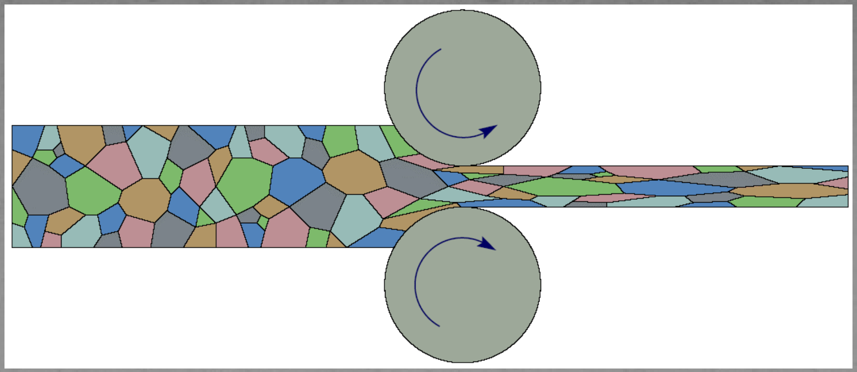


ROLL PASS DESIGN EVAULUATION USING SOFTWARE APPLICATION

ARINDAM MUKHERJEE

PROJECT MANAGEMENT CELL

UNDP/GEF PROJECT (STEEL)

OBJECTIVE OF ROLL PASS DESIGN

- Steel sections are generally rolled in several passes, whose number is determined by the ratio of initial input material and final cross section of finished product.
- The cross section area is reduced in each pass and form and size of the stock gradually approach to the desired profile.

ROLLING PROCESS

- Steel rolling consists of passing the material, usually termed the stock, between two rolls driven at the same peripheral speed in opposite directions (i.e. one clockwise and one anti-clockwise) and so spaced that the distance between them is somewhat less than the thickness of the section entering them.

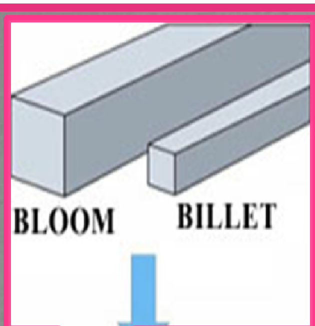
- In these circumstances the roll grip the material and deliver it reduce in thickness, increased in length and probably somewhat increased in width.

OBJECTIVE OF ROLL PASS DESIGN

- Production of correct profile within tolerance limits with good surface finish (free from surface defects).
- Maximum productivity at lowest cost.
- Minimum roll wear.
- Easy working.
- Optimum energy utilization.

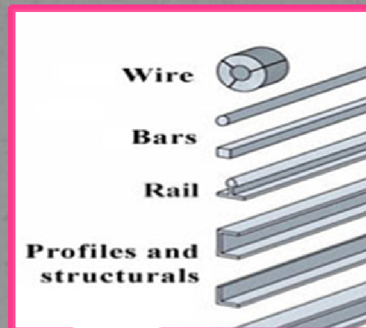
ROLL PASS IS BASED ON

CHARACTERISTICS OF INITIAL INPUT



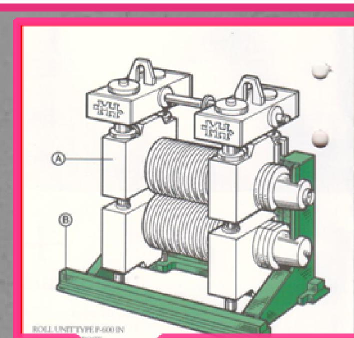
- Dimension and weight of billet
- Grade of steel
- Metal temperature before and in the course of rolling

CHARACTERISTICS OF FINISHED PRODUCT



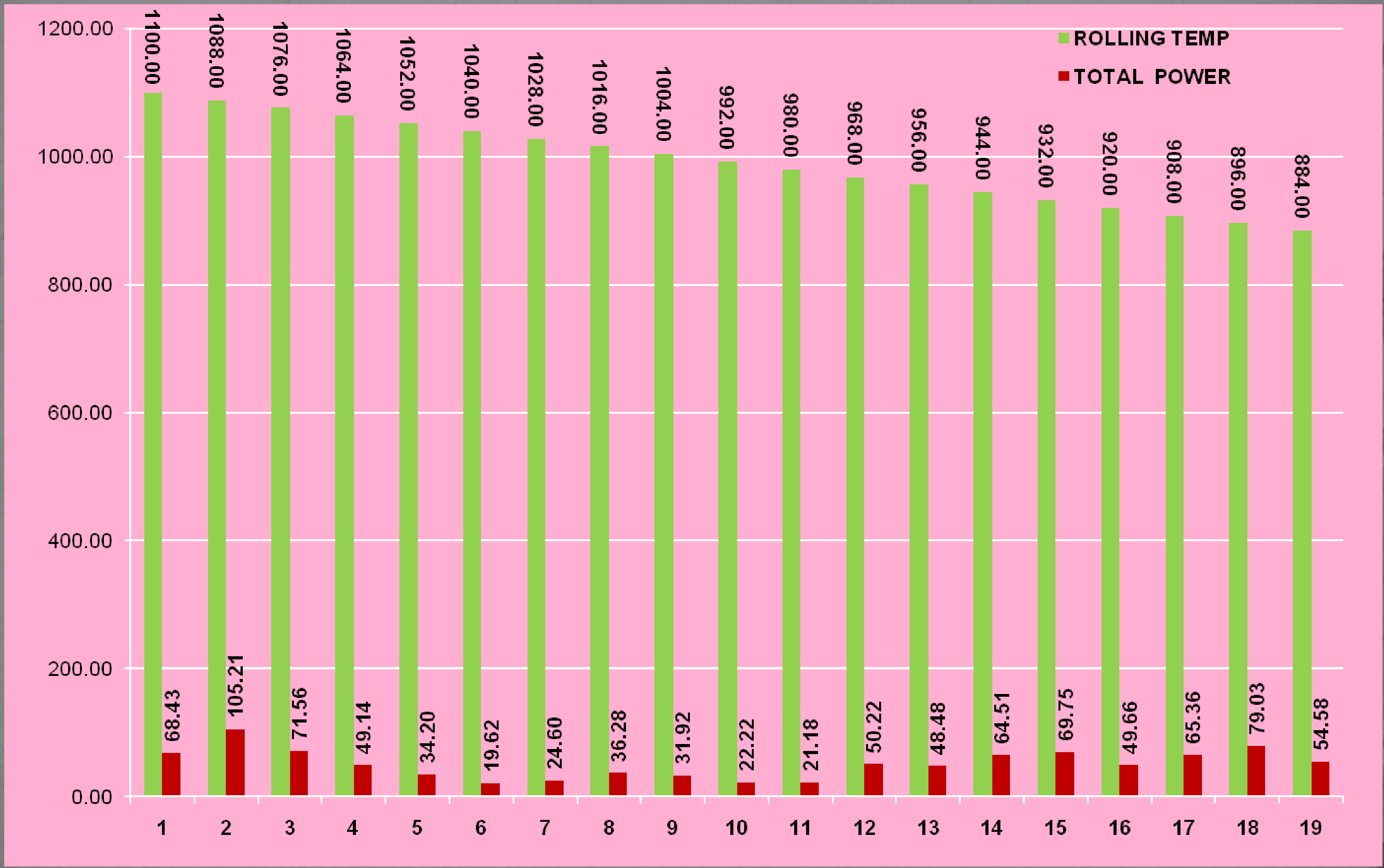
- Dimension of section
- Tolerances and specifications concerning to mechanical properties
- Surface finish of rolled product

