Paper 206-2009 Source of Nitrogen in Q-BOP Steel (Statistical Analysis)

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ABSTRACT

Structural grades of hot rolled low and medium carbon plates and sheets commonly used for deep drawing applications. Cracking on the bend faces, as well as aging effects are the major defects, which usually causes rejection of the sufficient volumes of steel. It is a common knowledge that steels containing interstitial nitrogen appear to be more susceptible than lownitrogen steels to stress-corrosion cracking. Nitrogen exists in steel primary in combination, as nitrides of metallic elements or as molecular nitrogen in cracks or blowholes. The solubility of nitrogen in ferrite at room temperature in low and medium carbon steel not exceeds 0.001%, and precipitation effects caused by nitrogen may occur in steel containing more than this amount. It is also well known that increased carbon content reduces the tendency of steel to fail by intergranuular cracking [1]. This article presents results of statistical study of sources of nitrogen in low to medium carbon Q-BOP steel and recommendations to improve melting practices to reduce nitrogen content.

DISCUSSION

Structural grades of hot rolled low and medium carbon plates and sheets commonly used for deep drawing applications. Cracking on the bend faces, as well as aging effects are major defects, which usually cause rejection of the sufficient volumes of steel. It is a common knowledge that steels containing interstitial nitrogen appear to be more susceptible than lownitrogen steels to stress-corrosion cracking. Nitrogen exists in steel primary in combination, as nitrides of metallic elements or as molecular nitrogen in cracks or blowholes. The solubility of nitrogen in ferrite at room temperature in low and medium carbon steel not exceeds 0.001%, and precipitation effects caused by nitrogen may occur in steel containing more than this amount. It is also known that increased carbon content reduces the tendency of steel to fail by intergranuular cracking [1]. This article presents results of statistical study of sources of nitrogen in Q-BOP low to medium carbon steel and recommendations to improve melting practices to reduce nitrogen content.

Over 135,000 tons of MCD (Mechanically Capped) and SSK (Silicon Semi Killed) melted steel, representing five hundreds thirty nine (539) heats from two Q-BOP vessels, hot rolled and shipped to customers in form of plates and coiled sheets, were used to analyze technological factors, which affects excessive Nitrogen contents in steel. These heats represent over two weeks of the Q-BOP operations. Nitrogen content in steel was determined based on final turndown and in the ladle chemical analysis. This analysis, according to metallurgical standards, represents official chemical composition of steel [2].

SAS[®] v.6.3 (Statistical Analysis Software) on the HP-9000 platform was used to collect and organize operational data and perform statistical analysis. All data collected from Geneva's' process control system, representing technological parameters for 283 heats from Q-BOP vessel # 1 and 256 heats from vessel # 2. Data were organized into two SAS[®] data sets QBOP.N2TRNDN and QBOP.N2FINAL for future analysis.

SAS[®] data set QBOP.N2TRNDN contained approximately 50 parameters, including heat #, total heat time, downtime (time between heats measured from end of tap to beginning of charge),

charged material consumption per ton of steel (heavy, light, pig iron, pit etc. scrap, coke weight, hot metal weight), hot metal parameters, preheat parameters, blowing time and material consumption during blowing period, number of reblows, turn down chemical composition of steel, steel temperature and oxygen content in steel (0_2 ppm), order requirements, etc. All material consumptions in this study normalized per ordered ton of steel.

Data set QBOP.N2FINAL contained heat tapping time, ordered and actual (in ingots) heat weight, deoxidation practice, requested chemical composition of steel, turn down temperature, 0_2 ppm, actual chemical composition of steel, ladle additions, in the ladle chemical analysis, temperature and 0_2 ppm after deoxidation and alloy ladle additions, final chemical composition of steel, taken during the teeming, according metallurgical standards from the second ingot of each heat and also total ingots' pouring time. This data set contained total of 45 steelmaking parameters. All conventional designations used in this article shown in APPENDIX 1.

Table 1 below shows statistical characteristic of analyzed steel parameters, including chemistry, measurements of turn down temperature, 0₂ ppm, etc.
Conventional designations are:
N - The number of observations (number of heats);
Mean - The average value of listed parameters;
Std Dev - The standard deviation of listed parameters;
Minimum, Maximum - the smallest and largest value;
Range - the range of listed parameters;
CV - the coefficient of variation (percent);
Skewness - the measure of skewness;
Kurtosis - the measure of kurtosis.

For future analysis, data from both vessels were combined into one data set, as Student's (T) and Fisher's (F) criteria showed statistically insignificant differences between most turn down parameters. Fig. 1- 5 below show statistical distributions of major operational parameters and turn down and in the ladle chemical composition of steel. While most of Q-BOP raw materials charge, preheat, oxygen, natural gas, argon blowing parameters, steel temperature, ladle additions, taping and steel pouring parameters have normal (Gaussian) distribution, final carbon, manganese and specially silicon content in steel are bimodal, as result of combining SSK (high carbon content) and MKD (low carbon content) steels into one data set.

Control charts of the final and turn down nitrogen content in steel, shows causal relations (see Fig. 6). Data points, generally scattered about the centerline indicates that process is under control and nitrogen variation is random (see daily mean control charts). Some data points outside the upper or lower control limits indicate periods when process went out of control. An unfavorable situation for both final and turn down nitrogen content in steel took place between 92/08/02 and 92/08/06 and between 92/08/13 and to 92/08/16, indicating that there were technological causes for excessive nitrogen content in steel. Fig. 6 also represents daily range of the nitrogen content in steel between 0.002% for turn down to 0.006% for final in ladle analysis, and for periods of high nitrogen content between 0.003% to 0.009% for turn down and between 0.004% and 0.011% for in ladle analysis.

To determine correlation between final nitrogen contents in steel and analyzed steel making parameters used Pearson Correlation statistics (SAS[®] PROC CORR). Diagonal matrix (see Fig. 7), shows individual correlation coefficients between analyzed parameters. The correlation coefficient equal ± 1 indicates functional relationship, while (+) or (-) sign in front of coefficient indicates direct or inverse relationship between parameters. Based on volumes of analyzed information, critical value of correlation coefficient was identified as equal to ± 0.15 . If the absolute

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value of calculated coefficient of correlation is less then critical value, the correlation considered as insignificant (no linear relation) between parameters. Otherwise correlation coefficient considered as significant and sing indicates strait (+) or inverse (-) relationship between parameters.

The strongest correlation of the final nitrogen content in steel, observed with carbon, manganese and silicon, where the correlation coefficient varied from 0.29 to 0.32. Statistically significant negative correlation between final nitrogen content in steel and phosphorus (R=-0.15), ingot pouring time (R=-0.21) and ladle Oxygen content in steel (0_2 ppm R=-0.31) require special study. Among other technological parameters highly correlated with final nitrogen content in steel are turn down nitrogen (R=0.62), TDSTTEMP (R=0.22), TDSTOPPM (R=0.13), HCFEMN (R=0.17), ALBUND (R=0.45) and COKEPORT (R=0.20).

Turn down carbon, manganese, phosphorus and steel temperature showed statistically significant negative correlation (ranging from -0.23 to -0.45) with turn down nitrogen content in steel. Also from major preheat and steel blowing parameters, the most correlated with turn down nitrogen in steel were HEATTIME (R=0.39), HMPOROT (R=-0.23), SCRPORT (R=0.20), HVYSCRPR (R=0.12), COKEPORT (R=0.24), etc.

