Improving EAF Meltshop Operations: Multiplant Transformational Consulting in Gerdau Long Brazil by Badische






During the challenging landscape of the COVID-19 pandemic in September 2020, Gerdau Long Brazil and Badische Stahl-Engineering (BSE) embarked on a collaborative journey with the goal of improving operations and impartially assessing equipment conditions in the meltshops at Cosigua (Rio de Janeiro), Açonorte (Recife) and Cearense (Maracanaú). This article explores both the Badische and Gerdau approaches to this consulting partnership including benchmarking, online coaching, on-site investigation, action plans and specific seminars at Badische Stahlwerke in Germany. It chronicles the preconsultation challenges faced by the three plants, details the strategic interventions employed and showcases the transformations achieved.

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Introduction

Gerdau Long Brazil (GAB), a major steel producer in Brazil primarily utilizing electric arc furnace (EAF)-based meltshops, has positioned itself as a global leader in steel production and innovation since its establishment in 1901. Demonstrating a dedicated focus on corporate social responsibility and environmental sustainability, Gerdau actively engages in initiatives fostering community development, education and environmental stewardship, aligning its operational strategies with robust principles of social and environmental responsibility.

Complementing this industrial landscape is Badische Stahl-Engineering (BSE), the consulting arm of Badische Stahlwerke (BSW) located in Kehl, Germany. The Badische Group, overseeing BSW, disseminates its extensive knowledge and operational insights through BSE (Badische Stahl-Engineering), its engineering and consulting branch, to steel plants worldwide.

Central to the core philosophy of Badische is the recognition that the human operator, characterized by comprehensive training and high value, significantly contributes to the operational success of a steel plant, accounting for up to 80% of overall efficacy. This principle has been systematically and successfully applied across various operational approaches, defining the operational excellence of BSW.

Motivated by the impactful operational philosophy of Badische, GAB has made the strategic decision to collaborate with BSE. This partnership signified a joint commitment to prioritize the human factor, acknowledging its pivotal role in shaping and optimizing steel plant operations. In this technical discourse, Badische and GAB delved into the intricacies of this collaboration, exploring how the integration of principles related to the human element enhances operational efficiency and fosters innovation within the steel production domain.

Project Scope

For the work, Gerdau has selected three mini-mills in Brazil, located in different regions and with different equipment setups, making the project even more diverse:

- Gerdau Cosigua, located in Rio De Janeiro state, is equipped with a 100-ton EAF, ladle furnace (LF) and a 6-strand caster producing 130-mm square and 160-mm square billets (Fig. 1).
- Gerdau Açonorte, located in Pernambuco state, equipped

Figure 1

Gerdau Cosigua's 100-ton electric arc furnace (EAF).

Figure 2

Gerdau Açonorte's 25-ton EAF.

with a 25-ton EAF, LF and 2-strand caster producing 130-mm square billets (Fig. 2).

- Gerdau Cearense, located in Ceará state, equipped with a 20-ton EAF, LF and 2-strand caster producing 100-mm square billets (100 mm at the time of the project, currently 130 mm) (Fig. 3).

The initial step in this process involved the client approaching BSE with the aim of exploring potential improvements through a consultancy and training project. The proposed consultancy approach encompasses several key objectives:

a. Uncover and pinpoint opportunities for efficiency gains within the existing operational framework.

b. Conduct a comprehensive evaluation of equipment conditions to ascertain their current state and performance.

c. Identify and address any maintenance or investment backlog that may be hindering optimal functionality.

d. Provide unbiased and impartial suggestions for a phased and strategic modernization of the equipment, presenting recommendations from a neutral standpoint. This stepwise approach aimed to facilitate an informed decision-making process for the client's enhancement initiatives.

Approach

Given the global COVID-19 outbreak and the resulting travel restrictions, GAB and BSE adopted a revised consultancy strategy to provide immediate support to GAB while travel bans were in effect. BSE initiated an in-depth

Figure 3

Gerdau Cearense's 20-ton EAF.

desktop analysis, followed by a series of video conferencing sessions. The goal was to pinpoint areas for improvement, identifying key focus points for on-site investigation, and offer technical guidance and coaching through video conferencing sessions. In total there were nine video conference sections, with action plans and follow-ups.

