



1



2

Tandem Mill – Interstand



3

Tandem Mill – Exit End



4

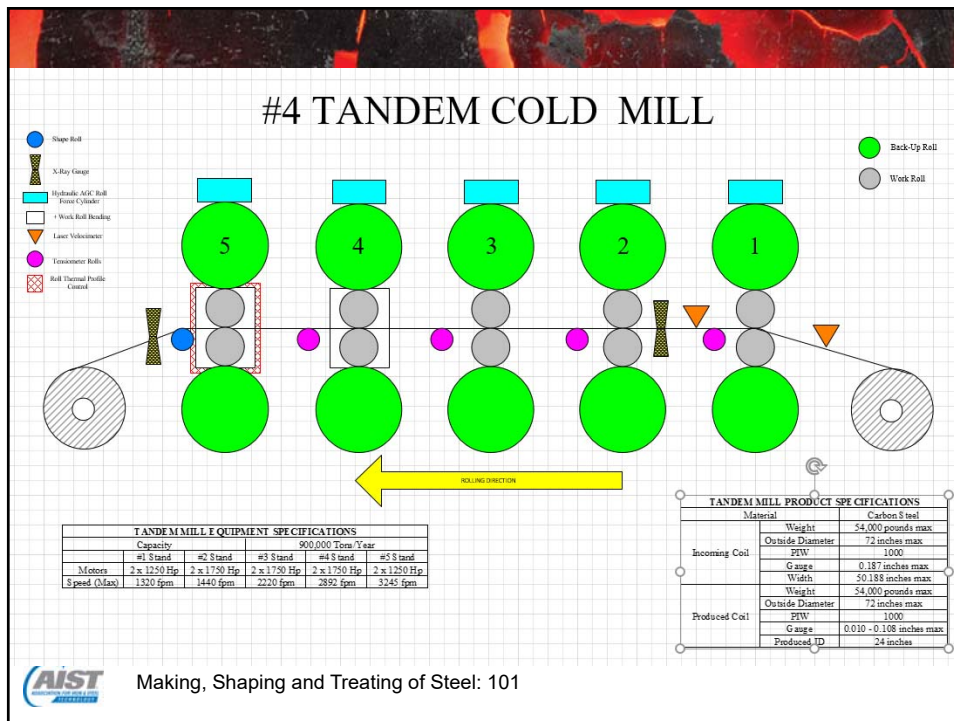
Tandem Mill Basic Characteristics

- Hydraulic Automatic Gauge Control (HGC). Tight gauge tolerance control.
- Closed Loop Flatness Control – Stand 5 Roll Bending (S4 Manual System).
- Closed Loop Flatness Control – Stand 5 Zone Cooling (Thermal Profile).
- Typical (non-guaranteed) flatness control is < 25 I-Units.
- ‘Mill Clean Practice’ – Fully Synthetic Rolling Solution, Lower Stand 5 Oil Concentration, Magnetic Separation.



Making, Shaping and Treating of Steel: 101

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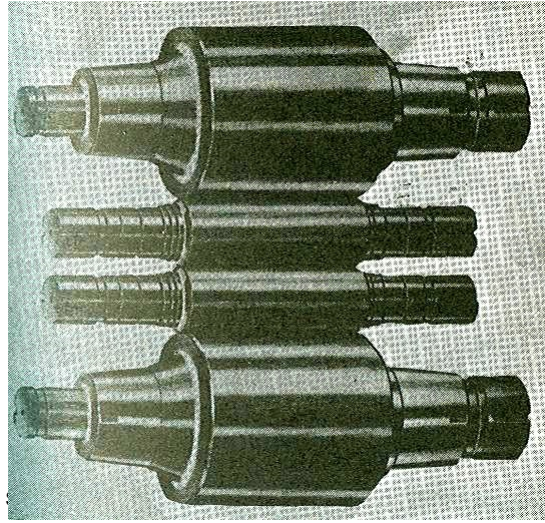


Making, Shaping and Treating of Steel: 101

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Conceptual View of a 4-High Roll Stack

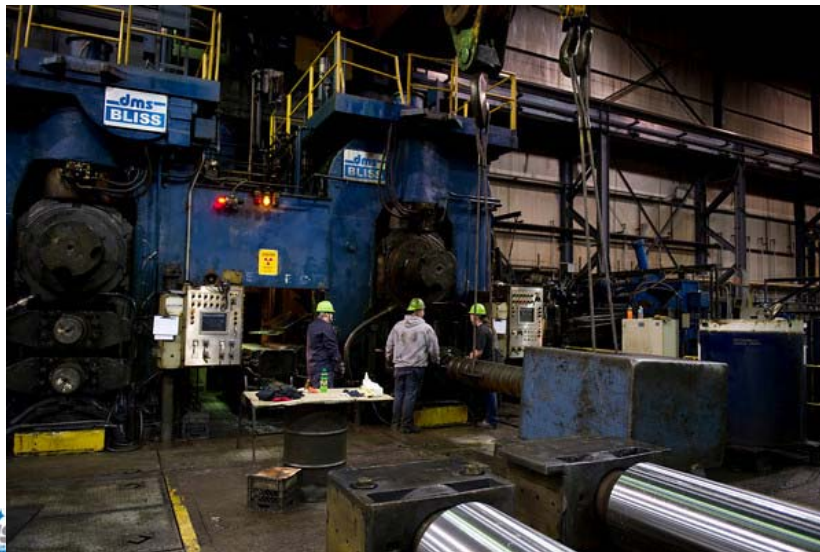
(note relative size of backup and work rolls)



Making.

