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49th Rolling Seminar - Processes, Rolled and Coated Products

SPEED INCREASING AT CM2 THROUGH THE ELIMINATION OF CBS SCRATCH GOUGE[1]

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Abstract

Anticipating market demands for fiscal year 2011/12 an extra 10 kt per year output in the Cold Rolling area was one of the main targets for "Novelis do Brasil". From the cold rolling perspective this was a quite challenging number considering the speed constraints at CM2 (Cold Mill #2), main process route for canning finishing passes, where average rolling speed was limited to 930 mpm due to a severe surface defect and secondary bearing issues. Historically CM2 had three main speed constraints(1): "Scratch gouge" (surface defect); work roll axial thrusting; work roll chocks overheating. The most severe one was the scratch gouge defect, because its incidence was a day-to-day routine and the average monthly rejection was 187 t. This defect is a more pronounced manifestation of wear and is formed during coiling when each new layer of aluminum lands on the already coiled metal. Due to the dynamics of coiling, some air is unavoidably wrapped into the coil. This air gap between the sheets is expected to persist for several laps into the coil and when this occurs the coiling stress is supported only by the highest asperities of the metal surface(2). Thus any transverse or longitudinal vibrations may cause wear at high stress points. This project outlined the mechanical initiation of the defect and confirmed its mechanism. Discussions of the proposed solutions are highlighted in this presentation.

Key words: Cold rolling; Surface defect; Aluminum flat rolling.

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1 INTRODUCTION

Anticipating market demands for fiscal year 2011/12 an extra 10 kt per year output in the Cold Rolling area was one of the main targets for "Novelis do Brasil". From the cold rolling perspective this was a quite challenging number considering the speed constraints at CM2 (Cold Mill #2), main process route for canning finishing passes, where average rolling speed was limited to 930 mpm due to a severe surface defect and secondary bearing issues.

Historically CM2 had three main speed constraints: "Scratch gouge" (surface defect); work roll axial thrusting; work roll chocks overheating. The most severe one was the scratch gouge defect, because its incidence was a day-to-day routine and the average monthly rejection was 187 t. This defect is a more pronounced manifestation of wear and is formed during coiling when each new layer of aluminum lands on the already coiled metal. Due to the dynamics of coiling, some air is unavoidably wrapped into the coil. This air gap between the sheets is expected to persist for several laps into the coil and when this occurs the coiling stress is supported only by the highest asperities of the metal surface. Thus any transverse or longitudinal vibrations may cause wear at high stress points.

The project goal was to achieve an extra 10 kt per year output in the Cold Rolling area through the elimination of speed constraints related to scratch gouge defects and other secondary speed constraints.

2 MATERIAL AND METHODS

Lean Six Sigma methodologies and tools were applied to identify the defect mechanism, propose solutions and achieve project target. The first step was a complete characterization of the defect and literature research(1-3) to develop solid background knowledge for discussions around the defect mechanism and potential solutions.

