# MUNDANDO A MENTALIDADE NA OTIMIZAÇÃO DE PROCESSO PARA RESULTADOS MELHORES *

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**Resumo**

A maioria dos gerentes de fábrica entende que uma planta não otimizada tem um impacto negativo em fatores-chave como produção, qualidade e meio ambiente. Como a causa raiz de uma planta não otimizada consume muito tempo para resolver o problema, a maioria das indústrias ainda precisa atingir um desempenho desejável para o processo e os negócios. O objetivo deste artigo é mostrar como superar esse cenário através da implementação e criaçãode uma cultura de otimização de processos baseada em valor, combinando: acesso a engenheiros de processo e automação; uma metodologia ágil e, o uso de inteligência artificial. Os casos de negócios que serão apresentados foram aplicados a grandes empresas do setor de mineração e metais no Brasil. Em um deles, foi alcançado um aumentode produtividade média de 5% em três plantas médias de mineração. Esses resultados também incentivam o desenvolvimento posterior, como o uso extensivo Inteligência Artificial e Ciência de Dados para aumentar o valor dos dados do processo. Entretanto, um grande desafio que precisa ser superado é como mudar a cultura e mentalidade dos clientes para ter um maior engajamento nesse tipo de projeto, o que resultaria em resultados mais rápidos em termos de eficiência de processos.

**Palavras-chave**:Otimização de Processo; Malha de Controle; Monitoramento de desempenho de controle;Metodologia Ágil

## SHIFTING THE MINDSET ON PROCESS OPTIMIZATION FOR BETTER RESULTS

**Abstract**

Most of the plant managers understand that a non-optimized plant has a negative impact in key factors as production, quality and environment. Because the root cause of a non-optimized plant consumes a lot of time to solve the issue, most of the industries still have difficulty to achieve a desirable process and business performance. The objective of this paper is to show how to overcome this scenario through theimplementation and creationof a value-based process optimization culture combining: access to process and automation engineers; an agile methodology and the use of artificial intelligence. The business cases that will be presented have been applied to big companies in the metals and mining sector in Brazil. In one of them, an average increase of 5% in productivity was achieved on three medium-sized mining plants. These outcomes also encourage further development, as an extensive use of Artificial Intelligence and Data Science to increase value on the process data. However, a big challenge that still need to be overcome is how to change client's culture and mindset in order toincrease engagement in this kind of project, which could in turn lead to faster results in terms of process efficiency.

**Keywords:** Process Optimization; Loop Control; Control Performance Monitoring; Agile Methodology.

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## 1 INTRODUCTION

The need to have an optimized industrial plant with its KPIs (Key Performance Indicators) controlled is far beyond the local requirements of each industry. Due to climate change **[1]** and the global economic recession scenario of 2008 until middle 2016 **[2]**, there is now an emerging need for change with respect to operational, productive and environmental efficiencies in manufacturing, especially in basic industry (mining, metal and steel).

The same comprehensive and holistic view foroptimizing production processes must alsobe taken into consideration on the factory floor of each plant, where most of the time, the optimization basically refers to the PID control loop performance (proportional, integral and derivative). However, there are several other factors that also impact the optimal point of a plant, such as a poorly designed logic for starting and stopping equipment, or even an inappropriate or misconfigured automation hardware (PLC, programmable logic controller) **[4]**.

Despite the large amount of problems that exist on the shop floor and that can be solved in different ways, the focus in the last thirty years was stillrestricted to performance analysis of PID control loops.The first signs of trying to monitor an industrial process date back to 1989 when the first KPI emerged, the minimum variance index**[5]**. Harris work (1989) motivated a lot of research on the subject, leading to the emergence of new plant performance KPIs. In 2002, the work of Desborough& Miller **[6]** showed that despite of scientific development, many industrial plants around the world continued with an unacceptable performance. From 2003 to 2007, a strong move on the development and use of monitoring software within control loops management industry could be observed**[7]**.

Nowadays, it should be natural to expect that this issue had already been resolved, i.e., that industrial plants would be operating in an optimal way or at least with their control loops operating quite efficiently. However, the truth is significantly different, as shown in the work of one of the greatest experts on the subject, Nina Thornhill **[8]**.Throughouther research using data from various industries for around the world, sheasserts that there is still a lot of work to be done regardingthe control of industrial processes. Another important aspect of Nina Thornhill article is about the use of control loops management software: it is inconclusive whether the adoption of such software really increased the performance of industrial plants.