Table 1

Variable	N	Mean	Std Dev	Minimum	Maximum	CV	Skewness	Kurtosis
DOWNTIME	529	1580.09	2252.60	257.00	14705.00	142.56	3.05	10.08
HEATTIME	532	3095.08	552.82	2037.00	6094.00	17.86	1.35	2.85
HMPORDT	489	1596.02	88.96	1341.69	1921.69	5.54	0.62	0.85
HM TEMP	535	2339.99	49.73	2127.00	2455.00	2.13	-0.58	0.61
HM MN	539	0.15	0.03	0.06	0.34	18.79	1.18	6.23
HM_SI	539	0.85	0.24	0.33	1.68	28.66	0.56	0.43
HM_P	539	0.09	0.01	0.04	0.11	14.55	-1.19	1.30
HM_S	539	0.02	0.01	0.00	0.07	37.96	0.66	2.24
SCRPPORT	492	604.11	95.34	186.38	831.60	15.78	-0.79	1.20
HVYSCRPR	533	0.35	0.08	0.00	0.57	22.73	-2.29	8.50
LTSCRPR	533	0.55	80.0	0.19	1.00	15.00	1.71	9.03
COKEPORT	550	4.79	5.31	0.00	16.78	110.90	0.22	-1.92
PHT_SECS	536	437.43	208.49	11.00	1200.00	47.66	0.57	0.14
PHT GAS	534	23877.15	11946.77	80.00	55430.00	50.03	0.54	-0.21
PHT O2	532	39525.19	19334.59	200.00	82500.00	48.92	0.46	-0.45
TO2PORT	495	2189.26	536.98	1707.95	5623.54	24.53	3.93	17.05
TGASPORT	496	233.55	110.08	110.20	1174.39	47.13	3.79	22.95
LIMEPORT	484	97.78	23.60	49.36	182.98	24.14	0.75	0.67
DOLOPORT	550	29.60	13.65	0.00	65.79	46.12	-1.07	0.52
BLWSPORT	386	7.67	1.52	3.85	12.87	19.80	-0.11	0.41
TN2PORT	496	1114.65	188.31	626.13	1416.47	16.89	-0.53	-0.75
BLW_SECS	415	1861.08	358.76	805.00	3148.00	19.28	-0.33	0.41
REBLOWS	538	0.65	0.81	0.00	4.00	124.20	1.26	1.52
TD_CARB	515	0.02	0.01	0.01	0.05	31.73	1.14	1.79
TD_SILIC	475	0.00	0.00	0.00	0.02	32.15	5.11	28.03
TD_MANG	500	0.08	0.02	0.01	0.17	29.23	0.27	0.68
TD_PHOS	499	0.01	0.00	0.00	0.02	30.42	1.32	2.05
TD_SULF	517	0.02	0.00	0.01	0.04	23.22	0.26	0.24
TD_NITRO	471	0.00	0.00	0.00	0.01	42.34	0.92	3.36
STL2_TMP	401	2956.92	29.13	2824.00	3075.00	0.99	-0.43	2.64
STL2 0	397	508.40	86.21	247.00	938.00	16.96	1.36	4.54
TAP_SECS	528	385.00	53.32	230.00	622.00	13.85	0.22	1.64
ING_WGT	531	487547.52	22605.32	404464.00	541669.00	4.64	-0.67	0.90
BUTT_WGT	535	6393.05	7008.80	0.00	27020.00	109.63	0.85	-0.39
ORD WGT	497	486181.04	15982.01	451054.00	508806.00	3.29	-0.25	-0.92

Q-BOP Blowing and Turn Down Performance (Statistical Characteristics)

Scatter plots with the calculated linear regression equations shown for some most correlated parameters on Fig. 8.

Table 2

Variable	N	Mean	Std Dev	Minimum	Maximum	Range	CV	Skewness	Kurtosis
FCARBON	417	0.1665	0.0548	0.05	0.25	0.2	32.93	-0.64	-0.73
FMANG	417	0.6735	0.2376	0.33	1.18	0.85	35.28	0.14	-1.34
FSILICON	417	0.0245	0.0264	0.004	0.08	0.076	107.51	0.62	-1.47
FPHOS	417	0.0077	0.0019	0.004	0.015	0.011	24.33	0.76	0.48
FSULFUR	417	0.0203	0.0044	0.009	0.032	0.023	21.57	0.19	-0.16
FNITROGN	417	0.0056	0.0014	0.003	0.016	0.013	25.03	1.36	7.57
LCARBON	409	0.1725	0.0548	0.055	0.27	0.215	31.78	-0.56	-0.75
LMANG	409	0.6967	0.2434	0.34	1.2	0.86	34.94	0.16	-1.31
LSILICON	409	0.0269	0.0295	0.004	0.16	0.156	109.90	0.75	-0.64
LPHOS	409	0.0075	0.0017	0.004	0.014	0.01	22.69	0.92	1.23
LSULFUR	409	0.0208	0.0045	0.008	0.034	0.026	21.74	0.22	-0.25
TEMP	403	2844.23	14.32	2790	2900	110	0.50	-0.20	2.13
O2_PPM	402	100.25	67.60	15	348	333	67.43	1.11	0.40
TAP_SECS	528	385.00	53.32	230	622	392	13.85	0.22	1.64
POR_SECS	357	1439.16	281.66	600	3000	2400	19.57	1.32	4.57
ING_CNT	407	9.7887	1.4434	3.0000	20.0000	17.0000	14.75	1.79	9.24
ING WGT	406	486440.54	33234.18	135516.0	541669.0	406153.0	6.83	-4.66	40.64
ORD_WGT	392	487105.79	16641.22	451054.0	546353.0	95299.0000	3.42	-0.28	-0.54
MOD_WGT	392	499969.81	18797.89	460082.0	538621.0	78539.00	3.76	-0.25	-0.78
HCFEMNPT	390	12.86	8.35	0.00	31.57	31.57	64.93	-0.16	-1.00
SIMNPORT	152	6.50	3.31	0.00	8.82	8.82	50.97	-1.46	0.17
FESI75PT	35	1.87	1.39	0.00	7.45	7.45	74.26	2.51	8.81
ALBUNDPT	301	0.52	0.43	0.00	2.75	2.75	83.80	1.11	2.55
COKEPORT	392	3.53	1.59	0.00	6.20	6.20	45.17	-0.74	-0.20
AR_MINS	539	4.14	2.56	0.00	12.00	12.00	61.84	-0.16	-0.11

Ladle Additions (Statistical Characteristics)

Table 3

Final (In Ladle & Ingots) Chemical Composition and Tap Parameters (Statistical Characteristics)

Variable	N	Mean	Std Dev	Minimum	Maximum	Range	CV	Skewness	Kurtosis
FCARBON	417	0.1665	0.0548	0.05	0.25	0.2	32.93	-0.64	-0.73
FMANG	417	0.6735	0.2376	0.33	1.18	0.85	35.28	0.14	-1.34
FSILICON	417	0.0245	0.0264	0.004	0.08	0.076	107.51	0.62	-1.47
FPHOS	417	0.0077	0.0019	0.004	0.015	0.011	24.33	0.76	0.48
FSULFUR	417	0.0203	0.0044	0.009	0.032	0.023	21.57	0.19	-0.16
FNITROGN	417	0.0056	0.0014	0.003	0.016	0.013	25.03	1.36	7.57
LCARBON	409	0.1725	0.0548	0.055	0.27	0.215	31.78	-0.56	-0.75
LMANG	409	0.6967	0.2434	0.34	1.2	0.86	34.94	0.16	-1.31
LSILICON	409	0.0269	0.0295	0.004	0.16	0.156	109.90	0.75	-0.64
LPHOS	409	0.0075	0.0017	0.004	0.014	0.01	22.69	0.92	1.23
LSULFUR	409	0.0208	0.0045	0.008	0.034	0.026	21.74	0.22	-0.25
TEMP	403	2844.23	14.32	2790	2900	110	0.50	-0.20	2.13
O2_PPM	402	100.25	67.60	15	348	333	67.43	1.11	0.40
TAP_SECS	528	385.00	53.32	230	622	392	13.85	0.22	1.64
POR_SECS	357	1439.16	281.66	600	3000	2400	19.57	1.32	4.57
ING_CNT	407	9.7887	1.4434	3.0000	20.0000	17.0000	14.75	1.79	9.24
ING_WGT	406	486440.54	33234.18	135516.0	541669.0	406153.0	6.83	-4.66	40.64
ORD_WGT	392	487105.79	16641.22	451054.0	546353.0	95299.0000	3.42	-0.28	-0.54
MOD_WGT	392	499969.81	18797.89	460082.0	538621.0	78539.00	3.76	-0.25	-0.78
HCFEMNPT	390	12.86	8.35	0.00	31.57	31.57	64.93	-0.16	-1.00
SIMNPORT	152	6.50	3.31	0.00	8.82	8.82	50.97	-1.46	0.17
FESI75PT	35	1.87	1.39	0.00	7.45	7.45	74.26	2.51	8.81
ALBUNDPT	301	0.52	0.43	0.00	2.75	2.75	83.80	1.11	2.55
COKEPORT	392	3.53	1.59	0.00	6.20	6.20	45.17	-0.74	-0.20
AR_MINS	539	4.14	2.56	0.00	12.00	12.00	61.84	-0.16	-0.11

Q-BOP Charging Materials





Coke, lb/ton

Light Scrap, %







Scrap Preheat Performance





Q-BOP Steel Blowing Performance







Oxygen Consumption, scf/ton









Oxygen Blow, sec





40 -

30

10

0.

