Identifying and Implementing Low Cost Rolling Mill Upgrades

Using

Rolling Mill Computer Simulations

and

Pass Design Optimization

A Paper Presented to

IRD Conference, Rancho Cucamonga

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Gerdau Rancho Cucamonga

- The mill was built in the 1950's and ran rebar, smooth rounds, and wire rod.
- In the mid 80's the mill was upgraded with new drives, roller bearings, and new u-joint spindles. The mill was switched to one product line, rebar.
- The mill runs 130mm square billets and can produce approximately 500,000 tons/year, while melt shop capacity is 700,000 tons/year.
- Product range: rebar sizes #4 (3-strand) to #18.

Gerdau Rancho Cucamonga

- 70% of the production is seismic grade rebar.
- 10 years ago, a plan was to upgrade the rolling mill with a new Danieli Mill and Reheat Furnace. The furnace was purchased, but never installed.
- Gerdau bought TAMCO in 2010.

Schweitzer Engineering Specialty

- Rolling Pass Design, Commissioning and Training
- Rolling Process Engineering, Mill Performance Analysis Mill Upgrades and Expansion Feasibility Studies
- Development of Specialized Software for rolling mills
- Supply of Rolls, Guides, Drive Train components, Spare Parts, Stands and Shears
- Training
- A network of Engineers and Designers, specializing in rolling of ferrous and non ferrous long products

Clients

Schweitzer
Engineering and Rolling Technology

SDI Steel Dynamics™

GERDAU

CMC Commercial Metals

NUCOR

ArcelorMittal

USS

NAS North American Stainless

stelco

Mid America Steel Inc.

MANA Max Aicher North America

Special Metals A PCC Company

The Alloy Experts

What is a "Rolling Mill Simulator"?

- A computer software simulating long product mills.
- Input: Mill information and Pass Design
- Output:
  - Powers and speeds in all stands, verifies mill capability to roll each product
  - Bottlenecks for each product
  - Throughputs for each product and mill annual throughput
  - Numerical and graphical representation of the results
  - The effects of mill upgrades on rolling loads, speeds, and mill throughputs

Schweitzer Rolling Mill Simulator

Simulator Mill Parameters Input

Number of Stands:		16							
Mill Title:		Gerdau Rancho							
Roll Diameter:		Max							
		Roll Max	Roll Min	Gear	Base	Rated	Rated	Stand	Power
#	Pass ID	Dia	Dia	Ratio	RPM	RPM	Power	Dist.	Overload
		mm	mm		rpm	rpm	kW	m	
1	N2-H	578	491	28.61	200	400	268	2.50	1
2	N3-H	502	426	35.23	300	600	268	2.50	1
3	N4-H	502	426	25.38	300	600	268	2.50	1
4	N5-H	502	426	22.35	400	875	400	2.50	1
5	N6-H	502	426	16.10	400	875	400	2.50	1
6	N7-H	400	340	19.05	850	1350	600	2.50	1
7	N8-H	400	340	13.38	850	1350	600	2.50	1
8	N9-H	400	340	10.66	850	1350	600	2.50	1
9	N10-H	400	340	7.95	850	1350	600	2.50	1
10	N11-H	349	297	6.48	800	1350	400	2.50	1
11	N12-H	349	297	5.04	800	1350	400	2.50	1
12	N14-H	349	297	4.17	850	1550	600	2.50	1
13	N15-H	343	305	3.36	950	1600	400	2.50	1
14	N16-H	343	305	2.52	800	1600	660	2.50	1
15	N17-H	343	305	2.19	800	1600	470	2.50	1
16	N18-H	343	305	1.91	800	1600	800	2.50	1
	FEND							4.00	

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Product (Pass Design) Information

Product ID:		1	Product Name:		4 Bar 3-slit						
Power Curve	Max Finish Speed [m/s]	Max Mill TPH [tph]	Billet Description	Billet Area [mm^2]	Billet AreaIn [mm^2]	Billet Length [m]	Billet Width [mm]	Billet Density [kg/m^3]	Billet Temp. [C]	Furnace Capacity [tph]	Min. Billet Gap [s]
2	15	150	135x135	18570	18570	6	127	7833	1100	116	0
Stand	Pass ID	Area	Width	Gap	Contin. Section						
	FEED	18570	135.00								
1	N2-H	15078	150	26.65	1						
2	N3-H	11475	156	15.7	1						
3	N4-H	8734	102	16	1						
4	N5-H	6123	122	11	1						
5	N6-H	4406	75	9	1						
6	N7-H	3458	94	8	1						
7	N8-H	2470	56	7	1						
8	N9-H	1906	73.5	7	1						
9	N10-H	1462	43	6.5	1						
10	N11-H	1174	56	5.5	1						
11	N12-H	889	33	5.02	1						
12	N14-H	818	45	18.9	1						
13	N15-H	652	49	3	1						
14	N16-H	558	50.8	0.7	1						
15	N17-H	504	66	3.2	1						
16	N18-H	369	38.1	2.15	1						

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Simulation Results – Summary

STAND ID	MAX ROLL SPEED [RPM]	MIN ROLL SPEED [RPM]	MAX PCT MAX MOTOR RPM [%]	MAX MOTOR POWER [KW]	MAX MOTOR LOAD [%]	MAX SPINDLE TORQUE [N-M]
N2-H	11.4	9.2	81.7	143.8	53.7	60111.2
N3-H	17	13.7	100	189.9	70.9	53309.4
N4-H	23	18.5	97.2	226.8	84.6	47255.9
N5-H	30.5	24.6	78	302.5	75.6	47316.7
N6-H	43.7	35	80.4	299.1	74.8	32892.8
N7-H	68.5	51.9	96.7	268.2	44.7	20399.4
N8-H	95.4	71.7	94.5	446.5	74.4	22354.9
N9-H	110.1	82.6	86.9	309.4	51.6	15692.2
N10-H	154.7	111.1	91.1	476.5	79.4	14706.9
N11-H	206.1	143.1	98.9	324.5	81.1	7588.2
N12-H	268	174	100	400	100	9536.6
N14-H	321.2	213.7	86.4	600	100	10835.7
N15-H	403.4	272.3	84.7	381	95.2	5206.5
N16-H	410.1	286.9	64.6	345.3	52.3	4020
N17-H	480.8	234.8	65.7	344.9	73.4	4404.2
N18-H	637.3	346	76.1	715.1	89.4	8151.7