2.1 Defect Characterization

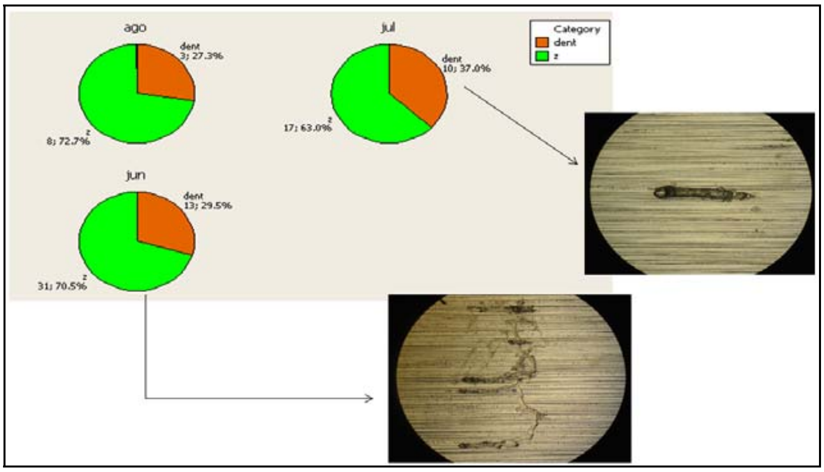
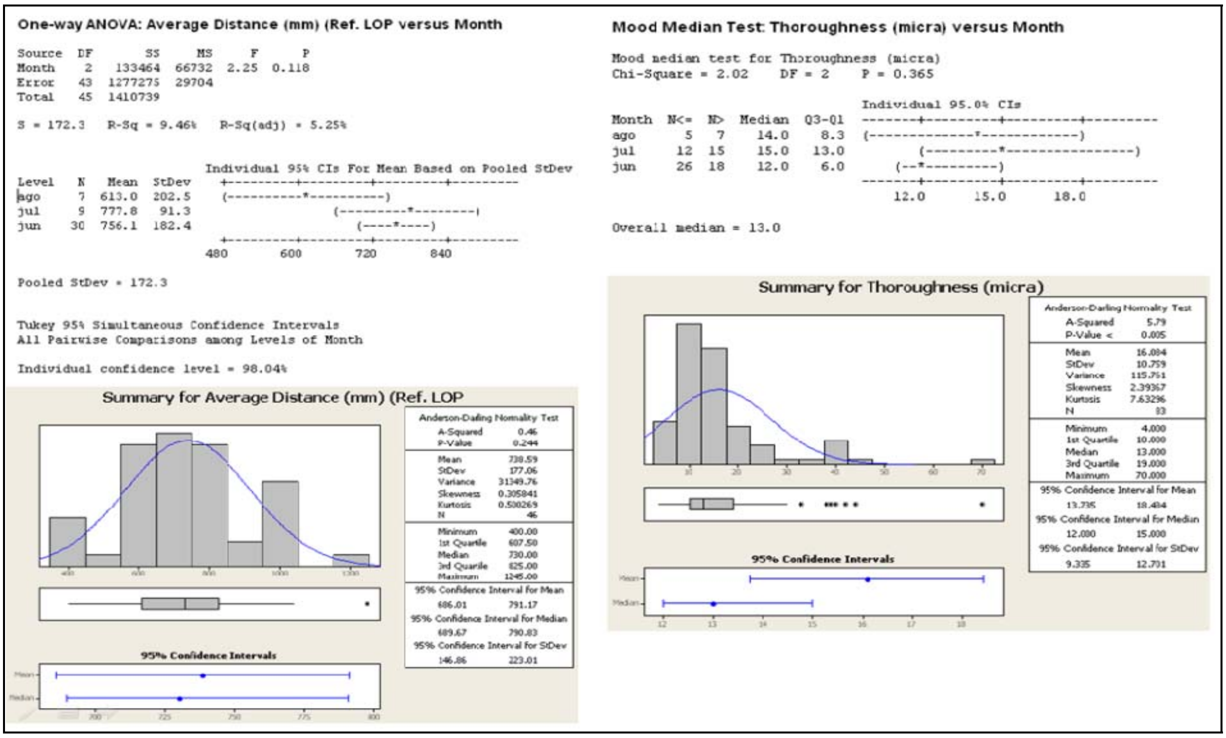


Figure 1 – Scratch gouge type determination: 70% Chinese Script and 30% Scratch Dent.



One-way ANOVA: Average Distance (mm) (Ref. LOP versus Month

```
Source  DF       SS     MS     F      P
Month    2   133464  66732  2.25  0.118
Error   43  1277275  29704
Total   45  1410739

S = 172.3   R-Sq = 9.46%   R-Sq(adj) = 5.25%


                            Individual 95% CIs For Mean Based on Pooled StDev
Level   N   Mean  StDev   +---------+---------+---------+---------
ago     7  613.0  202.5   (----------*----------)
jul     9  777.8   91.3                  (---------*--------)
jun    30  756.1  182.4                      (----*----)
                          +---------+---------+---------+---------
                         480       600       720       840

Pooled StDev = 172.3


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Month

Individual confidence level = 98.04%
```

Summary for Average Distance (mm) (Ref. LOP

Anderson-Daling Normality Test	
A-Squared	0.46
P-Value	0.244
Mean	738.59
StDev	177.06
Variance	31349.76
Skewness	0.305841
Kurtosis	0.500269
N	46
Minimum	400.00
1st Quartile	607.50
Median	730.00
3rd Quartile	825.00
Maximum	1245.00
95% Confidence Interval for Mean	
686.01	791.17
95% Confidence Interval for Median	
689.67	790.83
95% Confidence Interval for StDev	
146.86	223.01