Right after the video conferences, BSE orchestrated a comprehensive on-site investigation strategy. The expert team, led by three project managers (Fig. 4) and consisting of six specialists, conducted three successive

investigations across GAB's steel plants, delving into distinct facets crucial for process optimization.

Expert team from BSE and their on-site investigation approach:

1. Material Flow and Logistics Expertise:
   - Scrap bucket loading and crane movements analysis.
   - In-depth examination of material flow within the meltshop, encompassing liquid steel, ladle and tundishes.
   - Evaluation of billet handling processes.
   - Assessment of scrap yard and meltshop layout, coupled with bottleneck analysis.
2. EAF Process Optimization Specialist:
   - Scrutiny of EAF operation procedures.
   - Analysis and optimization of charge mix.
   - Profiling of electrical and chemical energy consumption.
   - Investigation into consumption figures and identification of delays and quality issues.
   - Management of EAF refractories and slag analysis for improvement.
3. LF and Continuous Caster Machine (CCM) Process Enhancement Specialist:
   - Alloying practices and LF operation assessment.
   - Ladle handling examination, covering plug, plates and nozzle aspects.
   - Quality issues related to secondary metallurgy.
   - Ladle and tundish refractory practices.
   - Comprehensive analysis of CCM operations, casting parameters and delays.
4. Mechanical Equipment and Maintenance Specialist:
   - Evaluation of major mechanical equipment across EAF, LF and CCM.
   - Identification and mitigation of mechanical delays.
   - Implementation of a preventive maintenance approach.
   - Documentation and management of drawings and spare parts.
5. Electrical Equipment and Maintenance Specialist:
   - Measurement of EAF and LF power input.
   - Inspection of major electrical equipment, including substations and transformers.
   - Analysis and resolution of electrical delays.
   - Assessment of automation processes.
   - Implementation of preventive maintenance strategies and spare part management.
1. Management Approach and Organization Specialist:
   - Examination of management approach and organizational structure.
   - Evaluation of motivation, qualification and manning levels.
   - Cost analysis and benchmarking practices.

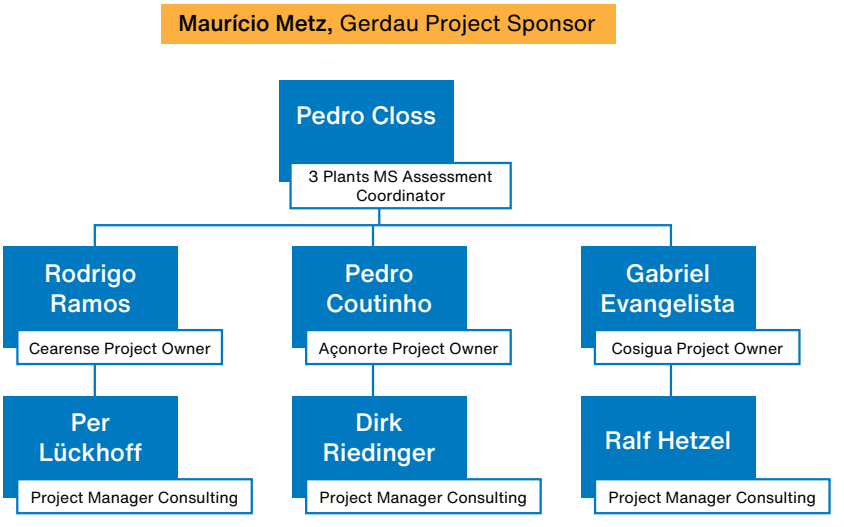
To ensure effective information exchange, GAB was required to appoint a counterpart for each BSE expert during the on-site investigations. The investigations were scheduled for specific durations at Cosigua, Cearense and Açonorte, with intermissions dedicated to summarizing findings and developing a rough concept. This approach included the presentation of quick wins, measures for immediate operational improvements without substantial investments.