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Simulation Results- Product by Product

PRODUCT ID:	1		LINE THROUGHPUT:	111.9	TON/HR
PRODUCT NAME:	4 Bar 3-slit		MAX. MILL THROUGHPUT:	150	TON/HR
BILLET:	135x135		FURNACE CAPACITY:	116	TON/HR
BILLET LENGTH:	6	M	MIN. BILLET GAP:		S
BILLET AREA:	18570	MM	BILLET CYCLE:	28.1	S
BILLET AREA IN:	18570	MM	POWER CURVE #:	2	
BILLET TEMPERATURE:	1100	C	MAX. FINISHING SPEED:	15	M/S

STAND ID	PASS ID	AREA [MM^2]	REDN [%]	BAR LENGTH [M]	BAR SPEED [MPS]	WORK DIA [MM]	ROLL SPEED [RPM]	MOTOR SPEED [RPM]	MOTOR SPEED [%]	PASS POWER [KW]	MOTOR POWER [KW]	MOTOR LOAD [%]	PROD RATE [TPH]	SPINDLE TORQUE [N-M]	ROLL FORCE [kN]
	BILLET	18570		6	0.214										
N2-H	N2-H	15078	18.8	7.39	0.263	504	10	285	71.3	125.5	125.5	46.8	111.9	60111	1120
N3-H	N3-H	11475	23.89	9.709	0.346	444	15	524	87.3	165.7	165.7	61.8	111.9	53198	1376
N4-H	N4-H	8734	23.89	12.757	0.454	432	20	510	84.9	197.9	197.9	73.9	111.9	47075	1844
N5-H	N5-H	6123	29.9	18.198	0.648	462	27	598	68.3	264	264	66	111.9	47113	1041
N6-H	N6-H	4406	28.03	25.286	0.9	452	38	613	70	261.1	261.1	65.3	111.9	32764	1489
N7-H	N7-H	3458	21.52	32.221	1.147	371	59	1124	83.3	213.4	213.4	35.6	111.9	17265	541
N8-H	N8-H	2470	28.57	45.109	1.606	363	85	1131	83.8	333.1	333.1	55.5	111.9	18820	396
N9-H	N9-H	1906	22.83	58.458	2.081	381	104	1112	82.4	286	286	47.7	111.9	13091	346
N10-H	N10-H	1462	23.29	76.211	2.713	373	139	1105	81.9	317.4	317.4	52.9	111.9	10896	562
N11-H	N11-H	1174	19.7	94.906	3.379	334	193	1253	92.8	301.1	301.1	75.3	111.9	7436	319
N12-H	N12-H	889	24.28	125.332	4.462	327	260	1311	97.1	400	400	100	111.9	7336	469
N14-H	N14-H	818	7.99	136.21	4.849	350	265	1104	71.2	134.2	134.2	22.4	111.9	2421	124
N15-H	N15-H	652	20.29	170.89	6.084	333	349	1174	73.4	381	381	95.2	111.9	5206	366
N16-H	N16-H	558	14.42	199.677	7.109	333	408	1029	64.3	277.1	277.1	42	111.9	3242	330
N17-H	N17-H	504	9.68	221.071	7.871	338	444	971	60.7	187.9	187.9	40	111.9	2020	170
N18-H	N18-H	369	26.79	301.951	10.75	335	612	1169	73.1	649	649	81.1	111.9	5062	546
FEND															

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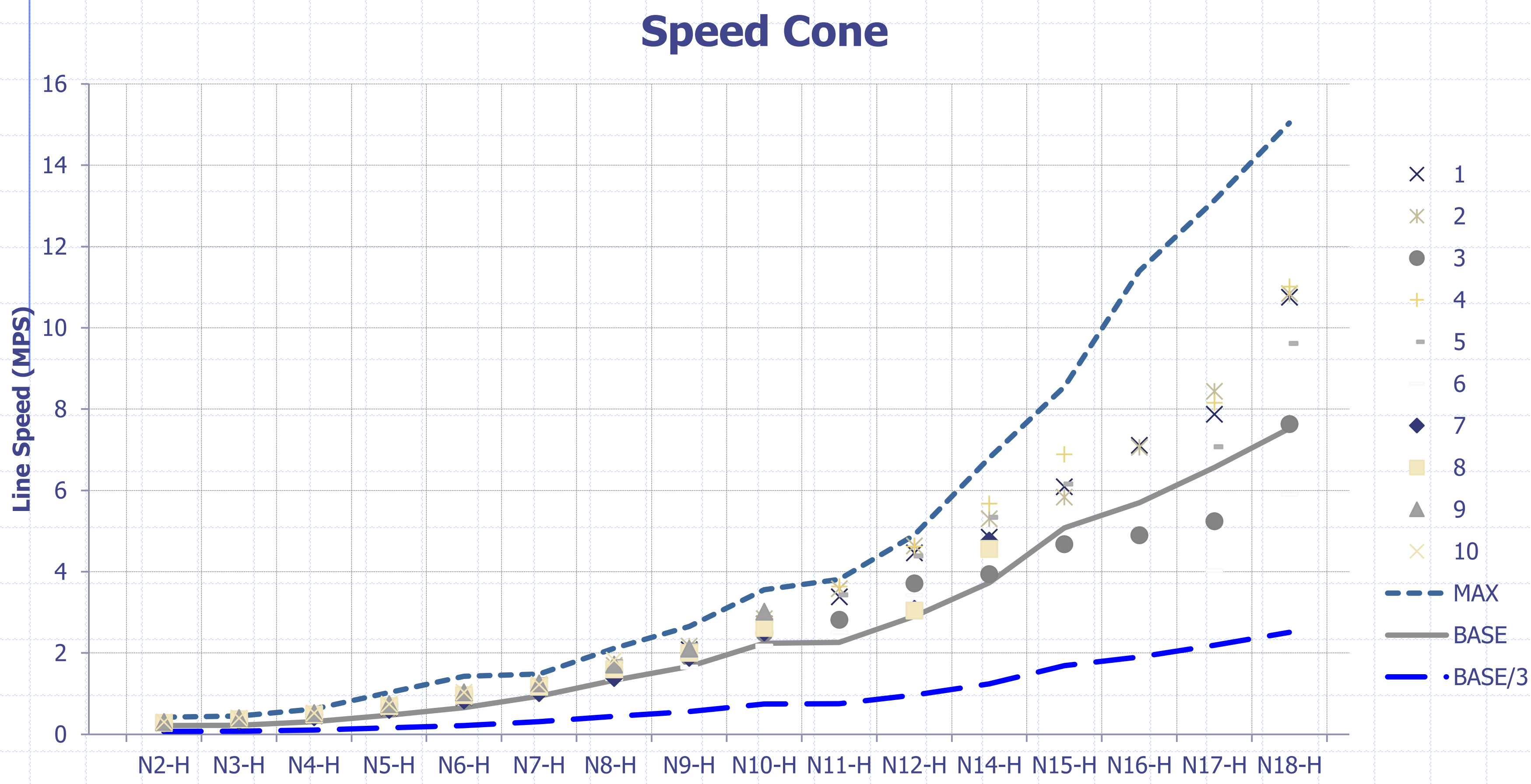
Simulation Results- Speed Cone



