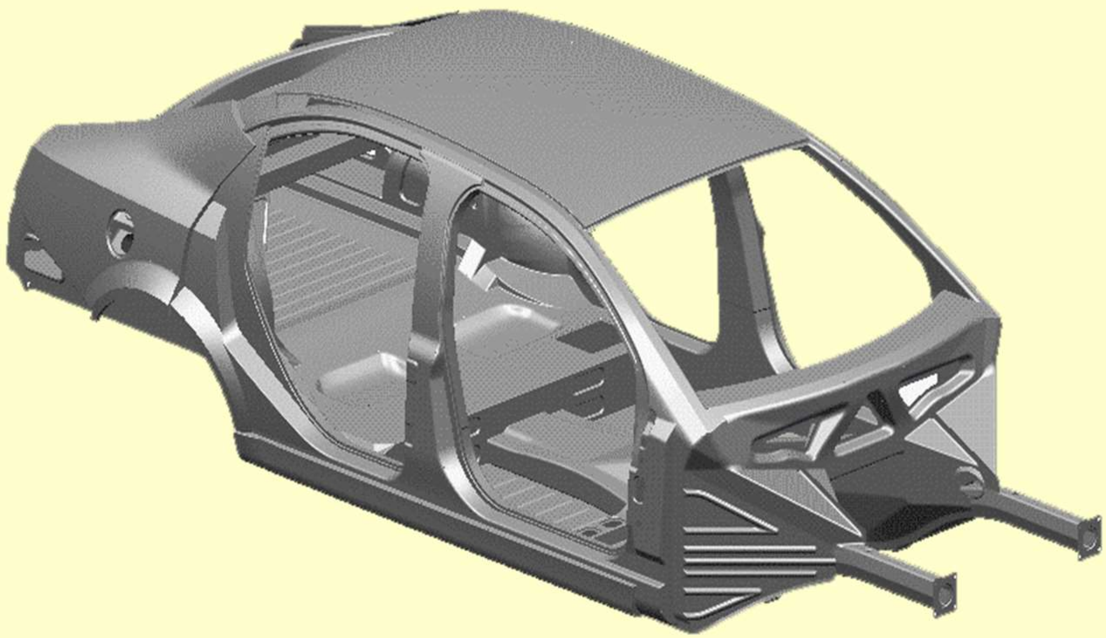
National Workshop on
"Recent Trends in Cold Rolling – Processes and Products",
Bokaro Steel City
November 20, 2010

1. High Strength Formable Steel Grades For Auto Body – Key Note Lecture (Dr O N Mohanty)
2. Expert System Based Heating Control System For Bell Annealing Line # 2, Cold Rolling Mill, Bokaro Steel Plant
3. Special Quality Cold Rolled Steel From BSL
4. Tayo Rolls- A One Stop Roll-Shop
5. High End Forged Steel Rolls For CRM
6. Characterization of Roll Pick Up In Annealing Furnace of A Continuous Galvanizing Line
7. Accumulator Control For Hydraulic System Through Pressure Transmitter
8. Computer Simulation of Cold Rolling Process Using Deform Software
9. Emerging Technologies In Automotive Steel
10. Processing of Advanced Cold Rolled Automotive Grades of Steel
11. Design Improvement of Deflector Roll In 4-Stand Tandem Mill
12. Development of Fuel Tank Substrate For Two Wheelers

HIGH STRENGTH FORMABLE STEEL GRADES FOR AUTO BODY



O.N.MOHANTY

Bokaro Steel

Nov. 20, 2010

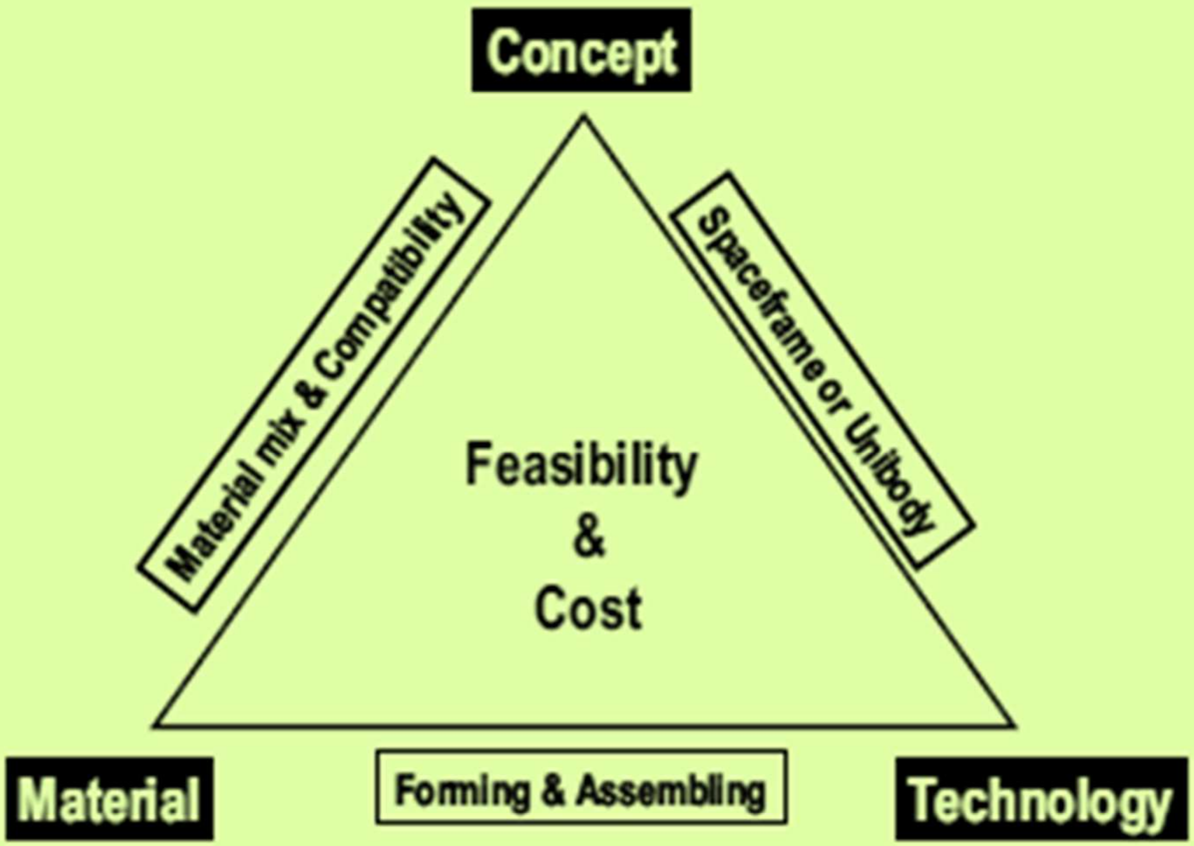


Figure 1. Principal aspects of modern car body engineering.

Requirement of Features in Automotive

- **PHYSICAL CHARACTERISTICS AND QUALITY**

  Strength, Stiffness, Durability

- **COST**

  Manufacturing, Operational , Use, Maintenance

- **PRODUCTION**

  Formability, Joinability, Paintability

- **STYLING / SPACE OPTIMISATION**

  Design Freedom, Cross Sections, Surface Quality

- **ENVIRONMENTAL IMPACT**

  Energy Consumption / CO_2 - emission

Many of the above are mutually conflicting !

Environment and Safety

For the Environment, reducing green house gases to prevent global warming is an urgent issue.

In order to reduce CO2 emissions, manufacturers have developed hybrid vehicles, while at the same time, actively proceeding with fuel cell vehicle development.

As for the internal combustion engine vehicle, various fuel consumption improvement techniques have been employed, such as those related to engine efficiency, combustion, transmission efficiency, and weight reduction.

Reducing vehicle weight has proven to be a highly effective method for reducing CO2 emissions.

Crash : CAE Analysis

- US-NCAP 100% Frontal Crash

  rigid barrier - 35 mph (56 km/h)
- EuroNCAP 40% Offset Frontal Crash

  deformable barrier - 64 km/h (40 mph)
- US-SINCAP 38.5 mph - 62 km/h
- Side Pole Impact

  rigid pole - 20 mph (32 km/h)
- Rear Impact

  moving barrier - 35 mph (56 km/h)
- Roof Crush/Rollover
- Low Speed Impact 100% Frontal Crash rigid barrier 15 km/h (9 mph)

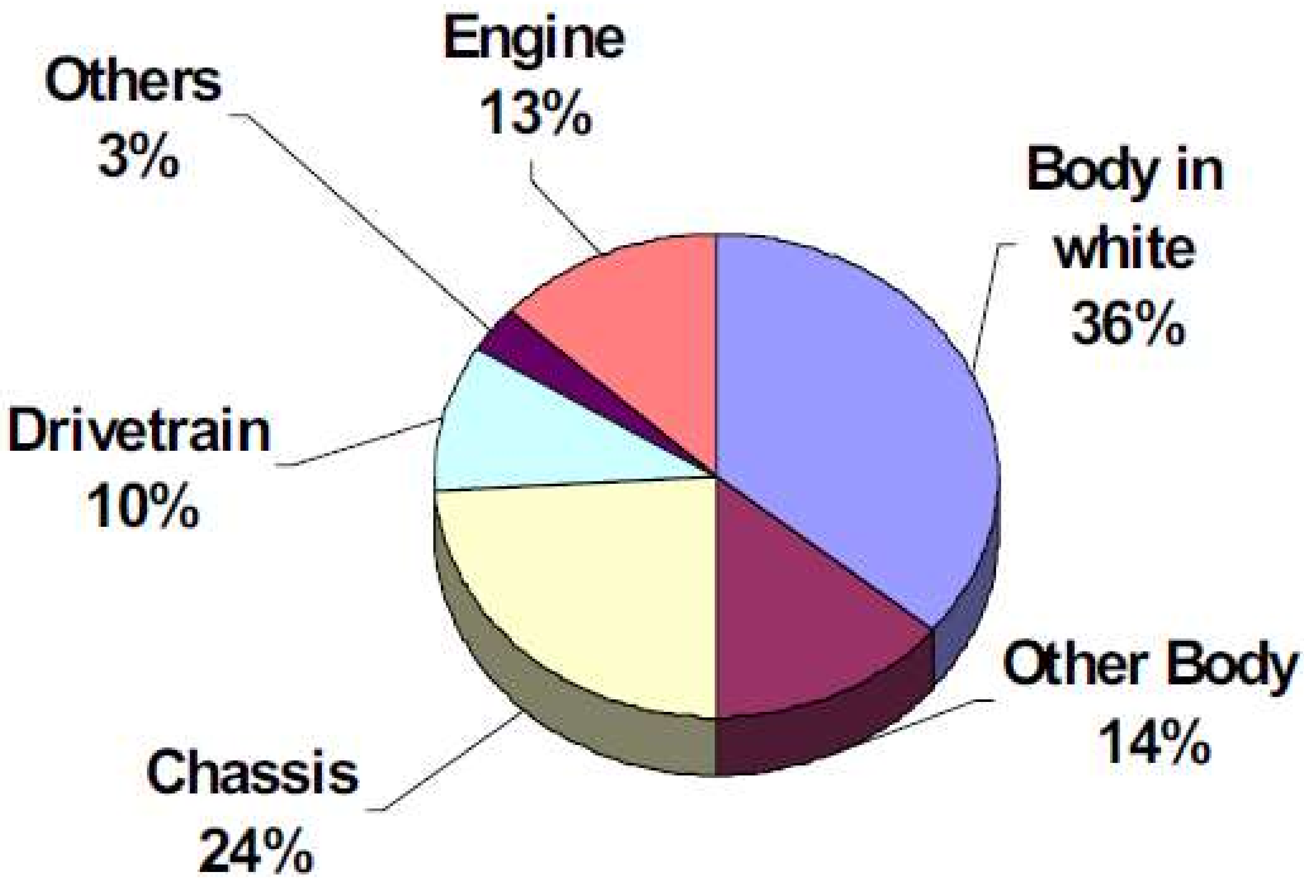


Figure 2. Weight ratio of each vehicle part.

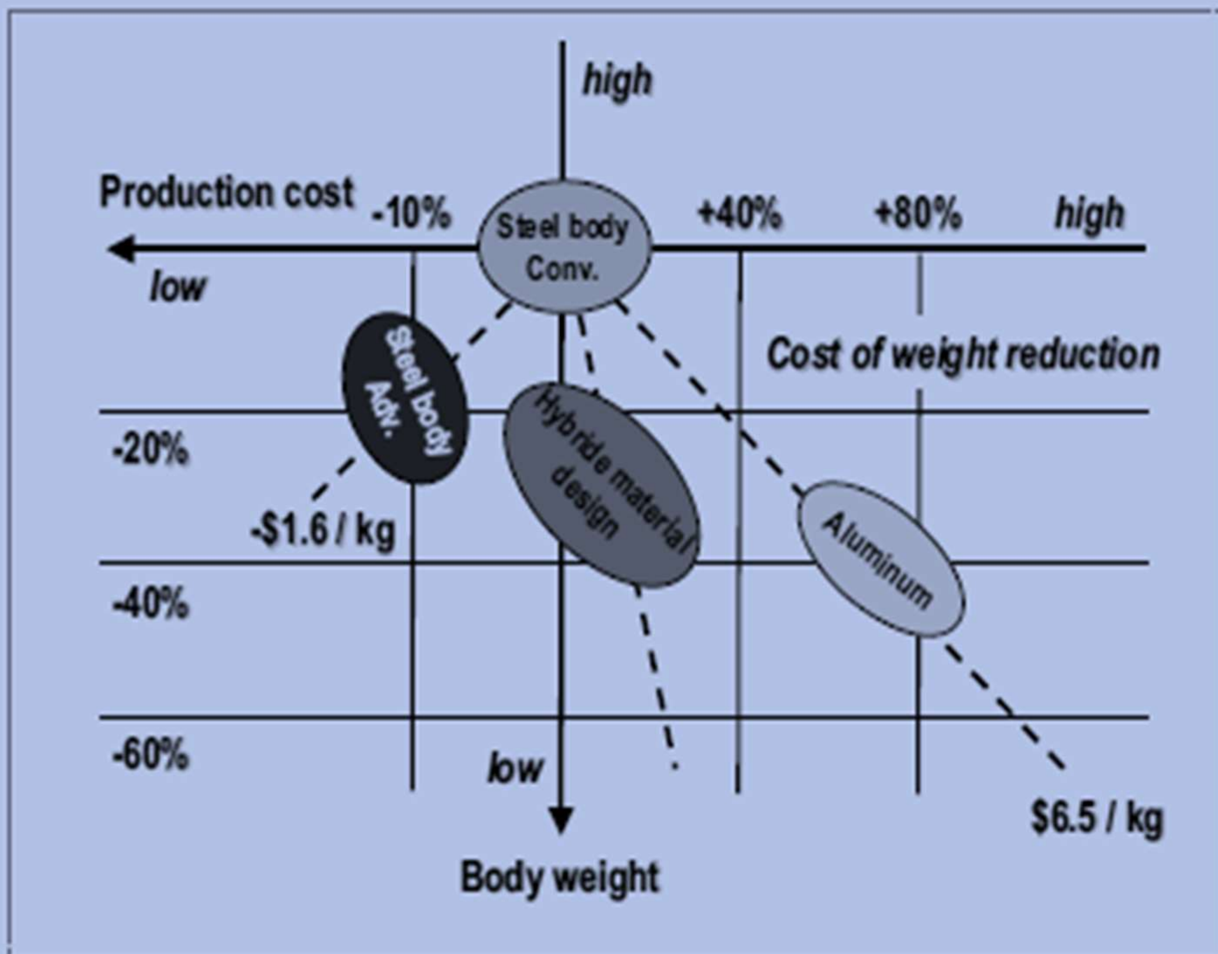


Figure 3. Impact of material concepts on the weight and cost balance of a car body.

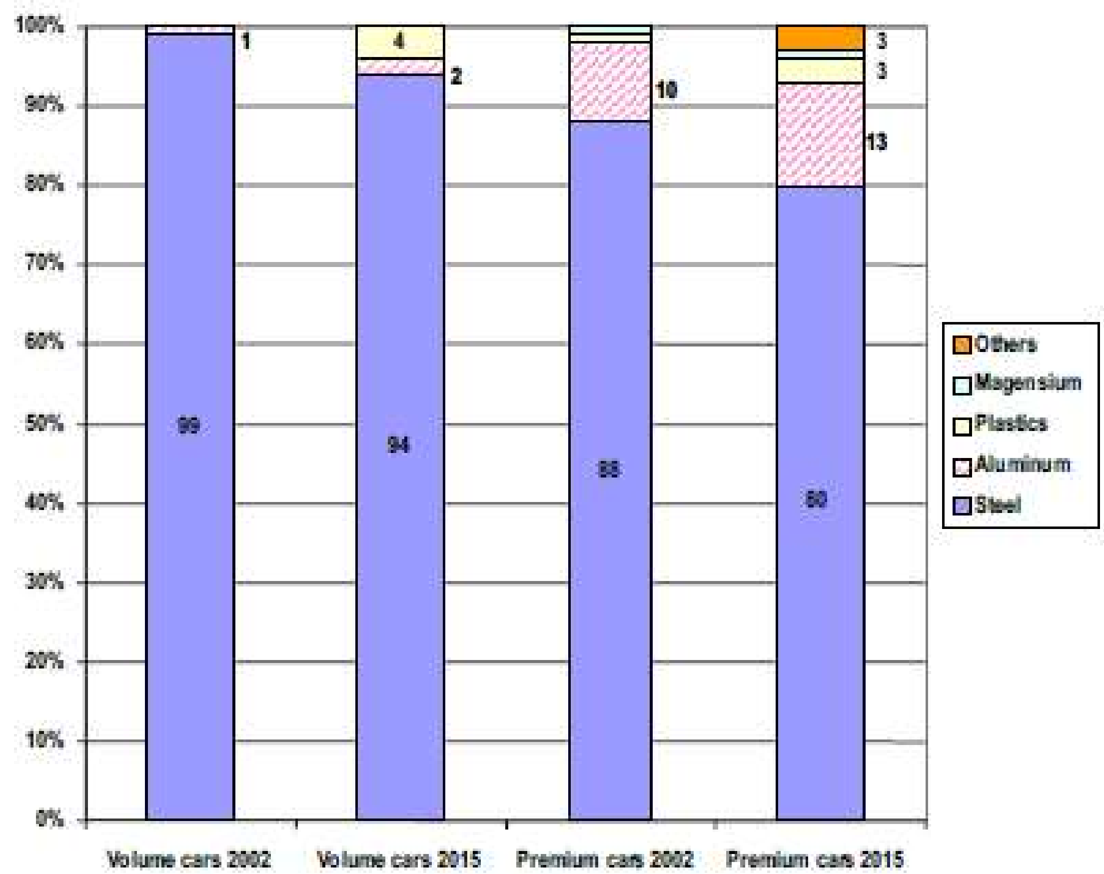


Figure 4. Evolution of material weight share in the body-in-white in volume and premium cars [5].

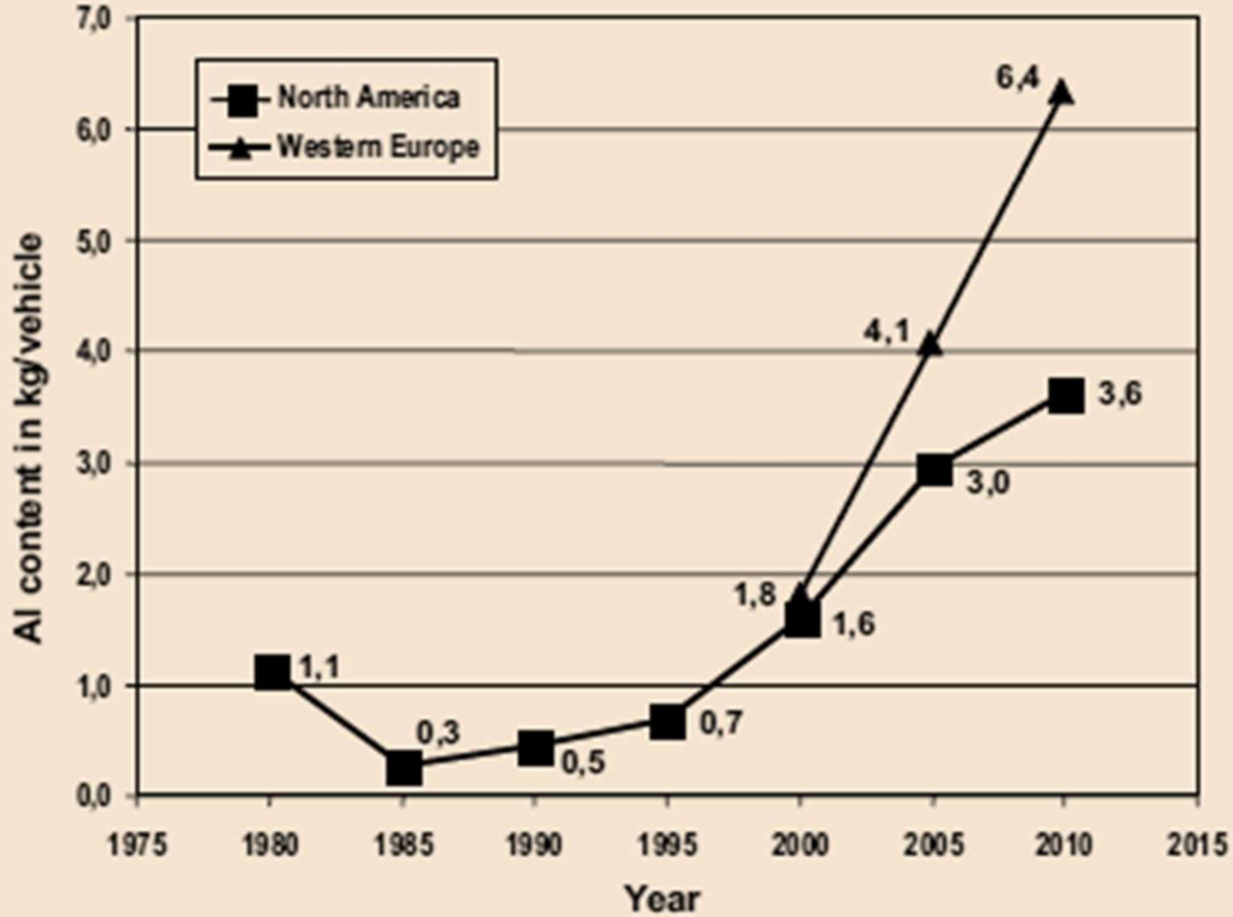


Figure 5. Evolution of the average aluminum consumption in volume cars.

ULSAB

Ultra Light Steel Auto Body

- ***A CONSORTIUM OF 33 STEEL COS.***

- ***PORSCHE ENGG. SERVICES CONSULTANT***

PERFORMANCE OF ULSAB STRUCTURAL

	BENCHMARK	ULSAB	CHANGE
- STATIC TORSIONAL RIGIDITY(Nm/deg.)	11,531	20,800	+80%
- STATIC BENDING (N/mm)	11,902	18,100	+52%
- FIRST BODY STR MODE (Hz)	38	60	+58%
- MASS (kg)	271	203	-25%
- CRASH RESISTANCE (5 diff. In H. test simulations)	R	R++	↑↑
- COST	~$1000	~$978	NO INCREASE

POSSIBLE DUE TO

- *LASER-WELDED TAILORED BLANKS*
- *HYDRO-FORMED TUBES & SHEETS*
- *HIGH STR.(> 210 MPa Y.S) & UHS (>550 MPa) STEELS>90%*

ULSAB-AVC

Ultra Light Steel Auto Body
Advanced Vehicle Concepts

ULSAB-AVC

Advanced Vehicle Concepts

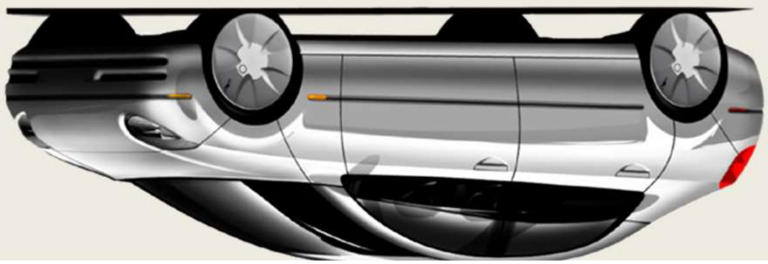
Program Drivers

- U.S. Partnership for a New Generation of Vehicles (PNGV)
- EUCAR

Key Objectives

Provides structural platform for achieving…

- ❖ Anticipated crash safety requirements
- ❖ Improved fuel efficiency
- ❖ Optimized environmental performance
- ❖ High volume manufacture/affordable costs



CAE Analysis

- US-NCAP 100% Frontal Crash
  rigid barrier - 35 mph (56 km/h)
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- US-SINCAP 38.5 mph - 62 km/h
- Side Pole Impact
  rigid pole - 20 mph (32 km/h)
- Rear Impact
  moving barrier - 35 mph (56 km/h)
- Roof Crush/Rollover
- Low Speed Impact 100% Frontal Crash rigid barrier 15 km/h (9 mph)

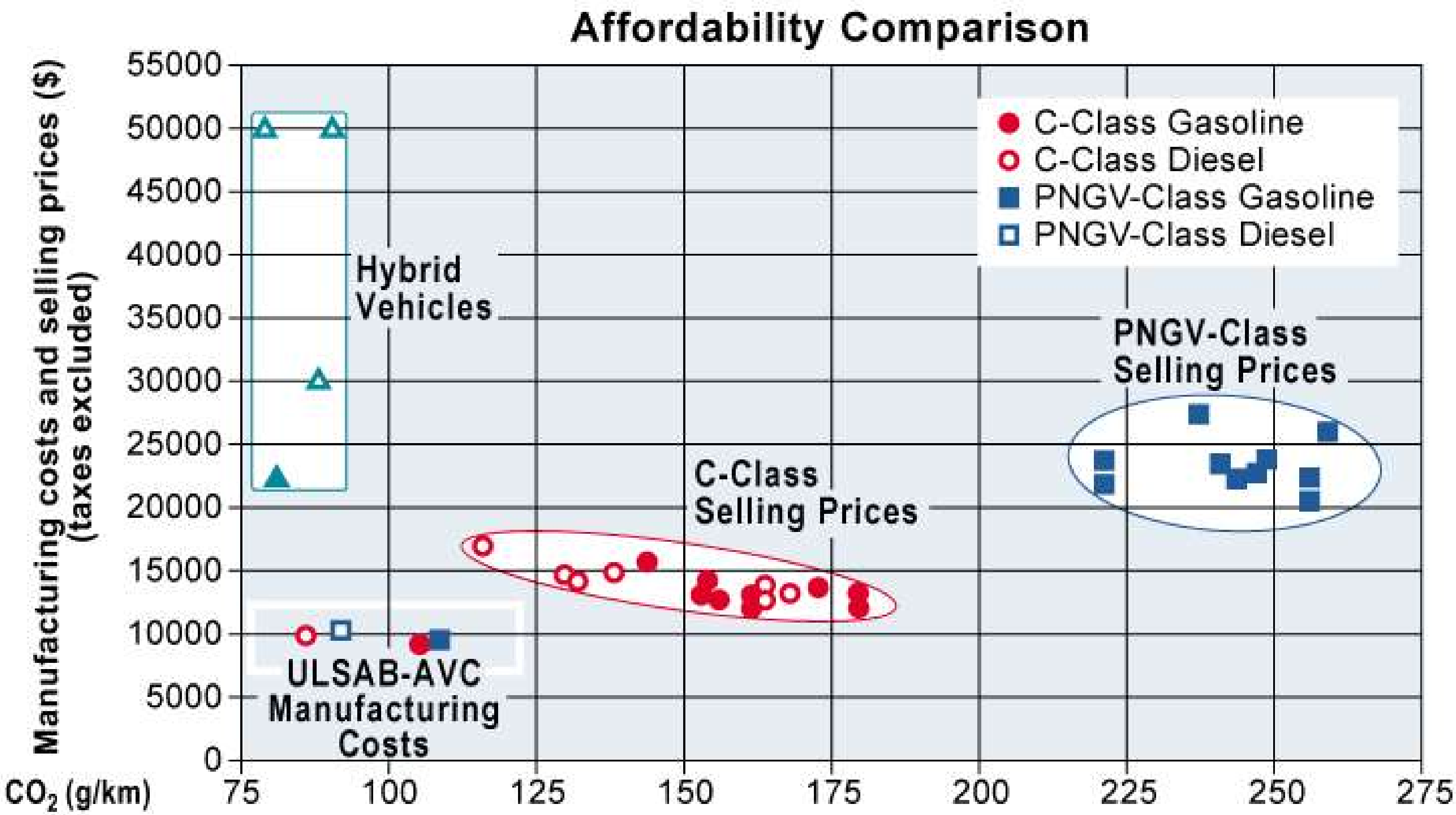
RELATIONSHIP BETWEEN STRENGTH - PROPERTIES

Portion	Surface rigidity	Dentability	Collapse strength	Parts
Outer panel	◎	○		Hood, Door
Inner panel	◎		○	Side-panel, Floor, Door-inner
Unsprung			◎	Center-pillar, Front-side-member
Structural usage			◎	Door-guard-bar
Material factor	$E.t^3$	$\sigma.t^2$	$E^{0.4}.\sigma^{0.6}.t^{1.8}$	-

Table I. Required component properties.

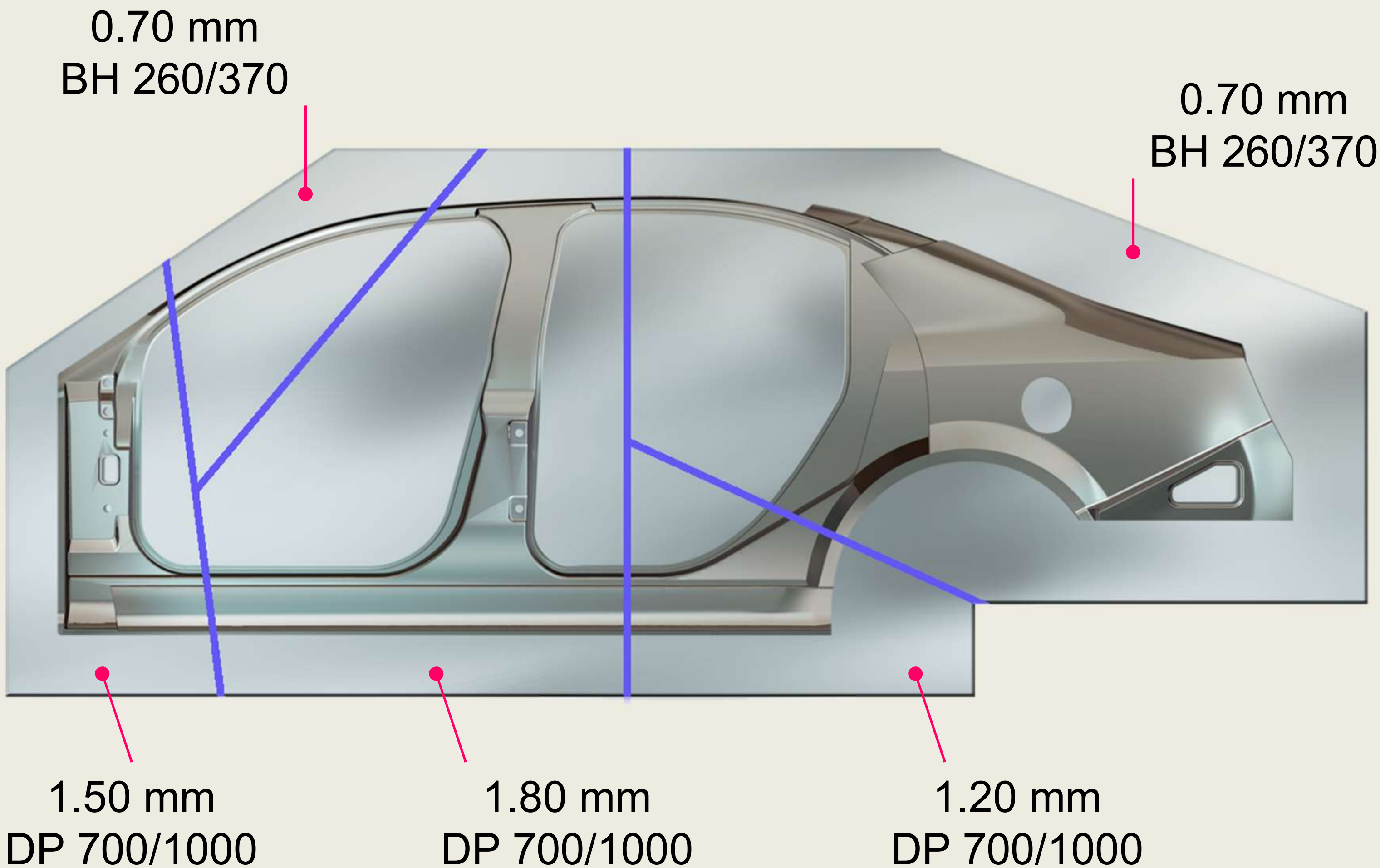
			Main Part	Required Property				
				Part Stiffness $\propto E \cdot t$	Tension Stiffness $\propto E \cdot t^3$	Anti Dent $\propto \sigma_y \cdot t^2$	Fatigue Strength $\propto \sigma_B \cdot t$	Impact Strength $\propto \sigma_y^{0.6}\, t^2$
Body	Exposed		Hood, Door, Luggage		○	○		
	Unexposed	Panel	Floor, Dash	○				○
		Structural	Side Member, Roof Rail	○			○	○
	Frame			○			○	○
Chassis			Suspension Arm	○			○	○
Others			Seat Frame	○			○	○
			Bumper R/F Door Impact Beam					○

AFFORDABLE

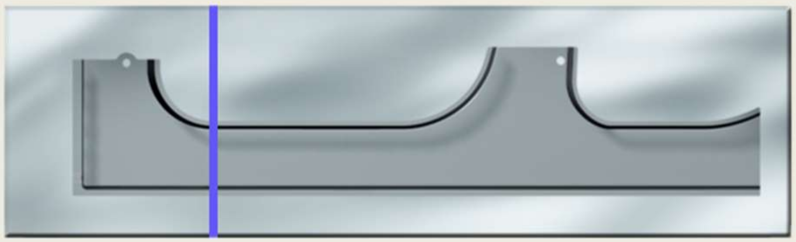


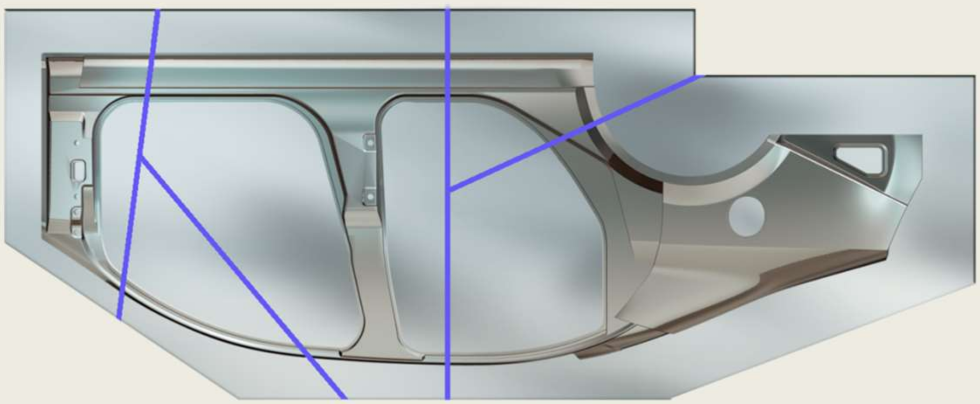
Affordability Comparison
Manufacturing costs and selling prices ($) (taxes excluded)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
CO2 (g/km)
75
100
125
150
175
200
225
250
275
C-Class Gasoline
C-Class Diesel
PNGV-Class Gasoline
PNGV-Class Diesel
Hybrid Vehicles
PNGV-Class Selling Prices
C-Class Selling Prices
ULSAB-AVC Manufacturing Costs

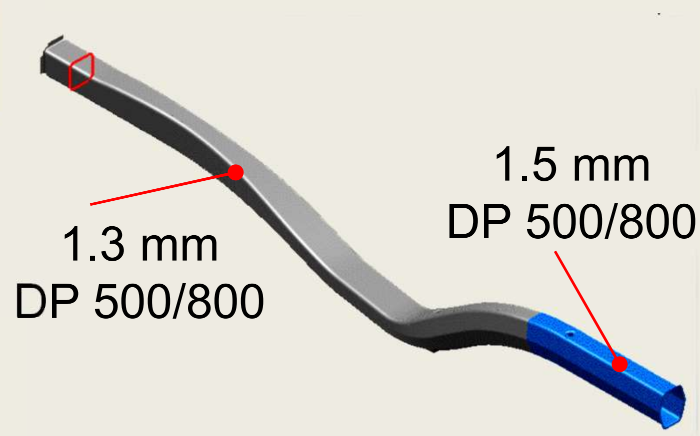
Tailored Blanks

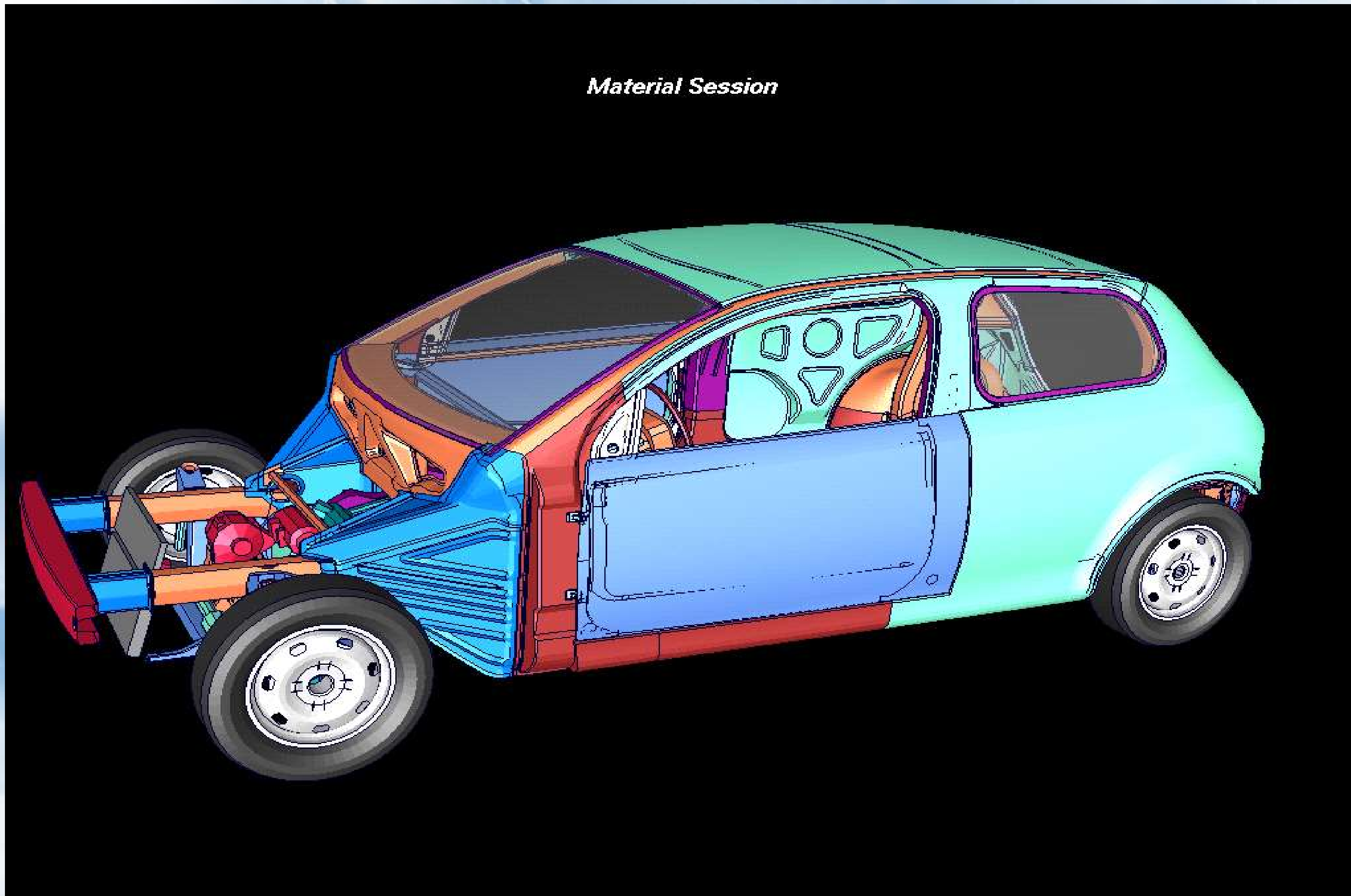


Materials & Processes

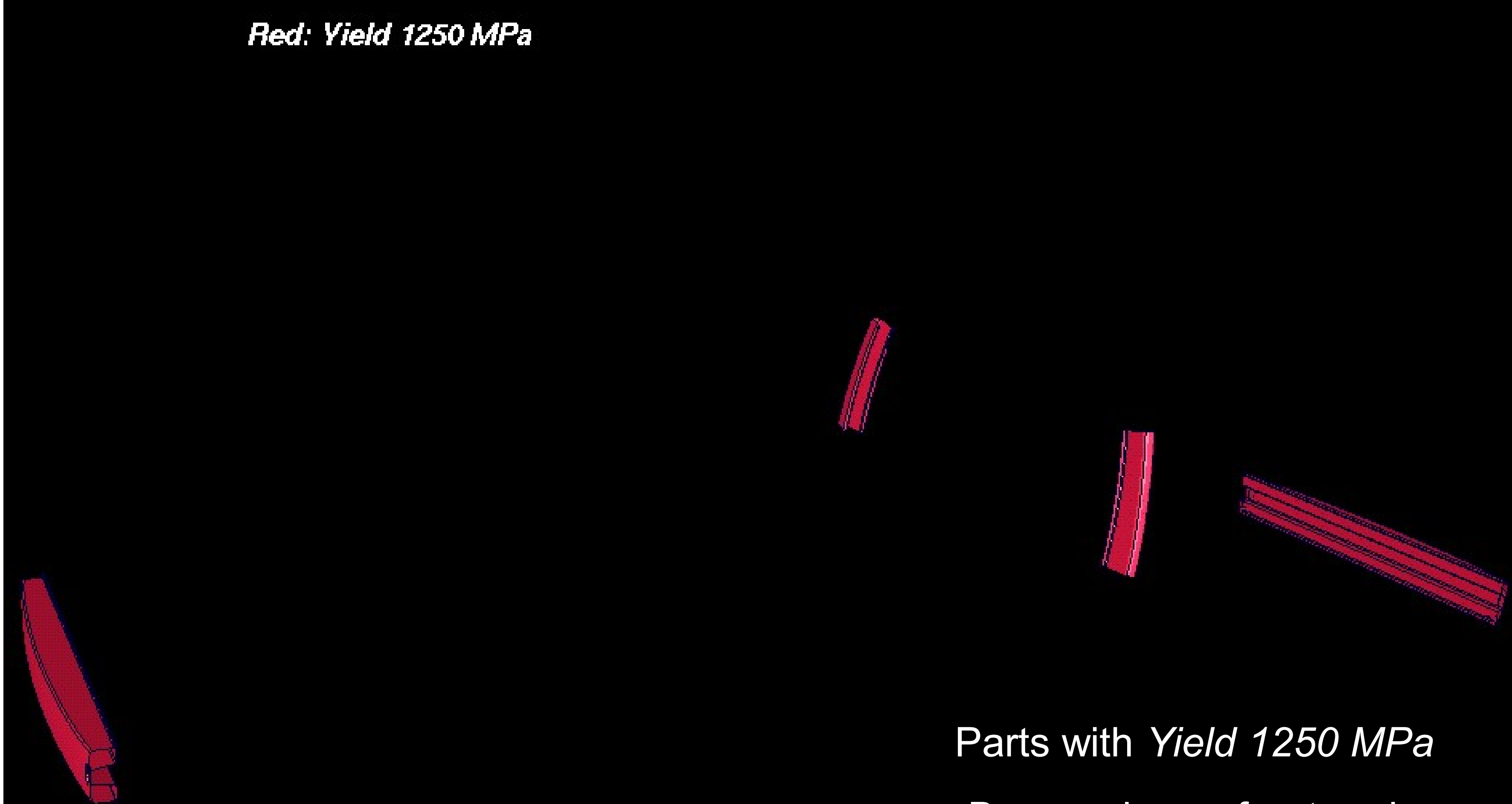








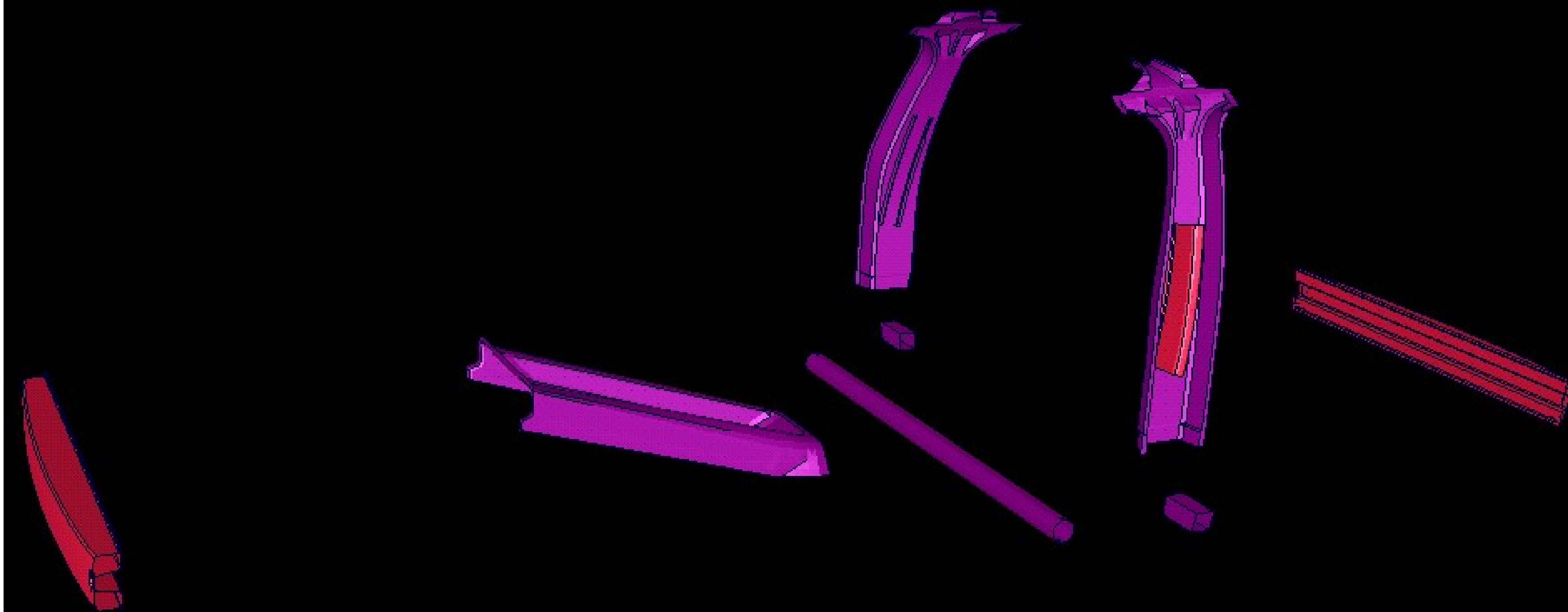
The innovative lightweighting Design Concepts of ULSAB-AVC are backed up by execellent material properties of advanced high strength grade steels offering ultimate tensile strengths upto 1500 MPa



Parts with *Yield 1250 MPa*

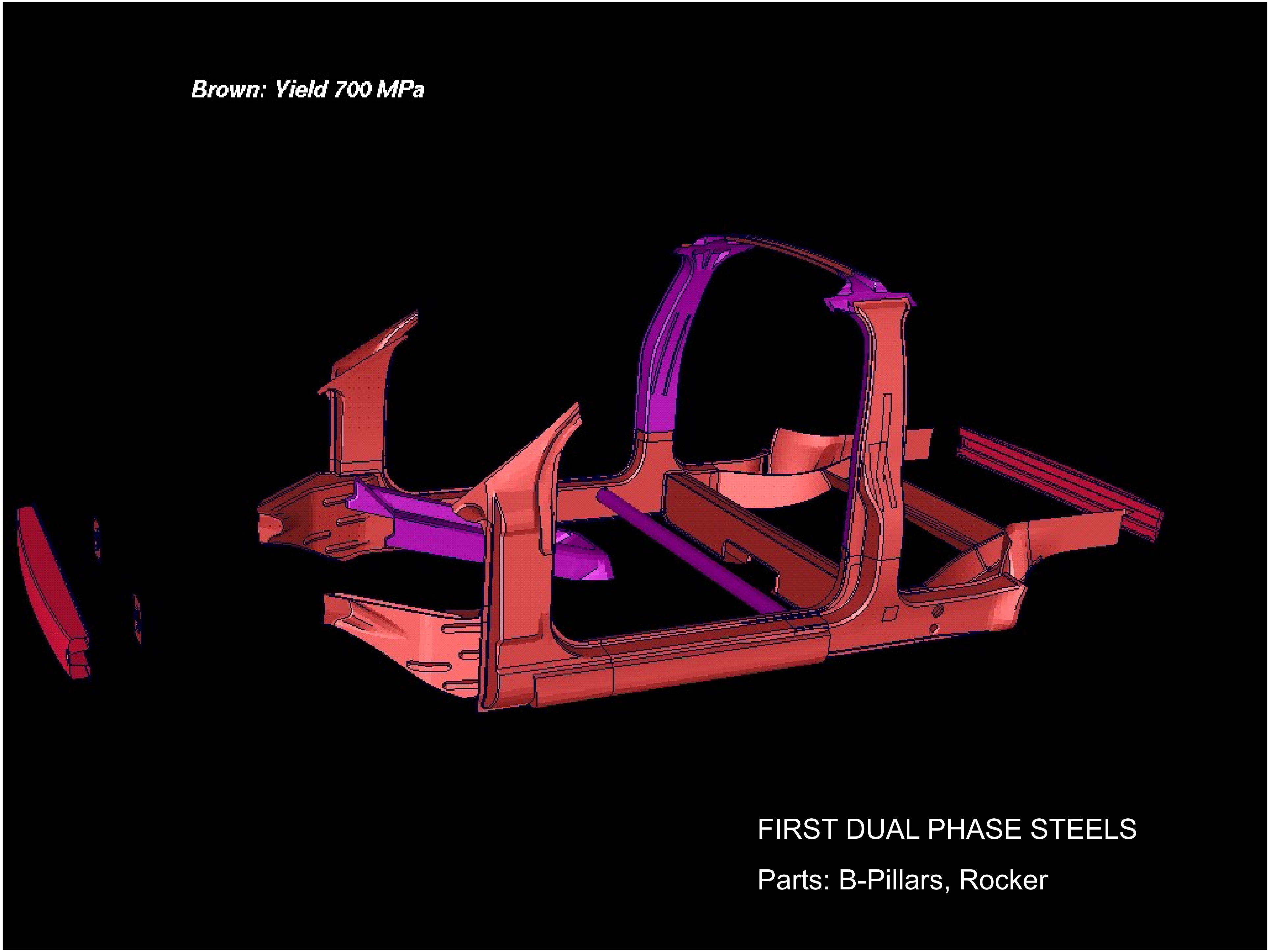
- Bumper beam front and rear
- Bumper beam inner and outer
- Reinforcement waist B-pillar inner

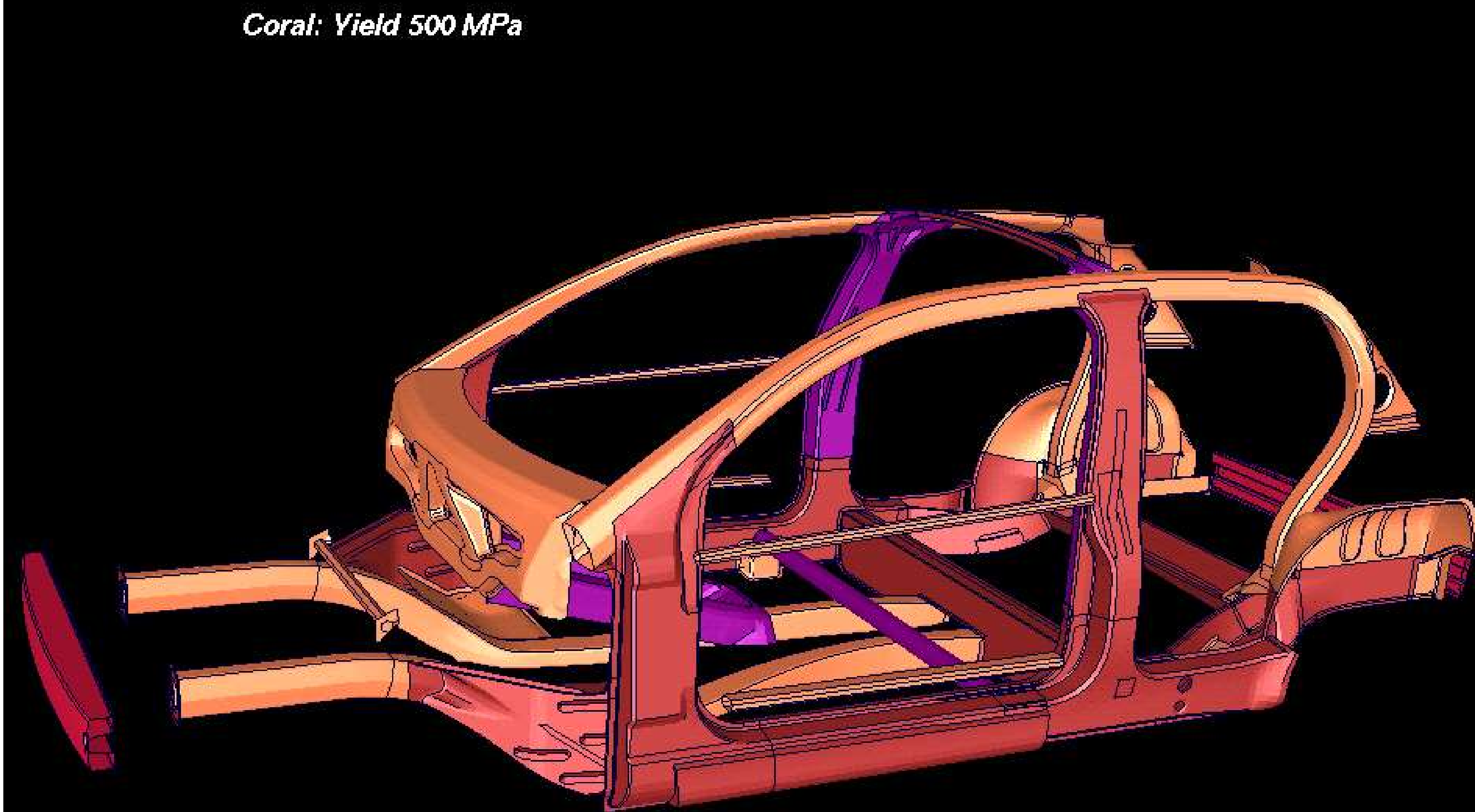
Magenta: Yield 950 MPa



Parts with *Yield 950 MPa*

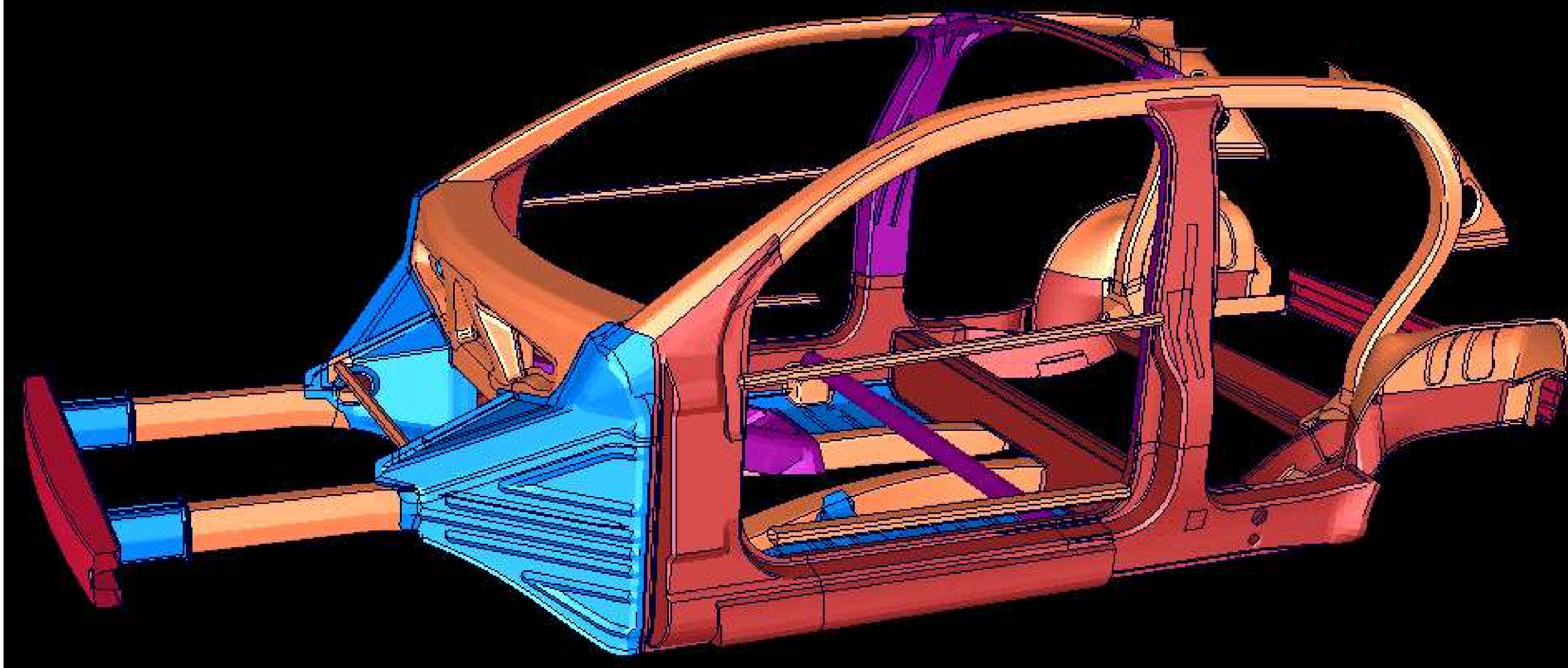
- B-pillar inner,
- Extension C-member kick-up
- Crossmember support for the front seat.


Brown: Yield 700 MPa
FIRST DUAL PHASE STEELS
Parts: B-Pillars, Rocker



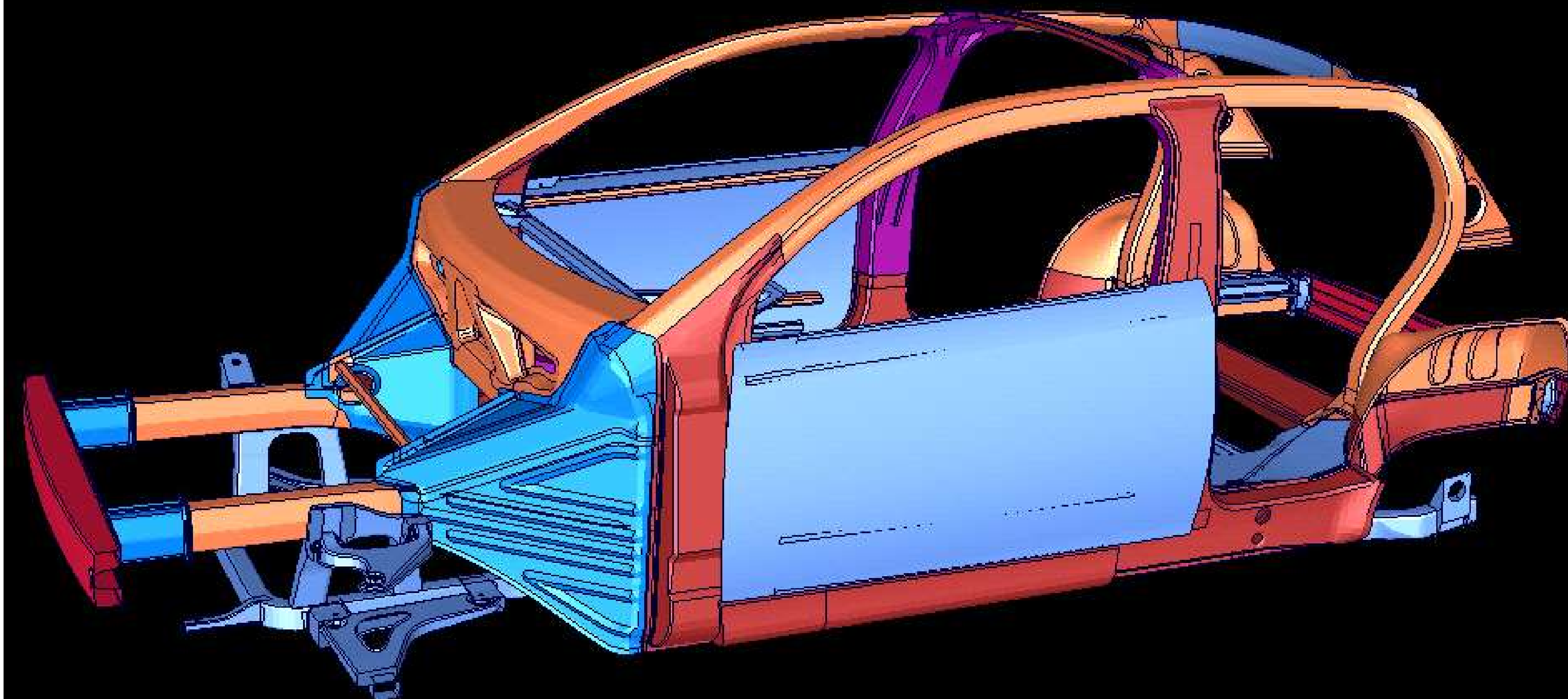
Material with YS 500 MPa are recommended for most of the passenger cell

Hydroformed front rails and the hydroformed body side members also use this material



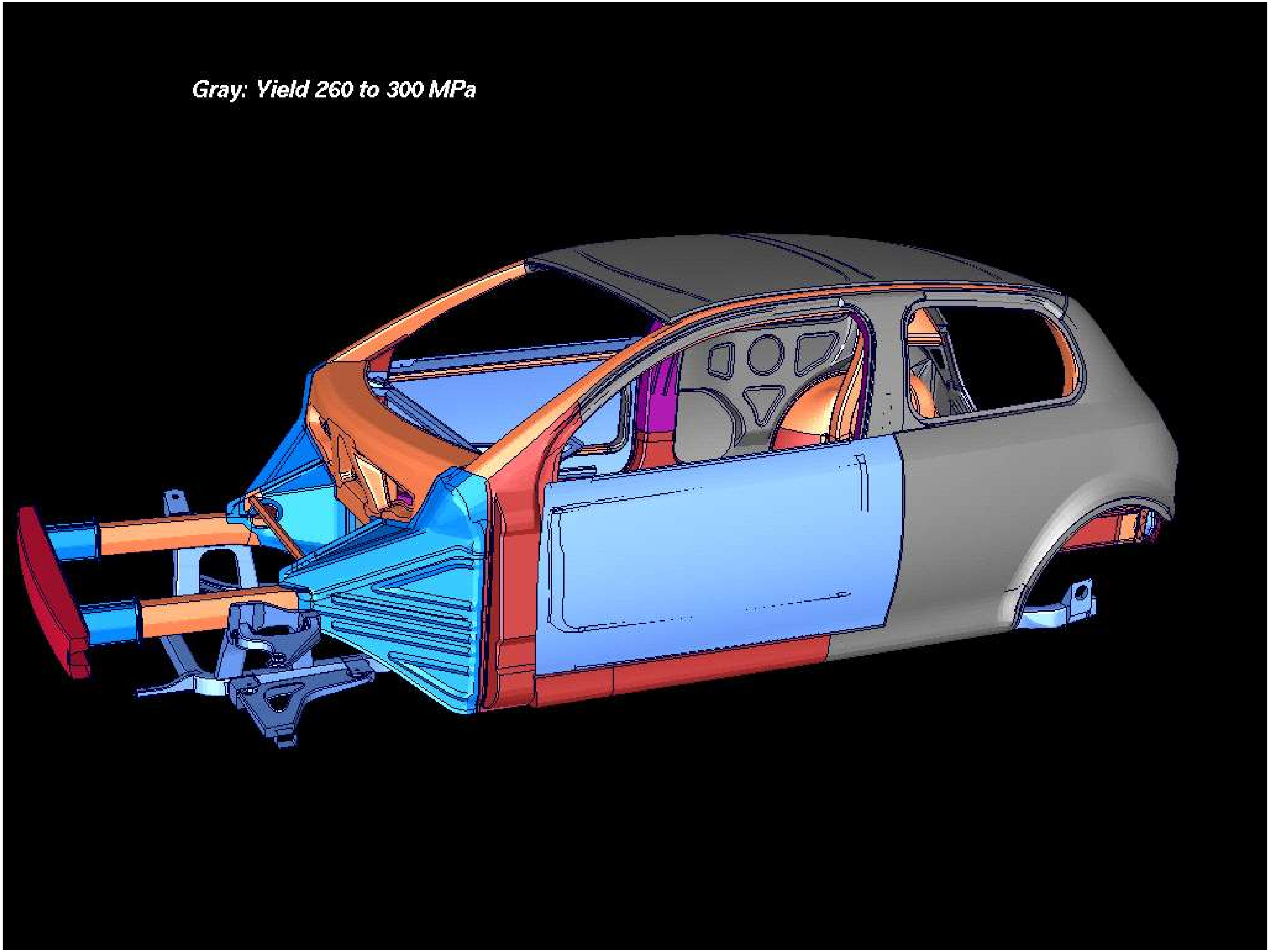
Parts: Inner and outer closeout between the crash box and the dash

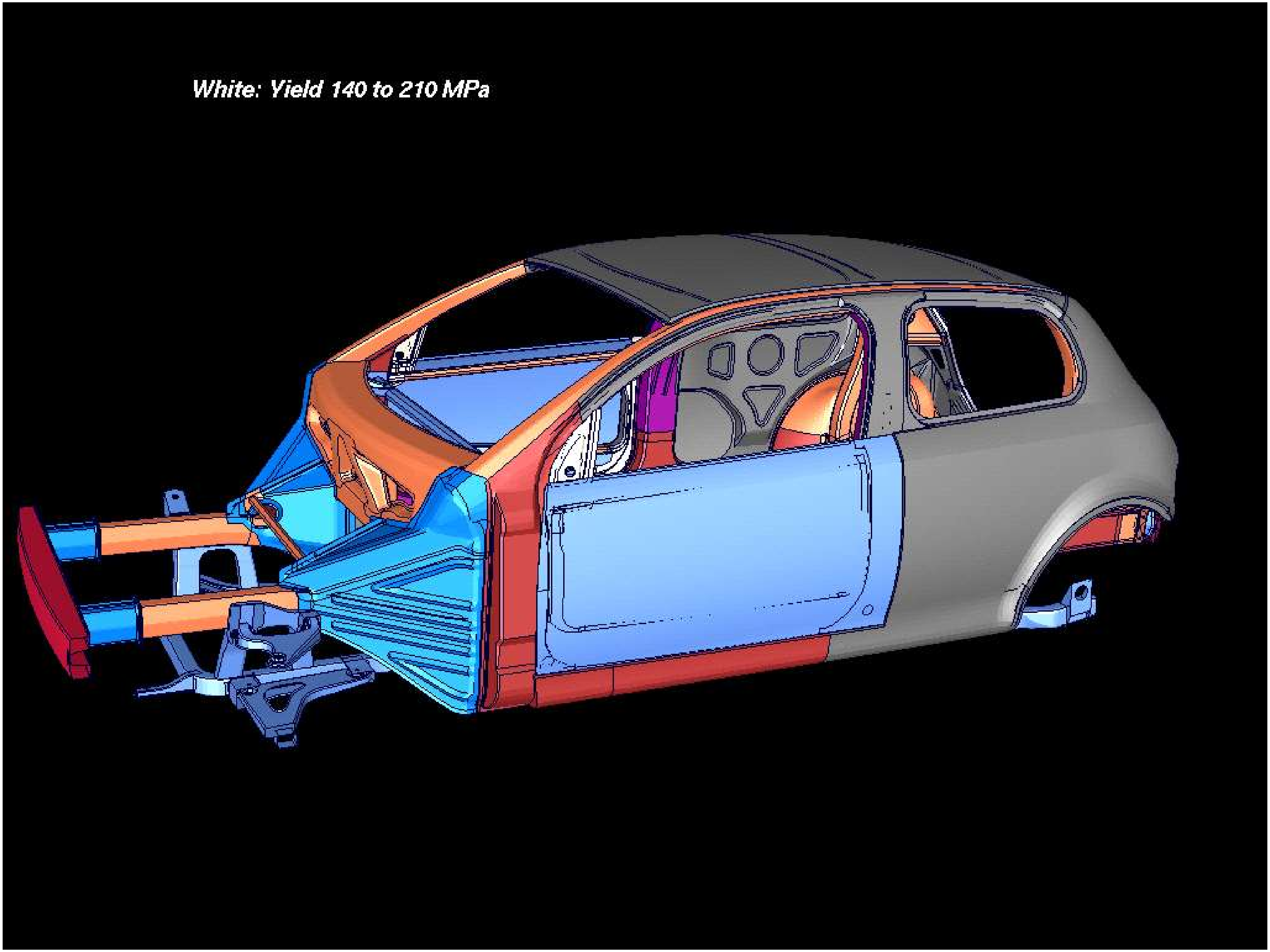
Blue: Yield 350 MPa



83% of body structure: ULSAB

63% of body structure: ULSAB-AVC


Gray: Yield 260 to 300 MPa


White: Yield 140 to 210 MPa

Steel Grades for Car Bodies

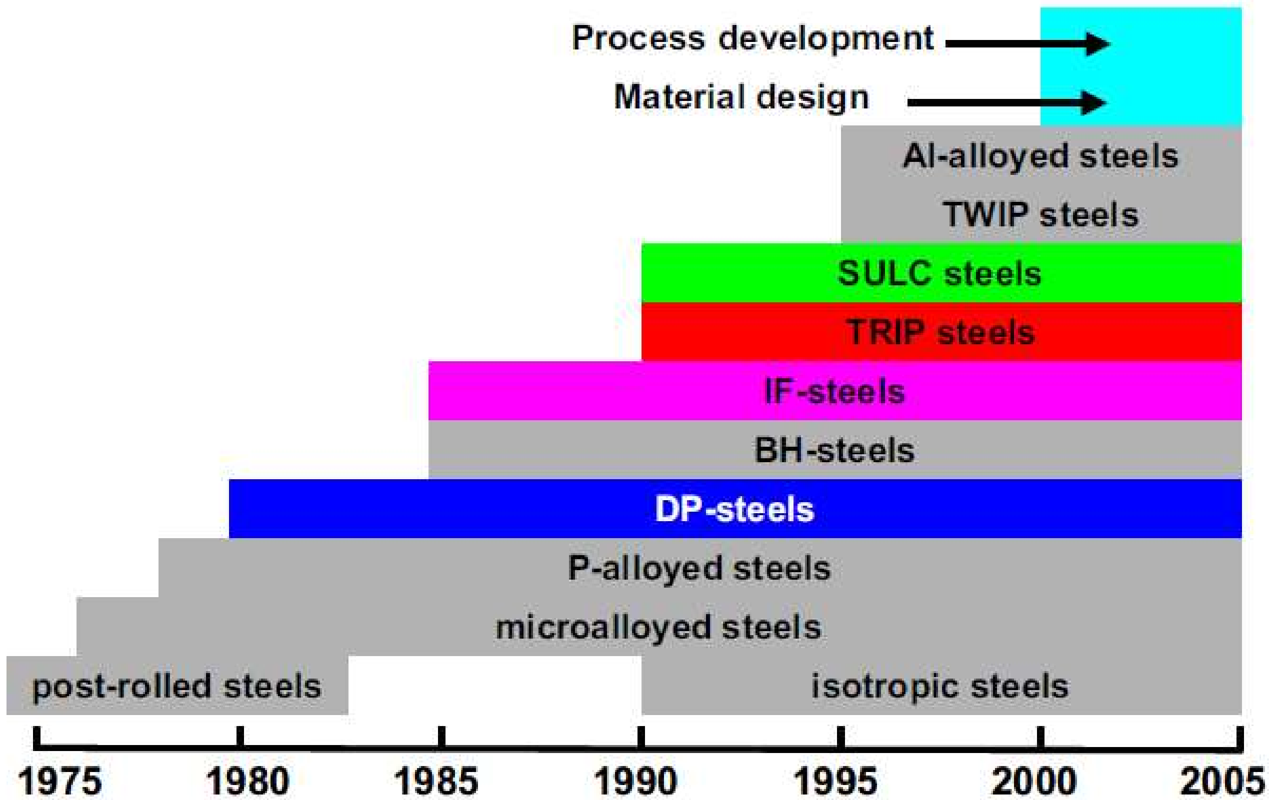
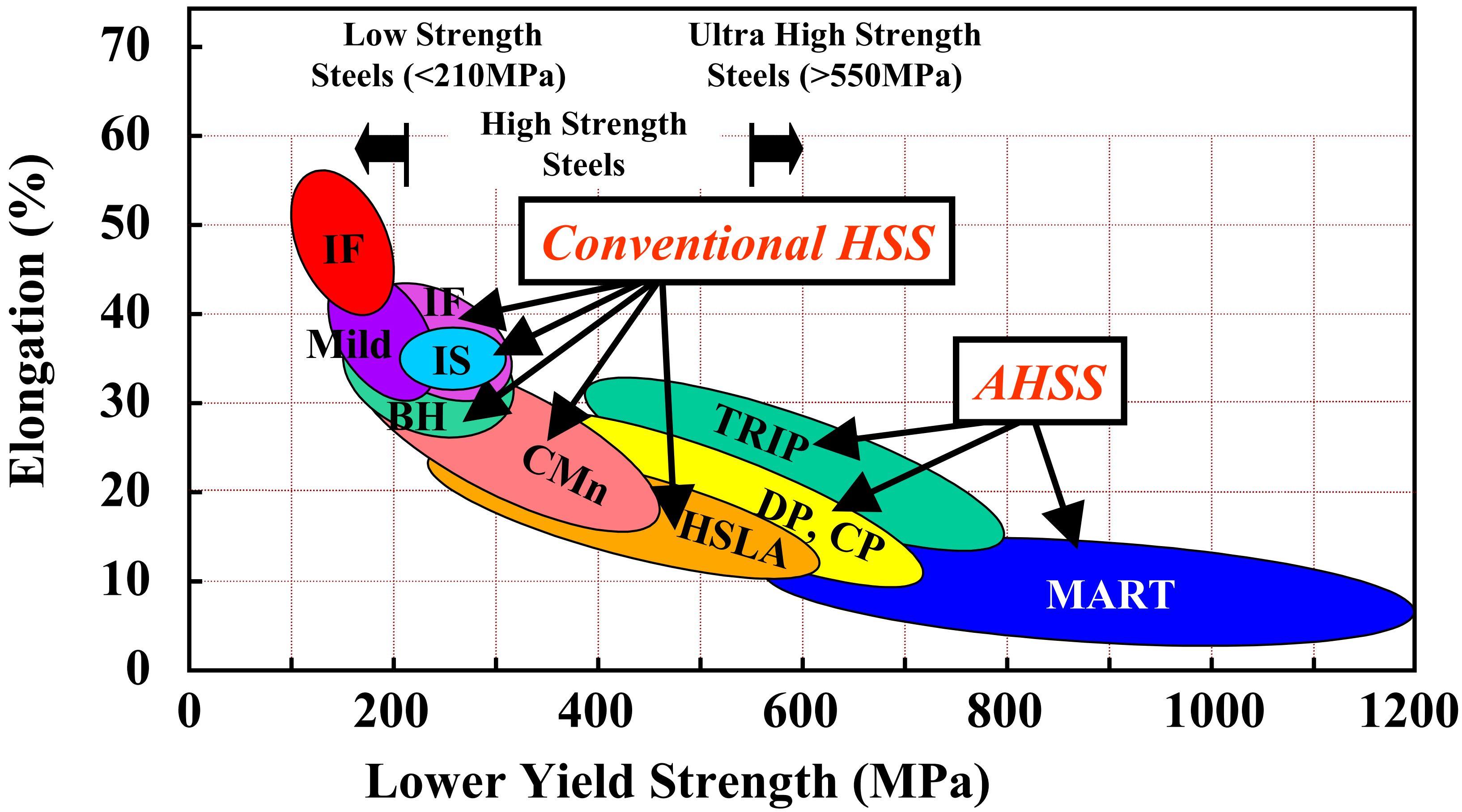


Figure 1. Chronological development of steel grades for car bodies [2].