20 - 20



Dolomite Consumption, lb/ton



Fig. 2

Lime Consumption, Ib/ton

Chemical Composition of Steel (First Turn Down)



Phosphorus, %

Sulphur, %









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Q-BOP Operations. Ladle Additions and Steel Performance



Q-BOP Operations. Ladle Taping Performance









Fig. 4

Chemical Composition of Steel (In the Ladle)







Phosporus, %





Nitrogen, %





Fig. 5



Q-BOP Operations Control Charts of the Average / Range Daily Nitrogen Content in Steel

Fig. 6

Q-BOP Operations Source of Nitrogen in Steel Blowing and Turn Down Performance Pearson Correlation Coefficients

Table 1

Turn Down Parameters	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nitrogen	Temperature	Oxygen	Heat Weight
Carbon	1	0.42	-0.04	0.23	0.12	-0.24	0.01	-0.21	-0.1
Manganese		1	-0.05	0.57	0.28	-0.44	0.32	-0.3	0
Silicon			1	-0.06	0.02	0.01	0.03	0.12	0.04
Phosphorus				1	0.13	-0.032	0.31	-0.06	-0.09
Sulfur					1	-0.03	-0.02	0.05	0.05
Nitrogen						1	-0.23	0.11	-0.01
Temperature							1	0.23	0.06
Oxygen								1	-0.01
Heat Weight									1

Table 2

Turn Down Parameters	Nitrogen	Down Time	Heat Time	Hot Metal per ton of Steel	Hot Metal Temperature	Hot Metal Manganese	Hot Metal Silicon
Nitrogen	1	-0.08	0.39	-0.23	-0.06	-0.09	0.11
Down Time		1	-0.09	0.26	-0.04	-0.02	-0.01
Heat Time			1	-0.11	-0.05	-0.03	0.06
Hot Metal per ton of Steel				1	-0.6	-0.23	-0.55
Hot Metal Temperature					1	0.3	0.29
Hot Metal Manganese						1	0.21
Hot Metal Silicon							1

Q-BOP Operations Source of Nitrogen in Steel Final (Ladle) Steel Performance Pearson Correlation Coefficients

Table 1

Turn Down Parameters	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nitrogen	Argon Blowing Time	Steel Pouring Time	Steel Temperature	Oxygen Content in Steel
Carbon	1	0.76	0.54	0.31	0.14	0.29	-0.1	-0.25	-0.3	-0.87
Manganese		1	0.63	0.35	0.09	0.29	-0.1	-0.37	-0.35	-0.73
Silicon			1	0.14	0.19	0.31	-0.02	-0.55	-0.18	-0.65
Phosphorus				1	0.12	-0.15	0.04	0.01	-0.13	-0.29
Sulfur					1	0.05	-0.06	-0.07	0.04	-0.14
Nitrogen						1	-0.06	-0.21	-0.01	-0.31
Argon Blowing Time							1	-0.06	0.19	0.06
Steel Pouring Time								1	0.07	0.3
Steel Temperature									1	0.32
Oxygen Content in Steel										1

Table 2

Turn Down Parameters	Nitrogen	Steel Pouring Time	eel Temperatu	Oxygen Content in Steel	Tap Time	Turn Down Nitrogen	Turn Down Steel Temperature
Nitrogen	1	-0.21	-0.02	-0.31	-0.05	0.62	-0.22
Steel Pouring Time		1	0.07	0.3	0.1	-0.12	0.09
Steel Temperature			1	0.32	0.04	-0.07	0.08
Oxygen Content in Steel				1	0.11	-0.17	-0.03
Tap Time					1	0.02	0.11
Turn Down Nitrogen						1	-0.23
Turn Down Steel Temperature							1

Q-BOP Operations Turn Down Nitrogen Content in Steel Scatter Plots



Over one hundred (100) technological parameters from 539 heats produced by two Q-BOP vessels (approximately 200,000 metric tons of steel) were analyzed to determine major steelmaking factors that affects the nitrogen content in steel.

Step forward PROC GLM SAS[®] regression procedure were used to find out individual effect of steel making parameters on turn down and final nitrogen content in steel. Statistically significant relationship were determined between final nitrogen content in steel and turn down nitrogen, coke and AL bundle additions into the ladle. The multi regression coefficient of 0.60 shows statistically significant linear dependency between analyzed parameters. Determination coefficient shows, that approximately 27% variation of final nitrogen content in steel could be explained by variation of turn down nitrogen, approximately 7.5% depends of AL bundle disparity and another 0.8% depends of ladle coke consumption. Increase of the turn down Nitrogen content in steel from 0.001% to 0.007%, fixing all other analyzed parameters on average level, would increase the average level of final Nitrogen content in steel from 0.003% to 0.007%. Final Nitrogen content in steel would also increase from 0.003% to 0.005% with increase of AL bundle consumption from 0 to 2.0 Lb per ton of steel. Other analyzed parameters do not have such a significant effect on the final Nitrogen content in steel.

As shown above, the main factor of the high final Nitrogen content in steel is a turn down Nitrogen. It depends of charging materials consumption and their characteristics, preheat, blowing and turn down parameters, vessel conditions, etc. Regression analysis, performed by SAS[®] PROC GRM procedure shows that total of eleven (11) statistically significant technological parameters explain approximately 34% of the turn down nitrogen variability. The most significant parameters were: scrap and coke consumption, which explain 15.3% and 6.2% respectively of turn down Nitrogen variability. Turn down Oxygen content in steel and steel temperature explain 2.7% and 1.9% turn down Nitrogen variability respectively. Scrap preheating time and numbers of reblow explain 5.9% of TD Nitrogen variability. Each additional reblow increases average TD Nitrogen content in steel by 0.0004%, while increase in Oxygen blow time from 15 to 30 minutes increases it for 0.0005%. The major source of variability of the turn down Nitrogen is heavy scrap consumption per ton of steel. Changing scrap consumption from 300 lb to 800 lb per ton of steel, while heavy scrap varied from 0 to 50% of charge, increases average level of the turn down nitrogen by 0.0025%. Increasing the light scrap in the charge reduces average level of turn down Nitrogen. Each additional 1 lb of coke per ton of steel, during scrap preheating, increases the average level of turn down Nitrogen by 0.00004%. Increasing turn down temperature of steel from 2850° to 3025° F reduces average turn down Nitrogen level by 0.0015%. Each additional 100 ppm of turn down Oxygen content in steel increased the average turn down Nitrogen by 0.00025%.

CONCLUSIONS

As results of this study, the following Q-BOP steelmaking practices were recommended to reduce nitrogen content in steel:

1. Limit heavy scrap consumption in the charge to less than 40% of scrap charge less than 500 lb per ton of steel and 25% - 30% for scrap charge more than 500 lb per ton of steel.

2. Limit coke charge to 10 - 12 lb per ton of steel.

3. Improve Q-BOP process control operational model to reduce the number of reblows. The first turn down Oxygen content in steel should not exceed 500 ppm, while temperature should not be less than 2950° F. 4. Perform analysis of argon rinse heats practices on the Nitrogen content in steel, measuring steel chemical composition before and after argon rinse. (The melting point of the Si and AL nitrides in steel is greater then 3000-3500 ° F. Liquid steel suspension with ultimate solid particles of nitride could be cleansed using an argon flotation practices).