7

Work Roll Change



8

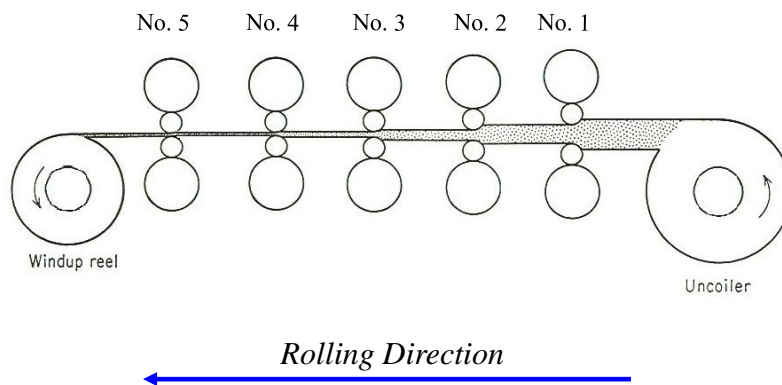
Bottom Backup Roll Being Installed



Making, Shaping and Treating of Steel: 101

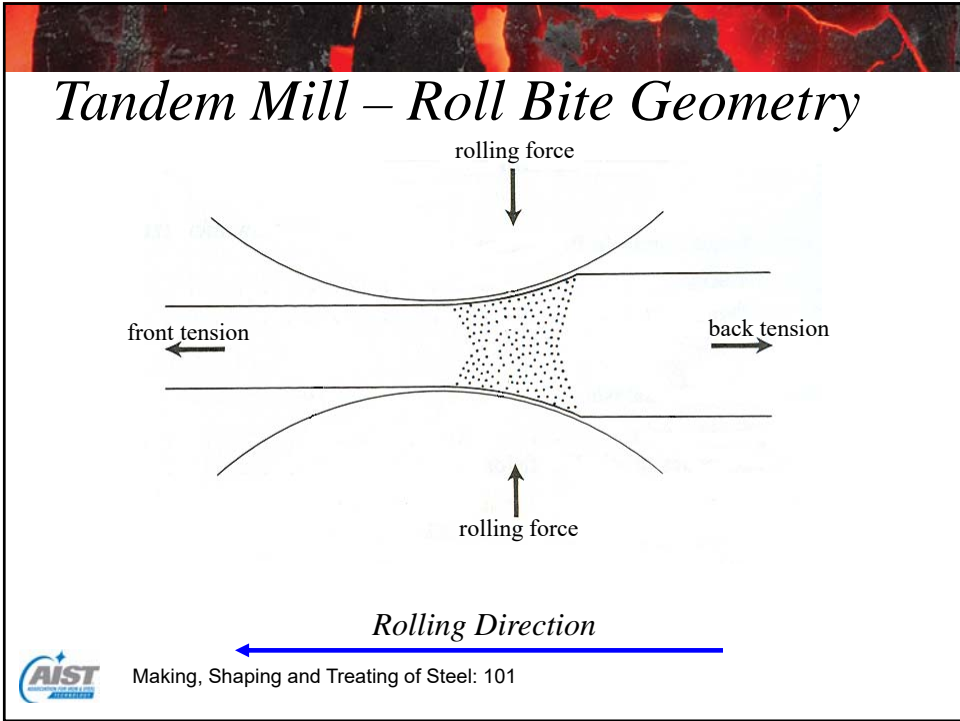
9

Tandem Reduction in 5 Stands

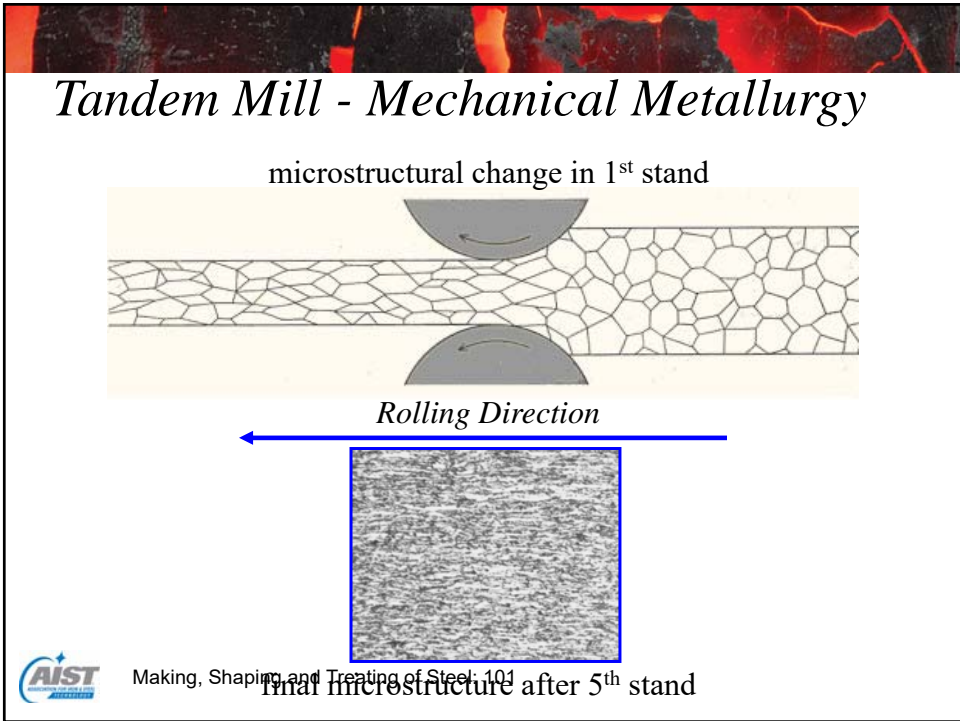