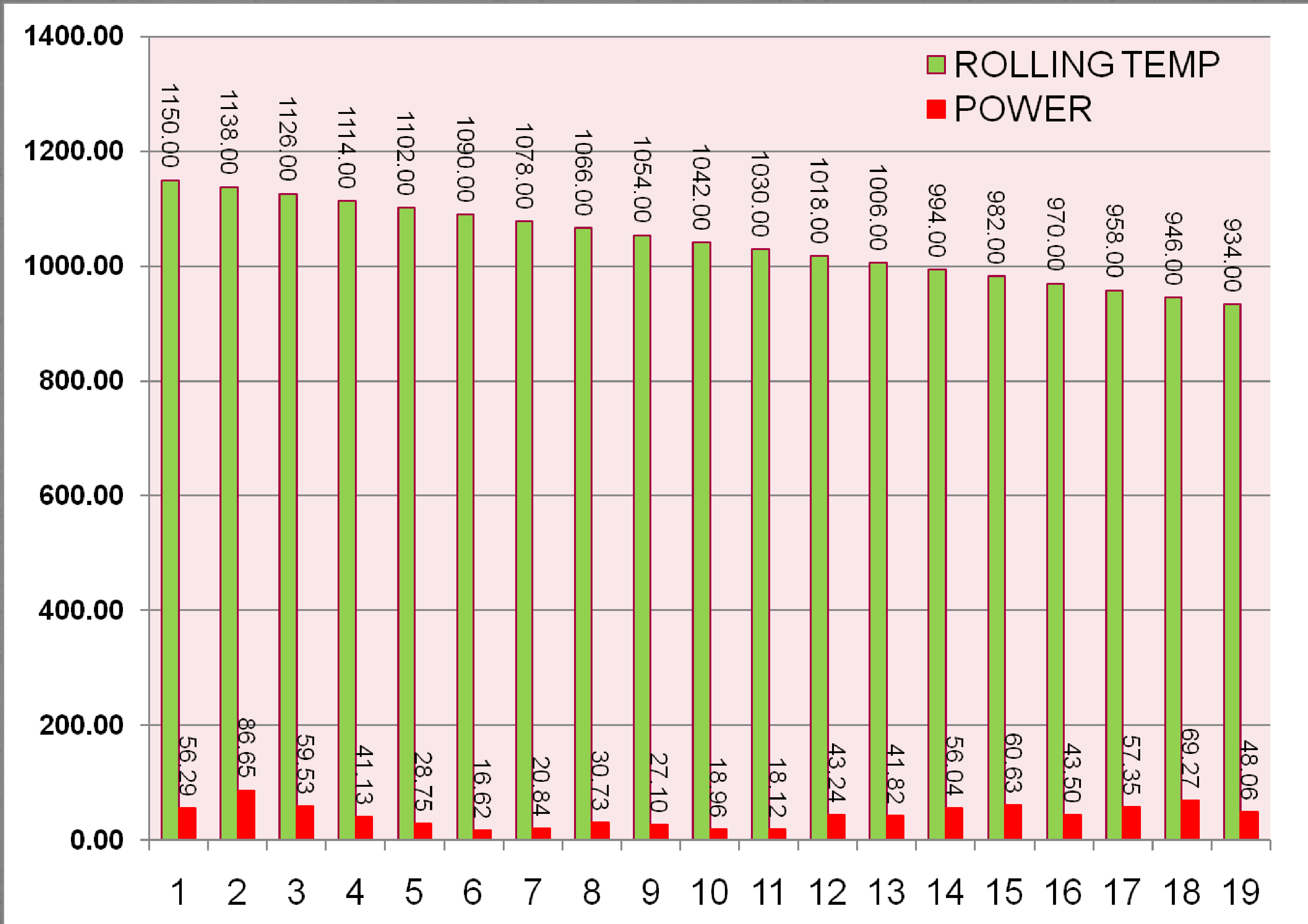
SPECIFICATION OF ROLLING MILL



- Number of stands
- Roll diameter
- Rolling speed
- Available power of the drive motor
- Available mill equipment
- Strength of rolls

IMPORTANCE OF TEMPERATURE




ROLLING TEMP
POWER
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1150.00
1138.00
1126.00
1114.00
1102.00
1090.00
1078.00
1066.00
1054.00
1042.00
1030.00
1018.00
1006.00
994.00
982.00
970.00
958.00
946.00
934.00
56.29
86.65
59.53
41.13
28.75
16.62
20.84
30.73
27.10
18.96
18.12
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41.82
56.04
60.63
43.50
57.35
69.27
48.06
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BASIC REQUIREMENTS FOR CORRECT ROLL PASS DESIGN

- Shape of sections in a particular passes must ensure a free metal flow in the roll gap/groove.
- Appropriate taper/groove angle in pass must be selected in order to avoid metal jamming in rolls.

TYPE OF PASS	% TAPER
Roughing pass	6 to 15
Forming pass	3 to 10
Finish pass	0.5 to 3.0%

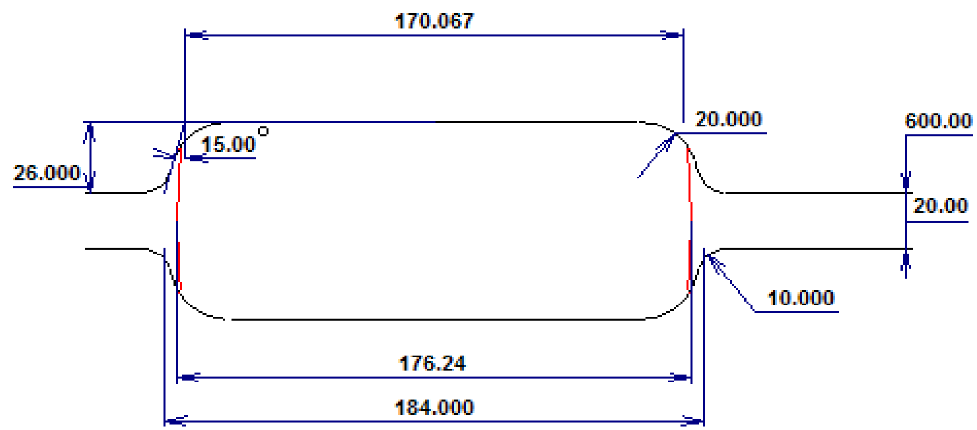
Thumb rules for
GROOVE ANGLE, RELIEF RADIUS, BOTTOM RADIUS & FITTING

- Groove angle for box pass should be 8 to 10^0 .
- Relief radius for box pass should be 10 mm.
- Groove angle for diamond pass should be > 90^0 .
- Relief radius for diamond should be around 18 mm .
- Groove angle for square pass should be 45^0 .
- Bottom angle for square pass should be around 90^0 .
- Relief radius for square pass should be 5mm .
- Groove angle for oval should be 60^0 .
- Relief radius for oval should be 5mm.
- Groove angle for intermediate round pass should be 60^0 .
- Groove angle for intermediate finish round pass should be 30^0 .
- Bottom radius for rounds is ½ of dia.
- Relief radius for rounds is 1/5th of bottom radius .
- Relief radius for rounds in finish pass should be 1.5.
- Fitting from oval to round should be 0.3 to 0.7.
- For ovals width to height ratio should be < 3.0.

Rolling Mill: WCONTI RD5.5: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,

File Help Get Groove data from file ROLL DRAWING INSERT DELETE COPY END Picture On/Off

Row no	GRV shape	GRV no (max 6 charact.)	HEIGHT (Depth) Hg mm	GROOVE ANGLE ag °	RELIEF RADIUS R0 mm	BOTTOM RADIUS 1 R1 mm	RADIUS R2 or dS(DI,XRD) mm	WIDTH at collar Wg mm	TOP WIDTH Wt mm	MIDDLE BOTTOM WIDTH mm	MIDDLE BOTTOM DEFLEC. mm	GAP mm
1	BX	101	42.50	15.00	10.00	20.00		178.00				20.00
2	TBX	201	26.00	15.00	10.00	20.00		184.00				20.00
3	TBX	301	49.00	10.00	10.00	24.00		98.00				20.00
4	OV	401	26.50									
5	RD	501	35.00									
6	OV	601	19.30									
7	RD	701	25.50									
8	OV	801	13.20									
9	RD	901	19.00									
10	OV	1001	8.90									
11	RD	1101	13.80									
12	OV	1201	6.60									
13	RD	1301	10.40									
14	OV	1401	6.50									
15	RD	101	9.50									
16	OV	1601	4.60									
17	RD	160	7.10									
18	OV	1	4.00									
19	RD	125	5.50									
20	OV	3	3.00									
21	RD	105	4.50									
22	OV	5	2.75									
23	RD	85	3.50									
24	OV	6	2.25									
25	RD	70	2.875									
26	OV	7	1.50									



Groove no: TBX 201

Check Coordinates

Size

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BASIC REQUIREMENTS FOR CORRECT ROLL PASS DESIGN

- The number and arrangement of passes in particular roll stand should assure the most uniform possible exploitation of all the passes in each stand.
- Uniform draught in last passes & different draught in early forming passes of profile , where the section is large & metal is hot.
- Draught should be distributed so as to ensure as far as possible uniform wear and to avoid overloading of drive installations and rolls .

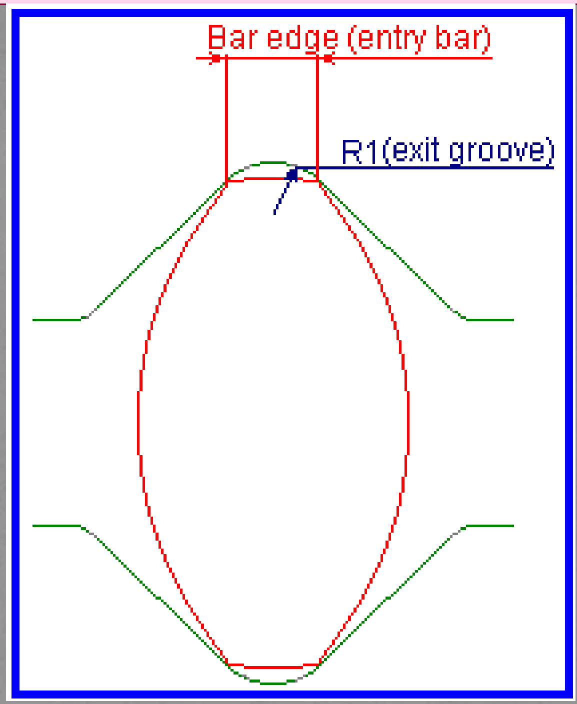
BASIC REQUIREMENTS FOR CORRECT ROLL PASS DESIGN

- Rolls should easily grip the material being rolled .