Auto Steels & Properties



HSLA Steels

High Strength Low Alloy (HSLA) steels, or more precisely micro-alloyed low carbon steels, are the classic solution for the automotive industry when high strength and good cold formability is required. They are used extensively in automotives.

By adding small amounts of niobium, titanium, vanadium strength is increased by grain refinement, precipitation, and solid solution hardening without significantly impairing formability.

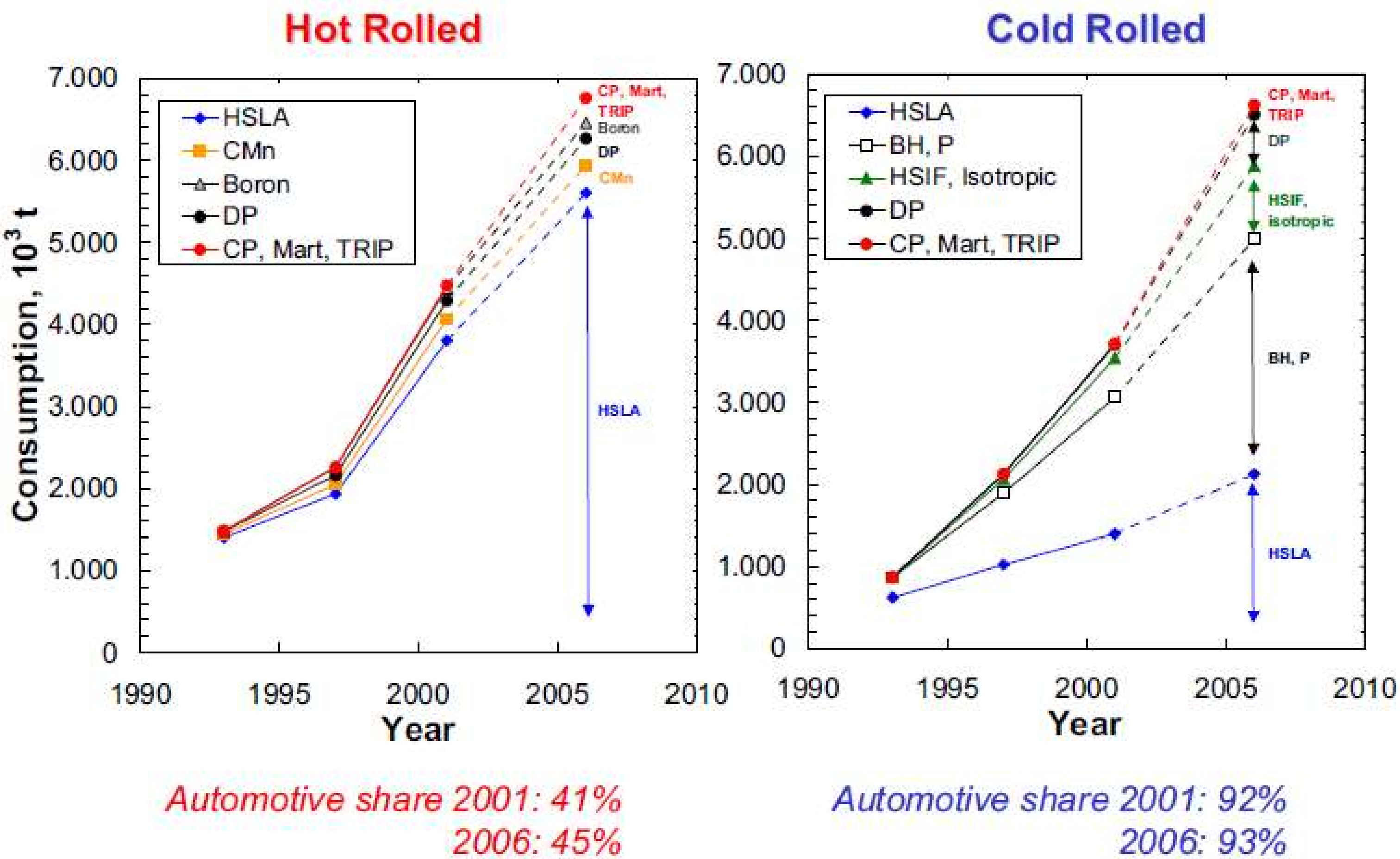


Figure 2. Consumption of HSLA steels in the European automotive industry.

European Norm EN-10292 for Micro Alloyed Steel

Table I. Chemical composition, max. amount in mass-%.

Element	*C*	*Si*	*Mn*	*P*	*S*	*Al*	*Ti*	*Nb*
Mass-%	0.11	0.50	1.00	0.025	0.025	0.015	0.15	0.09

Table II. Mechanical properties of several microalloyed steels [1,4].

Grade	Number	YS	TS	TE
-	-	MPa	MPa	min, %
Hot rolled high yield strength steel for cold forming				
S340MC	1.0974	> 340	420-540	25
S500MC	1.0984	> 500	550-700	14
S600MC	1.8969	> 600	650-820	13
S700MC	1.8974	> 700	750-950	12
Cold rolled higher yield strength for cold forming				
H260LAD	1.0929	260-330	350-430	26
H300LAD	1.0932	300-380	380-480	23
H340LAD	1.0933	340-420	410-510	21
H380LAD	1.0934	380-480	440-560	19
H420LAD	1.0935	420-520	470-590	17

HSLA steels display a wide range of properties !

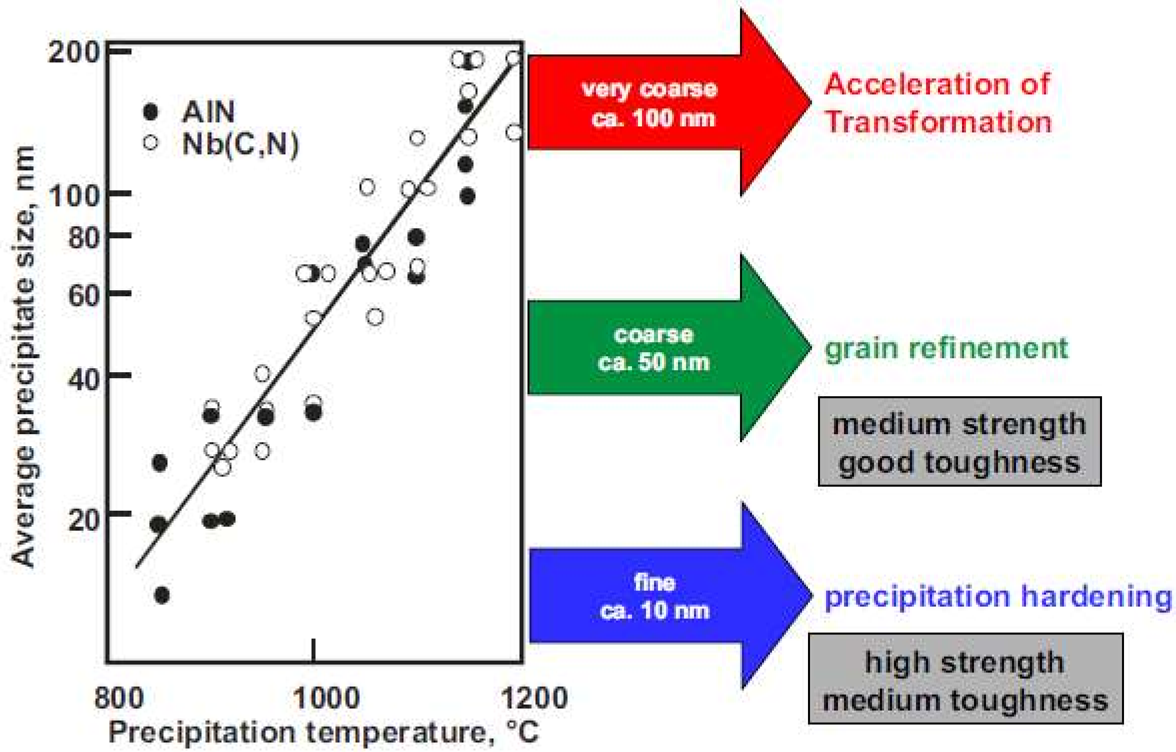


Figure 3. Influence of precipitation temperature on the precipitation size and some resulting effects.

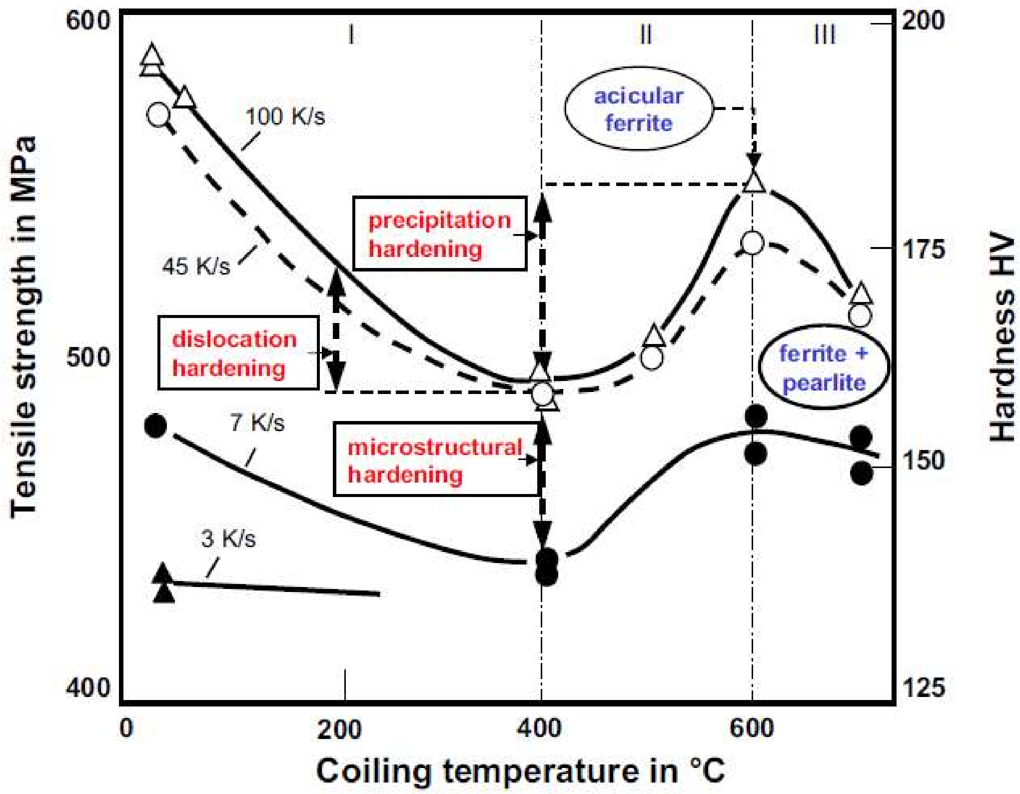


Figure 4. Strength increase as a function of cooling rate and coiling temperature of hot rolled strip.

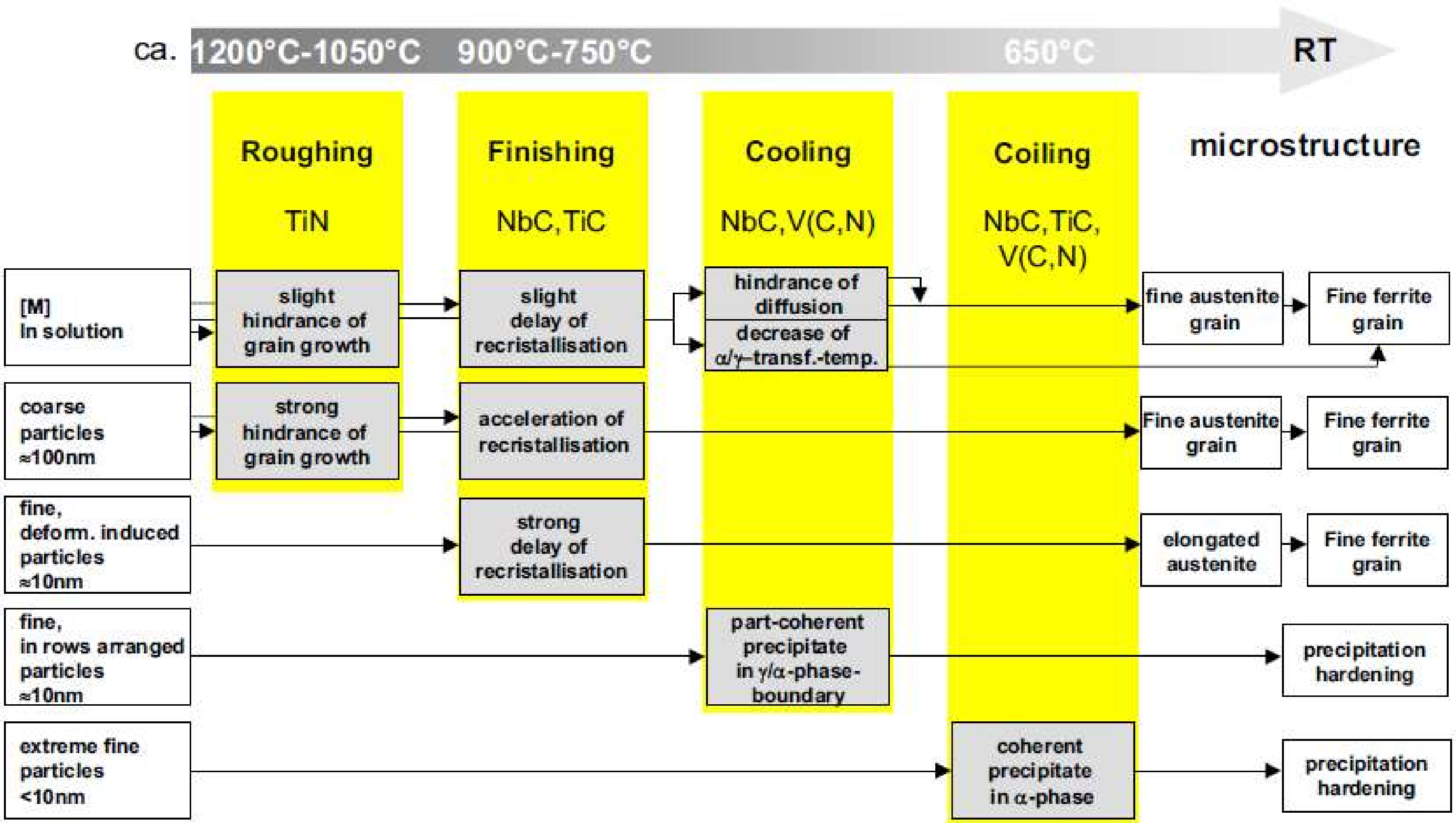


Figure 5. Effects of microalloying elements during hot strip processing.

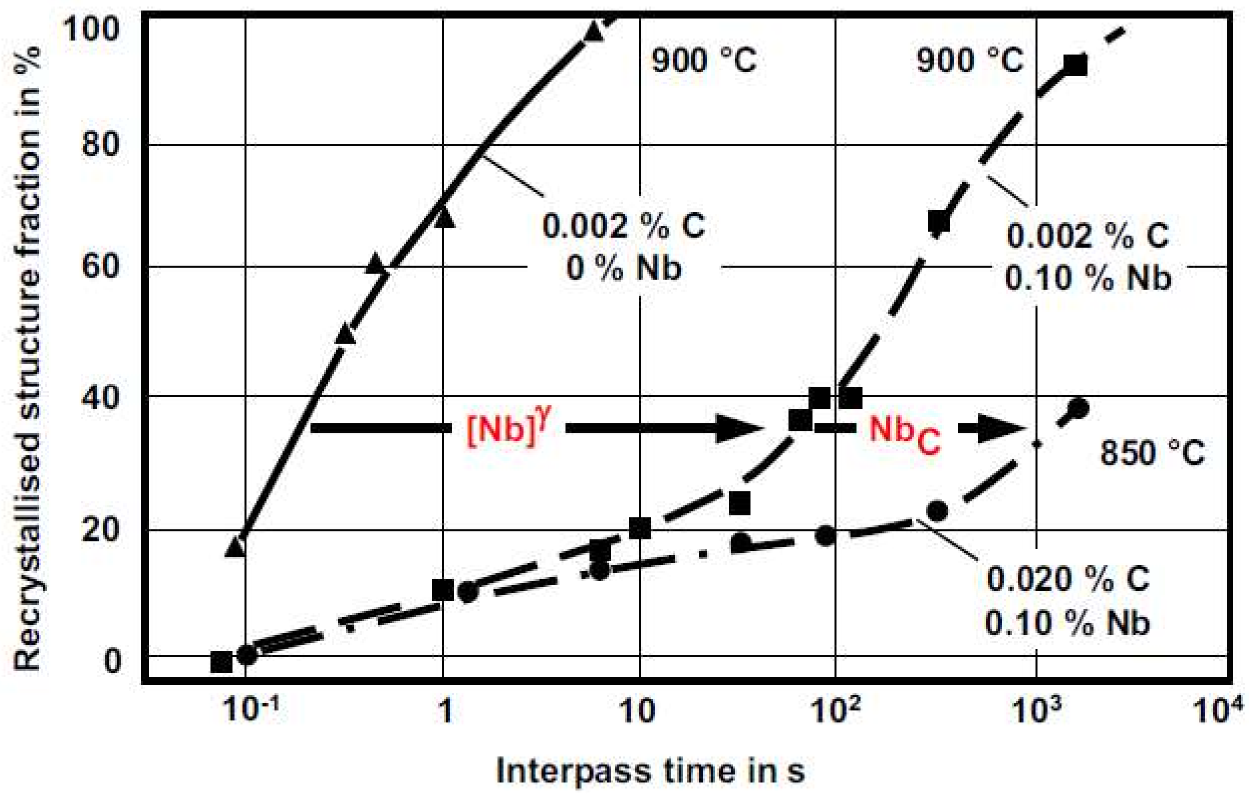


Figure 7. Effects of soluble and precipitated niobium on austenite recrystallization (rolling temperatures are indicated).

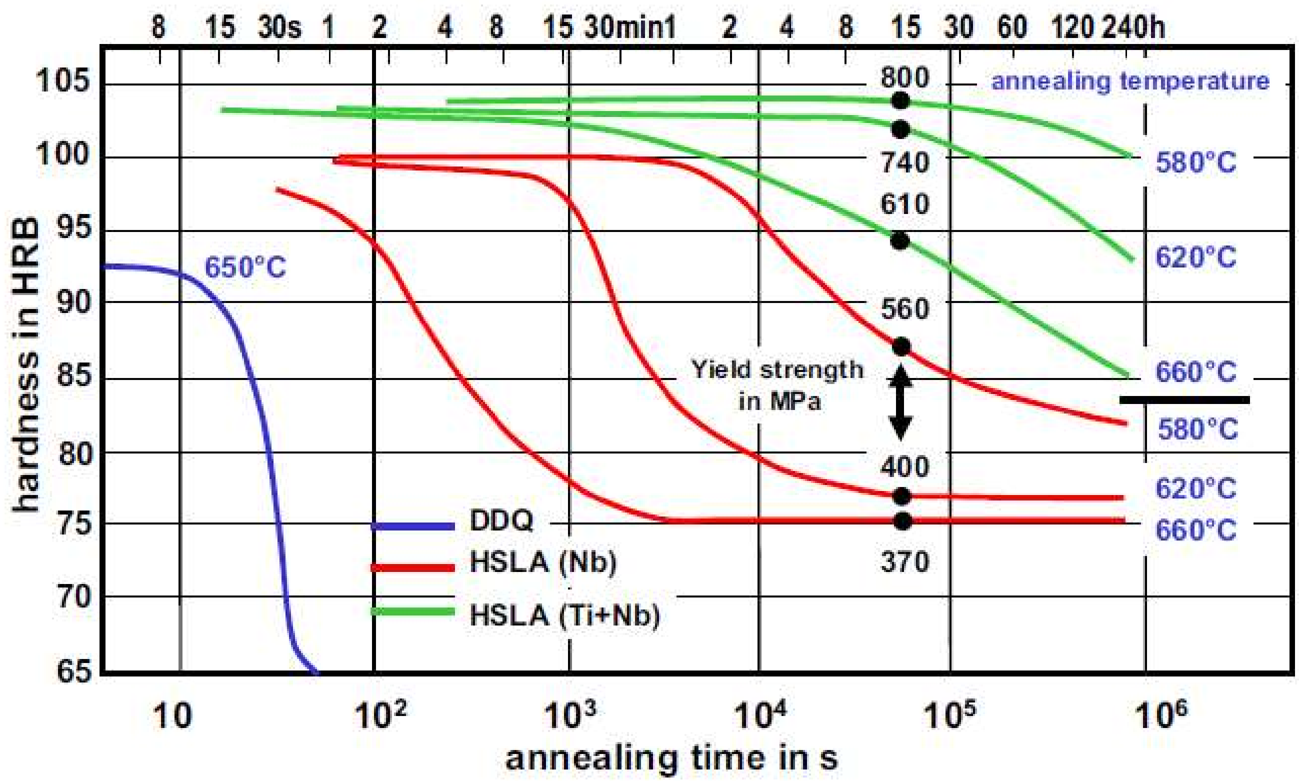


Figure 8. Effects of microalloying elements on hardness development during batch-type recrystallization annealing.

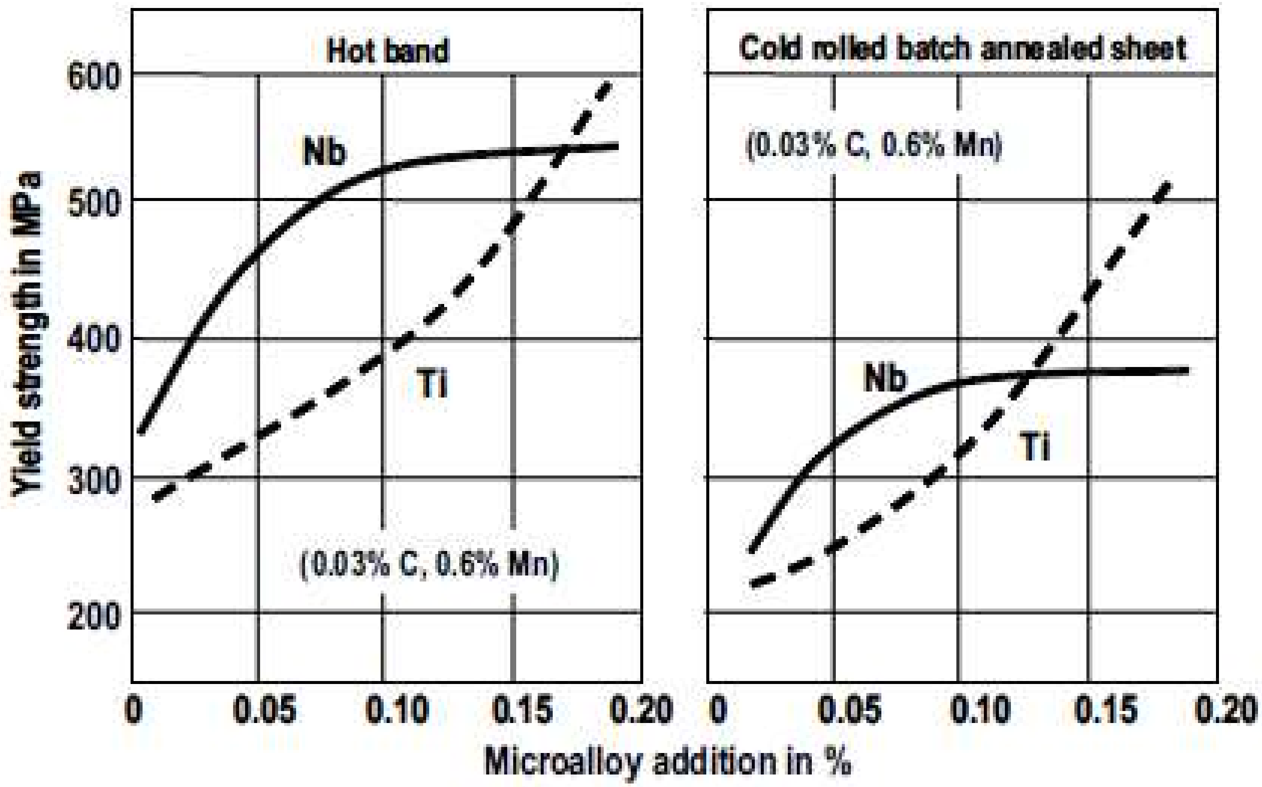


Figure 7. Strength increase of low carbon-manganese steel by Nb or Ti microalloying [1].

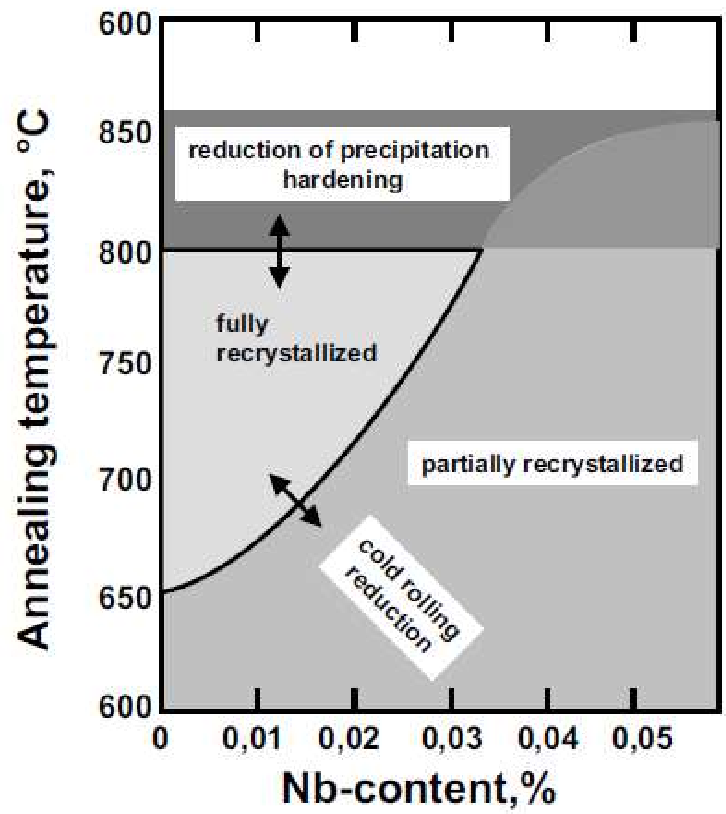


Figure 9. Annealing limits for HSLA steels in a hot-dip galvanizing line.

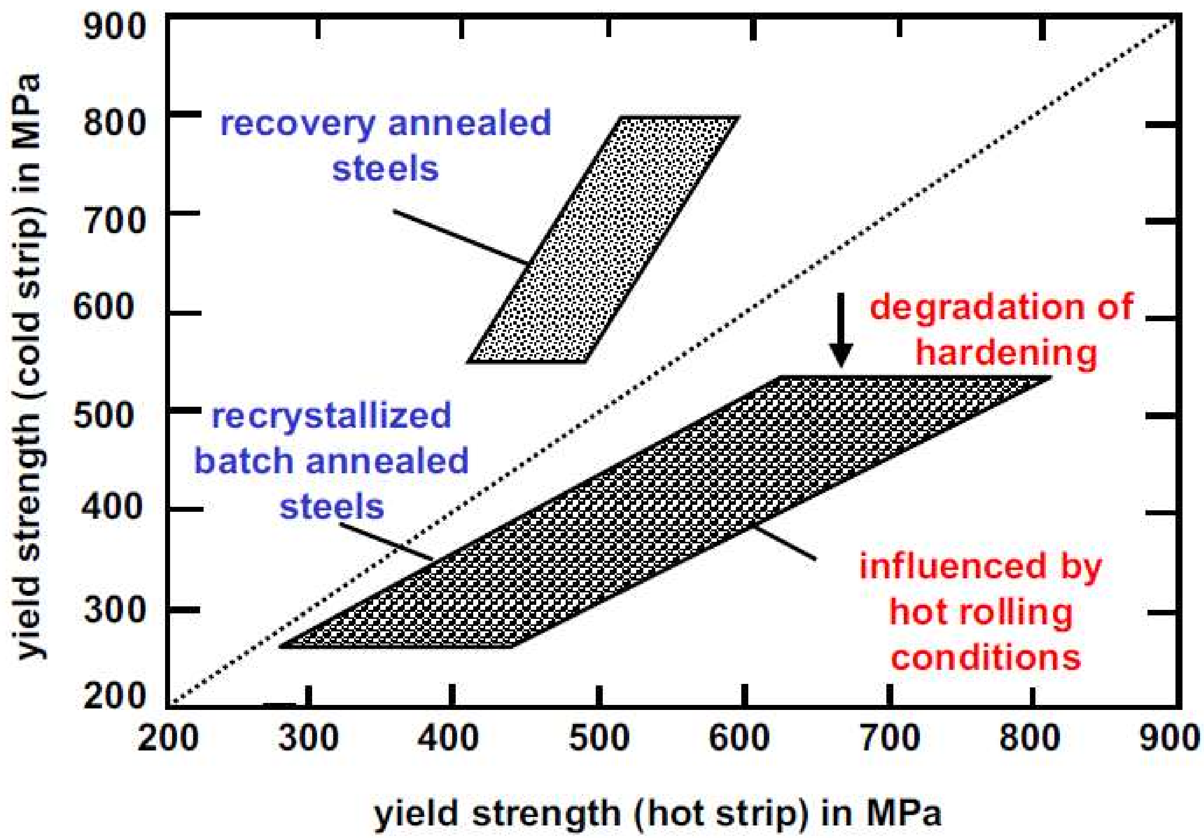


Figure 10. Relationship of hot strip and cold strip yield strength.

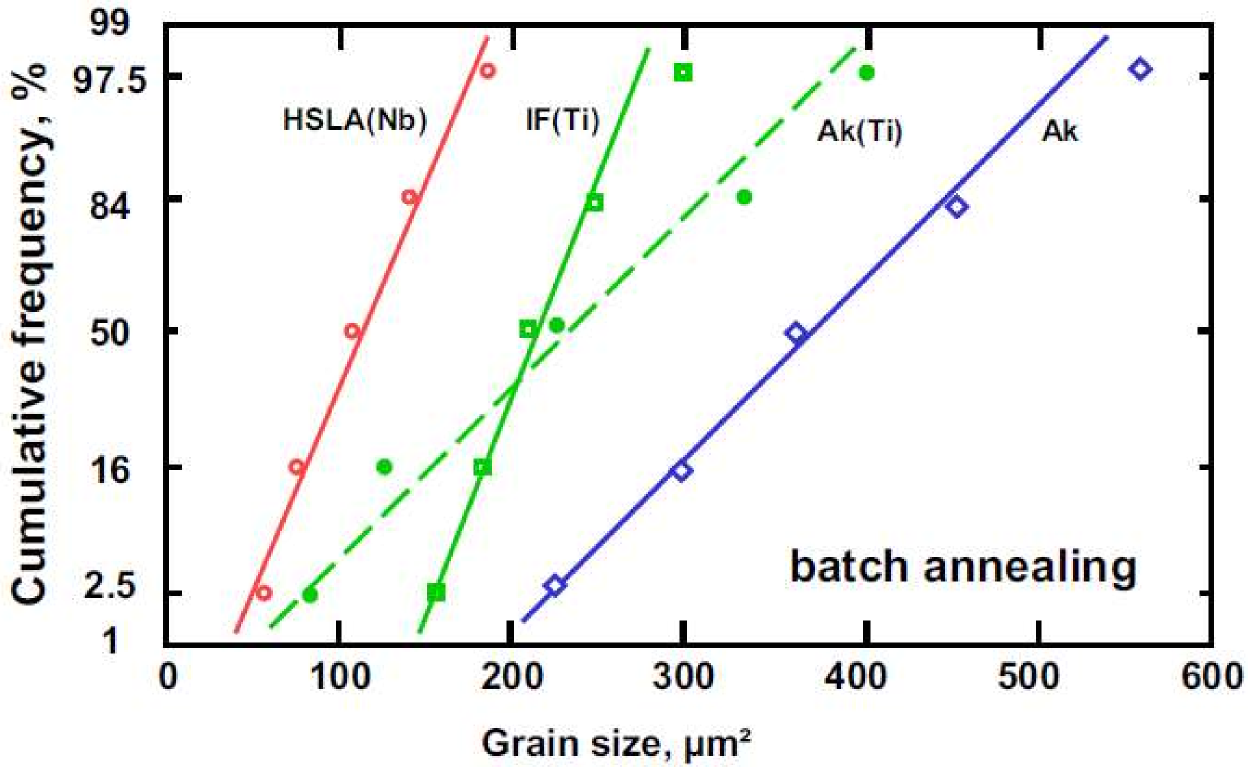


Figure 11. Grain size distributions of different cold-rolled steels after batch annealing.

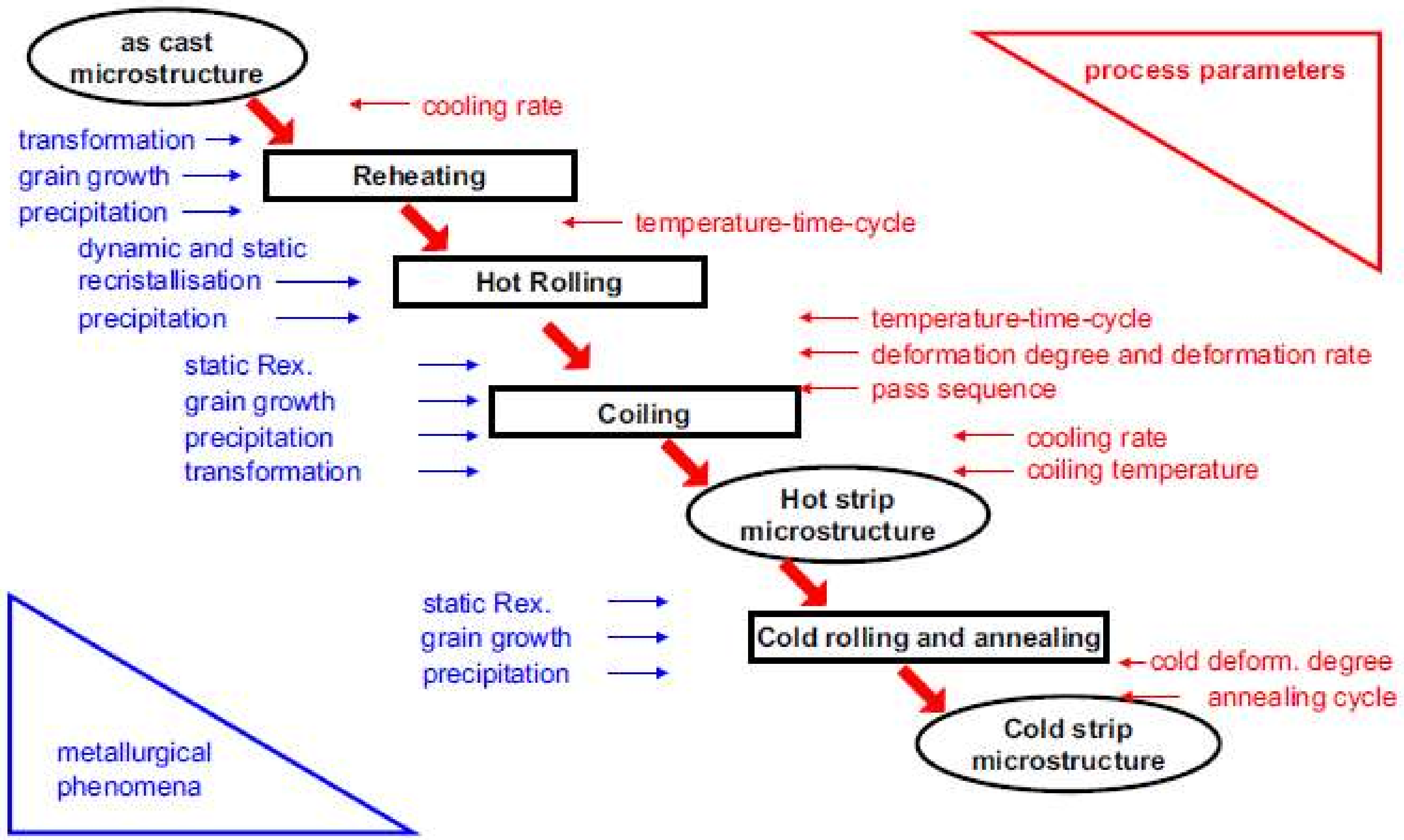
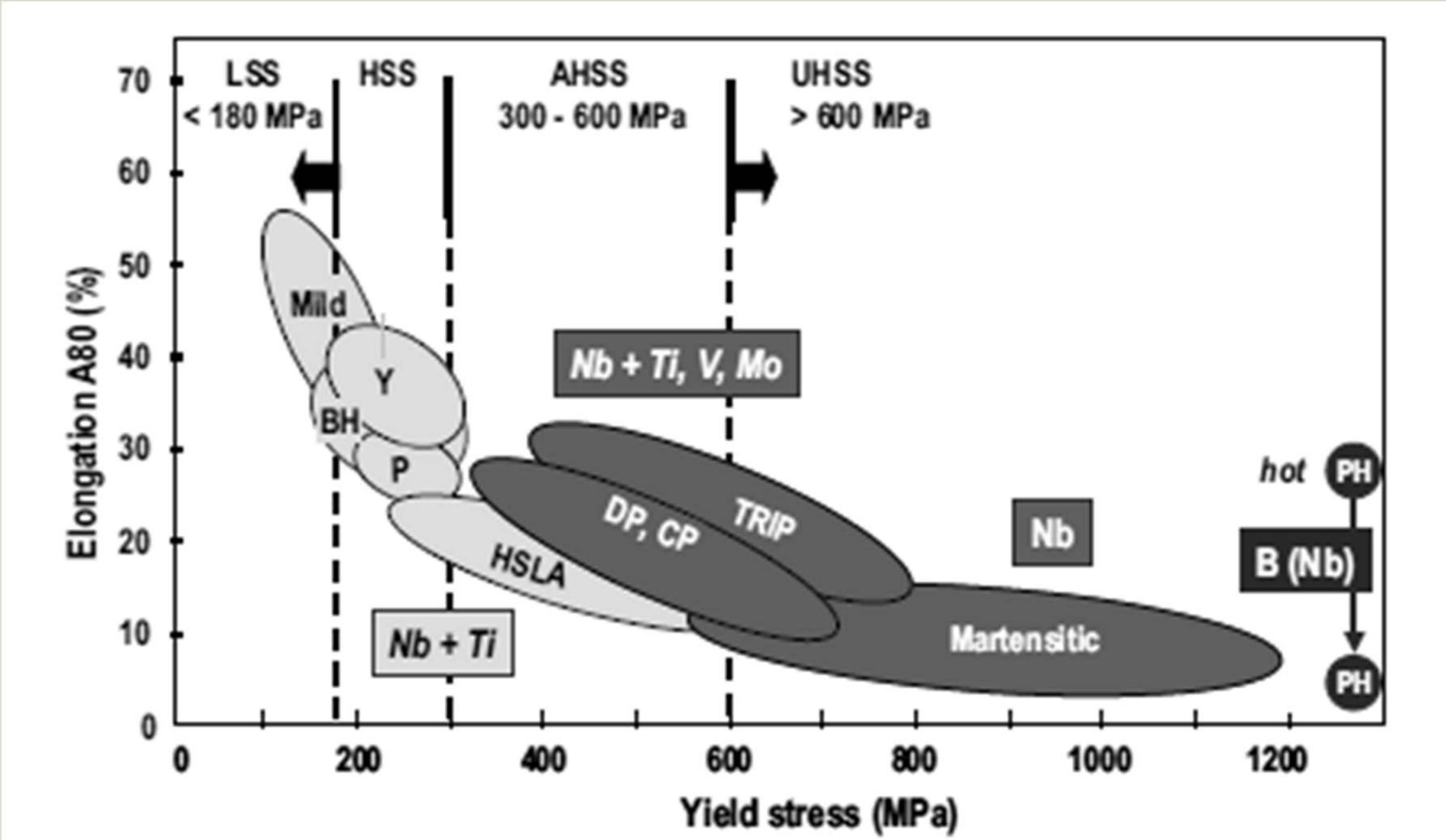


Figure 13. Metallurgical phenomena and process parameters during cold strip processing.

Advanced Steel Grades



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

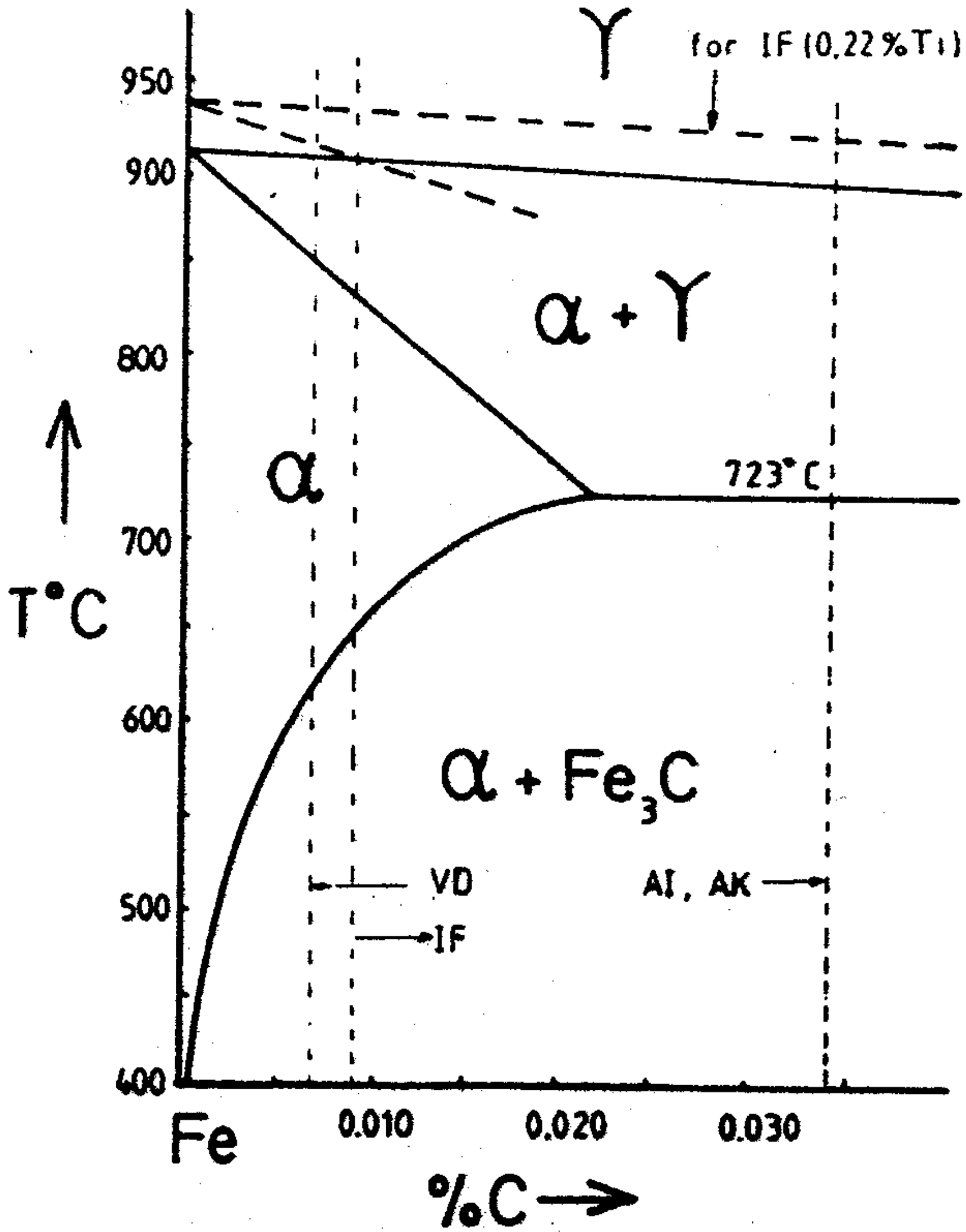
IF STEELS

SCENARIO & PROPERTIES

- EXISTING : OVER 25 Yrs
- COMMERCIAL PRODUCTION : Since'80s
- S:C:N 1:1:1 (S 0.004-0.010; C ~ 25 ppm; N~ 30 ppm)
- CARBON STABILIZING MECHANISM & PPTN. TYPE & SEQUENCE DIFFERENT [$TiN \rightarrow TiS \rightarrow Ti_4C_2S_2 \rightarrow TiC$]
- OUTSTANDING FORMABILITY IN CR+A CONDITIONS
- RESISTANCE TO AGEING

DEVELOPMENTS CONTRIBUTED TO IF :

- DEGASSERS (RH etc.)
- CONTINOUS ANNEALING PRACTICE
- HOT - DIP GALVANISING
- DEMAND FROM THE AUTO SECTOR
- DEVELOPMENT of IF-HS for AUTO SECTOR



3 Part of Fe–C phase diagram

Table 2.4.3.3.1-1 Typical Mechanical Properties of AHSS

Product	YS (MPa)	UTS (MPa)	Total EL (%)	n-value[a] (5-15%)	r-bar	k-value[b] (MPa)
DP 280/600	280	600	30-34	0.21	1.0	1082
DP 300/500	300	500	30-34	0.16	1.0	762
DP 350/600	350	600	24-30	0.14	1.0	976
DP 400/700	400	700	19-25	0.14	1.0	1028
TRIP 450/800	450	800	26-32	0.24	0.9	1690
DP 500/800	500	800	14-20	0.14	1.0	1303
CP 700/800	700	800	10-15	0.13	1.0	1380
DP 700/1000	700	1000	12-17	0.09	0.9	1521
Mart 950/1200	950	1200	5-7	0.07	0.9	1678
Mart 1250/1520	1250	1520	4-6	0.065	0.9	2021

Where: YS and UTS are minimum values, others are typical values.
Total EL % - Flat sheet (A50 or A80).
[a] n-value is calculated in the range of 5 to 15% true strain, if applicable.
[b] k-value is the magnitude of true stress extrapolated to a true strain of 1.0. It is a material property parameter frequently used by one-step forming simulation codes.

Table 1. Steel Grades selected for the final ULSAB-AVC body structure concept design.

Steel Grade	YS (MPa)	UTS (MPa)	Total EL (%)	n-value[1] (5-15%)	r-bar	K-value[2] (MPa)
	Flat sheet, as shipped properties					
BH 210/340	210	340	34-39	0.18	1.8	582
BH 260/370	260	370	29-34	0.13	1.6	550
DP 280/600	280	600	30-34	0.21	1.0	1082
IF 300/420	300	420	29-36	0.20	1.6	759
DP 300/500	300	500	30-34	0.16	1.0	762
HSLA 350/450	350	450	23-27	0.14	1.1	807
DP 350/600	350	600	24-30	0.14	1.0	976
DP 400/700	400	700	19-25	0.14	1.0	1028
TRIP 450/800	450	800	26-32	0.24	0.9	1690
DP 500/800	500	800	14-20	0.14	1.0	1303
CP 700/800	700	800	10-15	0.13	1.0	1380
DP 700/1000	700	1000	12-17	0.09	0.9	1521
Mart 950/1200	950	1200	5-7	0.07	0.9	1678
Mart 1250/1520	1250	1520	4-6	0.065	0.9	2021
	Straight tubes, as shipped properties					
DP 280/600	450	600	27-30	0.15	1.0	1100
DP 500/800	600	800	16-22	0.10	1.0	1250
Mart 950/1200	1150	1200	5-7	0.02	0.9	1550

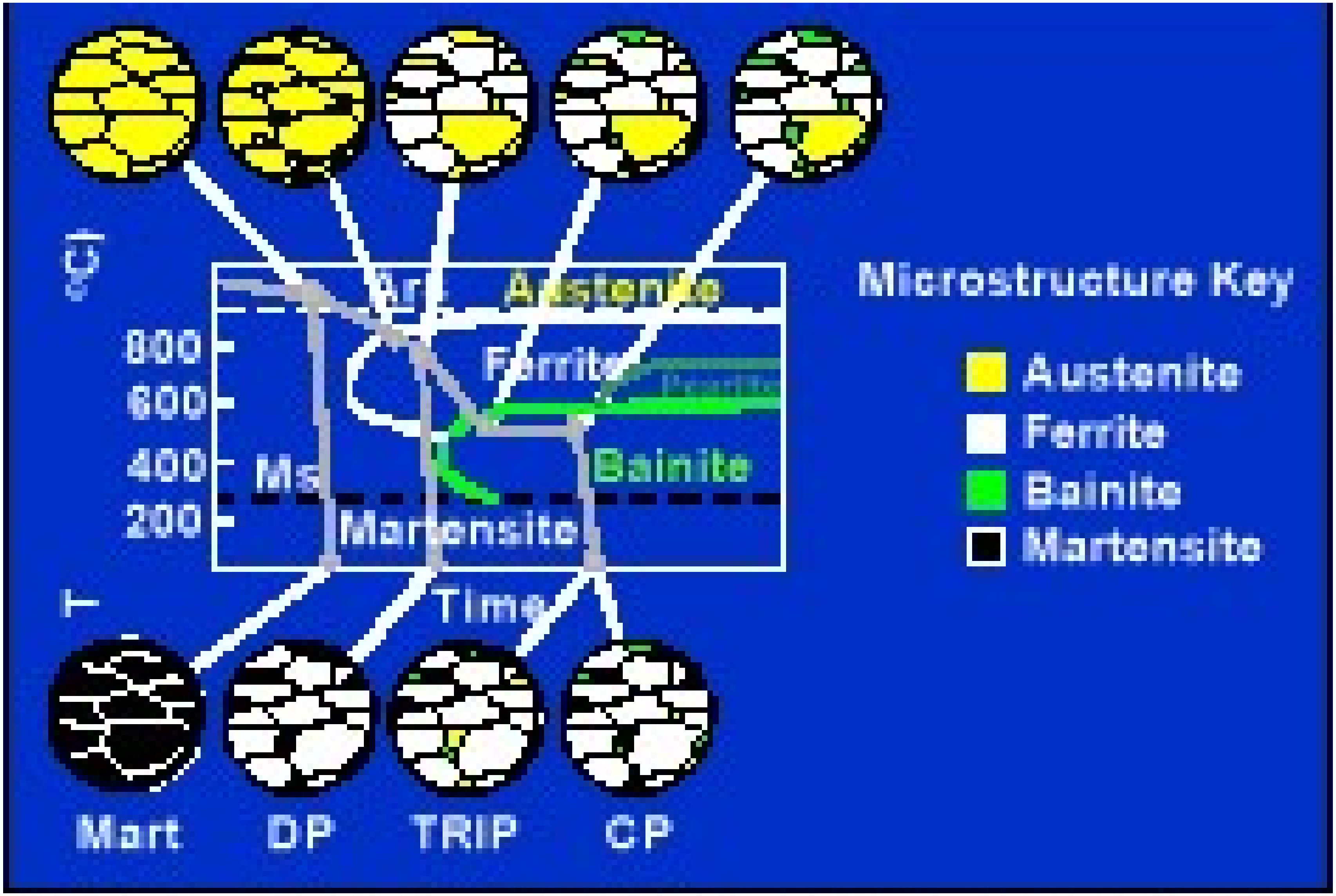


Figure 11. Cooling patterns and microstructural evolution in the production of AHSS.

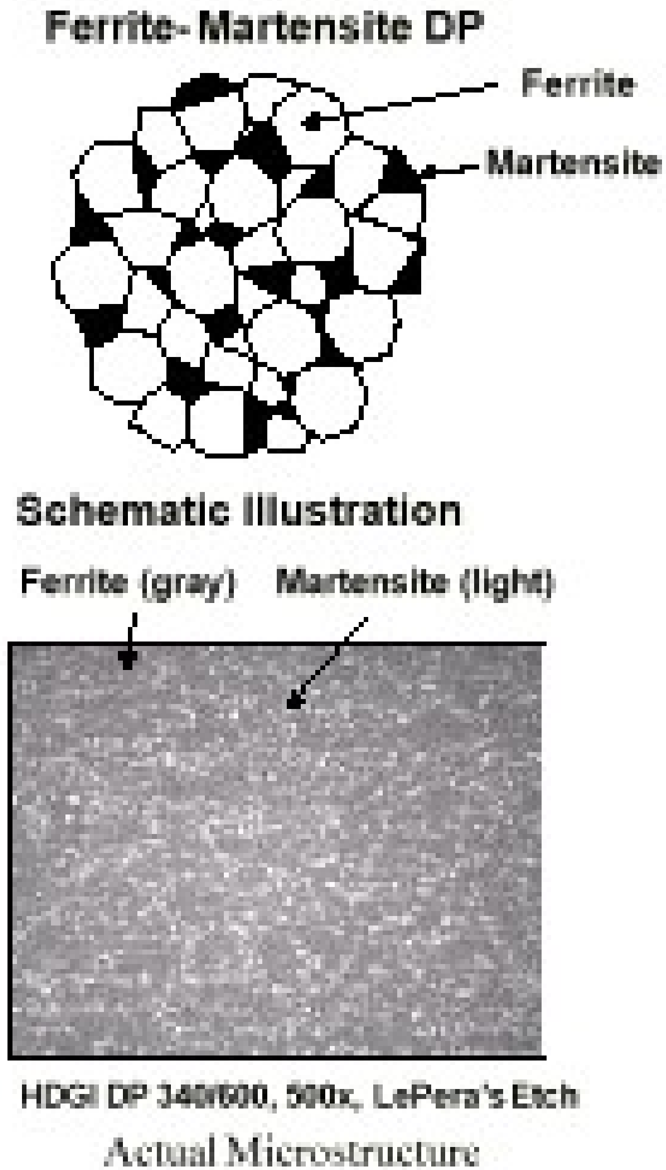
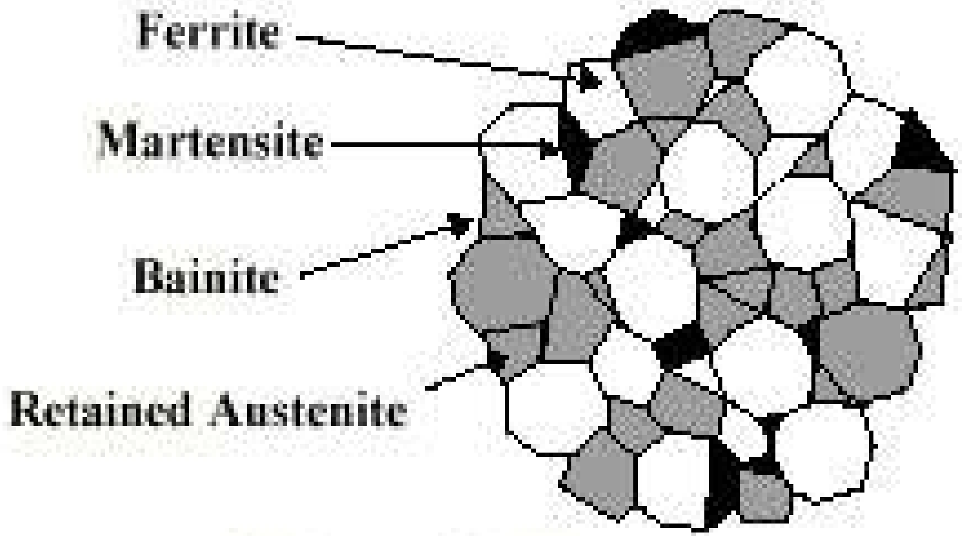
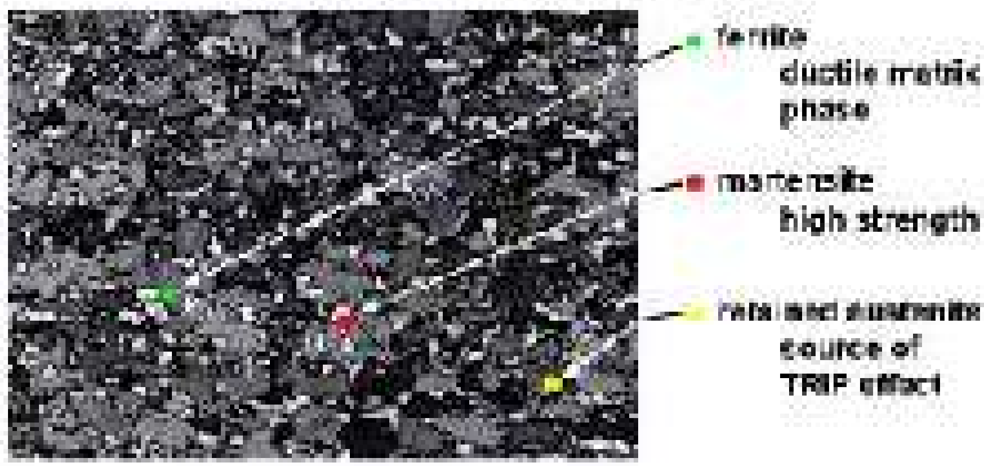


Figure 5. Microstructure of dual phase steel.



Schematic Illustration



Actual Microstructure

Figure 7. Microstructure of TRIP steel

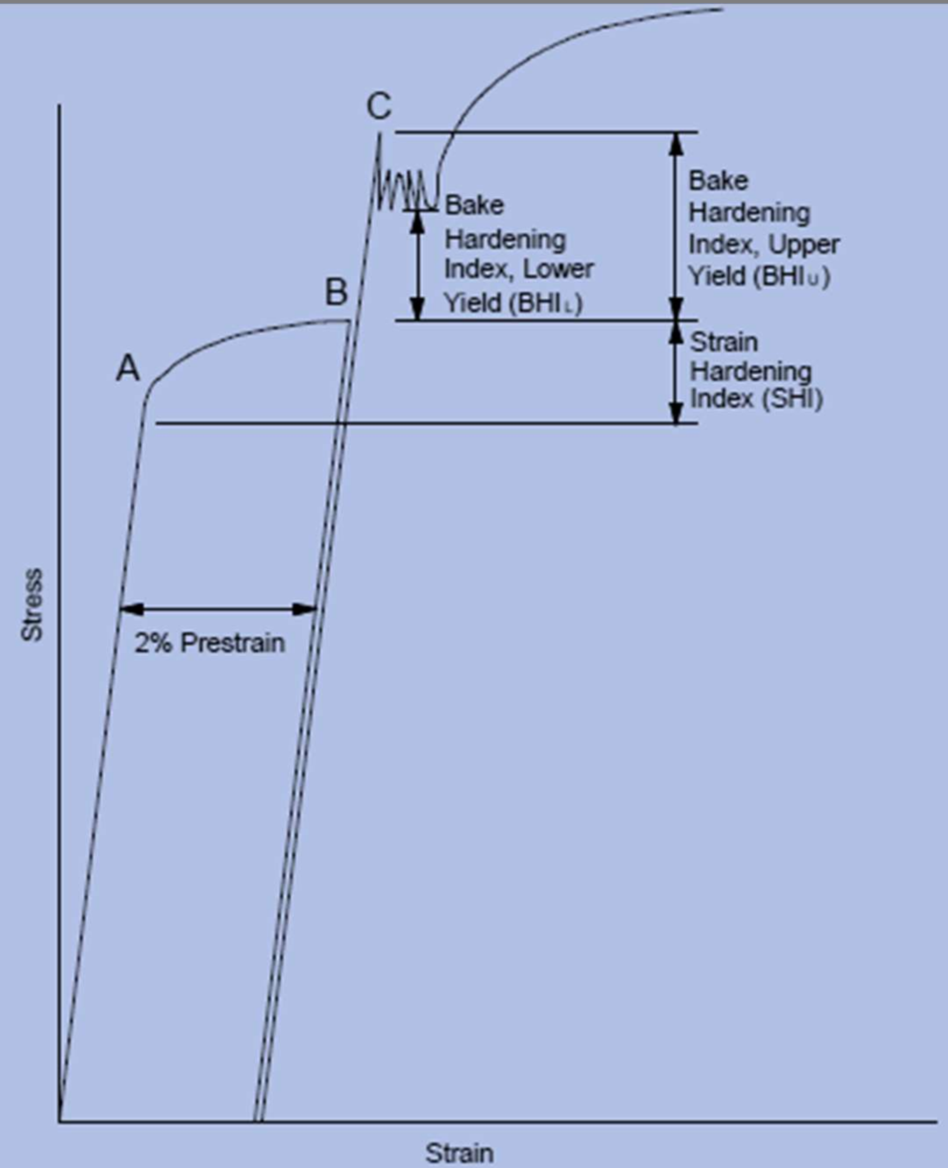


Figure 2.4.3.1-1 Schematic illustration showing strain hardening and bake hardening index and the increase in yield strength that occurs during the bake cycle

Table 2.4.3.1-1 Required minimum mechanical properties of Type A and Type B dent resistant cold reduced sheet steel as described in J2340

SAE J2340 Grade Designation and Type	As Received Yield Strength MPa	As Received Tensile Strength MPa	As Received n Value	Yield Strength After 2% Strain MPa	Yield Strength After Strain and Bake MPa
180 A	180	310	0.20	215	
180 B	180	300	0.19		245
210 A	210	330	0.19	245	
210 B	210	320	0.17		275
250 A	250	355	0.18	285	
250 B	250	345	0.16		315
280 A	280	375	0.16	315	
280 B	280	365	0.15		345

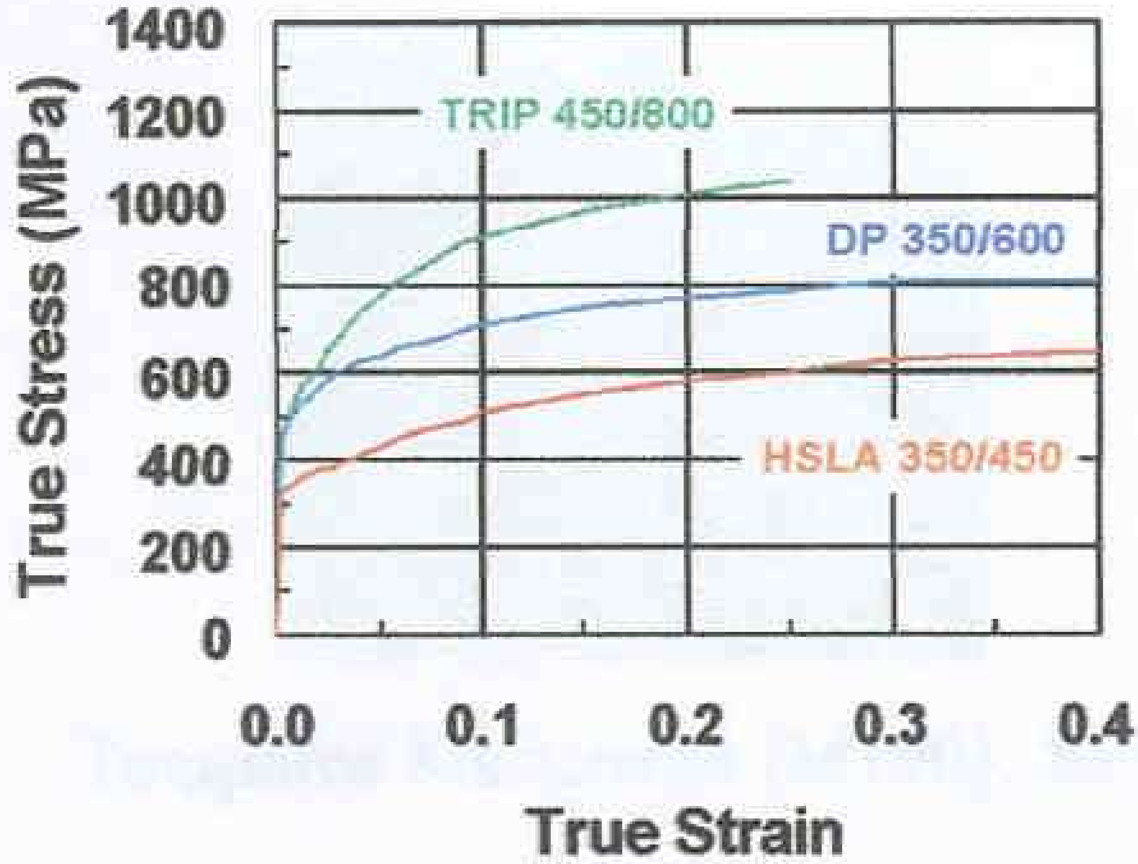


Figure 8. Comparison of the stress-strain behaviors of HSLA 350/450, DP 350/600, and TRIP 450/800 steels.