Making, Shaping and Treating of Steel: 101

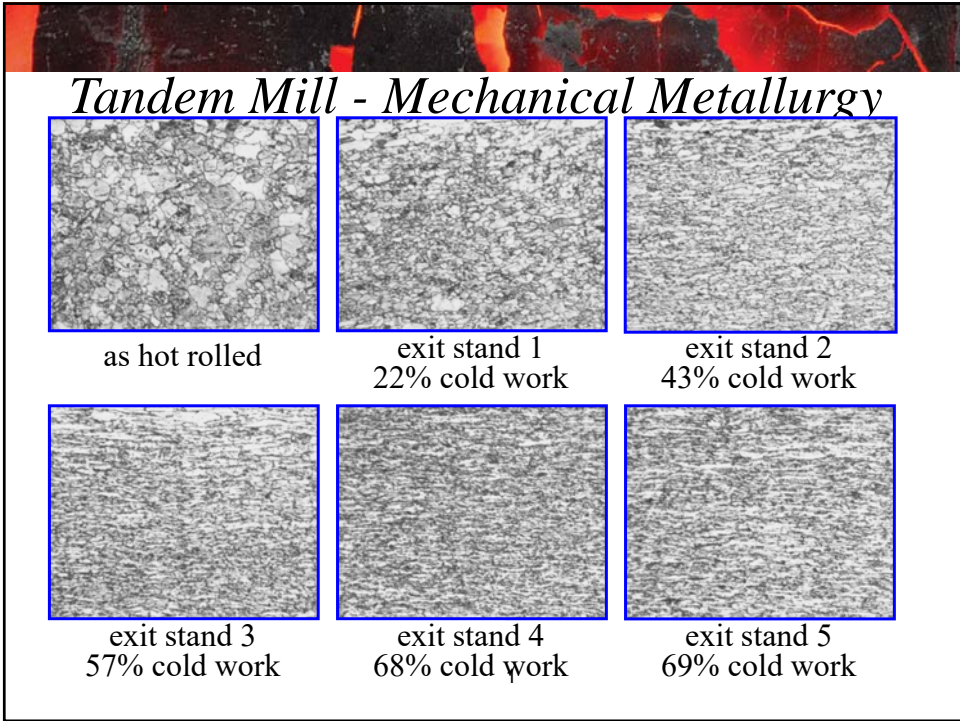
10



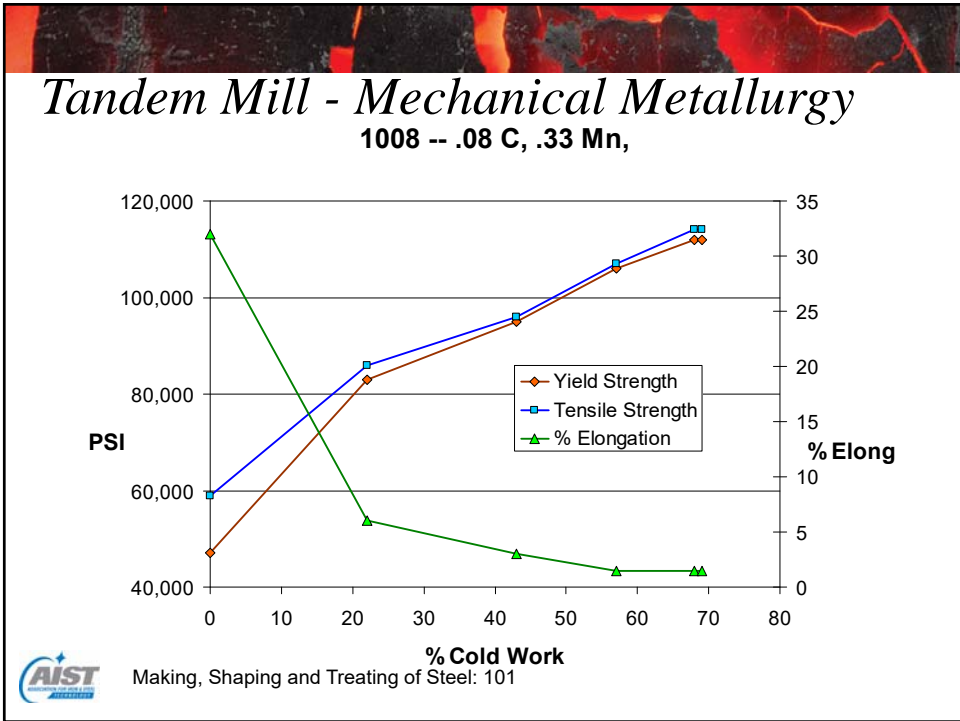
11



12



13



14

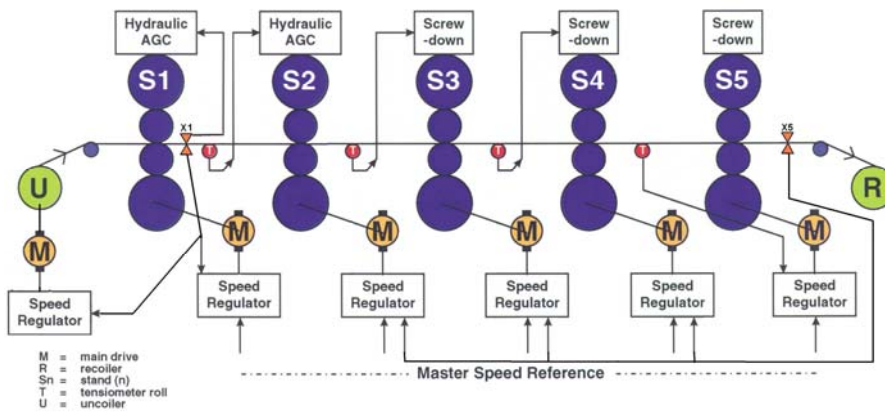
Tandem Mill – Inside the Roller’s Pulpit



15

Closed-Loop Automatic Gauge Control (AGC)