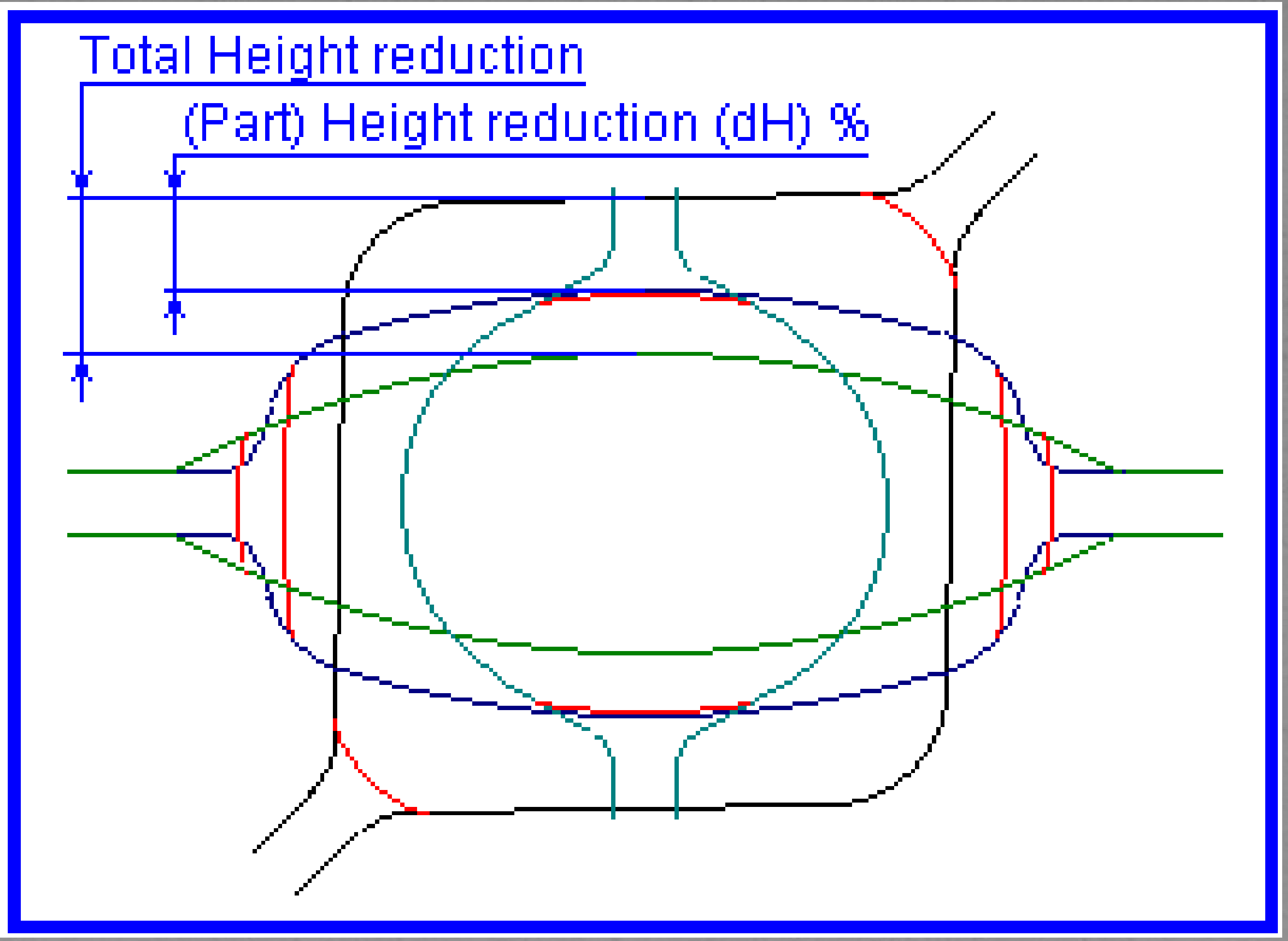
Rolls Finish	Max. Angle of Bite (in degrees) with reference to speed of mill							
	0	0.5	1	1.5	2	2.5	3	3.5
Smooth	25.5	24.5	23.5	22.5	19.5	16	12	9
Edged passes	29	27.5	26	24.5	21	17	12	7
Ragged	33	32	31	30	28	26	24	21

- Pass filling should be correct.

Fitting = Bar edge$_{(entry\ bar)}$ / 2 * Groove bottom radius$_{(exit\ groove)}$



The **Fitting** parameter should be 0.3 < Fitting < 0.7 to avoid problems with bad surface quality and bad wearing conditions of the groove bottom.


Total Height reduction
(Part) Height reduction (dH) %

BASIC REQUIREMENTS FOR CORRECT ROLL PASS DESIGN

- An optimum number of passes should be used.

If, Too greater in number → Lower the out put of the roll stand

Too smaller in number → Cause excessive roll wear

Danger of roll fracture or rolling defect

Total Elongation Coefficient λ_t at Different Reductions relative to No. of Passes								
Pass No.	λ_t for percentage reduction of							
	5	10	15	20	25	30	35	40
1	1.053	1.111	1.177	1.250	1.333	1.429	1.538	1.667
2	1.108	1.235	1.384	1.563	1.777	2.042	2.365	2.779
3	1.167	1.372	1.628	1.953	2.369	2.918	3.638	4.63
4	1.228	1.524	1.915	2.441	3.157	4.170	5.595	7.72
5	1.293	1.694	2.253	3.052	4.209	5.96	8.606	12.87
6	1.361	1.883	2.650	3.815	5.610	8.52	13.24	21.5
7	1.432	2.092	3.117	4.77	7.48	12.17	20.36	35.8
8	1.508	2.324	3.667	5.96	9.97	17.39	31.31	59.6
9	1.587	2.582	4.313	7.45	13.29	24.8	48.15	99.4
10	1.670	2.868	5.073	9.31	17.71	35.5	74.06	165.7128
11	1.758	3.187	5.967	11.64	23.61	50.7	114	276.2432
12	1.851	3.540	7.019	14.55	31.5	72.5	175	460.4974
13	1.948	3.933	8.256	18.19	42.0	104	269	767.6492
14	2.050	4.370	9.711	22.74	55.9	148	414	1279.671
15	2.159	4.855	11.423	28.42	74.6	212	637	2133.212
16	2.272	5.394	13.445	35.53	99.4	302	980	3556.064
17	2.392	5.992	15.824	44.41	132	432	1508	5927.959
18	2.518	6.658	18.625	55.51	177	617	2319	9881.908
19	2.651	7.397	21.922	69.39	235	882	3566	
20	2.790	8.218	25.802	86.74	314	1261	5484	
21	2.938	9.130	30.369	108.4	418	1802	8435	
22	3.092	10.143	35.744	135.5	558	2575		
23	3.255	11.269	42.071	169.4	743	3679		
24	3.427	12.520	49.497	211.8	991	5257		
25	3.607	13.910	58.257	264.7	1321	7513		

CALCULATION FOR NO. OF PASSES

Input Size = 200x200 mm

Finish Product = 50x50 mm

λ_t =200x200/50x50 = 16

With 25 % Redn. In every pass after

9th pass λ_t = 13.29 and after 10th pass λ_t =17.71.

10 passes will be sufficient with redn. Somewhtat less than 25 %.

Last pass = 5% , λ_t = 1.053

Preleader =10% , λ_t = 1.111

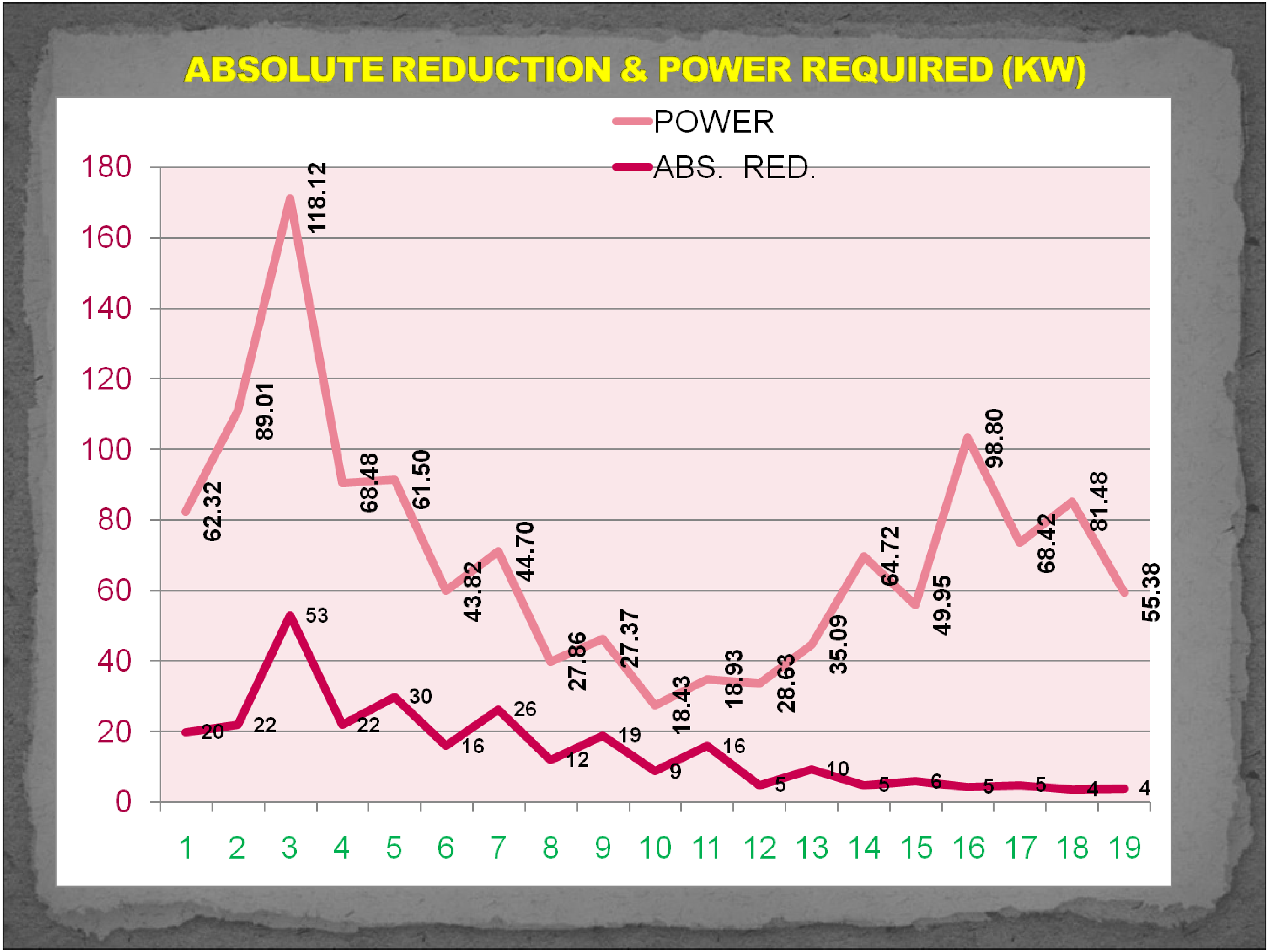
=1.053x1.111=1.168

λ_t= 16/1.168 = 13.7

With 30% redn. 13.7 can be achieved after 7 pass or we can say 8th pass.