Mood Median Test: Thoroughness (micra) versus Month

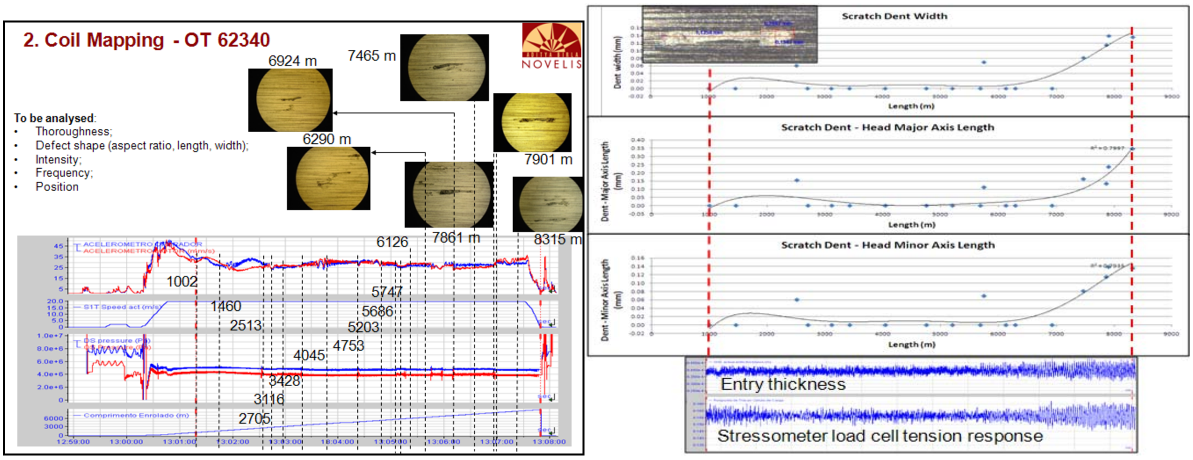
```
Mood median test for Thoroughness (micra)
Chi-Square = 2.02    DF = 2    P = 0.365

                                 Individual 95.0% CIs
Month  N<=  N>  Median  Q3-Q1  -------+---------+---------+---------
ago      5   7    14.0    8.3  (-------------*------------)
jul     12  15    15.0   13.0        (---------*----------------)
jun     26  18    12.0    6.0     (--*---------)
                               -------+---------+---------+---------
                                    12.0      15.0      18.0

Overall median = 13.0
```

Summary for Thoroughness (micra)

Anderson-Darling Normality Test	
A-Squared	5.79
P-Value <	0.005
Mean	16.084
StDev	10.759
Variance	115.751
Skewness	2.39367
Kurtosis	7.63296
N	83
Minimum	4.000
1st Quartile	10.000
Median	13.000
3rd Quartile	19.000
Maximum	70.000
95% Confidence Interval for Mean	
13.735	18.484
95% Confidence Interval for Median	
12.000	15.000
95% Confidence Interval for StDev	
9.335	12.701

Figure 2 – Scratch gouge characterization: Left – Average distance from operator side edge; Right – Average indentation depth.

A coil was rolled in high speed (1180 mpm) to produce a severe scratch gouge and then it was mapped to observe how the defect evolved through the coil.

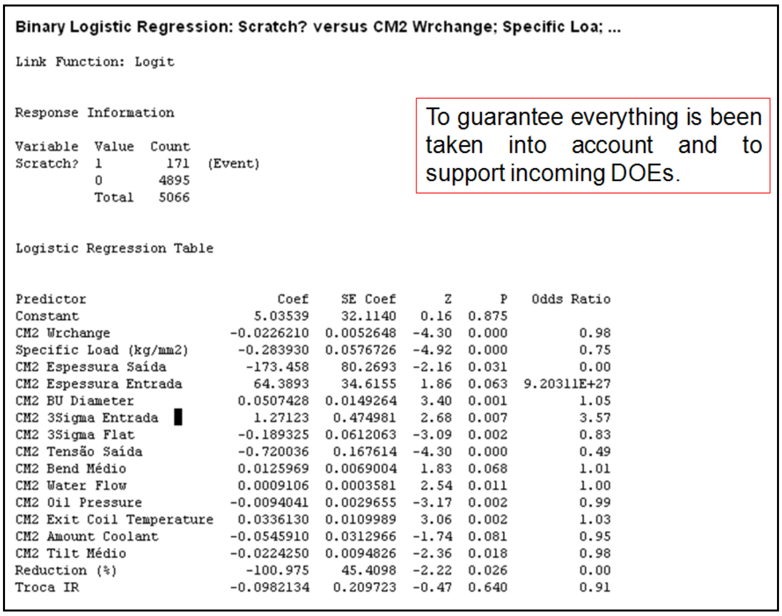


2. Coil Mapping - OT 62340

To be analysed:
- Thoroughness;
- Defect shape (aspect ratio, length, width);
- Intensity;
- Frequency;
- Position

Figure 3 – High speed test and coil mapping. Left – Coil mapping; Right – Defect dimensions evolution through coil length.

Binary logistic regression was conducted to elect the main inputs for the scratch gouge initiation and to support potential solutions.