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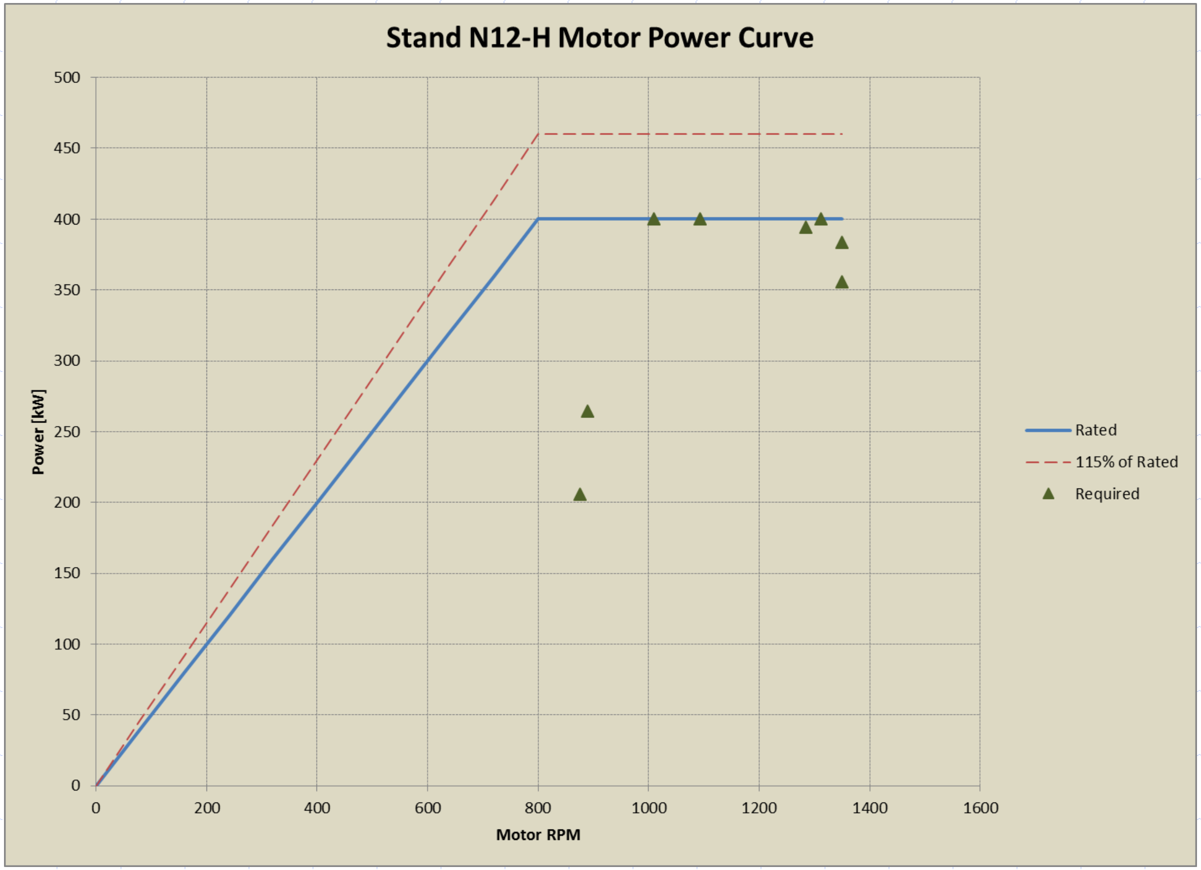
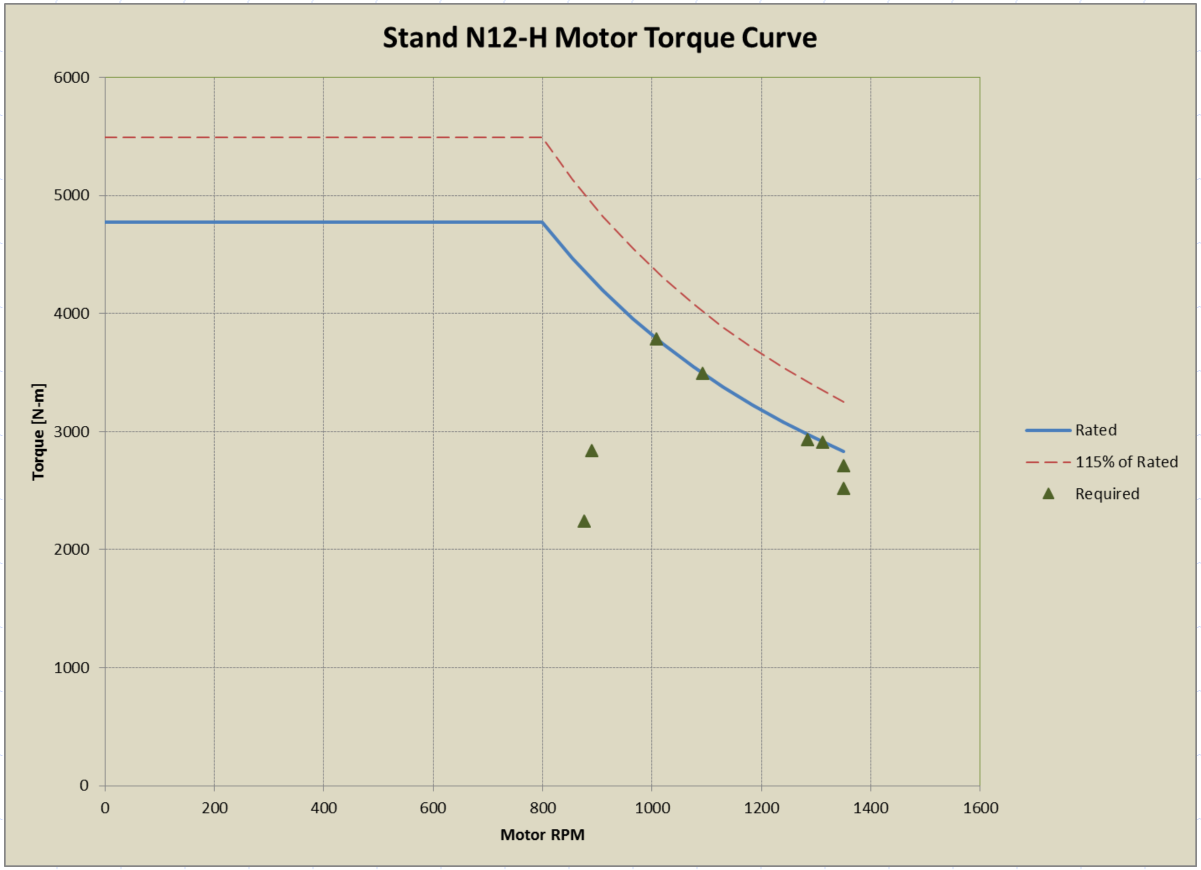
Simulation Results- Motor Power Curves