An interesting work that confirms some of the results obtained in the research of Bauer **[8]**article is Feldmann **[9],** which says that there is a "buried treasure" in the process industry: their data. A few, indeed, took advantage of this potential and, with increasing diffusion of algorithms and analysis technologies, such potential is even greater.

Based on the works of Bauer **[8]**and Feldmann **[9]** this paper aims to show that it is possible to reverse the scenario of low operational efficiency by adopting the following assumptions: (i) the optimization service on the shop floor should be extended to each and every problem that is impacting KPIs of plant business; (ii) such service must be done regardless of the existence of control loop monitoring software, that is, it must depend only on methodology that is solid, agile and focused on results; (iii) should make the most use of technological advances related to big data and artificial intelligence and (iv) the business model used should be based on co-creation and reduced costs that the format "as a service" delivers. All this framework guidelines are "encapsulated" and called Optimization Management Office (oMO™).

The present work will show that by using these guidelines, it was possible to increase productivity in iron ore processing units. It will also be shown the difficulties that still exist regarding this type of service, mainly due to the high dependence on qualified professionals and resistance to new technologies and new business models.

## 2 METHODOLOGY

The methodology developed for the optimization of industrial processes, whether continuous or batch, is based on solid experience in this field and best market practices for the implementation of projects based on agile **[3]**. An illustration of the operation of this methodology can be seen in Figure 1.

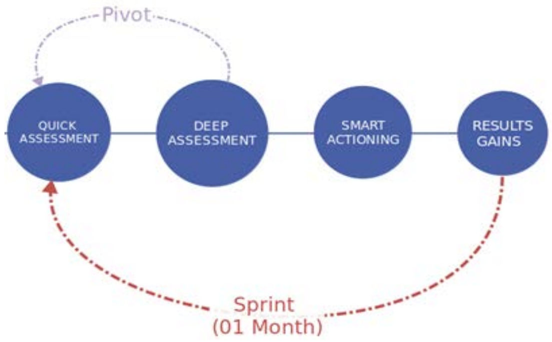


**Figure 1 -** Overview of the methodology

In general, the methodology allows:

- Identify problems quickly and evaluate their economic impacts of macro form (called step ***Quick* Assessment**)
- test hypotheses, analyze and thoroughly diagnose the root causes of the problem, and thus generate an action plan ***(Deep* Assessment**)
- Implement actions ***(Smart* actioning**)
- Measure gains ***(Result and* gains**).

A complete cycle of all stages, called Sprint, lasts about a month and aims to identify problems and implement solutions that capture measurable economic returns. The proposed methodology allows fast and efficient evaluation of the problems and, especially, is set to "fail fast", thus saving time and implementation costs. That way you can change the problem to be treated ("pivot") in case the analysis in the Quick Assessment step does not warrant further work. This happens for example when the action to be taken to solve the problem has a higher cost than estimated gain, or when the problem has no significant impact on the KPI business.

The four steps are structured in order to identify the highest financial return in relation to the effort required to solve the problem, focusing on the process of business KPI analysis and the cost of implementation of actions identified to address the root cause. Next, each step is described in detail.

### *Quick Assessment phase*

This stage begins with the activities that will leverage plant performance and return on investment (ROI). This phase consists mainly of macro understanding of the opportunities for improvement in the process with fast earning potential (short term), comprising the following steps:

- Business KPIs capability analysis or "gap" of opportunity (productivity, quality, energy, etc);
- Analysis of correlation with business KPIs and the control loops performance KPIs.

The importance of this step is the fact that, a priori, one should only choose potential problems associated with ROI. Such a decision should involve the perception of the process owner on the most relevant impacts and operational deviations. Intangible outcomes will also be captured and can be deciding factor on which option will be prioritized.

To choose which problem will be attacked, it takes into account mainly the impressions of the plant operation team economic criteria’s (business drivers). As an example, it can choose areas that have high economic importance control loops whose performance metrics are not satisfactory.

Another faster and most efficient way to choose the problem to be attacked is when there is possibility to use advanced data analysis tools **[11]** together with various plant data sources (stop, maintenance, MES, PIMS, LIMS and ERP). In this way, it can be established a relationship between productivity drop and the low performance of a critical control loop, or even excessive occurrence of stops in a specific equipment. In this case, a predictive model could also be used to predict performance loss on a certain business KPI.

This data driven kind of analysis will be called as "analytical culture" and should be used and exploited whenever possible**[10]**. Figure 2shows an example in which the oMO™ calculates how much a particular control loop performance represents in terms of ROI.