Q-BOP Operations Source of Nitrogen in Steel Stepwise Regression Analysis (Fragment)

multiple 4.8000000000000000000000000000000000000		OUT AP	0.00400000	0.0000000	0 00000255	7.76	4 66.84	
Articlour, 6.40040103 6.00040233 6.0004023 6.		DI 11 5575	a assocato	0 00000000	0.00000234	4 75	0.0144	
1112_repr		REPLONS	0.00000000	0 00011424	0.00000050	14 71	0 0012	
1112.0 1.000000000000000000000000000000000000		531 2 180	-0.00000620	0 00004234	4 60000653	8.23	0.0445	
CONSIST Standard Consist <		511.2 0	8.66000285	4 60004977	4 00001089	13 72	0.0003	
SQR DPDurf C 00000337 C 00000345 C 00000455 C 00000455 C 0.0000 Baunda en studition number: 247 2364, 5247 794 Step10 Veriable SCRPATD Imered E-cquare = 0.35601667 C(u) = T 11795555 Df Sum of Square = Neon Square = ProbJF Regrection 13 0.000000000 0.00000007 13.21 0.0001 Variable Composition C 000000000 0.00000007 13.21 0.0001 Variable Composition C 000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.0000000000 0.000000000 0.0000000000 0.0000000000 0.0000000000000000 0.00000000000000000000000000000000000		CONTRACT	4 46001134	0 00001165	4 444866.67	8 40	0 0001	
Baunda en condition number 247 2364, 5247 75 Step10 Variable SCRPATQ Intered E-cquare + 0 J3601767 (4) = 7.1179555 Di Sum of Squares Neon Squares Neon Squares F Prob/F Regression 13 0.0001055 Type II F Prob/F Variable Parameter Standary Neon Squares Neon Squares F Prob/F Variable Parameter Standary Type II F Prob/F PHI (5:05 0.00000050 0.00000015 0.0000015 0.0000165 0.00001		SCRPPORT	6 00000341	9.00004445	4 0000/180	21 46	0.0002	
Butter of the section water Cat find Bit case of Squares Neon Squares Neon Squares Neon Squares F Prob/F Regretcian 13 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 Versable Parameter Stander Stander Type II Stander Prob/F INTERCEP 0.00000000 0.00000000 0.000000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000 0.0000000000 0.000000000000 0.00000000000000 0.00000000000000000000000000000000000			1747 754					
Exception Variable SCRPAD Internel R-cquare = 0.33601767 C(u) = T.1178500 Df Sum of Squares Nean Squares Nean Squares Nean Squares Problif Error 260 0.00000000 0.000000000 0.000000000 0.00000000000000000000000000000000000	Mounds on condition higher	267 2364,	5242.774					
Di Sum of Squares Non Square F Probif Regression 100 0.00010555 0.0001055 13.21 0.0001 Trial Parameter Standary Type II Probif PHI_SEC 0.0001055 0.0001055 0.000105 13.21 0.0001 PHI_SEC 0.00040555 0.0000001 0.0000010 0.000001 0.000101 PHI_SEC 0.00040555 0.0000001 0.0000014 55.5 0.0001 PHI_SEC 0.00040555 0.0000001 0.0000001 0.0000001 0.0000001 STL2_THP -0.00040527 0.0000001 0.0000001 0.0000001 0.0000001 STL2_THP -0.00000012 0.00000012 0.00000012 0.0000012 0.0000012 STL2_THP -0.00000012 0.0000012 0.0000012 0.0000012 0.0000012 STL2_THP -0.00000012 0.0000012 0.0000012 0.0000012 0.0000012 STL2_THP -0.0000012 0.0000012 0.00000012 0.0000012	Etep10 Variable SCRPRTO I	tniered Ricqu	are = 0 3369176	$7 - C(\mu) = -7.1179$	15960			
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Brind Tetal Parameter Parameter Standary Encode Type II Type II For Sum of Squares F Probl INTERCOP 0.0034050 0.0034050 0.0034050 0.0034050 7.29 0.0074 INTERCOP 0.0034050 0.0034050 0.0034050 0.0034050 7.29 0.0074 PHI_DAS 0.0034050 0.0034050 0.0034050 0.0034050 7.29 0.0074 PHI_DAS 0.0034050 0.0034050 0.0034050 7.29 0.0074 PHI_DAS 0.0034050 0.0034050 0.0034050 7.29 0.0074 PHI_DAS 0.0034050 0.0034050 0.0034050 7.0034000 0.0034050 7.0034000 PHI_DAS 0.0034050 0.0034050 0.0034050 7.0034000 7.000000 7.000000 Step11 Variable HMPORDT Entered R-square + 0.33073352 C(p1 + 8.42420333 0 0 0.0000075 12.04 0.0001 Variable HMPORDT Entered R-square + 0.33073352 C(p1 + 8.42420333 0 0 0.0000075 12.04		Regression	10	0.00010450	0.00001045	13.81	0.0001	
Variable Parameter Fatiatie Standard Error Type II Standard Type II From Standard F Prob/F Mil SiCS -0.0041852 0.004566 0.00040163 2.14 0.0071 PHI DS 0.0041652 0.0044666 0.00040163 2.14 0.147 PHI DS 0.0044666 0.00446666 0.00041627 3.25 0.0726 BLU_SCS 0.0046666 0.00446267 0.00446267 0.00446267 0.00446267 BLU_SCS 0.00466664 0.00446267 0.00446267 0.00446267 0.00446267 BLU_SCS 0.00466664 0.00446267 0.00446267 0.00446767 0.00446767 SILE_TIMP -0.00446664 0.04466267 0.00446765 1.37 0.00437 SILE 0.04466641 0.04466665 1.37 0.00437 SILE 0.0446666 0.0446665 1.37 0.00437 SILE 0.0446666 0.04466665 1.37 0.00437 SILE 0.0446666 0.0446666 0.0446666 0.00466666 SILE<		Total	260	0 00020566	0.0000073			
Parameter Standary Type II INTERCEP 0.1004835 0.4435116 0.00038366 7.29 0.0074 PHI_CAS 0.0004855 0.0004855 0.0000105 2.14 0.1447 PHI_CAS 0.0000868 0.00048507 2.14 0.1447 PHI_CAS 0.0000867 0.00008657 3.25 0.001 STL2_THP -0.0000867 0.0000867 0.0000877 0.0000877 0.0000877 STL2_THP -0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.0000877 0.000077 0.0000877 0.000077 0.000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.0000077 0.00000077 0.00000077 0.00000077 0.00000077 0.00000077 0.000000077 0.000000077 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>								
Variable Partialité Error Samo Solares P Prob/P INTERCEP -0.004152 0.4030516 7.23 0.4034 5.54 0.4034 PHI_SES -0.004152 0.4030564 7.55 0.4034 5.54 0.4147 PHI_D7 0.40486500 0.40486504 0.404865257 3.25 0.0034 St_2CTS 0.40486500 0.40486524 0.40486525 3.33 0.0011 St_2CTS 0.4048654 0.40486577 0.4048655 3.31 0.0044 St_2DF 0.40486561 0.4048655 1.31 0.011 0.4048655 St_2DF 0.4048657 0.4048655 1.31 0.0121 0.4048655 Step11 Variable HMPORDY Entered R-square < 0.3071352			Parameter	Standard	Type If			
Print 0.00004455 0.00004455 0.00004455 7.89 0.0074 PHI_GAS 0.00004455 0.00004455 1.14 0.1447 PHI_GAS 0.00004456 0.000041527 1.13 0.001 BLU_SECS 0.00004456 0.000041527 1.13 0.001 SIL2_10 -0.00004455 0.000044557 1.13 0.001 SIL2_10 -0.00004551 0.00004751 0.00004751 0.001 SIL2_10 -0.00000075 0.00000755 1.00000075 0.0000076 SIL2_10 -0.00000076 0.0000076 0.0000076 0.0000076 SIL2_10 -0.00000076 0.00000076 0.00000076 0.00000076 SIL2_10 -0.00000000 0.00000000 0.000000076 0.00000000 SIL2_10 S		Variable	Futinate	Error S	ion of Squares	۴	Prob)P	
PHI_SECS -0.00001152 0.000000000 0.000000000 0.00000000000000000000000000000000000		INTERCEP	0.01084685	0.00558176	0 00000576	7.29	0.0074	