EVALUATION BASED ON ABSOLUTE REDUCTION

Pass no	Pass Shape	Initial width	Initial height	Initial Area	Final width	Final height	Final Area	Mean width	Abs. red.	Pass wise Power(Kw) Required for Deformation
		B	H	Fo	b	h	F1	Bm	dh	
		mm	mm	mm2	mm	mm	mm2	mm	mm	
1	Box	100.00	100.00	9940.00	110.00	80.00	7920.00	105	20	62.32
2	Box	110.00	80.00	7920.00	125.00	58.00	6525.00	118	22	89.01
3	Square	58.00	125.00	6525.00	72.00	72.00	5184.00	65	53	118.12
4	Box	72.00	72.00	5184.00	86.00	50.00	3870.00	79	22	68.48
5	Square	50.00	86.00	3870.00	56.00	56.00	3136.00	53	30	61.50
6	Box	56.00	56.00	3136.00	66.40	40.00	2376.00	61	16	43.82
7	Square	40.00	66.40	2376.00	40.00	40.00	1600.00	40	26	44.70
8	Oval	40.00	40.00	1600.00	48.00	28.00	1055.04	44	12	27.86
9	Square	28.00	48.00	1055.04	29.00	29.00	841.00	29	19	27.37
10	Oval	29.00	29.00	841.00	36.00	20.00	565.20	33	9	18.43
11	Square	20.00	36.00	565.20	20.00	20.00	400.00	20	16	18.93
12	Oval	20.00	20.00	400.00	24.00	15.00	282.60	22	5	28.63
13	Square	15.00	24.00	282.60	14.50	14.50	210.25	15	10	35.09
14	Oval	14.50	14.50	210.25	18.00	9.50	134.24	16	5	64.72
15	Round	9.50	18.00	134.24	12.00	12.00	113.04	11	6	49.95
16	Oval	12.00	12.00	113.04	15.00	7.50	88.31	14	5	98.80
17	Round	7.50	15.00	88.31	10.00	10.00	78.50	9	5	68.42
18	Oval	10.00	10.00	78.50	12.00	6.30	59.35	11	4	81.48
19	Round	6.30	12.00	59.35	8.00	8.00	50.24	7	4	55.38


ABSOLUTE REDUCTION & POWER REQUIRED (KW)
POWER
ABS. RED.
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
62.32
89.01
118.12
68.48
61.50
43.82
44.70
27.86
27.37
18.43
18.93
28.63
35.09
64.72
49.95
98.80
68.42
81.48
55.38
20 22 53 22 30 16 26 12 19 9 16 5 10 5 6 5 5 4 4

Total power
Abs. red.
120
100
80
60
40
20
0
1
2
3
4
5
6
7
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10
11
12
13
14
15
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17
18
19
56.29
78.98
49.50
50.38
28.79
28.99
22.63
21.68
17.86
20.64
14.20
44.77
21.74
79.27
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50.65
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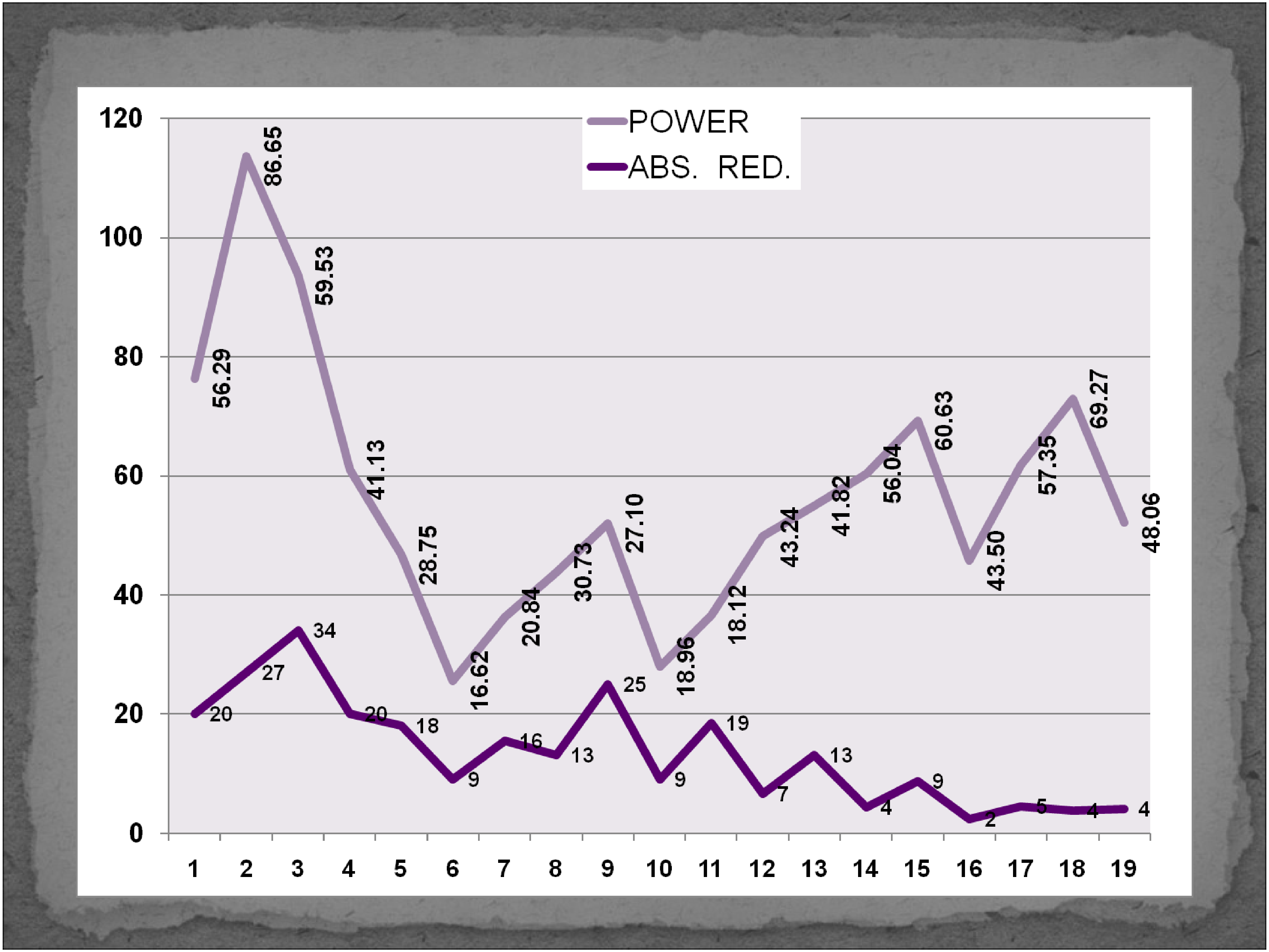
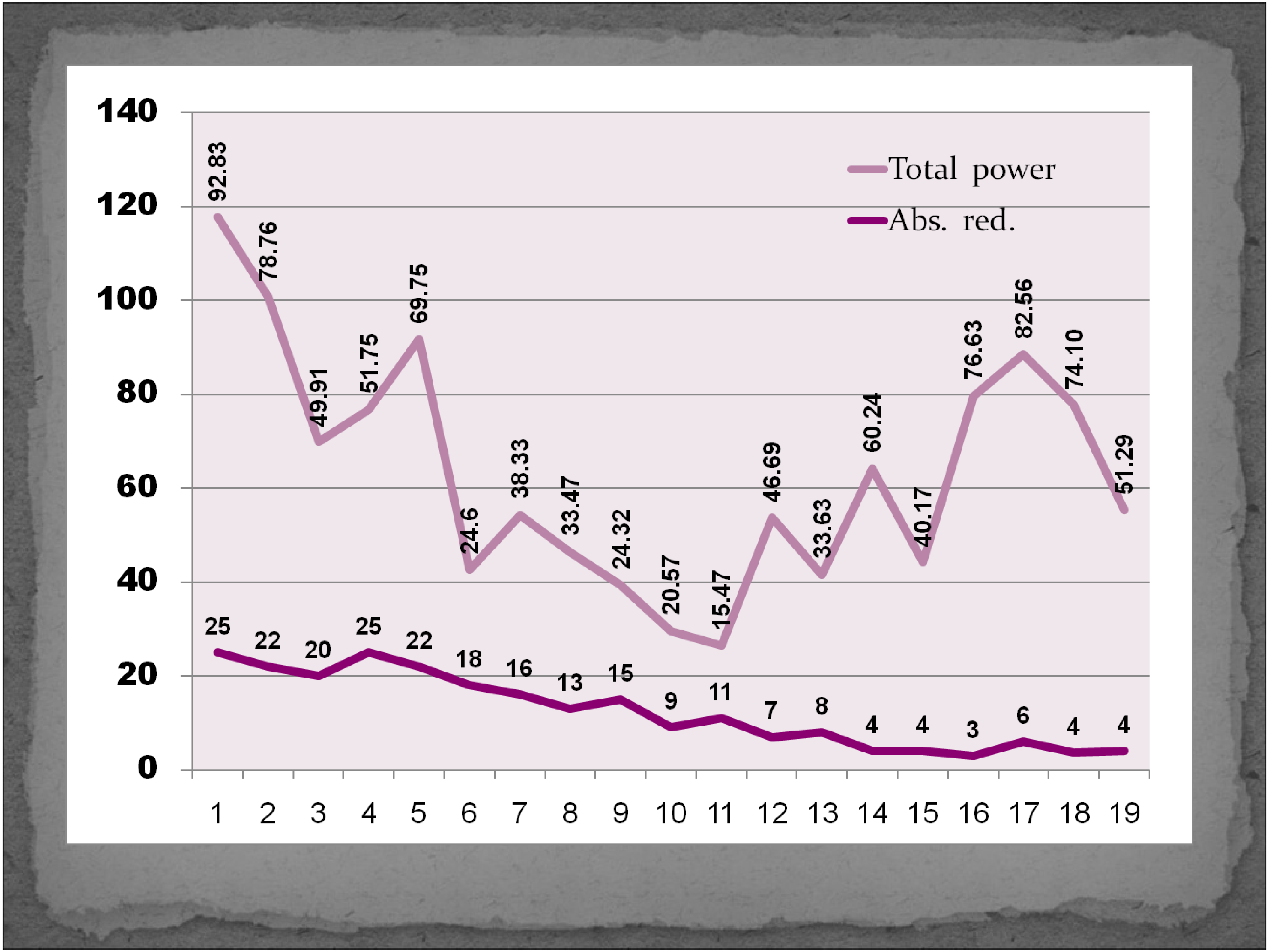