Binary Logistic Regression: Scratch? versus CM2 Wrchange; Specific Loa; ...

```
Link Function: Logit


Response Information

Variable  Value  Count
Scratch?  1        171  (Event)
          0       4895
          Total   5066


Logistic Regression Table


Predictor                        Coef    SE Coef      Z      P   Odds Ratio
Constant                      5.03539    32.1140   0.16  0.875
CM2 Wrchange               -0.0226210  0.0052648  -4.30  0.000         0.98
Specific Load (kg/mm2)      -0.283930  0.0576726  -4.92  0.000         0.75
CM2 Espessura Saída          -173.458    80.2693  -2.16  0.031         0.00
CM2 Espessura Entrada         64.3893    34.6155   1.86  0.063  9.20311E+27
CM2 BU Diameter             0.0507428  0.0149264   3.40  0.001         1.05
CM2 3Sigma Entrada            1.27123   0.474981   2.68  0.007         3.57
CM2 3Sigma Flat             -0.189325  0.0612063  -3.09  0.002         0.83
CM2 Tensão Saída            -0.720036   0.167614  -4.30  0.000         0.49
CM2 Bend Médio              0.0125969  0.0069004   1.83  0.068         1.01
CM2 Water Flow              0.0009106  0.0003581   2.54  0.011         1.00
CM2 Oil Pressure           -0.0094041  0.0029655  -3.17  0.002         0.99
CM2 Exit Coil Temperature   0.0336130  0.0109989   3.06  0.002         1.03
CM2 Amount Coolant         -0.0545910  0.0312966  -1.74  0.081         0.95
CM2 Tilt Médio             -0.0224250  0.0094826  -2.36  0.018         0.98
Reduction (%)                -100.975    45.4098  -2.22  0.026         0.00
Troca IR                   -0.0982134   0.209723  -0.47  0.640         0.91
```

To guarantee everything is been taken into account and to support incoming DOEs.

Figure 4 – Binary logistic regression.

3 DISCUSSION

Building a solid understanding of the issue the team was able to clearly build a defect model to illustrates the defect initiation mechanism and use it as a basis for solutions generation.

3.1 Defect Model

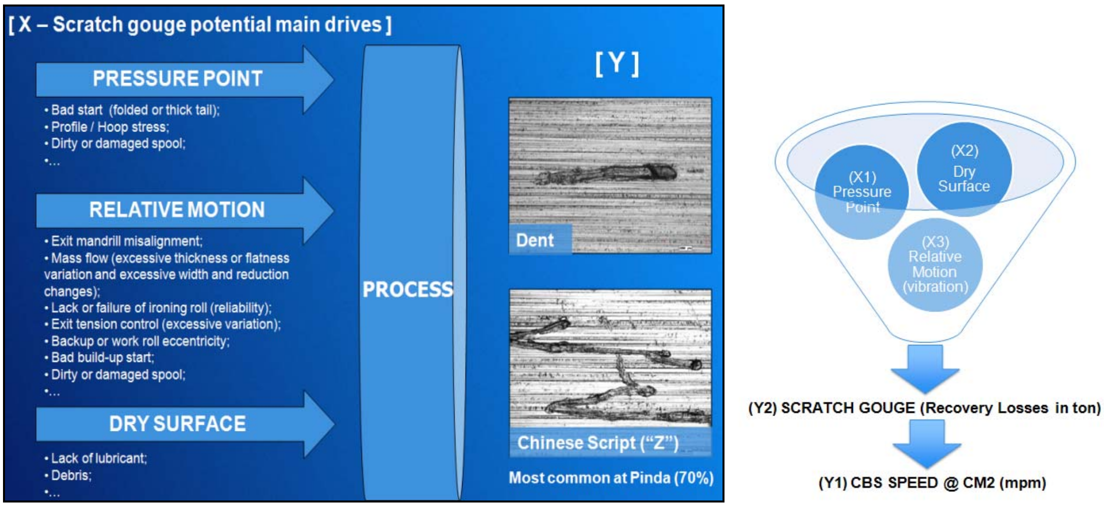


Figure 5 – Left: Scratch gouge mechanical initiation model; Right: Key project metrics.

Once the defect model and the key variable were identified a series of tests were conducted to define the best solutions to drive the desired results. The main solutions are listed below divided by the mechanism field:

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3.2 Proposed Solutions

3.2.1 Solutions related to pressure point (X1)

- New ironing roll coverage design: A series o modeling conducted at NGTC (Novelis Global Technology Centre) to determine an ironing hardness able to absorb higher levels of vibration (one of the main actions).