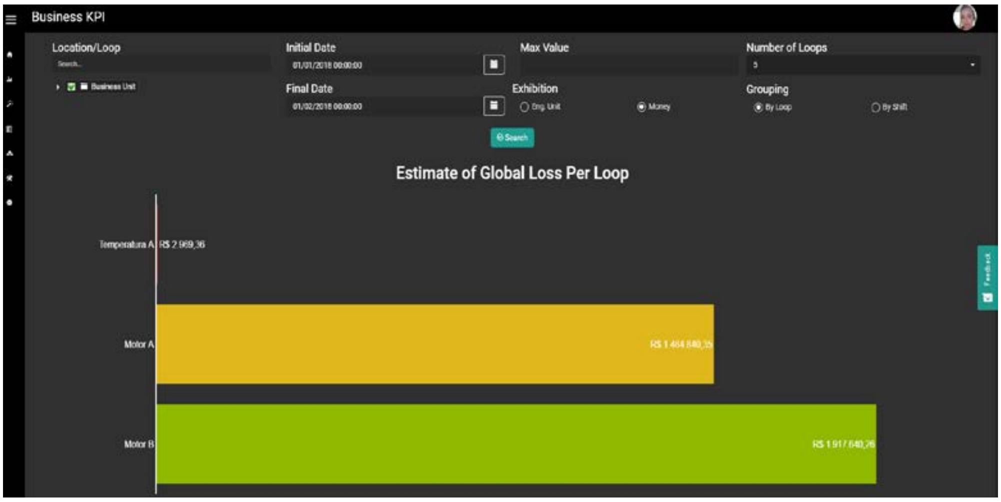


**Figure 2 -** ROI opportunity established between a business KPI and loop performance

### *Deep Assessment phase*

Deep Assessment stage consists of detailed and thorough investigation of the improvement opportunities, analyzing and identifying the root cause of the problem by understanding the operational characteristics, process flow charts, diagrams of

P&ID type and the testimony of operators and process engineers. All these analyzes should be recorded in a concise way and summarized in a focused action plan on the estimated result or improvement potential glimpsed in the previous step.

The first action is to elaborate hypotheses, validating such assumptions based on statistical analyzes, operational reports, process analyzes and other tools that allow to investigate if the causes of the problem have a cause and effect relation, in order to allow the proposition of effective actions.Figure 3 shows the dashboard that oMO™use as toolto monitor the loop control performance of a business unit.If the performance is poor, one can navigate through the hierarchy to investigate which Plant / Operational Unit / Area / Equipment has the worst performance, which is the indicator that most contributes negatively to this scenario, which are the loop control with the worst performing and for which reason they are the worst.

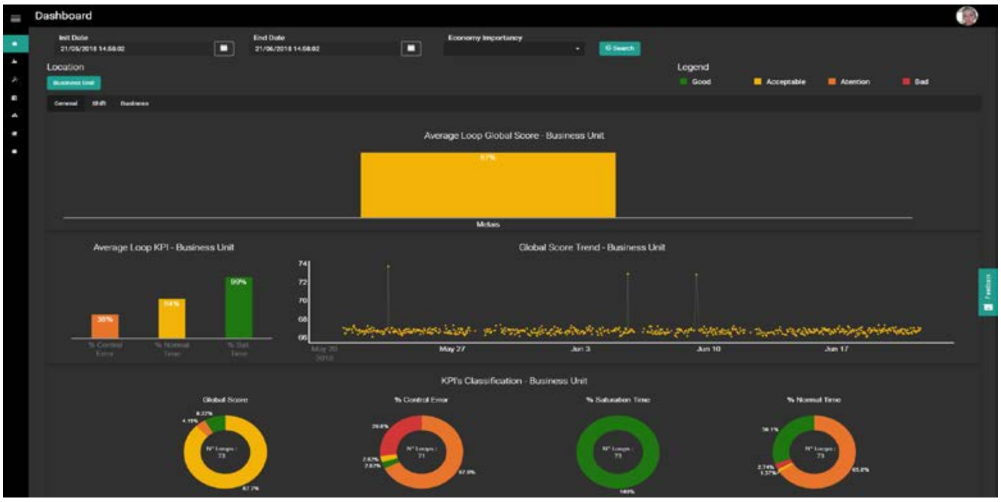


**Figure 3 -** Dashboard displaying the control loops performance of a fictional plant

If the diagnosis indicates an inconsistent hypothesis, one should "pivot" the hypothesis and seek another solution proposal for the problem. Such interaction should be rapid and intense in the involvement of those responsible for the process in order to make a robust analysis of the problem and seek effective solutions.