POWER
ABS. RED.
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
56.29 86.65 59.53 41.13 28.75 16.62 20.84 30.73 27.10 18.96 18.12 43.24 41.82 56.04 60.63 43.50 57.35 69.27 48.06
20 27 34 20 18 9 16 13 25 9 19 7 13 4 9 2 5 4 4



Total power
Abs. red.
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51.75
69.75
24.6
38.33
33.47
24.32
20.57
15.47
46.69
33.63
60.24
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76.63
82.56
74.10
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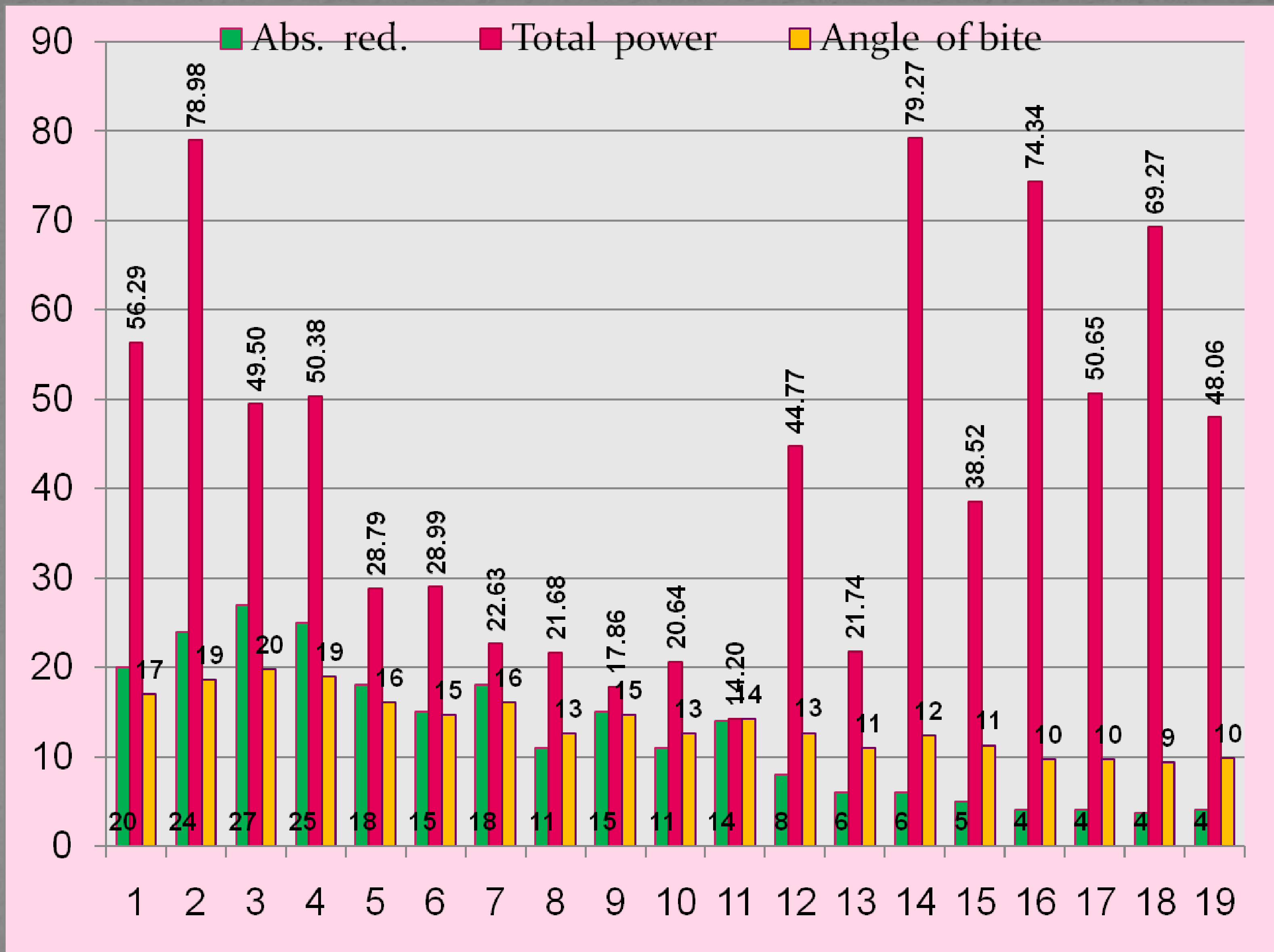