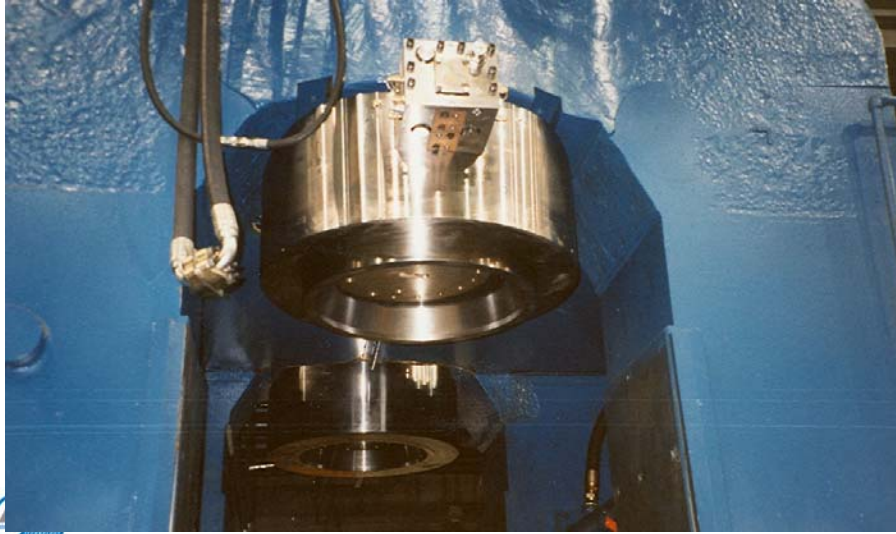
WITH FEED-FORWARD AND FEED-BACK CONTROL



Making, Shaping and Treating of Steel: 101

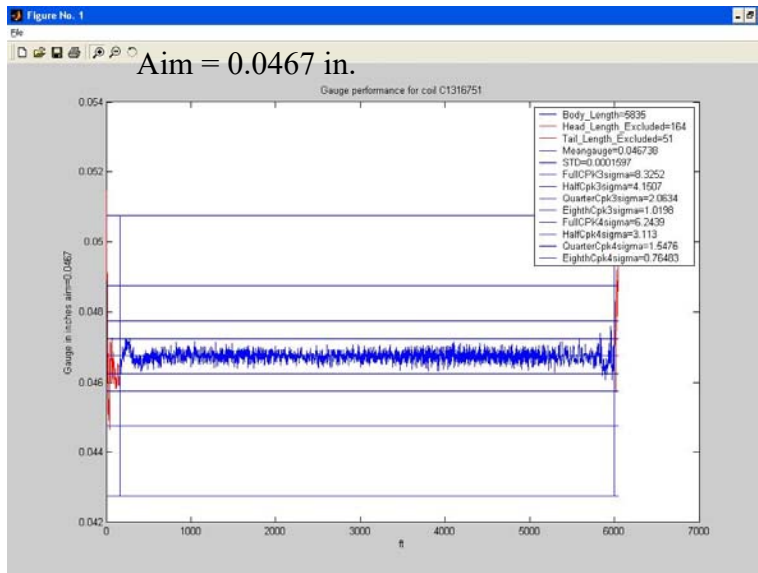
16

Hydraulic AGC Capsules



17

Tandem Mill – Centerline Gauge Trace

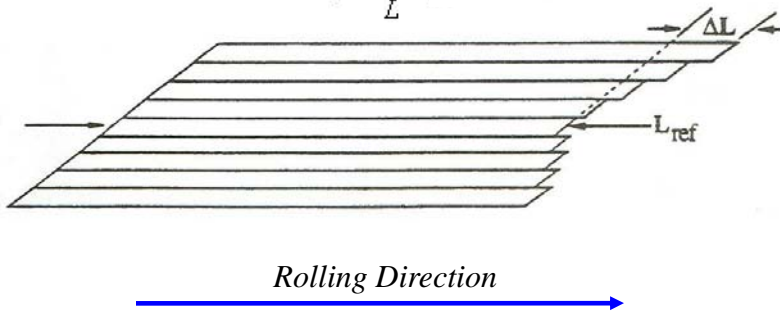


18

Measuring Flatness

theoretical I-units

$$I = \frac{\Delta L}{L} \times 10^5$$

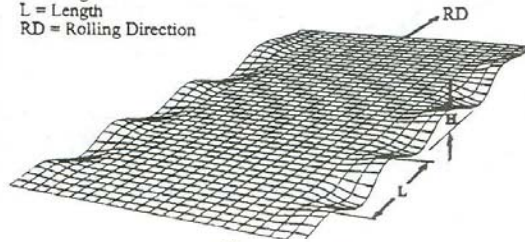


Making, Shaping and Treating of Steel: 101

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ASTM Flatness Standard

H = Height
L = Length
RD = Rolling Direction



A 568/A 568M

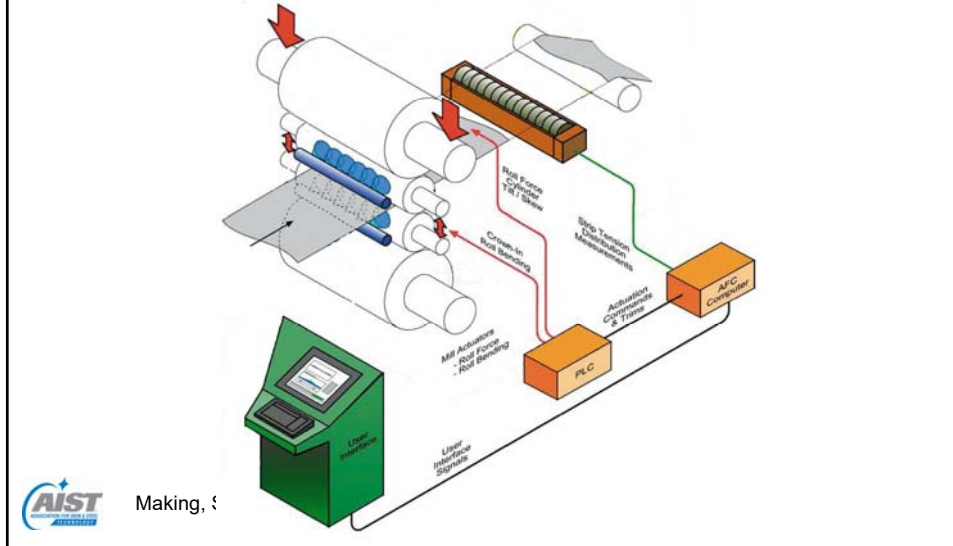
TABLE X5.1 I-Unit Conversion Chart

Wave Height (in.)	Wavelength (in.)																																								
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40										
1/32	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1/16	8	7	6	5	4	4	3	3	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
3/32	22	18	15	13	11	10	8	7	6	5	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
1/8	39	32	27	23	20	17	15	13	12	11	10	9	8	7	7	6	6	5	5	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	
5/32	60	50	42	36	31	27	24	21	19	17	15	14	12	11	10	9	8	8	7	7	6	6	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
3/16	87	72	60	51	44	38	34	30	27	24	22	20	18	16	15	14	13	12	11	10	10	9	8	8	7	7	6	6	6	6	6	6	6	6	6	6	6	6	5		
7/32	118	98	82	70	60	53	46	41	36	33	30	27	24	22	21	19	17	16	15	14	13	12	12	11	10	10	9	9	8	8	8	8	8	8	8	8	8	8	7		
1/4	154	128	107	91	79	69	60	53	46	43	39	35	32	29	27	25	23	21	20	18	17	16	15	14	13	13	12	11	11	10	10	10	10	10	10	10	10	10	10		
9/32	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34	31	29	27	25	23	22	20	19	18	17	16	15	14	14	13	13	12	12	12	12	12	12	12	12		
5/16	241	199	168	143	123	107	94	83	74	67	60	55	50	46	42	39	36	33	31	29	27	25	24	22	21	20	19	18	17	16	15	15	14	14	14	14	14	14	14	14	
11/32	292	241	203	173	149	130	114	101	90	81	73	66	60	55	51	47	43	40	37	35	32	30	29	27	25	24	23	21	20	19	18	18	17	17	17	17	17	17	17	17	
3/8	347	287	241	206	177	154	136	120	107	96	87	79	72	66	60	56	51	48	44	41	39	36	34	32	30	28	27	25	24	23	22	22	21	21	21	21	21	21	21	21	21
13/32	408	337	283	241	208	181	159	141	126	113	102	92	84	77	71	65	60	56	52	48	45	42	40	37	35	33	31	30	28	27	25	25	24	24	24	24	24	24	24	24	
7/16	473	391	326	280	241	210	185	164	146	131	118	107	98	89	82	76	70	65	60	56	53	49	46	43	41	39	36	35	33	31	30	29	29	28	28	28	28	28	28	28	
15/32	543	449	377	321	277	241	212	188	168	150	136	123	112	103	94	87	80	74	69	65	60	56	53	50	47	44	42	40	38	36	34	33	32	32	32	32	32	32	32	32	32
1/2	618	510	429	365	315	274	241	214	191	171	154	140	128	117	107	99	91	85	79	73	69	64	60	57	53	50	46	45	43	41	39	37	36	36	36	36	36	36	36	36	