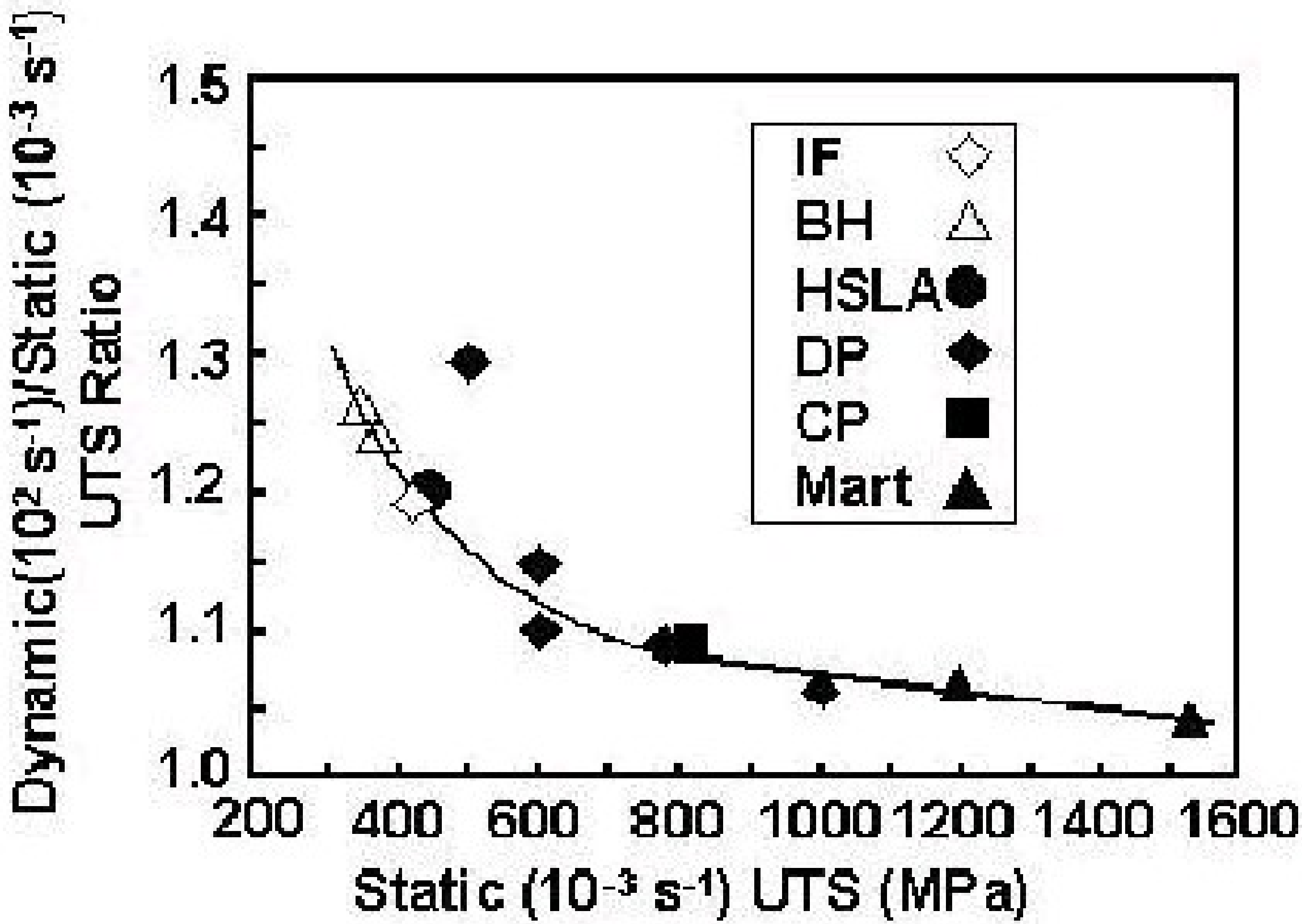
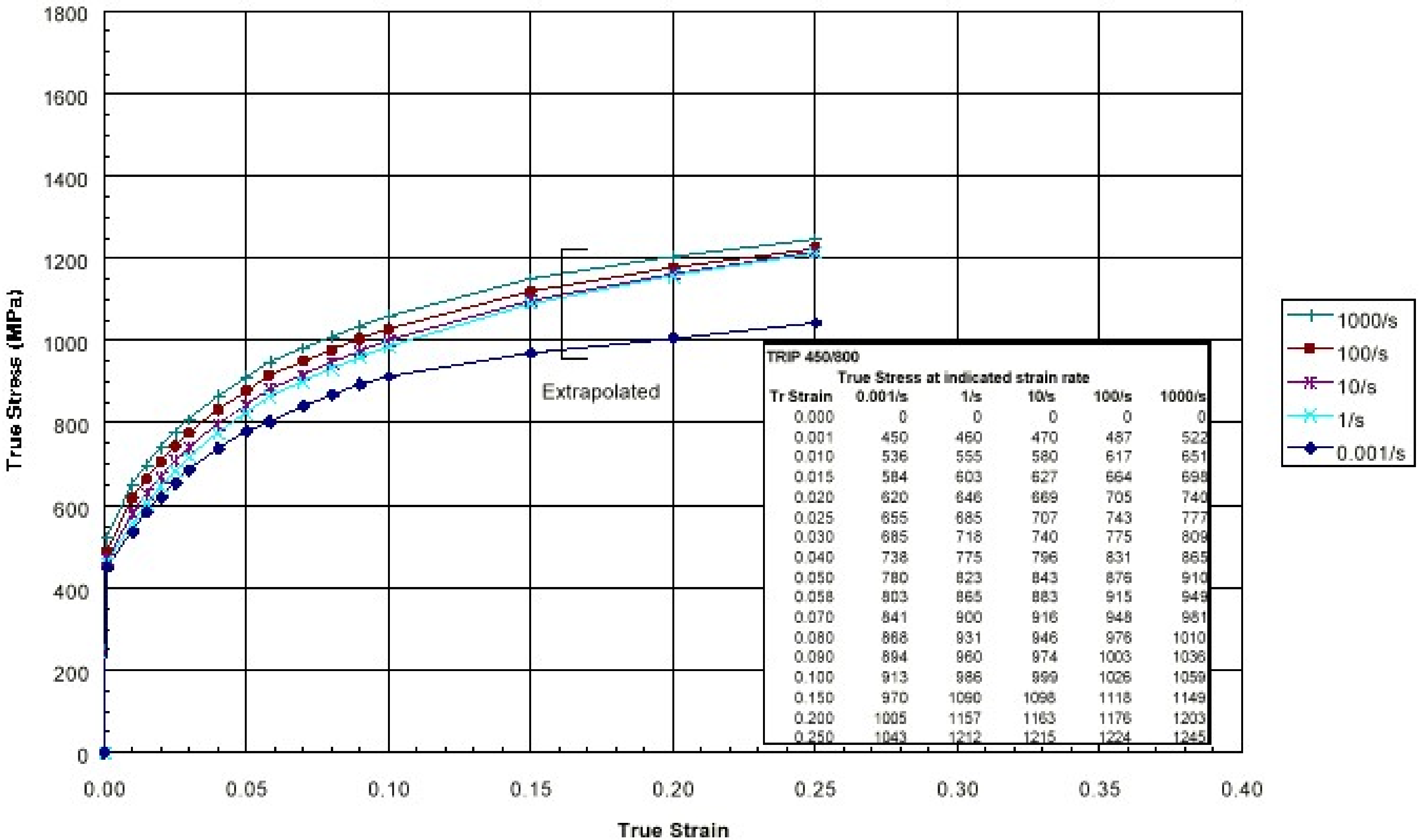


Figure 1. Ratios of static and dynamic UTS of steels in ULSAB-AVC Steel Grades Portfolio.

TRIP 450/800



TRIP 450/800

	True Stress at indicated strain rate				
Tr Strain	0.001/s	1/s	10/s	100/s	1000/s
0.000	0	0	0	0	0
0.001	450	460	470	487	522
0.010	536	555	580	617	651
0.015	584	603	627	664	698
0.020	620	646	669	705	740
0.025	655	685	707	743	777
0.030	685	718	740	775	809
0.040	738	775	796	831	865
0.050	780	823	843	876	910
0.058	803	865	883	915	949
0.070	841	900	916	948	981
0.080	868	931	946	976	1010
0.090	894	960	974	1003	1036
0.100	913	986	999	1026	1059
0.150	970	1090	1098	1118	1149
0.200	1005	1157	1163	1176	1203
0.250	1043	1212	1215	1224	1245

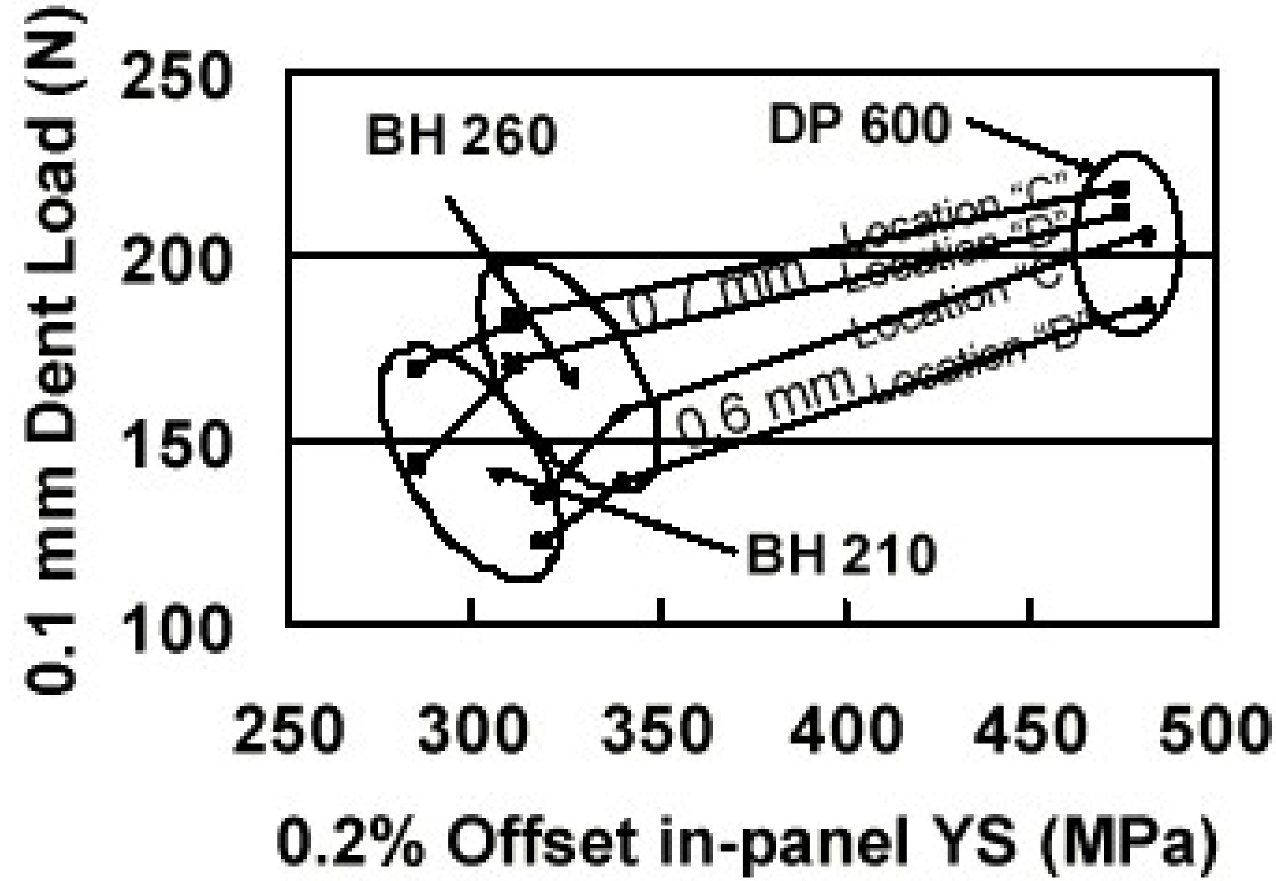


Figure 7. Effect of 0.2% offset in-panel YS on dent load in ULSAC doors (13).

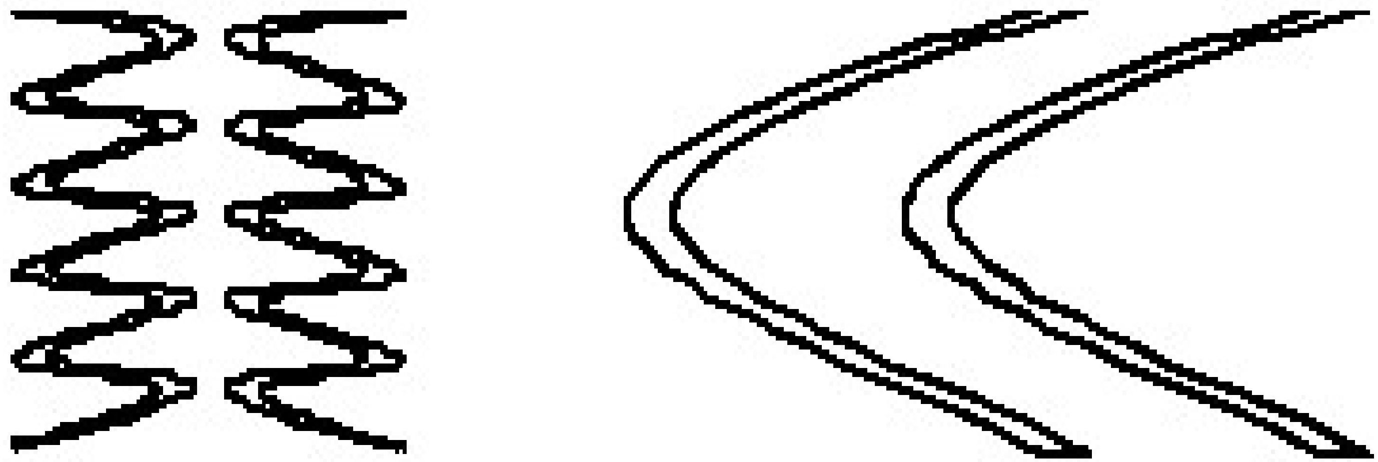


Figure 4. Comparison of deformed geometry resulting from stable axial collapse and unstable plastic buckling.

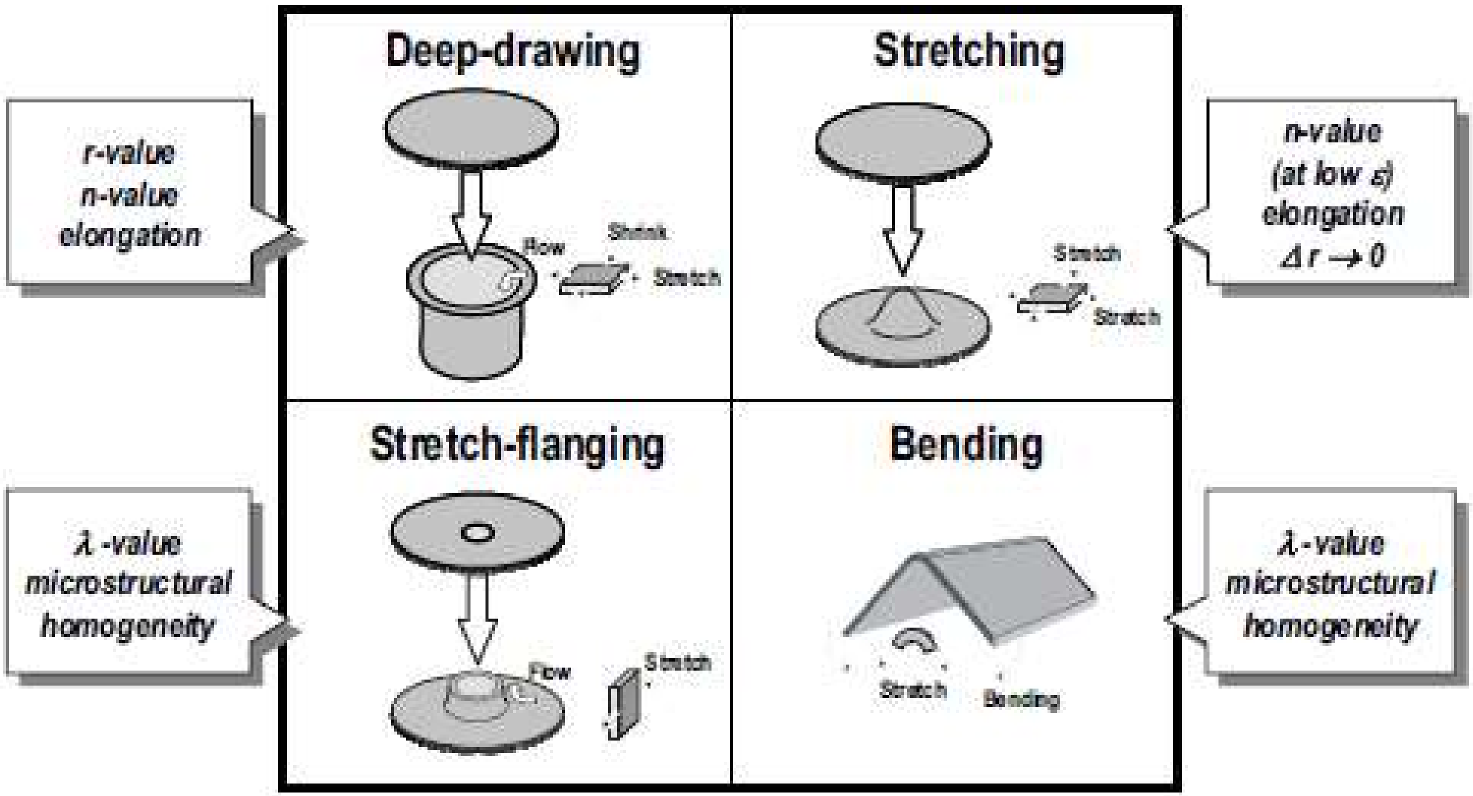


Figure 6. Different modes of sheet metal forming and characteristic material properties influencing the forming behavior.

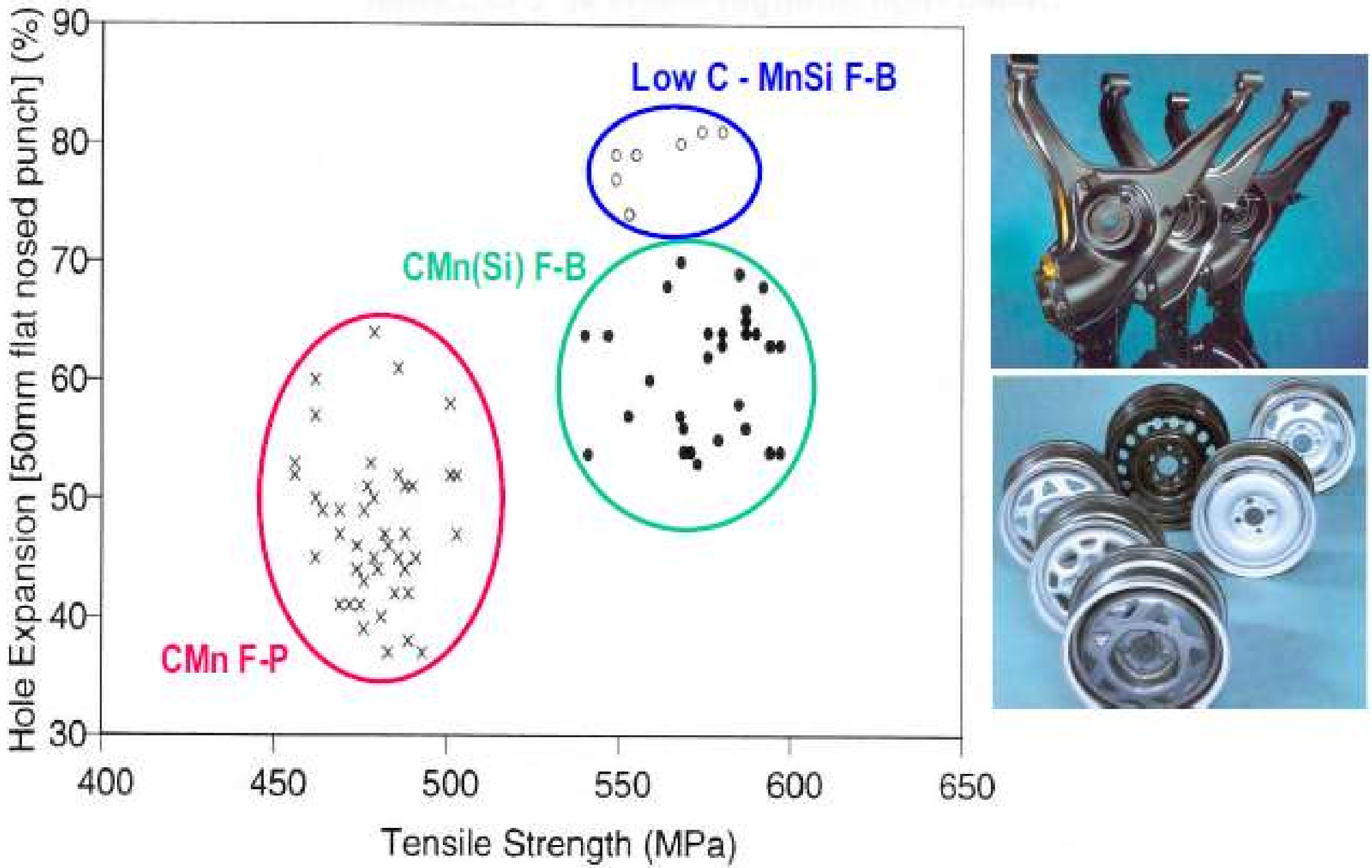


Figure 9. Relationship between hole expansion ratio and tensile strength for various steel types (F-P: ferritic-pearlitic, F-B: ferritic bainitic) and typical applications.

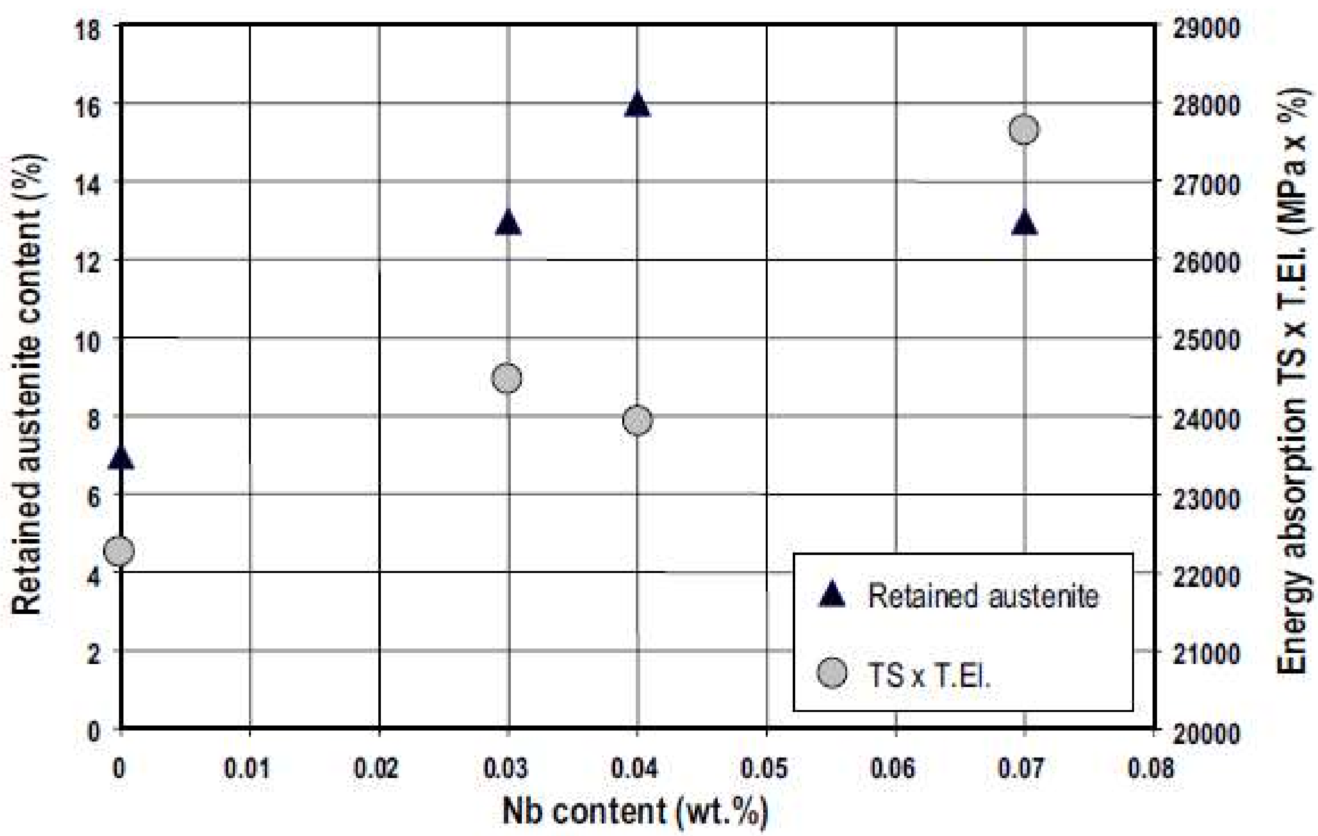


Figure 8. Effect of niobium on energy absorption capability and volume fraction of retained austenite in hot-rolled CSiMnAl TRIP steel [19].

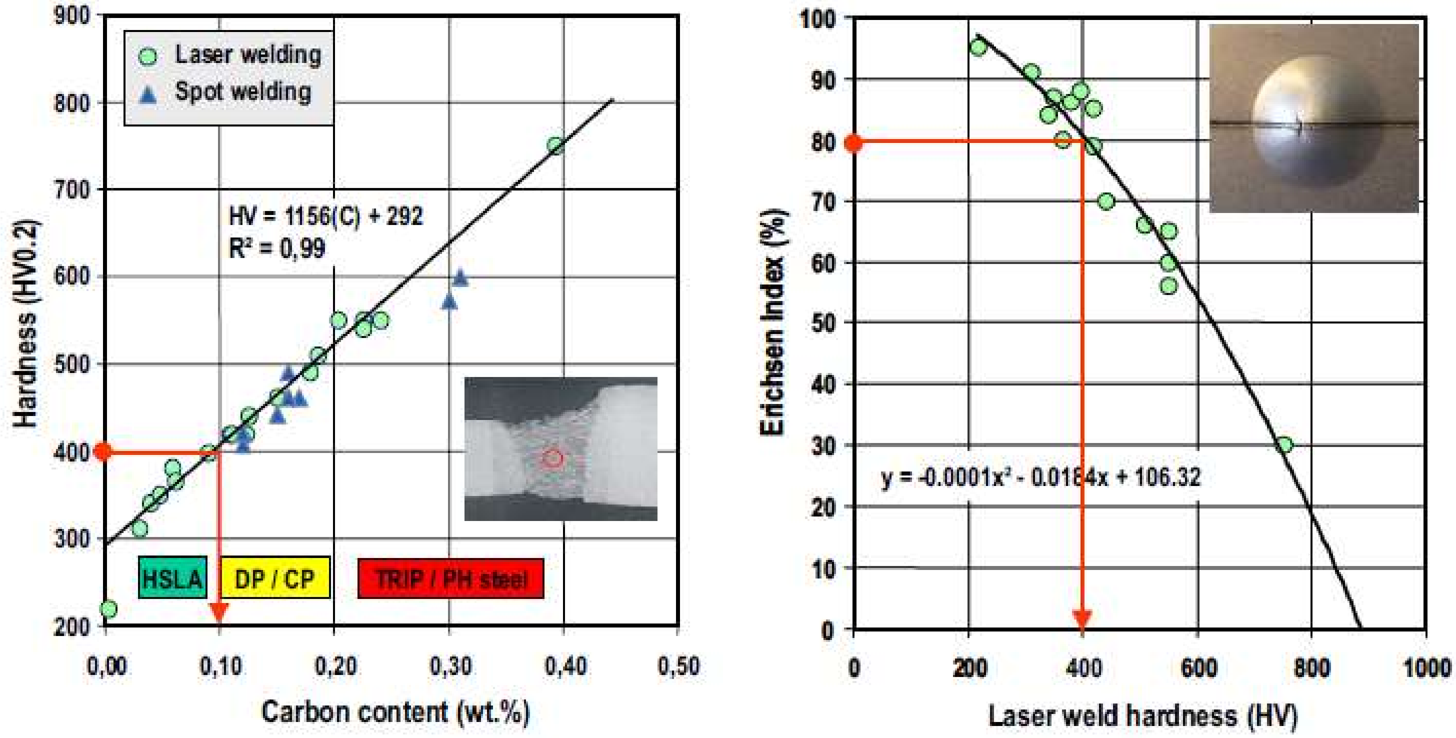


Figure 10. Relationship between carbon content and weld hardness in automotive steel after laser and resistance spot welding (left). Correlation between weld ductility and weld hardness after laser welding evaluated by Erichsen cup testing (right).

Table I. Technological achievements of the ULSAB projects and current implementation in serial production vehicles.

	ULSAB	USLAB-AVC	Serial 2004 +
Steel grades (YS)			
HSS < 350 MPa	83%	33%	30-60%
EHSS < 700 MPa	10%	61%	5-30%
UHSS > 700 MPa	—	4%	2-15%
Tailored Products			
Tailor welded blanks	✓	✓	✓
Tailored tubes	—	✓	occasional
Tailor rolled blanks	—	✓	✓
Roll Forming	—	—	✓
Hot Forming	—	—	✓
Tube Hydro Forming	✓	✓	occasional
Sheet Hydro Forming	✓	✓	occasional
Laser Welding / Brazing	<20 m	> 100 m	up to 60 m

Table III. Product forms of different steels in commercial production or customer trials.

	Hot rolled			Cold rolled		
	uncoated	Electro-galvanised	Hot dip galvanised	uncoated	Electro-galvanised	Hot dip galvanisied
BH				√	√	√
IF-HS				√	√	√
P				√	√	√
IS				√	√	√
HSLA	**√**	**√**	**√**	**√**	**√**	**√**
DP	√			√	√	√
TRIP	√	√		√	√	√
CP/PM	√			√		

√ : available

SUMMARY

- HSLA Steels still are the most preferred steels
- AHSS steels are coming up, require the confidence building on spring – back, cost etc.
- Auto- Steel Partnership is a must for taking the area forward with benefit for both


Thank You

Expert System based Heating Control system for Bell Annealing Line # 2, Cold Rolling Mill, Bokaro Steel Plant

S. Mitra*, S. K. Saha*, M. Gangadaran*, B. K. Prasad*, A. K. Paul*, S. K. Roy*, N. K. Ghosh, S. Chattopadhyay**, S. Roy Choudhary****

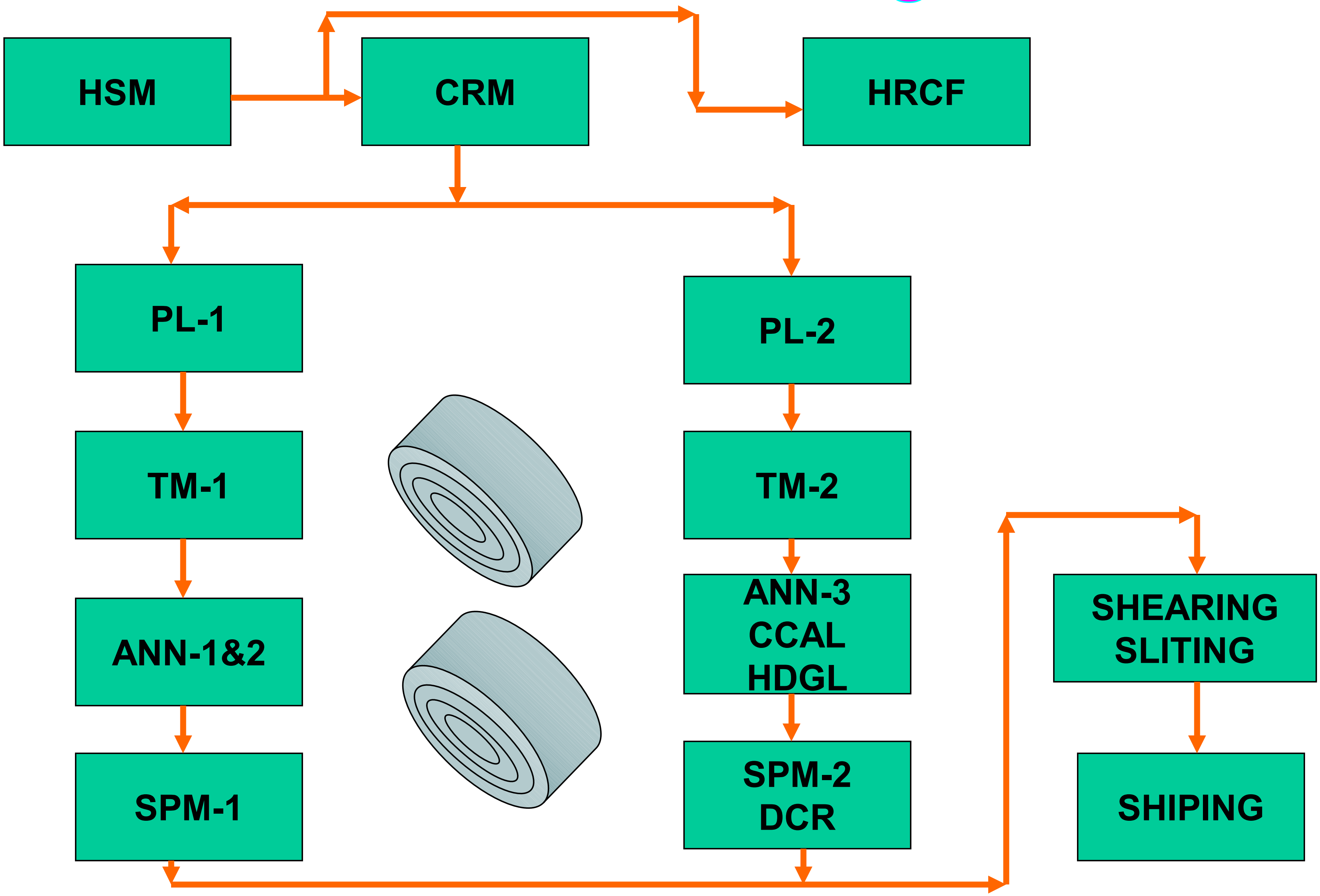
*** R & D Center for Iron & Steel, Ranchi**

**** Bokaro Steel Plant, Bokaro**

Background

- Cold rolling of coils in mills makes the coil grains distorted, elongated and dislocated
- **This severely deteriorates the key mechanical properties like hardness, ductility, formability, tensile strength etc.**
- Annealing is a process to remove these mechanical defects
- **CR coils after tandem rolling is heated following a certain regime and then cooled slowly**

material flow diagram

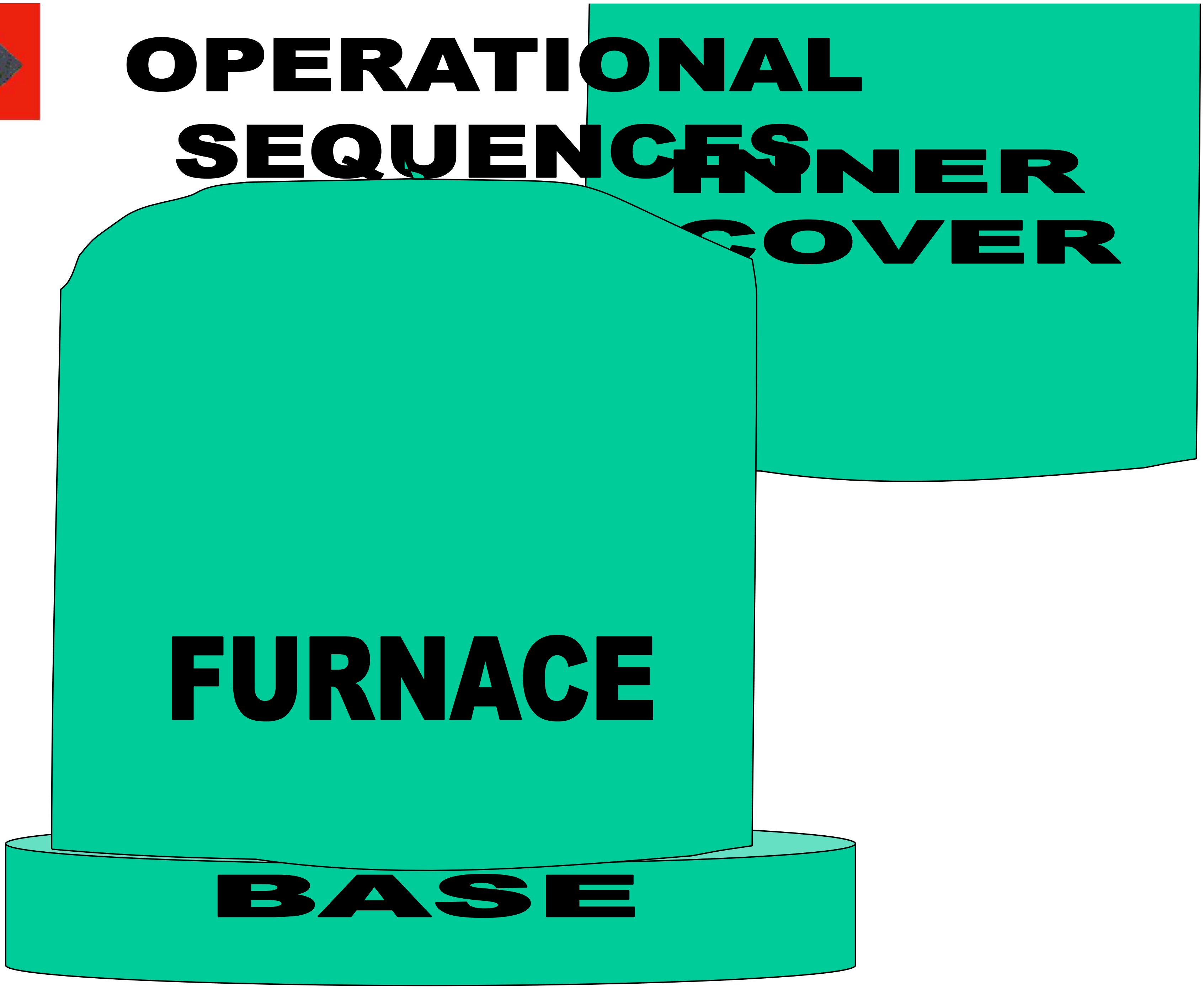


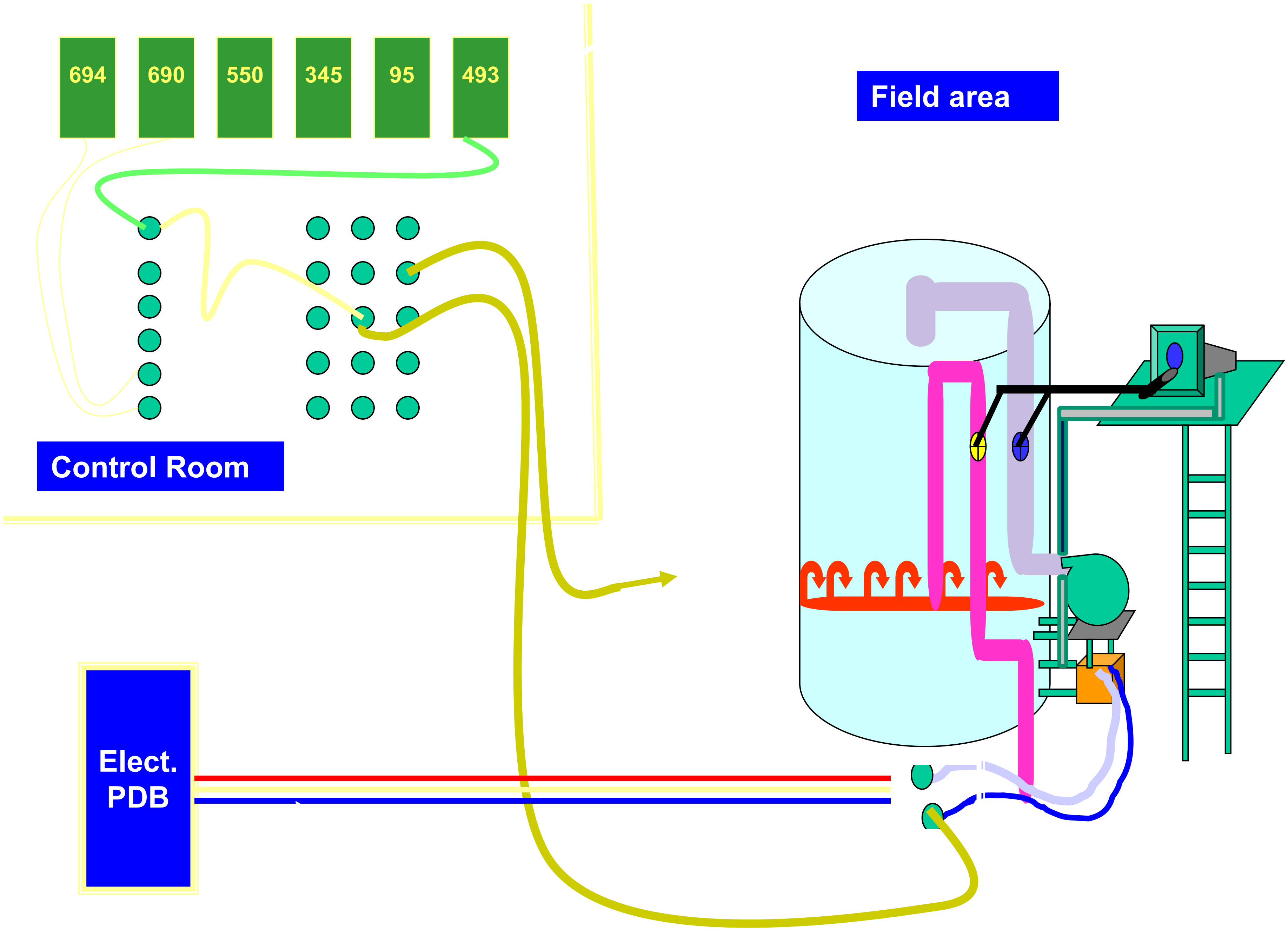
Bell Annealing Line #2, CRM, BSL

Bell Annealing Line # 2 of CRM, BSL Comprises 92 bases and 43 movable furnaces

A Typical Bell Annealing Furnace in Bokaro Steel

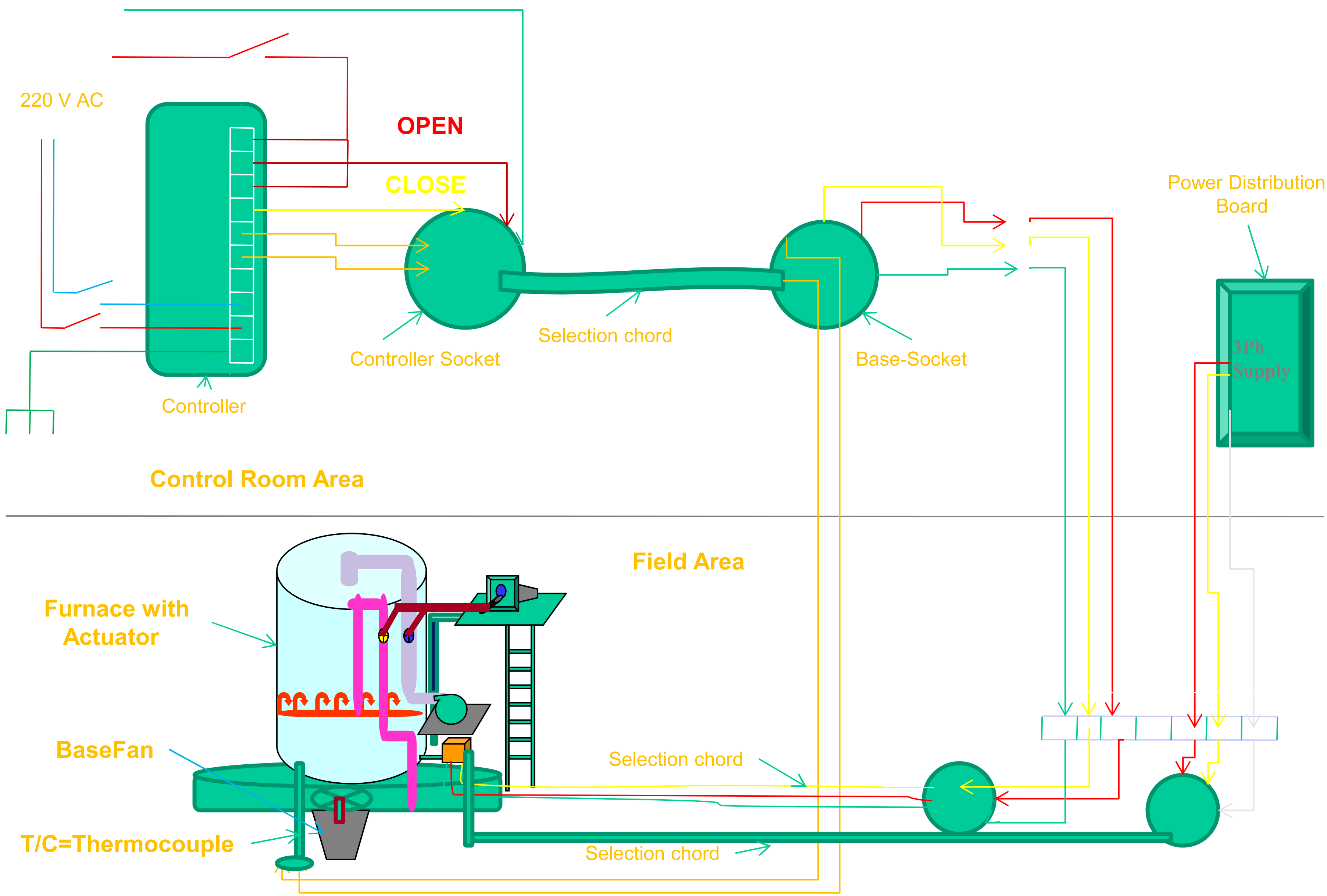
OPERATIONAL SEQUENCES





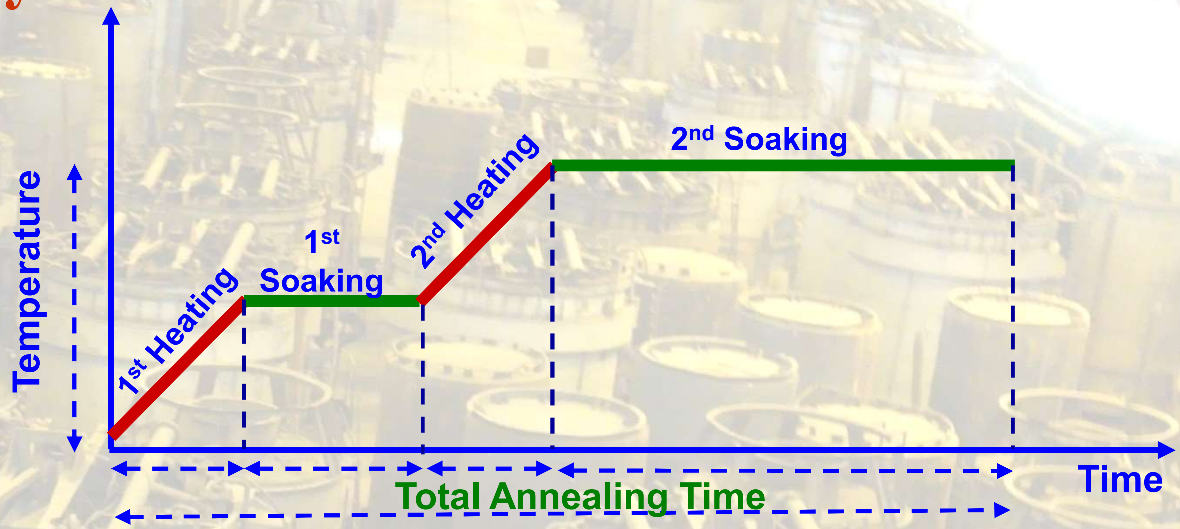
694
690
550
345
95
493
Field area
Control Room
Elect.
PDB

Electrical Circuit Diagram



Background

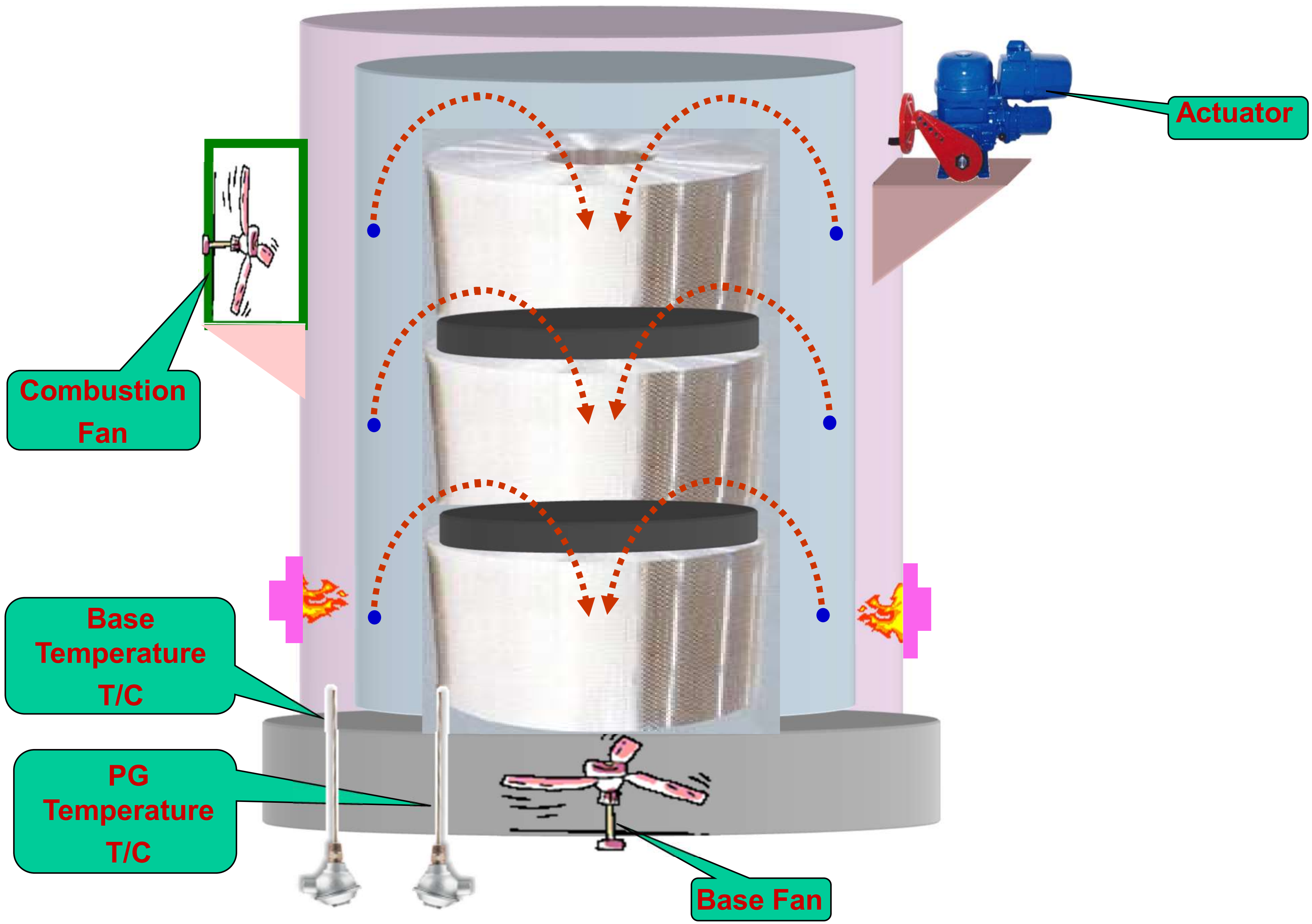
- **Selection of Optimum Annealing Cycle is imperative for coil quality**



A Typical Ideal Annealing cycle

- **Annealing Cycle depends on following Parameters :**
  - COIL WIDTH
  - COIL WEIGHT
  - STEEL GRADE
  - COIL GAUAGE

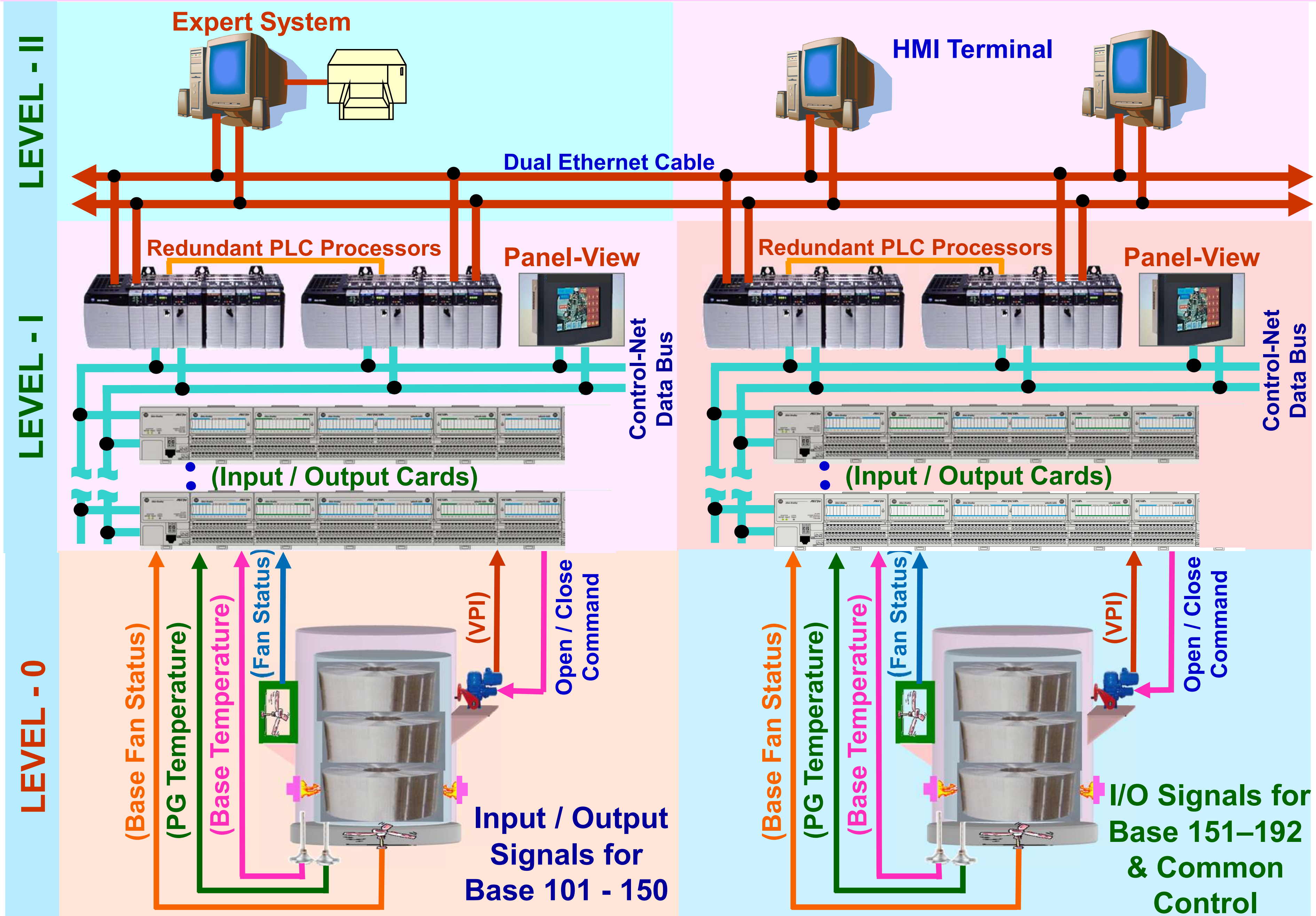
Bell Annealing Furnace



Objective

- **Introduction of Expert System and PLC based Close Loop Control System for:**
  - Selection of Optimum Annealing Cycle
  - Precision temperature control within ± 5 ^{o}C.
  - Improvement in annealing line productivity and product quality
  - Reduction in energy consumption
  - Development of Users Friendly Human Machine Interface

System Configuration (Hierarchical Control System)



Functions of Expert System

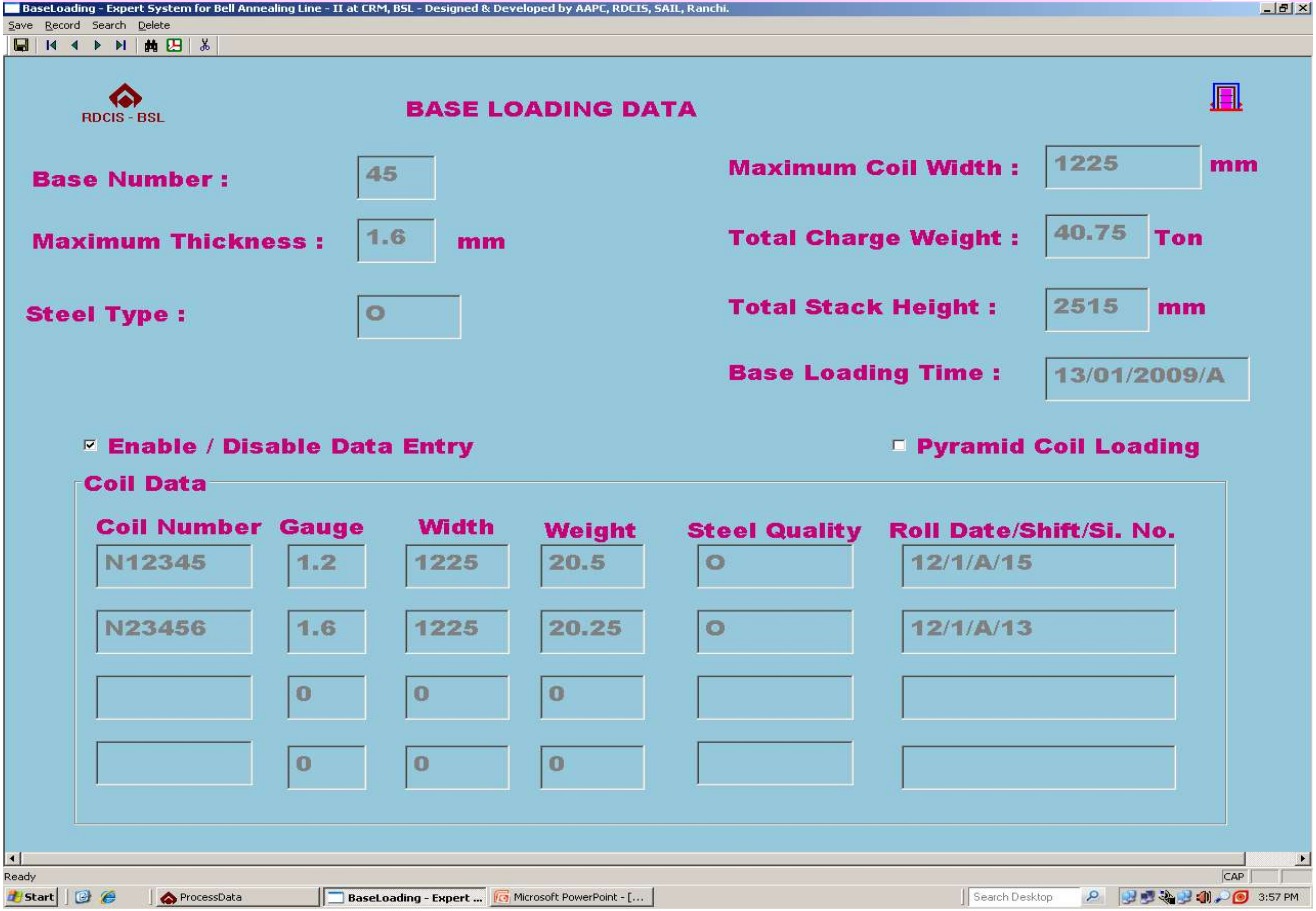
Rule based Expert System :

- Operators Guidance in Coil Selection, Mixed Charging, Total Coil Height etc.
- Selection of Optimum Annealing Cycle
- Annealing Cycle Extension

Production and Status Report Generation

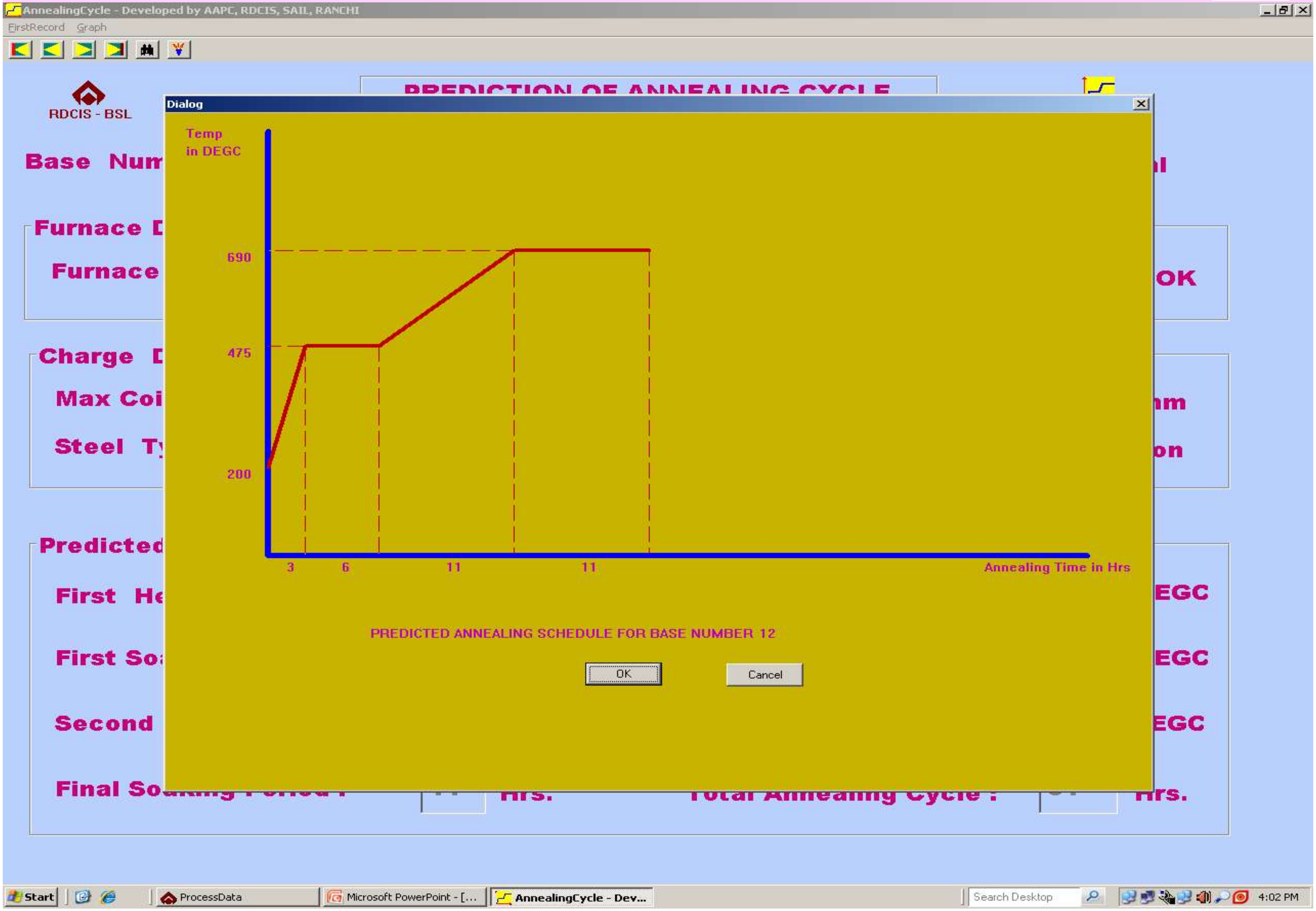
- Base Status Report
- Production Report
- Loading Report
- Unloading Report
- Base Fan Status Indication
- Defective Base Status
- Combustion Fan Status
- Excess Temperature Indication