Simulation Results- Motor Torque Curves



Why “Rolling Mill Computer Simulations?

- Calculation of required powers, ideal gear ratios, and mill throughput is quite cumbersome:
  - Each mill rolls many different products, with different cross sections, throughputs and power requirements
  - Each mill uses many stands, motor sizes, gear ratios, range of roll sizes, different pass designs
- Allows fast and accurate calculations,
- Used by mill builders for optimization of mill equipment sizing.
- Used for mill upgrades and studying “what if” scenarios

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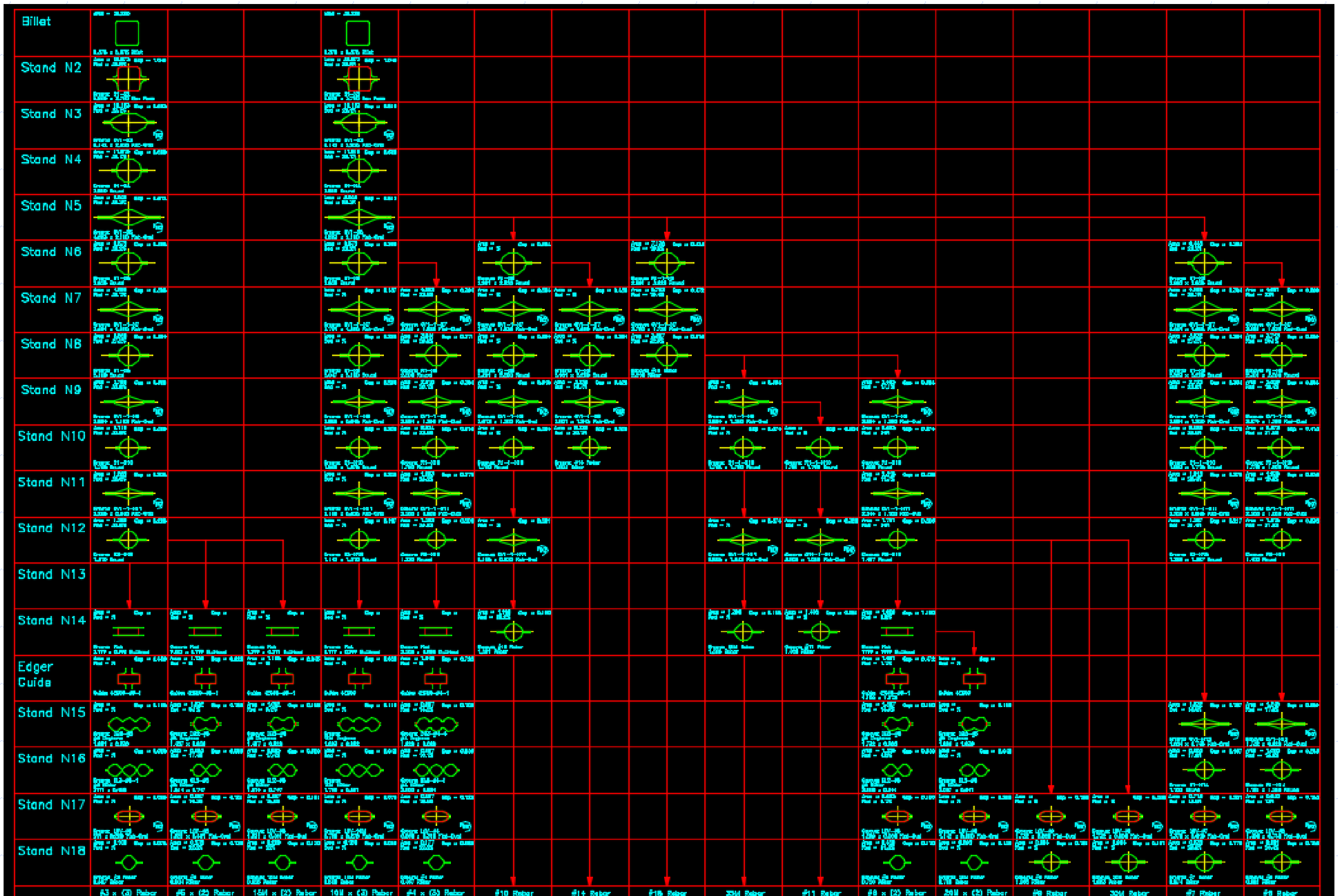
Rancho Cucamonga Mill and Project