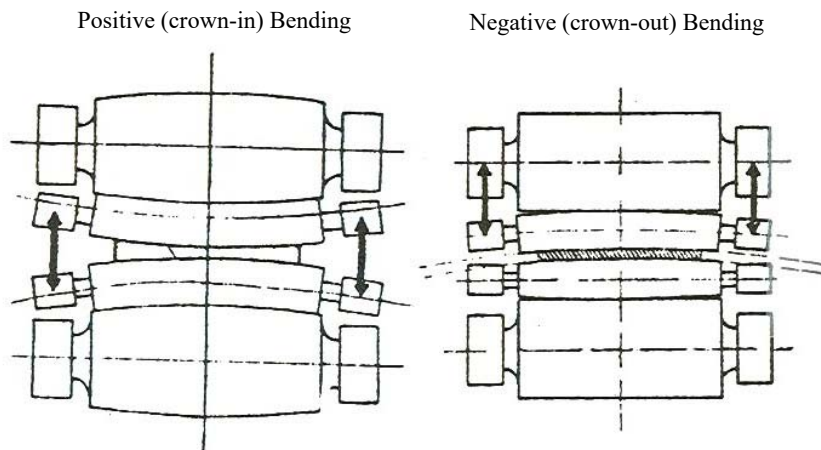
20

Closed-Loop Automatic Flatness Control WITH FEED-BACK CONTROL



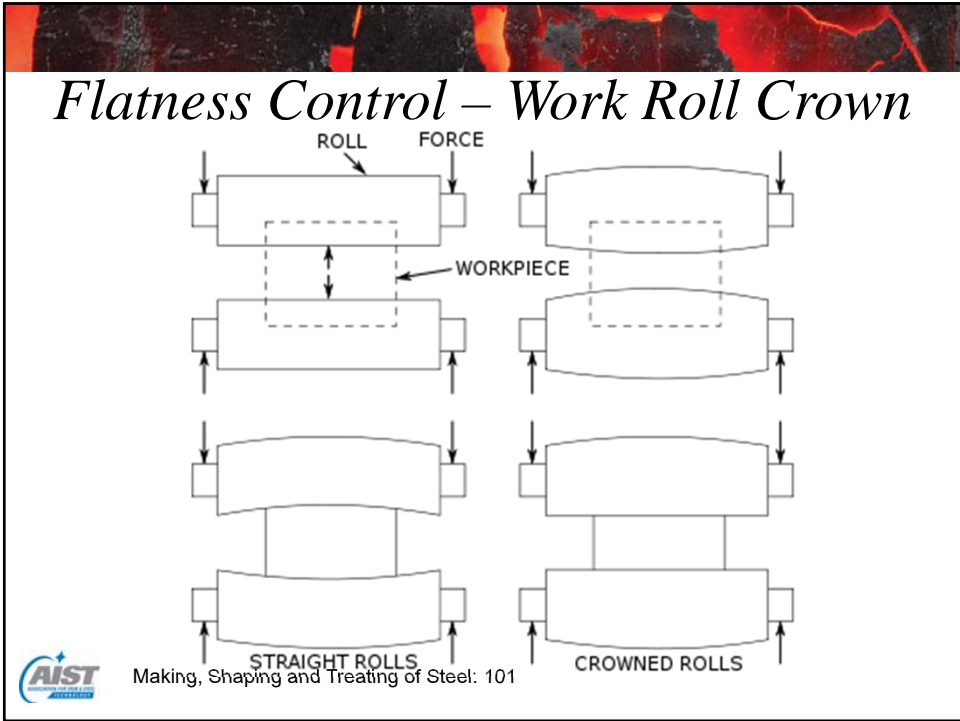
21

Flatness Control – Roll Bending

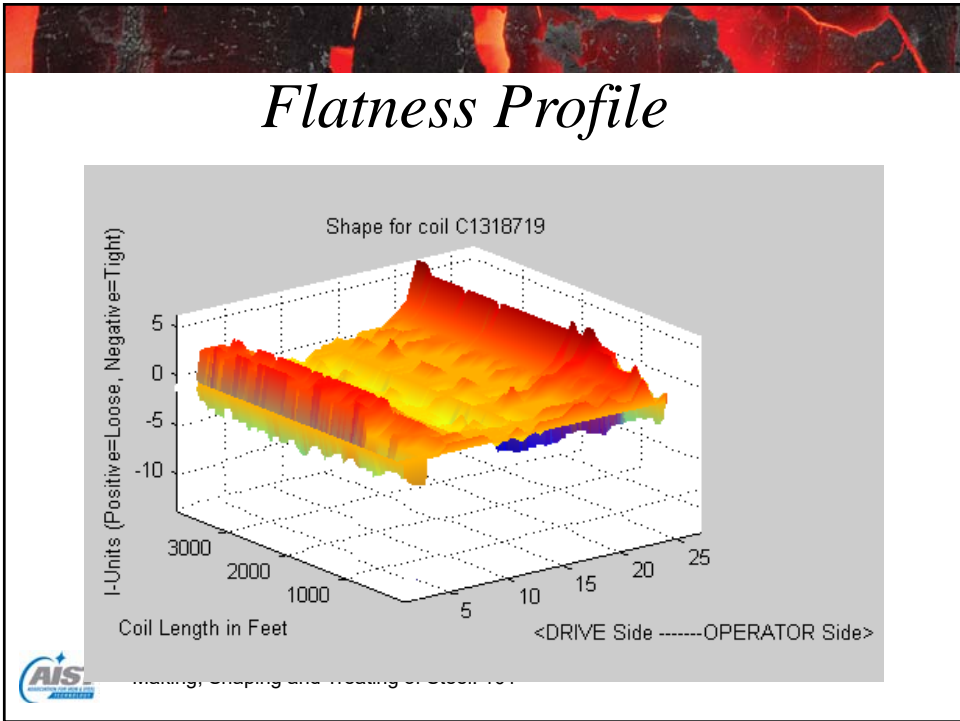


Making, Shaping and Treating of Steel: 101

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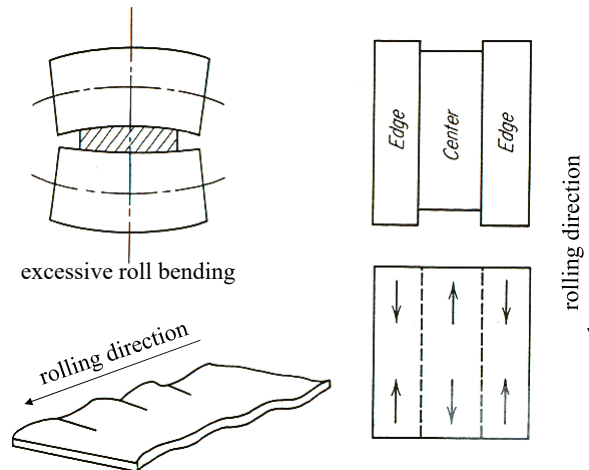
24

Lechler Spray Bars - No. 5 Stand - Entry Side



25

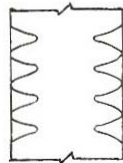
Creation of an Edge Wave Condition



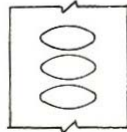
Making, Shaping and Treating of Steel: 101

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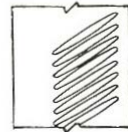
Non-Ideal Shape Profiles



