**Trip Report for Trip to
Steel Warehouse Inc. Southbend Indiana
May 4, 1995**

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On May 4, 1995 I visited a steel plate and coil ,cold reduction facility at Steel Warehouse Inc. located in South Bend, Indiana about 150 miles from Argonne. Some very interesting facts were learned about cold reduction of hot rolled steel during this visit. The company selected is only a cold reduction mill and buys steel from a number of steel producers. I spent a total of about three hours with these people, and this included a tour of their pickling line, the small cold reduction mill which at present is limited to 15.5 in width maximum, and their large cold reduction mill which produces sheet and coil up to 72 in. wide.

Some of the things ,that were learned, that will have an impact on the production of the Atlas steel plates are listed below. It is my impression that this facility is fairly typical of what one might expect from any similar facility.

1. Hot rolled coils have some inherent, interesting, characteristics that must be taken into consideration when being cold reduced.

- Due to the fact that HR coils cool from the outside to the inside, the ends and the edges of the coil have different hardness characteristics. This will have an affect on the cold reduction process.
- The crown that exists in the original HR coil will remain in the narrower coils that are slit from it. This means that any taper that exists in the original HR coil as a result of crown will be reproduced in the cold reduced coil although not as large in amplitude. Coils cut from the center of the HR coil will generally reduce with smaller transverse thickness variations
- Any cyclical thickness variations that exist in the HR coil along its length will again be reproduced in the reduced coil but have smaller amplitudes.
- The plates are cold reduced in a dry condition since oil on the plates if it has some thickness causes the plate to float between the rollers and as a result the thickness will vary accordingly.

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2. The monitoring of the coil thickness is only done along the center line of the coil, this has a serious impact on QC of plates cut from this coil for a number of reasons.

- The accuracy of the gamma ray source monitoring gauge although proported to be $\pm .010$ mm is more like $\pm .025$ mm in practice. This suggests that asking for a tolerance of less than .025 is probably not achievable.
- The cold reduced coil edges may have different thickness dimensions than the center, There is no effective way of monitoring the edge thickness on the reduced coil except by manual measurement. This is impossible to do on the fly since the material is moving at a rate of approximately 400-500 ft/min. Cut sheets can only be produced after the coil is rolled and therefore measurement would delay the production process. To monitor during rolling it would be necessary to mount two additional measuring heads on the machine for monitoring the edges.
- If a systematic taper exists across the width of the sheet ,it will have a major impact on stacking unless measures are taken to neutralize it by turning every other sheet as it is sheared from the end of the coil after rolling. This is not a normal operation for the production line.

3. Hot rolled coils of steel in this particular instance may come from a number of different sources, The company buys steel and stocks it in hot rolled coil form. This could cause problems if magnetic permeability is a serious issue.

- The specification should stipulate that all steel come from a single source or that the permeability fall into a certain range.
- The coil characteristics may vary if the steel comes from different hot roll mills and some of the problems described above will become more important.
- All plate should be pickled before cold rolling to remove scale and oil.

I have copies of the profile plots (see attached) that are generated by the measuring system and the analysis that is computer generated from those plots. The statistical analysis confirms my original suspicions that monitoring only the centerline does not give a true representation of the average thickness of the plate overall. This is confirmed by the fact that I have a sample of the plate which shows a variation of only about $\pm .0007$ in (.01778mm) but has a taper of about .0015in (.03810mm).

The attachments are meant to be typical and do not necessarily represent the same coil of steel.

Attachments

Attachment A1 and A2	Typical coil report from data analysis
Attachment B	Typical input and output profile plot along the center of the sheet
Attachment C	Typical input and output plot of statistical analysis of coil

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DATA MEASUREMENT COIL REPORT
FOR
STEEL WAREHOUSE

United Temper Mill

TIME 12:04
DATE May 4, 1995

COIL NO. 217038
OPERATOR NO. 195187

9-10

COIL STATISTICS - PART A

RUN TIME 00:04:11
GRADE NO. GRDO
NOMINAL THICKNESS 121.00
MAXIMUM TOLERANCE 123.00
MINIMUM TOLERANCE 119.00

AVERAGE THICKNESS 121.01 MILS
AVERAGE SPEED 443.2 ft/min
LENGTH OVER TOL. 8.5 feet
LENGTH UNDER TOL. 1.7 feet

THICKNESS VARIATION HISTOGRAM

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	LENGTH (feet)	
-	111.00	+	:	:	:	:	:	:	:	:	:	:	:	:	:	:	+	0.0
-	112.00	+															+	0.0
-	113.00	+															+	0.0
-	114.00	+															+	0.0
-	115.00	+															+	0.0
-	116.00	+															+	0.0
-	117.00	+															+	0.0
-	118.00	+															+	1.7
-	119.00	+															+	12.1
-	120.00	+	*	*	*	*	*	*	*	*	*	*	*	*	*		+	875.9
TARGET	121.00	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	+	954.0
	122.00	+															+	2.0
	123.00	+															+	8.5
	124.00	+															+	0.0
	125.00	+															+	0.0
	126.00	+															+	0.0
	127.00	+															+	0.0
	128.00	+															+	0.0
	129.00	+															+	0.0
	130.00	+															+	0.0
	131.00	+															+	0.0
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