Abs. red.
Total power
Angle of bite
90
80
70
60
50
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10
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50.38
28.79
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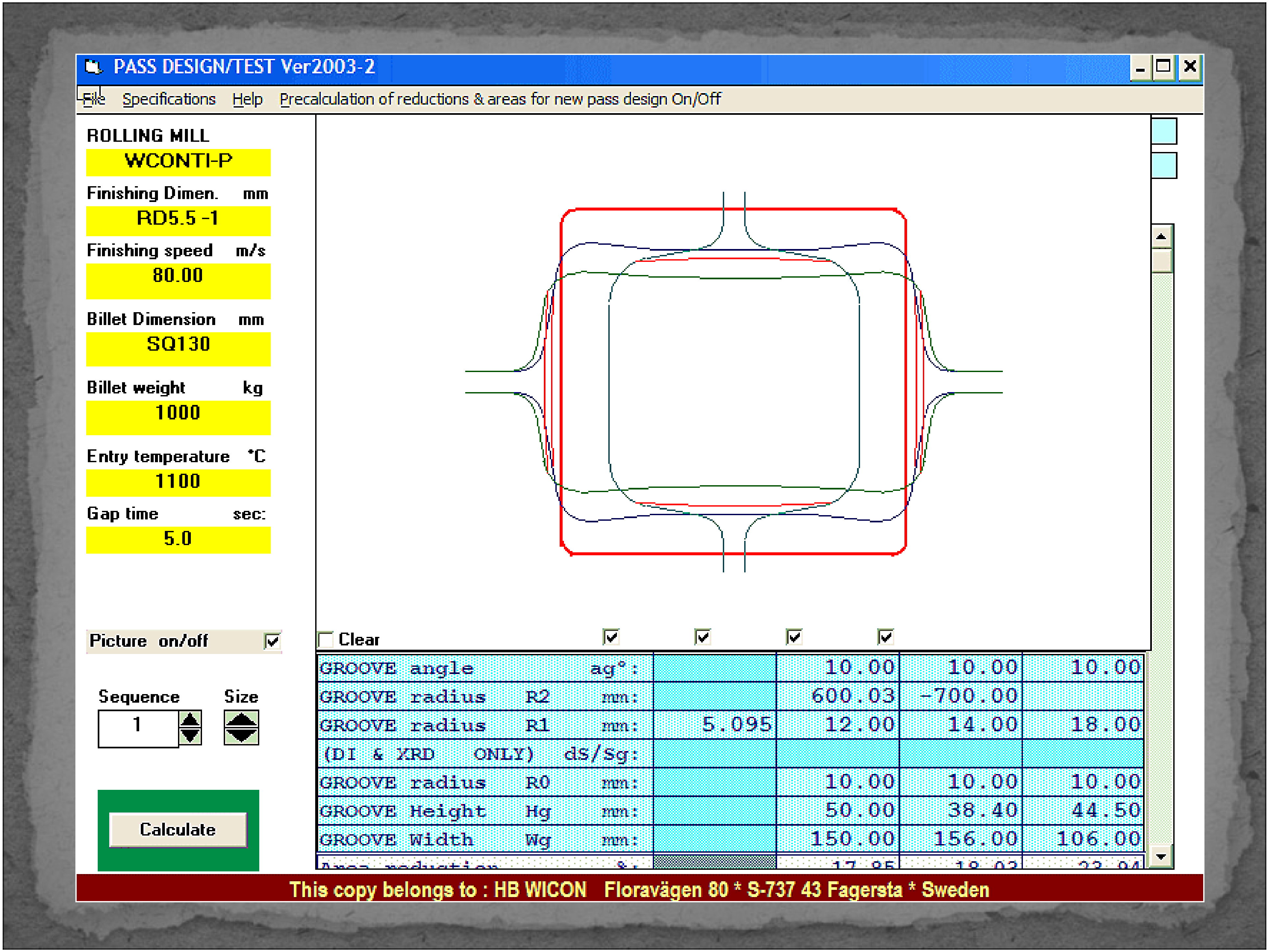
PASS DESIGN/TEST Ver2003-2
File
Specifications
Help
Precalculation of reductions & areas for new pass design On/Off
ROLLING MILL
WCONTI-P
Finishing Dimen. mm
RD5.5 -1
Finishing speed m/s
80.00
Billet Dimension mm
SQ130
Billet weight kg
1000
Entry temperature °C
1100
Gap time sec:
5.0
Picture on/off
Sequence
1
Size
Calculate
Clear
GROOVE angle ag°: 10.00 10.00 10.00
GROOVE radius R2 mm: 600.03 -700.00
GROOVE radius R1 mm: 5.095 12.00 14.00 18.00
(DI & XRD ONLY) dS/Sg:
GROOVE radius R0 mm: 10.00 10.00 10.00
GROOVE Height Hg mm: 50.00 38.40 44.50
GROOVE Width Wg mm: 150.00 156.00 106.00
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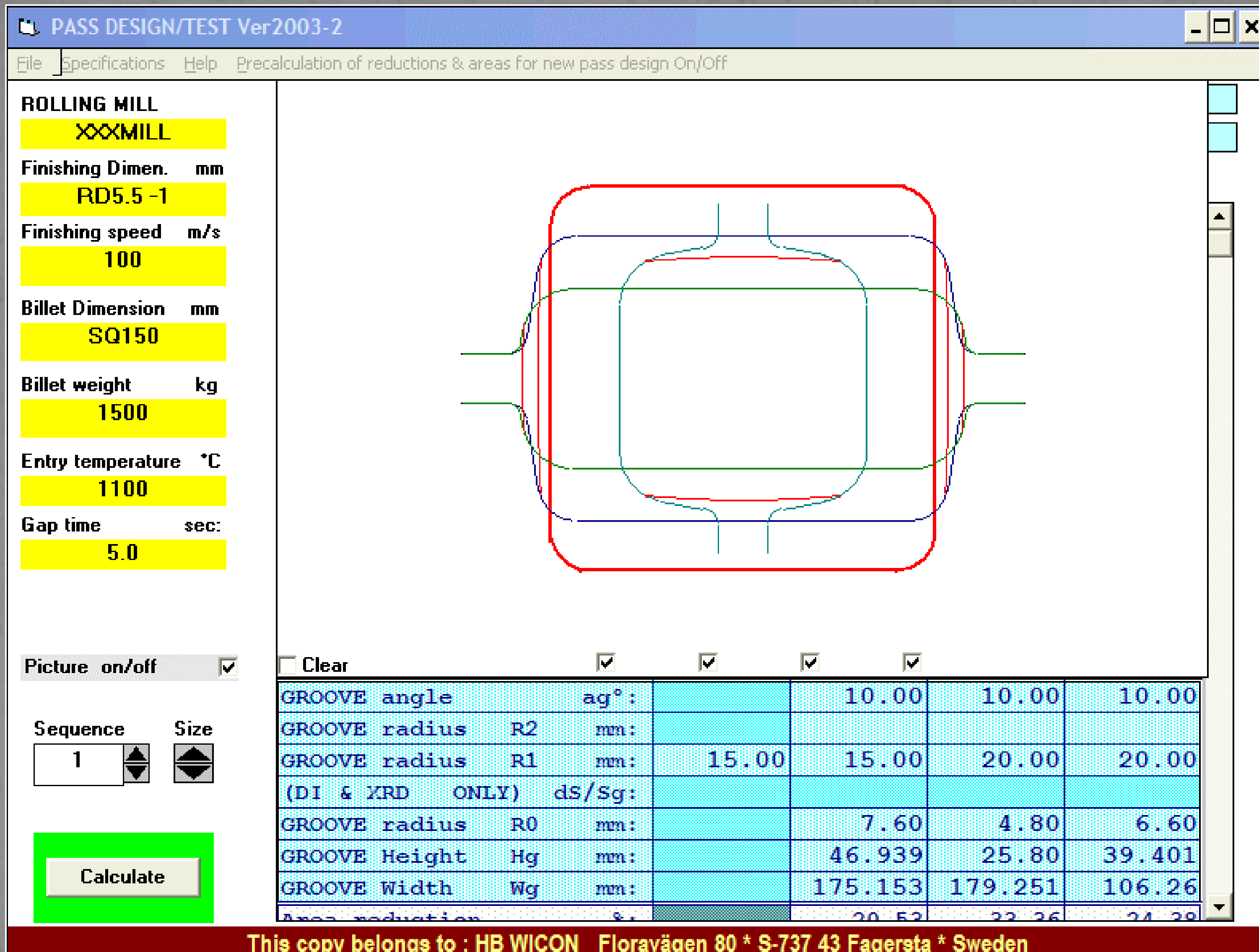
PASS DESIGN/TEST Ver2003-2
File Specifications Help Precalculation of reductions & areas for new pass design On/Off
ROLLING MILL
XXXMILL
Finishing Dimen. mm
RD5.5 -1
Finishing speed m/s
100
Billet Dimension mm
SQ150
Billet weight kg
1500
Entry temperature °C
1100
Gap time sec:
5.0
Picture on/off
Sequence
1
Size
Calculate
Clear
GROOVE angle ag°: 10.00 10.00 10.00
GROOVE radius R2 mm:
GROOVE radius R1 mm: 15.00 15.00 20.00 20.00
(DI & XRD ONLY) dS/Sg:
GROOVE radius R0 mm: 7.60 4.80 6.60
GROOVE Height Hg mm: 46.939 25.80 39.401
GROOVE Width Wg mm: 175.153 179.251 106.26
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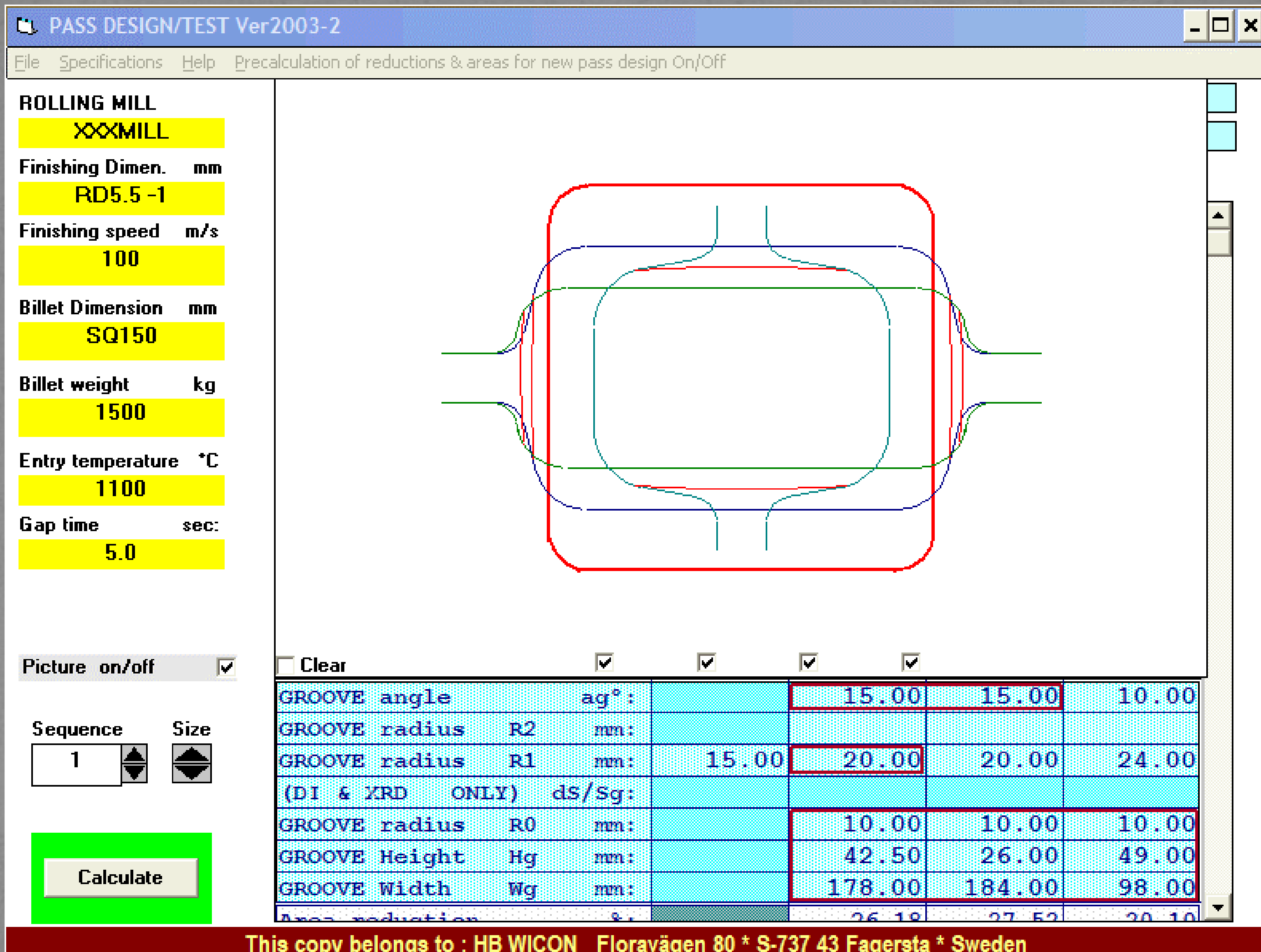
PASS DESIGN/TEST Ver2003-2
File Specifications Help Precalculation of reductions & areas for new pass design On/Off
ROLLING MILL
XXXMILL
Finishing Dimen. mm
RD5.5 -1
Finishing speed m/s
100
Billet Dimension mm
SQ150
Billet weight kg
1500
Entry temperature °C
1100
Gap time sec:
5.0
Picture on/off
Sequence
1
Size
Calculate
Clear
GROOVE angle ag°: 15.00 15.00 10.00
GROOVE radius R2 mm:
GROOVE radius R1 mm: 15.00 20.00 20.00 24.00
(DI & XRD ONLY) dS/Sg:
GROOVE radius R0 mm: 10.00 10.00 10.00
GROOVE Height Hg mm: 42.50 26.00 49.00
GROOVE Width Wg mm: 178.00 184.00 98.00
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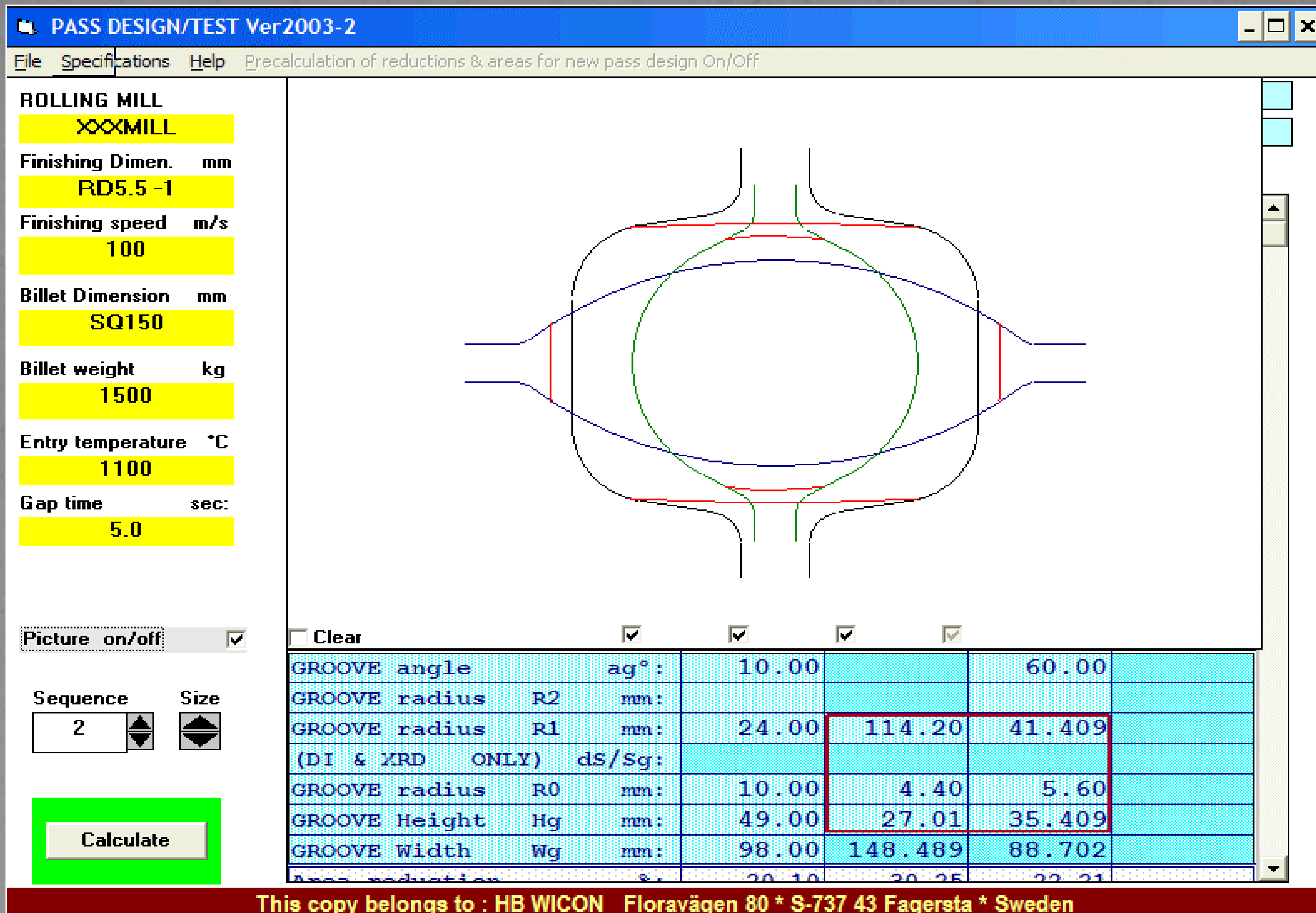