Data Entry Screen

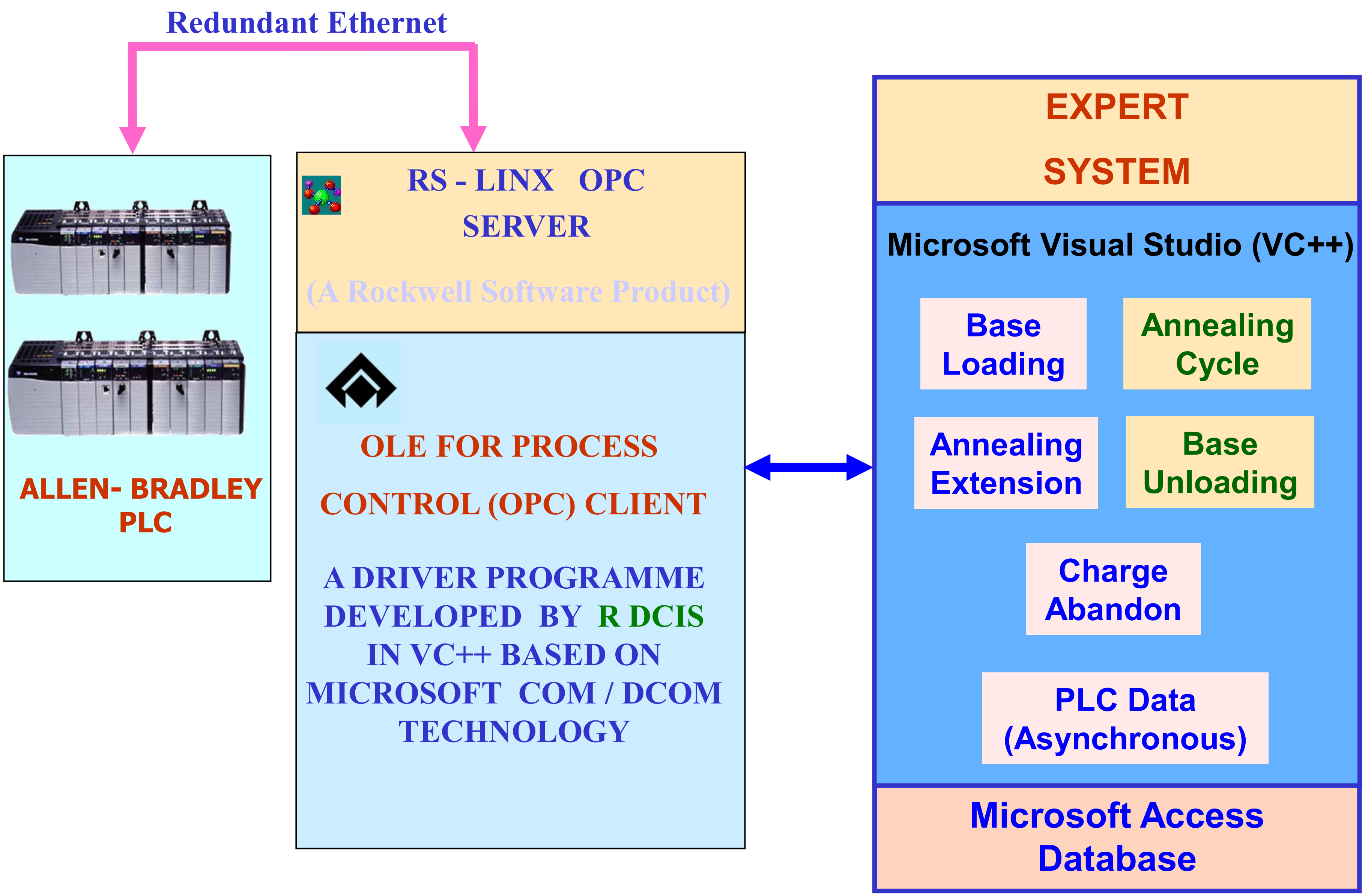


Annealing Cycle Prediction Screen

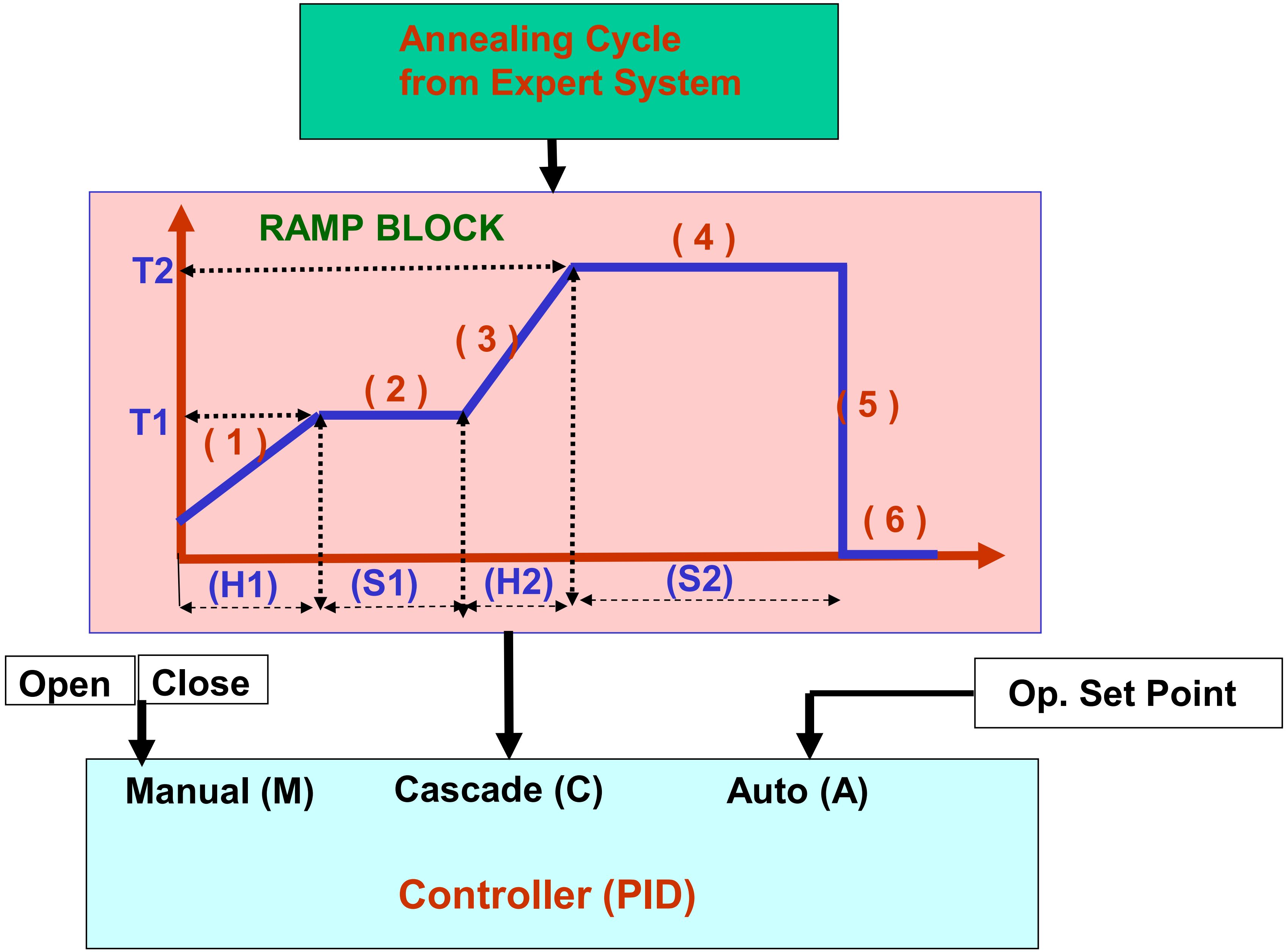
Annealing Cycle Prediction Screen



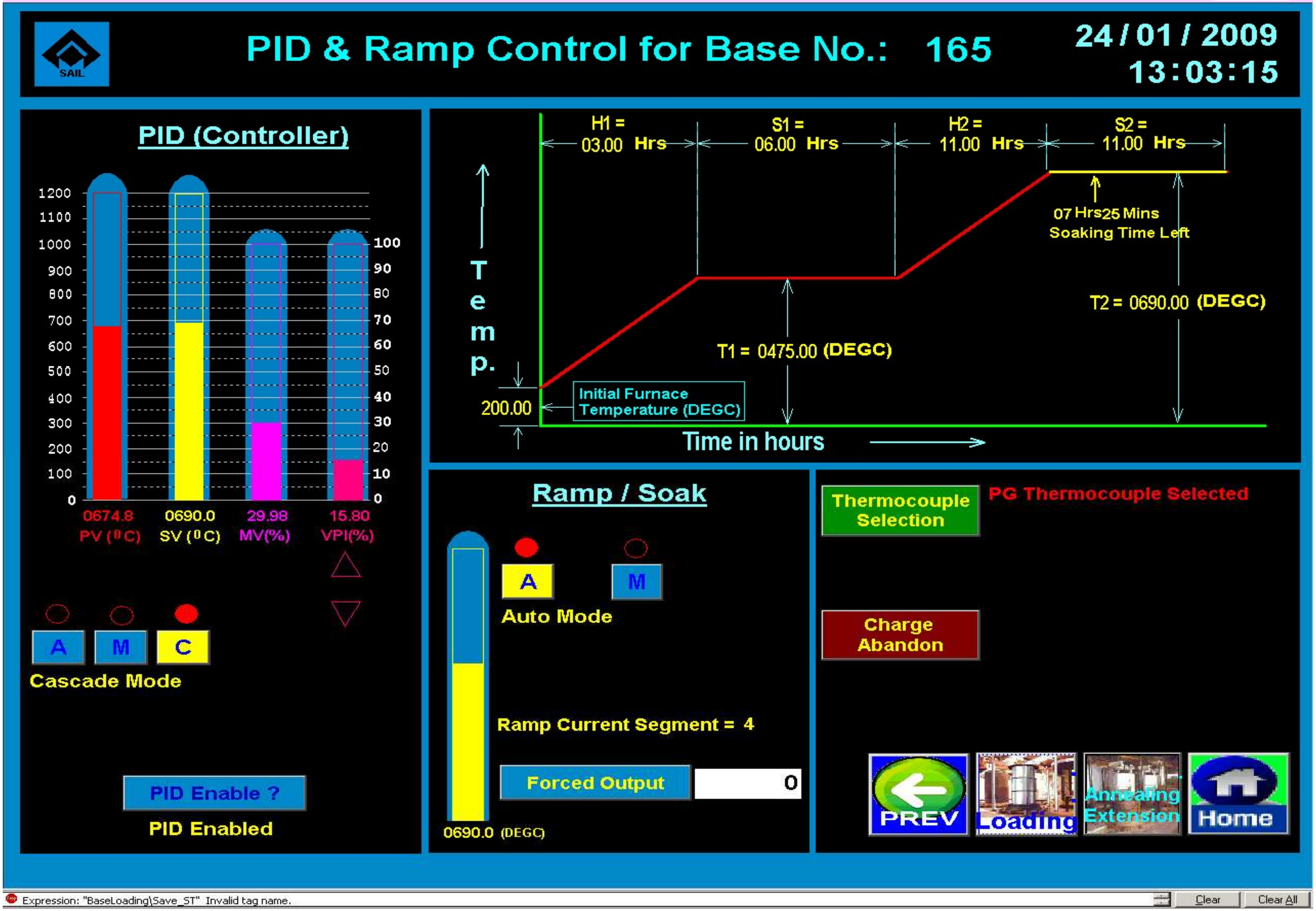
OPC based Data Communication



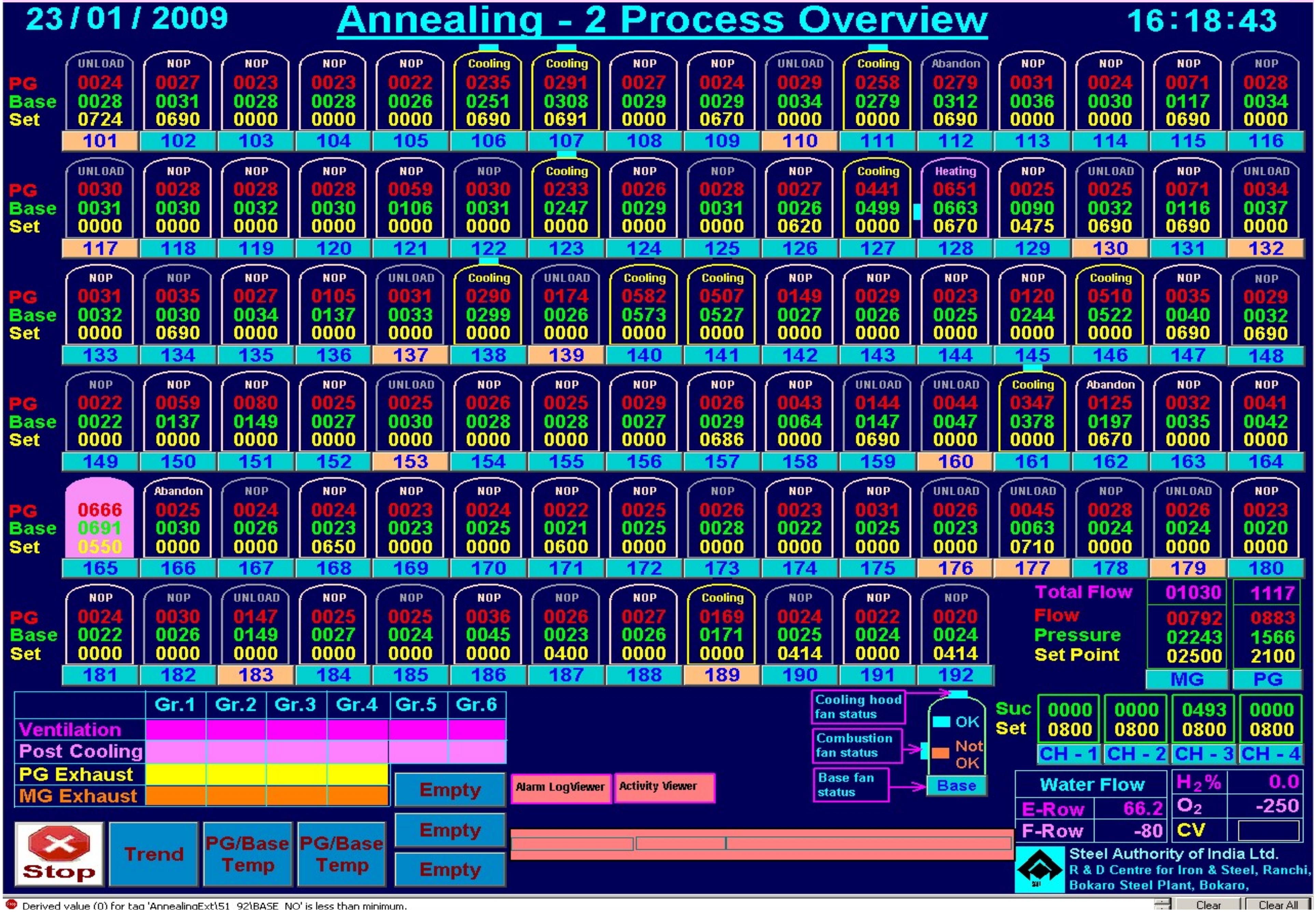
Function Block Configuration in PLC



HMI Screen for PID Control (PLC HMI)



HMI Overview Screen (PLC HMI)



HMI Overview Screen (PLC HMI)

AUTOMATED STATUS SIGNAL

Actual Process Trend (PLC HMI)

Base Status Report (Expert System HMI)

BaseStatusReport - Expert System for Bell Annealing Line - II at CRM, BSL - Designed & Developed by AAPC, RDCIS, SAIL, Ranchi.

Help Print Print Preview

BASES STATUS REPORT

BSL - RDCIS

READY BASES :

121, 142,

TOTAL READY BASES = 2 Nos.

BASES UNDER HEATING :

111, 112, 120, 123, 124, 127, 136, 141, 144, 149, 151, 154, 155, 158, 170, 183, 184, 185, 186,

TOTAL BASES UNDER HEATING = 19 Nos.

BASES UNDER COOLING :

105, 106, 107, 108, 115, 118, 119, 128, 135, 138, 140, 143, 146, 150, 163, 164, 165, 178, 180, 188,

TOTAL BASES UNDER COOLING = 20 Nos.

BASES READY FOR UNLOADING :

109, 126, 161, 168, 177,

TOTAL BASES READY FOR UNLOADING = 5 Nos.

DEFECTIVE BASES :

101, 103, 110, 113, 114, 116, 117, 122, 125, 130, 132, 134, 137, 139, 147, 148, 153, 156, 160, 166, 167,
169, 173, 174, 176, 179, 181, 182, 187, 190, 191, 192,

TOTAL DEFECTIVE BASES = 32 Nos.

EMPTY BASES :

102, 104, 129, 131, 133, 145, 152, 157, 159, 162, 171, 172, 175, 189,

TOTAL EMPTY BASES = 14 Nos.

Ready CAP NUM

Start ProcessData BaseStatusReport - E... Search Desktop 4:43 PM

Production Report (Expert System HMI)

ProductionReport - Untitled

File Edit View Help

ISO/WKS/CRM/ANN/03

PRODUCTION REPORT ANNEALING SECTION -II (C.R.M.)
COLD ROLLING MILL
BOKARO STEEL PLANT

SAIL

Date: 23:01:2009
Time: 12:41:05
Shift: A (23:01:2009)

Base No.	Chrg. No.	Fur. No.	Ann. Temp.	Ann. Hrs.	Coil No.	Coil Gauge	Coil Width	Coil Wt.	Coil Grade	Chrg. Wt.
127	2046	25	690	31	142436	1.20	1582	24.75	OBR	49.55
					142435	1.20	1582	24.80	OBR	
		TOTAL HOURS :		31				TOTAL WEIGHT :		49.55

Nos. Weight

Base Loaded :

Base UnLoaded :

Ready Bases :

Bases Under Heating :

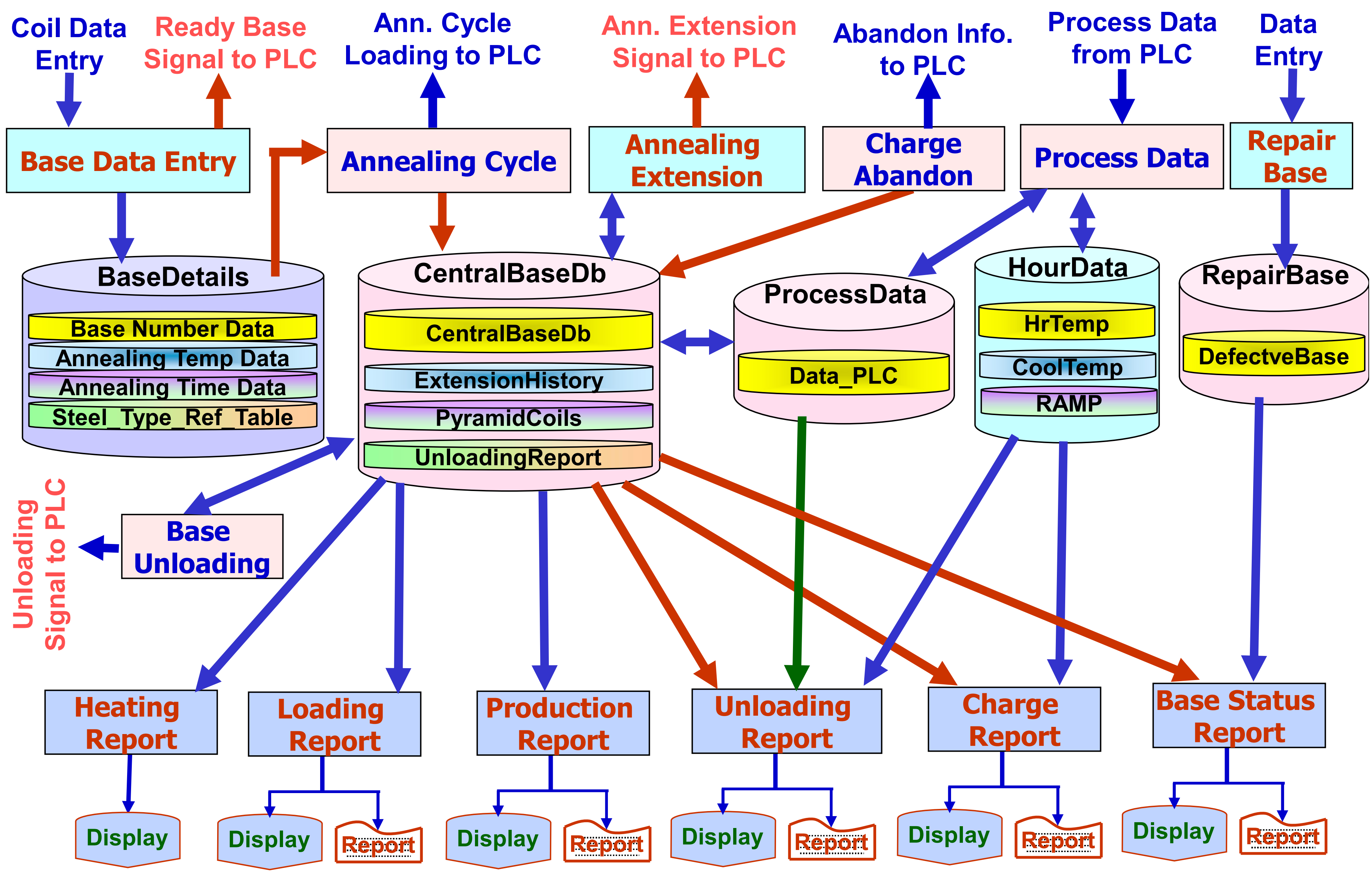
Bases Under Cooling :

Total Under Annealing :

Ready NUM

Start ProcessData RSLogix 5000 - PLC1 i... Instruction1.doc [Com... Microsoft PowerPoint -... ProductionReport - ... Search Desktop 12:41 PM

Software Configuration



Conclusion

- Close Loop Expert System is in regular use at CRM, BSL since January' 2009
- Monitoring and control of entire line from centralized control room
- Effective application of OPC for on-line communication between Expert System and PLC
- Very Precision temperature control with ± 5 ºC
- Base Productivity Improvement by 7.9 %
- Reduction in Specific heat Consumption by 8%


" THANK YOU "
There's a little bit of SAIL in everybody's life

Special quality cold rolled steel from BSL

Anjana Deva, Saikat K De, S Chakraborty*, S Roychoudhury*, S Mallik*, B.K. Jha,

* BSL

Cold rolled steels

- **Applications**
  - Auto,
  - white goods
  - construction
  - power segments

- **Grades**
  - Cold rolled boron steel for critical forming applications,
  - Thinner gauge SAILCOR for regenerator air-preheater elements and
  - Customised DD for electrostatic precipitator

Boron containing super EDD steel

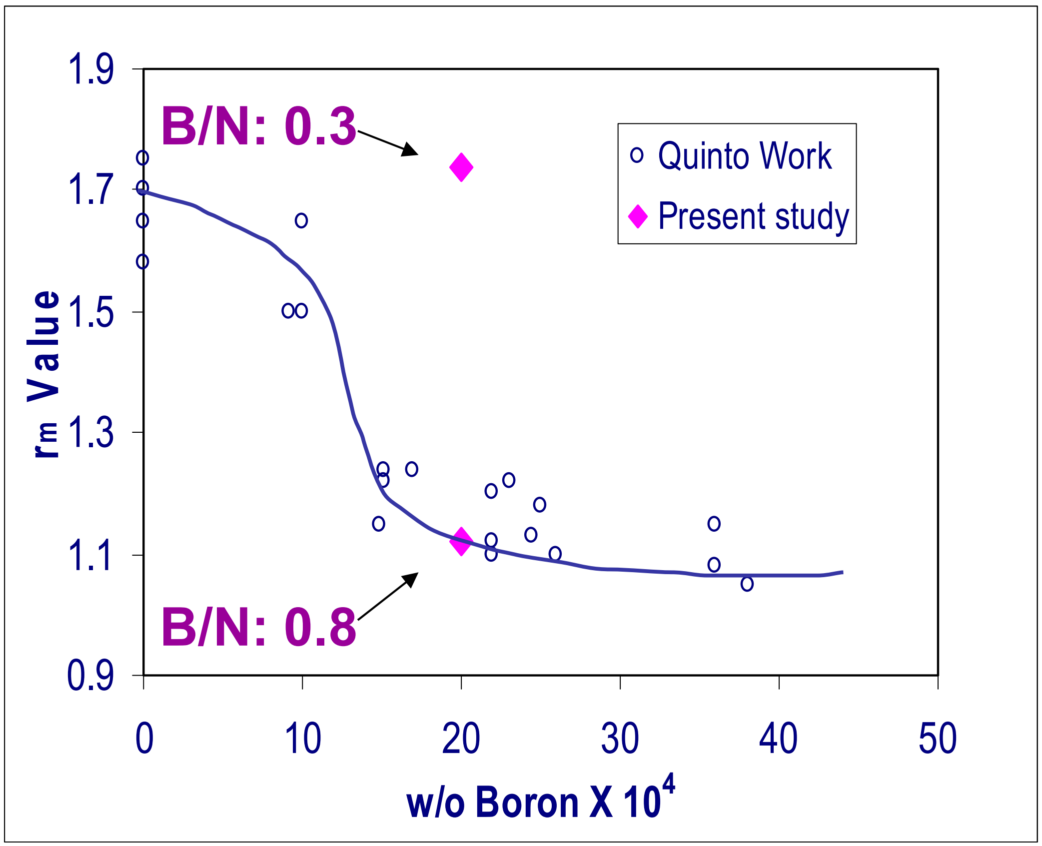
- B in continuous annealed low carbon steel
  low YS and high r_m value - attributed to ferrite grain growth after recrystallisation in the annealed steel

- B in batch annealed IF steel for reducing cold work embrittlement

- Influence of boron in batch annealed low carbon aluminum killed steel - limited Work

Boron in Batch annealed CR

- B results a pronounced deterioration in the [111] texture and r_m value
- Absolute B rather than B/N ratio : Main contributory factor in deterioration of r_m value



Author :
D. T. Quinto &I. F.Hughes

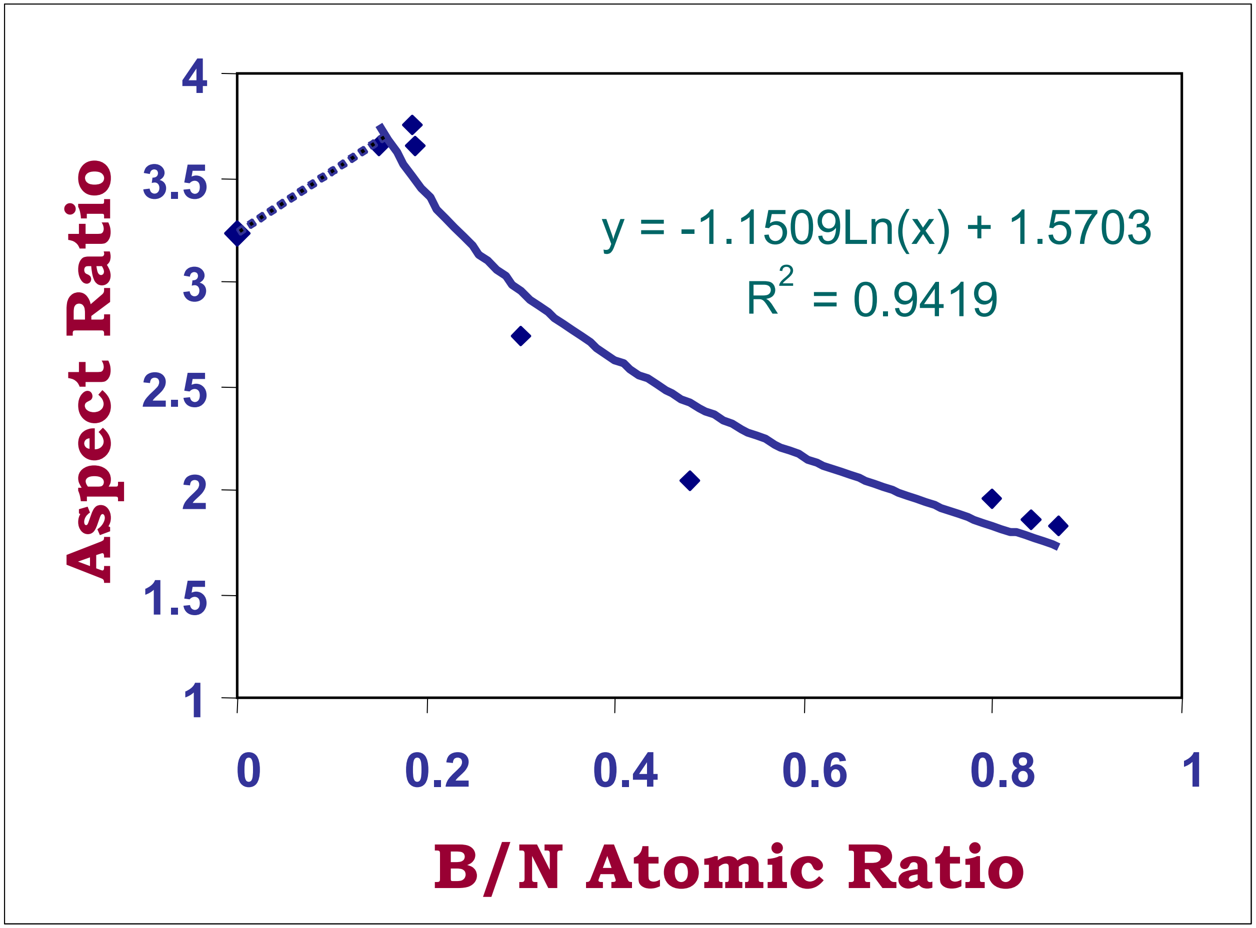
Journal:
Met Trans A,

- Present Work

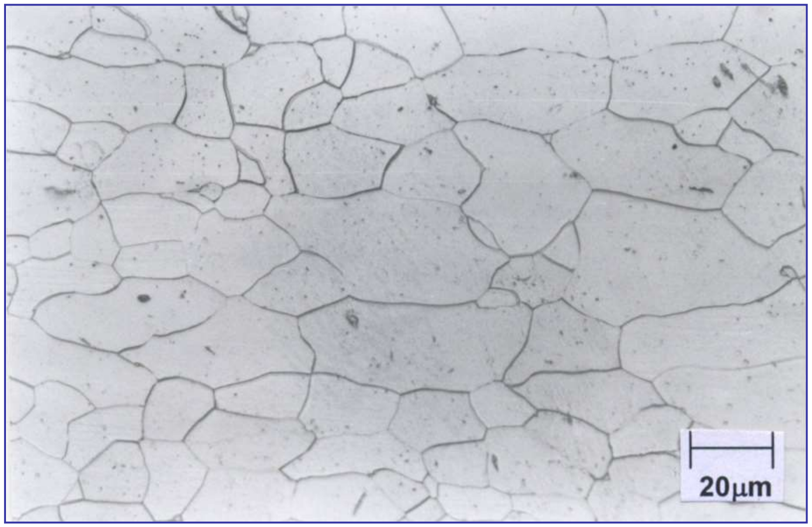
C : 0.03-0.06 %
Mn : 0.15-0.20
B/N : 0-0.87

Variation in 'Aspect Ratio'

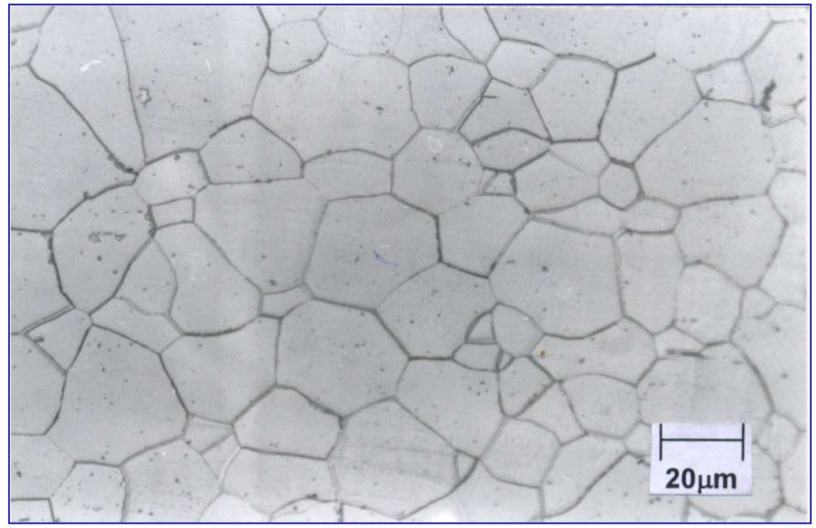
(with increasing B/N ratio)



Effect of B/N on microstructure



B/N: 0.3
(r_m:1.76)



B/N : 0.8,
(r_m:1.12)

High r_m value and pan-caking observed in low C (~ 0.06 %) batch annealed Boron (20 ppm) added steel

Boron containing super EDD steel

- B/N ratio (Not the absolute boron) - controls the properties of batch annealed aluminum killed steel
- Optimum amount of boron, nitrogen and aluminum - can lead to coarse pancake structure - ideally suited for improved formability
- B/N ratio (0.3) with controlled processing parameter has led to development of super EDD with

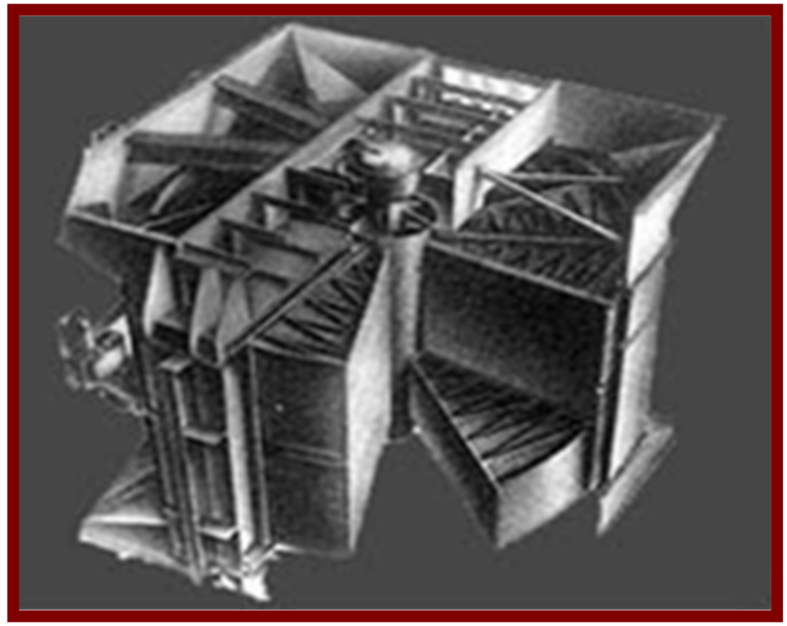
  Lower YS (150-170 MPa),

  High elongation (42-44 %) and

  High r_m (1.8 min.)

Thinner gauge (1.21 mm) SAILCOR

- BHEL Ranipet requirement
  SAILCOR grade steel
  1.21 X 300 mm slit coils
  thickness tolerance,
  +0.07 mm and - 0 mm



Roll formed section for regenerator air-preheater elements
Heat transfer purpose

- Although CORTEN steel, under the brandname of SAILCOR
  developed by SAIL earlier

- Never been trial to produce in such a lower thickness range (< 1.4 mm)

Plant Trial

- HSM - PL II - TM II – Annealing – Slitting route
- For cold rolling of 1.2 mm thick CR coils of such a high strength, special measures undertaken
  - Increasing inter stand tension by 20 % more as compared to that in normal grade
  - Introduction of 0.8 % emulsion concentration in 1st strand instead of only hot water
  - Increase in emulsion concentration from 1.5 -2 % to 2% in remaining strand
  - Equal amount of reduction is given to first four strands while fifth strand was used for only skin pass

Performance Trial

- Coils were successfully tried at M/s BHEL, Ranipet, Processing steps includes

  Decoiling of the supplied slit coils of 300 mm width to feed to crimping line / cut to length plain sheet line

  to produce profiles cut sheets and plain sheets

- These crimped sheet / plain sheets are used as alternate layers in heat transfer boxes

Customized CR – Deep Drawing grade

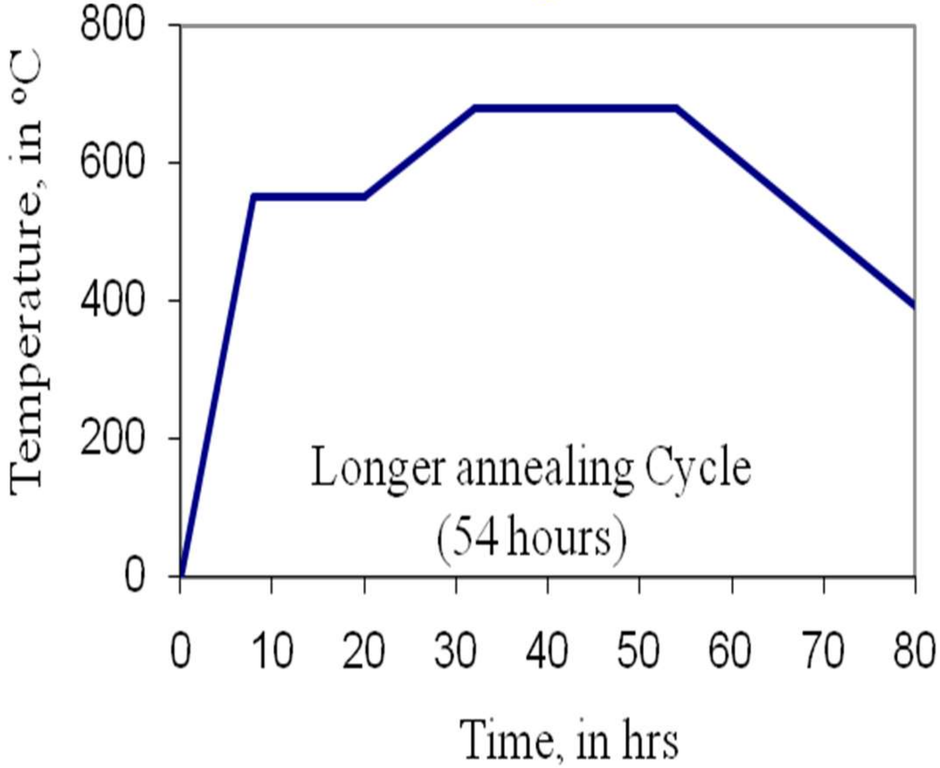
- BHEL requirement for fabrication of electrostatic precipitator,
  Cold rolled batch annealed DD grade steel (equivalent to JISG 3141 SPCD-SD)
  Hardness : less than 45 HR_B

- Annual Demand : 35000 - 40000 T
  thickness : 1.25 mm and width : 903 mm

- Dimensional requirement input material includes
  tolerance on thickness : - 0 + 0.07 m,
  tolerance on width : - 0 + 3 mm

Plant Trial

- Low carbon steel processed through CC – HSM – PL II – TM II –Annealing



Standard EDD annealing cycle

- Annealed with specially designed annealing cycle - higher rate of heating (14 C/hr in place of 10.8 /hr) increased final soaking temperature (690 C)

Performance Trial




- Collecting electrodes fabricated successfully at M/s BHEL, Ranipet

- Innovative annealing cycle has resulted

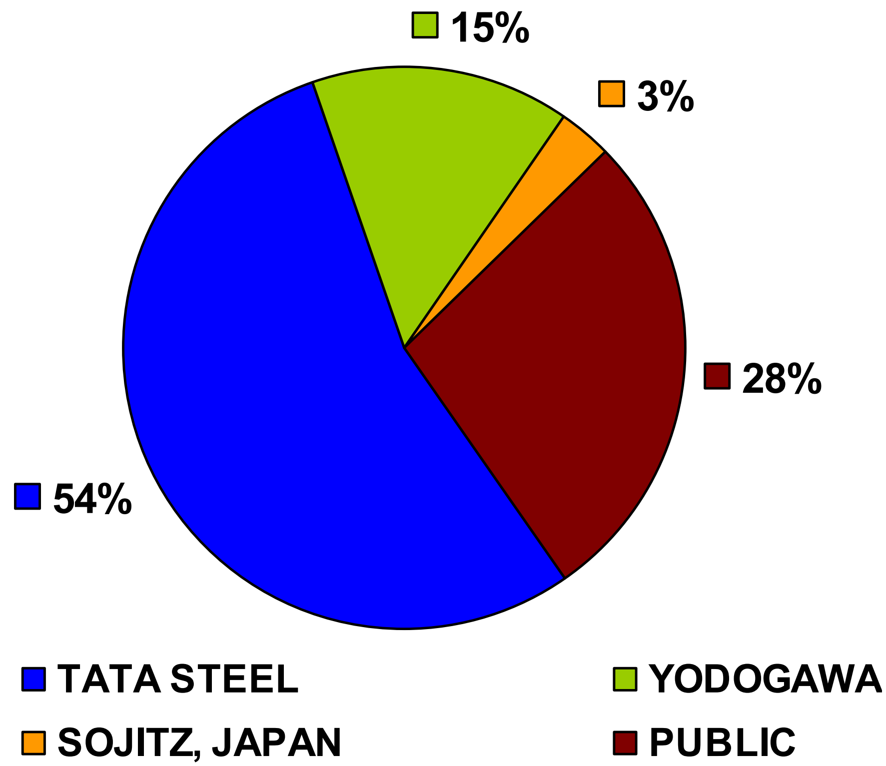
  - Desired hardness (38 to 44 HR_B)
  - Improved productivity (52 hrs in place of 54 hrs)

Thank You

TAYO ROLLS

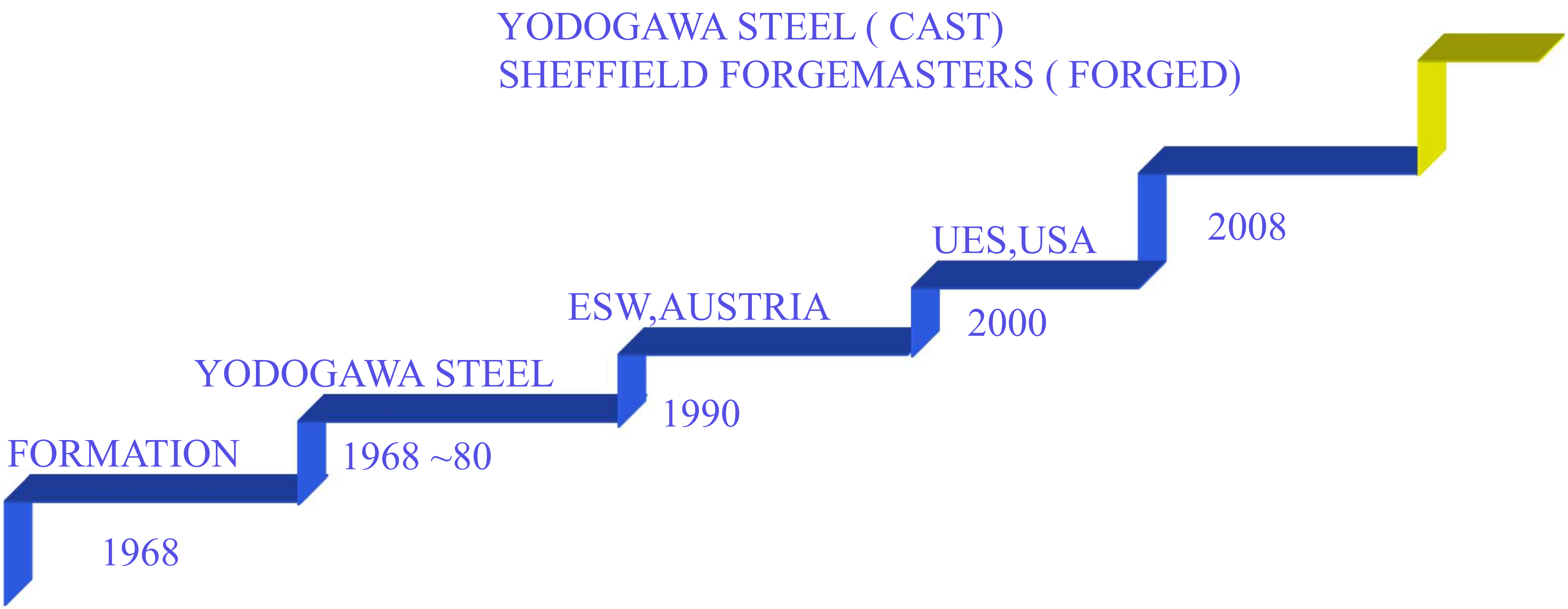
A ONE STOP ROLL-SHOP

SHARE HOLDING PATTERN



ASSOSIATION OVER THE YEARS

ROLLS FOR HOT ROLLING
ROLLS FOR COLD ROLLING



Started business activity in manufacture of Forged Rolls

TECHNOLOGY SOURCE

Sheffield Forgemasters Steel Limited

Sheffield

United Kingdom

New Forged Roll Complex

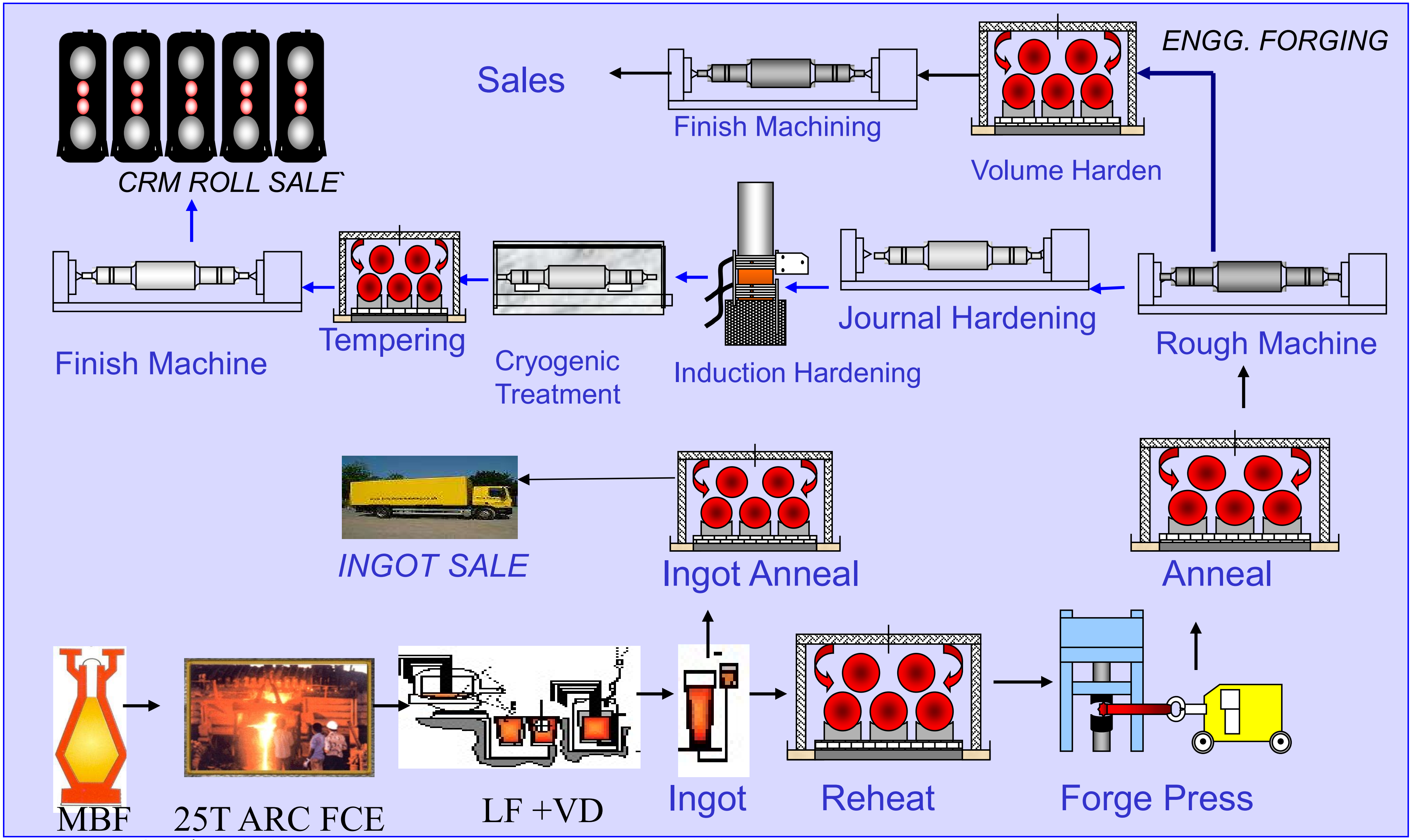
Forged Roll Composition

- 2 % Cr.
- 3 % Cr.
- 4 – 5 % Cr.

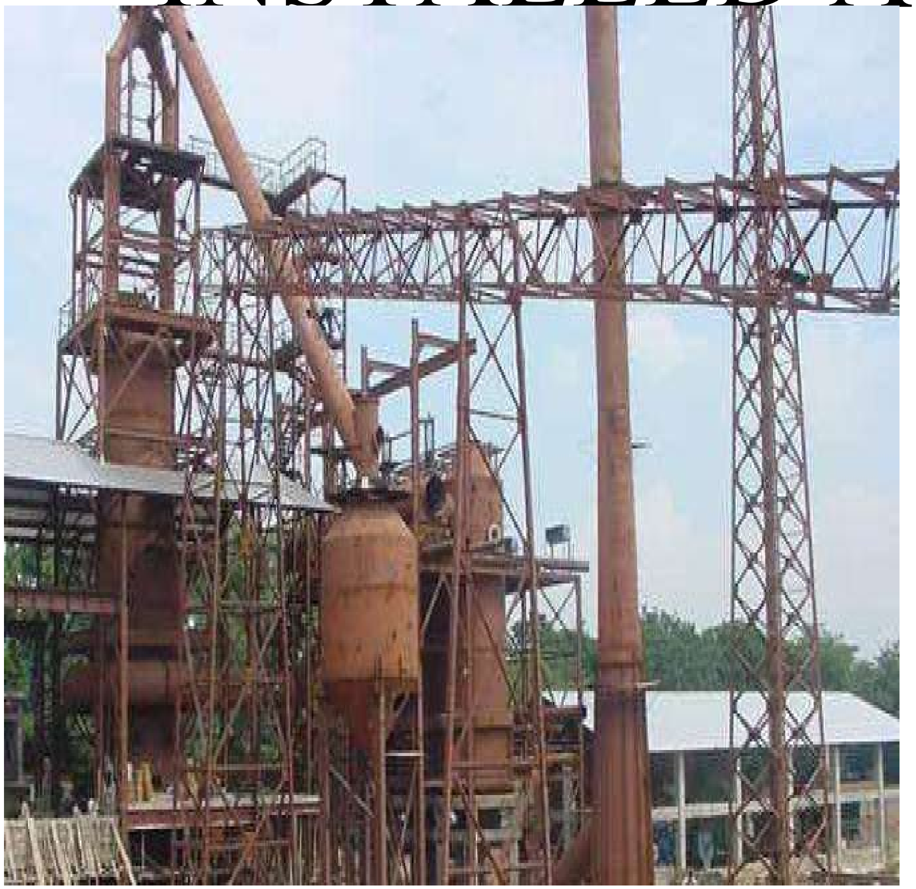
CRITICAL TO FORGED ROLL QUALITY

- Control of Melting Variable
- Forging Ratio
- Prior Structure
- Hardening Technique

PROCESS FLOW – FORGED ROLLS



KEY FACILITIES INSTALLED AT TAYO



MBF

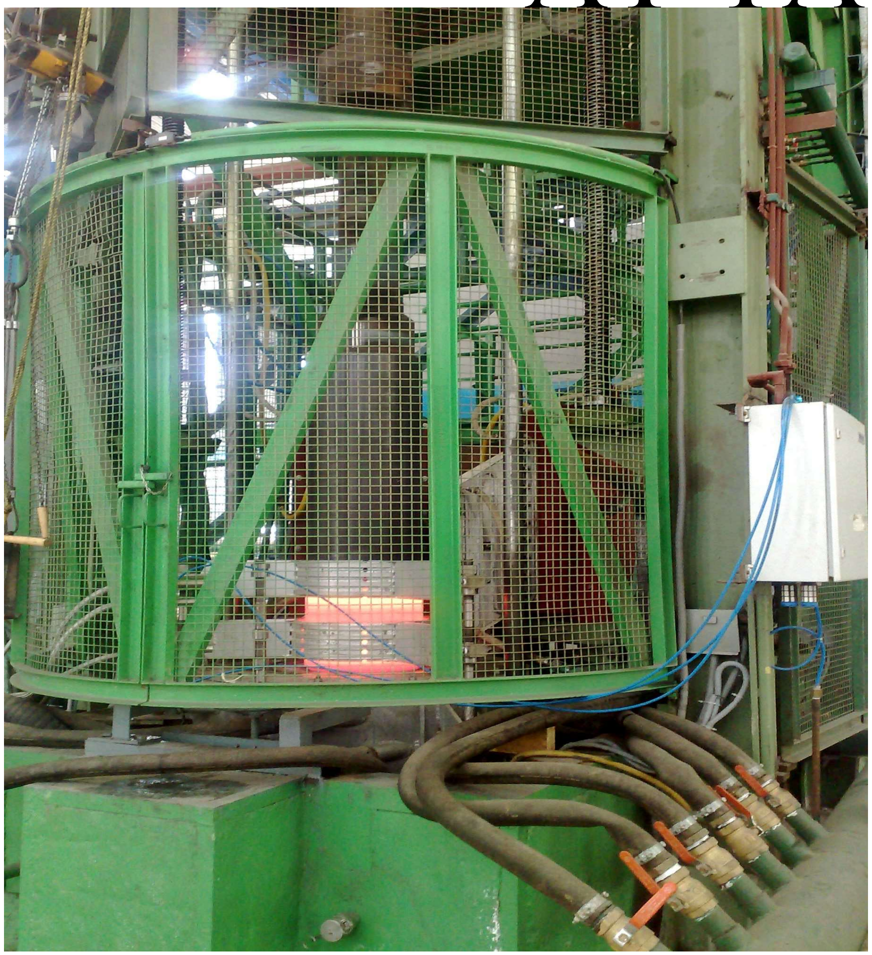
EAF

KEY FACILITIES INSTALLED AT TAYO

FORGING PRESS

MANIPULATOR

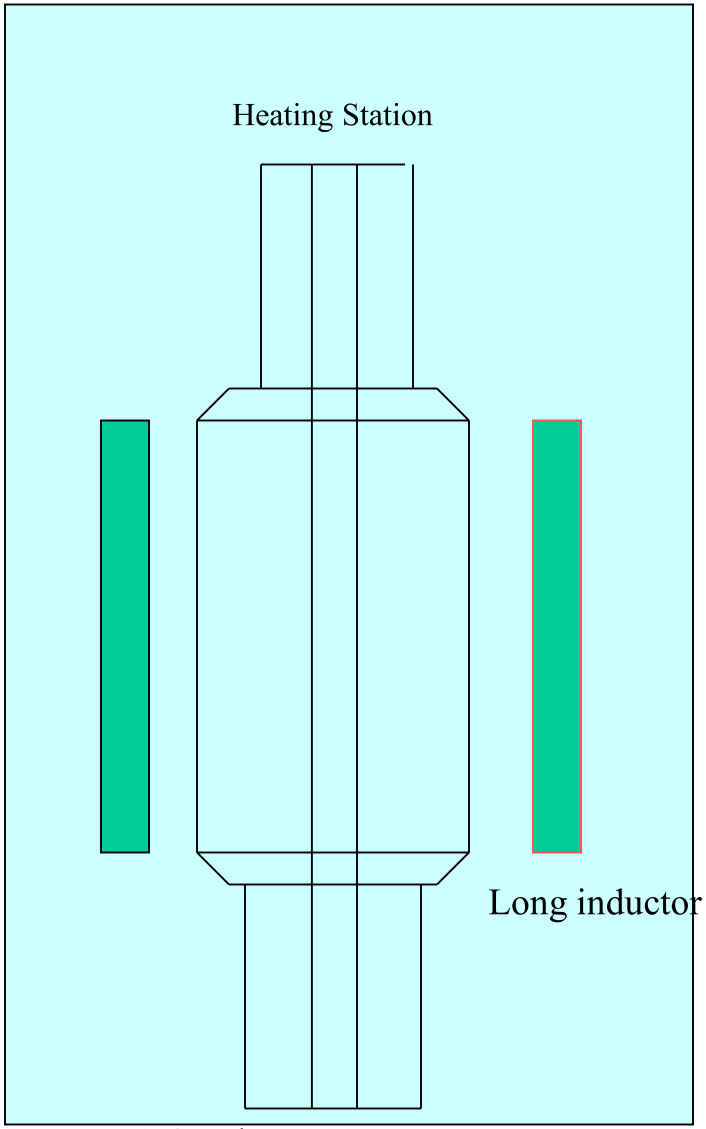
KEY FACILITIES INSTALLED AT TAYO

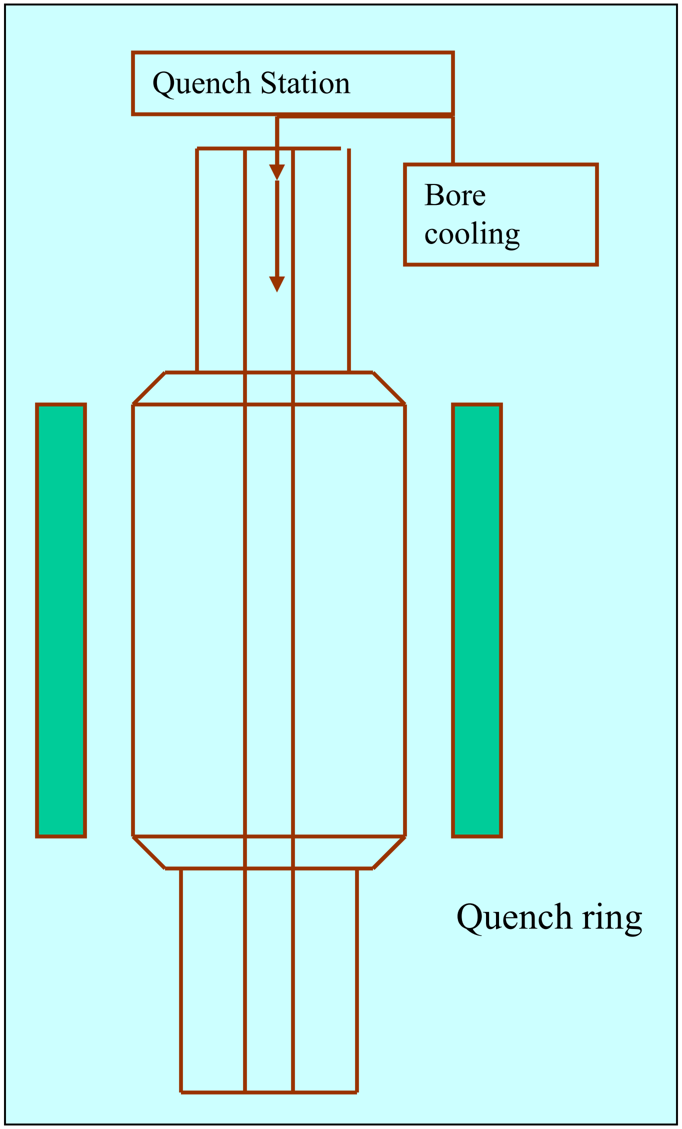


BARREL HARDENING M/C

JOURNAL HARDENING M/C

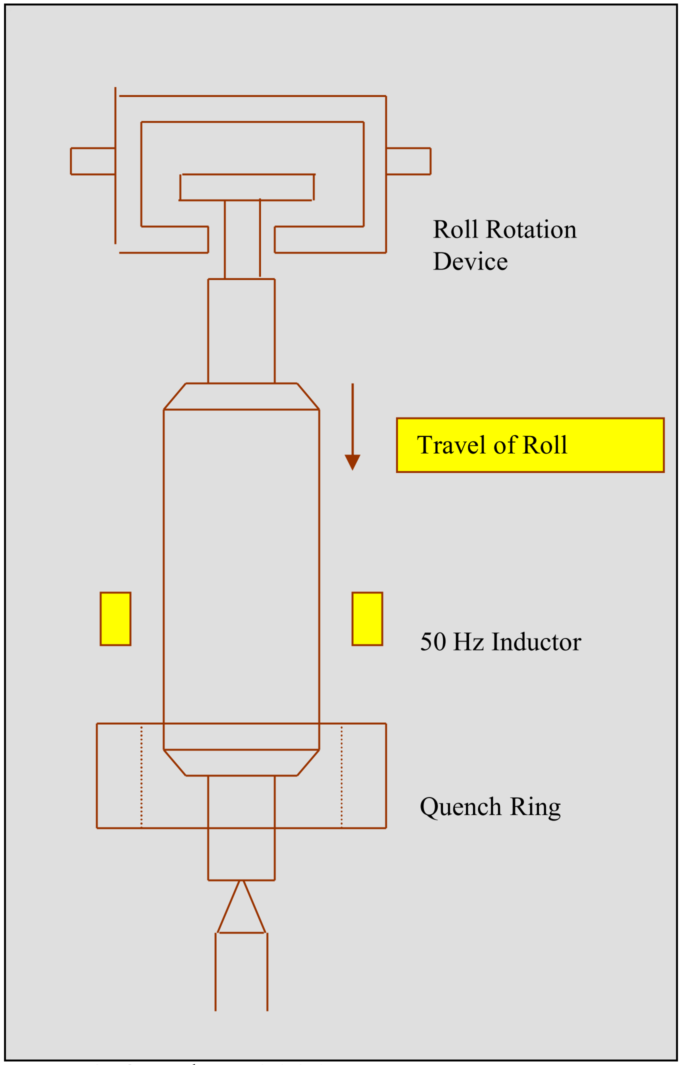
Classical Hardening





Progressive Hardening

Single Coil Set Up



Heating is by Induction Effect

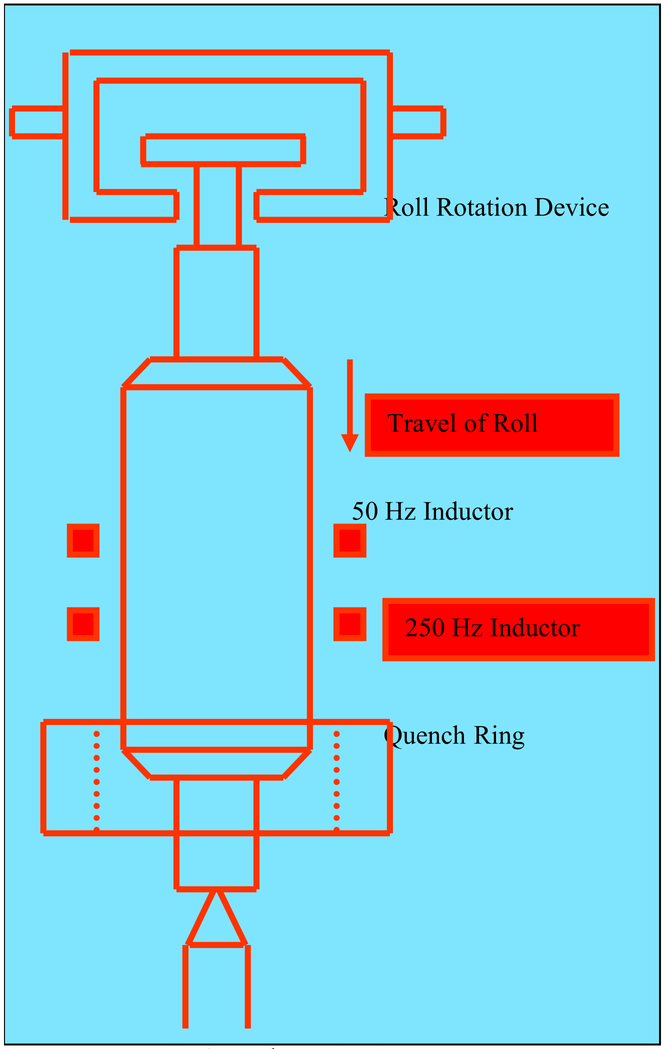
Works on Power Control

Temperature overshoot at subsurface

Demands operator's intervention

Progressive Hardening

Double Coil Set Up



Heating is through Induction and Conduction mode

Works on Temperature Feedback Control

Eliminates human intervention

LF Inductor creates a Heat Barrier

MF Inductor allows non magnetic in phase heating as well as compensates radiation loss at the surface

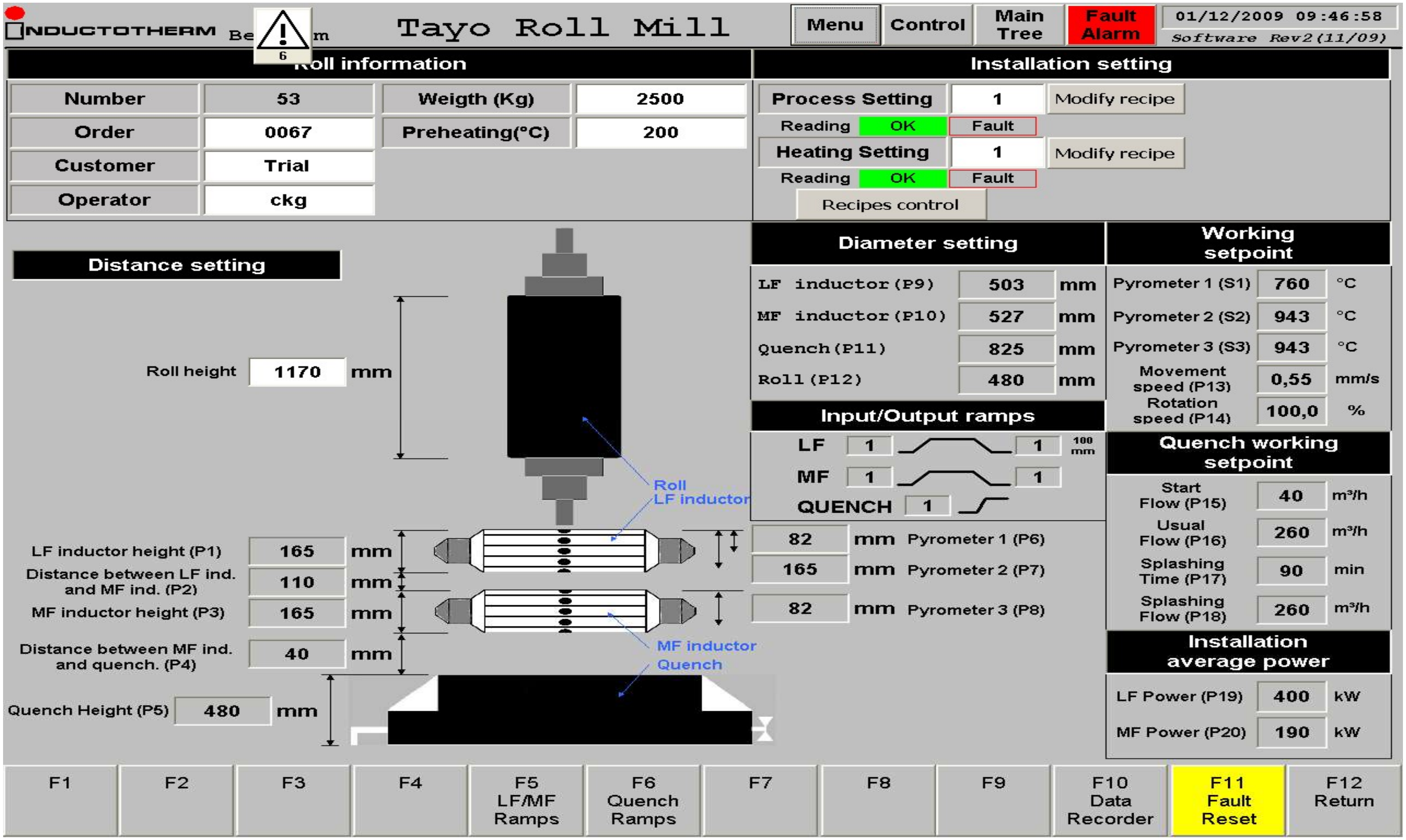
FACTORS GOVERN HARDENING QUALITY

Preheater

- Preheating Temperature
- Selection of Hardening Parameter
- Quench Efficiency

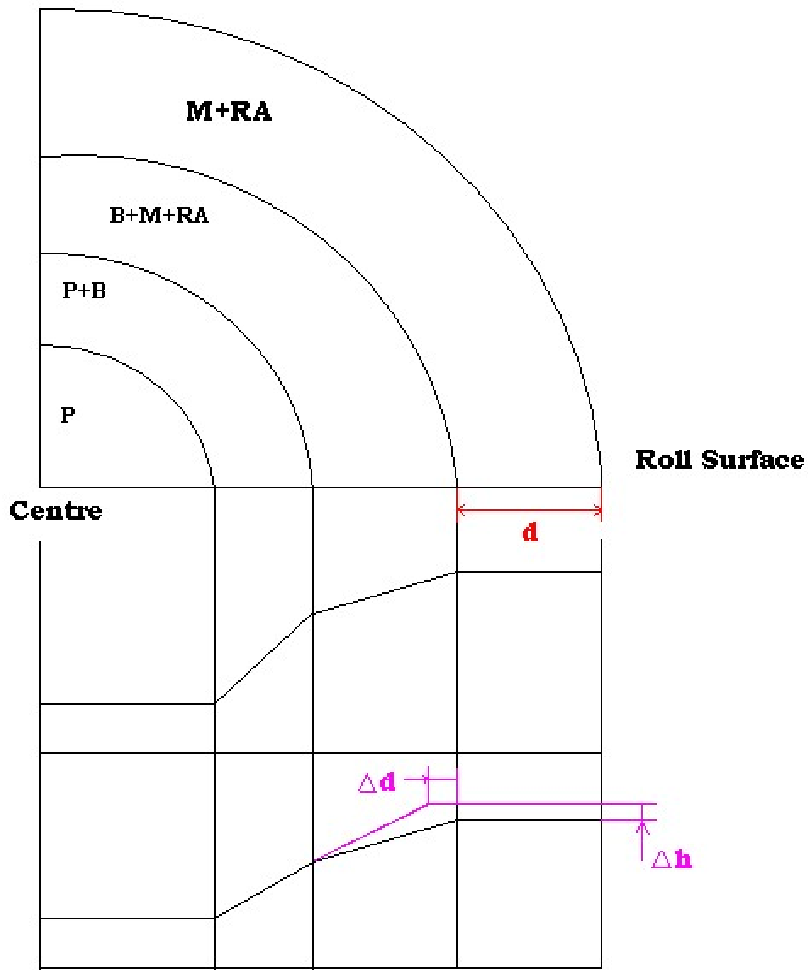
Chiller

HARDENING PARAMETER: EXAMPLE



QUENCH EFFICIENCY

Before
Sub-Zero



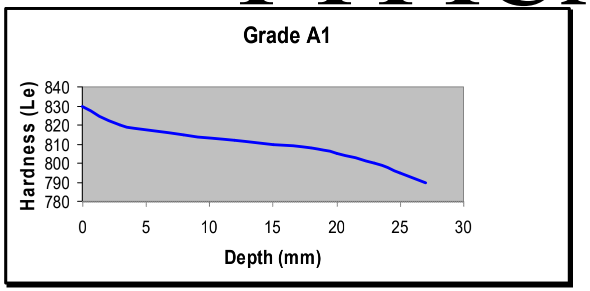
After
Sub-Zero

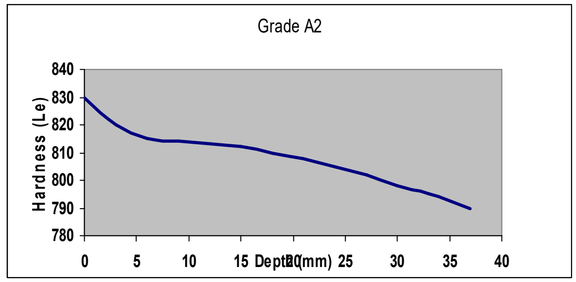
Chilled Water System

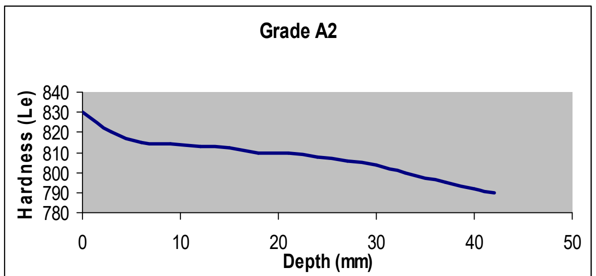
Pit water exhaust

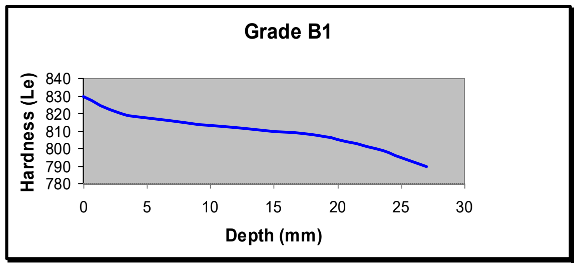
Cryogenic treatment

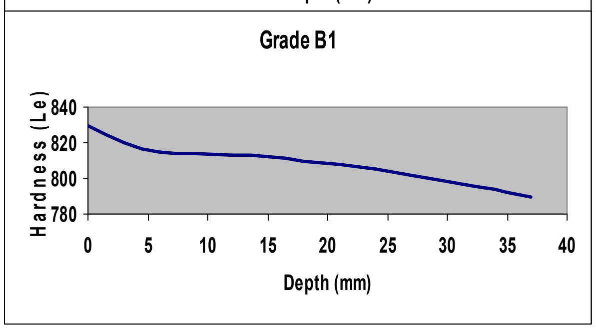
DEPTH OF HARDNESS : TYPICAL EXAMPLES

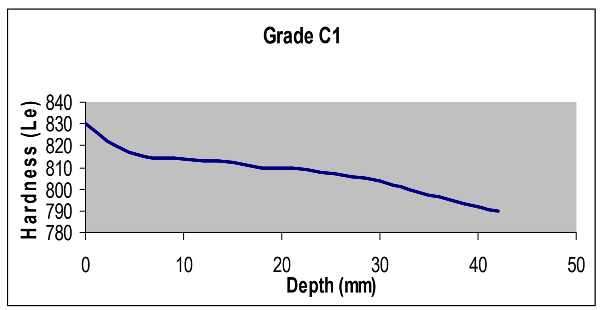












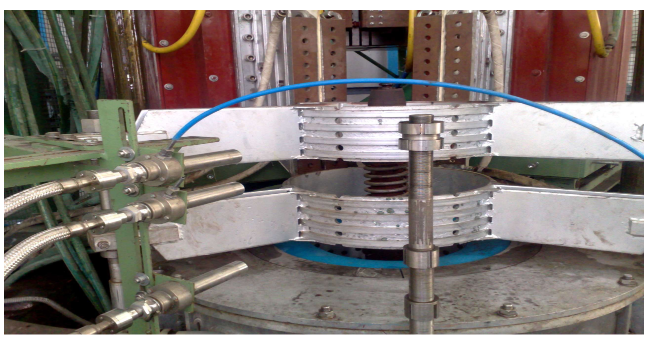
Preheat Temperature
Composition
Scan Speed
Hardening Temperature

It is possible to have different hardness profile on same composition by adjusting hardening parameters

QUALITY CHECK - TEMPERATURE

Calibration – Black Body Furnace LandCal R1200P [Land UK]

Land Special Thermometer Type Specials 600-1600°C R1 600/1600C-Y-L35-A40 [Land UK]



Temperature Measurement [Manual] –

Cyclops 100 [Land UK]

Fluke 572 [Fluke USA]

QUALITY CHECK – UT & HARDNESS

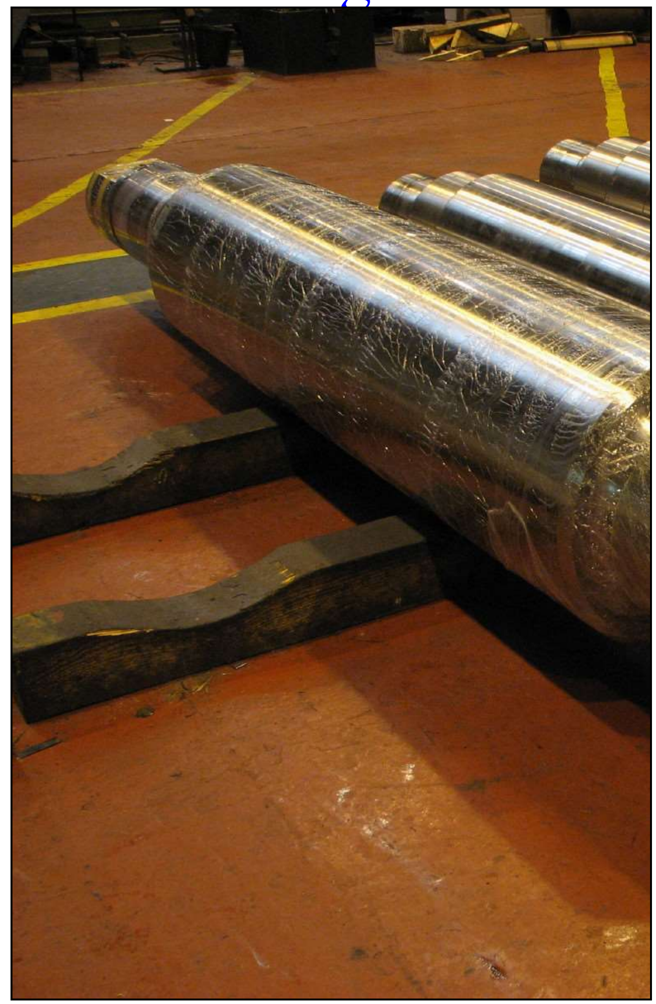
Ultrasonic Testing –
Krautkramer USN 58L [Germany]

Hardness Testing –
Equotip 3
Proceq Switzarland

Penetrascope
AC Belgium

Product Capability

Work & Intermediate Rolls – Ferrous & Non-Ferrous Rolling



Roll Specification -

Diameter✦ : 300mm ~ 700mm
Weight : 2.0 T ~ 6.0 T

Grades : (%age Cr) : 2~5% Cr

Depth of Hardness : 40mm Max

Roll Body Hardness : 870 HLe Max

✦Capable upto 840mm Dia

Lets Strengthen the Bond

THANK YOU

High end Forged Steel Rolls for CRM

A presentation by

Gontermann-Peipers (India) Ltd. Kolkata

Outline……..