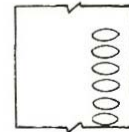
LONG EDGE



LONG MIDDLE



HERRINGBONE



QUARTER BUCKLE

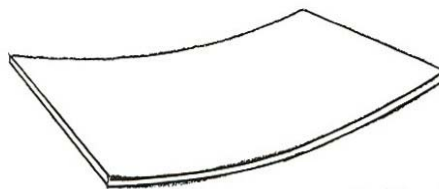


Making, Shaping and Treating of Steel: 101

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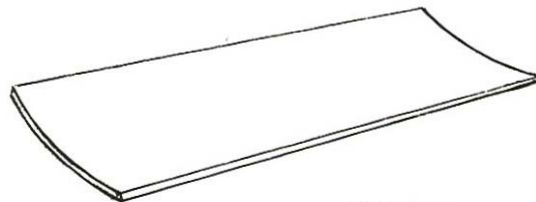
Other Non-Ideal Shape Conditions

Rolling
Direction



Coilset

Rolling
Direction



Crossbow



Making, Shaping and Treating of Steel: 101

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Controlled Application of Lubricant and Coolant



Making, Shaping and Treating of Steel: 101

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Lubricant / Coolant Filtration



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Other Cold Mill Operations

Z-Mills, Reversing Mill

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Single-stand Reversing Mill



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Twin-Stand Reversing Mill



Making, Shaping and Treating of Steel: 101

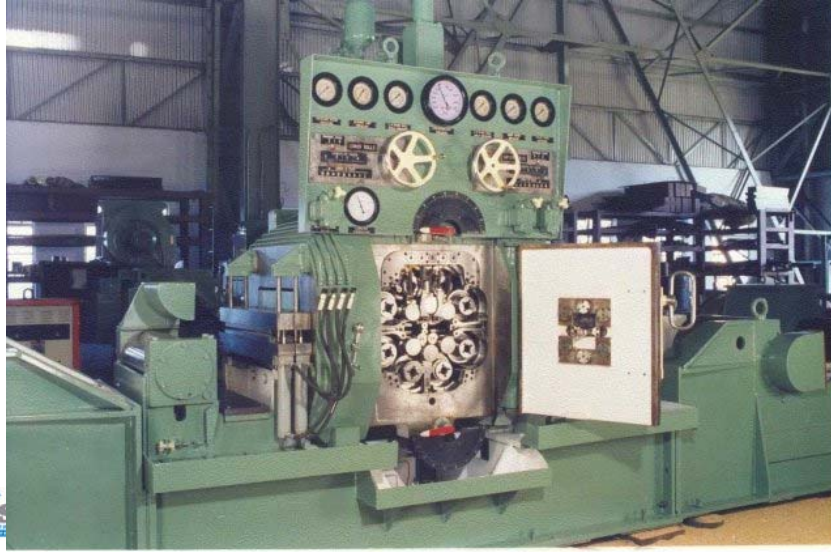
33

Sendzimir (Z) Mill



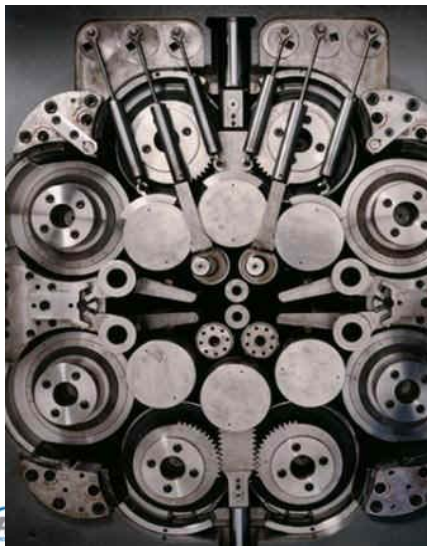
34

Sendzimir (Z) Mill

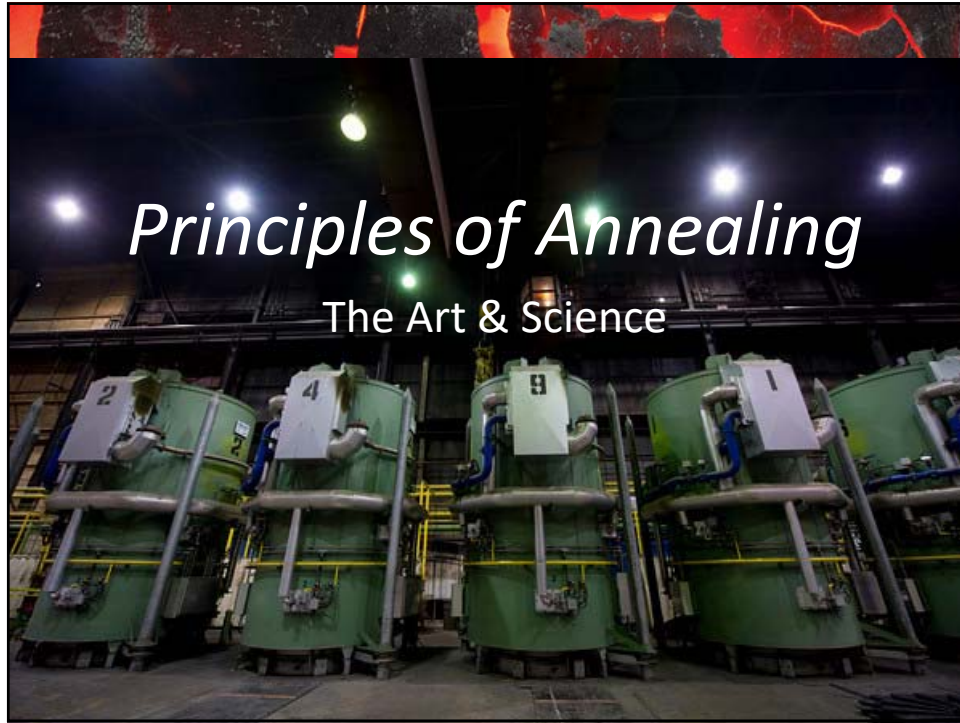


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20-High Roll Cluster



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Principles of Annealing

The Art & Science

37



Hydrogen (H₂) Batch Annealing



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Batch Annealing Basic Characteristics

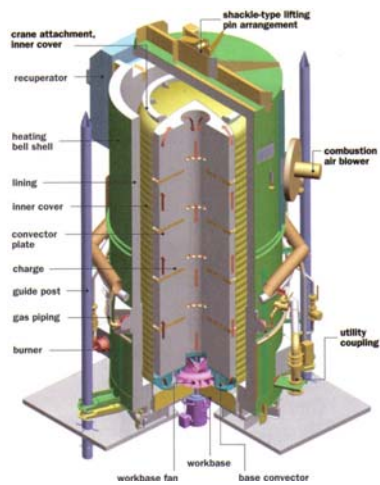
- Fully automated, precision cycle control for property homogenization throughout coils.
- Hydrogen 'scrubbing' to volatilize synthetic tandem mill rolling solution.
- Wide range of annealing cycle offerings: 'Cold Spot' Anneal, CQ, DQ, Spheroidization, Stress-Relief / Solution Burn-Off.
- Sealed atmosphere eliminates formation of discolored iron oxide film.
- The mill uses a fully-synthetic rolling solution like the tandem mill, but a different formulation.