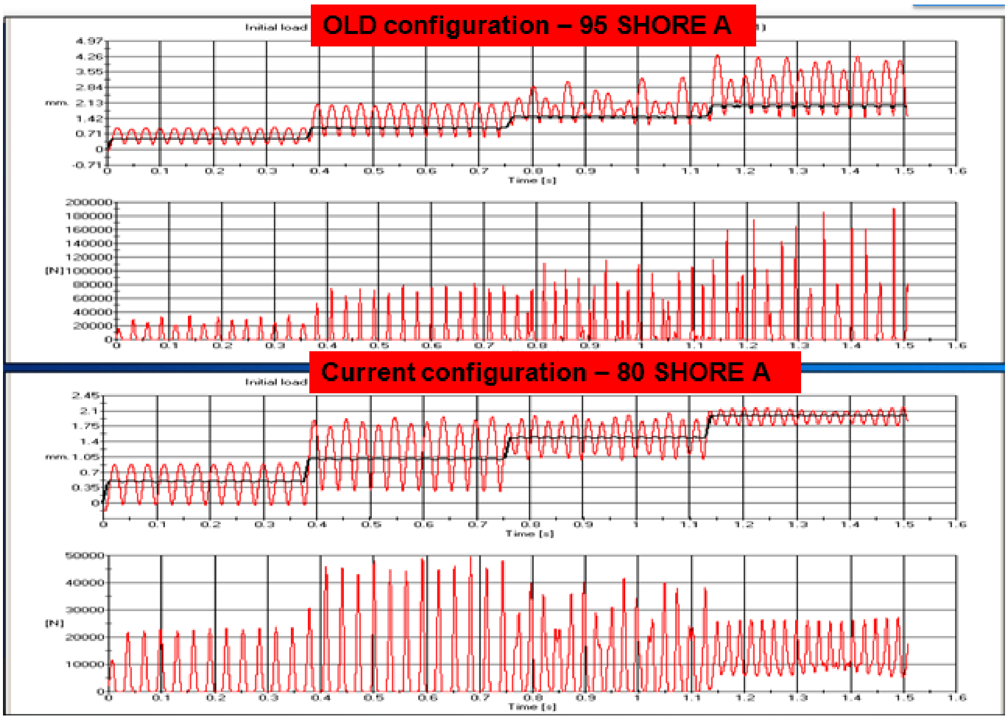


Figure 6 – Top: Modelling of old configuration considering a harder coverage; Bottom: Modeling of the current configuration considering a softer coverage.

- Ironing roll coverage width increased from 1000 mm to 1200 mm following network information from Logan plant (Don Miller – Cold Rolling Automation). This achieve a better force distribution in minimize air entrapments (one of the main actions).
- Acquisition of 250 new steel spools.
- Implementation of on-line monitoring system for on-line temperature and vibration measurement of the ironing roll.

Monitoramento de Scratch

OT 29842
Velocidade Laminador 709 m/min
Diametro Ironning Roll 709

Freq. Backup 1.2 Hz
Freq. Work
Freq. Ironning Roll 2.2 Undefined
Freq. Enrolador 2.2 Undefined
Freq. Desenrolador 2.2 Undefined

Figure 7 – Ironing roll monitoring system.

3.2.2 Solutions related to relative motion/vibration (X2)

- Work roll roughness increased from 18-21 µin to 21-24 µin. This provides better grip between laps and on the exit deflector, providing better stability to the strip, thus avoiding relative motion and surface wear (one of the main actions).
- After a series of vibration measurements the exit mandrill was replaced. The measurements identified frequency maps characteristically from rotational looseness and damaged bearings.