1. Evolution of Forged Rolls for CRM
2. Manufacturing Best Blanks
3. Manufacturing of Forged Rolls at GPI
4. Identifying Defects and its Cure
5. Product Profile and Back-up Rolls

Evolution of Forged Rolls for CRM

Influencing Factors

✓**Demand of increased production of cold rolled sheets by customer industries**

✓**Demand of critical surface finish/texture & gauge tolerance of rolled products**

✓**Demand of roll shops improved efficiency.**

Chronology of Development

Phase-1 (in 1950's)

- **Low alloy steel (Cr-1-2%) through EAF route; no secondary refining.**
- **Rolls with homogeneous body hardness and hence prone to catastrophic failure in mill.**

Phase-2 (in 1960's)

- **Steel melting (Cr-2-3%) with secondary refining, vacuum degassing gradually introduced.**
- **Reduction of spalling & breakage tendency along with improved hardening depth.**

Phase-3 (in 1970's)

- **Demands of higher mill productivity and higher quality of rolled products' flatness, tolerance, texture etc.**
- **More carbide with 3-4% Cr along with Mo/V addition**
- **Regular use of NDT technique, hardness checking after each campaign introduced.**

Phase-4 (in 1990's)

- **Increased campaign length, higher depth of hardness, high surface hardness (Around 100 ShC) along with higher forging ratio in blanks**
- **Forged roll with higher alloy content(4-5% Cr with Mo/V etc) introduced**
- **This new variety exhibits lower frictional co efficient,consistent hardness during life cycle etc.**

Property requirements for Forged Steel Rolls

- **Outstanding wear resistance**
- **High hardness & strength to withstand indentation / deformation**
- **Sufficient depth of hardened layer for adequate tonnage output during life cycle**
- **Fatigue resistance to prevent spalling**

Manufacturing Best Blanks

Process Route

MELTING	✓Chemistry. ✓Hydrogen Analysis
VACUUM DEGASSING	✓Chemistry ✓Dissolved Gases ✓Non Metallic ✓ Inclusions
INGOT CASTING	✓Tapping Temperature ✓Teeming Temperature ✓Teeming Time
FORGING	✓Soaking Time & ✓Temperature ✓Reduction Ratio
HEAT TREATMENT WITH ANTIFLAKING	✓Soaking Time & ✓Temperature
INSPECTION	✓Microstructure,dimensions ✓Surface Hardness,ultrasonic

Effect of Alloying Elements

	Strength	Hardness	Hardenability	Hot Hardness	Wear Resistance	Ductility	Others
C	↑	↑			↑	↓	M_3C
Mn	↑		↑				
Si	↑						Deoxidise, Cleanliness
Mo	↑	↑		↑			
V	↑			↑	↑		Grain Refiner, MC
Cr	↑		↑		↑		M_7C_3

Forging controls blank quality

- Forging reduction of ingots is necessary to provide high compactness & optimum fine grain structure.
- Upsetting & elongation operation to ensure a forging reduction ratio of over 4
- The forging ratio which is more pronounced on the roll neck, induces longitudinal formation of fibers giving the roll excellent toughness.
- This characteristic makes the forged rolls highly resistant to stresses generally encountered in CRM rolls
- The forge finish temperature is monitored to control the grain size to obtain finer grain size.

Anti-flaking treatment is a must…….

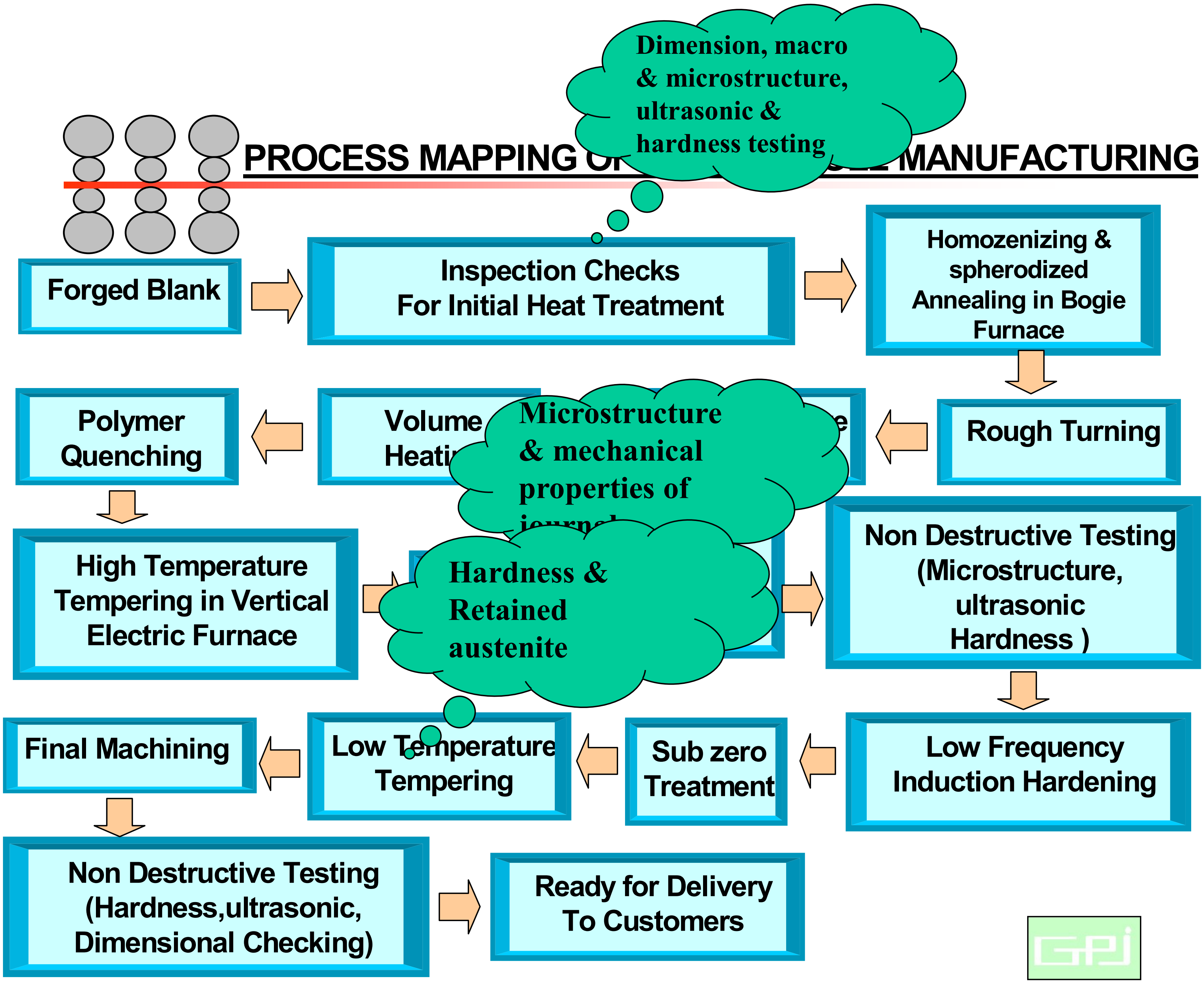
- Forging is prone to flake formation
  - also called shatter cracks
  - very fine hair-line cracks which develop in the interior

- Flakes develop because of:
  1. Stress develop by the pressure exerted by Hydrogen.
  2. Thermal and transformational stress developed during cooling.

- When allowed to build up these stresses may exceed the cohesion strength of steel leading to rupture at these microscopic and sub-microscopic cavities, thus forming flakes.

Manufacturing Forged Rolls at GPI

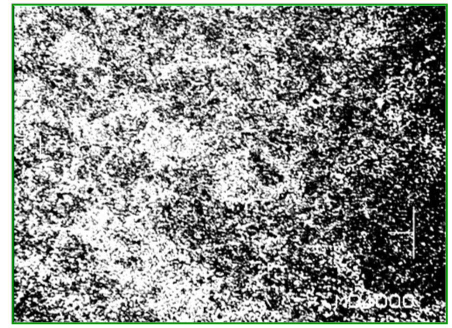
PROCESS MAPPING OF ... MANUFACTURING



Pre-Treatment of Blank

Spheroidising Annealing

✓After austenitisation, cooled slowly (@20-40°c/hr) to 600-700°c & then held isothermally
✓Maximum softness & ductility
✓lower hardness and improved machinability



TS- 600- 800 Mpa, %El – 10 to 15
Barrel Hardness-30-34 ShD
Micro Hardness- 180- 220 HV

Volume Hardening

✓After austenitisation quenched inside organic polymer bath
✓Cooling rate is controlled by concentration of polymer, bath temperature and degree of agitation
✓To achieve required neck hardness
✓To get better response in Ind. Hardening

TS- 900- 1100 Mpa,
Surface Hardness-45-50 ShD
Micro Hardness- 300 - 350 HV

Heat-Treatment – Induction Hardening

- ✓Induction heating by inductor coil
- ✓Rapid quenching by cold water
- ✓Low frequency for higher hardness depth
- ✓High hardness by martensitic Transformation
- ✓Minimum retained austenite

Cryogenic Treatment

- Quenching of the hardened roll (with high RA) to a temperature below 0°c or nearer its M_f temperature.
- To transform retained austenite to martensite with high wear & abrasion resistance.
- Specially designed vessel
- Liquid nitrogen is used as coolant
- Treatment temperature based on chemistry and depth requirement.
- Total treatment time around 2-4 hrs.

Post-Treatment – Multistage Tempering

- Heating the hardened steel rolls to comparatively lower temperature, soaking at this temperature & then cooling at a slow rate.
- Multiple tempering technique is followed.
- To relieve quenching stresses developed during hardening
- To restore ductility & toughness with decrease in hardness & strength
- To improve dimensional stability by decomposing retained austenite

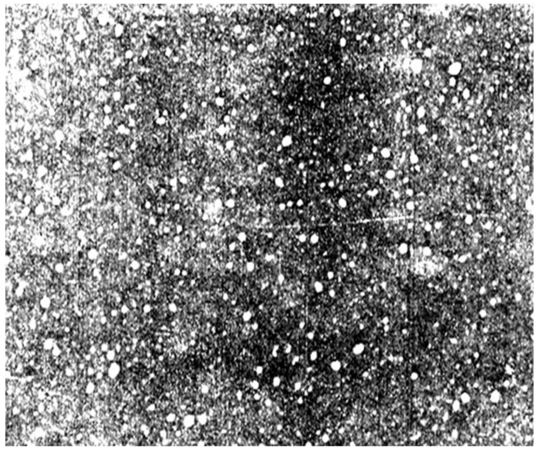
Identifying Defects & its Cure

From Manufacturer's side

- Steel making defects - presence of different types of inclusions
- Casting/forging defects – coarse grain structure, agglomerated carbides, grain boundary carbide network
- Heat treatment faults – non uniform hardened layer, poor carbide morphology, high amount retained austenite, unfavorable residual stress

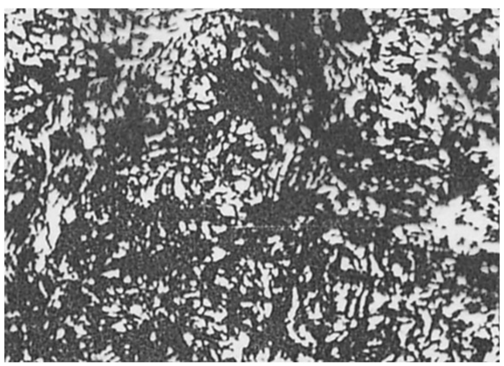
Roll microstructure

Desirable

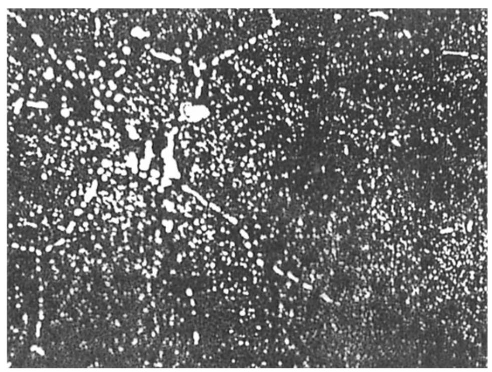


- uniformly distributed fine spherical carbides
- tempered martensitic matrix
- minimum retained austenite

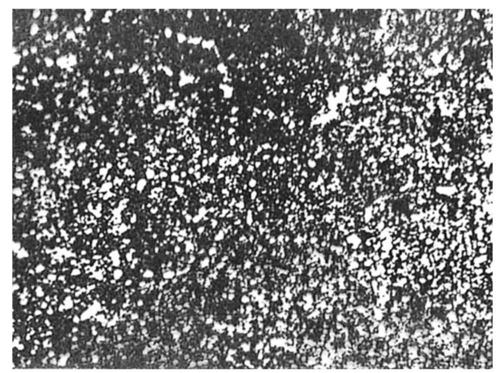
Undesirable



High amount RA with coarse martensite



Improper carbide shape/ distribution & network



Non uniform & clustered type carbides

From User's side

- Generation of bruise, fire crack, tail end mark, metal pick up on roll barrel surface during mill operation
- Subsurface crack initiated due to local stress concentration particularly at barrel edge contact area
- Development of soft spots due to localized heating & thereby change in microstructure

✓Identification of the damaged spots by Etching, NDT, Hardness testing
✓Complete removal of defect traces by grinding before sending it to mill
✓Monitoring & ensuring proper roll body & emulsion temperatures
✓Providing wiper at entry point to clean the strip surface
✓Checking spray nozzles at regular intervals to ensure adequate & uniform emulsion flow
✓Maintaining proper barrel end chamfer to avoid stress concentration
✓Customise roll chemistry, heat treatment & final barrel hardness level to suit specific mill conditions

Spalling:

A) from surface origin- fire crack, bruise, dent mark, mechanical damage

Causes –

- Overloading, improper crowning localized stress concentration
- Improper stock removal- left over crack after grinding
- Insufficient roll cooling causes thermal stress & phase transformation
- Sharp temperature gradient on the roll surface- hardness variation
- Improper grinding practice- high tensile stress on surface- fine crack generation

Prevention –

- Avoid mill related damages
- Proper stock removal in grinding & constant use of ECT, UST to ensure defect free roll
- Shorter campaign life with reduced roll pressure.

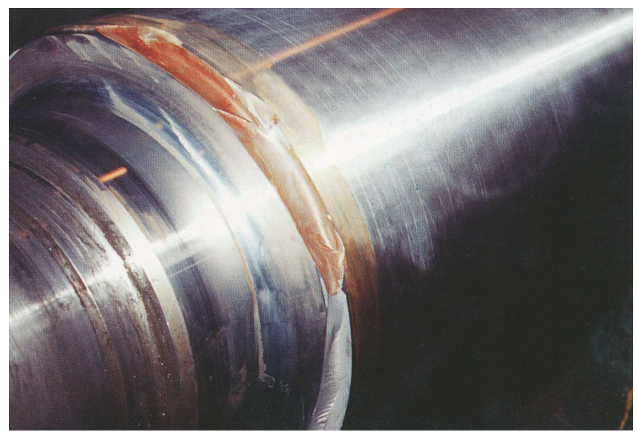
Typical service problems, its causes & preventions :

B) from subsurface origin- Due to applied load & localised flattening of the roll at contact points; the max shear stress located at short distance below roll surface (Hertzian stress). If this stress level exceeds compression strength then multiple cracks will be generated & ultimately may lead to spalling.

- Generally occurs at roll edge
- Excessive bending & poor edge relief is responsible

Photo-1- spalling due to surface originated defect

Photo- 2- barrel edge spalling originated due to subsurface crack



Recommendations for Roll Handling and Storage

Handling –

- Avoid roll to roll contact by moving one roll at a time.
- Proper sling to be used at appropriate area on roll neck; should never be handled with electromagnet.
- Roll body should never come in contact with any hard surface during transport.

Storage –

- Roll body & journal areas should be protected from any corrosion
- Avoid sudden temperature change in roll body by storing in proper environment.
- Rolls from mill should be ground after its body reaches ambient temperature any type of sudden cooling to achieve this temperature must be avoided.

Product Profile of GPI (CRM)

Forged Steel Rolls

Quality	Usage Area	Barrel Dia (mm)	Barrel Length (mm)	Total Length (mm)	Hardness Sh C	Weight
Forged Rolls	CRM – WR / IMR	240 - 610	2000 (max)	5000 (max)	90 - 100	0.6 – 4.8 MT
Forged BUR	Back Up Roll	1500 (max)	2700 (max)	7000 (max)	55 -70	40.0 MT (max)

Differential Hardening Furnace for BUR

- Latest Split Body design
- Effective heat treatment dimensions – 2200mm X 2250 mm
- Maximum heating temperature – 1100^{o}C
- High Speed automated burners to achieve high surface temperature in shortest possible time
- Impulse Control Burners designed for efficient heat distribution
- Temperature variation on roll body +/- 5^{o}C
- Furnace Loading capacity – 50T
- Collapsible quenching facility to suit roll dimensions

Differential Hardening Furnace for BUR

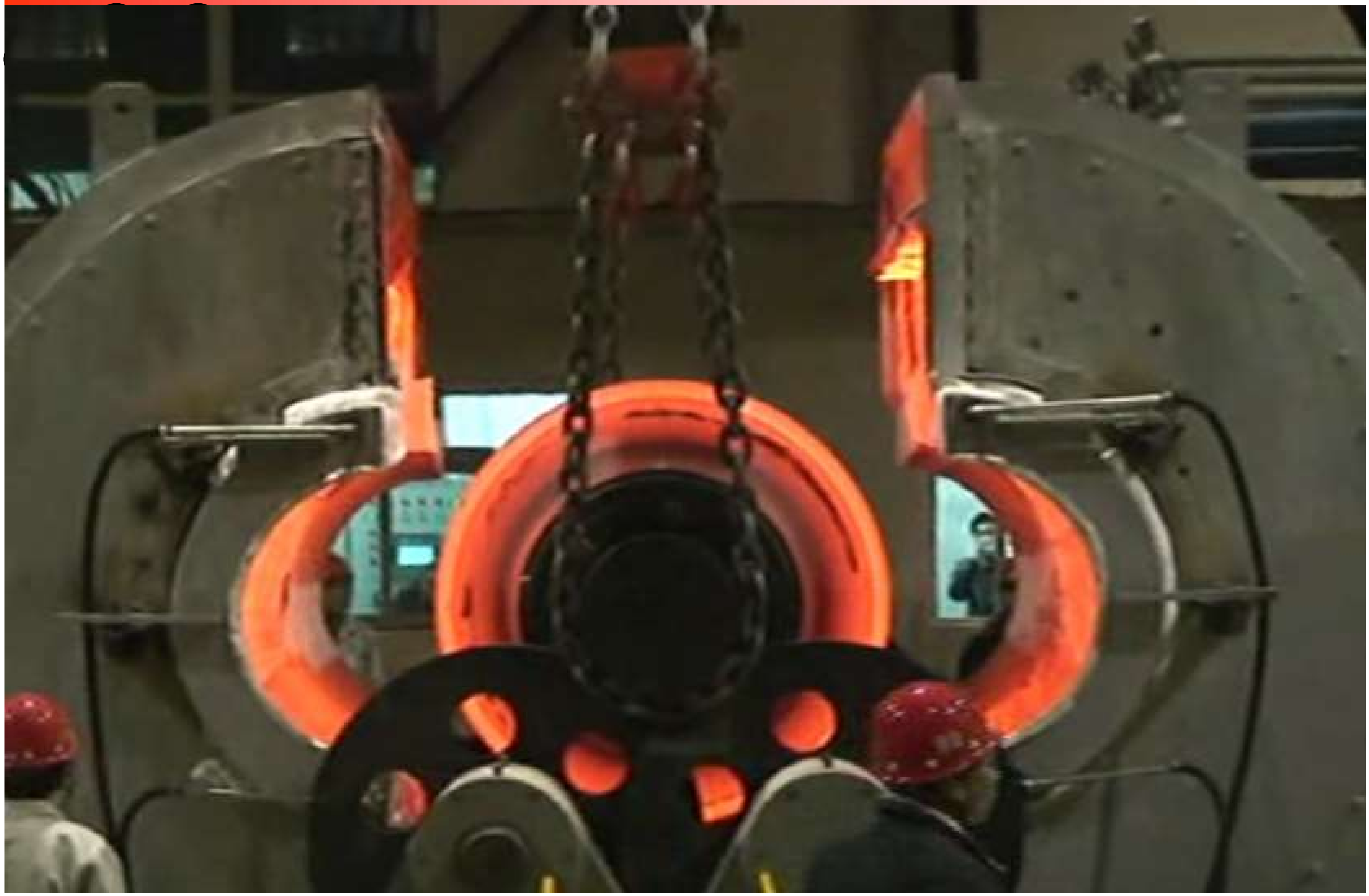
Differential Hardening Furnace for BUR

Differential Hardening Furnace for BUR

Differential Hardening Furnace for BUR

Differential Hardening Furnace for BUR

Differential Hardening Furnace for BUR



Differential Hardening Furnace for BUR

Forged Steel Back-up Rolls

- Customized Heat Treatment to meet Specific Depth Hardness
- Depth of Hardness 120 mm
- Supporting layer up to 120 mm
- Wide range of hardness possible – 55 to 70^{o}Sh C
- Drop in Hardness 5 - 7^{o}Sh C across working diameter

Cast Steel Back-up Rolls

- ✓ Latest casting technology being implemented
- ✓ Shakeout and cooling technology comparable with the best in the world
- ✓ Customized Heat treatment process followed to get the homogeneous metallurgical properties
- ✓ Process control & Quality checks at each stage of manufacturing process
- ✓ Specific Depth Hardened Rolls

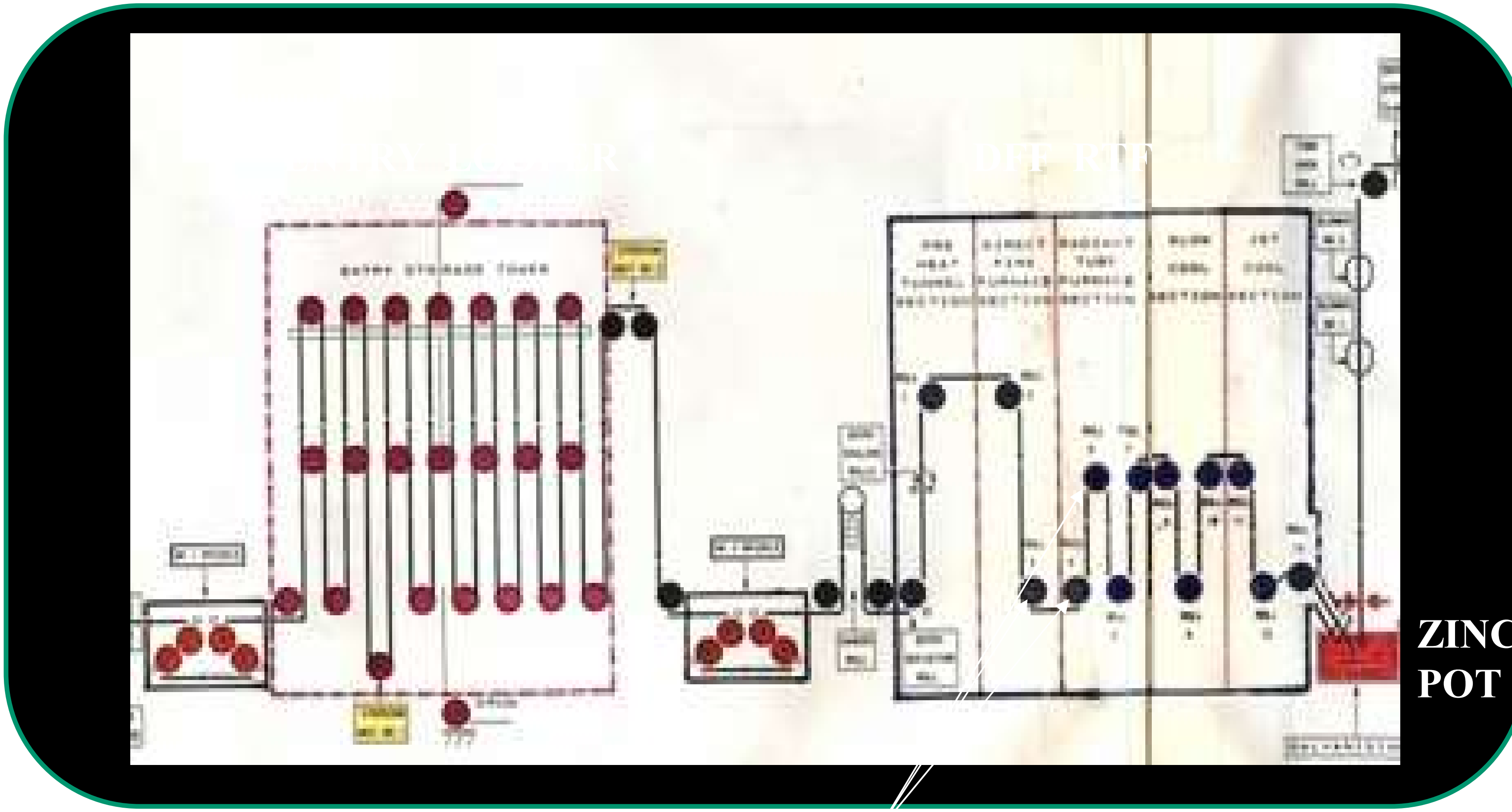
THANK YOU

CHARACTERIZATION OF ROLL PICK UP IN ANNEALING FURNACE OF A CONTINUOUS GALVANIZING LINE

S K MOHAPATRA, A P SINGH, D S GUPTA,
RAM AVTAR & D MUKERJEE
RDCIS, SAIL

National Workshop on Recent Trends in Cold Rolling-Processes & Products,
Bokaro, 20th Nov' 10

ANNEALING FURNACE LAYOUT OF BOKARO GALVANIZING LINE



Vulnerable Deflector Rolls

ROLL PICK UP & ITS EFFECT

Used
Deflector Roll

Close up view of
Roll Pick Up

Dents on
finished sheet

सेल SAIL

DEFLECTOR ROLL COMPOSITION, SIZE AND PROPERTY

	C	Cr	Ni	Si	Mn	Mo	P	S
Wt.%	0.2-0.5	24-28	11-18	2.0	2.0	0.5	0.04	0.04

Material: Stainless Steel

Diameter: 915mm

Barrel Length: 1524mm

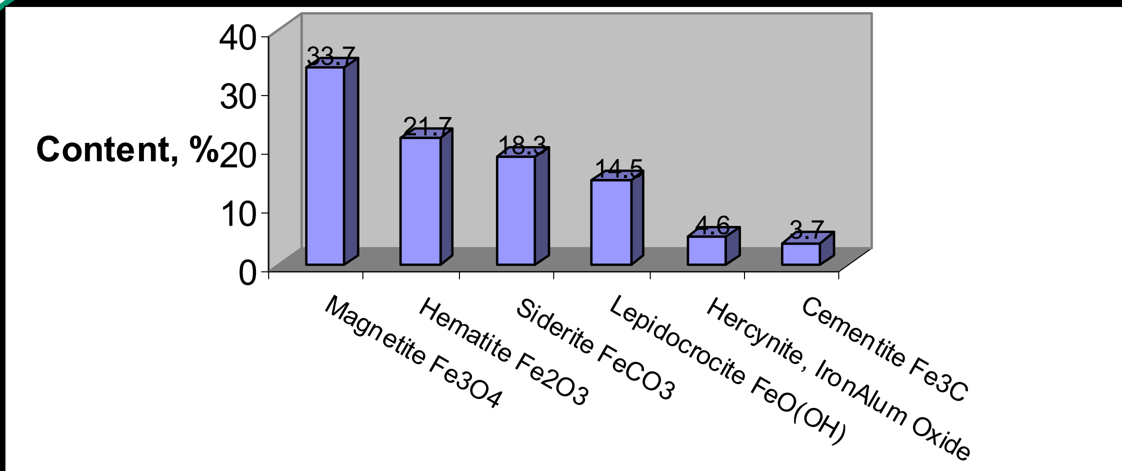
Hardness, minimum: 180 BHN / 32 Shore

ANALYSIS OF FURNACE SCALE FOR CORRELATION

Accumulated scale at furnace bottom

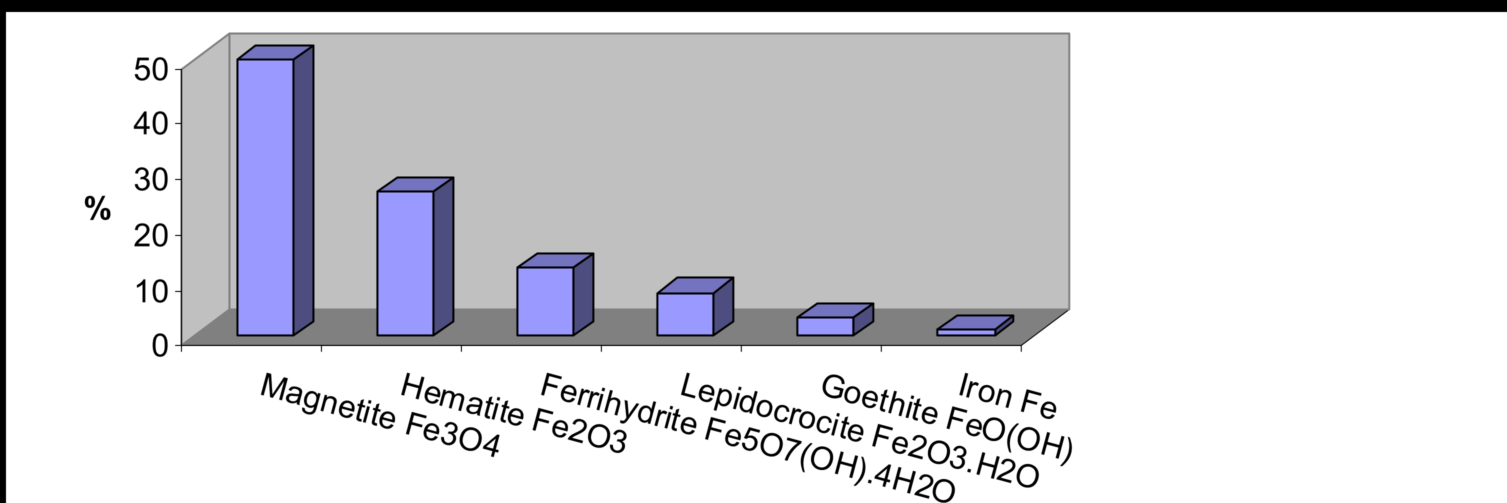
Furnace scale composition was determined by XRD analysis to correlate with roll pick up composition

XRD ANALYSIS OF FURNACE SCALE

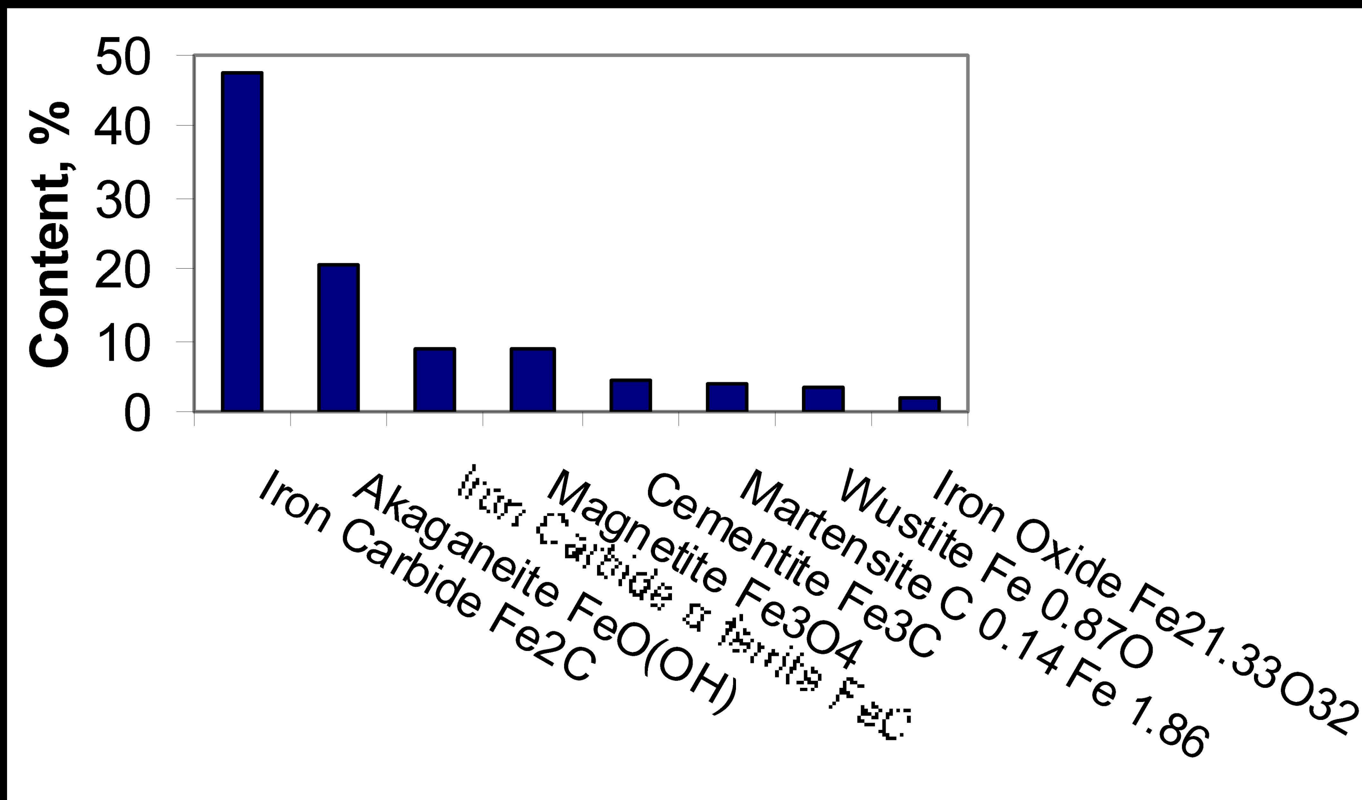


Mostly consists of Magnetite and Hematite.

3.7% Cementite found in one sample



XRD ANALYSIS OF ROLL PICK UP



Mostly consists of Iron Carbide Fe_2C

Iron oxides are present to a limited extent

GAS METAL REACTION IN DIRECT FIRED FURNACE

$FeO + H_2 = Fe + H_2O$

$FeO + CO = Fe + CO_2$

COKE OVEN GAS CONTAINS 58% H_2 AND 6% CO
H_2O AND CO ARE CUMBUSTION PRODUCTS
IRON OXIDES GET REDUCED AT HIGHER TEMPERATURE
IRON OXIDES FORMED AT LOWER TEMPERATURE
CO/ CO_2 AND H_2/ H_2O RATIOS ARE GOVERNING FACTORS

ABOVE 650^{o}C: (For Roll and Strip)

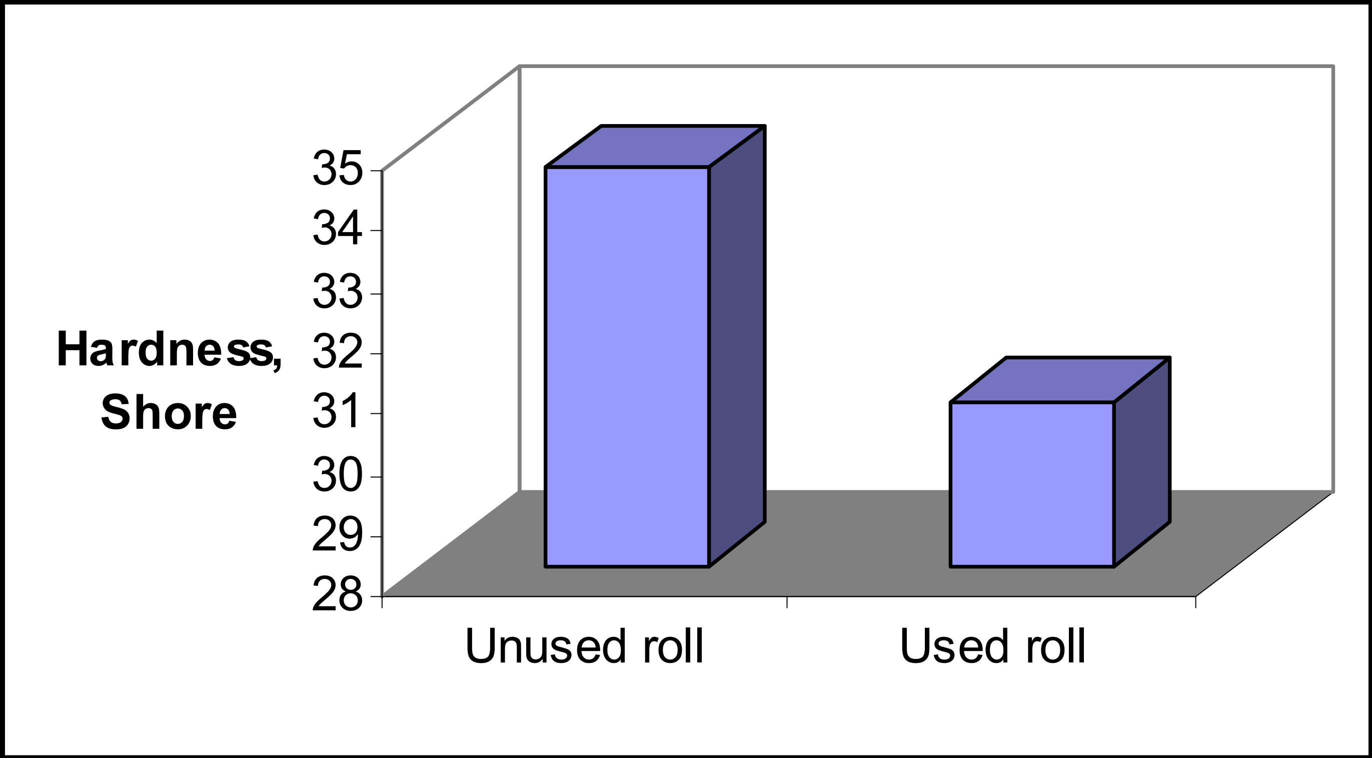
$C_{\text{in Fe}} + H_2O = CO + H_2$

$2CO = C_{\text{graphite}} + CO_2$

$3Fe + 2CO = Fe_3C_{\text{cementite}} + CO_2$

Fe_3C TRANSFORMS TO Fe_2C AND FeC WITH HIGHER AVAILABILITY OF CARBON FROM GAS REACTIONS

CHANGE IN HARDNESS DUE TO DECARBURIZATION OF ROLL



Drop in roll surface hardness supports decarburization of furnace rolls

PREVENTION OF FURNACE ROLL DECARBURIZATION BY METALLIC COATING

Roll operating temperature: 800~950^{o}C
Modern lines use metallic coated rolls coated with HVOF (High Velocity Oxy Fuel) technique
Coating material: Chromium carbides in Ni-Cr matrix

Functional requirements to be considered by roll coater:
Preventing carbon diffusion
Corrosion protection
Heat insulation
Matching coefficient of linear thermal expansion
Superior ductility
Resistance to impact load

CONCLUSIONS

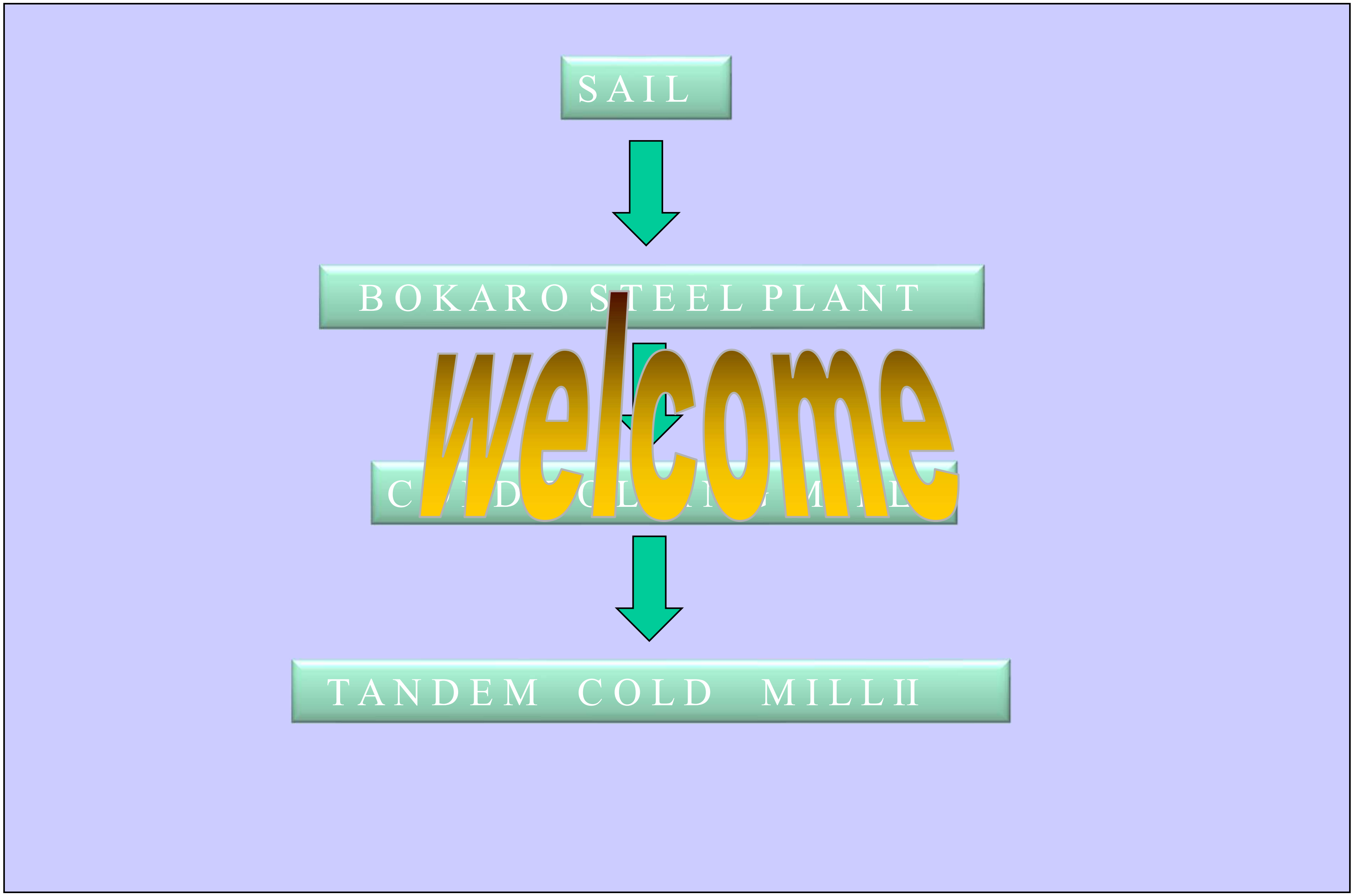
- The main constituent of furnace roll pick up is iron carbide Fe_2C (48%)

- Above 650°C, roll and strip surface gets decarburized to form cementites Fe_3C. Cementites get transformed to Fe_2C and combine with iron oxides to generate roll pick ups

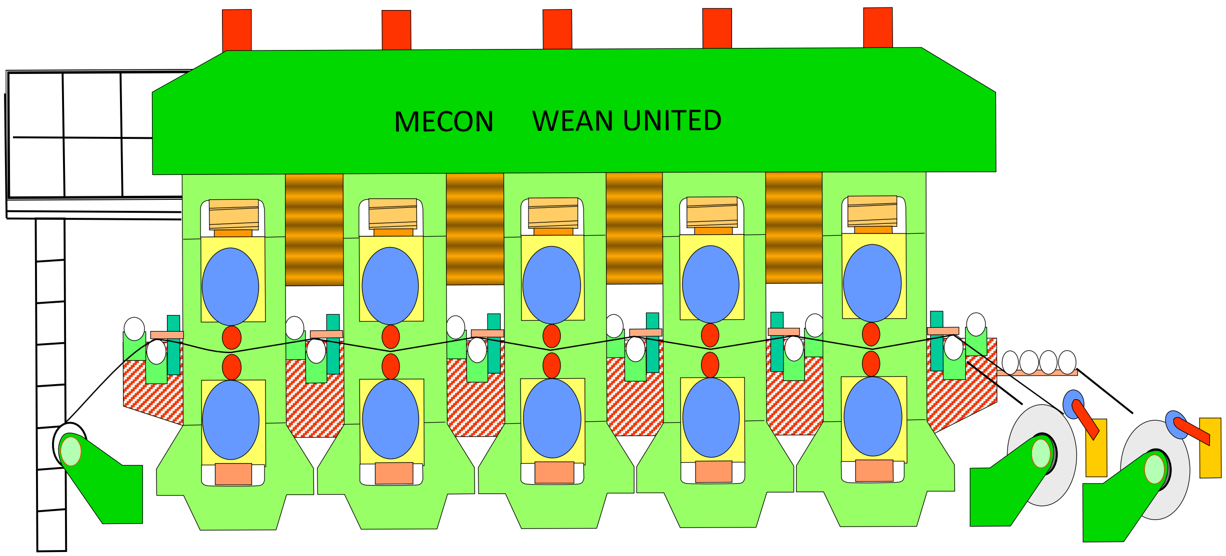
- A suitable metallic coating can reduce roll surface decarburization, formation of roll pick ups and meet other service requirements


सेल SAIL
Thank you

O U R IDENTITY



Accumulator control for Hydraulic System through Pressure Transmitter



By S.Bhattacharya, GM (Elect.),
D.N.Mohanty DGM I/C (E),
R.Prasad AGM (E),
N.C.Thakur Sr.Mgr. (E)

Tandem Mill II Features

- Mill:600/1420X1420mm 4-HI, 5-stand TCM
- Input strip: 1.8-4.0mm
- Output: 0.15-1.6mm
- Strip width:650-1250mm
- Max coil weight: 30T
- Mill Speed: 2030 MPM

→

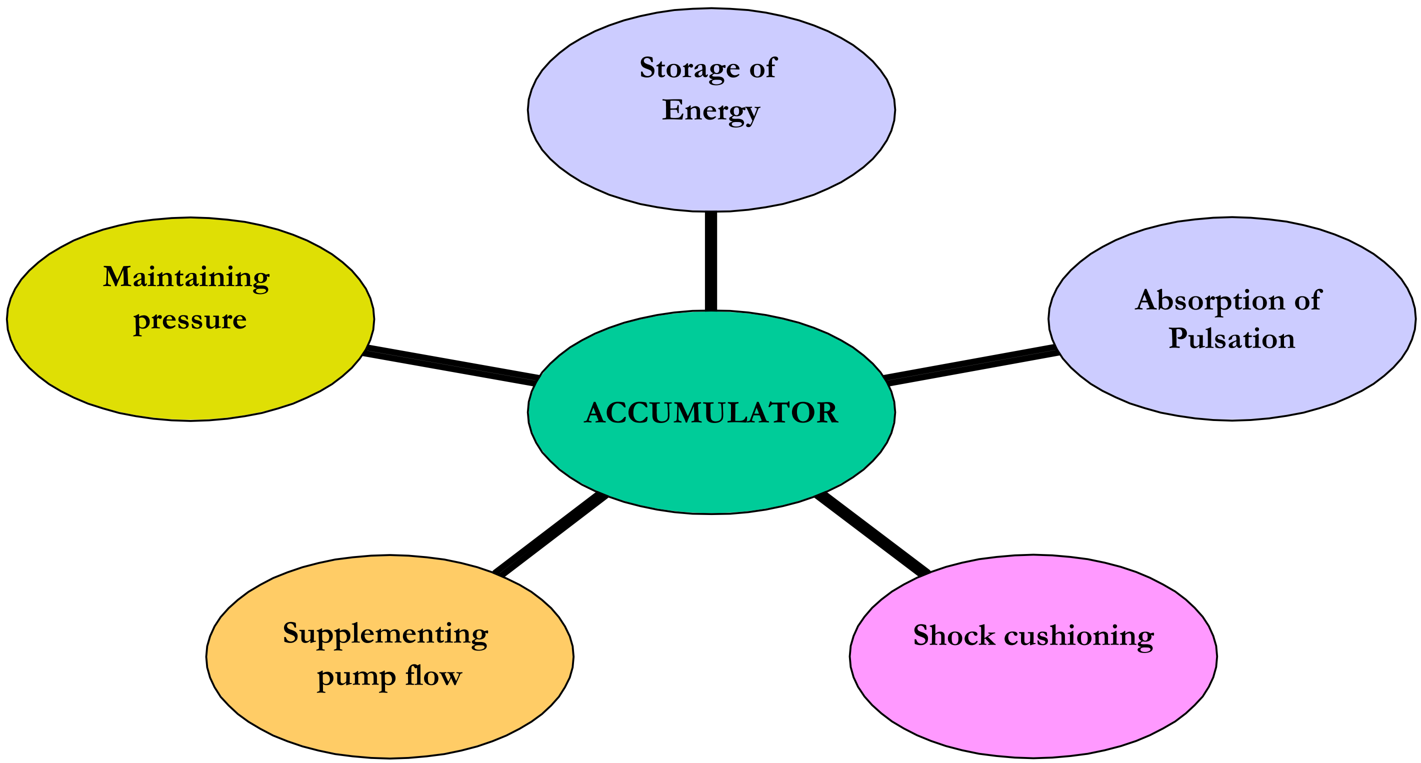
- Fully computerized
- Hydraulic A G C
- Two Step roll bending for shape control
- Quick WR change cars
- Future provision for continuous rolling

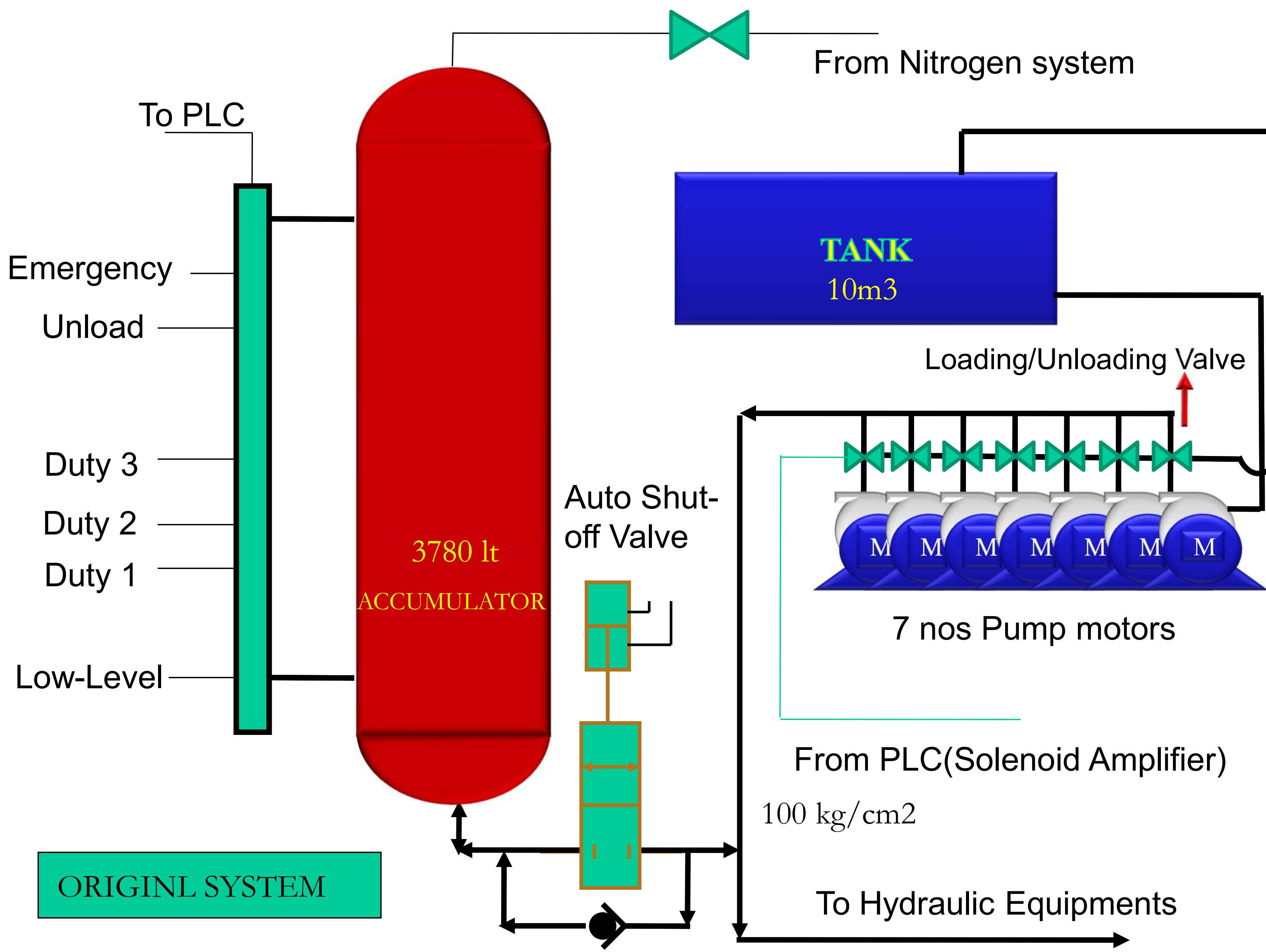
HYDRAULIC SYSTEM **B**

HYDRAULIC SYSTEM **A**

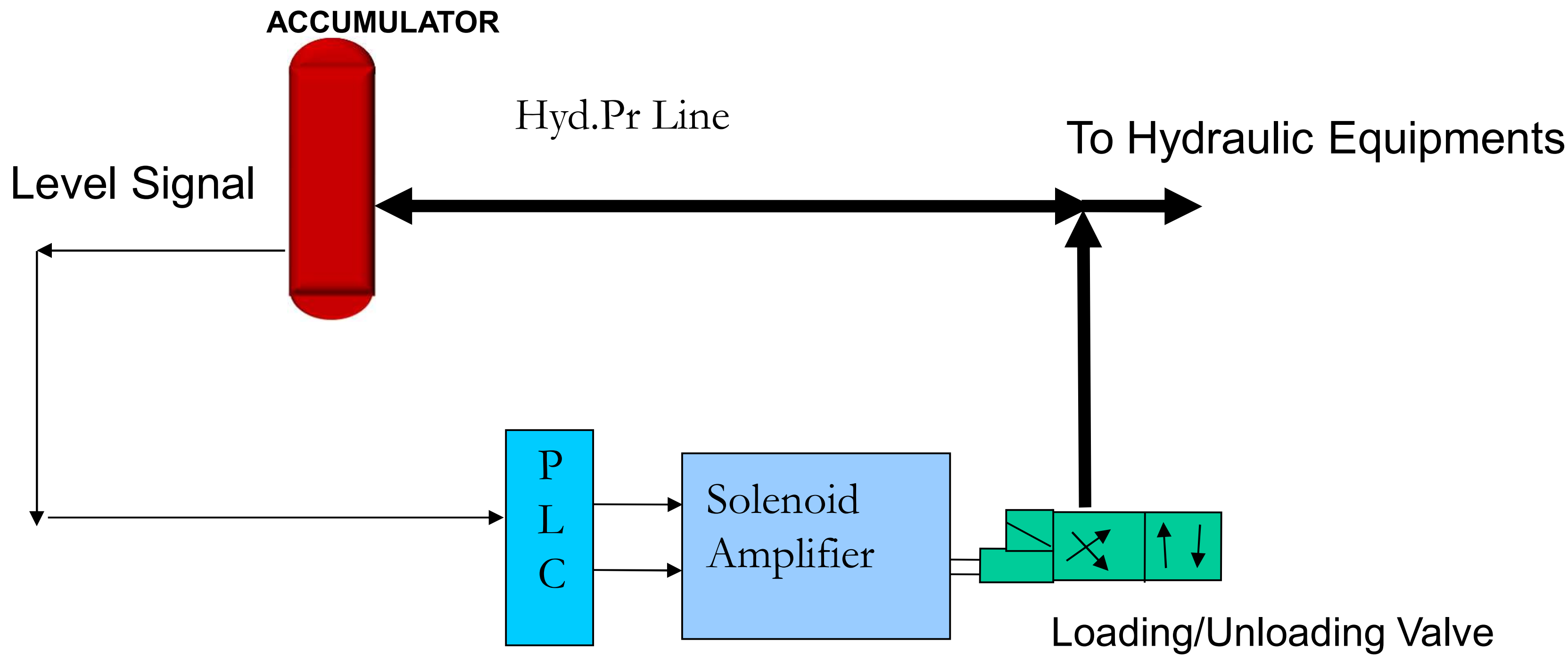
HYDRAULIC SYSTEM **C**

ACCUMULATOR




From Nitrogen system
To PLC
Emergency
Unload
Duty 3
Duty 2
Duty 1
Low-Level
3780 lt
ACCUMULATOR
TANK
10m3
Loading/Unloading Valve
M
M
M
M
M
M
M
7 nos Pump motors
Auto Shut-off Valve
From PLC(Solenoid Amplifier)
100 kg/cm2
To Hydraulic Equipments
ORIGINL SYSTEM

FUNCTIONAL BLOCK DIAGRAM



IMPACTS

- Mill stoppages.
- Rolling in Collapsed Mandrel.
- Un-reliable Valve functioning.
- Shock in equipments.
- Vibration in pump-motor.
- Increase in Nitrogen consumption.

FINANCIAL IMPACT

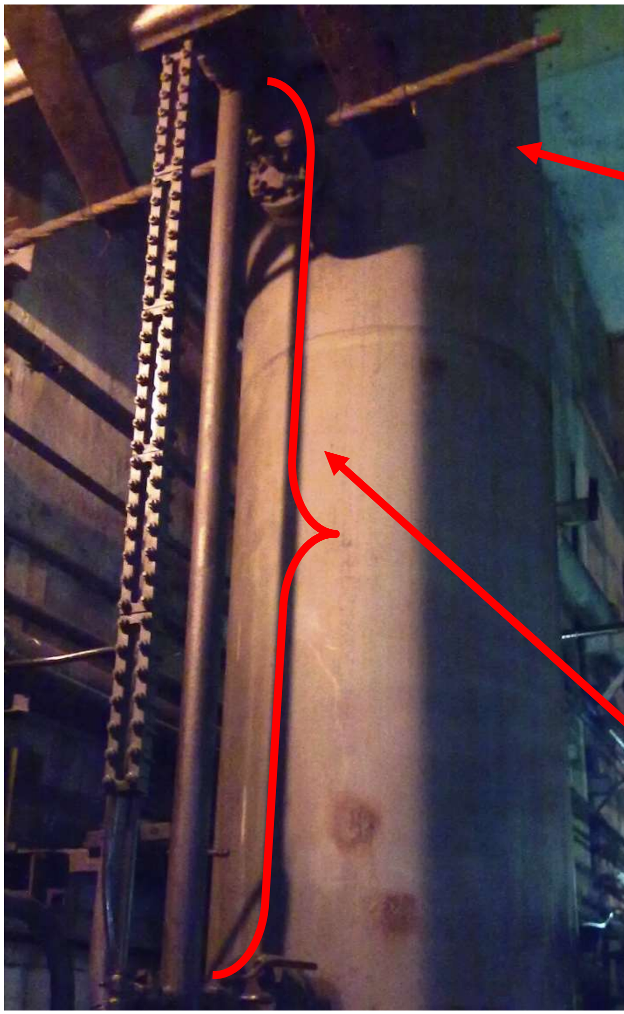
- **System C fault**
- Yearly Loss = Rs 1440000
- **Nitrogen Consumption (leakage)**
- Yearly Loss = Rs 453600
- **Total Loss on account of leakage in Nitrogen and Mill stoppages = Rs 1893600**

POSSIBLE SOLUTION

- ✖ Procurement of original imported sensors
- ✖ Similar type of level sensor of different make as a developmental case
- ✖ Pressure switch Installation
- ✖ Accurate pressure measuring device

LEVEL SENSOR

PROBLEMS IN LEVEL SENSOR OF DIFFERENT MAKE



- Column type design
- Sensor dia was more
- System Pressure very high
- Working was not reliable

PRESSURE SWITCH

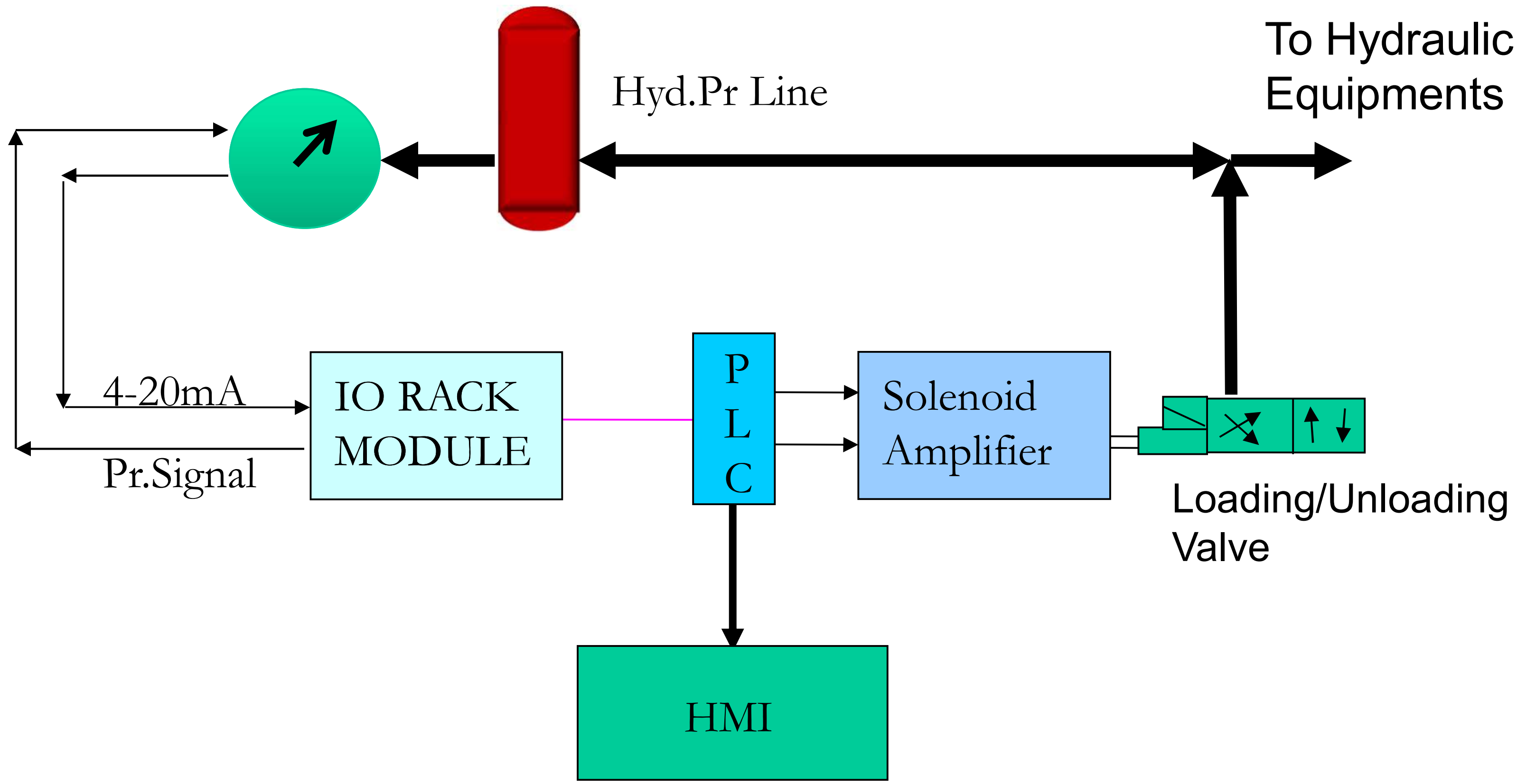
Problems with Pressure Switch

- System operation at exact pressure not possible
- Due to hysteresis many pressure switch could not be used (Unloading signal not getting Low)
- Pressure switch failure was very high.
- Nitrogen leakage was frequent due to delayed shut-off valve operation

Pressure Switch

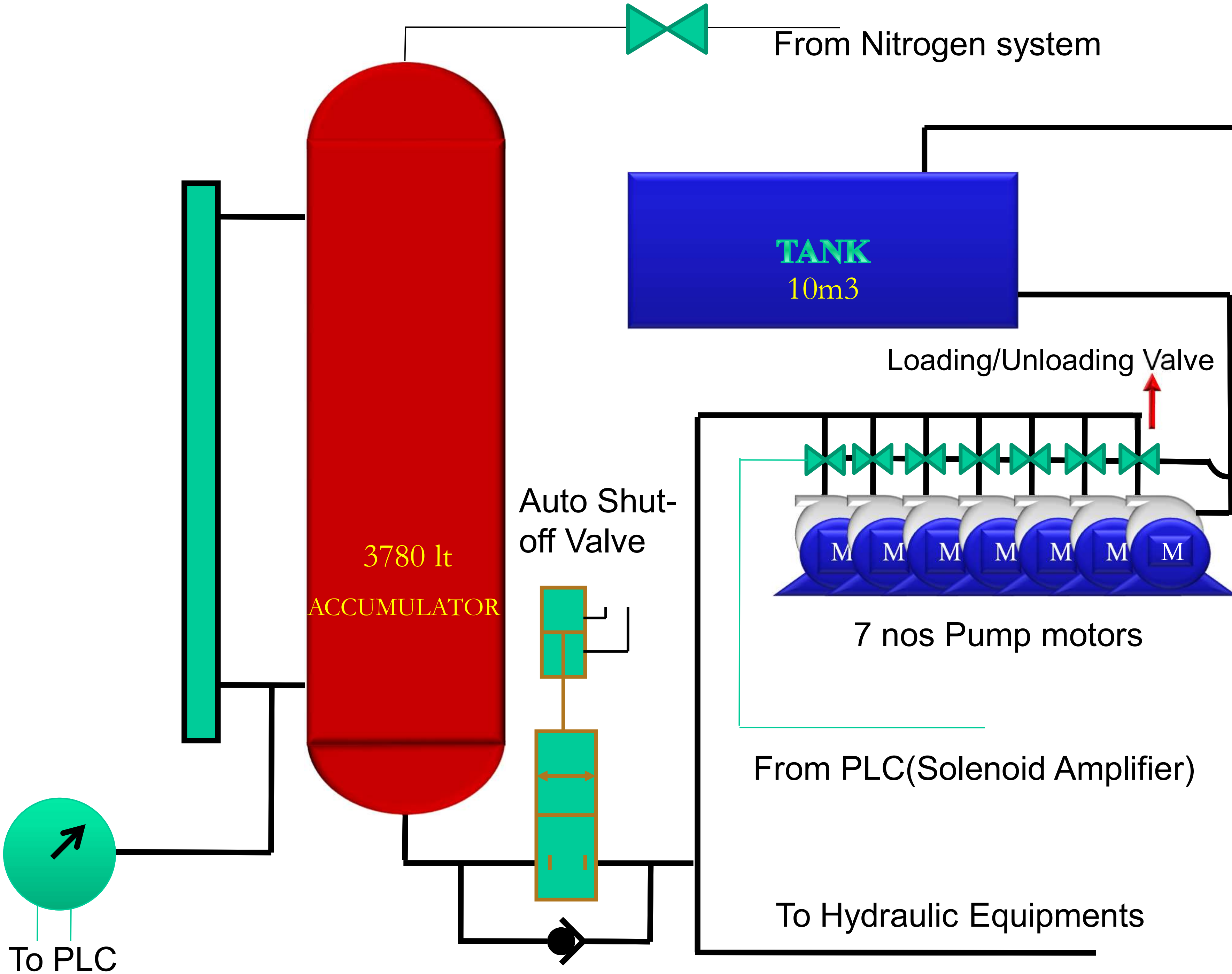
SELECTED SOLUTION

- Pressure Transmitter in place of Level sensor



JOBS DONE

- ✖ Calibration of pressure Transmitter
- ✖ Erection at suitable place
- ✖ Interfacing of Pressure Transmitter signal with existing PLC system
- ✖ Level Signal Generation
- ✖ Control checking stabilisation & monitoring



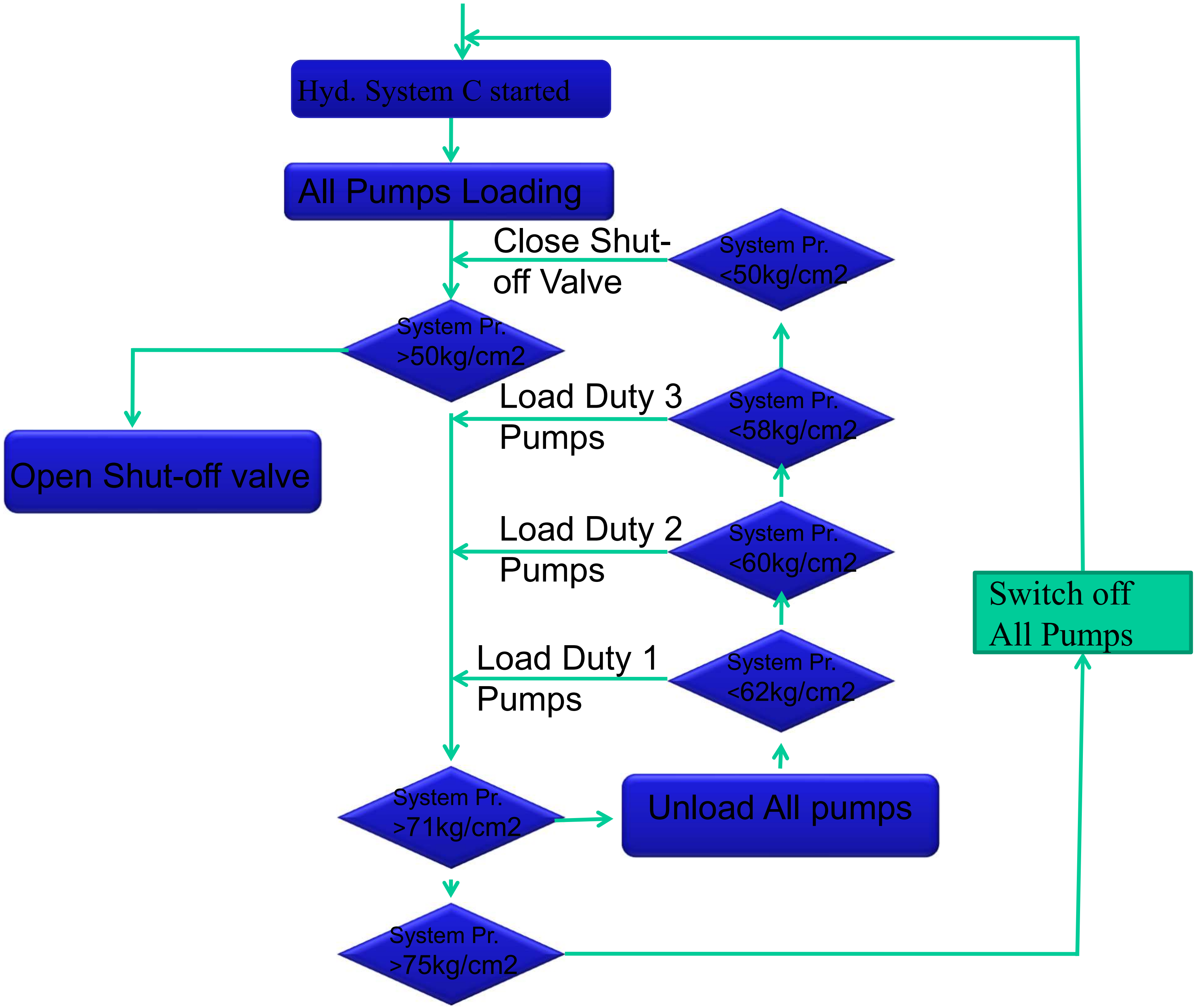
From Nitrogen system
TANK
10m3
Loading/Unloading Valve
3780 lt
ACCUMULATOR
Auto Shut-off Valve
M
M
M
M
M
M
M
7 nos Pump motors
From PLC(Solenoid Amplifier)
To Hydraulic Equipments
To PLC

Interfacing of Pressure Transmitter signal with existing PLC system

- Analogue input SM331 module was configured and put into IO rack.
- Hardware configuration of PLC modified
- SM331 module connected to installed Pressure transmitter
- Software was prepared for reading the analogue values from pressure transmitter.

