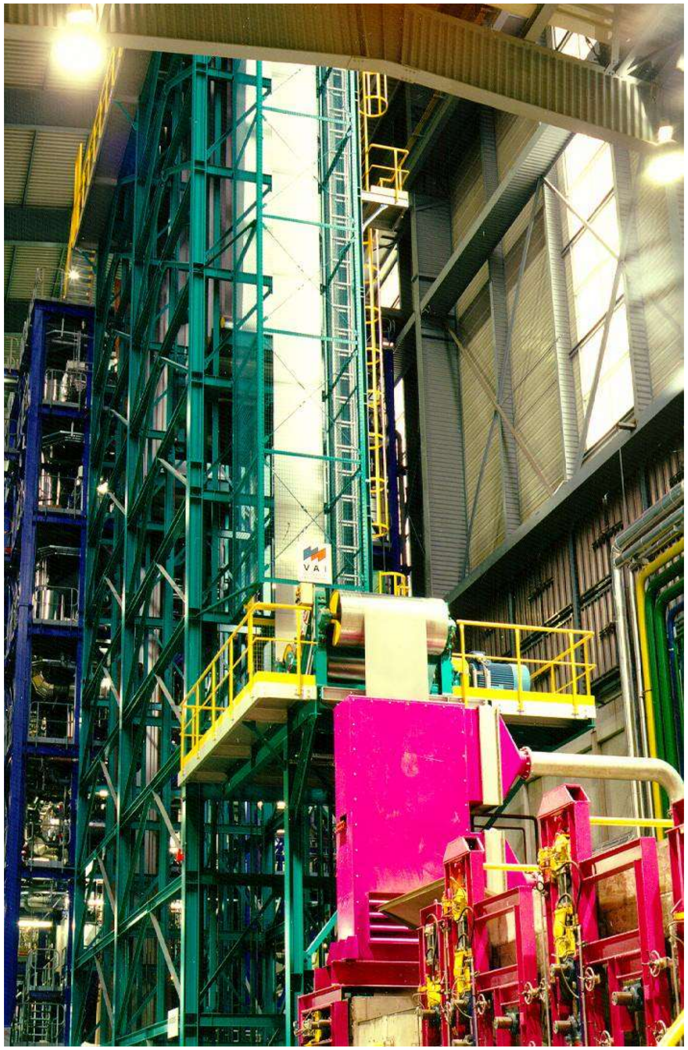
Siemens VAI supplies cleaning sections for all processing lines (ECL, HDGL, CCL, ETL, CAL).
The best technologies (Spraying or immersion, with brushes, electrolytic tank, rinsing,…) are available in terms of :

- Investments costs (civil works included),
- Operating cost (waste treatment included)
- Environmental impact
- Design optimized to suit application

Latest ***References***

- SCGL: ECL, India
- MAANSHAN : CAL, China
- TANGSHAN: CGL, China
- Bokaro Steel: ECL, India
- BLUESCOPE : CGL&CCCL Thailand/Indonesia
- HUTA FLORIAN: CCL Poland
- BAOTOU: CGL China
- Tata BLuescope:MCL &CCL,
- FSI ETL Iran
- BENXI 1 &2: CGL China
- HANDAN: CGL China
- CHINA STEEL: CGL Taĭwain

Continuous Annealing line



Siemens VAI is one of the leading suppliers in the field of Continuous Annealing Lines.

- Tinplate
- Sheet
- Silicon Steel

Latest References

- Masteel, China
- Voest Alpine, Austria
- Rasselstein, Germany
- Amag, Austria
- Outokumpu, Finland
- Columbus, RSA
- Wuhan, China

Continuous Color Coating Lines

Siemens VAI Color-Coating Lines
Siemens VAI-supplied Color-Coating Lines for reliable operation, high throughput rates and top-quality products. The demands of the full range of product applications are fully met, especially for the automotive and household appliance industries.

Latest References

- **BlueScope Steel, Indonesia**
- **Mittal Steel, Poland**
- **Galvasid, Mexico : Combined CGL and CCL**
- **Magnitogorsk MK, Russia**
- **Tata BlueScope Steel, India**

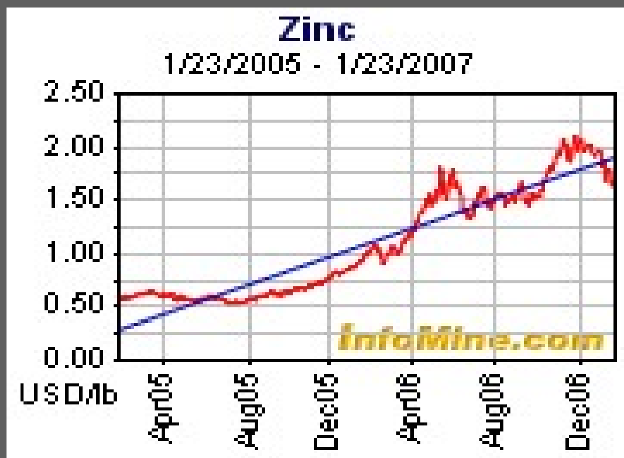
Special Equipment - Welder

CLECIM (MT France) WELDER

Siemens VAI is one of the leading suppliers in the field of strip welding (more than 80 welders references since 1990)

- Flash Butt CLECIM® FB21S,C
- Mashed Lap CLECIM® ML21 H,M ,L
- CLECIM® LW21L,H

Special Equipment – Dynamic Air Knives (DAK®)



Dynamic Air Knives

Siemens VAI is one of the leading suppliers for air knives with DAK®, for hot dip galvanizing lines for automotive or construction products. DAK® E is only solution for Zinc saving by combination of longitudinal and transversal close loop control.