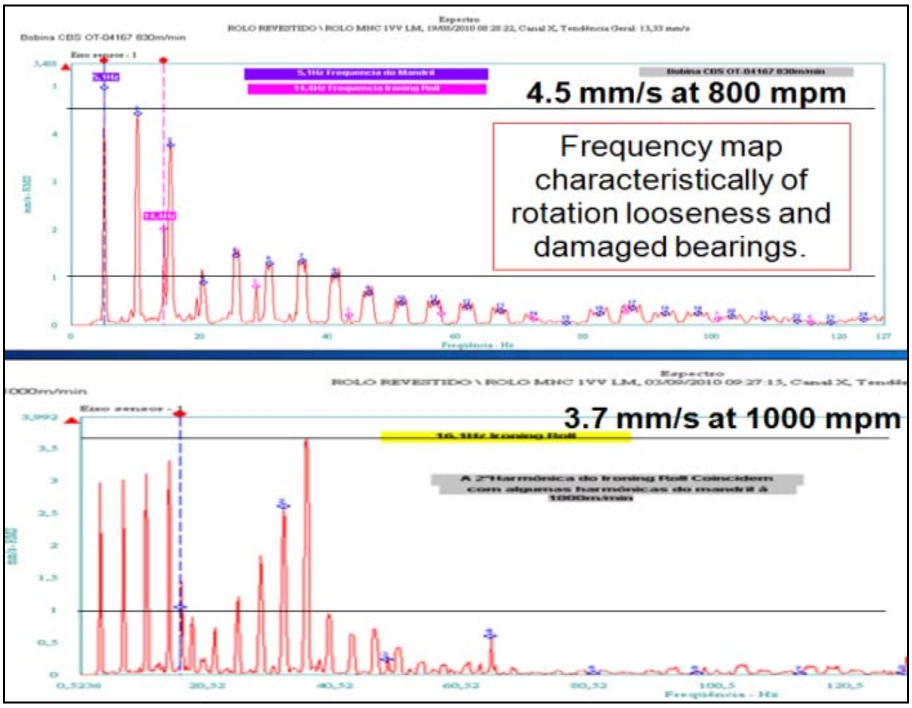


Figure 8 – Exit mandrill vibration maps. Top: Before replacement; Bottom: After replacement.

3.2.3 Solutions related to dry surface (X3)

- Increased the content of C16 alcohol in the additive package from 47% to 57%. Increased strip lubricity during coiling as C16 takes more time to volatize than C14.(3)

3.2.4 The RIE event: solving secondary speed constraints

The RIE event was prepared with a series of conference calls from February to March 2011 with participants from six different sites. Extensively pre-work was conducted in other to prepare measurement system and testing equipments for the RIE week. Testing equipment where locally rented, and also shipped from sites in North America and Europe. An impressive mobilization was achieved. The RIE was finally conducted from March 14th to 18th 2011.

The RIE team was divided into two different teams:

- bearing team: focused on chock and bearing overheating.
- mill window team: focused on axial thrusting.

The main tool used during the RIE was iBA analyzer associated with position transducers to identify the behaviors of the chocks inside the mill. Also extensively brainstorming and DOE where conducted during this event.

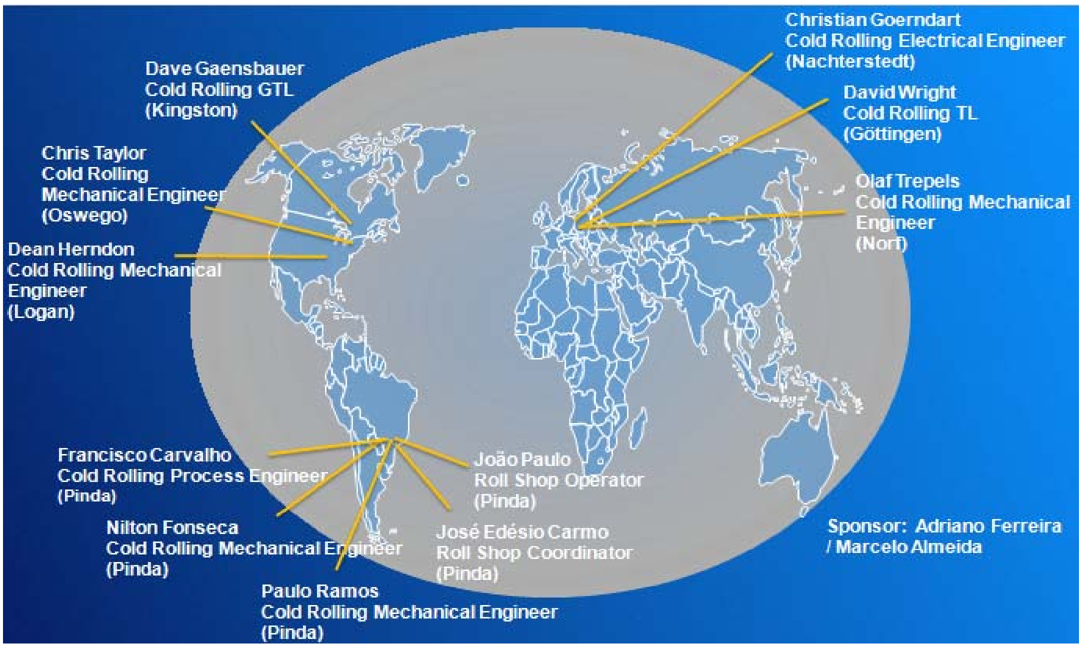


Figure 9 – Worldwide team.

4 RESULTS

The project results are kept very stable, scratch gouge incidence has been maintained for several months and average speed continues to increase every month. Any special cause is identified and solved fast as the mechanism for the main speed constraints are well know and controlled now.