PHT_EAS 0 000000000 0 000000000 0 0000000000 0 000000000000000000000000000000000000		PHI SECS	-0.00001152	0 00500468	0.00000448	5 54	0.0191	
PHI_DZ 0.04440000 (0.00440000) 0.044400000 (0.00440000) 0.044400000000000000000000000000000000		PHT_6AS	0 00000008	0 00448006	0 00000163	2 1 4	0.1447	
BLG_SECS 0.00000000000000000000000000000000000		PH1_07	0 04066666	0.0000004	0.00460257	3.25	0 0726	
Product 0.00000000000000000000000000000000000		BLW_SECS	0.00082849	0.00000024	0.00094387	4 13	0 0431	
Stitzin Originalized Construction Originalized Construction <thoriginalised Construction Originalized Construc</thoriginalised 		OTLD THD	0.00040564	0.00013672	0.00000767	0.75	0 0031	
ChitPort 0.13887300 0.03881161 0.03881151 0.13.6 SCRPPort 0.13860061 0.03660043 0.03881155 1.17 0.1621 SCRPPort 0.138000205 0.10000074 0.1800059 13.89 0.0002 Buunds an condition mumber 207.2332 S553.026		STL2_10	0.0000000000	0 00000231	0.00000000	12 95	0.0004	
SCRPFRI 0.0000001 0.0000001 0.0000010 0.0000010 0.0000010 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.0000001 0.00000001 0.000000001 0.0000000000000 0.00000000000000000000000000000000000	*	CONFRONT	0.0000727700	0.0000000077	0 000000000	8 43	0.0049	
ECRPPENT 0.00000205 0.00000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.0000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000076 0.00000077 0.00000077 0.00000077 0.00000077 0.0000000077 0.0000000077 0.0000000077 0.0000000077 0.0000000077 0.0000000077 0.0000000077 0.0000000077 0.00000000077 0.000000000077 0.00000000000000000000000000000000000		SCREPTO	0 00000001	0 00560043	0 00000155	1 97	1621	
Pounds an condition number: 267.232. 5853.026 Step11 Variable IMPORDT Entered R-square + 0.33071362 C(p) + 8.42426833 OF Sum of Squares Hean Square F. Preb3F Regression 11 6.00000255 12.96 0.0001 Error 220 0.0002155 0.00000073 12.96 0.0001 Variable Paramoter Standard Type II F. Preb3F IMTERCEP 0.00207252 0.00718958 0.00000073 7.45 0.0027 PHT_SELS -0.00001174 0.00000489 0.0000053 7.45 0.007 PHT_GAS 0.0000003 0.000000489 0.00000456 5.75 0.1417 PHT_GAS 0.00000030 0.000000449 0.0000021 3.42 0.065 BLW_SFCS 0.00000031 0.00000044 0.0000021 3.42 0.005 SIL2_0 0.00000058 0.0000024 0.0000051 12.01 0.0000051 SIL2_1MP -0.00000668 0.00000236 0.0000051 12.01		SCRPPORT	0.0000205	0.00000076	0.0001099	13.89	0.0062	
Regression Line 11 270 0 0002050 0.0000073 12 06 0.0000073 0 0001 Parameter Iotal 270 0.0002073 0.0000073 0.0000073 0.0000073 Parameter Iotal 270 0.0002073 0.0000073 0.0000073 0.0000073 Parameter Iotal 270 0.00010015 0.00000073 1700 1700 Variable Estimate Error Sum of Squarex F Probin INTERCEP 0.00207252 0.00718958 0.00000630 7.45 0.0054 PHT_645 0.0000000 0.00000049 0.000006456 5.75 0.0172 PHT_645 0.0000001 0.00000044 0.0000064 0.0000021 3.42 0.056 BLW_SFC5 0.00000051 0.00000024 0.00000236 0.00000236 0.00000236 0.00000051 12.01 STL2_0 0.00000264 0.00000051 0.00000051 12.01 0.0000051 12.01 0.0000051 STL2_0 0.00000264 0.00000051 0.00000051 12.01 0.000005	Stepti Variable RMPDRDT (Entered R-squ	6F# - 0 3387136	2 C(p) = 8.424; Sum of Squares	Mean Square	F	Preb)F	
Error 253 0.000202510 0.00000073 Istal 270 0.0001015 0.0000073 Farametei: Standard Type II Variable Estimate Error Sun of Squarex F INTERCEP 0.0000049 0.0000049 0.0000040 7.45 0.005 PHT_SELS -0.000001174 0.00000048 0.00000456 5.75 0.015 PHT_SELS -0.0000009 0.00000048 0.0000021 3.42 0.055 PHT_64S 0.00000011 0.00000004 0.0000024 0.0000021 3.42 0.005 BLW_SFCS 0.0000024 0.00000236 0.00000236 0.0000051 12.01 0.0000 STL2_0 0.00000264 0.0000051 12.01 0.0000055 12.61 0.0000 IMPORDT -0.00000264 0.0000055 0.73 0.4022 COMEPORT -0.00000251 0.00000172 0.0000056 0.73 0.4022 SCRMPAR 0.00000259 0.00000172 0.0000056 <t< th=""><th></th><th>Regression</th><th></th><th>0 00010505</th><th>0 00000355</th><th>12 06</th><th>0 0001</th><th></th></t<>		Regression		0 00010505	0 00000355	12 06	0 0001	
Parameter Standard Type II Variable Estimate Error Sum of Squarex F Probat INTERCEP 0.0202/252 0.00718958 0.0000630 7.45 0.0055 PHT_SELS -0.00001174 0.00000489 0.00000465 5.75 0.172 PHT_GAS 0.0000000 0.0000004 0.0000021 3.42 0.055 BLW_SFCS 0.0000021 0.00000024 0.00000515 4.42 0.036 SLL2_NP -0.00000269 0.00000236 0.00000633 8.00 0.005 SLL2_NP -0.00000269 0.00000236 0.0000051 12.01 0.00000236 SLL2_NP -0.00000269 0.00000236 0.0000055 0.70 0.402 SLL2_NP -0.00000269 0.00000310 0.0000056 0.70 0.402 SLL2_ND -0.00000269 0.00000310 0.0000056 0.70 0.402 SLL2_ND -0.00000269 0.00000130 0.0000056 0.70 0.402 SLL2_ND		Leror fotal	259	0.00020510	0.00000375			
Parameter: Standard Type II Variable Estimate Error Sum of Squares F Proble INTERCEP 0.0227252 0.00718958 0.0000630 7.95 0.005 PHT_SELS -0.00001174 0.0000489 0.0000636 5.75 0.017 PHT_GAS 0.0000000 0.0000006 0.0000021 3.42 0.065 BUW_SFCS 0.00000051 0.00000024 0.0000074 0.0000744 9.45 0.005 BUW_SFCS 0.00000680 0.00000021 0.00000021 3.42 0.005 SIL2_1MP -0.00000680 0.00000021 0.00000051 12.01 0.0000 SIL2_00 0.000002640 0.00000051 12.01 0.0000 0.0000051 12.01 0.0000 SIL2_00 0.000002640 0.00000051 0.0000055 0.76 0.4024 SCREPQR1 0.0000059 0.000000738 0.0000055 0.76 0.0000 SCRPAT0 0.000003469 0.000000738 0.0000056 0.76								
INTERCEP 0 02027252 0 00718958 0.0000630 7.95 0.0052 PHT_SELS -0.00001174 0.00000489 0.00000456 5.75 0.0172 PHT_GAS 0.00000009 0.0000006 6 0000170 2.15 0.144 PHT_G2 0 00000001 0.00000004 0.000000271 3.42 0.056 BtU_SFGS 0.00000051 0.00000024 0.00000150 4.42 0.036 REELOWS 0.0000068 0.00000024 0.00000788 9.45 0.002 SIL2_1MP -0.0000068 0.000000236 0.0000051 12.01 0.005 SIL2_0 0.0000268 0.0000078 0.00000951 12.01 0.000 INHPORD1 -0.00000269 0.0000078 0.0000051 12.01 0.000 INHPORD1 -0.00000269 0.00000130 0.0000055 1.2.01 0.000 INHPORD1 0.00000250 0.00000130 0.0000055 0.76 0.002 SL2_0 0.0000259 0.00000130 0.0000051 4.25 0.075 SCRPPOR1 0.00000251 0.00000043 0.00000146 1.05 0.1755 SCRPPOR1 0.00000251 0.000000126 0.00000146 1.05 0.1755 SCRPPOR1 0.00000251	,	Variable	Parameter Estimate	Standar Erre	rdi or Sun⊧of	Type II Squarer	F	Probai
IntExter 0		INTERCO	0.00001050	0 007100		00004 70		0.0052