Making, Shaping and Treating of Steel: 101

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Hydrogen (H_2) Batch Annealing



01

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Building a Charge



Making, Shap

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Applying an Inner Cover



Making, Shap

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Applying a Furnace

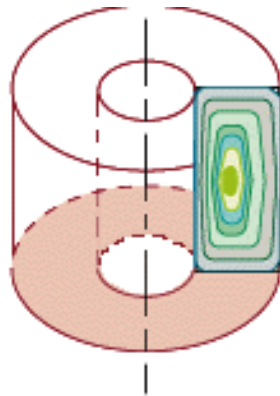


Making, Shap

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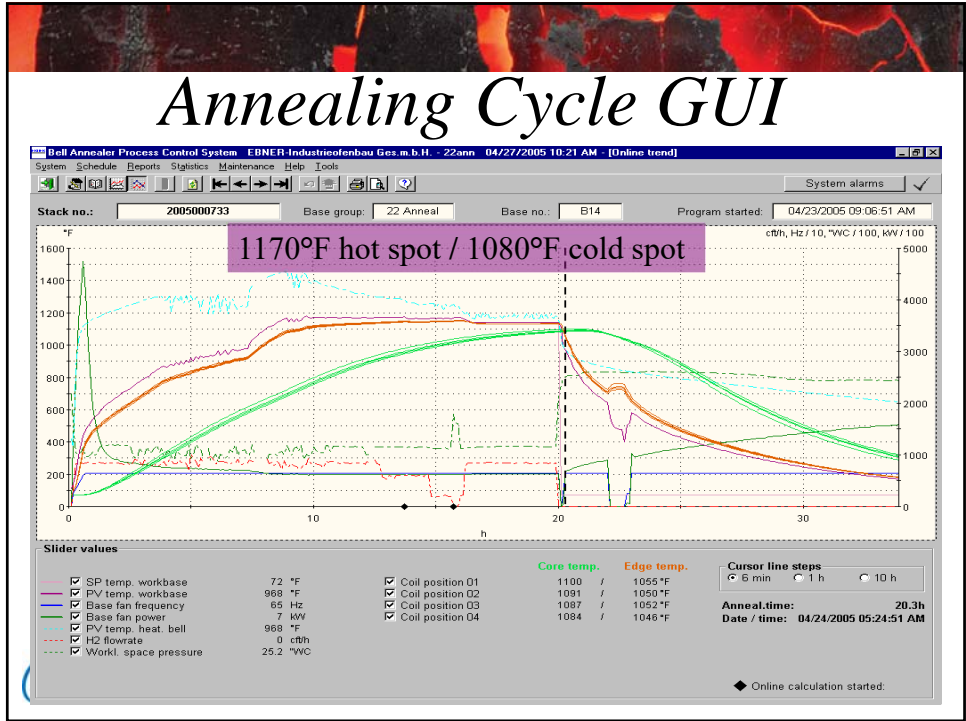
Hot Spot vs. Cold Spot

CONTROL TEMPERATURES

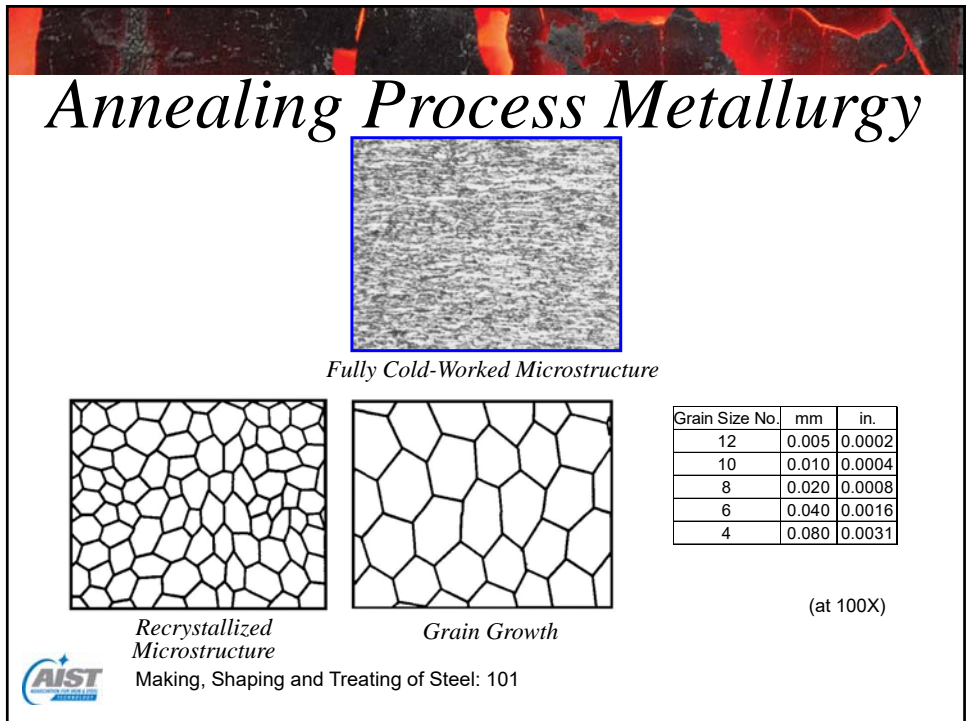


Making, Shaping and Treating of Steel: 101

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Temper Rolling Basic Characteristics

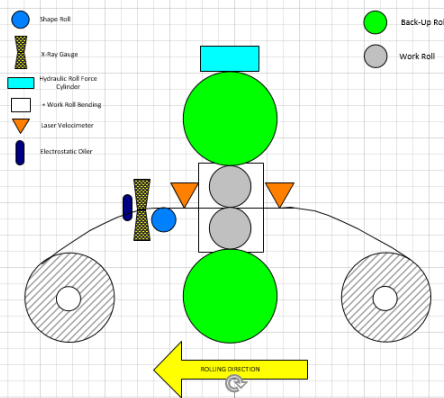
- Units perform **temper rolling** (properties) and **skin pass** (finish).
- Temper offerings include **CS, DS, DDS, and special tempers**. The variation in properties to meet product requirements are achieved via a combination of annealing cycle and degree of temper 'extension'.
- Finish offerings include a range of bright and matte finishes:
 - **Bright:** 25 AA Max, 15 AA Max
 - **Matte:** Light Matte (20/40 AA), Medium Matte (40/65 AA), Heavy Matte (60/90 AA)
- Base temper solution is a **water soluble** solution. High velocity blowoffs are employed to minimize carryover into the coil.
- A **dry product** can be offered by our 28Mill which employs a vacuum roll to produce a temper dry product. This product cannot be warranted against rust.
- **Rust preventative oil** is Quaker EGL (replaces 61-AUS) and is applied electrostatically in a range of 80 to 320 mg/ft² (one-sided application).