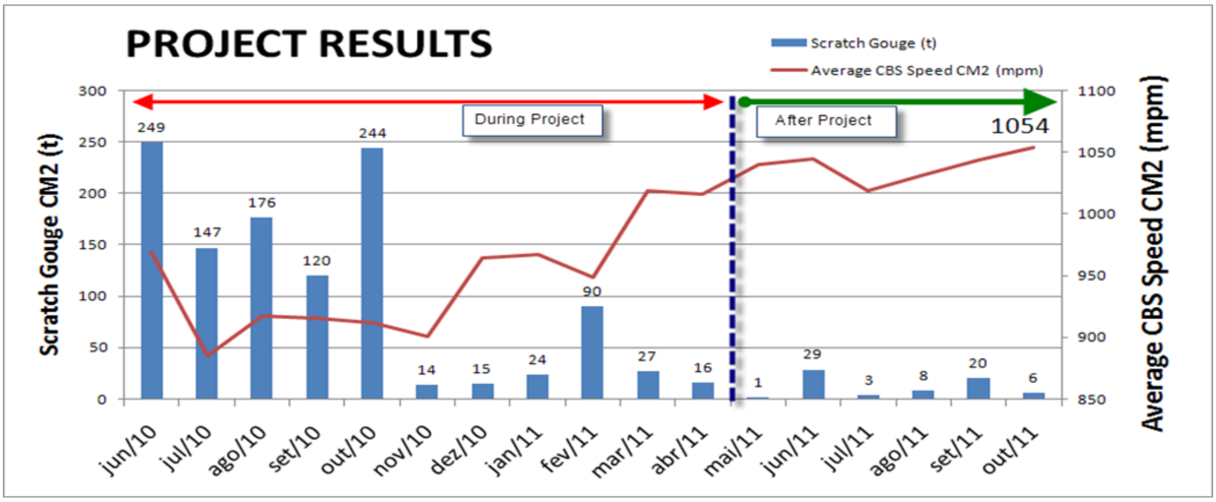


Figure 10 – Rejection (in tons) during and after the Project.

- Recovery losses: Decreased from 187 ton/month to 15 ton/month.
- Average CBS speed: Increased from 930 mpm to 1054 mpm.
- Cold rolling capacity improvement: 12000 tons/yr (goal was 10000 tons/yr).
- EBTDA generation: US$ 6 million (considering lowest margin product: CBS).

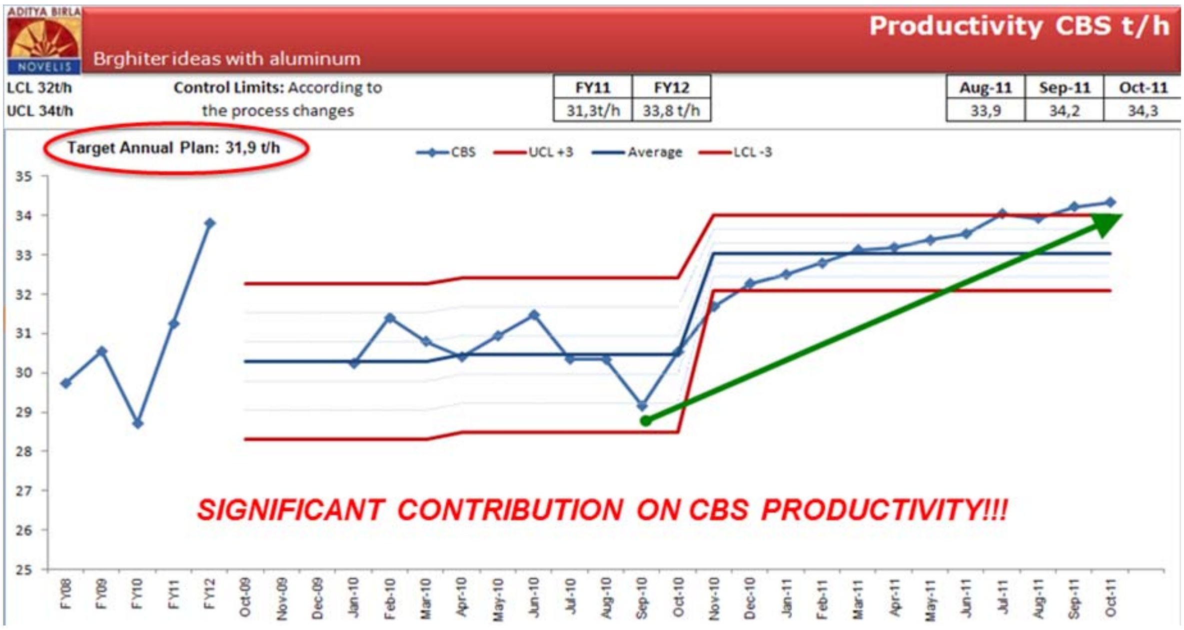
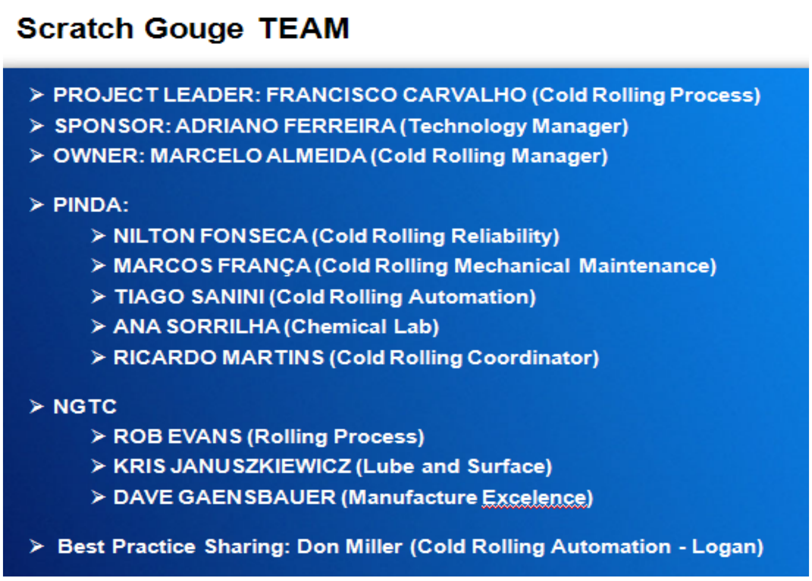