LEVEL SIGNAL GENERATION

- ✖ Oil level (through sight glass) of the level column was compared with pressure values.
- ✖ Pressure values with comparator module were used to get different signals.


Hyd. System C started
All Pumps Loading
Close Shut-off Valve
System Pr. <50kg/cm2
System Pr. >50kg/cm2
Open Shut-off valve
Load Duty 3 Pumps
System Pr. <58kg/cm2
Load Duty 2 Pumps
System Pr. <60kg/cm2
Load Duty 1 Pumps
System Pr. <62kg/cm2
Switch off All Pumps
System Pr. >71kg/cm2
Unload All pumps
System Pr. >75kg/cm2

OTHER BENIFITS

- Financial Losses minimised.
- Smooth behavior of equipments
- Reduced maintenance requirement in pump-motor.
- Constant mandrel pressure.
- It can be implemented in three more hyd. Sys in CRM.

COMPUTER SIMULATION OF COLD ROLLING PROCESS USING DEFORM SOFTWARE

S. Rath, A.P. Singh, A.K. Marik, D.S. Gupta & Ram Avtar

R&D Centre for Iron and Steel
SAIL, Ranchi-834002

Next 10 minutes...

- Slab Method based Mathematical Modeling of Cold Rolling Process
- Computer Simulation of Cold Rolling using FEM software DEFORM
- Results and Discussions
- Conclusion

Importance of Roll Force

- Allowable Roll Force is the most important mill structure limitation
- Torque and power are calculated from Roll Force which are limitations of main motors
- Flatness of the material depends on Roll Force

Methods of Calculation of Roll Force

White Box

- **Slab method (Bland & Ford)**
- **Slip line field theory**
- **Upper- & lower-bound solution**
- **Finite element method**

Black box

- **Artificial Neural Network (ANN)**

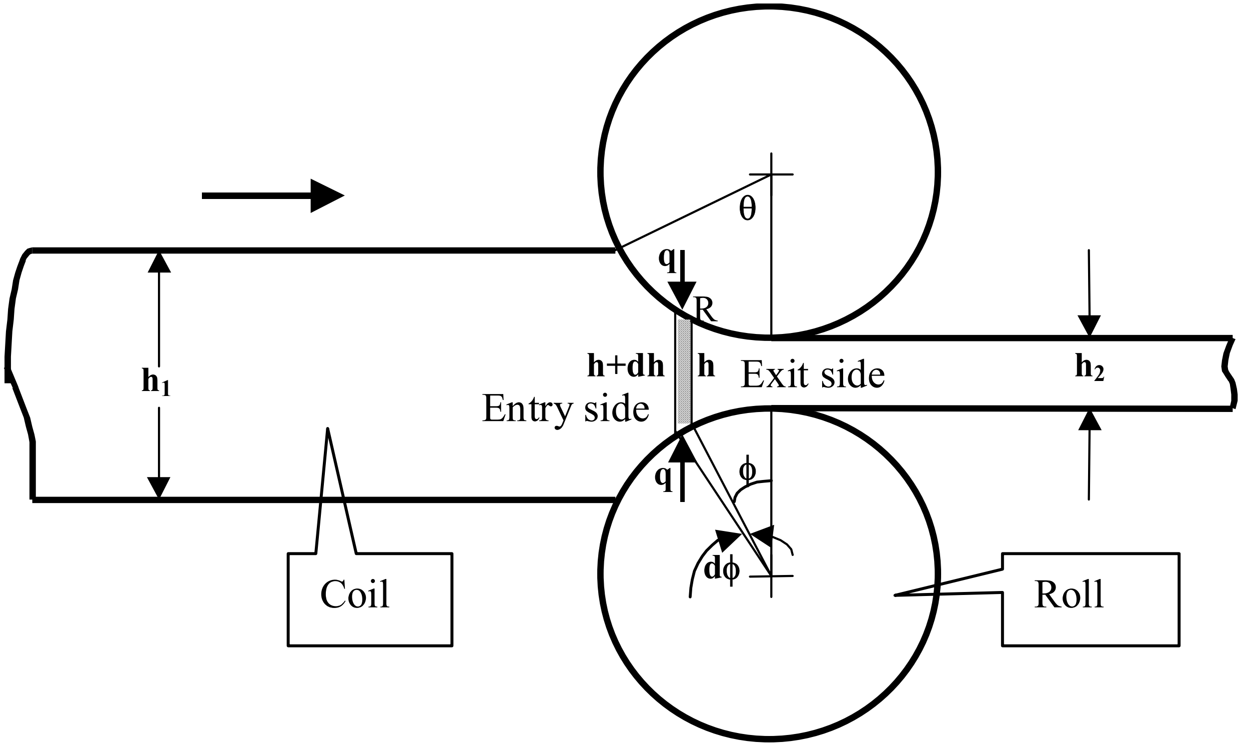
Grey box

- **Hybrid B&F with ANN model**

Rolling Model Development for Cold Rolling Mill

- Plastic deformation analysis for prediction of pressure distribution at roll bite using
  - Equilibrium equation
  - Yield criterion
  - Stress-strain relationship
- Prediction of roll force
- Tunning & validation of model

The problem



Angle of bite $\theta = 2\mathrm{Sin}^{-1}\left(\frac{1}{2}\sqrt{\frac{\Delta h}{R}}\right)$

Assumptions

- Friction is slipping type
- Coefficient of friction is constant at arc of contact
- Elastic compression is negligible
- The deformation is plane strain
- von Misses yield criterion is applied
- Vertical plane remains vertical

Derivation of equations

Equilibrium Equation

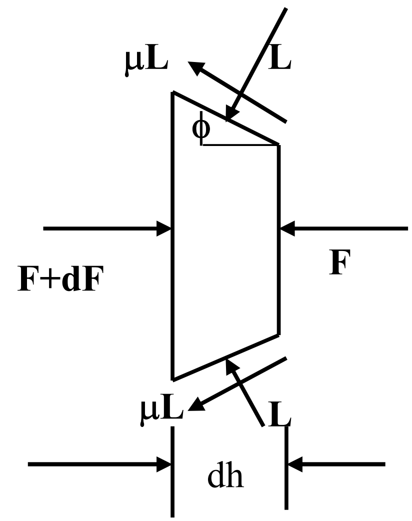
$F+dF = 2L_h+2N_h+F$

$L_h = q(Rd\phi)\sin\phi.$

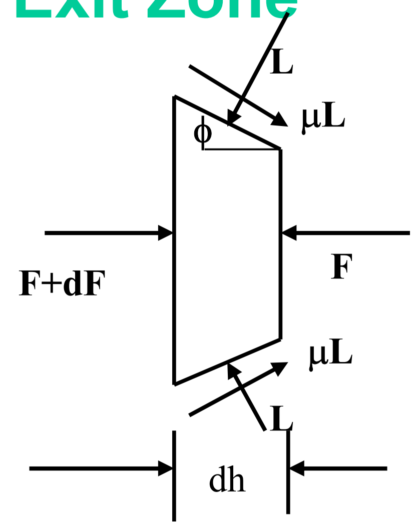
$N_h= \quad \pm\mu q(Rd\phi)\cos\phi$

(-ve for entry zone)

$$\frac{dF}{d\phi} = 2Rs(\sin\phi \mp \mu\cos\phi)$$



Exit Zone



Entry Zone

Stress-strain relationship

$\varepsilon_x = \sigma_x - \nu(\sigma_y+\sigma_z),$
$\varepsilon_y = \sigma_y - \nu(\sigma_x+\sigma_z),$
$\varepsilon_z = \sigma_z - \nu(\sigma_x+\sigma_y)$

$\varepsilon_x+\varepsilon_y+\varepsilon_z=0, \Rightarrow \nu= ½$

For plane strain condition $\varepsilon_y = 0$
$\Rightarrow \sigma_y= ½ (\sigma_x+\sigma_z)$

Derivation of equations

Yield criterion

von Misses yield criterion is

$(\sigma_x-\sigma_y)^2+(\sigma_y-\sigma_z)^2+(\sigma_z-\sigma_x)^2 = 2Y^2$

$\Rightarrow \sigma_z-\sigma_x = 1.155Y = K$

(K is resistance to homogeneous deformation)

$\Rightarrow F = \sigma_x h = h(\sigma_z - K)$

$$\Rightarrow \quad \frac{dF}{d\phi} = (hK)\frac{d\left(\frac{\sigma_z}{K}\right)}{d\phi} + \left(\frac{\sigma_z}{K} - 1\right)\frac{d(hk)}{d\phi}$$

Derivation of equations

Pressure distribution

$$q_e = \frac{hK}{h_1}\left(1-\frac{\sigma_1}{K_1}\right)e^{\mu(H_1-H)}$$

$$q_x = \frac{hK}{h_2}\left(1-\frac{\sigma_2}{K_2}\right)e^{\mu H}$$

$$H = 2\sqrt{\frac{R}{h_2}}\tan^{-1}\left(\sqrt{\frac{R}{h_2}}\phi\right)$$

Determination of neutral angle

$$H_n = \frac{H_1}{2} - \frac{1}{2\mu}\ln\left(\frac{h_1}{h_2}\frac{\left(1-\frac{\sigma_2}{K_2}\right)}{\left(1-\frac{\sigma_1}{K_1}\right)}\right)$$

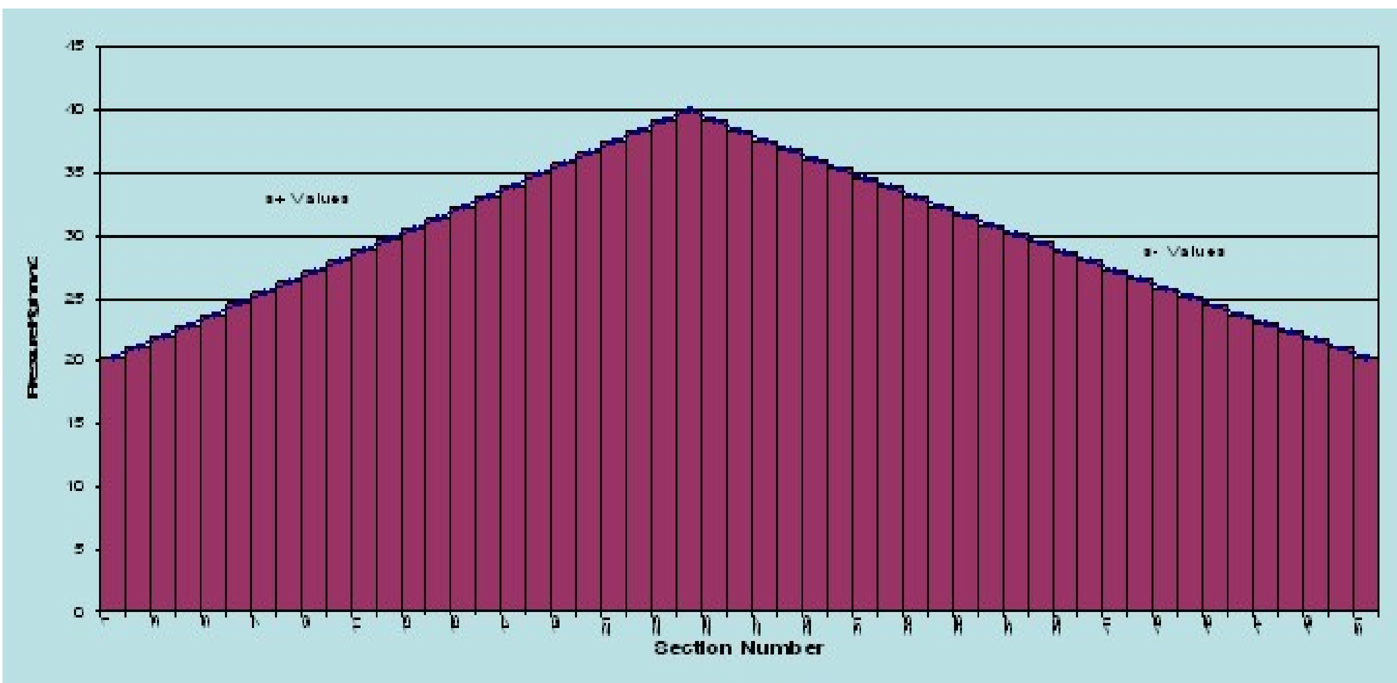
$$\phi_n = \sqrt{\frac{h_2}{R}}\tan\left(\sqrt{\frac{h_2}{R}}\frac{H_n}{2}\right)$$

Roll Force Determination

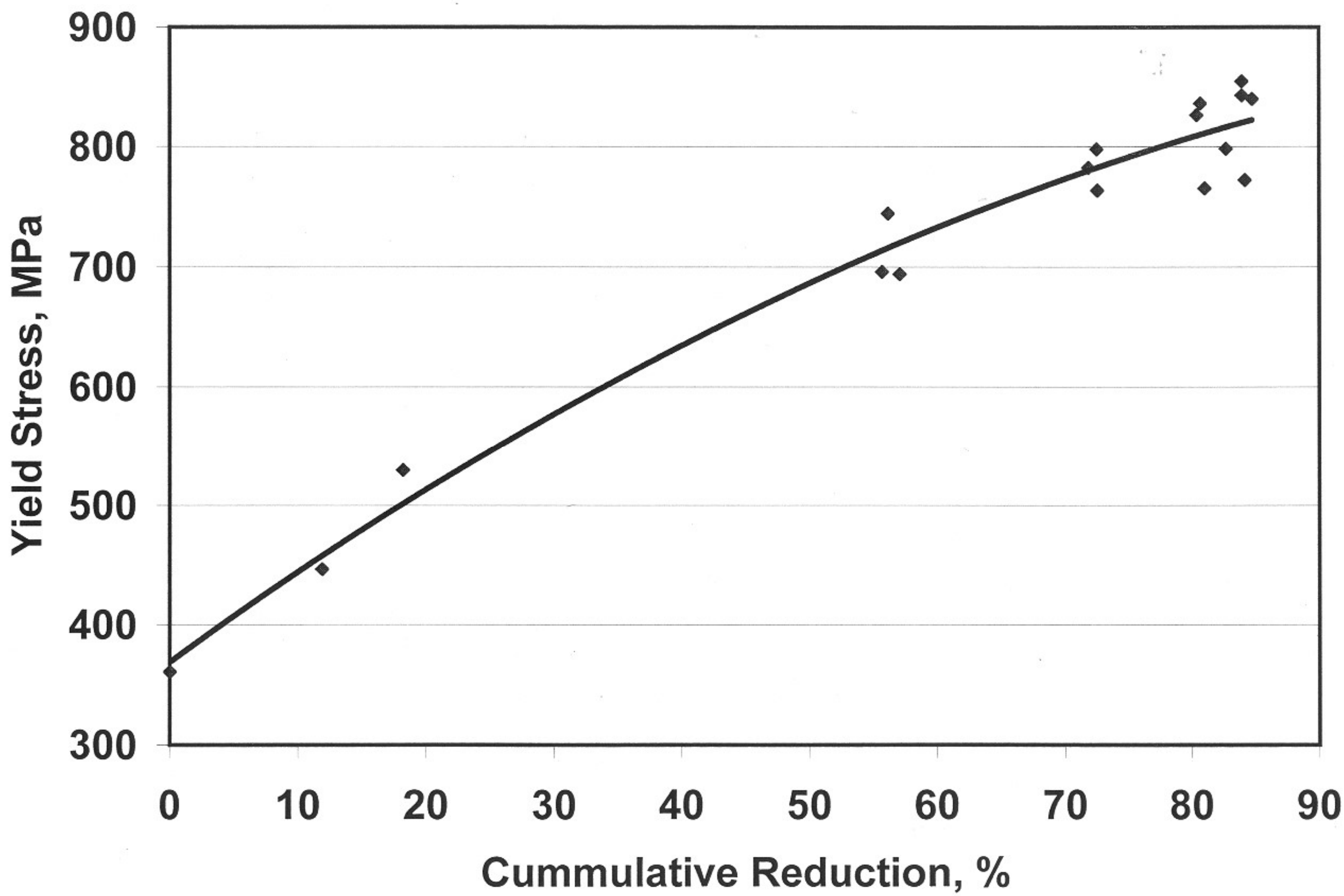
Determination of roll force

$$P = Rb\left(\int_{0}^{\phi_n} q_x d\phi + \int_{\phi_n}^{\theta} q_e d\phi\right)$$

$$P = Rb\left(\left(\frac{1}{2}q_{e1} + \sum_{i=2}^{i=n-1} q_{ei} + \frac{1}{2}q_{en}\right) + \left(\frac{1}{2}q_{xn} + \sum_{i=n+1}^{i=m} q_{xi} + \frac{1}{2}q_{x(m+1)}\right)\right)\Delta\phi$$

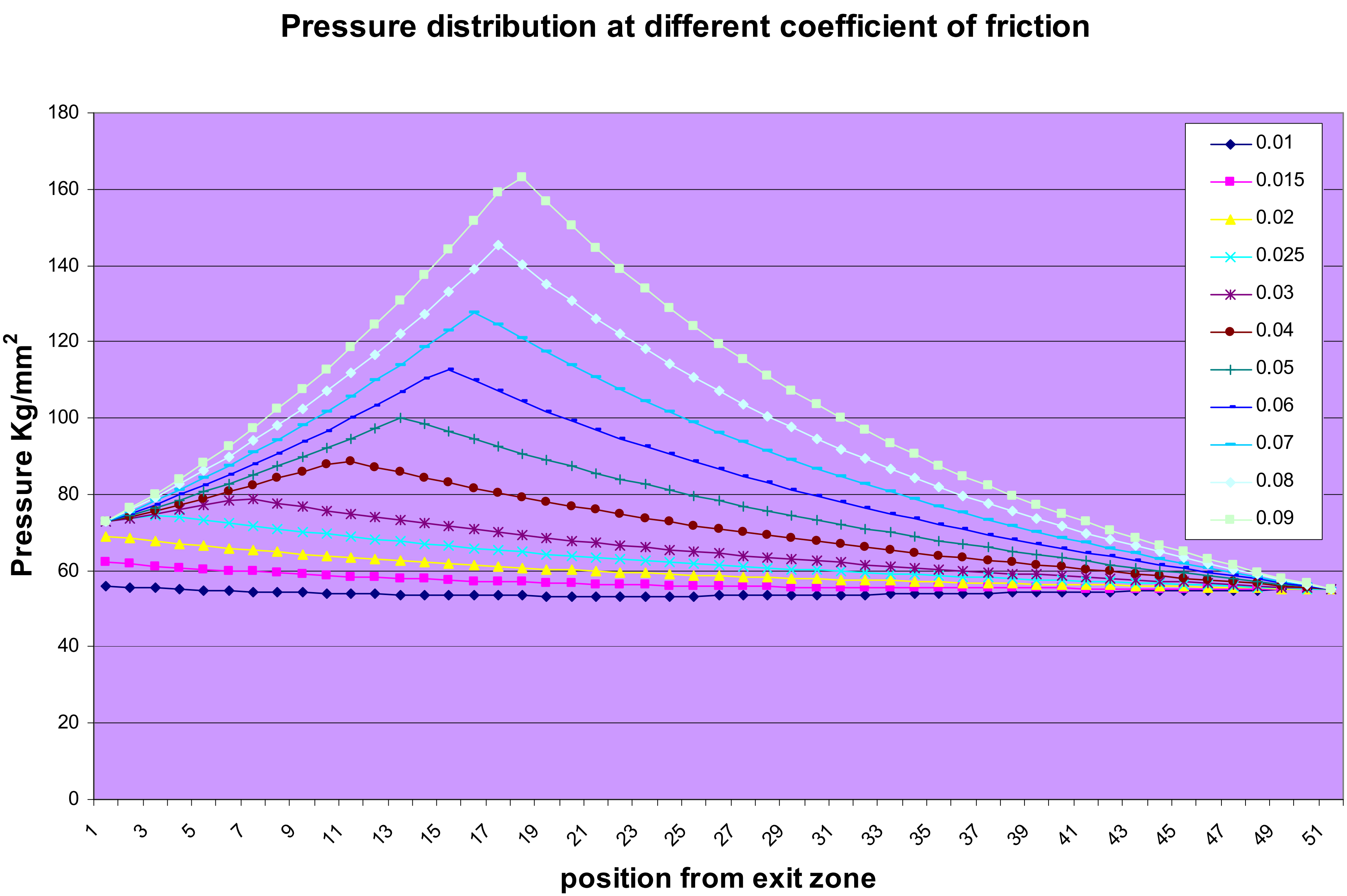


Dynamic YS

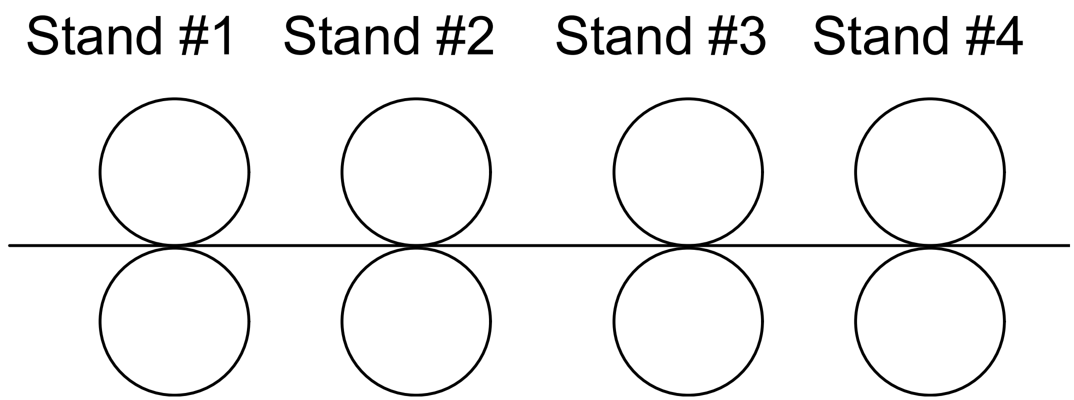


900
800
700
600
500
400
300
Yield Stress, MPa
0
10
20
30
40
50
60
70
80
90
Cummulative Reduction, %

Numerical analysis of q: Effect of μ



Scheme for Tandem Cold Rolling



Entry thickness	H1(1)	H1(2)	H1(3)	H1(4)	
Exit thickness		H2(1)	H2(2)	H2(3)	H2(4)
Entry Tension	T1(1)	T1(2)	T1(3)	T1(4)	
Exit Tension		T2(1)	T2(2)	T2(3)	T2(4)
Speed		V(1)	V(2)	V(3)	V(4)

Roll radius	R(1)	R(2)	R(3)	R(4)	
Forward Slip	f(1)	f(2)	f(3)	f(4)	
Roll force	F(1)	F(2)	F(3)	F(4)	
Torque	T(1)	T(2)	T(3)	T(4)	
Power	Pw(1)	Pw(2)	Pw(3)	Pw(4)	

Visual Basic based model screen

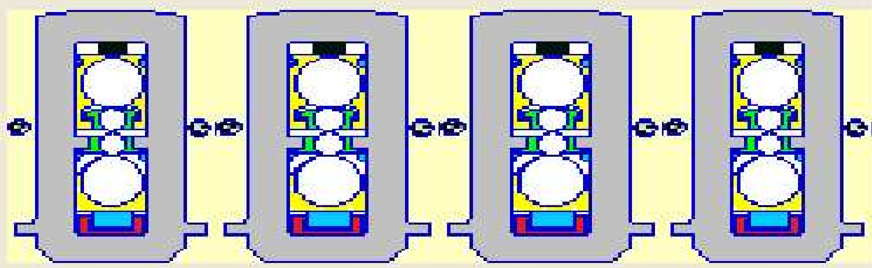
Model Results

SIMULATOR FOR TANDEM MILL-I, BSL

सेल SAIL

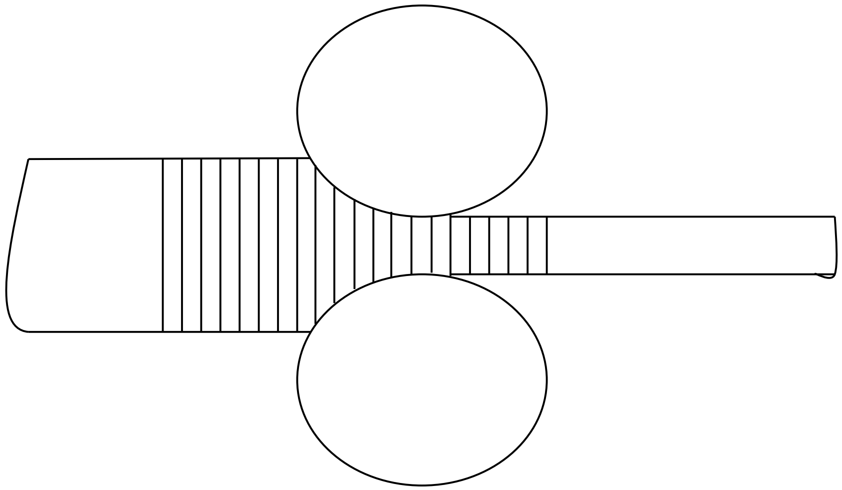
Input | Print | Exit

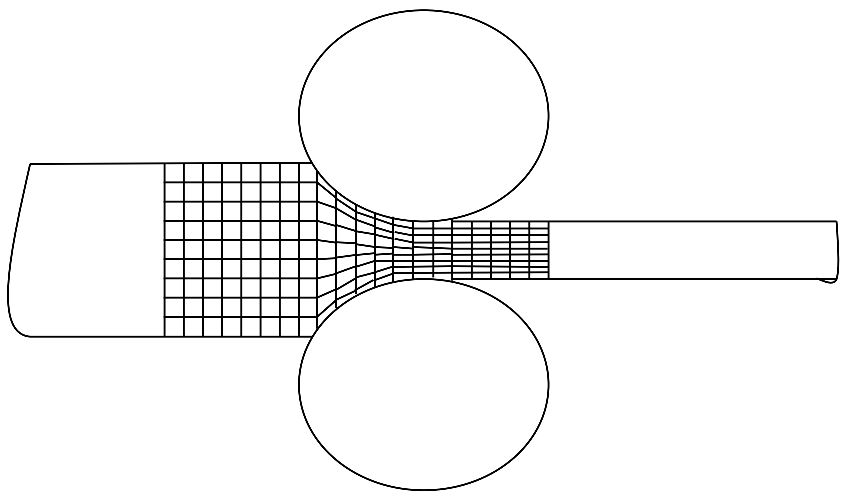
DEVELOPED BY RDCIS



		Stand#1	Stand#2	Stand#3	Stand#4
Thickness (mm)	2.20	1.58	1.11	0.80	0.63
Speed (mpm)		4.80	6.80	9.50	12.00
Stand Reduction (%)		28.41	29.41	28.42	20.83
Cummulative Reduction (%)		28.41	49.47	63.83	71.36
Part of Total Reduction (%)		39.81	29.51	20.13	10.56
Coefficient of friction		0.07	0.05	0.05	0.05
Deformed Roll Diameter (mm)		575.09	575.13	590.18	600.19
Roll Force (Ton)		1611.12	1651.69	1587.98	1235.08
Rolling Torque (Ton-m)		19.30	18.10	14.69	8.47
Rolling Power (KW)		3951.04	5250.50	5801.14	4156.96

Difference between Slab Method & FEM Method





Why DEFORM?

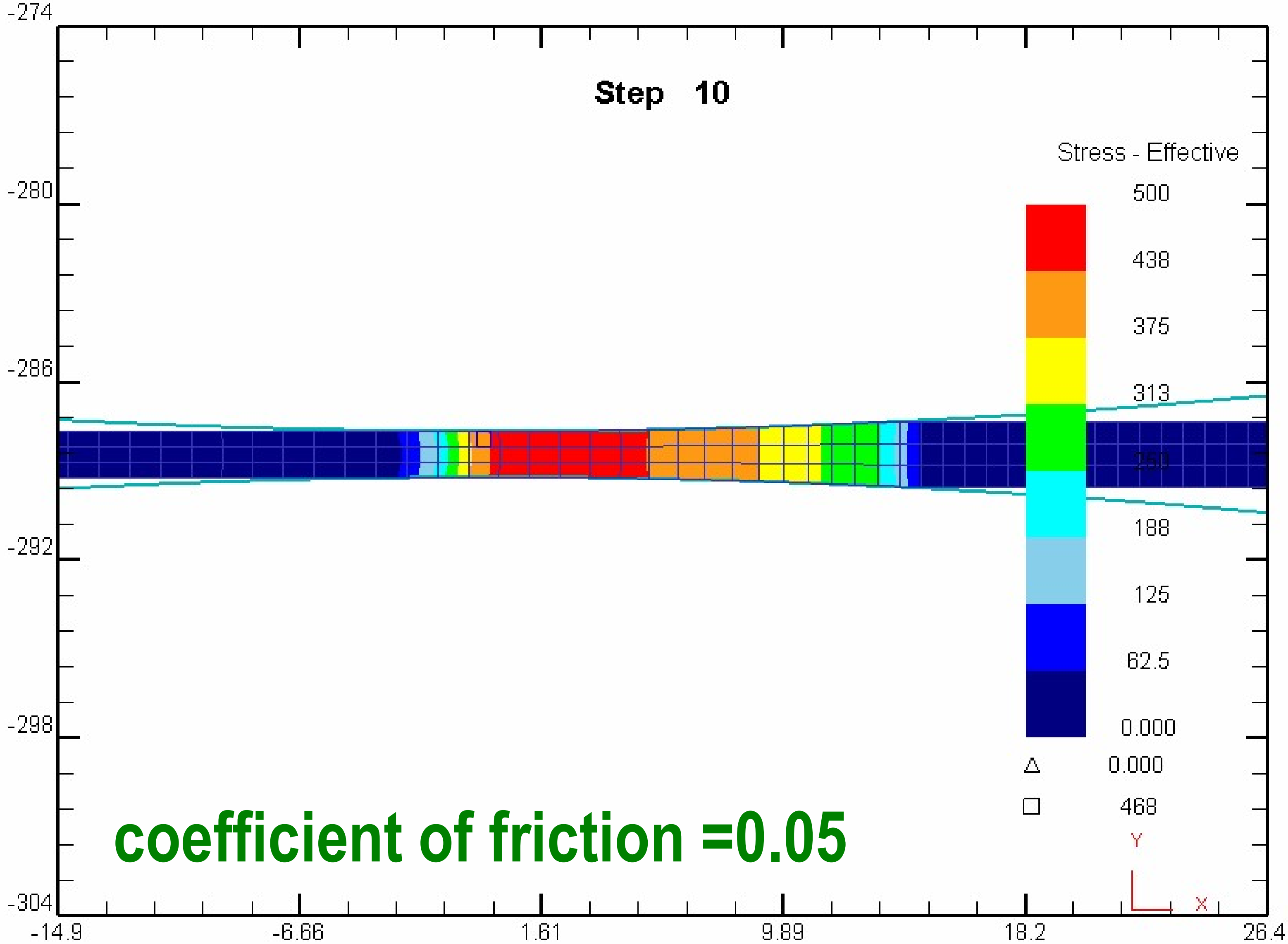
- **DEFORM has capabilities for FEM analysis of elastic, plastic, thermal & microstructure evolution problems.**
- **Software has been upgraded by SFTC, USA for rolling process in consultation with RDCIS**
- **It has a very strong pre-processor and post-processor for formulation of problems and analysis of results.**
- **It has a on-line application capability**

DEFORM Simulation with different Coefficient of friction

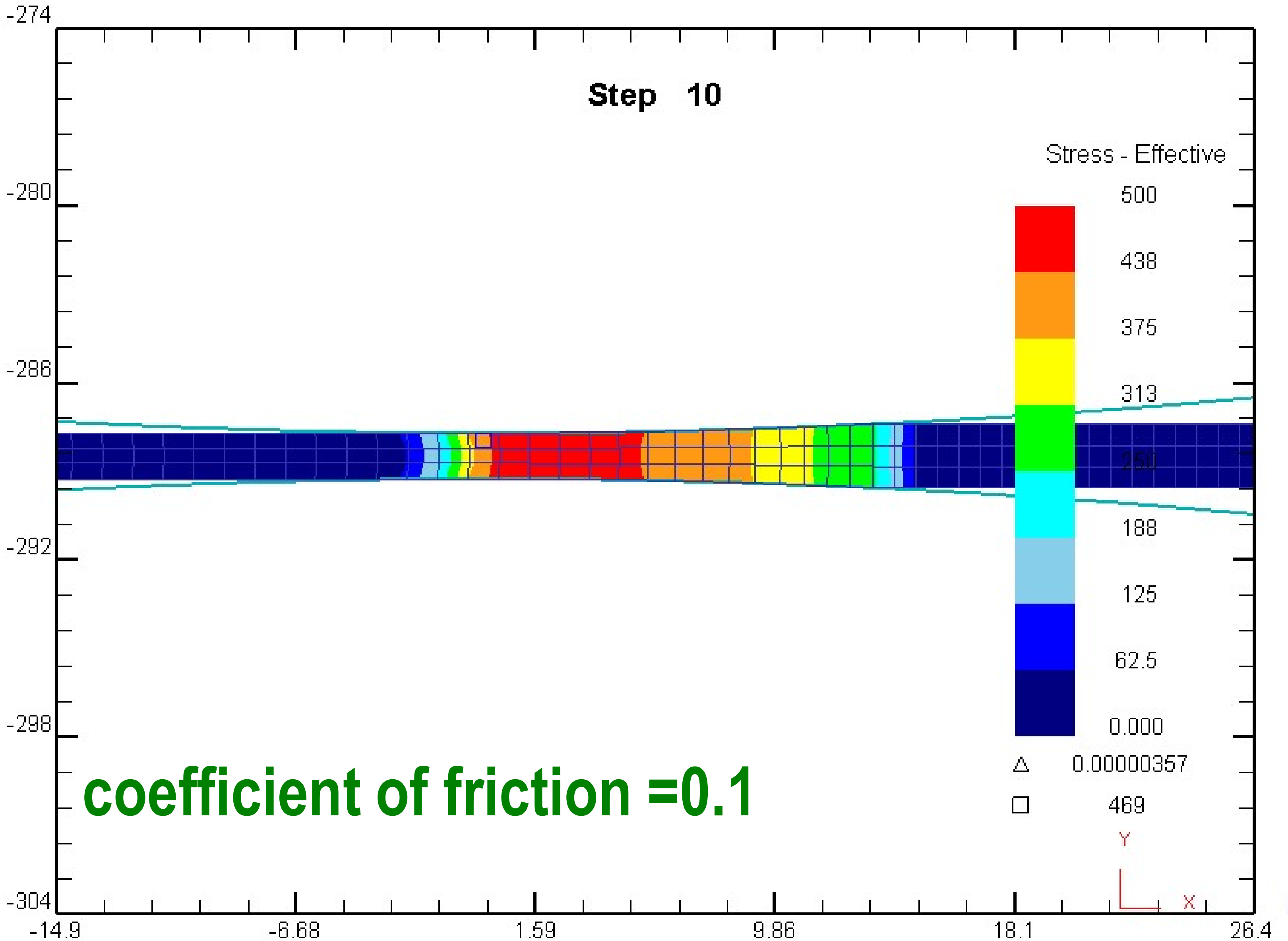
Table 1: Parameters for simulations to study the for a typical pass (Effect of Coefficient of friction)

Parameter	Values
Roll diameter	575 mm
Entry thickness of strip	2.2 mm
Exit thickness of strip	1.58 mm
Reduction	28.18%
Rolling Speed	4.8 m/s
Coefficient of friction(μ)	0.04,0.05,0.06,0.07,0.08,0.09,0.10, 0.11,0.12,0.13,0.14,0.15,0.16,0.17 0.18,0.19
Roll material type	Rigid
Roll temperature	55 °C
Strip Width	1600 mm
Total No. of Simulations	17

DEFORM Simulation Results

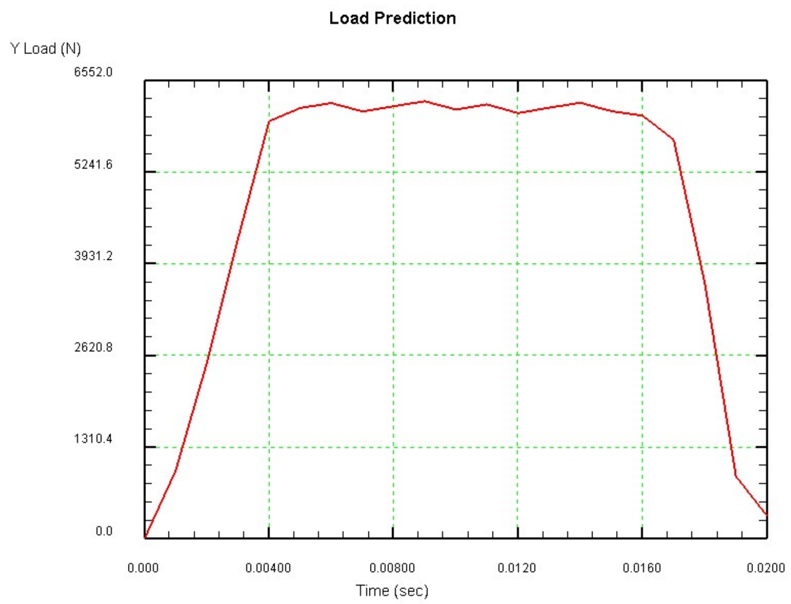


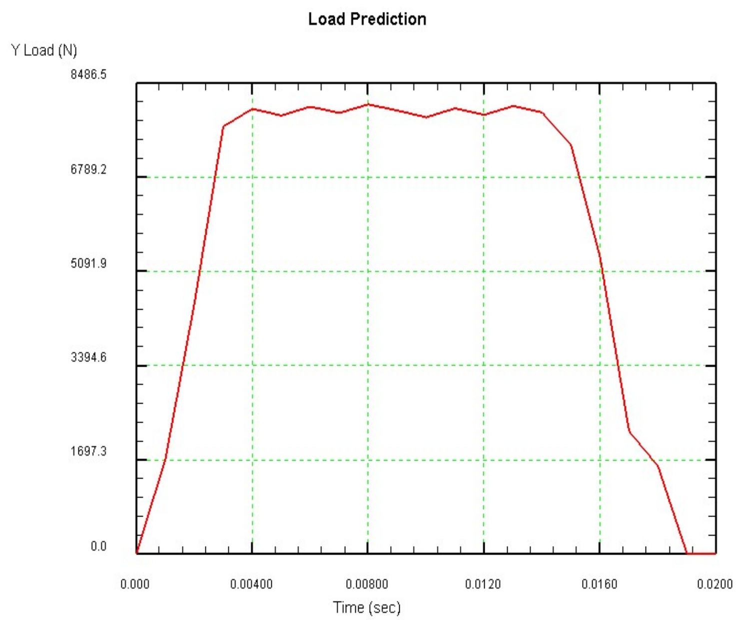
DEFORM Simulation Results



coefficient of friction =0.1

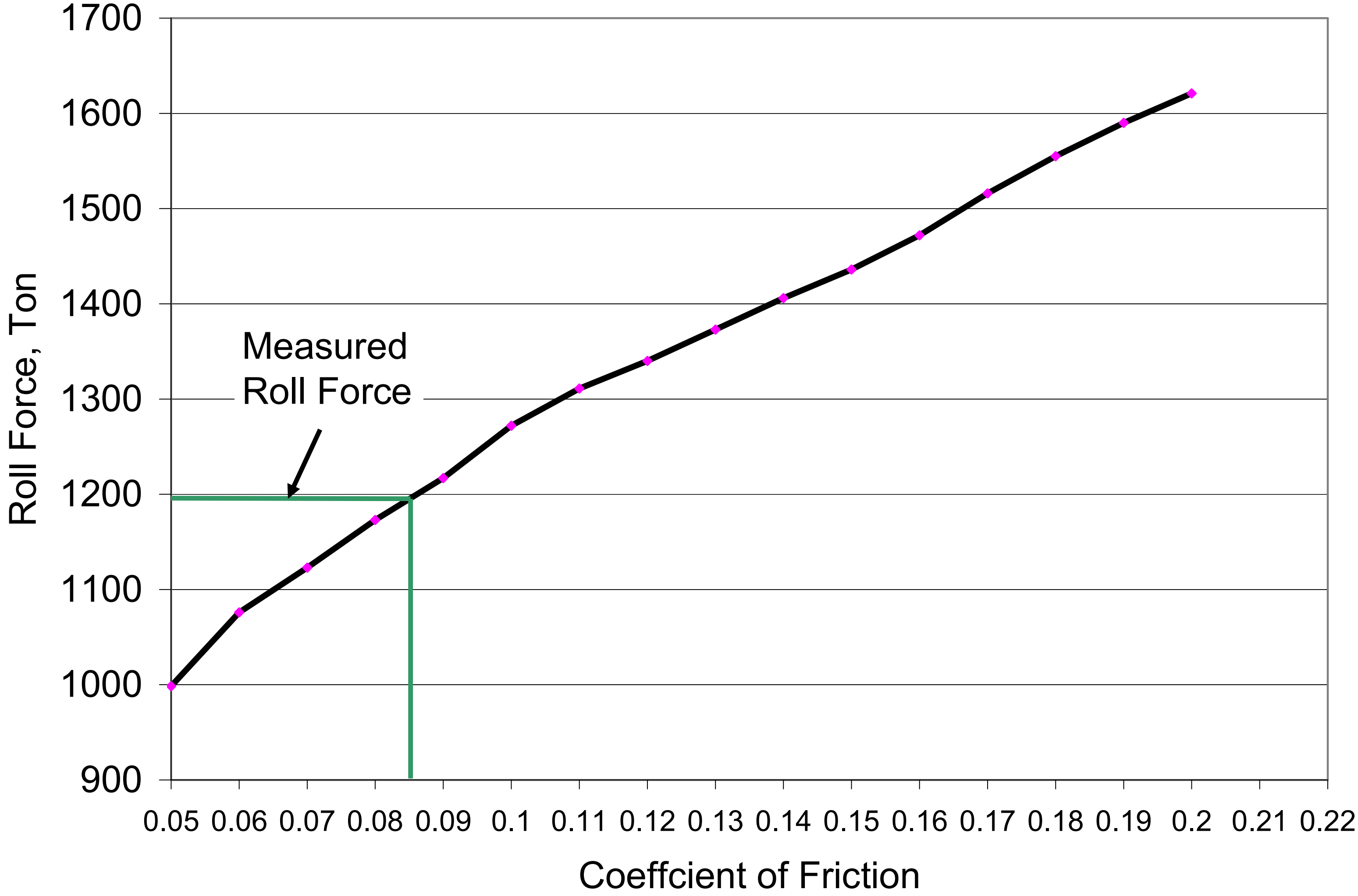
DEFORM Simulation Results: Roll force prediction



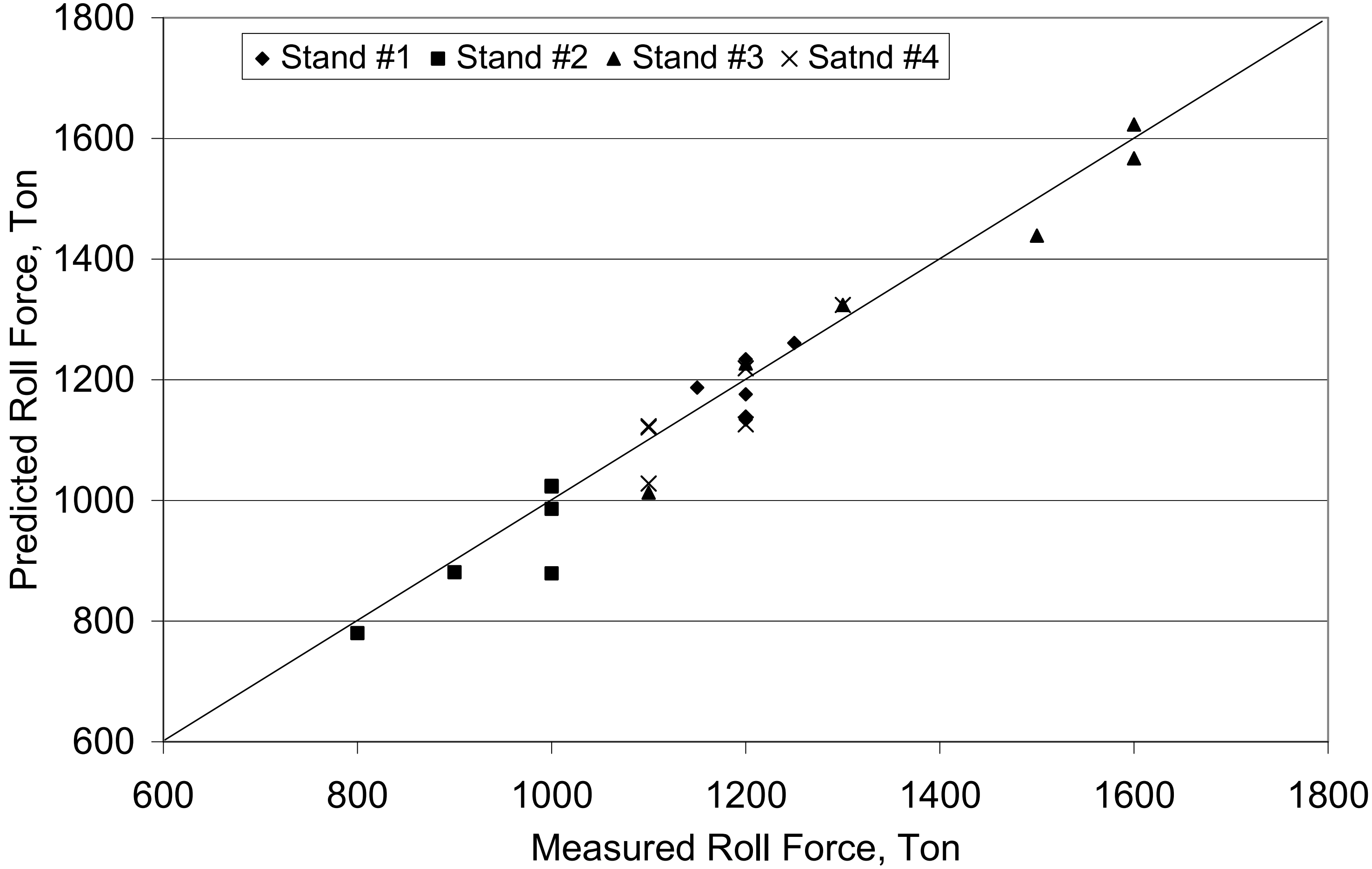


coefficient of friction =0.05 **coefficient of friction =0.1**

DEFORM Simulation Results: Roll force prediction

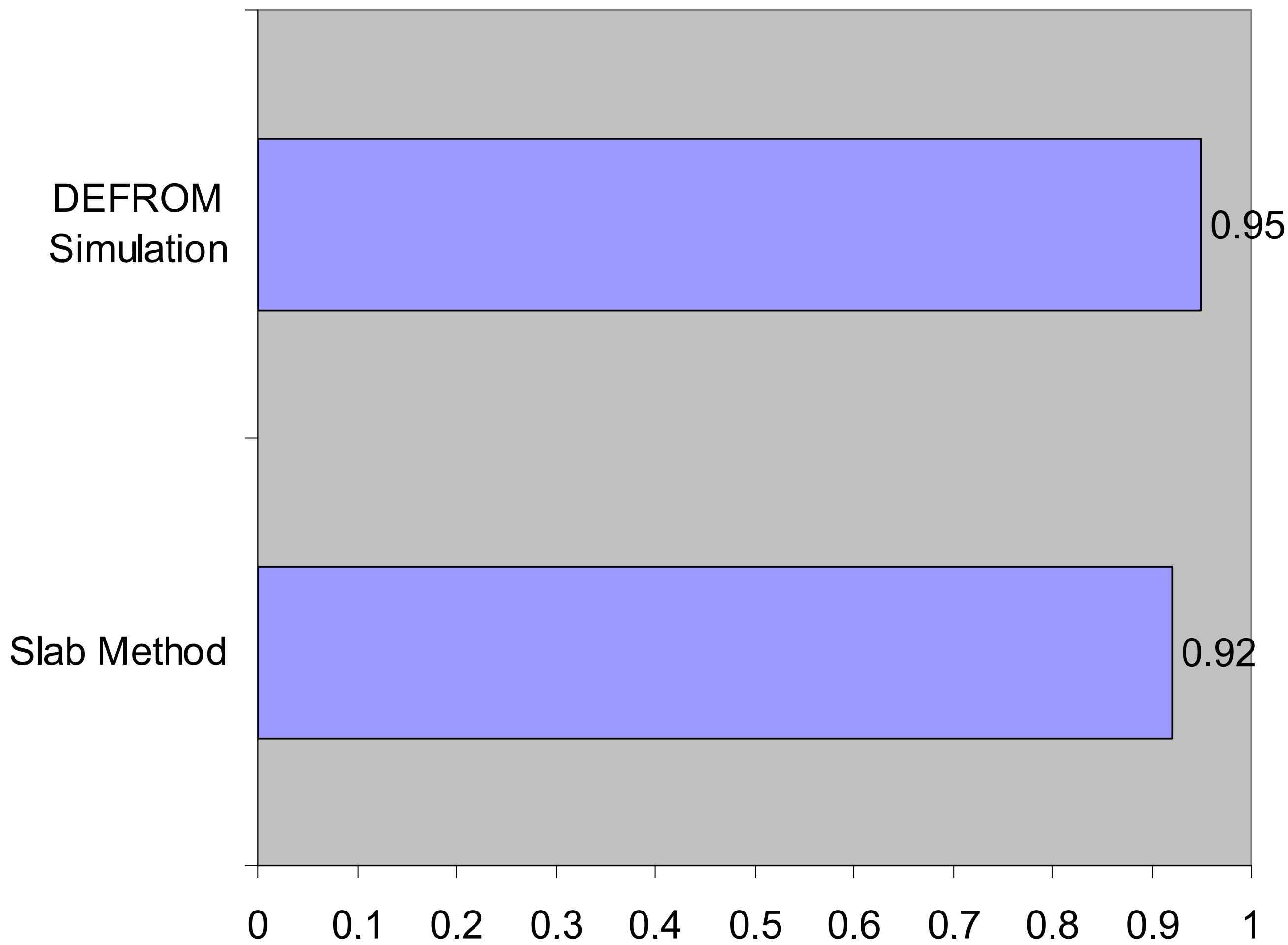


DEFORM Simulation Results: Validation of Roll force prediction



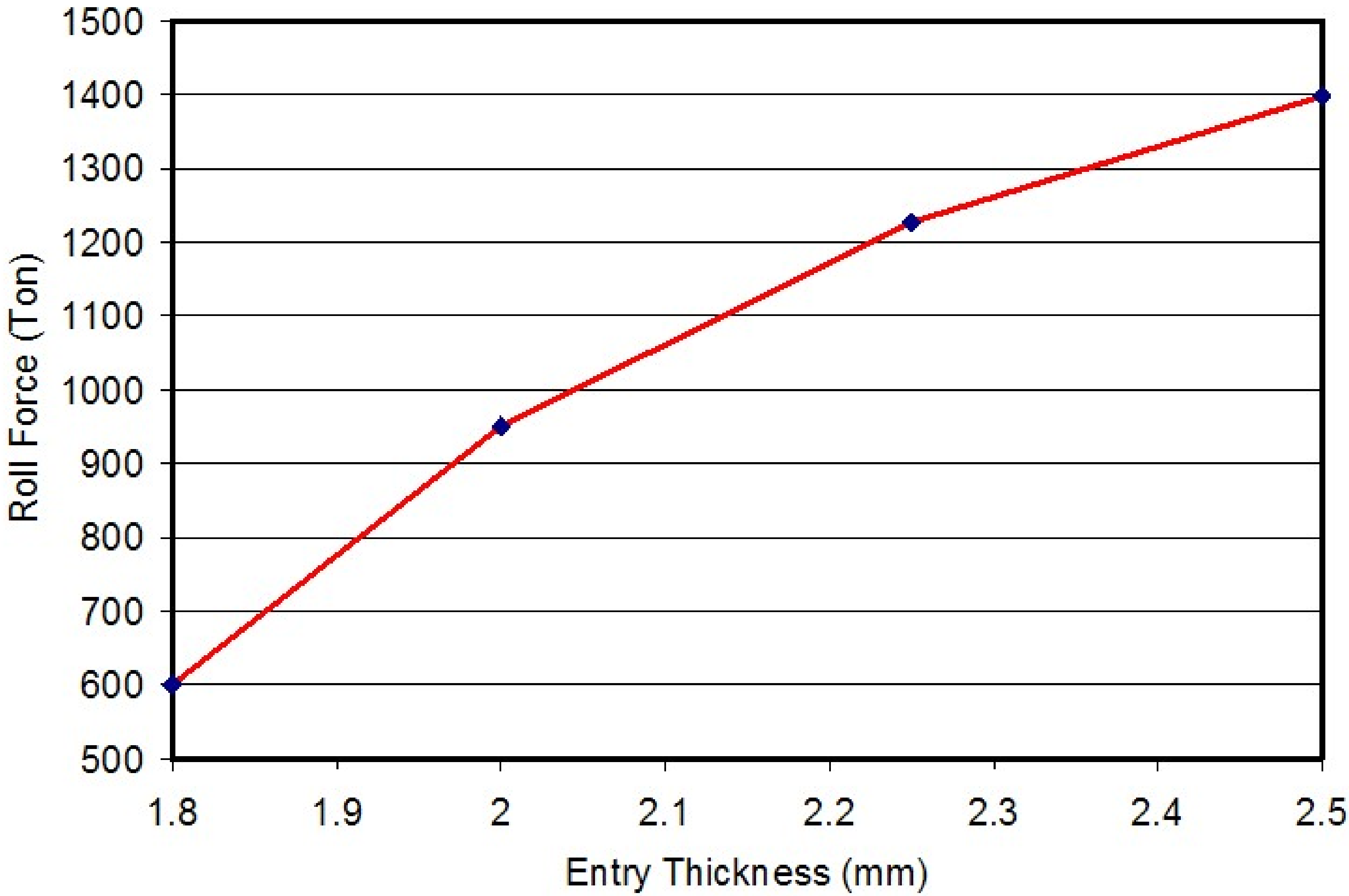
DEFORM prediction is highly accurate with r^2 value 0.95

DEFORM Simulation Results: Validation of Roll force prediction

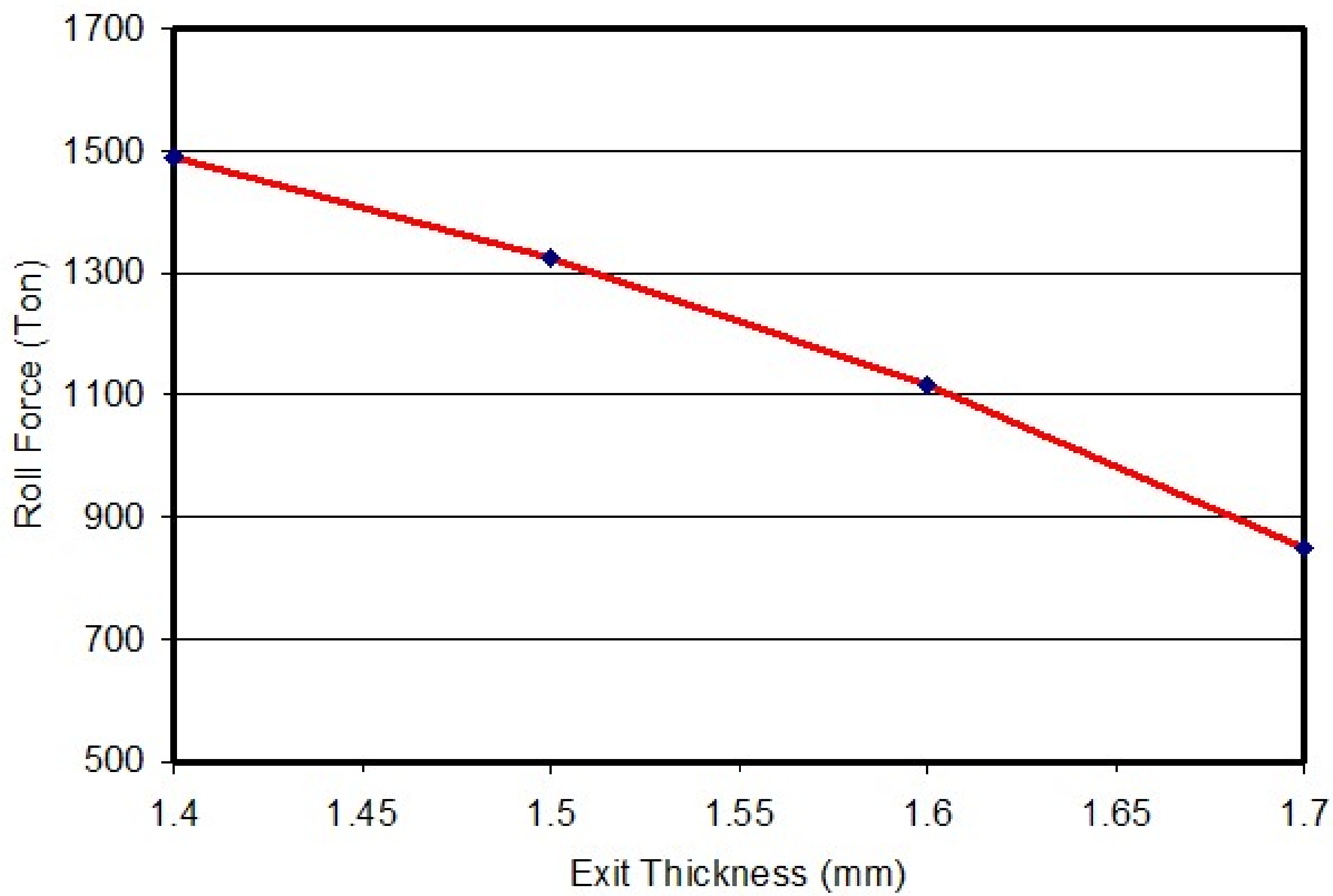


Comparison of r^2 values

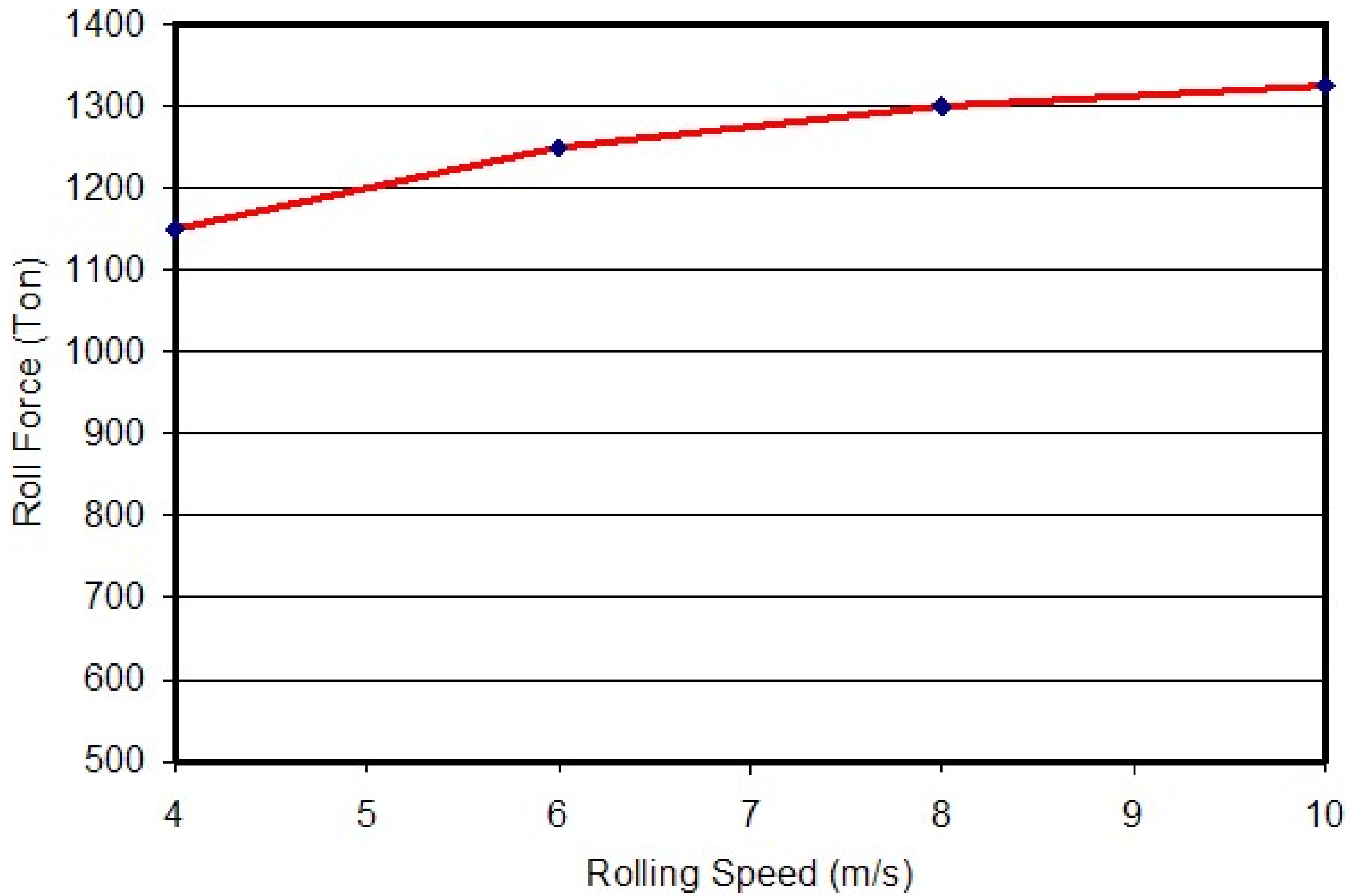
DEFORM Simulation Results



DEFORM Simulation Results



DEFORM Simulation Results



Conclusions

- Roll force prediction is more accurate in DEFORM than slab method
- Coefficient of friction has been calculated inversely from roll force
- This simulation helps in designing of reduction schedules during tandem rolling process