Pirt_SELS -0.00001171 0.00000489 0.00000456 5.75 0.017 Pirt_GAS 0.00000000 0.00000006 6.0000176 2.15 0.1430 Pirt_02 0.0000008 0.00000004 0.00000021 3.42 0.0650 Bt U_SFC5 0.0000051 0.0000024 0.0000024 0.0000024 0.00000236 Bt U_SFC5 0.0000024 0.00000236 0.00000236 0.00000238 0.00000231 8.00 0.00000235 S1L2_1MP -0.00000249 0.000000236 0.000000236 0.000000231 8.00 0.00000235 S1L2_1MP -0.00000249 0.00000078 0.00000051 12.01 0.000 S1L2_1MP -0.00000249 0.000000330 0.00000051 12.01 0.000 S1L2_1MP -0.00000249 0.000000330 0.00000051 12.01 0.000 S1L2_1MP -0.00000249 0.000000330 0.00000051 12.01 0.0000 S1L2_1MP -0.00000249 0.000000330 0.00000056 12.01 0.0000 <tr< td=""><td></td><td>INTERCEP</td><td>0 02027252</td><td>0 007189</td><td>58 0.0</td><td>0000030</td><td>7.75</td><td>0.0052</td></tr<>		INTERCEP	0 02027252	0 007189	58 0.0	0000030	7.75	0.0052
PHIL_GAS 0.0000009 0.00000006 6 0400176 2 15 0 1441 PHIL_G2 0 0000009 0.0000004 0.0000021 3 40 0055 BR.W_SFCS 0.00000051 0.00000024 0.00000350 4 42 0.0364 RFRLOMS 0.00000668 0.00000236 0.0000051 8.00 0.005 SIL2_1MP -0.00000668 0.00000236 0.00000551 12.01 0.005 SIL2_0 0.00000269 0.0000078 0.00000551 12.01 0.000 IMMPORDI -0.00000130 0.00000551 12.01 0.000 IMMPORDI 0.00000269 0.00000130 0.0000055 12.01 0.000 IMMPORDI 0.00003469 0.00000132 0.0000055 0.76 0.002 SCREPORI 0.0000359 0.00000132 0.00000146 1.05 0.1755 SCREPORI 0.00000201 0.00000126 0.0000014 2.53 0.1124 on condition number: 267 9872, 6531.057		ATT_SECS	-0.00001174	0.000048	89 0.0	0900456	5 75	0 0172
PHT_02 0 0000000 0 00000004 0 000000211 3 42 0 0.054 BR W_SFCS 0.00000051 0.00000024 0.00000350 4 42 0.036 BF 0000051 0.00000000000000000000000000000		PH1_GAS	0.00000009	0.000000	66 66	00:0170	515	0 1438
BLU_SFCS 0.0000051 0.0000024 0.0000150 4 42 0.0346 REBLOWS 0.0000051 0.00000236 0.0000078 9 45 0.002 51L2_1MP -0.00000668 0.00000236 0.00000551 12.01 0.000 STL2_0 0.00000269 0.0000078 0.00000551 12.01 0.000 10MP0RD1 -0.00000130 0.0000055 0.70 0.002 COMEPORT 0.00003469 0.00001172 0.0000055 0.76 0.002 COMEPORT 0.0000029 0.00000137 0.00000146 1.05 0.1755 SCRPPORT 0.0000029 0.00000126 0.00000146 1.05 0.1755 SCRPPORT 0.00000201 0.000000126 0.00000146 1.05 0.1755		S0_1119	0.00000008	0 000000	04 00	0000271	3 42	0 0656
REGIONS 0 00042456 0 00013011 0 00006748 9 45 0 002 51L2_INP -0 00000668 0 00000236 0 00000051 12.01 0 0.0001 1%L2_0 0 0 0 00000236 0 000000551 12.01 0 0.0001 1%HP0RD1 -0 0 0 00000130 0 00000056 0 <td></td> <td>and the second state of the second</td> <td></td> <td>0.000000</td> <td>24 0.0</td> <td>0000350</td> <td>4 42</td> <td>0.0366</td>		and the second state of the second		0.000000	24 0.0	0000350	4 42	0.0366
51L2_1MP -0 00000668 0.00000236 0.0000633 8.00 0.005 51L2_0 0.00000269 0.0000078 0.00000551 12.01 0.000 18H7058D1 -0.0000109 0.00000130 0.00000556 0.70 0.022 COMEPOR1 0.00003469 0.00001172 0.00000556 0.76 0.022 SCRPR10 0.0000029 0.0000013 0.00000146 1.05 0.1755 SCRPPOR1 0.0000029 0.00000126 0.00000146 1.05 0.1755 SCRPPOR1 0.00000201 0.000000126 0.00000126 1.253 0.1128 on condition number: 267 9872, 6531.057		BL W_SFCS	0.00000051				0.45	0 0023
STL2_0 0.00000269 0.0000078 0.0000078 100000951 12.01 0.000 1HH/0RD1 -0.0000019 0.0000130 0.0000056 0.74 0.402 CDAE/POR1 0.00003469 0.00001172 0.0000054 0.402 SCREPOR1 0.0000359 0.00000043 0.00000146 1.85 0.1755 SCREPOR1 0.00000201 0.00000126 0.00000201 2.53 0.1121 on condition number: 267 9872, 6531.057 0.00000126 0.00000201 0.00000000000000000000000000000000000		BLW_SFCS REBLOWS	0.00000051	0 000130	0.0	6063748	9.45	
1HHP0RD1 -0.00000109 0.00000130 0.00000056 0.74 0.4024 COXEPOR1 0.00001469 0.00001172 0.00000146 0.00000130 0.000000146 0.00000130 SCRPART 0.00000059 0.000000130 0.000000146 1.85 0.1755 SCRPORT 0.00000201 0.00000126 0.00000201 2.53 0.1125 on condition number: 267 9872, 6531.057 0.000000126 0.000000126 0.000000126		BLW_SECS REBLOWS SIL2_1MP	0.00000051	0 000130	1 0.0	6063748 0000633	8.00	0.0051
CONEPORT 0 00003469 0.00001172 0 00000146 8.26 0 002 SCRIPRIO 0 00003469 0.00000043 0.00000146 1.85 0.1755 SCRIPRIE 0.00000201 0.00000126 0 0000201 2.53 0.1120 on condition number: 267 9872, 6531.057		BLW_SECS REBLOWS S1L2_1MP S1L2_0	0.00000051 0.00042456 -0.00000668	0 000130	11 0.0 36 9.0 78 0.0	6063748 0000633 0000951	9.45 8.00	0.0051
SCRIPTIG 0.00000059 0.00000172 0.00000146 1.85 0.1755 SCRIPTIG 0.00000201 0.00000126 0.00000201 2.53 0.1124 on Condition number: 267 9872, 6531.057		BLW_SFCS REBLOWS 51L2_1MP \$TL2_0 1HP0801	0.00000051	0 000130	11 0.0 36 0.0 78 0.0	6063748 6000633 0000951	9.45 8.00 12.01 0.74	0.0051
SCRIPTOR 0.00000201 0.000000126 0.00000126 2.53 0.1121		BLW_SFCS REBLOWS 51L2_1MP STL2_0 IMPORD1 FOREBOR3	0.00000051 0.00042456 -0.00000668 0.00000269 -0.00000269	0 000130 0.000002 0 000000 0 000001	11 0.0 36 0.0 78 0.0 10 0.0	0003748 0000633 0000951 0000056	9.45 8.00 12.01 0.70 8.75	0.0051 0.0006 0.4024
on condition number: 267 9872, 6531.057		BLU_SFCS REGLOUS STL2_1MP STL2_0 INPORDT COKEPORT	0.00000051 0.00042456 -0.00000668 0.00000269 -0.00000109 0.00003469 0.00003469	0 000130 0.000002 0 000000 0 000001 0.000011	11 0.0 36 0.0 78 0.0 10 0.0 72 0.6	0063748 0000633 0000951 0000056 0000056	9.45 8.00 12.01 0.70 8.76	0.0051 0.0006 0.4024 0.0034 0.1755
on Condition number: 267 9872, 6531.057		BLU_SFCS REGLOVS 51L2_1MP 51L2_0 IMPORDT COXEPOR1 5CRPRT0 5CRPRT0	0.00000051 0.00042456 -0.00000668 0.00000269 -0.00000269 0.00003469 0.00003469 0.00003469	0 000130 0 000002 0 0000001 0 0000011 0 0000011 0 0000011	11 0.0 36 0.0 78 0.0 30 0.0 72 6.6 43 0.6	6063748 0000633 0000951 0000056 0000056 0000056 0000146	9.45 8.00 12.01 0.70 8.76 1.85	0.0051 0.0006 0.4024 0.0034 0.1755
		BL W_SFCS REBLOWS S1L2_1HP S1L2_0 IHPORD1 COXEPOR1 SCRPPOR1 SCRPPOR1	0.00000051 0.00042456 -0.000066845 0.00006249 -0.00000249 0.00003469 0.00003469 0.00000201	0 000130 0 000002 0 000000 0 000001 0 000001 0 000000 0 0000000 0 0000001	11 0.0 36 9.0 78 0.0 10 0.0 72 6.6 43 0.6 26 6.0	0003748 0000633 0000951 0000056 0000056 0000146 0000146 0000146	9.45 8.00 12.01 0.70 8.76 1.65 2.53	0.0051 0.0006 0.4024 0.0034 0.1755 0.1128
	on condition number:	BLU_SFCS RFBLOWS SIL2_IMP SIL2_O IMPORDT COXEPORI SCRPPORI SCRPPORI 267 9872,	0.00000051 0.0000042456 -0.00000249 -0.00000249 0.000003469 0.000003469 0.000003469 0.00000201 6531.057	0 000130 0 000002 0 000000 0 0000011 0 0000011 0 000000 0 00000011	11 0.0 36 0.0 78 0.0 10 0.0 72 0.6 43 0.6 26 0.6	0003748 0000633 0000951 0000056 0000056 0000146 0000146 0000146	9.45 8.00 12.01 0.70 8.76 1.85 2.53	0.0051 0.0006 0.4024 0.6034 0.1755 0.1128