- Mill throughput needs to be increased.
- Mill originally installed with 18 horizontal stands, stands 1 and 13 were removed later.
- The feedstock size, product range, mill operation and pass design were changed over the years.
- Mill experiences motor speed limitations in roughing stands once rolls are turned down below the half useful diameters. Mill discards roughing rolls in their half lives to avoid throughput bottleneck.
- Overload in Stand 10 and motor tripping off.

Project Scope

- Conduct a rolling mill train and pass design analysis using Schweitzer Computer Simulation Software
- Identify process bottlenecks for all products
- Identify low cost mill upgrades to increase throughput and make use of full life of rolls
- Increase productivity by pass design optimization

Project Results- Pass Design Flow Chart



Results- Problem Identification

- Improper drive train for current billet size, pass design, and production rate.
- First three roughing stands limit throughput for most of the products due to improper gear ratios
- Discarding rolls in roughing stands at 94% of the new roll diameter versus at 80~85%, i.e. using half the useful life of rolls.
- Reported overloads in stand 10 by mill, not supported by simulator results.

Results – Max Motor Loads and Speeds

STAND ID	MAX ROLL SPEED [RPM]	MIN ROLL SPEED [RPM]	MAX PCT MAX MOTOR RPM [%]	MAX MOTOR POWER [KW]	MAX MOTOR LOAD [%]	MAX SPINDLE TORQUE [N-M]
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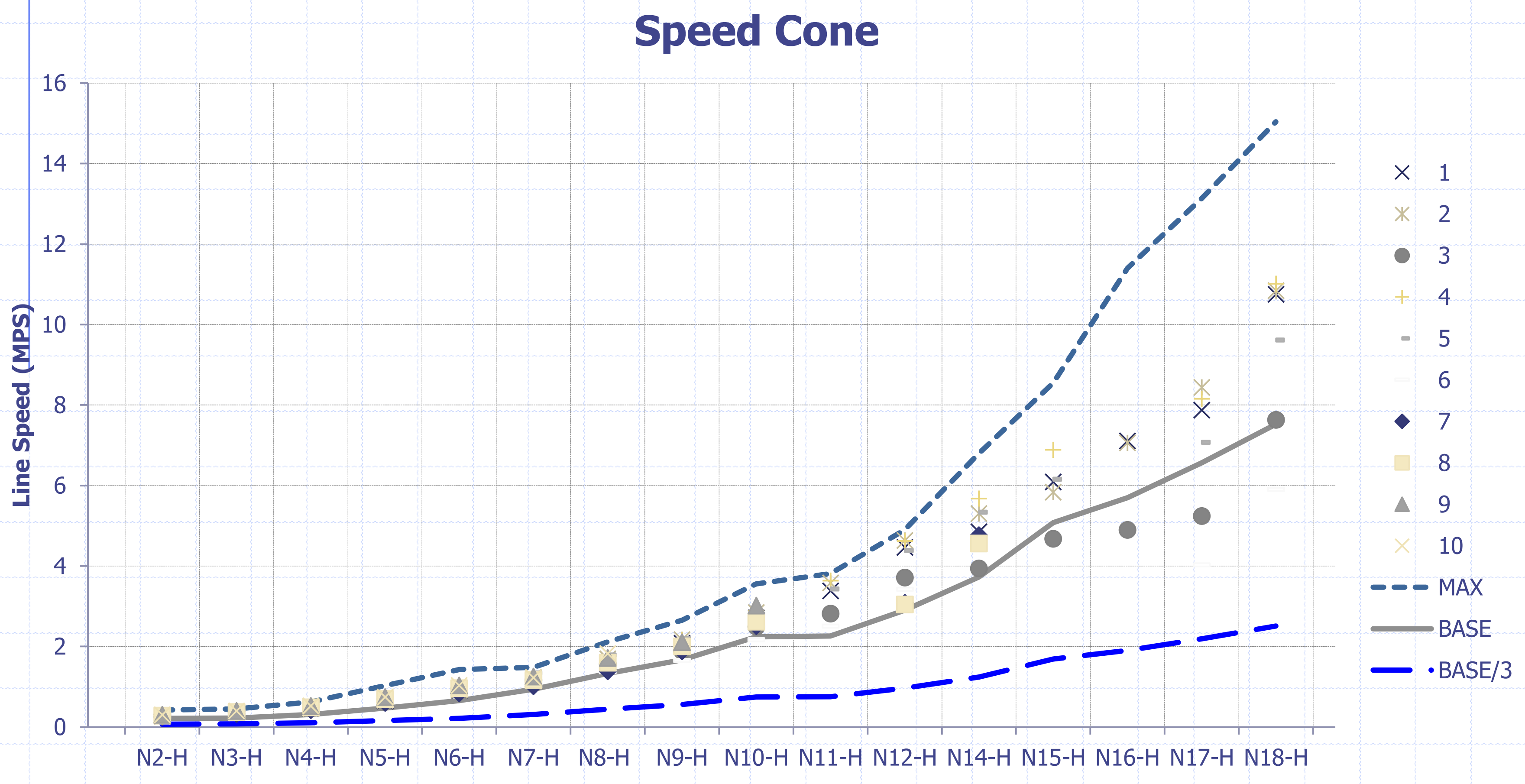
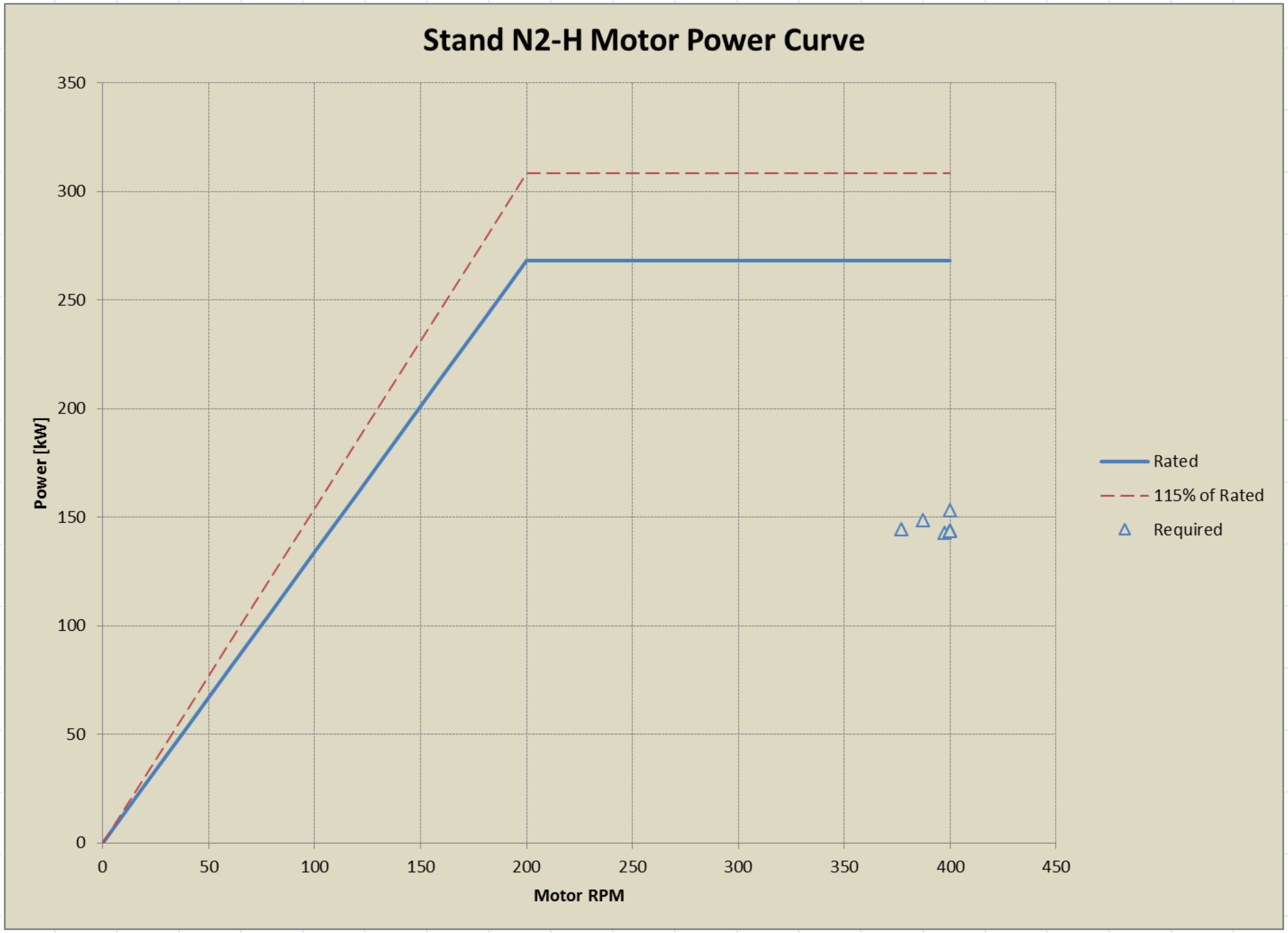
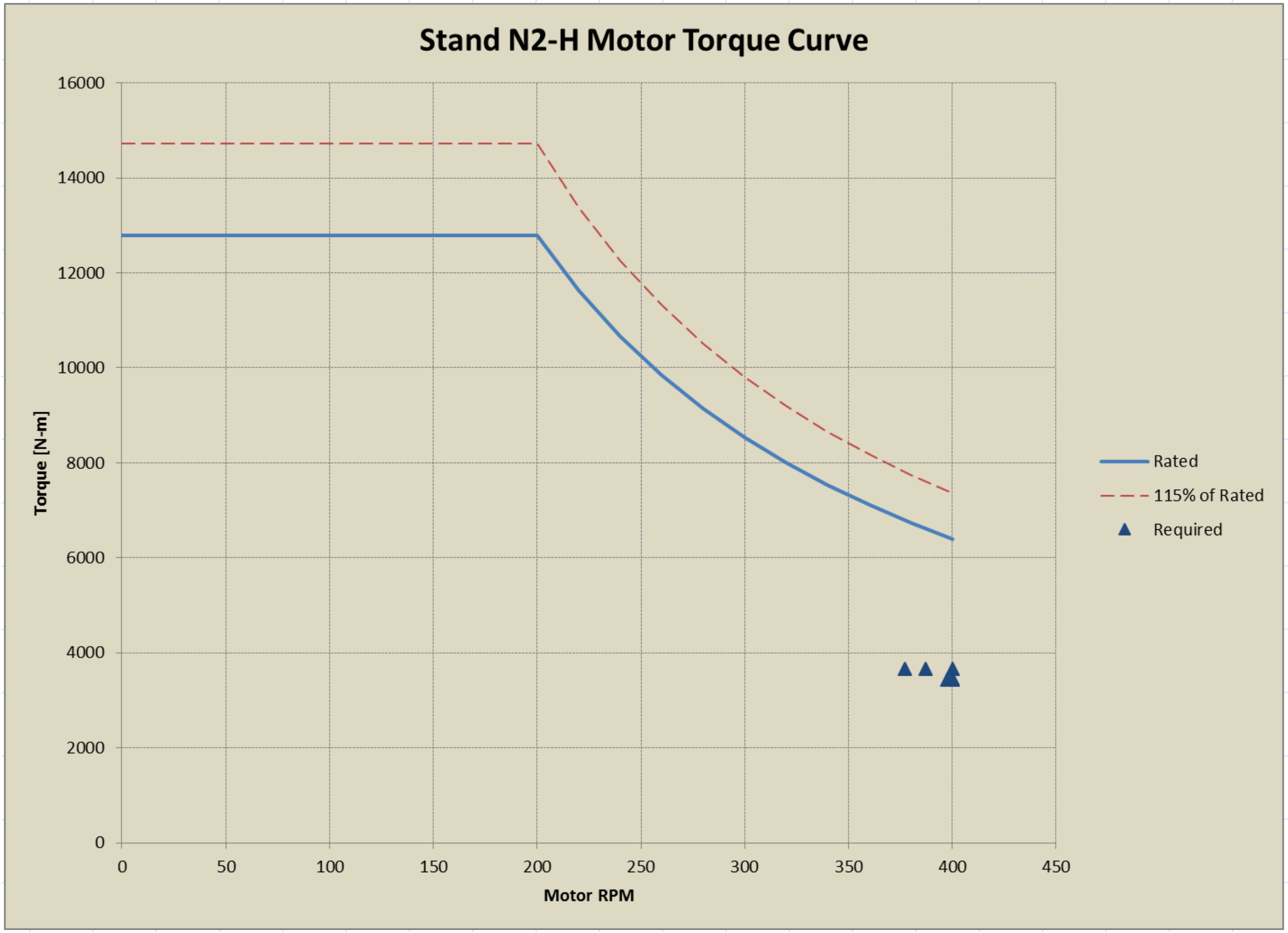