Thank You

Emerging technologies in automotive steel

Rajesh Pais

Tata Steel

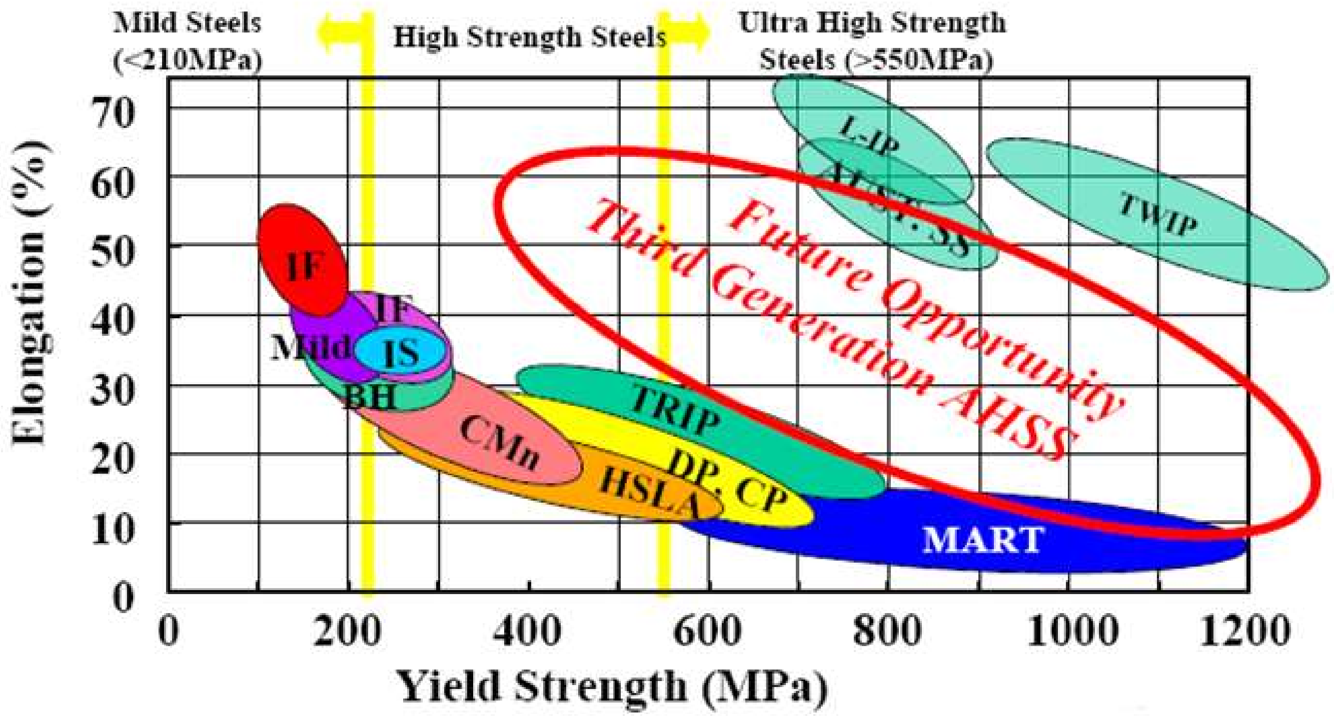
20 Nov 2010

Content

Drivers for Change in the Automotive Industry

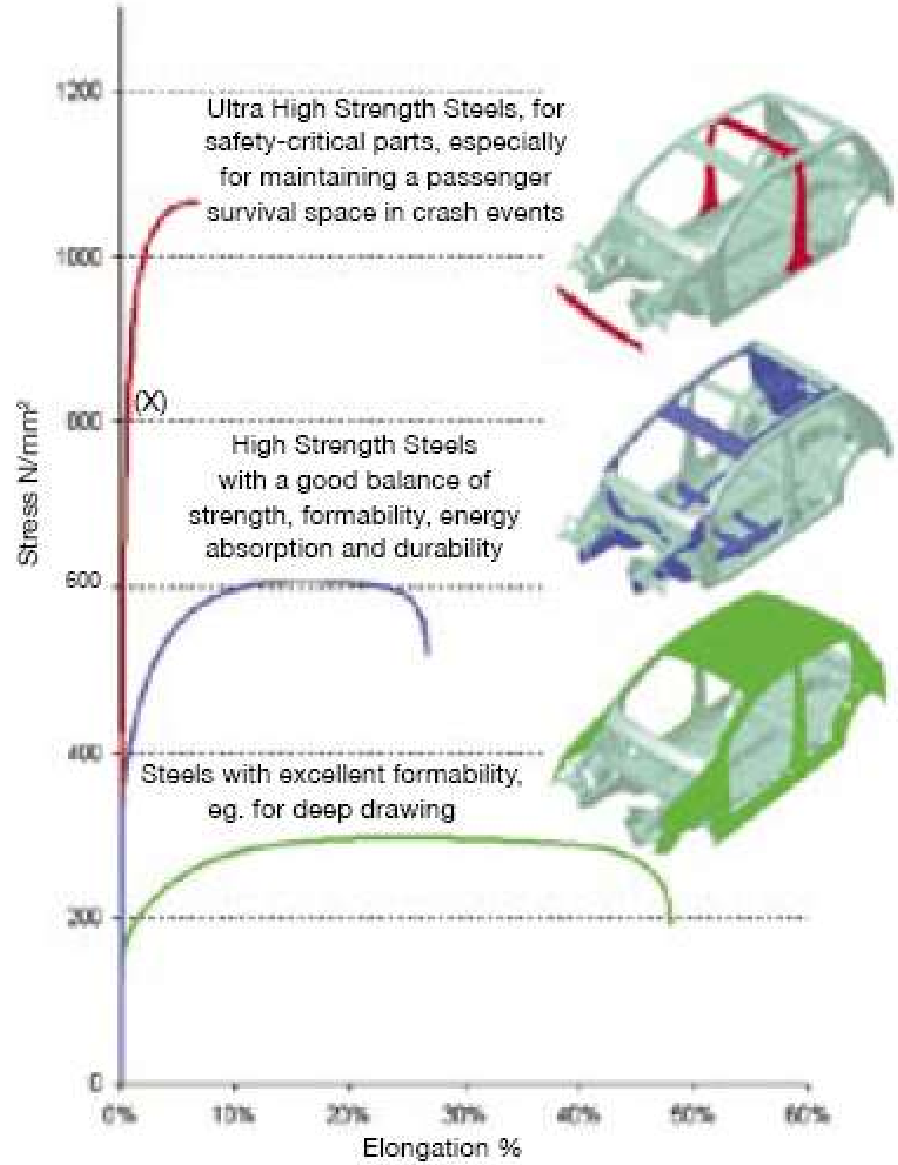
Regulatory and environmental issues	Customer satisfaction	Cost/affordability	Globalization
• Emissions Drivers for change in the automotive industry • Fuel economy • Recyclability • Safety	• Noise, vibration and harshness (NVH) reduction • Price/performance • Warranty/service/lif e	• Materials • Manufacturing process	• Engineering • Sourcing • Market growth • Competition • Trade policies

Evolution of High strength steel

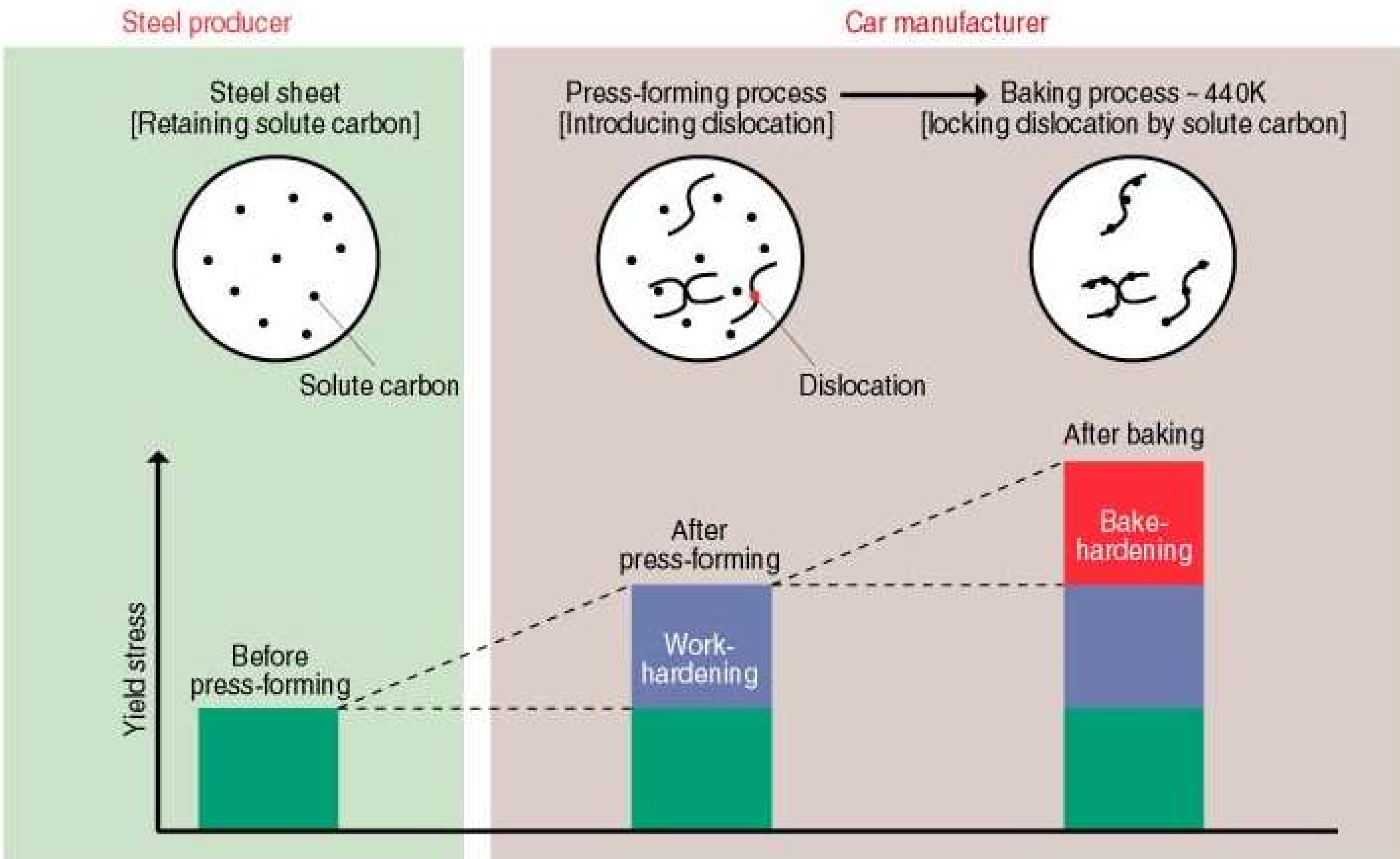


Advanced High Strength Steel

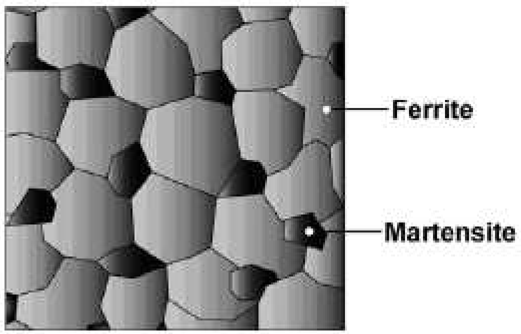
Type	Description
IF	Interstitial Free
BH	Bake Hardening
HSLA	High Strength - Low Alloy
CMn	Carbon Manganese
DP	Dual Phase
Boron	Boron steel
TRIP	Transformation Induced Plasticity
MART	Martensitic
TWIP	Twinning Induced Plasticity

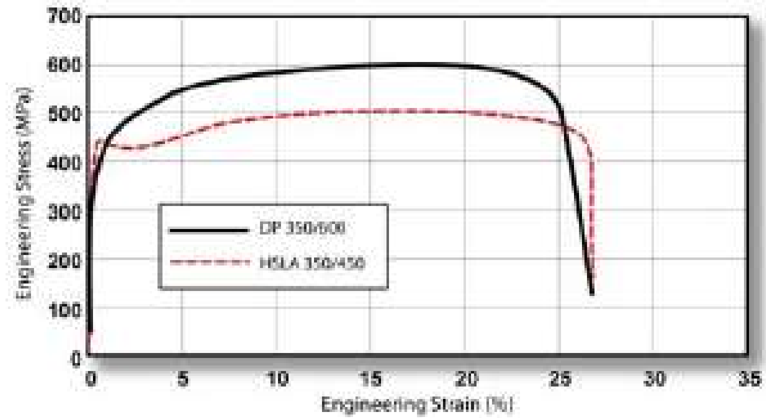


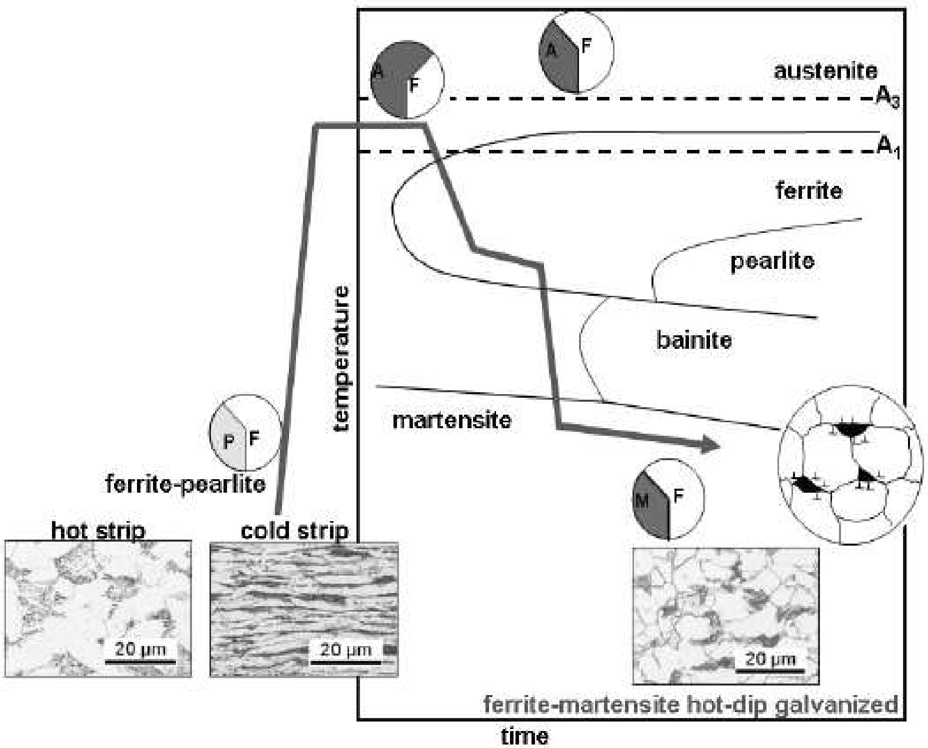
Bake Hardening Steel

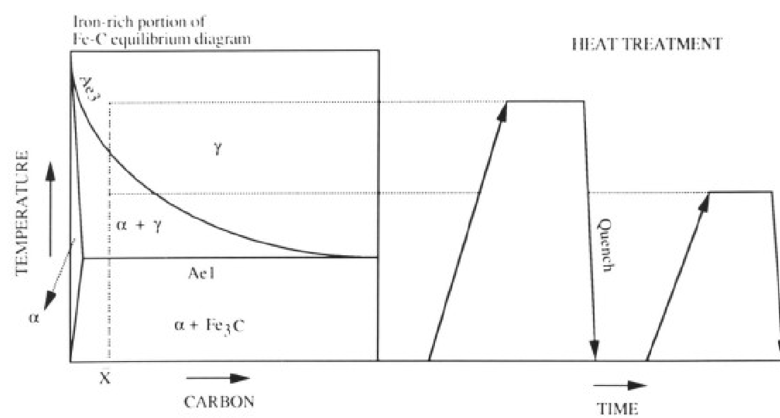


Dual Phase steel



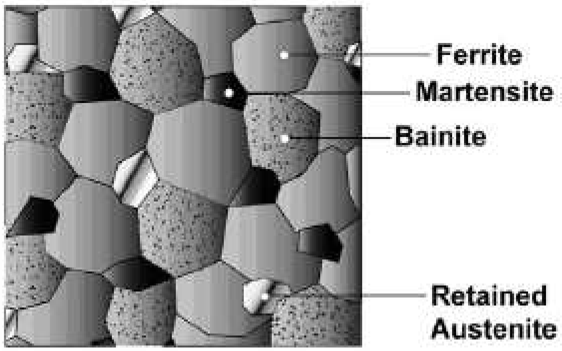


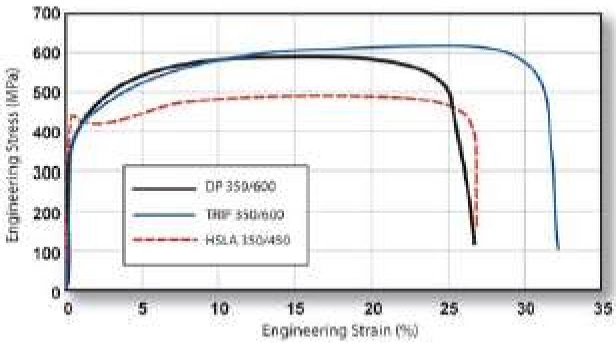




Schematic representation of heat treatments to produce dual phase steels.

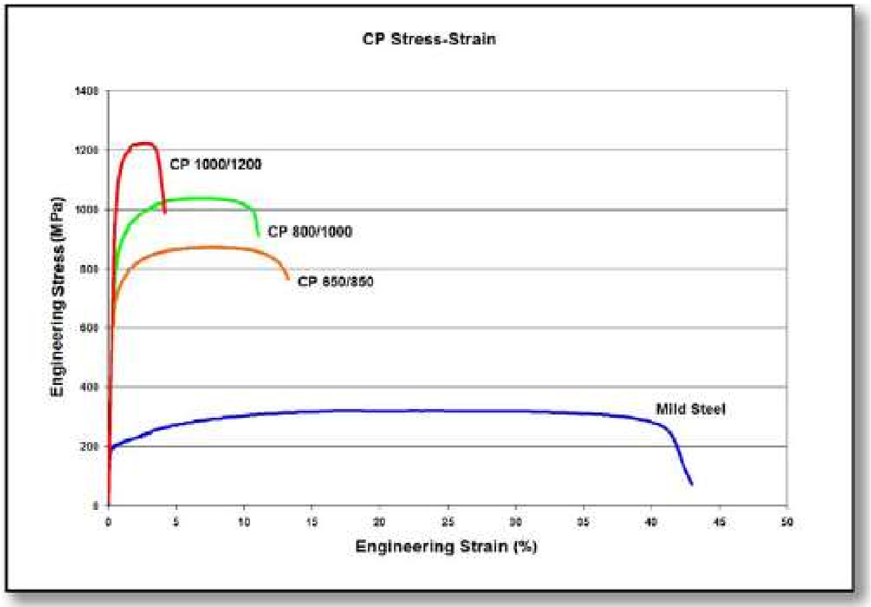
TRIP Transformation Induced Plasticity

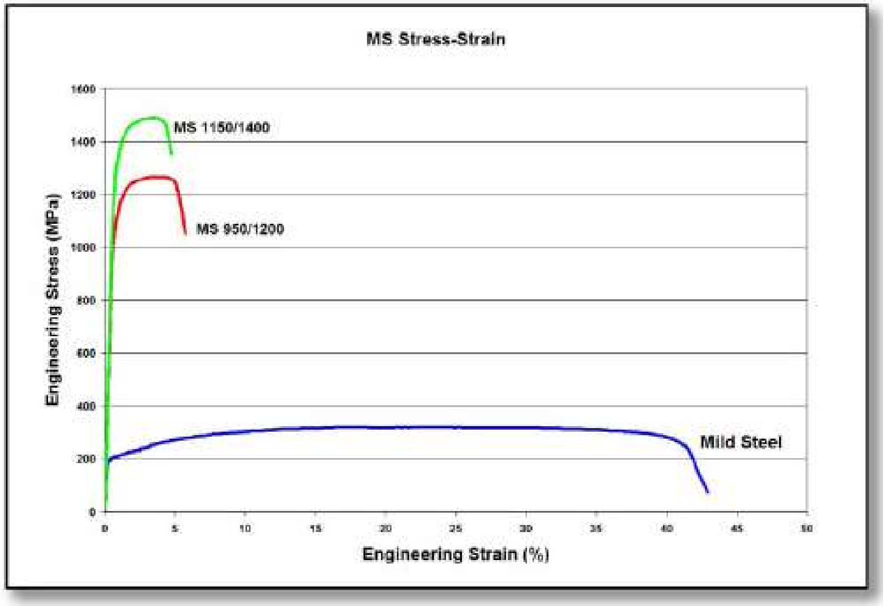




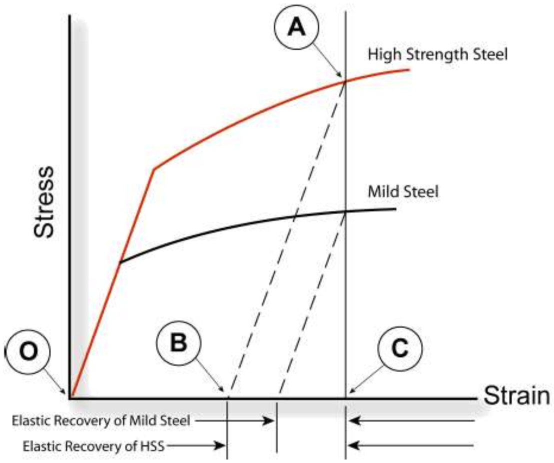
CP Complex Phase

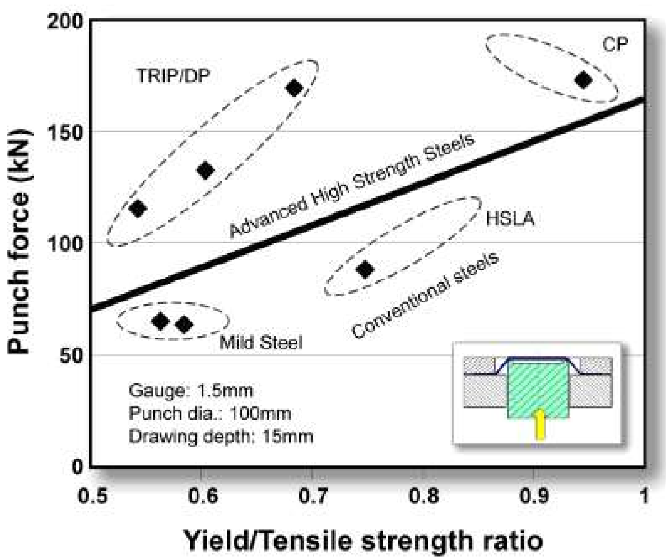
MS Martensitic Steel



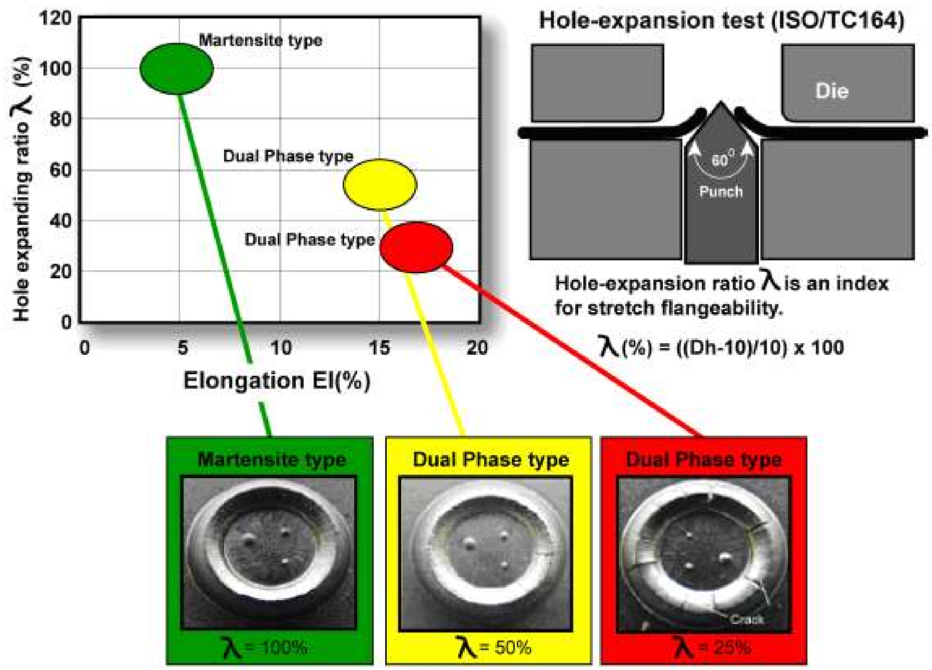


Dual Phase steel – Spring back, HES



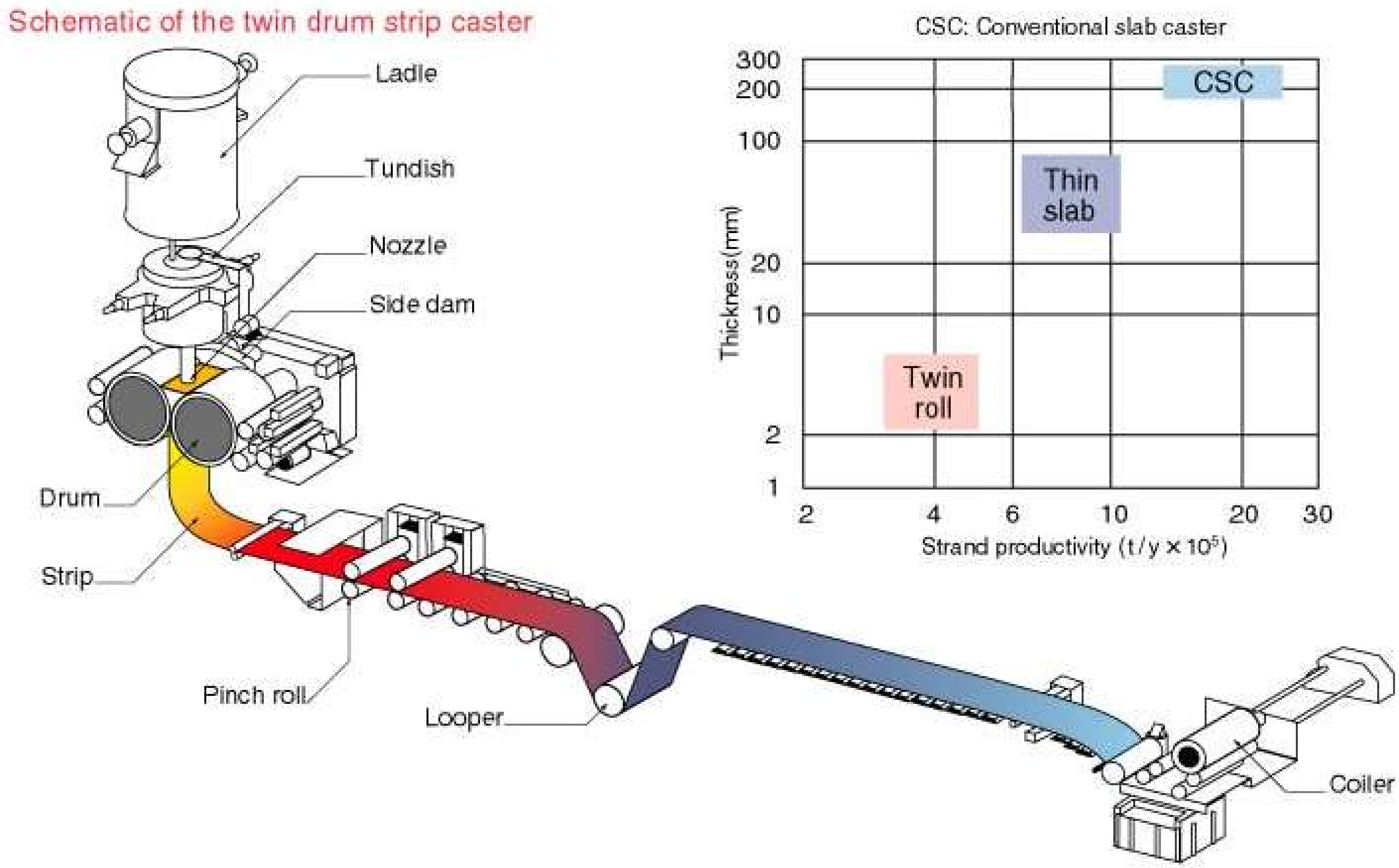


Punch forces from Marciniak cup-stretch forming tests for AHSS and conventional steel types.

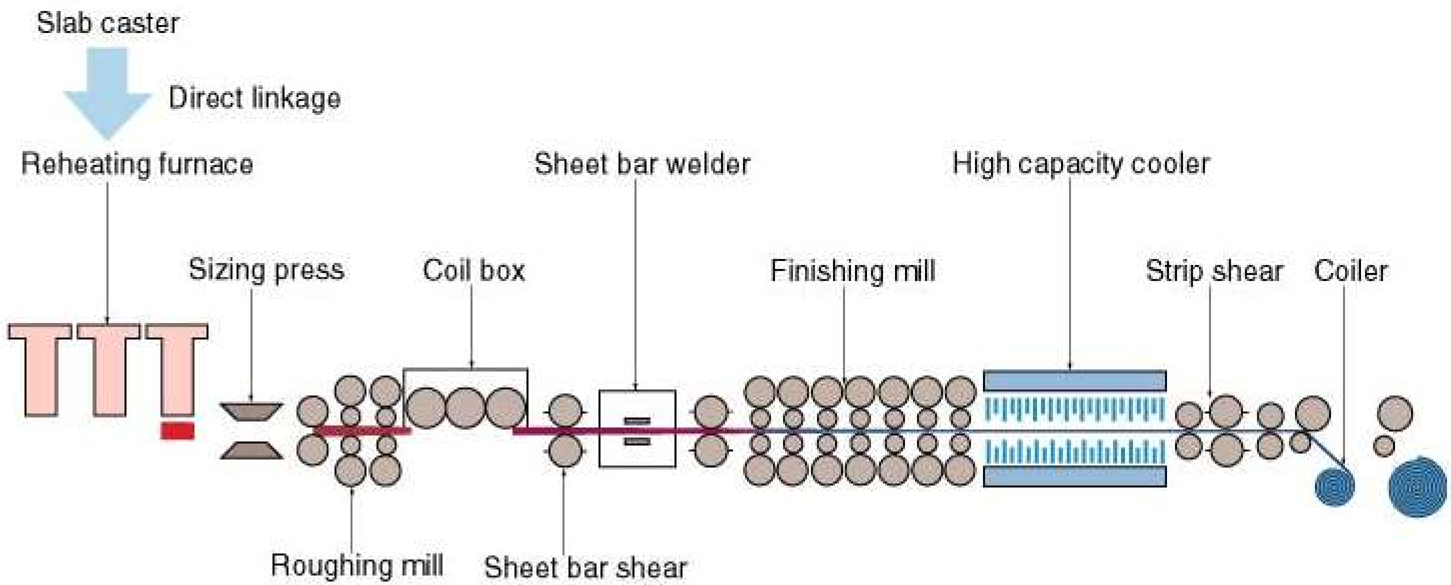


Balance between elongation and stretch flangeability of 980 MPa class AHSS and surface appearance of mechanical joint at the back side.

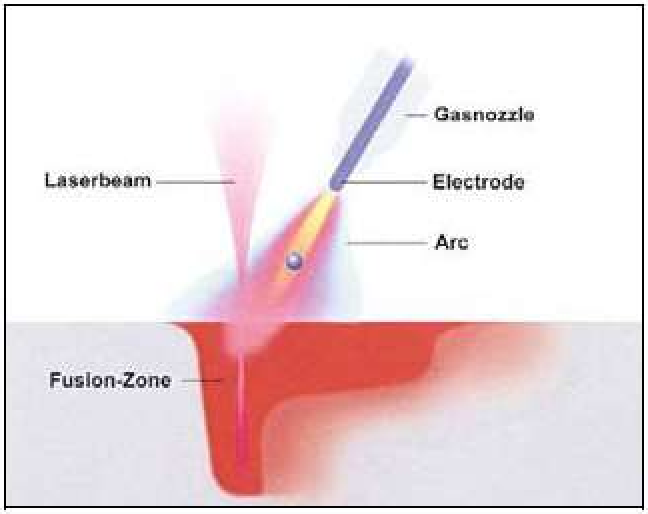
Strip Casting



Endless Hot Strip Rolling Mill



Laser Welding

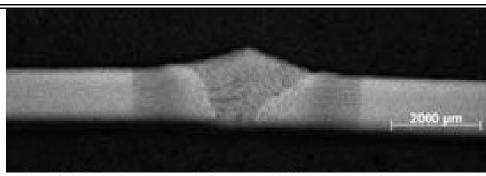


Hybrid laser welding

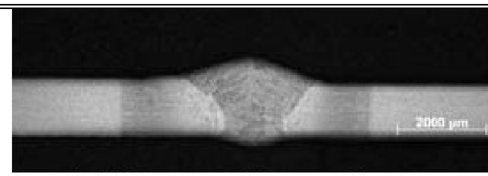
- Combination of Laser welding and an arc welding process.

•To overcome

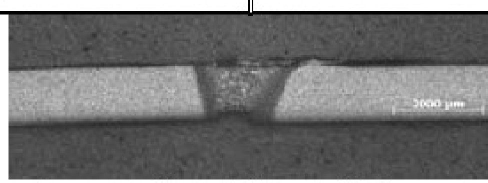
- •Insufficient gap bridging capability of laser welding.
- •Required precision in positioning.
- •Low wall plug efficiency



Hybrid laser weld, weld gap of **0,3 mm**.
Laser power 1,5 kW – Arc power 3,3 kW
Welding speed: 3,9 m/min



Hybrid laser weld, gap of **0,5 mm**.
Laser power 1 kW – Arc power 2,4 kW
Welding speed: 3 m/min



Laser weld, weld gap of **0,1 mm**.
Same welding parameters as for weld *YL*.
Welding speed: 4,8 m/min

Cross sections of 2 hybrid laser welds and 1 laser weld with constant weld gap.

•To improve

- •Very high energy density 10^6W/cm2 (“keyhole”)
- •Welding speed.
- •Welding penetration.

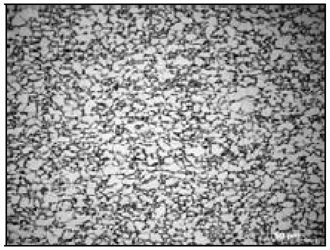
Laser Welding

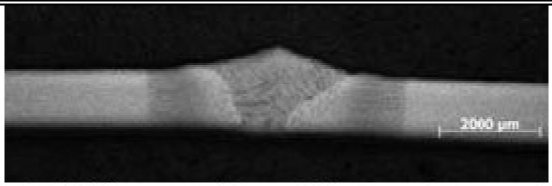
Chemical composition of DP600 parent material.

C	Mn	Si	P	S	Cr	Mo	Pcm	CE(IIW)
0,080	1,51	0,26	0,020	0,004	0,35	0,06	0,19	0,41

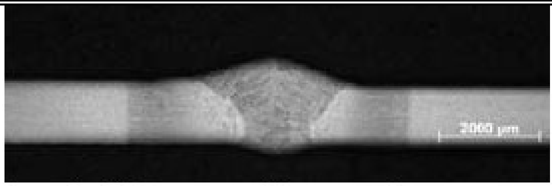
Mechanical properties of the DP600 parent material.

R_e [MPa]	R_m [MPa]	A_{80} [%]
380	649	23,0

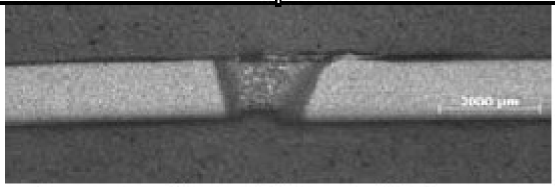




Hybrid laser weld, weld gap of **0,3 mm**.
Laser power 1,5 kW – Arc power 3,3 kW
Welding speed: 3,9 m/min



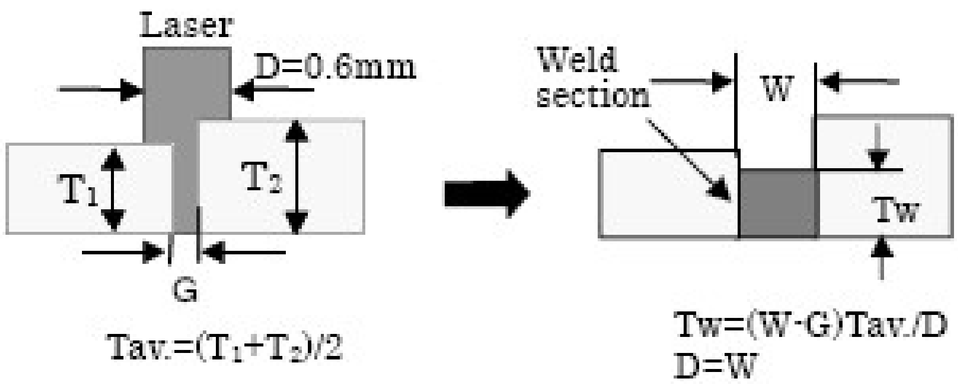
Hybrid laser weld, gap of **0,5 mm**.
Laser power 1 kW – Arc power 2,4 kW
Welding speed: 3 m/min



Laser weld, weld gap of **0,1 mm**.
Same welding parameters as for weld *YL*.
Welding speed: 4,8 m/min

Cross sections of 2 hybrid laser welds and 1 laser weld with constant weld gap.

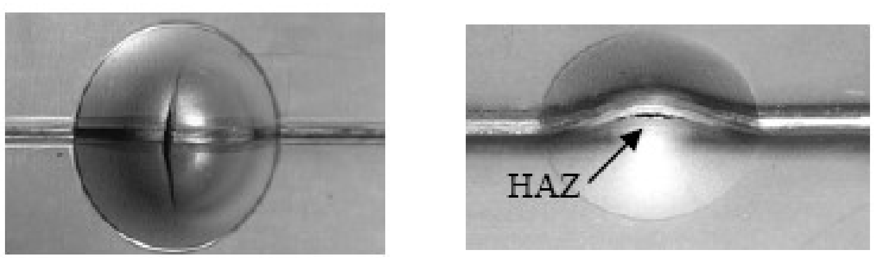
Laser Welding



Conditions required at welds of differential thickness joints (thickness ratio up to three)

Laser welding conditions

Kind of laser	CO_2 laser
Laser power	6kW
Welding speed	7m/min
Shieding gas	Ar 20 l/min

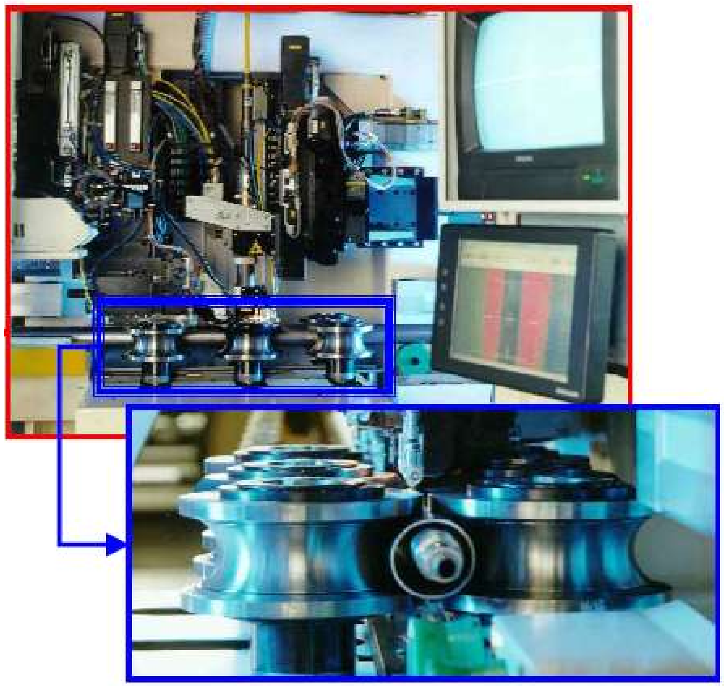


P=6kW,v=7m/min P=3kW,v=4m/min

CR980MPa 1.0t

Erichsen stretch test results of high strength TWB

Laser welding – Post annealing



International Institute forWelding (IIW),

IIW > 0.18 wt%C,

$$CE = C + \frac{Mn + Si}{6} + \frac{Ni + Cu}{15} + \frac{Cr + Mo + V}{5} \text{ wt\%},$$

The Ito–Besseyo CE formula

Ito–Besseyo < 0.18 wt%C,

$$CE = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B \text{ wt\%}.$$

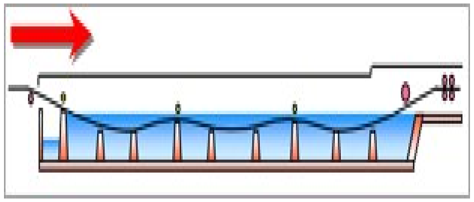
Seam Heat Treatment

Tailored Blanks, TRIP Steel (400/700+Z), t = 1,2 mm

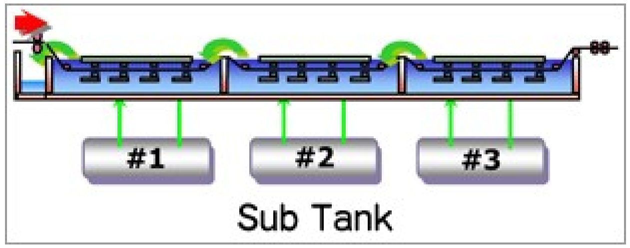
Unwelded Base Material	Seam without annealing	Seam after annealing (450°C)
• 240 HV0,5	• 500 HV0,5	• 280 HV0,5
• 12,7 mm	• 6,2 mm	• 9,8 mm

A post heat treatment can be used to improve the formability of AHSS laser welds. Testing performed with Erichsen cup test.

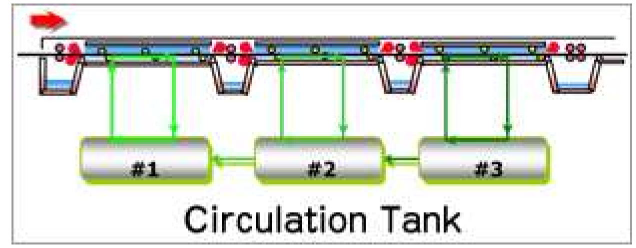
Pickling technology



Shallow Bath Type



i BoxPickling Tank



Jet Pickling Tank

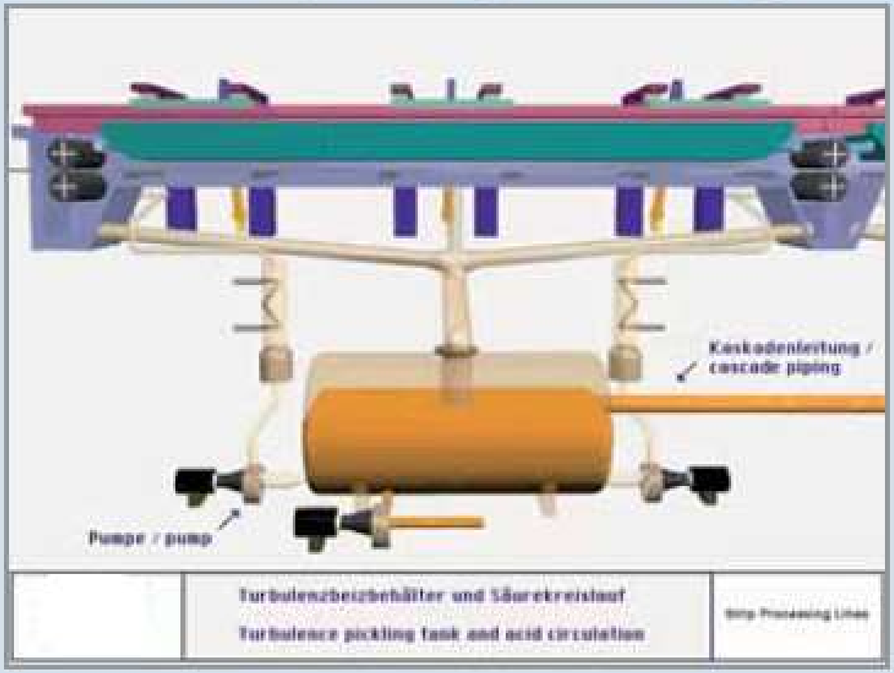
Tank type	Liquid depth	Strip catenary	Boundary layer thickness	Pickling time(Sec)		% Reduction in Pickling time
	mm	mm	H	LCT(580^0 C)	HCT(740^0 C)	
Deep bath	1300	1100	1H	23	44	100%
Shallow bath	800	600	0.8H	19	34	83%
Cross injection	400	200	0.7H	17	34	74%
Immersed box	600-1100	200	0.1H	14	24	61%
Jet type	200	20	0.1H	12	22	52%

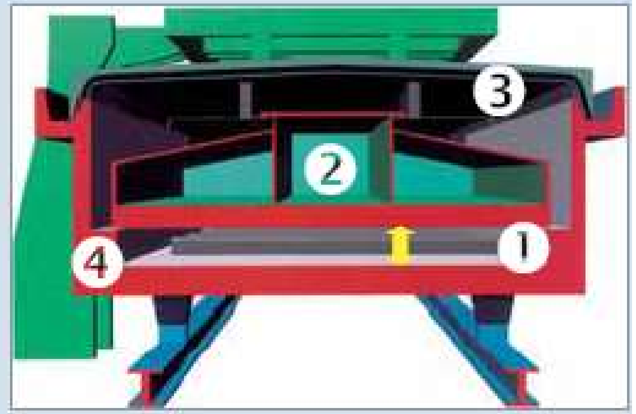
Advantages in Jet & turbulent pickling:

- **Pickling time is less - high processing speed**
- **Easy concentration control due to less volume of acid**
- **Very stable strip centering**
- **Less acid fumes**

Pickling technology

Turbulence pickling technology

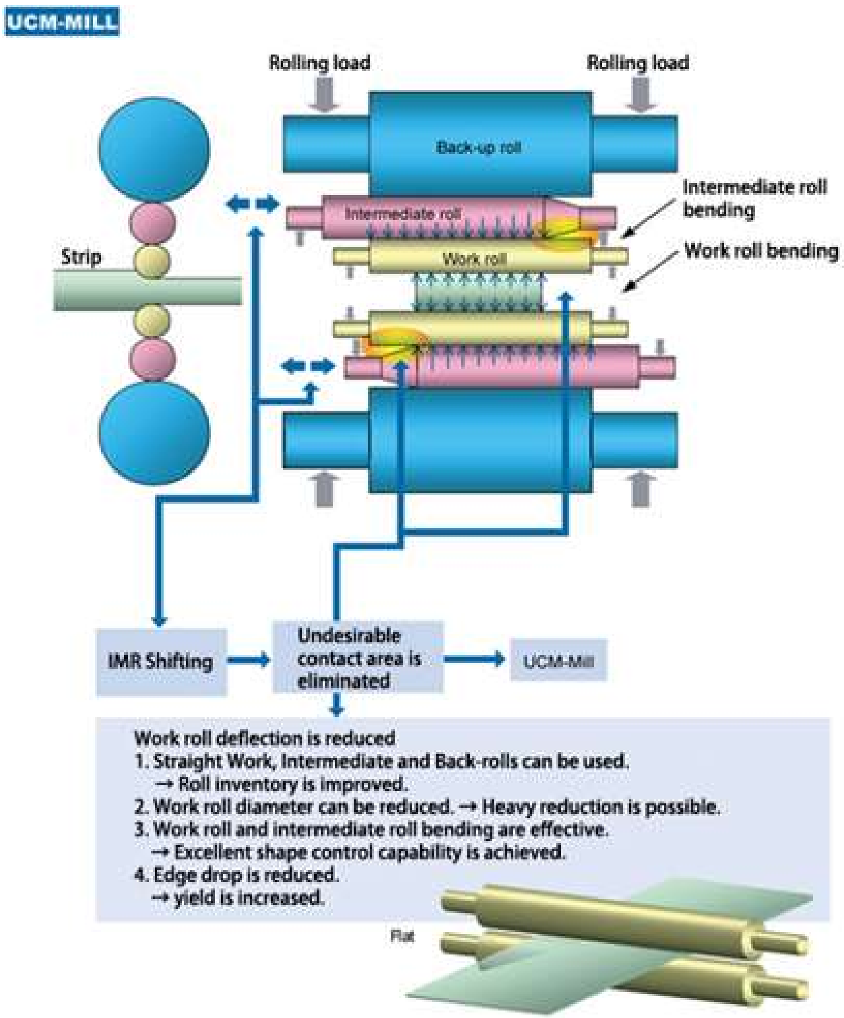


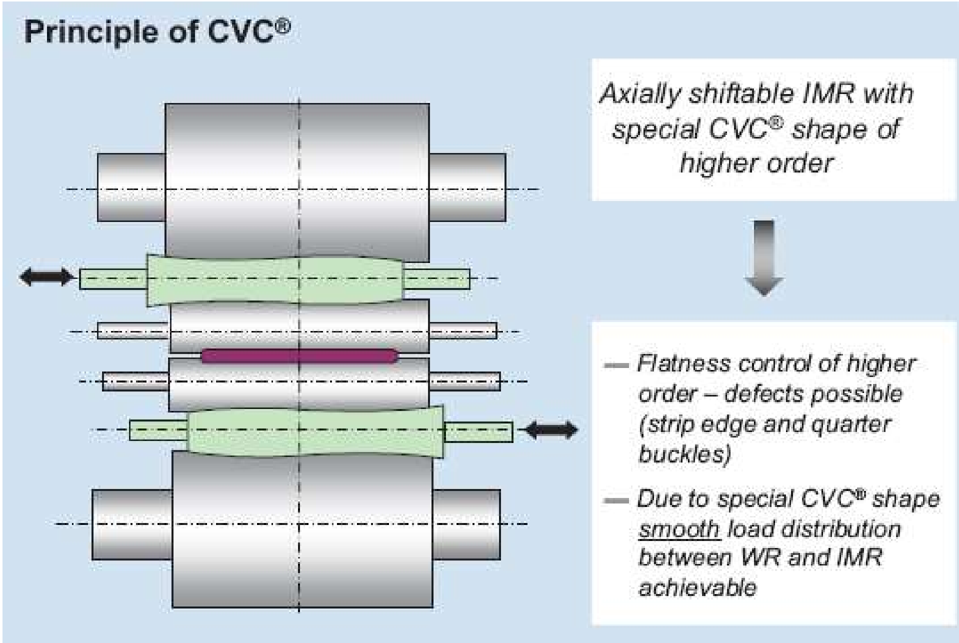


1. Turbulence pickling channel
2. Immersion cover
3. Outer cover
4. Pickling tank

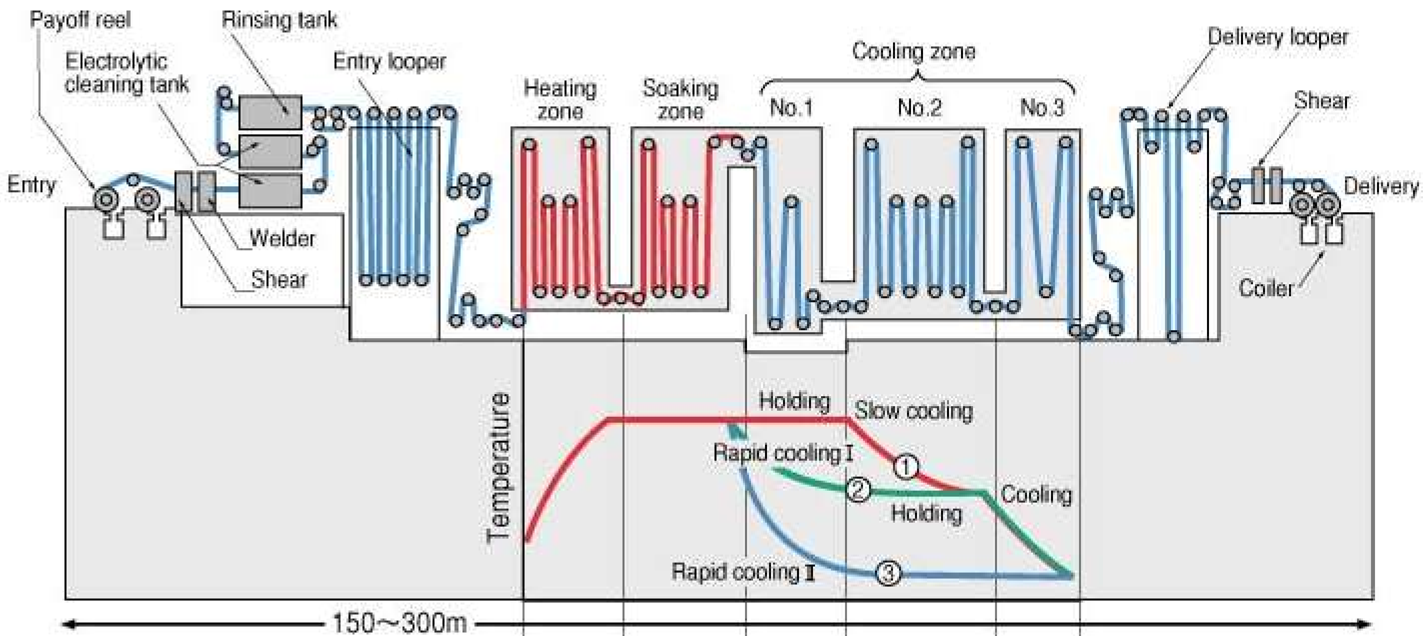
- Flat and horizontal pickling channel
- Immersion covers – less acid evaporation
- Hydrodynamic sealing

Cold Rolling technology





Continuous Annealing Line



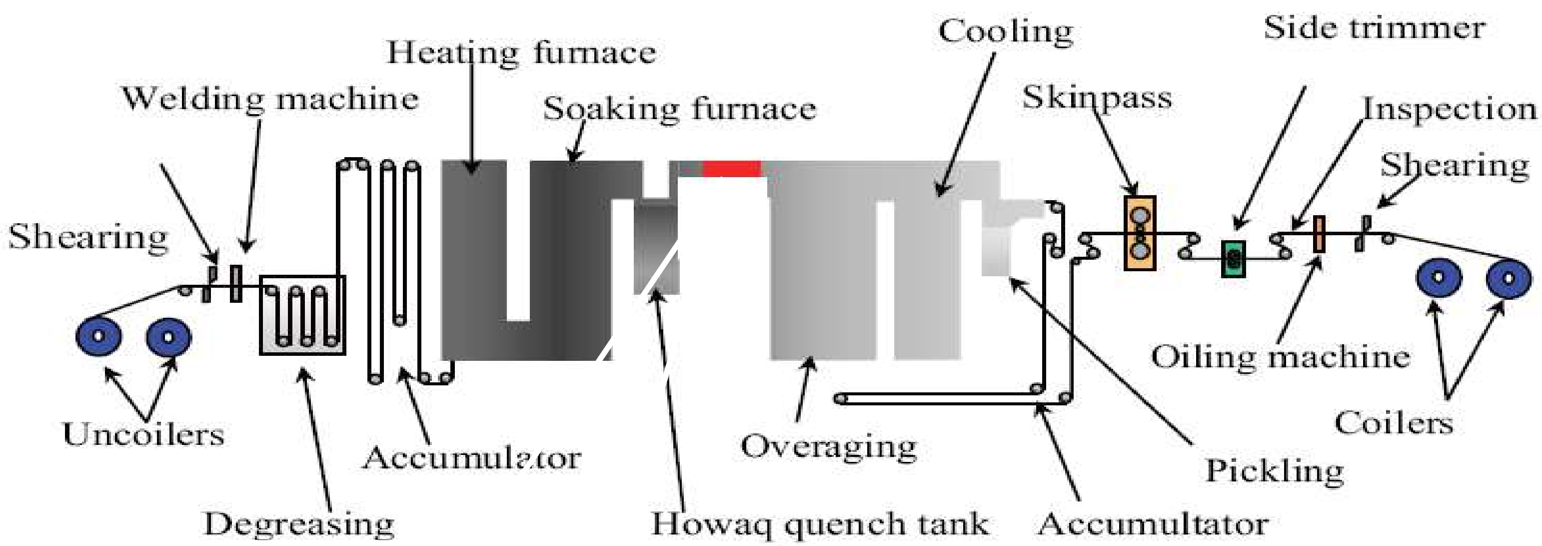
Hard black plate, Electrical steel strip → Heat cycle ①

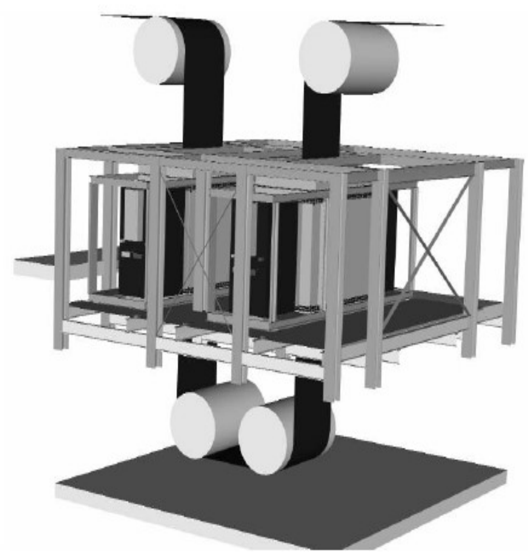
Soft black plate, Cold rolled steel strip → Heat cycle ②

High strength steel strip → Heat cycle ③

Induction heaters in Continuous Annealing

(water quenching up to more than 1000°C/sec)

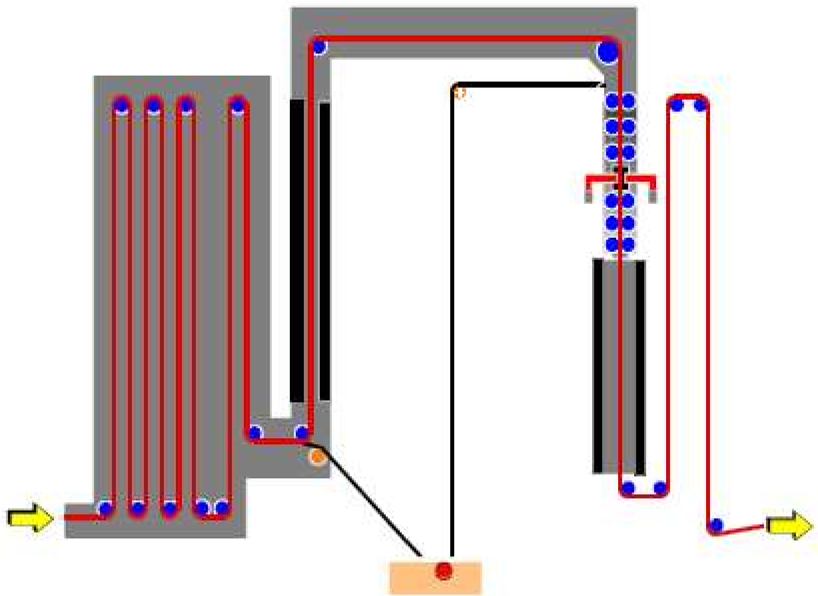


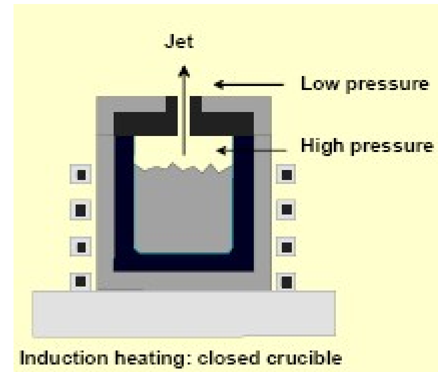


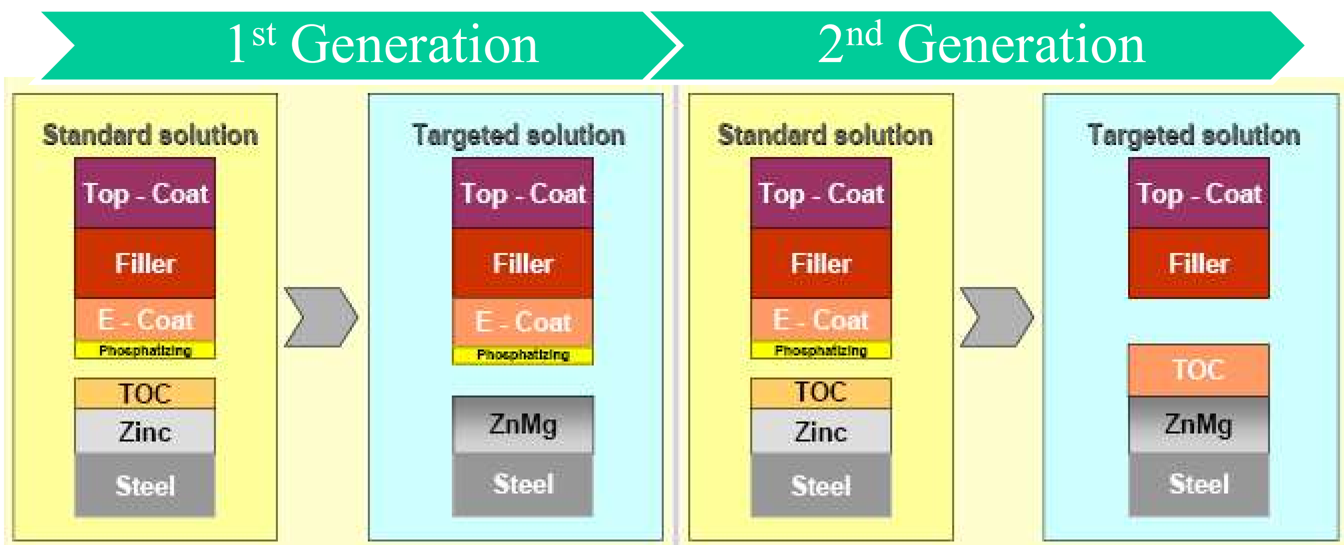
- A new U-shaped section with the first 2.3 MW Uniseal in down pass to dry the strip after the water quench

- The 5 MW Uniseal in parallel up pass to reheat rapidly the strip in a non oxidising atmosphere.

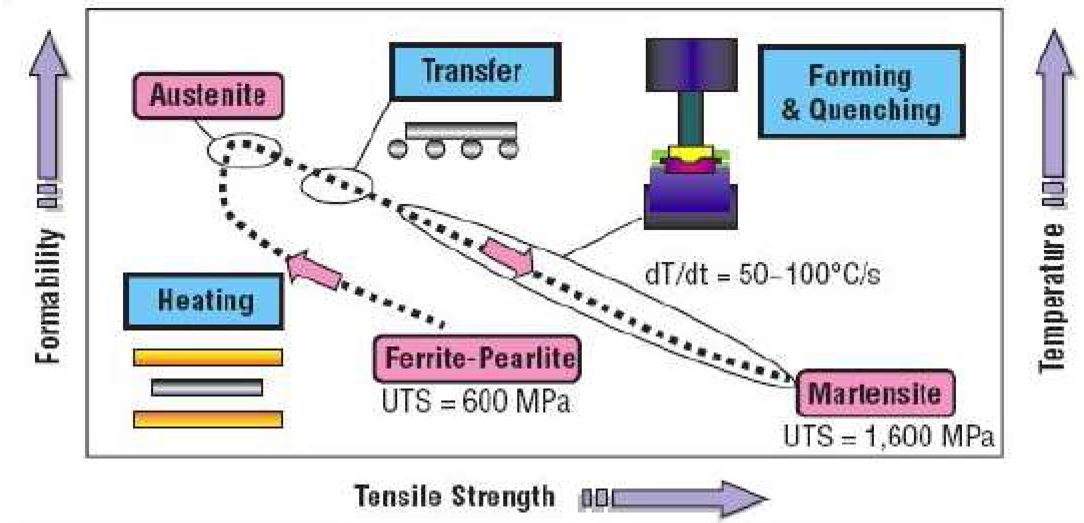
Emerging coating technology – PVD / JVD

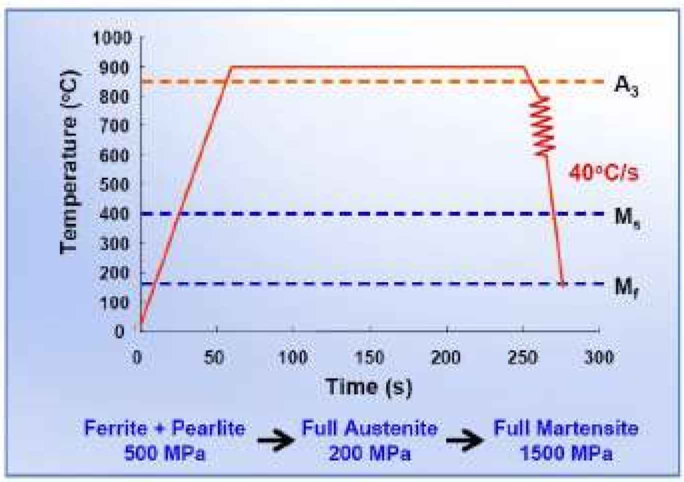


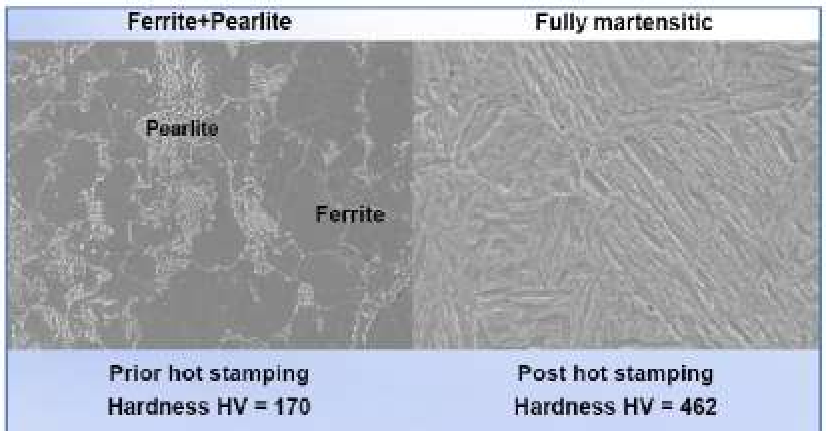




Why Hot Stamping



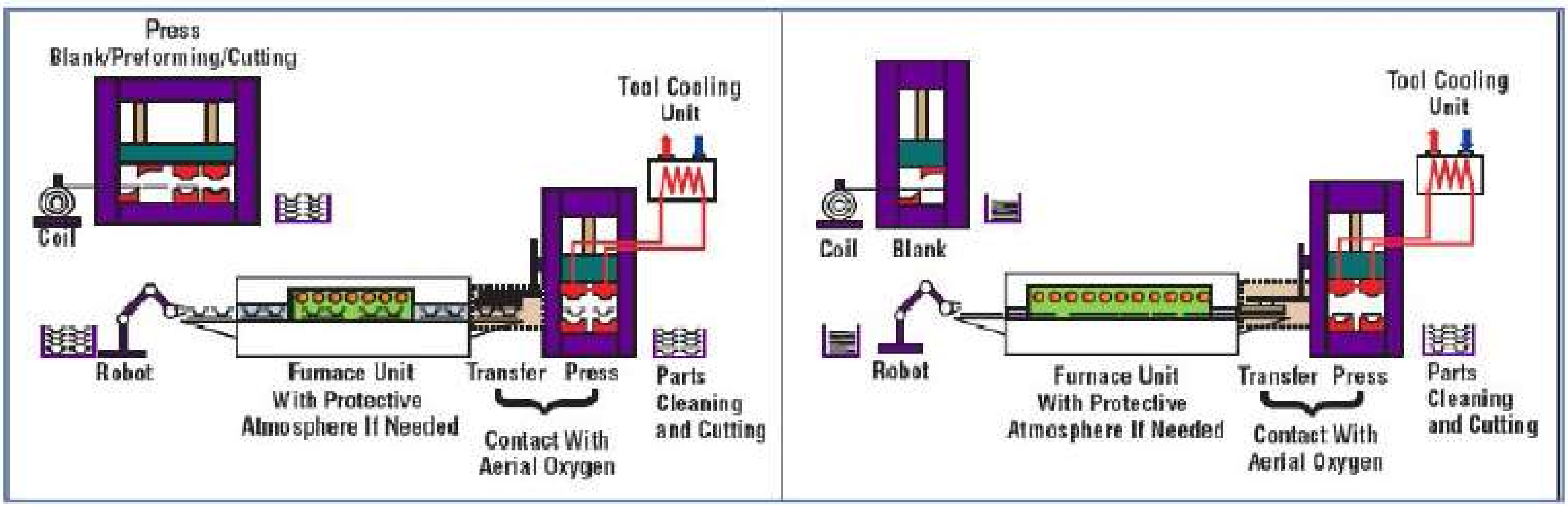




Hot stamping process

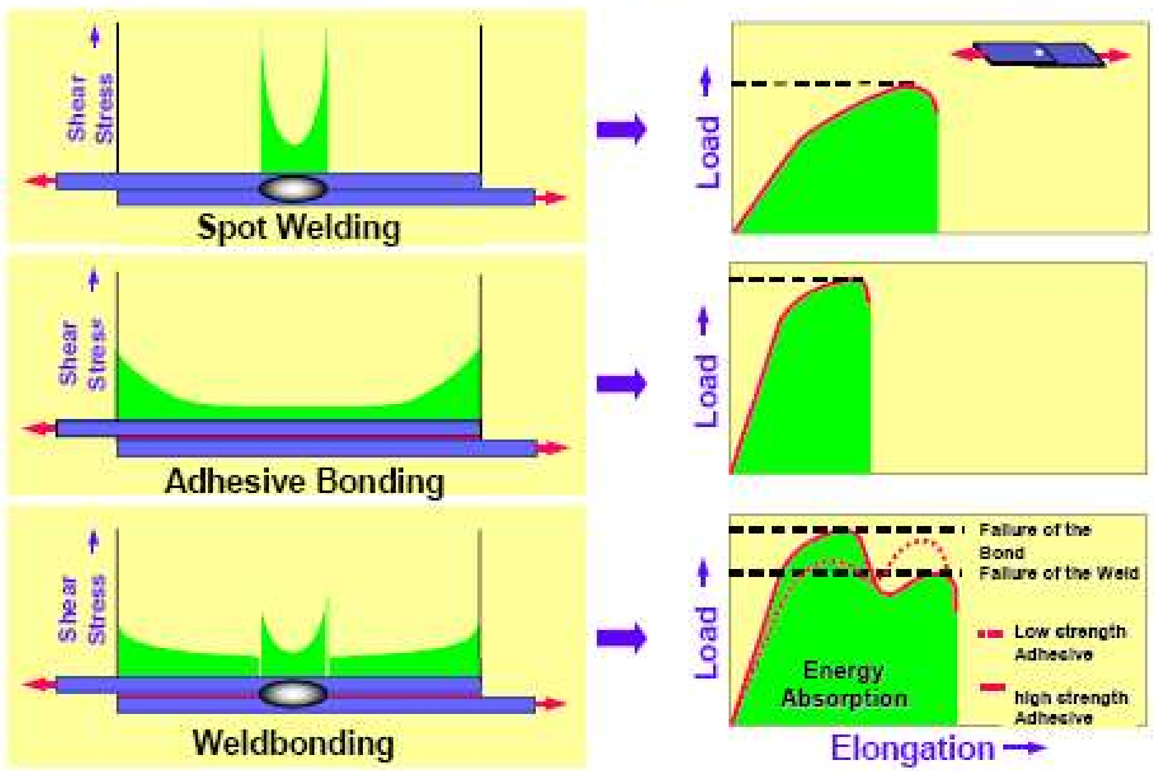
Steel	C [%]	Si [%]	Mn [%]	Cr [%]	P [%]	S [%]	B [%]	Al [%]	Ti [%]	Mo [%]	Ms [°C]
1	0.23	0.29	1.25	0.211	0.013	0.003	0.003	\	\	\	405
2	0.2	0.19	1.22	0.24	\	\	0.0019	\	\	\	420
3	0.225	0.25	1.25	0.155	0.0025	0.008	0.0035	0.015	0.035	0.1	406
4	0.211	0.25	2.14	\	0.012	0.006	\	0.031	\	\	388

$$M_s = 499-308\times C-32.4\times Mn-27.0\times Cr-16.2\times Ni-10.8\times(Si+Mo+W)+10\times Co$$



Adhesive joining

Bearing Capacity of Single and Hybrid Joints



Anyone who stops learning is old, whether at twenty or eighty.