This meticulous on-site investigation and expert analysis endeavored to provide GAB with actionable insights and strategies for refining its steel production processes.

In addition to the on-site investigations and expert analyses previously outlined, BSE was committed to delivering an even more comprehensive optimization strategy for GAB. The following elements have been incorporated into the overall approach:

Figure 4

Organization and leads of the three projects from Gerdau and Badische.



Elaboration of Comprehensive Improvement Concepts:

- Development of three detailed improvement concepts, each tailored to a specific GAB plant.
- Inclusion of a cost/benefit analysis for the proposed improvement measures, ensuring a clear understanding of potential investments and returns.

Stepwise Approach for Meltshop Development:

- Formulation of a stepwise approach for the evolution of each meltshop.
- Submission of this developmental concept within 6 weeks after the conclusion of each on-site investigation.
- The stepwise approach encompasses a detailed plan for systematic enhancements, addressing identified issues and capitalizing on quick wins.

Bottleneck Calculation and Performance Indicators:

- Bottleneck calculation utilizing operational data provided by GAB.
- Baseline performance determined based on these calculations, allowing accurate identification of bottlenecks.
- Recommendations for necessary improvement measures and investments provided for each developmental phase.

Progress Indicators for Plant Development:

- Implementation of performance indicators to monitor and evaluate plant progress.
- Regular assessment and reporting of key metrics to track the effectiveness of implemented measures.

This extended approach aimed not only to identify areas for improvement but also to provide GAB with actionable plans for enhancing operational efficiency and overall performance. The integration of cost/benefit analyses, stepwise development concepts, bottleneck calculations and progress indicators ensures a holistic strategy for sustained improvement across GAB's steel plants. BSE remains committed to delivering these comprehensive concepts and actionable insights to empower GAB in its pursuit of operational excellence.

In pursuit of comprehensive knowledge exchange, BSE introduced structured steel plant seminars, offering valuable insights into its operations and fostering a culture of continuous improvement for GAB.

Training Seminars

The program comprised of two 1-week seminars at Badische operations, accommodating up to 14 participants. There was an option for a complete staff rotation for the second week, and plant managers were warmly invited for a few days. Seminars ran from Monday to Friday. The training program is customizable based on client requests and major issues identified during on-site investigations. Detailed seminar programs are developed to meet specific client requirements.

Seminar Objectives:

- Understanding Badische's operating practices.
- Observing highly productive operations to inspire belief in achievable plant improvements.
- Facilitating team building across different departments and shifts in the steelmaking shop.
- Identifying potential improvements in participants' own plants through observations of BSW's processes and equipment.
- Rolling out a cultural change to the shop floor level.
- Empowering participants to become multipliers of new ideas in their home countries upon return.

Findings, Actions and Improvements

Crucial for every consulting project is to be on-site in the steel plant to feel and understand the local reality. The current situation is not only based on historical developments but also on certain constraints, understandings, and a certain way and philosophy of dealing with things. Product mix, resourced educts and equipment already have a major influence on the way steel is produced. Skills, culture and experience do the rest on forming the way each steel plant is producing steel.

While at the Açonorte steel plant, it became clear that the team spirit and company culture were very positive and focused on problem-solving. This was very motivating for the local personnel to solve problems and constantly improve without having a Clean-in-Place (CIP) system in place. Further, the maintenance practices were well established, with good L2 automation and reporting supporting it. Visual management was in place with well-founded key performance indicator (KPI) selection and attention to safety.

With these many good points mentioned, the plant had potential in only a few areas. Most of the time, the consistency of the production process was not constant. The hot topics were:

- Ladle preparation: Improve the thermal efficiency, internal logistics reducing of preparation time, preheaters update.
- CCM: Eliminate transversal cracks, new design of cooling nozzles, reduce the power-off, increase the caster speed.
- TSM (temperature and sample manipulator): Door cleaning, adjustment to TSM position, parameters adjustment to avoid measure failure.
- Productivity: Ladle capacity increasing (refractory profile), changing in the reactor tap and EAF power program (electrical and chemical), tapping temperature optimization.