No other variable met the 0 5000 significance level for entry into the model.

Summary of Forward Selection Procedure for Dependent Variable TD_NITRO

	Variable	Number	Partial	Node 1		_	
Step	Entered	In	R4+5	8**5	C(p)	F	Prob/F
1	SCRPPORT	1	0.1531	0.1531	68 1176	48.6296	0.0001
2	COREPORT	s	0.0618	0 2149	38.2342	21 1082	0.0001
3	REBLOWS	3	0.0367	0.2516	26.0532	13 0991	0.0004
4	STL2_0	4	0750 0	0 2786	17 6315	9.9493	0 0018
5	SIL2 THP	5	0 0189	0 2976	12 3207	7.1404	0.0080
6	BLW_SECS	6	0.0135	0 3110	9 1236	5 1957	0.0240
7	50_TH9	7	0.0068	0.3178	8.5152	2.6433	0.1078
8	PHT_SECS	8	0.0090	0.3268	7 0446	3.4968	0 0626
2	PHT_GAS	9	0 0052	0.3319	7 0541	2 0131	0 1571
10	SCRPRIB	10	0 0050	0 3169	7.1100	1 9655	0 1621
11	HMPORDT	11	0.0018	0 3387	8 4243	0 7034	0 4024

Q-BOP Operations Source of Nitrogen in Steel Stepwise Regression Analysis (Initial Steps)

Stepwise Procedure for Dependent Variable FNITROGN

:op | Variable TD_NITRO Entered R-square = 0.27377079 C(p) = 26.28065373

		9F	Sum of Squares	Mean Square	F	Prob)F
	Regression	1	0.00098918	0.00008918	77.28	0.0001
	EFFOF	205	0.00023657	0.00900115		
	Total	206	0.00032575			
		Parameter	Standard	Type II		
	Varieble	Estimate	Error	Sum of Squares	F	Prob)F
	INTERCEP	0.00390564	0.00019588	0 00045879	397.57	0.0001
	TD_NITRO	0.54558354	0.06206227	0.00008918	77.28	0.0001
bunds on condition number:	ь	1				

lep 2 Variable ALBUNDPT Entered R-square = 0.34790457 C(p) = 4.87559151

		DF	Sum of Squares	Mean Square	F	Prob)F
	Regression	n 8	0.00011333	0.00005666	54.42	0.0001
	Error	204	0.00021242	0.0000104		
	Total	296	0.00032575			
		Parameter	Standard	Type 11		
	Variable	Estimate	Error	Sum of Squares	F	Prob)F
	INTERCEP	0.00367611	0.00019207	0.00038142	366.30	0.0001
	TD NITRO	0.47883501	0.06056073	0.00006510	62.52	0.0001
	ALBUNDPY	0.00085433	0.00017740	0.00002415	23.19	0.0001
bunds on condition number:	1.055275,	4.221102				

Step 3 Variable COKEPORT Entered R square # 0.35583525 C(p) = 4.37176541

	DF	Sum of Squares	Mean Square	F	Prob)F
Regress Error Total	203 · 203 · 206	0.00011591 0.00020984 0.00032575	0.00003864 0.00000103	37.38	0.0001
Variable	Paramoter Estimate	Standard Error	Type II Sum of Squares	F	Prob)F
INTERCEP TO_NITKO COREPORT ALBUNDPT	0 00338557 0.47815747 0.00008629 0.00076589	0.00026533 0.06034093 0.00005459 0.00018540	0.00016830 0.00006491 0.00000258 0.00001764	162.82 62.79 2.50 17.07	0.0001 0.0001 0.1155 0.0001
ounds on condition number	9.969555				

All variables left in the model are significant at the 0 \pm 500 level. No other variable met the 0.1500 \pm ignificance level for entry into the model.

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Summary of Stepwise Procedure for Dependent Variable FNITROGN

Step	Variable Entered Removed	Number In	Partial R**2	Model R**2	С (р.)	F	Prob≯F
1	TD_NITRO	1	0 2738	0.2738	26.2807	77 2800	0 0001
2	ALBUNDPT	2	0.0741	0.3479	4.8756	23 1918	0.0001
3	COKEPOR1	3	0.0079	0.3558	4.3718	2 4992	0.1155

Q-BOP Operations Source of Nitrogen in Steel Stepwise Regression Analysis (Final Equation)

(Final Regression Parameters Estimate)

		Anarysi	15 01	variance		
Source	DF	Sum Squar	of	Mean Square	F Value	Prob>F
Model		0.00010505	37 9	55033786-6	12.060	0.0001
Error	259	0.00020510	13 7	9189678E-7		
C fotal	270	0.000	31	1		
Root MSE		0.00089	R-	square	0.3387	
Dep Mean		0.00278	Ad	R-sq	0.3106	
C . V .	3	1.98396				