Figure 11 – Productivity (in tons/hour) during and after the project.

Acknowledgements

Would like to acknowledge the extensive participation of technical team at "Novelis do Brasil Ltda" and several other contributors at Novelis Inc. that also contributed for the Project.



Scratch Gouge TEAM

- PROJECT LEADER: FRANCISCO CARVALHO (Cold Rolling Process)
- SPONSOR: ADRIANO FERREIRA (Technology Manager)
- OWNER: MARCELO ALMEIDA (Cold Rolling Manager)

- PINDA:
    - NILTON FONSECA (Cold Rolling Reliability)
    - MARCOS FRANÇA (Cold Rolling Mechanical Maintenance)
    - TIAGO SANINI (Cold Rolling Automation)
    - ANA SORRILHA (Chemical Lab)
    - RICARDO MARTINS (Cold Rolling Coordinator)

- NGTC
    - ROB EVANS (Rolling Process)
    - KRIS JANUSZKIEWICZ (Lube and Surface)
    - DAVE GAENSBAUER (Manufacture Excelence)

- Best Practice Sharing: Don Miller (Cold Rolling Automation - Logan)

Figure 12 – Scratch Gouge Team.

RIE TEAM

- TEAM Mill WINDOW:
  - Chris Taylor (Oswego Plant – Cold Rolling Mechanical Engineer)
  - Dave Gaensbauer (Manufacture Excellence – Cold Rolling GTL)
  - Francisco Carvalho (Pinda Plant – Cold Rolling Process Engineer)
  - Jorge Schaefer (Pinda Plant – Venus Project)
  - Leandro Ribeiro (Pinda Plant – Reliability Technician)
  - Olaf Trepels (Norf – Cold Rolling Mechanical Engineer)
- TEAM BEARING:
  - Christian Goerndart (Nachterstedt – Cold Rolling Electrical Engineer)
  - David Wright (Manufacture Excelence – Cold Rolling TL)
  - Dean Herndon (Logan Plant – Cold Rolling Mechanical Engineer)
  - João Paulo (Pinda Plant – Roll Shop Operator)
  - José Edésio (Pinda Plant – Roll Shop Coordinator)
  - Nilton Fonseca (Pinda Plant – Cold Rolling Reliability Leader)
  - Ricardo Martins (Pinda Plant – Cold Rolling Coordinator)
- SUPPORT TEAM:
  - Sérgio Ferreira (Pinda Plant – Black Belt)
  - Paulo Ramos (Pinda Plant – Cold Rolling Mechanical Engineer)
  - Marcelo Andrade (Pinda Plant – Cold Rolling Electrical Engineer)
  - Ademir Alves (Pinda Plant – Cold Rolling Electrical Technician)
  - Newton Pessenti (Pinda Plant – Venus Project)

Figure 13 – RIE Team.

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