Anyone who keeps learning stays young.

The greatest thing in life is to keep your mind young.

Henry Ford

PROCESSING OF ADVANCED COLD ROLLED AUTOMOTIVE GRADES OF STEEL

B K Jha, Anjana Deva, S. Mukhopadhyay,
B Sarkar & A.S. Mathur

RDCIS, SAIL, Ranchi - 834002

Introduction

Interstitial free (IF) steels are being extensively used for the fabrication of outer auto body components

These steels are characterized by high formability

The low carbon content(~30 ppm) in the steel necessitates vacuum degassing and the use of low carbon mould powders

Addition of titanium and /or niobium is made for stabilisation of solutes in the final steel after processing

Introduction

Control of precipitation during reheating and hot rolling is crucial to obtain the hot band with desirable characteristics in terms of crystallographic texture and grain size

Optimization of chemistry, hot rolling, cold rolling and annealing parameters is necessary for obtaining the final IF steel sheets with desirable properties

Processing of IF steel

Chemistry

Casting

Reheating

Roughing

Finishing

Runout Table Practice

Coiling

Cold rolling

Annealing

Skin Pass Rolling

Coating

Activities carried out at SAIL

Characterization of cold rolled IF steel

Tensile Test

Optical Microscopy

Average Plastic Anisotropy Ratio (r_m)

Forming Limit Diagram (FLD)

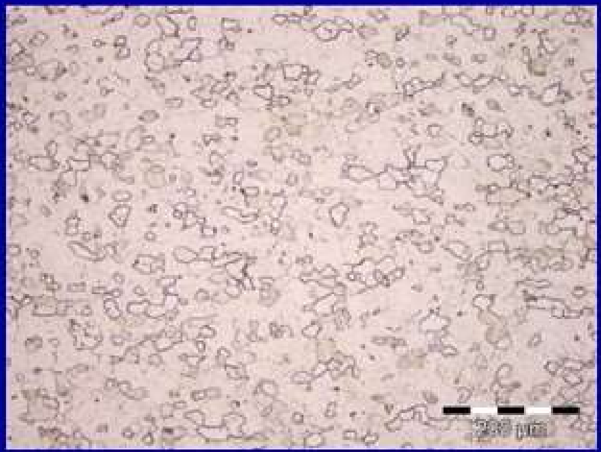
Chemical composition

C	Mn	P	S	Al	Si	Ti
0.0022	0.143	0.0099	0.0048	0.038	0.013	0.056

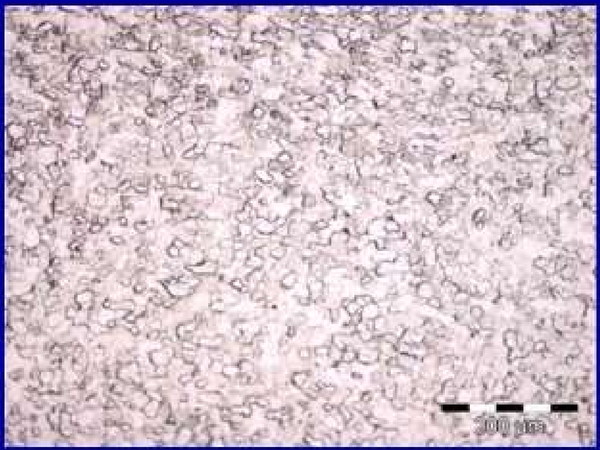
Tensile and formability properties

YS, MPa	UTS, MPa	% Elong.	Hardness, VPN	r_m	n	Bend
175	300	48.75	80	1.85	0.24	OK

Optical micrograph

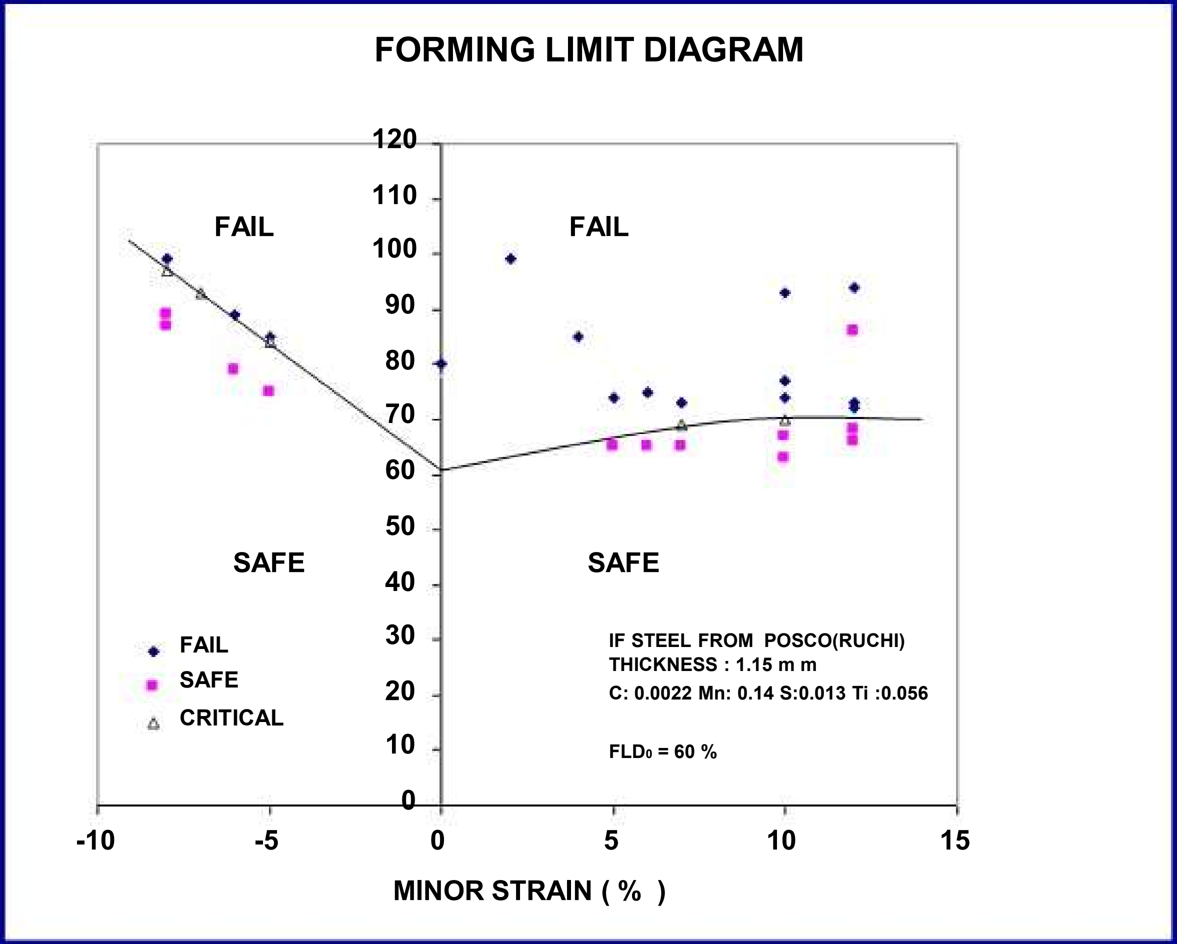


longitudinal section



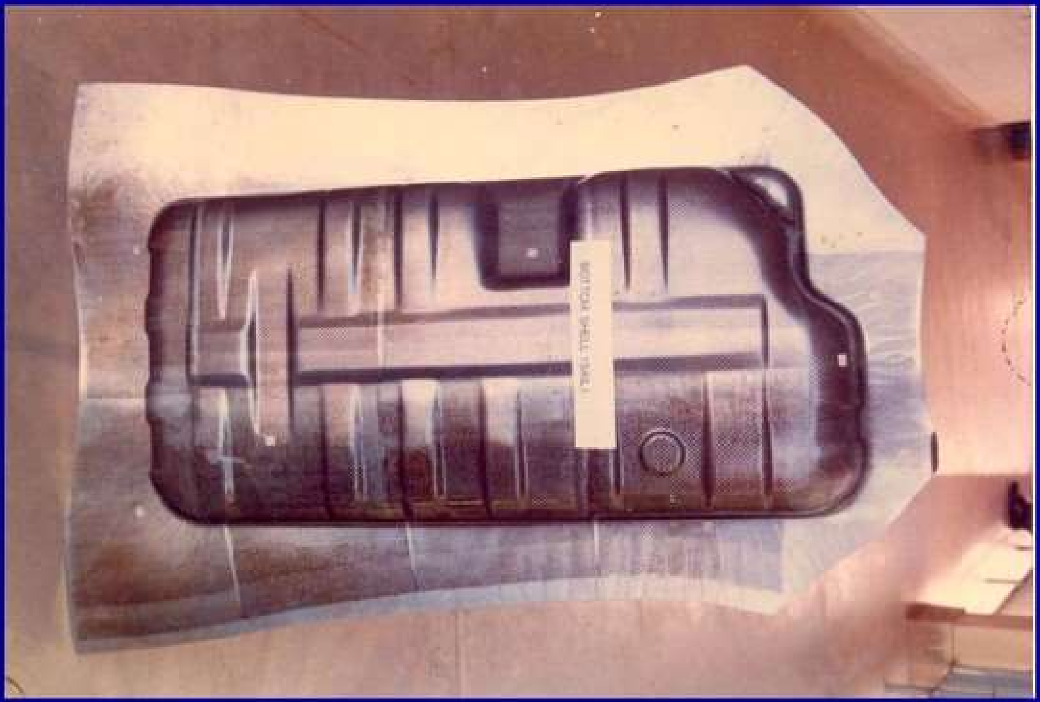
transverse section

Forming Limit Diagram

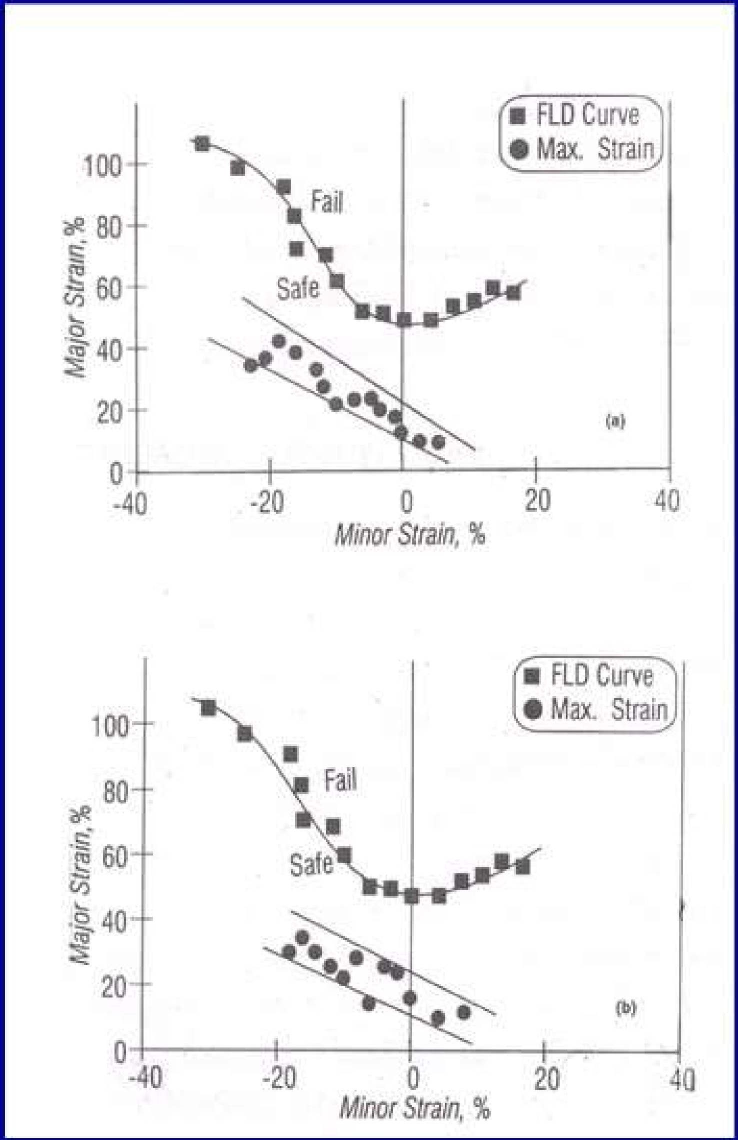


Strain Analysis

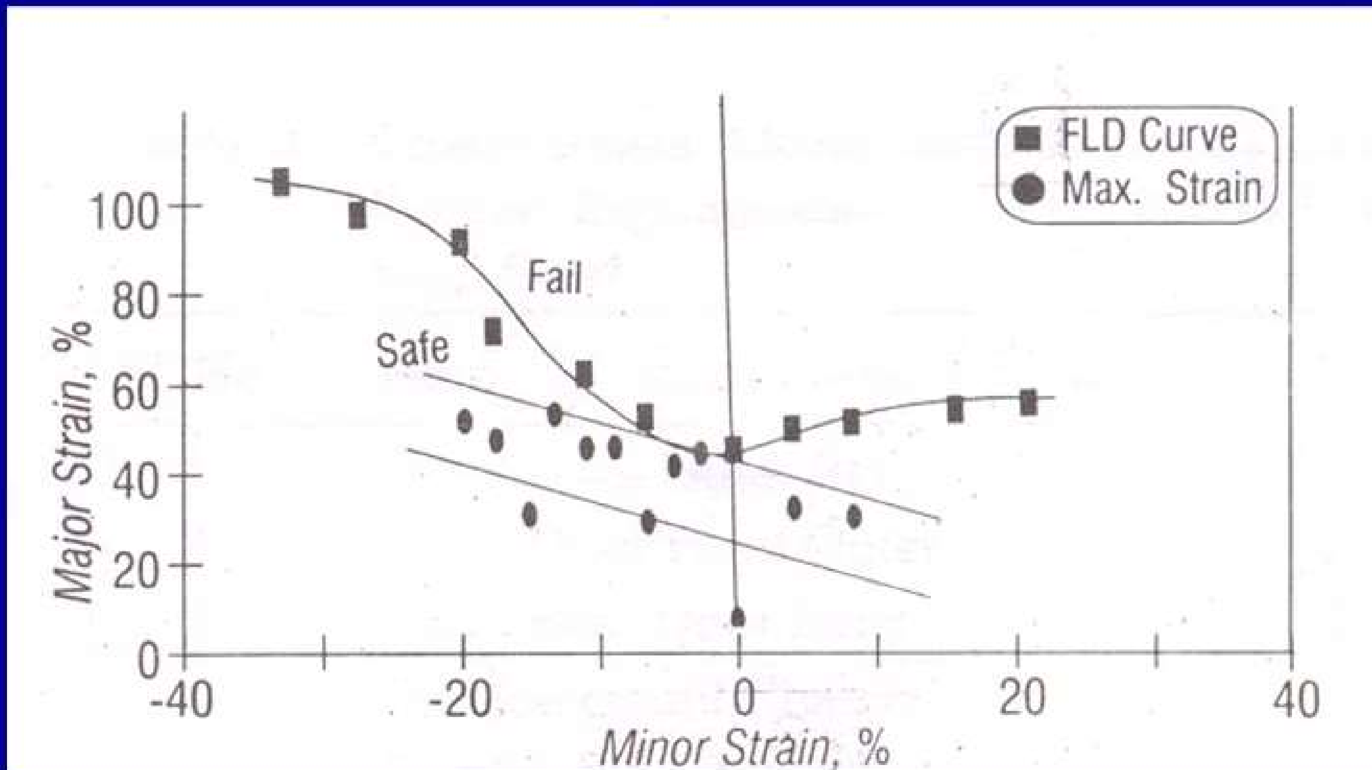
Grid marked oil sump formed from imported steel



Grid marked Bottom shell formed from SAIL EDD steel



Strain data for press formed Bottom shell made from (a) SAIL & (b) imported sheets superimposed on FLD curve of 1.0 mm SAIL EDD steel

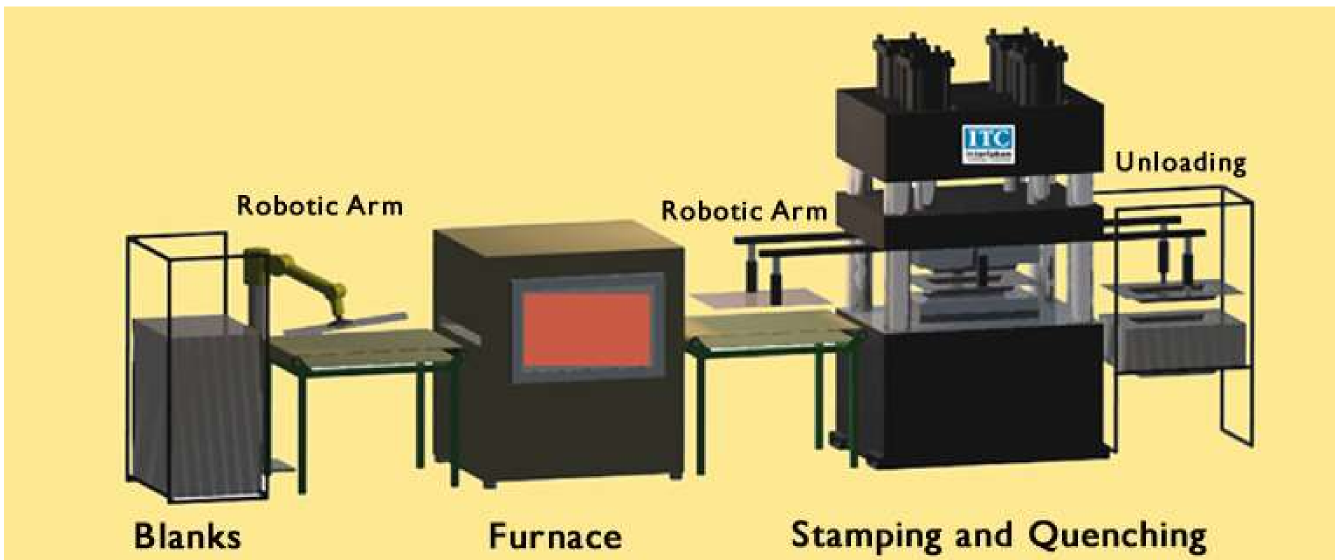


Strain data obtained for the oil sump component superimposed on the FLD curve of 1.6 mm SAIL EDD sheet

Mn B steel / hot stamped and quenched grade

Hot stamping process

- Blanks austenitized inside a continuous-feed furnace
- Transferred to an internally cooled die set via a transfer unit
- Blanks are stamped and cooled down under pressure for a specific amount of time according to the sheet thickness after drawing depth is reached



- Compared with cold-formed parts, hot-stamped parts provide better formability at high temperatures and exhibit no springback on the final part.
- Application: A- and B-pillar reinforcements, roof rails, side-wall members, and beams for crash management structures

Mn B steel / hot stamped and quenched grade

Metallurgical fundamentals

- Hot stamping is compatible with boron-alloyed steel's chemical composition, because it creates a robust process window for quenching, which causes martensitic transformation
- Boron steels belong to a group of martensitic steels with good hardenability at low cooling rates.
- Base material has a ferritic-pearlitic microstructure
- After the part is hot-stamped and quenched, it has a martensitic microstructure and increased strength, up to 250 percent of its initial value

SAIL's Initiative

- Interacted with M/s KLT Automotives, Pune and Automotive Research Association of India (ARAI), Pune for joint development
- C-Mn Boron grade cold rolled sheet of 1.2 mm thickness (YS: 350 to 450 MPa) will be produced at BSL - hot stamping by M/s KLT

Conclusions

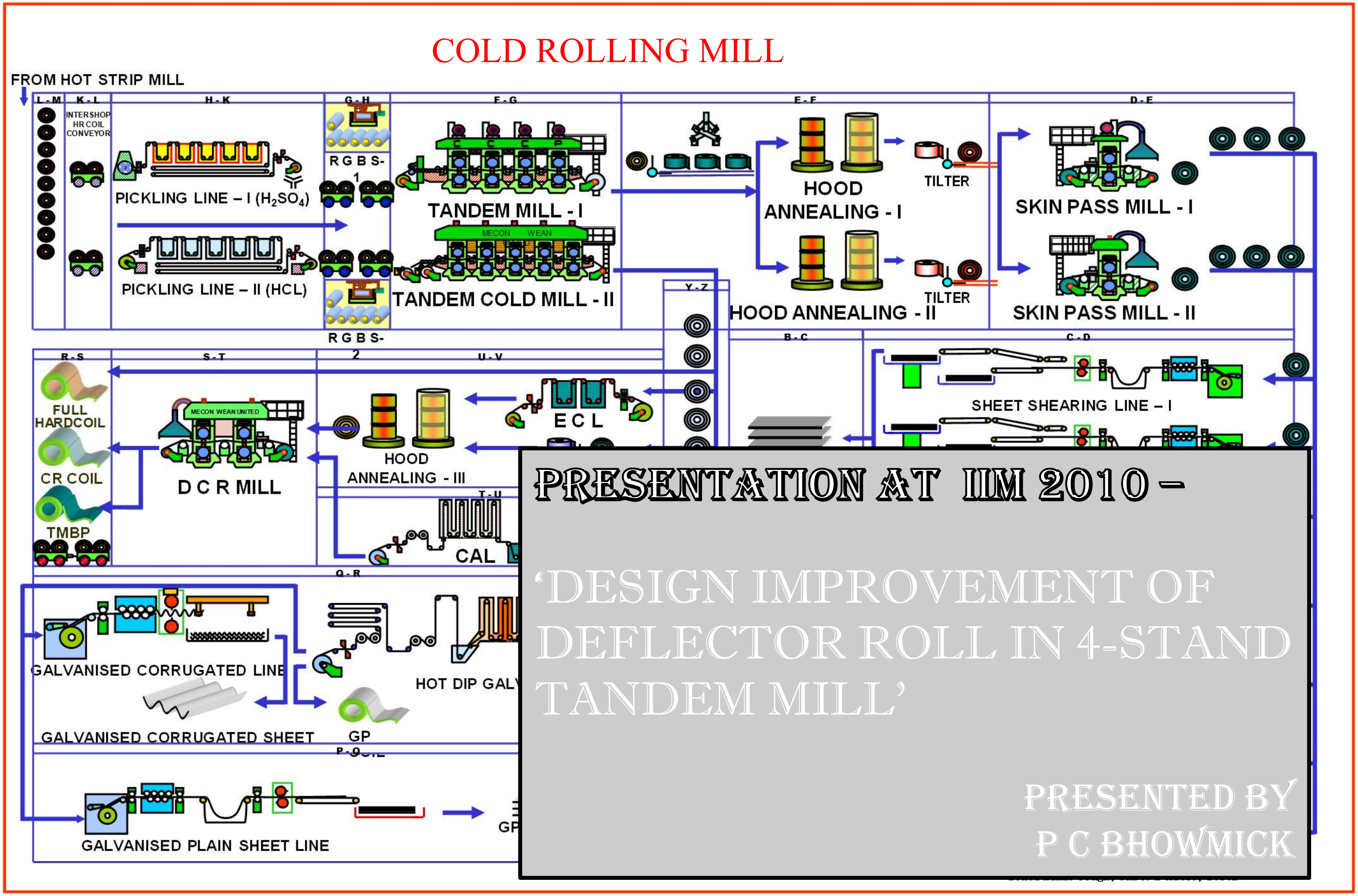
Cold rolled imported IF steel characterized

Strain Analysis carried out on critical automotive components

The severe requirements of formability can be met only by IF steel

Hot Stamping is likely to emerge as a frontline technique for auto parts manufacture

Thank You

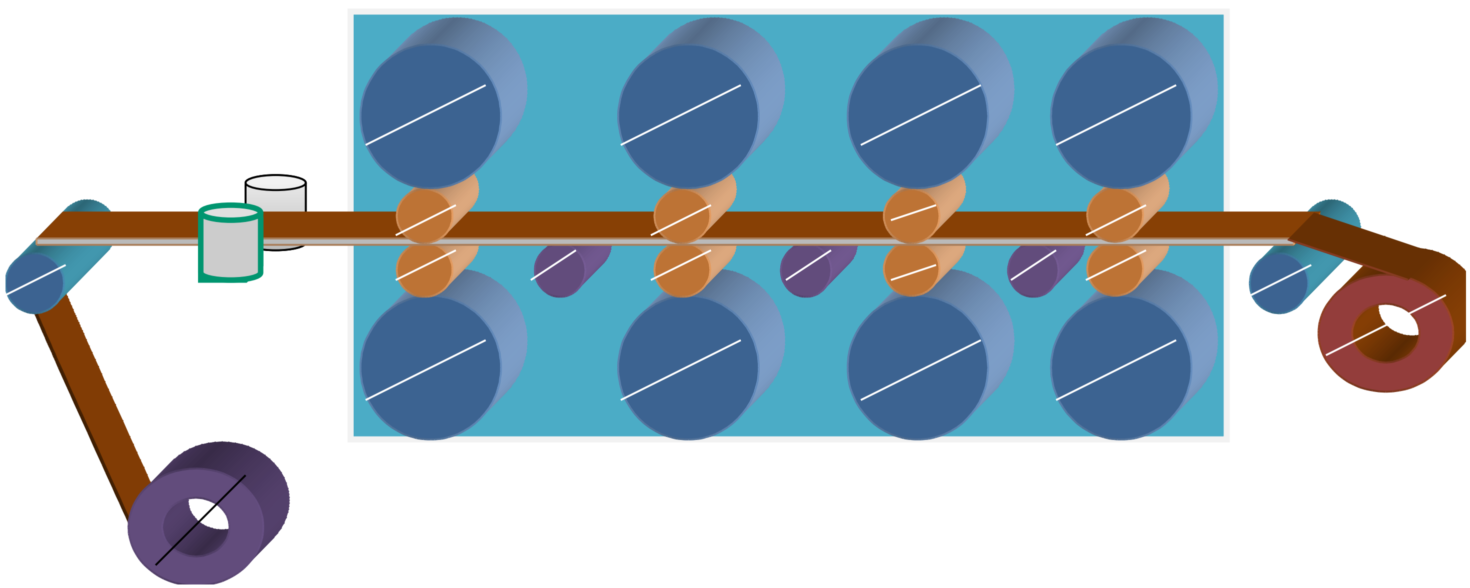


PRESENTATION AT IIM 2010 –

'DESIGN IMPROVEMENT OF DEFLECTOR ROLL IN 4-STAND TANDEM MILL'

PRESENTED BY
P C BHOWMICK

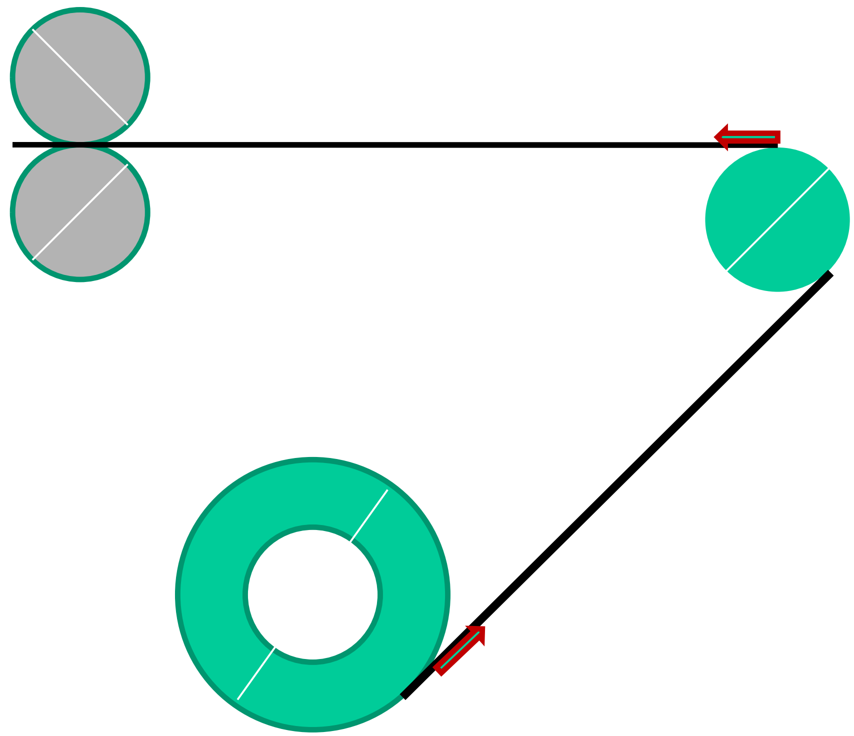
TANDEM MILL 1



EFFECT OF FAILURE OF ROLL / BEARING

- SIDE TRACKING OF STRIP
- IMPACT ON SHAPE AND EDGE
- ROLL MARK
- STRIP BREAKAGE
- LOSS OF YIELD
- PRODUCTION DELAY
- MATERIAL LOSS (BEARINGS, ROLLS)

REASONS OF FAILURE



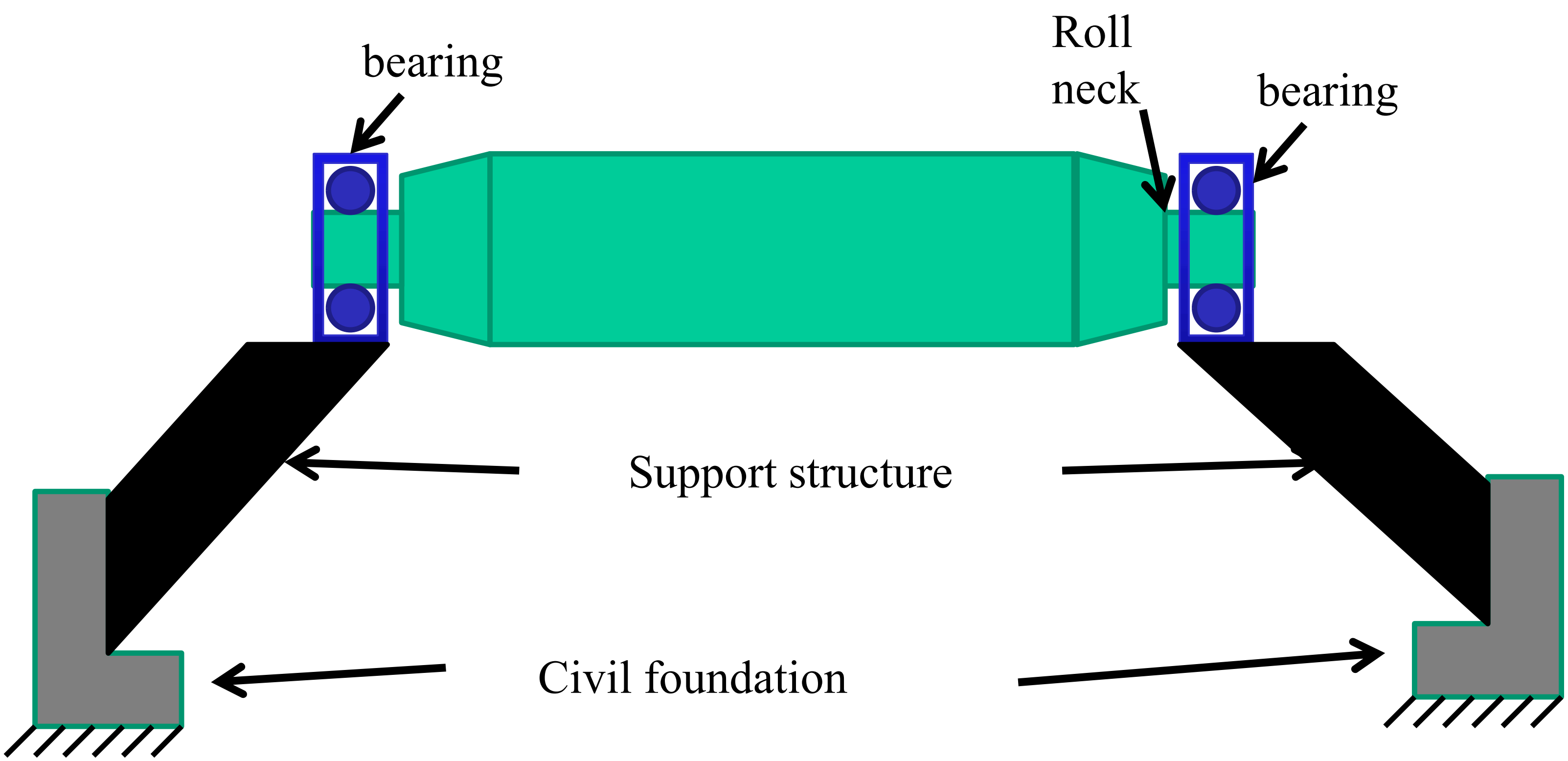
UNCOILER IN GENERATING MODE.

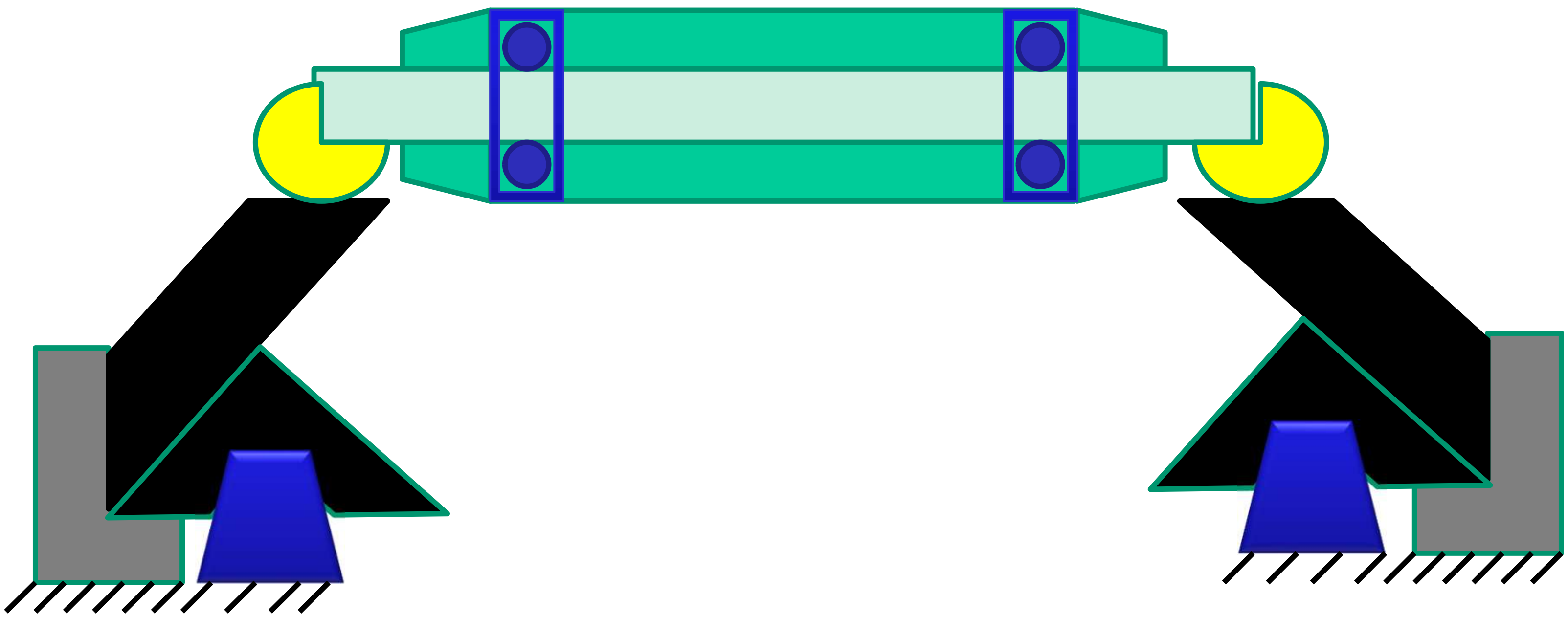
LOOSE COILING MAKES IT RORATE IN REVESE DIRECTION.

SUDDEN JERKS COME ON DEFLECTOR ROLL.

CANTILEVER SUPPORT STRUCTURES BUCKLES

COMPONENTS THAT BREAKS





BEARING CHANGED
FROM
SKF 2223624 TO
SKF 2223626

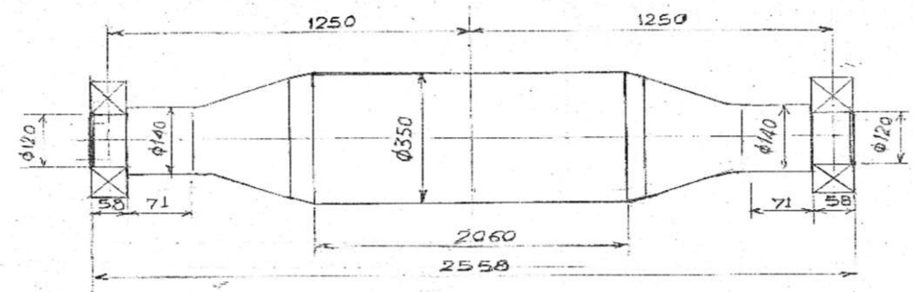

1250
1250
φ120
φ140
φ350
φ140
φ120
58
71
71
58
2060
2558

FIG-1

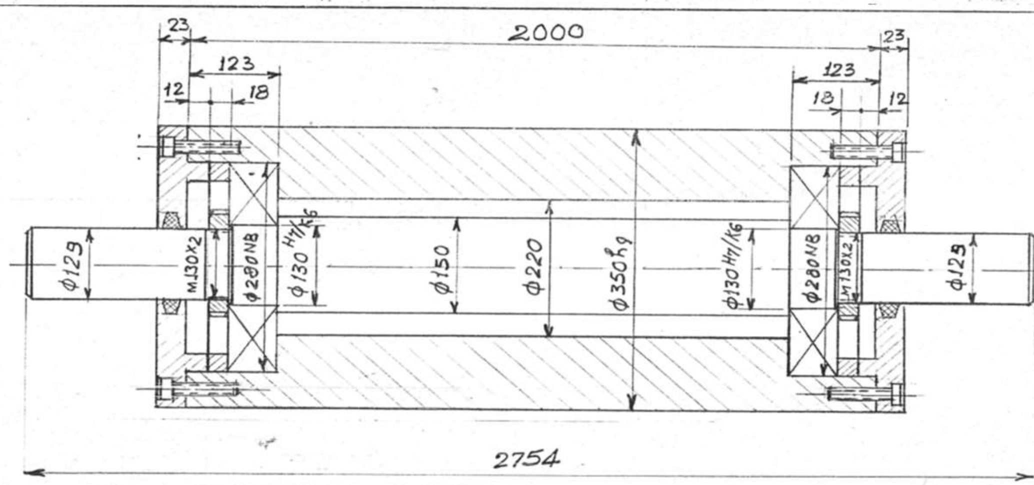
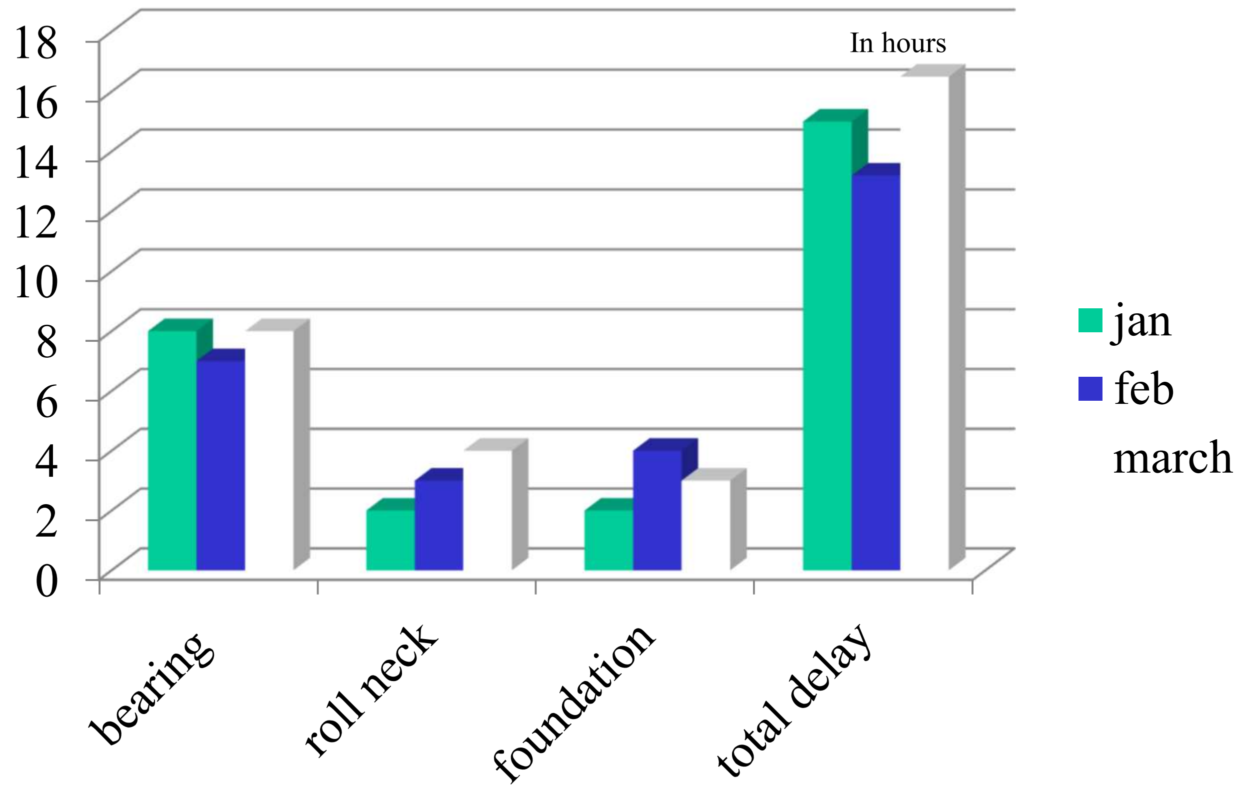

23
2000
23
123
123
12
18
18
12
φ129
M130X2
φ280NB
φ130 H7/K6
φ150
φ220
φ350h9
φ130 H7/K6
φ280NB
M130X2
φ125
2754

FIG. 2

BEFORE IMPLEMENTATION



RESULTS: (after implementation)

1. ZERO failure
2. No hydraulic oil loss
3. No safety hazards
4. Financial savings : 2.5 Cr /year

DEVELOPMENT OF FUEL TANK SUBSTRATE FOR TWO WHEELERS

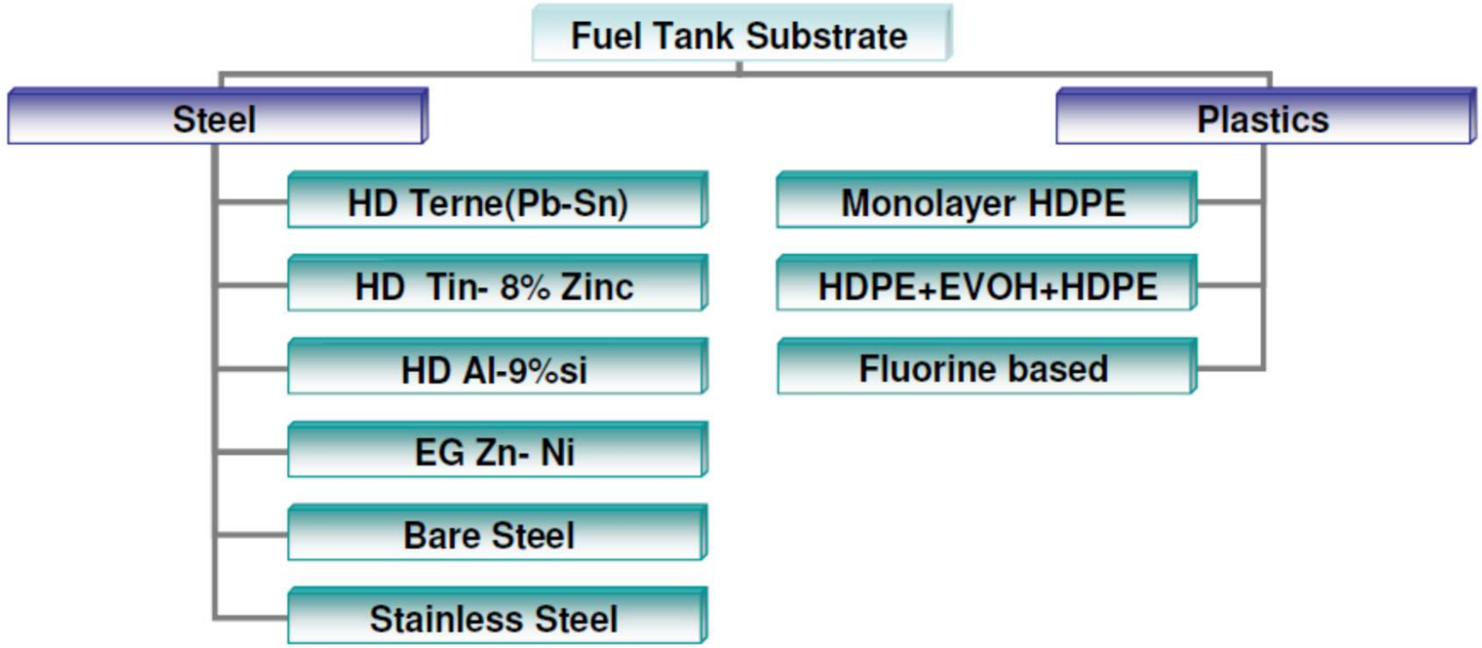
DR. T VENUGOPALAN

Fuel Tank Substrate

REQUIREMENTS

- **Corrosion resistance** : **Resistance to fuel medium**
- **Formability: Complex geometries**
- **Weldability: Various welding processes**
- **Paintability: Corrosion protection & aesthetics**

Fuel Tank Substrates– General Trends



Steel (with corrosion resistance coating): still the preferred option-

- Recyclability,
- Low permeability
- Cost

Two Wheeler Fuel Tanks : Domestic Scenario

Conventional material:	HD Terne Coated Sheet 92% Lead and 8% Tin
Drawbacks:	Environmental issue

Recent Product:	Single side EG Zinc –Nickel Sheet 90% Zinc-10% Nickel
Drawbacks:	Corrosion resistance Cost

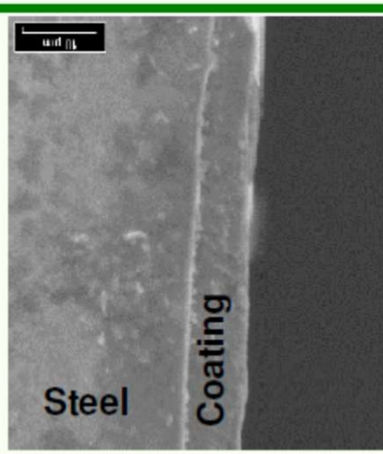
Both are not produced in India

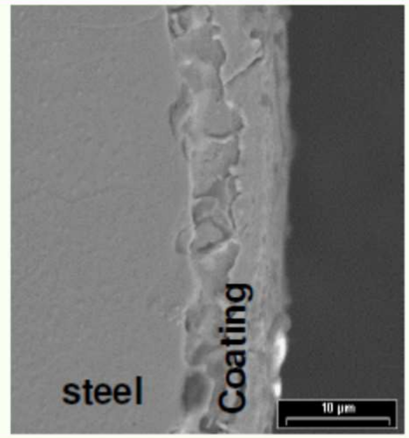
Need for Present Development

- Domestic supply
- Superior product at affordable cost
- Equivalent or better corrosion performance
- Adaptable to customer processes

Our Choice of Material

Galvanized	Galvannealed
Pure Zinc Coating	Zinc-Iron Alloy coating





Galvannealed Material (+ corrosion resistance coating) :

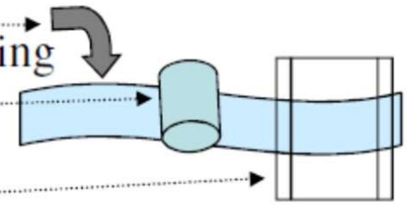
- Good weldability and paintability
- Most auto industry familiar with Zn-Ni and Terne coated sheet

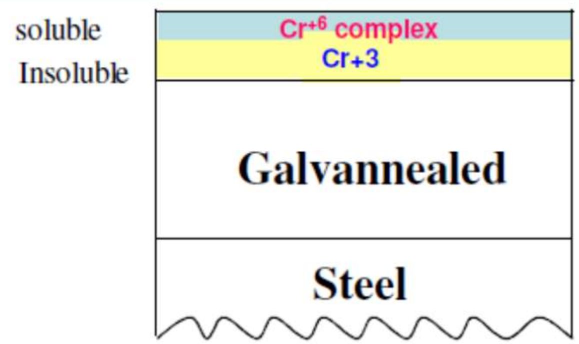
The Development Process

Design of CR coating at R&D

- Substrate coating definition
- CR coating formulation
- Coating application
- Preliminary test

- Spraying coating
- Squeezing
- Oven drying





SST- After 168 hrs

Petrol blended water

GALVAGUARD PLUS

PATENT FILED

The Development Process

CR coating
R&D, Tata Steel

Customer
R&D evaluation

- Corrosion resistance (SST)
- Formability
- Weldability
- Phosphating
- Painting

The Development Process

CR coating R&D, Tata Steel → Customer R&D evaluation → Product characterization/ definition

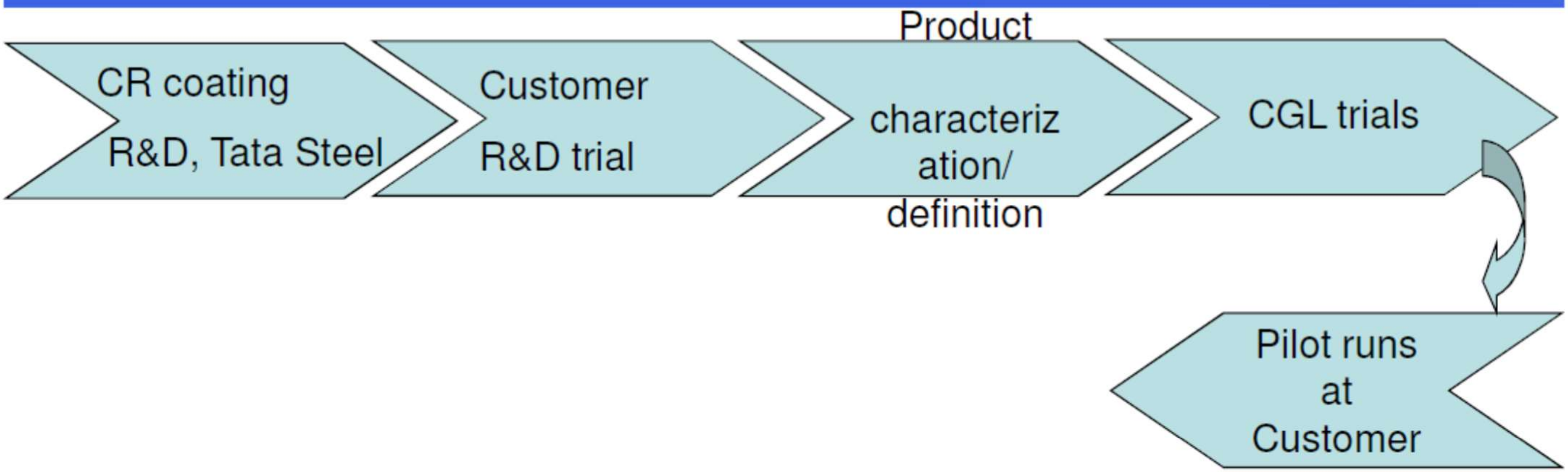
- Substrate coating specs
- CR coating specs

The Development Process

CR coating R&D, Tata Steel → Customer R&D trial → Product Characterization/ definition → CGL trials

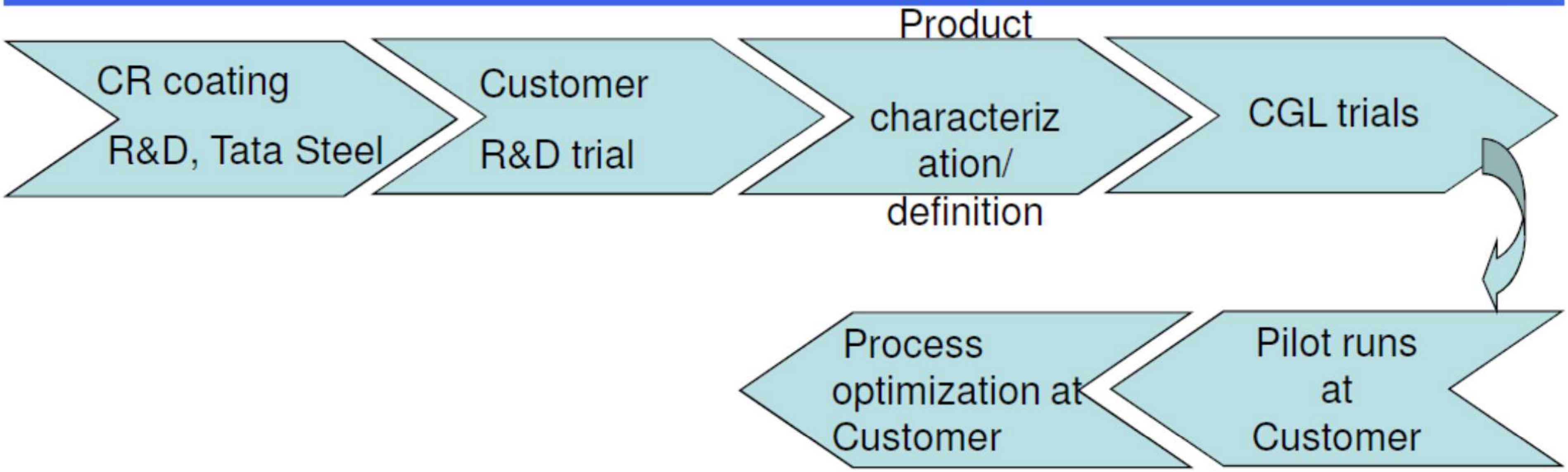
- Process specs
- Process adaptation
- Pilot runs
- Product evaluation

The Development Process



- Forming operations
- Welding operations
- Painting operations
- Process capability evaluation

The Development Process



- Forming operations
- Welding operations
- Painting operations

Customer Process Optimization - FORMING

FLD (formability limit diagrams) analysis

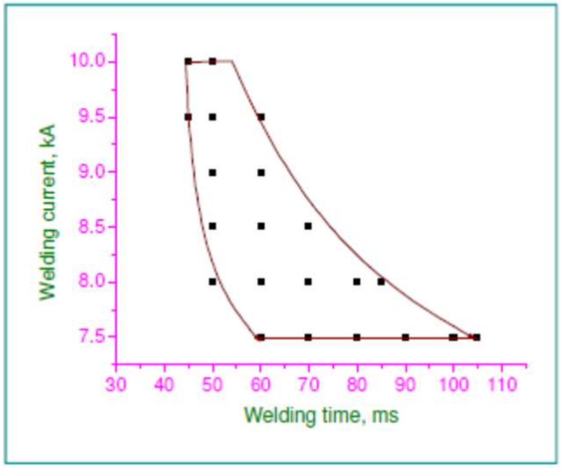
Forming simulations

Tribological analysis – selection of pre-lube oil & quantity

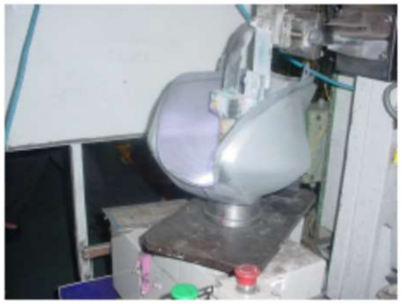
Establishment of process windows & operating procedures

Customer Process Optimization - WELDING

- Development of weldability lobe
- Collaboration with Research Institute and Academia
- Adapt & optimize welding processes

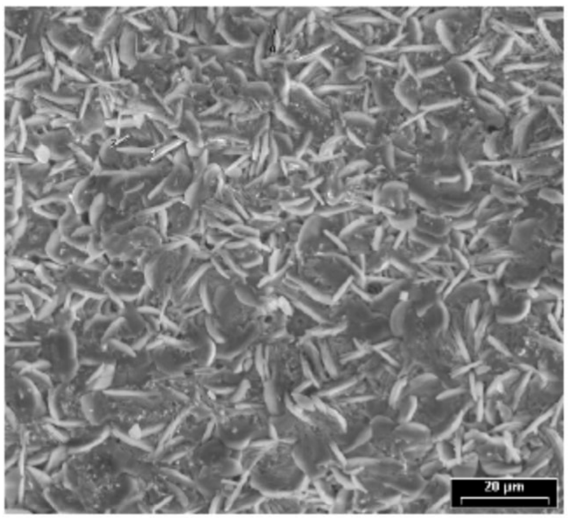


Weldability lobe of 0.8mm GA sheet



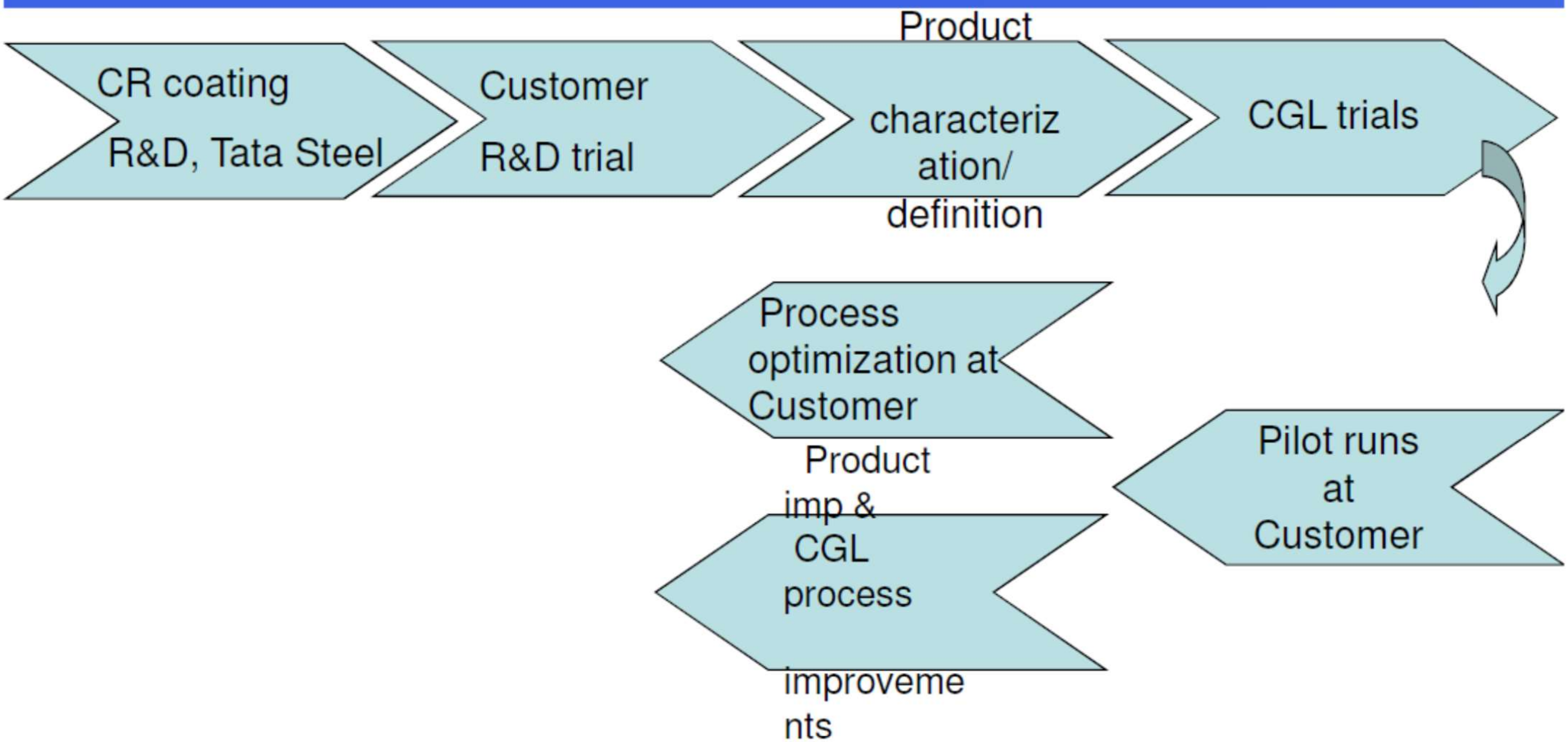
Customer Process Optimization - PAINTING

- Analysis of pretreatment & painting processes
- Adaptation of pre-treatment (phosphating) & paint systems in collaboration with chemical & paint suppliers
- Optimization of process windows

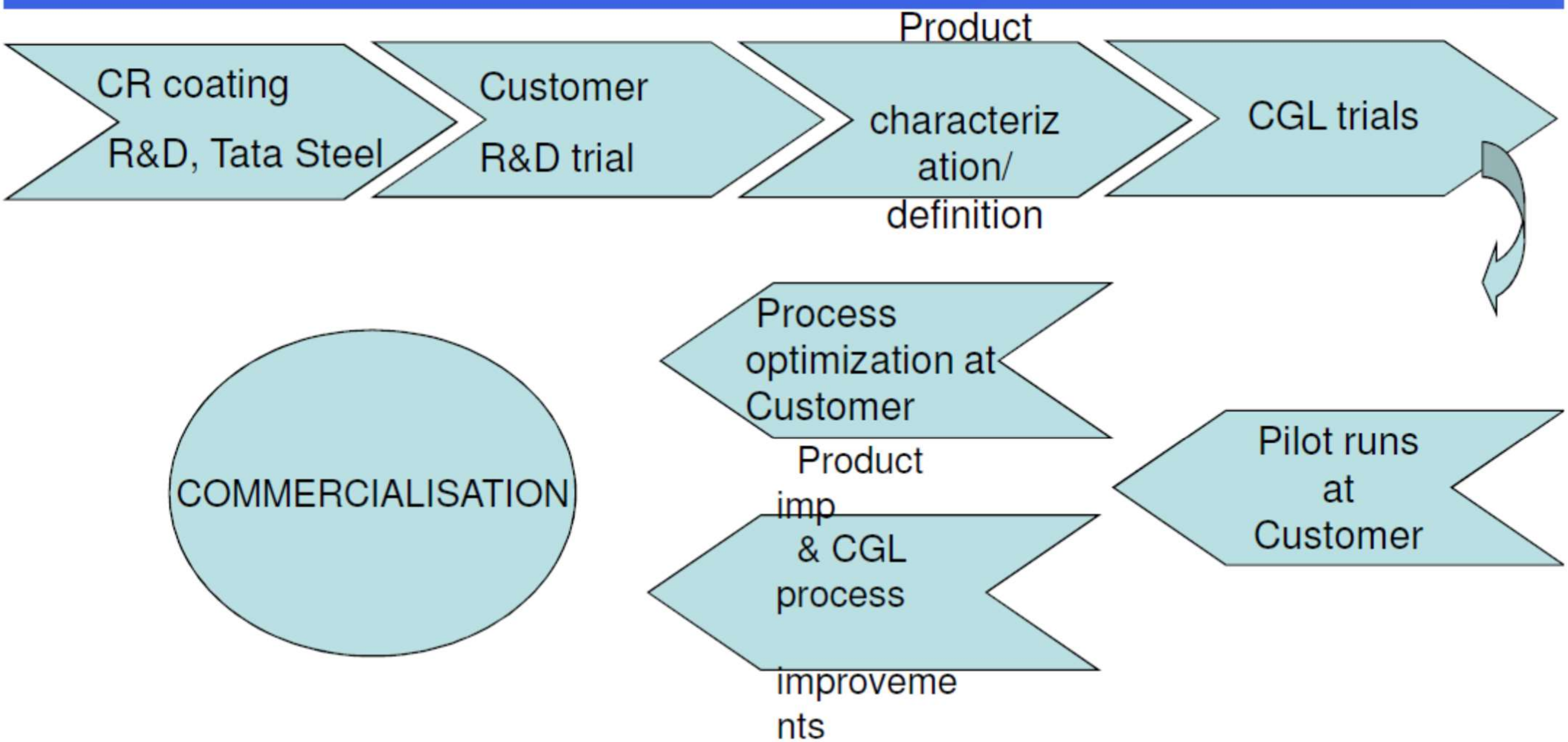


Phosphated GA sheet

The Development Process



The Development Process

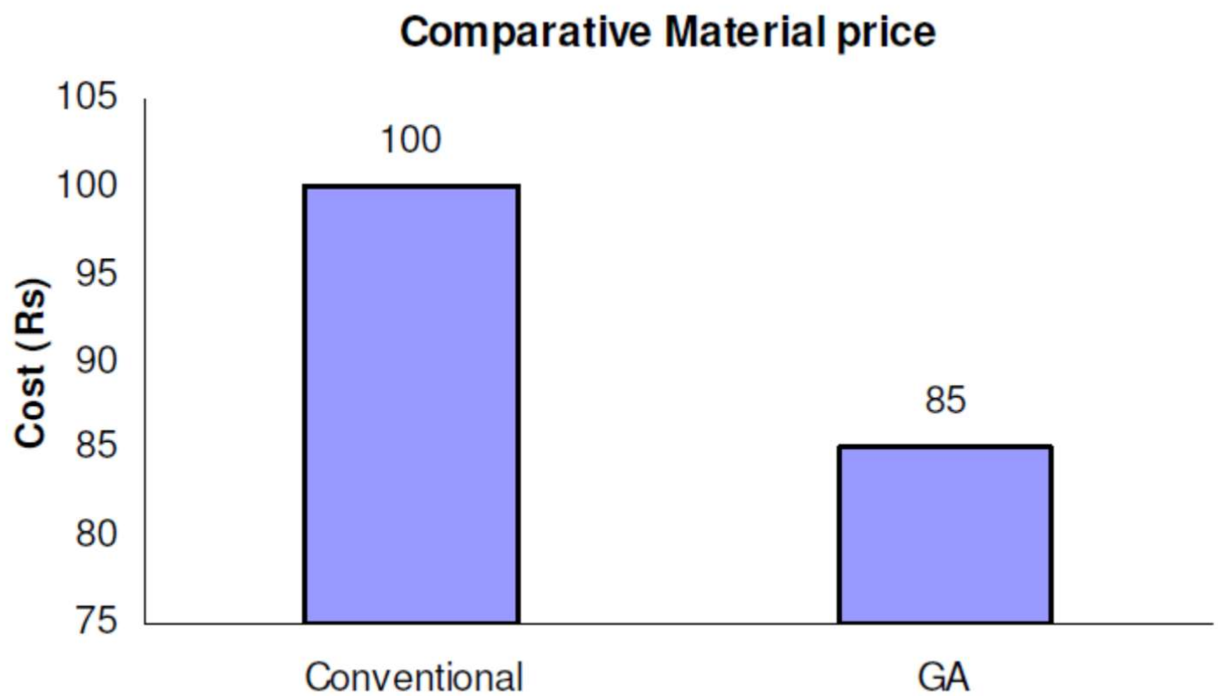


The Development Process

The Development Process

2.5 million Bajaj motorcycles on road with Tata Steel's GA

Economics


Comparative Material price
Cost (Rs)
105
100
95
90
85
80
75
100
85
Conventional
GA

Looking Ahead…….

- Development process initiated at all other 2-wheeler manufacturers
  - Hero Honda
  - TVS
  - Honda Motorcycles & Scooters India
  - LML
- Extension to 4-wheeler manufacturers
- Development of alternatives to corrosion resistance surface coatings
  - Epoxy coatings
  - Thin organic coatings
- Membership with 'Strategic Alliance For Steel Fuel Tank' (SASFT)

Partnership with Stakeholders

Development Possible

- Team work between Tata Steel & Bajaj Auto
- Support provided by Bajaj Auto.
- Collaboration with WRI, Trichy and IIT Bombay
- Partnerships with Pretreatment chemicals and Paint Suppliers
- IIT Madras for tribological support
- Oil supplier for the development of pre-lube

Thank You