EACH (*) = 3.45 % OF COIL LENGTH

COIL SEGMENT OUT OF TOLERANCE

THICKNESS	START	STOP
118.5 -	2.9	5.2
123.8 +	430.7	439.7

COIL STATISTICS - PART B

STANDARD DEVIATION	0.419	MAXIMUM THICKNESS	123.84
CP	3.185	MINIMUM THICKNESS	118.46
CPK	1.584		

Attachment A-2

Attachment B

POINT THICKNESS DEVIATION IN INCHES FROM 0.01 INCHES TO 0.05 INCHES

STEEL WAREHOUSE
MINI 4HIGH MILL

DATE 05/04/95 TIME 12:41:06
Customer =
Plant No. =
Job No. =

Job Order =
Size =

Bundle No. =
Operator =

ENTRY DATA

SET GAGE = .12800 STANDARD DEVIATION = .00105
TOTAL FEET = 1812 MEAN = .12541

MILL DIRECTION RIGHT

% +OR- DEVIATION (.001) LENGTH FEET

HISTOGRAM

100.0 %	+1.000	1
5.8 %	+0.960	0
5.4 %	+0.920	0
5.1 %	+0.880	1
4.7 %	+0.840	0
4.4 %	+0.800	0
4.2 %	+0.760	1
3.7 %	+0.720	4
3.1 %	+0.680	4
2.7 %	+0.640	0
2.4 %	+0.600	0
2.3 %	+0.560	2
2.0 %	+0.520	0
1.8 %	+0.480	0
1.5 %	+0.440	1
1.5 %	+0.400	2
1.4 %	+0.360	0
1.1 %	+0.320	0
0.9 %	+0.280	1
0.7 %	+0.240	1
0.6 %	+0.200	2
0.3 %	+0.160	1
0.3 %	+0.120	2
0.2 %	+0.080	0
0.0 %	+0.040	2
0.0 %	0.000	0
	-0.040	0
	-0.080	1
	-0.120	0
	-0.160	0
	-0.200	2
	-0.240	1
	-0.280	3
	-0.320	4
	-0.360	3
	-0.400	2
	-0.440	0
	-0.480	5
	-0.520	4
	-0.560	2
	-0.600	3
	-0.640	5
	-0.680	3
	-0.720	7
	-0.760	9
	-0.800	2
	-0.840	7
	-0.880	6
	-0.920	5
	-0.960	8
	<-1.000	1705

EXIT DATA

SET GAGE = .12100 STANDARD DEVIATION = .000256
TOTAL FEET = 1880 MEAN = .12102
UPPER SPEC LIMIT = .12300 Cp = 02.60
LOWER SPEC LIMIT = .11900 Cr = 00.38
Cpk = 02.57

% +OR- DEVIATION (.001) LENGTH FEET

HISTOGRAM

100.0 %	+2.50	0
100.0 %	+2.40	0
100.0 %	+2.30	0
100.0 %	+2.20	0
100.0 %	+2.10	0
100.0 %	+2.00	0
100.0 %	+1.90	0
100.0 %	+1.80	0
99.9 %	+1.70	0
99.9 %	+1.60	0
99.9 %	+1.50	0
99.8 %	+1.40	0
99.8 %	+1.30	0
99.8 %	+1.20	0
99.8 %	+1.10	0
99.8 %	+1.00	0
99.8 %	+0.90	0
99.8 %	+0.80	0
99.7 %	+0.70	5
99.4 %	+0.60	29
98.7 %	+0.50	81
90.1 %	+0.40	126
78.1 %	+0.30	227
57.7 %	+0.20	249
31.5 %	+0.10	272
4.1 %	0.00	77
	-0.10	243
	-0.20	244
	-0.30	156
	-0.40	99
	-0.50	44
	-0.60	21
	-0.70	2
	-0.80	1
	-0.90	0
	-1.00	0
	-1.10	0
	-1.20	0
	-1.30	1
	-1.40	0
	-1.50	0
	-1.60	1
	-1.70	0
	-1.80	1
	-1.90	1
	-2.00	0
	-2.10	0
	-2.20	0
	-2.30	0
	-2.40	0
	-2.50	0

-----UPPER SPEC LIMIT-----

-----LOWER SPEC LIMIT-----

RUN TIME 00:00:40 AVERAGE SPEED = 216.9 FPM MAX. SPEED = 407 FPM
MIN. GAGE = .11917 AT 2 FEET MAX. GAGE = .12169 AT 1192 FEET

TOTAL NUMBER OF OUT OF TOLERANCE LOCATIONS = NO OUT OF TOLERANCE LOCATIONS IN LENGTH OF COIL.

Attachment C