- Maintenance: A vacant coordinator position in crane maintenance was critical, as this position is highly loaded with work.

After 1 year into the cooperation, the production figures improved in almost all areas (Table 1). The productivity increased by 2.2 tons/hour (25-ton EAF) due to increased tap weights and decreased tap-to-tap (TTT) times. The electrical demand decreased not only at the EAF, but also at the LF. Finally, even the electrode consumption decreased despite a slight increase in the use of chemical energy.

When the expert team visited Cosigua, it experienced a very young but highly motivated team working in a well-designed plant layout. The 112 MVA transformer was strong, the slag practice sound and the dedusting more than sufficient.

Identified opportunities were mainly the knowledge and experience level of the personnel. Training for younger workers with corresponding knowledge transfer of people close to retirement were a major issue. This went hand in hand with less specialization in some areas, which could be overcome with the implementation of shift supervisors. Some further recommendations were made regarding scrap loading, CCM oscillation and cooling parameters, as well as dedusting.

The hot topics for Cosigua were:

- Power-off reduction, mainly maintenance delays.
- Productivity/optimization of EAF energy: changing in the EAF power profile (electrical and chemical).
- Instability in carbon injection system.

Overall, these and further minor and major process optimizations at Cosigua (Table 2) led to a significant impact on kWh/t consumptions combined in EAF and LF together with increase active power and therefore decreased power-on time, oxygen blowing and carbon consumption. These are all factors decreasing the OPEX of the steel produced. The knowledge issue did not improve within 1 year, and also there was a change in

Table 1

Baseline and Achieved Improvement Results After Less Than a Year at Açonorte Steel Plant

Key performance indicator	Unit	Delta
Productivity	tgb/hour	2.20
Tapping weight	tgb/heat	0.70
Tap-to-tap time	min/heat	–1.20
Power-off	min/heat	–0.80
Power-on	min/heat	–0.80
E.E. EAF + LF	kWh/tgb	–13.90
E.E. EAF	kWh/tgb	–8.00
E.E. LF	kWh/tgb	–7.20
EAF active power	MW	0.90
Carbon sources	kg/tgb	–1.40
O_2 EAF	Nm^3/tgb	2.90
CH_4 EAF	Nm^3/tgb	0.60
Electrodes EAF + LF	kg/tgb	–0.13

Table 2

Baseline and Achieved Improvement Results After Less Than a Year at Cosigua Steel Plant

Key performance indicator	Unit	Delta
Productivity	tgb/hour	–5.59
Tapping weight	tgb/heat	0.02
Tap-to-tap time	min/heat	3.27
Power-off	min/heat	4.92
Power-on	min/heat	–1.65
E.E. EAF + LF	kWh/tgb	–11.63
E.E. EAF	kWh/tgb	–13.26
E.E. LF	kWh/tgb	1.89
EAF active power	MW	1.84
Carbon sources	kg/tgb	–1.30
O_2 EAF	Nm^3/tgb	–2.49
CH_4 EAF	Nm^3/tgb	0.20
Electrodes EAF + LF	kg/tgb	0.04

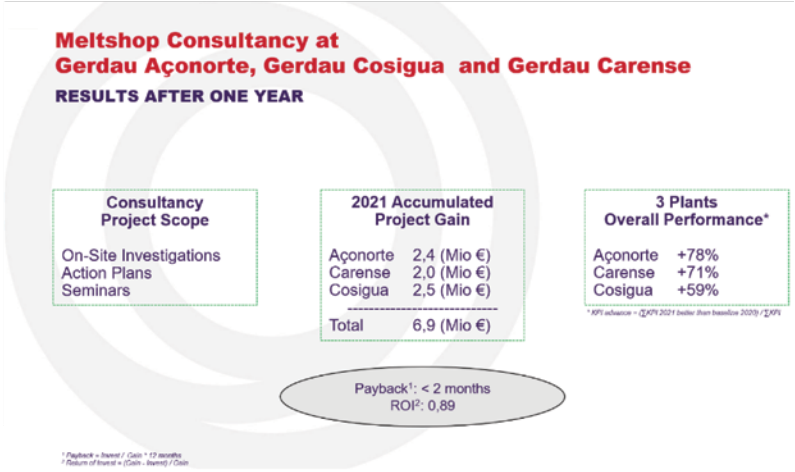
Table 3

Baseline and Achieved Improvement Results After Less Than a Year at Cearense Steel Plant