Making, Shaping and Treating of Steel: 101

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Single Stand Temper Mill

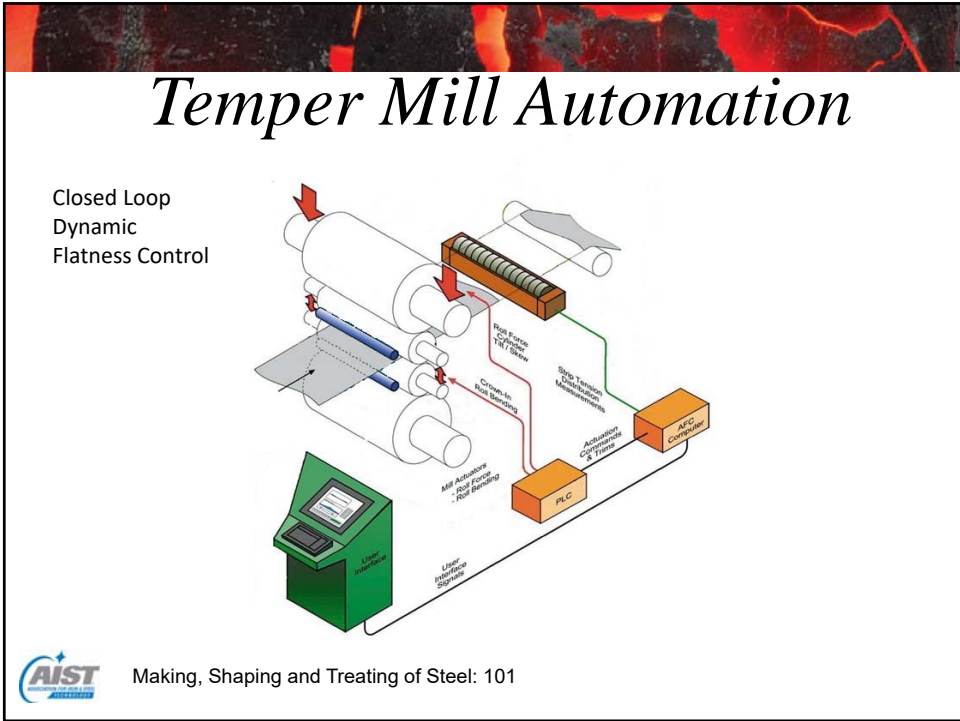


TEMPER MILL PRODUCT SPECIFICATIONS		
Material	Carbon Steel	
Weight	50,000 rounds max	
Outside Diameter	72 inches max	
Incoming Coil	PIW	1000
	Gauge	0.125 inches max
Width	50.188 inches max	
	Weight	50,000 rounds max
Produced Coil	Outside Diameter	72 inches max
	PIW	1000
Gauge	0.010 - 0.125 inches max	
	Produced ID	24 inches



Making, Sh

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Cold Mill Roll Shop



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Roll Grinder – Front View



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Roll Grinder—Side View



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Shot Blaster



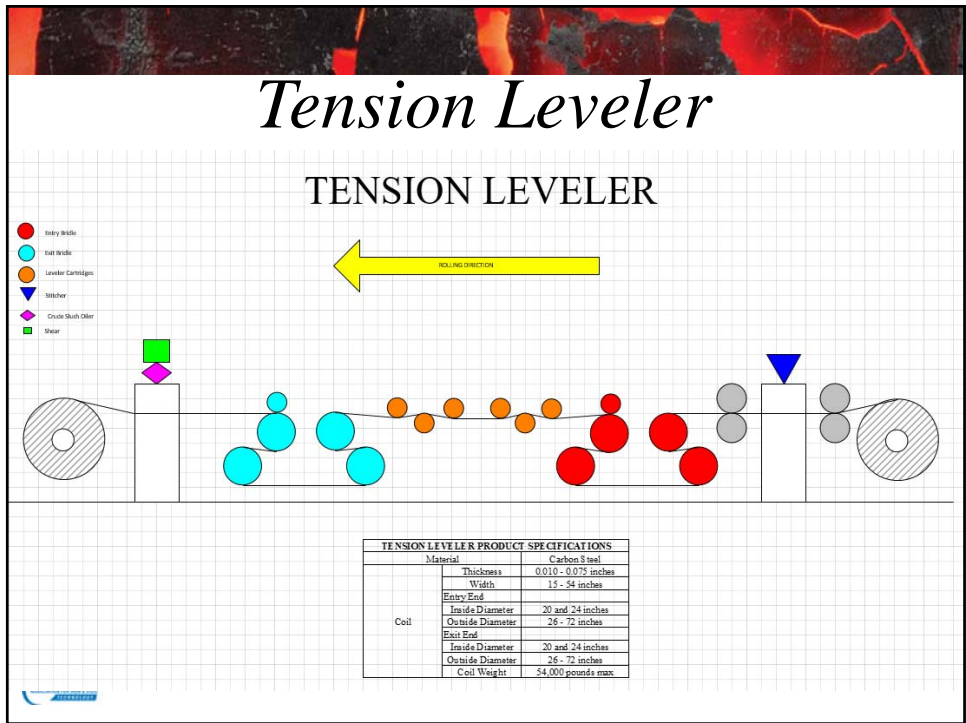
56



Tension Leveling

Flatness Control

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Tension Leveler



Making, Shaping and Treating of Steel: 101

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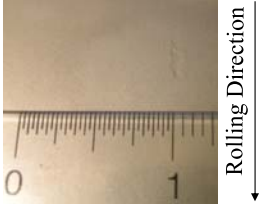
Basic Cold Rolled Defects




Making, Shaping and Treating of Steel: 101

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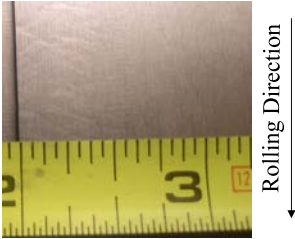
Cold-Rolled Defects



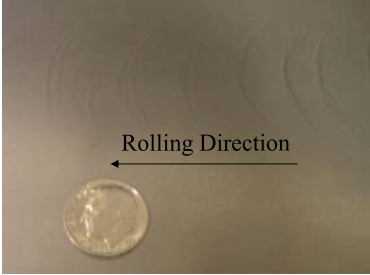
Roll Mark




Hot Mill Skid Tear



Edge Strain



Sticker Marks


 Making, Shaping and Treating of Steel: 101

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Cold-Rolled Defects



Work Roll Chatter


 Making, Shaping and Treating of Steel: 101

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