Results- Sample Motor Power Curve



Results- Sample Motor Torque Curve



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Remedy and Results- Bottleneck Removal

- Reduced Gear Ratio in Stand 2 and in Common gearbox of Stands 3 and 4 by 25%; Two gear sets in total
- Removed roughing stands bottleneck for all products, even with the minimum useful roll diameter
- Possible redistribution of pass reductions in some passes to match mill configuration
- Increased expected mill throughput for rebar #6 and larger by 6% to 21%, rolling on minimum roll diameter.

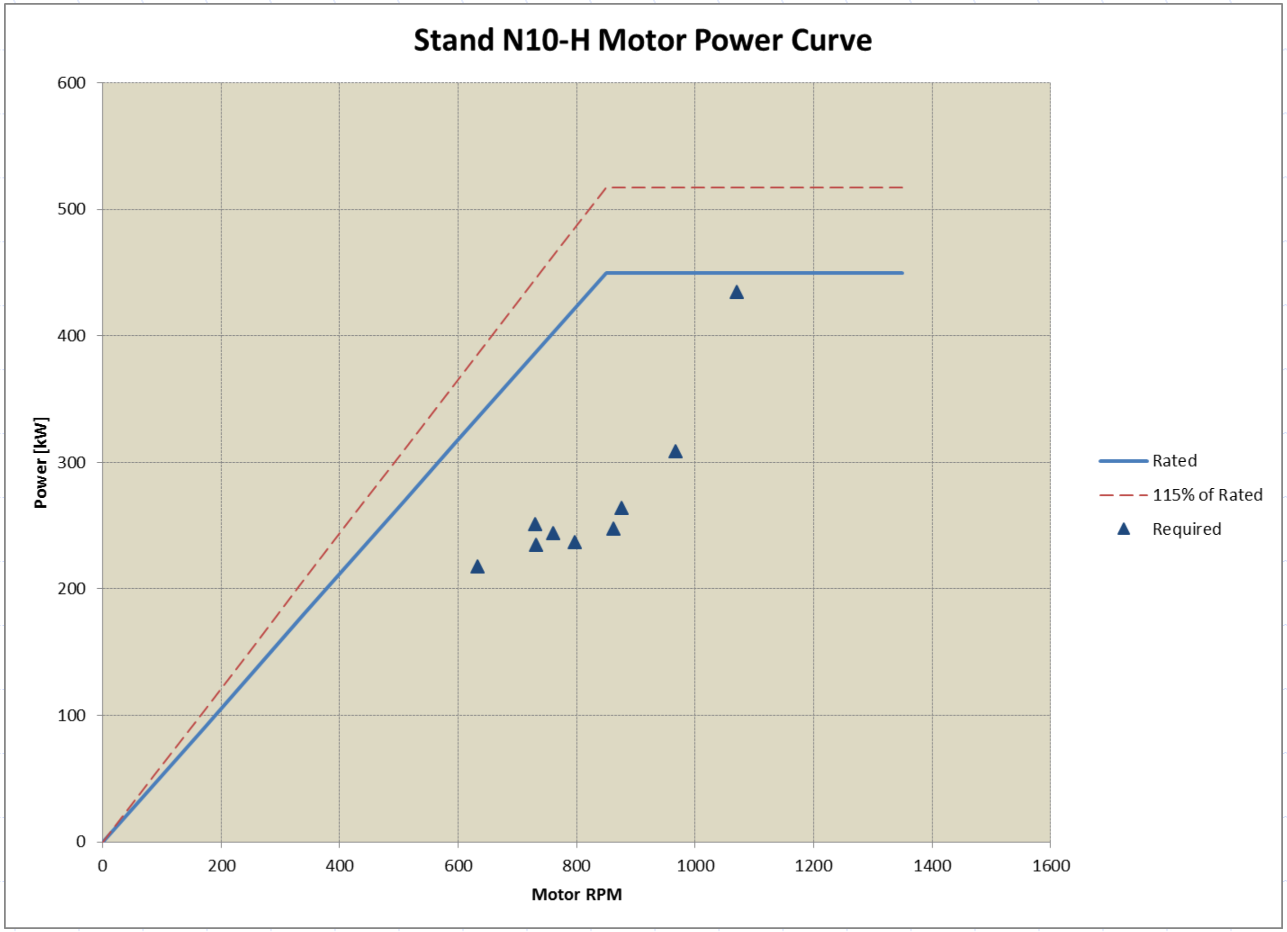
Gear Ratio Change in Stands 2 and 3-4

- Parts ordered and received, around 100,000 dollars investment.
- Scheduled to change gears on the next outage.

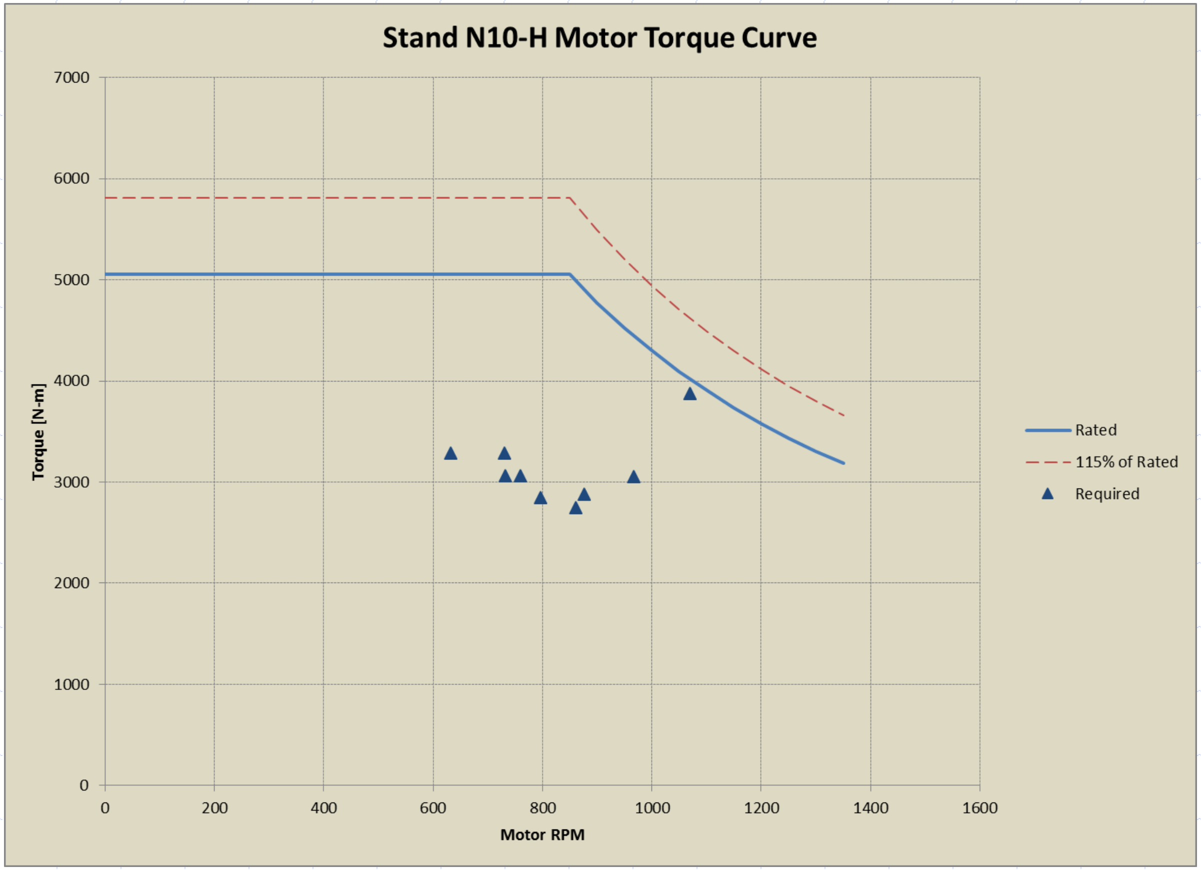
Results- Stand 10 Motor Overload

- Mill has had issues with Stand 10 motor and its overload for many years, resulting in frequent cobbles in this stand
- Stand motor and gear ratio was changed in the past, did not solve the problem
- Results of the simulations did not show this overload

Stand N10 – Motor Power Curve



Stand N10 – Torque Curve



Stand 10 Drive Replacement

- Discrepancy between real operation and simulation results, prompted mill to conduct a detailed study of this stand and its drive system
- Mill found out that due to an installation error, the load reading was not correct and the motor overloads were false! This issue was there from the initial installation of the drive installed in 1980's upgrade
- A new ABB drive was installed: load readings match simulation results now, issue is resolved for good!
- Unintended but not uncommon side benefit of simulation

Summary to Remember

- Rolling Mill Simulators are great tools to:
  - Verify pass designs for rollability,
  - Calculate throughputs and bottlenecks in a mill,
  - Run "what if" scenarios and finding "low hanging fruits"
  - Develop optimized mill upgrade scenarios
- They are not expensive
- Schweitzer Engineering and Rolling Technology one source for all:
  - Rolling Process Expertise, Pass Design, and Mill Simulations.
  - Local and affordable

Thank You