Latest references

Borcelik, Turkey
Bluescope Steel,Thailand
Galvasid, Mexico - Panzhihua, China
Handan, China - Jinan, China
Baotou, China - Shougang, China
Wisco, China - China Steel, Taiwan
Segal, Belgium - NISCO, Iran
Ilva Taranto, Italy - IMSA, Mexico

Special Equipment – Skin Pass Mill & Tension leveller

Skin Pass Mill & Tension Leveller

With more than 430 references Siemens VAI is the world leader of

- CLECIM® In Line Temper Mill,
- CLECIM® Tension Leveler
- CLECIM® Scale Breaker

covering CGL, ETL, CPL, CAL, CCL, for new lines or modernization of existing ones

RECENT STRIP ROLLING AND PROCESSING PROJECTS IN INDIA

•**Recent Start-ups / Commissioning**

- 4.3 meter wide Plate Mill for Jindal Steel &Power (New)
- 2-Stand Reversing Mill for Uttam Steel, Khopoli (New, E&A supply)
- Continuous 5 Stand TCM for Essar Steel, Hazira (Extension)
- Bokaro HSM Finishing Stands (Revamp)
- Welspun Gujarat Plate/ Steckel Mill (New)

•**New Orders**

- 0,45mtpy RCM (6-hi)Indian Steel Ltd, Ghandidham
- 1.3mtpy PLTCM for SAIL, Bokaro Steel Plant
- 0.4mtpy HDGL (Autobody) for SAIL, Bokaro Steel Plant
- 0.4mtpy ECL for SAIL, Bokaro Steel Plant
- 0.25mtpy Zinc Alume Line for Tata BlueScope Steel
- 0.15mtpy Colour Coating Line for Tata BlueScope Steel
- Hot Strip Mill for Jindal Stainless, Angul, Orissa

Reversing cold mill for Indian Steel Ltd, Ghandidham, India

Scope of supplies and services

- Single-stand, 6-high mill stand
- Automatic roll change
- Planicim® flatness roll on exit side
- Pay-off and tension reels
- Roll coolant system
- Hydraulic and pneumatic systems
- SINAMICS drive system
- SIROLL^{CIS} automation system with AGC/AFC/self-learning L2
- Supervision of erection, commissioning and operational training

Benefits

- Reliable and future oriented equipment and automation solutions based on standard SIROLL^{CIS} CM lead to high strip quality from the very first coil
- Processing of a wide range of products – from soft steel to high strength steel grades with the optimum operation cost
- Highly automated operation
- Safe and comfortable operating condition allowing operator to concentrate on product quality

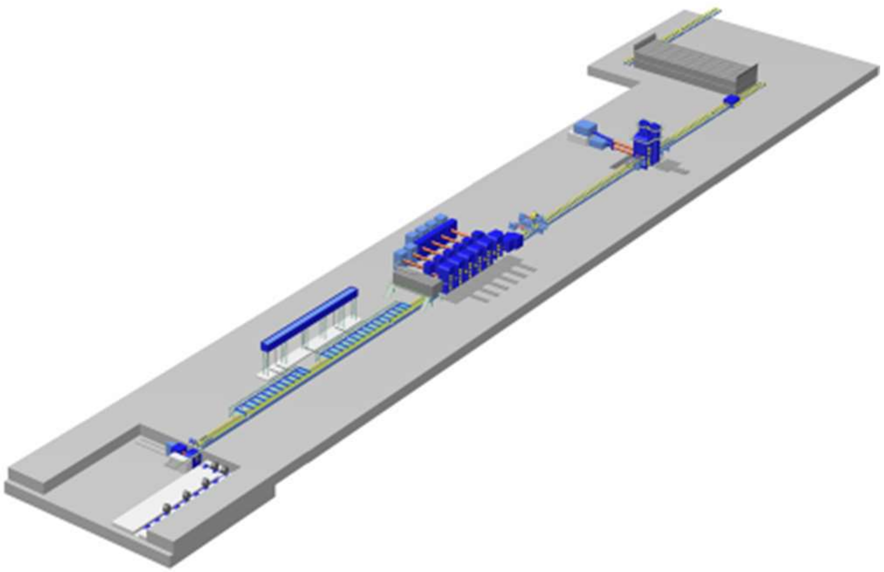
What‘s innovative?

- Level 2 including self-learning models
- Operator and maintenance friendly diagnostic system

Plant Data

Start-up:	2010
Mill type	single-stand, 6-high
Capacity	450,000 t/a
Thickness	0.25–2.50 mm
Width	1,650 mm
Coil weight	35 t
Speed	1,200 m/min
Mill power	6,000 kW

Jindal Stainless Limited



Plant Data

Strip Dimension	
Thickness	1.5 - 12.5 mm
Width	1000 - 1,650 mm
Max. coil weight	36.3 t
Capacity	
Annual capacity	1,600,000 t/a
Start-up	2009
Project Execution	Linz / Erlangen

Siemens-VAI Scope of Supply

- Primary Descaler
- Quarto Reversing Roughing Mill with attached Edger
- Coilbox
- Crop Shear & Secondary Descaler
- 6-Stand 4-High Finishing Mill with SmartCrown®
- Mill Exit Section with Laminar Cooling
- 1 Standard Coiler
- Drives, Electric and Automation

…

- With the new 1800 mm hot strip mill, Jindal Stainless Limited India will operate a mill dedicated for stainless steel, with an annual capacity of 1,600,000 t/a (phase 1).
- The supply of the hot strip mill is based on Siemens VAI's latest technology for the production of stainless steel grades and includes engineering, supply, installation and commissioning. The contract has been signed in April 2007. Start of production is planned in 2009.
- In a later project step it is possible to upgrade the plant up to 3,600,000 t/a, with the installation of a third reheating furnace, 7th mill stand and a second coiler.

Thank you for your kind attention!