PASS DESIGN/TEST Ver2003-2
File Specifications Help Precalculation of reductions & areas for new pass design On/Off
ROLLING MILL
XXXMILL
Finishing Dimen. mm
RD5.5 -1
Finishing speed m/s
100
Billet Dimension mm
SQ150
Billet weight kg
1500
Entry temperature °C
1100
Gap time sec:
5.0
Picture on/off
Sequence
2
Size
Calculate
Clear
GROOVE angle ag°: 10.00 60.00
GROOVE radius R2 mm:
GROOVE radius R1 mm: 24.00 114.20 41.409
(DI & XRD ONLY) dS/Sg:
GROOVE radius R0 mm: 10.00 4.40 5.60
GROOVE Height Hg mm: 49.00 27.01 35.409
GROOVE Width Wg mm: 98.00 148.489 88.702
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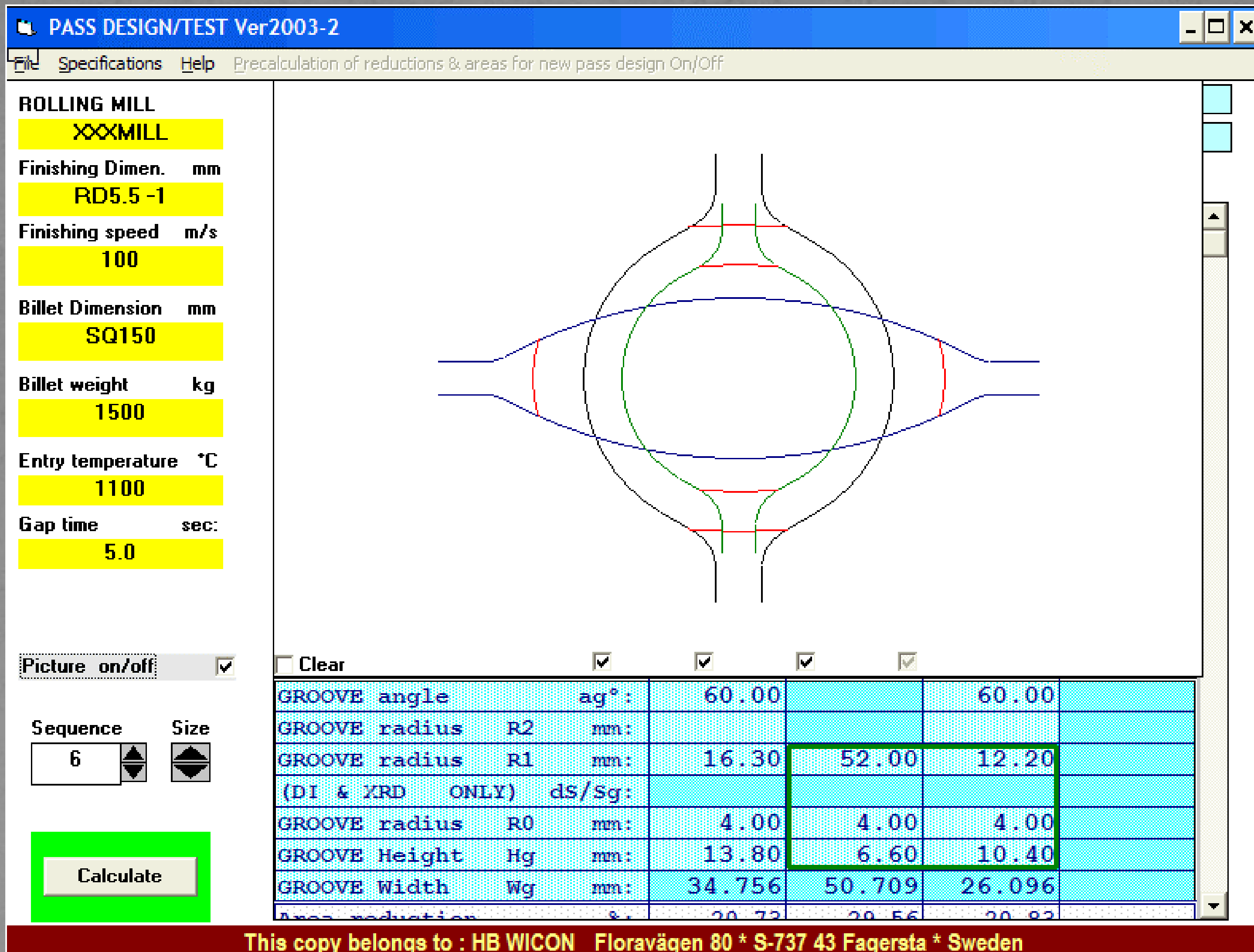
PASS DESIGN/TEST Ver2003-2
File
Specifications
Help
Precalculation of reductions & areas for new pass design On/Off
ROLLING MILL
XXXMILL
Finishing Dimen. mm
RD5.5 -1
Finishing speed m/s
100
Billet Dimension mm
SQ150
Billet weight kg
1500
Entry temperature °C
1100
Gap time sec:
5.0
Picture on/off
Sequence
Size
6
Calculate
Clear
GROOVE angle ag°: 60.00 60.00
GROOVE radius R2 mm:
GROOVE radius R1 mm: 16.30 52.00 12.20
(DI & XRD ONLY) dS/Sg:
GROOVE radius R0 mm: 4.00 4.00 4.00
GROOVE Height Hg mm: 13.80 6.60 10.40
GROOVE Width Wg mm: 34.756 50.709 26.096
This copy belongs to : HB WICON Floravägen 80 * S-737 43 Fagersta * Sweden

WCONTI Rolling schedule: RD5.5-111 Material: 3. Carbon Steel 1.00C (*1.00)

File Help Flow Stress Properties Rearrangements on/off Change data on/off Graphs on/off Picture on/off