Key performance indicator	Unit	Delta
Productivity	tgb/hour	–0.4
Tapping weight	tgb/heat	0.9
Tap-to-tap time	min/heat	3.9
Power-off	min/heat	4.5
Power-on	min/heat	–0.5
E.E. EAF + LF	kWh/tgb	–40.4
E.E. EAF	kWh/tgb	–38.7
E.E. LF	kWh/tgb	–1.8
EAF active power	MW	–0.2
Carbon sources	kg/tgb	0.2
O_2 EAF	Nm^3/tgb	1.7
CH_4 EAF	Nm^3/tgb	–0.8
Electrodes EAF + LF	kg/tgb	–0.1

Figure 5

Presented results to higher management of Gerdau regarding the Gerdau-Badische cooperation.



the operating regime with less availability of hours for preventive maintenance, so that the delays and power-off increased slightly. But the steel plant was very motivated by the first results and later improved in power-off as targeted, reducing 2.8 minute/heat in 2023 compared to the base.

The Cearense plant had personnel who were very eager to improve with clear and pragmatic management goals. Overall, the staff was very motivated and paid much attention to safety. This was well implemented as the overall skill level was good; standard operating procedures were defined, available and implemented; and many tasks were internalized.

With the practical and hands-on way of running the plant, there were potentials identified to improve visual management, decrease the coordination workload and further expand training. Empowerment of personnel, especially on the operator level, should rise, giving people responsibility.

Cearense also changed its operating regime to increase asset occupancy, leaving fewer hours available for maintenance.

The hot topics for Cearense were:

- Power-off reduction.
- Optimization of EAF energy: New chemical profile, current adjustments and increase, superheat reduction, and postcombustion improvement.
- Improving the metallic yield: Reduced the amount of oxygen.
- Productivity: Tapping weight increasing.

Being on such a good level with a small 20-ton furnace with good productivity, the main gains in this project were OPEX-wise on electrical consumption (Table 3). With a clear focus on operations, the skill level and interactions increased to a healthy level, laying the foundation for continuous operational improvement which finally led to decrease production costs.

The evolution in the results of performance indicators contributed to the reduction of variable costs and fixed costs of the three meltshops' OPEX. Additionally, the increase in productivity made it possible to increase financial gains through the greater volume of final products sold at the Açonorte plant, thanks to the greater steel output due to the reduction in tap-to-tap time.

In the other two plants, GAB had an increase in tap-to-tap time due to the higher power-off, which was not fully compensated by the gains in power-on, so these gains in contribution margin were not achieved as in Açonorte. It is

important to contextualize that in Cosigua and Cearense, favorable market conditions required the hiring of an additional operational team. With the increase in occupancy in these plants, GAB had a significant change in the operating regime, reducing the hours available for maintenance and temporarily increasing interruptions (power-off).

Fig. 5 summarizes the gains obtained in the plants considering OPEX and contribution margin (in the case of Açonorte).

Conclusions

The cooperation between Gerdau Long Products Brazil and Badische aimed to analyze three Brazilian EAF steel plants, identify potentials, and support execution for improved operations. The four steps to this project were:

a. Uncover and pinpoint opportunities for efficiency gains.

b. Conduct a comprehensive evaluation of equipment conditions.

c. Identify and address any maintenance or investment backlog.

d. Provide unbiased and impartial suggestions for a phased and strategic modernization of the equipment.

The overall success of the cooperation shows that despite different realities in each plant, the consulting approach helped to screen and eventually improve the way each plant is organizing and executing its operations and maintenance. The agile approach helped to identify different areas with opportunities for improvement and fostered the development and continuous improvement successfully. ✦

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