Parameter Eslimates

						Squared	Squared	Squar
	Parameter	Standard	1 for HO:			Semi-partial	Partial	Semi-parti
DF	Estimate	Error	Parameter=0	Prob > T	Type II SS	Corr Type I	Corr Type I	Corr Type
1	0.020273	0 00718958	2.820	0.0052	0.000006296			
1	-0.000011739	0.0000489	-2.399	0.0172	0.000004556	0.07506180	0.07506180	0.014688
1	8.5103373E-8	0.0000006	1.466	0.1438	0.000001703	0.01921367	0.02077292	0 005490
1	7.77938516-8	0.0000004	1.849	0.0656	0.000002708	0.01357348	0.01498632	0.008730
1	0.00000507	0.0000024	2.101	0.0366	0.000003497	0.00528929	0.00592869	0 011274
1	0.000425	0.00013811	3.074	0.0023	0.000007483	0.05412416	0.06102885	024126
1	-0.000006684	0.00000236	-2.828	0.0051	0.000006332	0.04018033	0.04825089	0 020414
1	888500000.0	0.0000078	3.465	0.0006	0.000009508	0 02684178	0.03386730	0.030656
1	-0.000001091	0 00000130	-0.839	0.4024	0.000000557	0.06274547	0.08194358	0 001795
1	0.000034688	0.00001172	2.960	0.0034	0.000006940	0.02620840	0.03728239	0.022374
1	0.00000591	0 00000043	1.359	0.1755	0.000001462	0.00900990	0.01331326	0.004712
1	0.000002006	0.0000126	1.591	0.1128	0.000002005	0.00646535	0.00968227	0 006465
	Squared							
	Partial		Variance					
DF	Corr Type []	Tolerance	Inflation					
1			0.00000000					
1	0.02172957	0.00373152	267.98715206					
1	0 00823416	88507700.0	129.82165465					
1	0.01303099	0.00561505	178.09282603					
1	0.01676378	0.51423378	1.94464082					
1	0.03520059	0.49976416	2.00094379					
	DF 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Parameter Estimate 1 -0.020273 1 -0.000011739 1 8.5103373E-8 1 0.00000507 1 0.00000507 1 0.00000507 1 0.000005684 1 0.000002688 1 0.000002688 1 0.000002688 1 0.00000501 1 0.000002006 Squared Partial DF Gorr Type II 1 0.02172957 1 0.01330399 1 0.013676378 1 0.01676378 1 0.03520059	Parameter Estimate Standard Error 1 0.020273 0.00718958 1 -0.000011739 0.00000489 1 8.5103373E-8 0.00000064 1 0.00000507 0.00000024 1 0.000000684 0.00000236 1 0.000002688 0.000001381 1 -0.00001691 0.00000172 1 0.00000591 0.00000131 1 0.00000588 0.0000172 1 0.00000591 0.00000172 1 0.00000591 0.00000172 1 0.00000591 0.00000172 1 0.00000591 0.00000172 1 0.00000591 0.00000172 1 0.000002066 0.00000126 Squared Partial DF DF Gorr Type II Tolerance 1 0.01373152 0.00373152 1 0.01373099 0.0551505 1 0.03520059 0.4976416	Parameter Estimate Standard Error 1 for H0: Parameter=0 1 0.020273 0.00718958 2.820 1 -0.000011739 0.0000489 -2.399 1 8.5103373E-8 0.0000006 1.466 1 7.7793851E-8 0.00000024 2.101 1 0.00000507 0.0000024 2.101 1 0.000006684 0.00000236 -2.828 1 0.000002688 0.00000130 -0.839 1 0.000002668 0.00000172 2.960 1 0.000002066 0.00000126 1.591 5quarcd Partial Variance DF Gorr Type II Tolerance Inflation 1 0.01303099 0.0051505 178.09282603 1 0.01303099 0.0561505 178.09282603 1 0.01576378 0.5142378 1.94464082	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Parameter Estimate Standard Error 1 for H0: Parameter=0 Prob > [T] Type II SS 1 0.020273 0.00718958 2.820 0.0052 0.000006296 1 -0.000011739 0.00000489 -2.399 0.0172 0.000004556 1 8.5103373E-8 0.0000006 1.466 0.1438 0.000001703 1 7.7793851E-8 0.00000024 2.101 0.0356 0.000003497 1 0.00000507 0.00000246 -2.828 0.0051 0.00000783 1 -0.000016684 0.00000236 -2.828 0.0051 0.00000783 1 -0.000001688 0.00000130 -0.839 0.40624 0.00000597 1 0.00000251 0.00000172 2.960 0.0034 0.000000594 1 0.00000206 0.00000126 1.591 0.1128 0.00000205 1 0.00000206 0.0000126 1.591 0.1128 0.00000205 1 0.00000206 0.0000126 1.591 0.1128 0.00000205 <td>Parameter Estimate Standard Error I for H0: Parameter=0 Prob [T] Type II SS Semi-partial Corr Type I 1 0.020273 0.00718958 2.820 0.0052 0.00006296 1 -0.000011739 0.0000489 -2.399 0.0172 0.00004556 0.07506180 1 8.5103373E-8 0.0000006 1.466 0.1438 0.000002703 0.01921367 1 7.7793851E-8 0.00000024 2.101 0.0366 0.00003497 0.09528229 1 0.000006684 0.00000236 -2.828 0.0051 0.00000532 0.0418033 1 -0.000001091 0.0000078 3.465 0.00000557 0.0624547 1 -0.00000191 0.0000078 3.465 0.00000557 0.06264178 1 -0.00000191 0.00000172 2.960 0.0034 0.00000557 0.06264178 1 0.000000591 0.00000126 1.591 0.1725 0.000001462 0.00900090 1 0.000000591 0.000000126 1.591</td> <td>Parameter Estimate Standard Error I for H0: Parameter=0 Prob > [T] Type II SS Semi-partial Corr Type I Partial Partial 1 0.020273 0.00718958 2.820 0.0052 0.000006296 .<</td>	Parameter Estimate Standard Error I for H0: Parameter=0 Prob [T] Type II SS Semi-partial Corr Type I 1 0.020273 0.00718958 2.820 0.0052 0.00006296 1 -0.000011739 0.0000489 -2.399 0.0172 0.00004556 0.07506180 1 8.5103373E-8 0.0000006 1.466 0.1438 0.000002703 0.01921367 1 7.7793851E-8 0.00000024 2.101 0.0366 0.00003497 0.09528229 1 0.000006684 0.00000236 -2.828 0.0051 0.00000532 0.0418033 1 -0.000001091 0.0000078 3.465 0.00000557 0.0624547 1 -0.00000191 0.0000078 3.465 0.00000557 0.06264178 1 -0.00000191 0.00000172 2.960 0.0034 0.00000557 0.06264178 1 0.000000591 0.00000126 1.591 0.1725 0.000001462 0.00900090 1 0.000000591 0.000000126 1.591	Parameter Estimate Standard Error I for H0: Parameter=0 Prob > [T] Type II SS Semi-partial Corr Type I Partial Partial 1 0.020273 0.00718958 2.820 0.0052 0.000006296 .<

APPENDIX 1

CONVENTIONAL DESIGNATIONS

HEATTIME - Heat time, sec; DOWNTIME - Time between heats, sec HMPORDT - Hot metal consumption per ordered ton of steel, 1b/ton; HM_TEMP - Hot metal temperature, F; HM_C, HM_MN, HM_SI, HM_P, HM_S - Hot metal chemical composition, %; SCRPPORT - Scrap consumption per ordered ton of steel, 1b/ton; HVYSCRPR - Percent of heavy scrap, %; LTSCRPR - Percent of light scrap, %; SCRPRTO = SCRPPORT*HVYSCRPR/LTSCRPR; COKEPORT - Coke consumption per ordered ton of steel, 1b/ton; PHT SECS - Preheat time, sec; PHT_GAS - Preheat gas consumption, scf; PHT 02 - Preheat oxygen consumption, scf; TO2PORT - Total oxygen consumption per ordered ton of steel, scf/ton; TN2PORT - Total nitrogen consumption per ordered ton of steel, scf/ton; TGASPORT - Total gas consumption per ordered ton of steel, scf/ton; LIMEPORT - Total lime consumption per ordered ton of steel, lb/ton; DOLOPORT - Total dolomite consumption per ordered ton of steel, scf/ton; BLW_SECS - Total blowing time, sec; BLWSPORT - Total blowing time per ordered ton of steel, sec/ton; REBLOWS - number of reblows; TD_CARBON, TD_MANG, TD_PHOS, TD_SULF, TD_NITRO - Turndown chemical analysis of steel, %; STL2 TMP - Turndown steel temperature, F; STL2_0 - Turndown oxygen ppm in steel; TAP_SECS - Tapping time, sec; ING_WGT, BUTT_WGT, MOD_WGT, ORD_WGT - Actual ingot weight, butt weight, model weight and ordered weight of steel, 1b; HCFEMNPT - Ladle additions of high carbon FEMN per ordered ton of steel, lb/ton; SIMNPORT - Ladle additions of SIMN per ordered ton of steel, lb/ton; FESI75PT - Ladle additions of FESI per ordered ton of steel, lb/ton; ALBUNDPT - Ladle additions of AL bundle per ordered ton of steel, lb/ton; COKEPORT - Ladle additions of coke per ordered ton of steel, lb/ton; AR_MINS - Argon rinse time, min; POR_SECS - Pouring time of ingots, sec; TEMP - Temperature of steel after ladle additions, F; O2_PPM - Oxygen ppm in steel after ladle additions; FCARBON, FMANG, FSILICON, FPHOS, FSULFUR, FNITROGEN - Final chemical analysis of steel, %. The sample location is taken during the teeming of second ingot of each heat. LCARBON, LMANG, LSILICON, LPHOS, LSULFUR, LNITROGEN - Ladle test of chemical analysis of steel, %.

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