PASS / SEQUENCE no	18/9	19/9	20/10	21/10	22/11	23/11	24/12	25/12	26/13	27/13
STAND no	15-1	15-2	15-3	15-4	15-5	15-6	15-7	15-8	15-9	15-10
GROOVE no	OV	RD	OV	RD	OV	RD	OV	RD	OV	FRD
Billet:S0152.8	1	125	3	105	5	85	6	70	7	55
ROLL GAP(empty) mm	1.67	2.13	2.08	1.44	0.99	1.44	0.70	1.09	1.21	1.45
ROLL GAP(active) mm	2.20	2.40	2.40	1.60	1.20	1.50	0.80	1.05	1.20	1.30
PRIOR Gap -"- mm										
Gap DIFF. -"- mm										
Bar HEIGHT Hb HOT	10.20	13.40	8.40	10.60	6.70	8.50	5.30	6.80	4.20	5.55
Bar WIDTH Wb HOT	20.73	12.80	16.29	10.58	13.28	8.63	10.98	6.99	9.09	5.52
Inscr. circle Si HOT										
Elongation	1.253	1.238	1.237	1.238	1.232	1.250	1.230	1.249	1.238	1.242
ROLL DIAMETER mm	216.0	216.0	216.0	216.0	216.0	216.0	216.0	216.0	216.0	216.0
EFFECTIVE dia. mm	223.67	222.39	224.29	223.11	223.87	224.81	224.44	225.15	226.18	225.67
MOTOR revolution rpm	1356	1356	1356	1356	1356	1356	1356	1356	1356	1356
SPEED m/sec	14.5	18.0	22.2	27.5	33.9	42.3	52.1	65.0	80.5	100.0
Loop/Pull MIN m or %	- 0.2%	- 0.2%	- 0.2%	- 0.2%	- 0.2%	- 0.2%	- 0.2%	- 0.2%	- 0.2%	T. Prod.
Loop/Pull CAL. m or %	- 0.9%	- 1.3%	- 1.1%	- 1.6%	- 1.3%	- 1.6%	- 1.5%	- 1.5%	- 2.4%	61.62
Loop/Pull MAX m or %	- 2.0%	- 2.0%	- 2.0%	- 2.0%	- 2.0%	- 2.0%	- 2.0%	- 2.0%	- 2.0%	tons/h
ENTRY temperature °C	1029	1030	1032	1036	1043	1053	1065	1080	1096	1116
LOAD kN	112	72.0	83.3	59.5	71.2	49.7	59.3	40.1	48.9	30.4
TORQUE kNm	2.19	1.57	1.40	1.16	1.12	0.90	0.86	0.67	0.65	0.46
POWER kW	284	254	278	286	339	337	397	387	463	409
Power MAX kW	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	3833
Power MEAN kW	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	3719
Power AVAILABL kW	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	=====>	4000
Angle of Bite °	13.7	15.4	11.7	13.5	11.0	12.3	10.2	11.4	9.3	10.5
Bar Area HOT mm²	168.2	135.9	109.9	88.72	72.03	57.63	46.86	37.53	30.30	24.40
Bar length HOT m	1196	1481	1832	2268	2795	3494	4299	5369	6652	8264
Spread Coefficient :	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20
! OBSERVATIONS !						+T			-L	

ROLLING OBSERVATIONS

- +T Risk of tilting in the next groove due to too large width
- -T Risk of tilting in the next groove due to too small width
- +F The ratio Bar Edge/Groove Bottom Diameter of the next groove is >0.7
- +O Overfilling (Bar width>Groove Width)
- +W Width of finishing dimensions is more than 1.5% TOO LARGE
- -W Width of finishing dimensions is more than 1.5% TOO SMALL
- +D Sb,Db or Hb of finishing dimensions is more than 1.5% Too Large
- -D Sb,Db or Hb of finishing dimensions is more than 1.5% Too Small
- +L Loop Growth by repeater rolling is TOO LARGE . Tension by block rolling is TOO SMALL
- -L Loop Growth by repeater rolling is TOO SMALL . Tension by block rolling is TOO LARGE
- -N Motor revolution is below the base revolution . Full power is not available

Pass no	Initial width B mm	Initial height H mm	Initial Area Fo mm2	Final width b mm	Final height h mm	Final Area F1 mm2	Mean width Bm mm	Abs. red. dh mm	Roll dia. max. Dk mm	Work dia Dwk mm	Roll rpm n rpm	Linear speed V m/s	Angle of bite < deg.	Coeff of draught /u	Rolling temp t o C	Metal comp. Comp.	Coeff of friction F	Coeff of viscosity n/ kgf s/m 2	Relative deform rate U 1/s	Sigma o- kgf s/m 2	Mean sp. rolling pr. p kgf/m m 2	Rolling force P T	Rolling torque Ma kgm	Power for deform. Na kW	Torque for friction Mn kgm	Power for friction Nn kW	Total power N kW	Cum Power N kW
1	100.00	100.00	9940	105	75	7875	103	25	460	377	90	0.42	19	1.12	1125	2.30	0.49	0.03	1.60	7.70	8.98	69.82	5029.41	90.88	1059.82	1.95	92.83	
2	105.00	75.00	7875	109	53	5724	107	22	460	399	90	0.42	18	1.17	1113	2.30	0.49	0.03	2.05	6.60	8.14	61.93	4184.92	77.03	940.07	1.73	78.76	
3	53.00	109.00	5724	92	92	4265	72	17	460	380	90	0.42	16	1.16	1101	2.30	0.50	0.03	1.15	6.88	7.89	35.83	2133.64	48.91	543.95	1.00	49.91	
4	65.00	65.00	4265	95	50	2980	80	15	460	402	90	0.42	15	1.20	1089	2.30	0.51	0.03	1.88	7.15	8.99	42.24	2356.80	50.57	641.15	1.18	51.75	
5	50.00	95.00	2980	65	65	2025	58	30	460	396	90	0.42	21	1.21	1077	2.30	0.51	0.03	1.91	7.43	8.91	42.56	3355.59	68.56	646.03	1.19	69.75	
6	45.00	45.00	2025	66	36	1487	55	9	460	412	90	0.42	11	1.17	1065	2.30	0.52	0.03	2.07	7.71	10.26	25.79	1114.91	23.88	391.57	0.72	24.60	
7	36.00	66.00	1487	46	46	1056	41	20	460	412	90	0.42	17	1.19	1053	2.30	0.52	0.03	2.24	7.98	10.32	28.71	1851.96	37.53	435.88	0.80	38.33	
8	32.50	32.50	1056	48	19	731	40	13	460	424	90	0.42	14	1.20	1041	2.30	0.53	0.04	3.90	8.26	13.16	29.06	1515.63	32.66	441.21	0.81	33.47	
9	19.00	48.00	731	33	33	527	26	15	460	426	90	0.42	15	1.18	1029	2.30	0.54	0.04	2.73	8.53	11.98	18.41	1043.51	23.81	279.54	0.52	24.32	
10	23.00	23.00	527	36	14	396	30	9	460	436	90	0.42	11	1.15	1017	2.30	0.54	0.04	4.53	8.81	15.62	20.97	906.38	19.99	318.33	0.59	20.57	
11	14.00	36.00	396	25	25	306	19	11	460	435	90	0.42	13	1.14	1005	2.30	0.55	0.04	3.09	9.09	13.73	13.53	653.94	15.09	205.42	0.38	15.47	367.61
12	17.50	17.50	306	27	11	266	22	7	330	312	180	1.70	11	0.32	993	2.30	0.55	0.04	23.91	9.36	16.40	11.91	373.78	45.36	129.74	1.33	46.69	
13	10.89	26.50	266	19	19	179	15	8	330	312	180	1.70	12	1.22	981	2.30	0.56	0.04	16.05	9.64	14.44	7.62	256.44	32.78	82.96	0.85	33.63	80.32
14	13.36	13.36	179	19	9	135	16	4	260	247	290	4.40	11	1.15	969	2.30	0.57	0.04	72.09	9.913	17.17	6.62	149.61	58.31	56.76	1.92	60.24	
15	9.00	19.00	135	15	15	106	12	4	260	257	290	4.40	10	1.13	957	2.30	0.57	0.04	47.16	10.189	15.16	4.23	94.46	38.94	36.30	1.23	40.17	100.41
16	10.43	10.43	106	16	7	90	13	3	280	271	380	7.56	9	1.08	945	2.30	0.58	0.05	131.59	10.465	19.98	5.66	115.20	73.81	52.29	2.82	76.63	
17	7.15	16.00	90	10	10	78	9	6	280	278	380	7.56	10	1.08	933	2.30	0.58	0.05	120.34	10.741	18.99	4.72	129.96	80.21	43.61	2.35	82.56	159.19

CHARACTERISTICS OF A GOOD ROLL PASS DESIGN

- To ensure a profile with a smooth surface and correct dimensions within the stipulated limits of standards.
- To ensure the minimum expense in terms of energy, power and roll consumption,
- To give deformation in such a way and at stages to have minimum internal stresses in the finished product.
- To create a simple and convenient work culture at stand, minimizing the manual operation to the minimum possible extent and to introduce the automation of technological process.
- To optimize the number of passes required for rolling to reduce the total rolling time cycle, with minimum time spent for changing and adjusting of rolls.

ROLL PASS DESIGN PROCESS

- Determination of finished product dimensions.
- Calculation of steel contraction factor.
- Calculation of average elongation and number of passes required.
- Determination of appropriate pass shapes.
- Calculations of rolling power required and mechanical equipment loads.
- Determination of pass progression and family tree.
- Drawing of detailed pass shapes.

TYPICAL HEATING SCHEDULE

Group	Type of steel	Temperature,OC
I	Carbon and low-alloy steels (up to 0.45% C)	1200-1220
II	Carbon, low-and medium alloy steels (up to 0.65%C)	1180-1200
III	Carbon and medium alloy steel (up to 0.9%C)	1140-1160
IV	Carbon and alloy steel; tool and bearing steel (up to 1%C)	1120-1140
V	Carbon and medium alloy steel; tool and high manganese steels (up to 1.3%C)	1100-1120
VI	Nichrome and stainless steels	1200-1220
VII	High-speed steels	1180-1200

THANKYOU

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