If no hypothesis is accepted as potential or if the proposed solution is discarded, the cycle ends, and a new opportunity will be analyzed. It is not interesting to have an action plan in a worksheet at the end of this step. Ideally, there would be an online and digitized way of managing action plans, decision makers and tasks, all in the same environment, in an integrated way. This facilitates and greatly increases the productivity of the engineer or analyst who is seeking to solve the optimization problem. Figure 4 shows an example of the actions recorded for a Sprint.

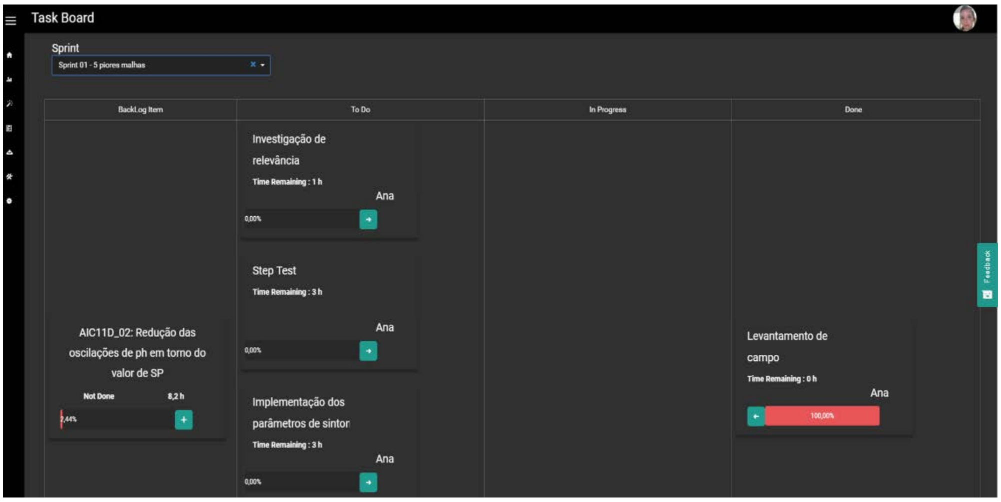


**Figure 4 -** Online action plan for process optimization

### *Smart actioning phase*

This step focuses on the actions defined in the action plan, consisting of its execution and assisted operation. It is important to note that the proposed actions are not limited to the improvement of performance of PID control loops, but include a complete evaluation of the process, allowing problems to be dealt with in areas such as sequencing, interlocking and operation logic, operational and protection alarms of equipment, advanced control loop strategies (feedforward, override) and also APC implementation (Advanced Process Control).

The multidisciplinary of actions allows a systemic approach in the treatment of the problem and in the sustainability of the identified gains. At this stage, the "as a service" business model becomes very attractive, since the client can "access" shared professionals at the right time and at the right time to execute the services, reducing their operational cost.

### *Results phase*

This step, which may occur parallel to the beginning of a new cycle of Sprint, aims to monitor and ensure that the actions that generated tangible or intangible results are continuously monitored, seeking the long-term sustainability of results.

Financial gains will be continuously computed and monitored and if there is any deviation or loss of benefit, mitigating actions will be mapped and executed in order to sustain the benefits achieved. Analytical culture and the use of data analysis tools also make perfect sense for this step. It is not at all interesting to implement an improvement and not continuously know if what has been done has worked and continues to deliver value.

## RESULTS AND DISCUSSION

The results demonstrated in this section are the result of the application of this work: the implantation of oMO™ in three iron ore beneficiation plants in one of the largest mining companies in Brazil. With five Sprints completed in different stages of processing, the accumulated gain was approximately 579 thousand tons in productivity (t/year) and 333,8 thousand US $/year in reduction of reagent consumption. Figure 5shows the tangible gain of each Sprint executed. It is also seen in the same figure that with the same Sprint it is possible to obtain gains in more than one KPI of business (Sprint 4).

Figure 6shows the relationship between measurable productivity gains and the type of action performed on each Sprint. Modification of PLC/SDCD programming logic is the type of action responsible for catching 89.2% of the current cumulative gain. However, actions such as the adequacy of actuator parameters, such as an inverter for a pulp pump, also generate a significant economic return.

The results show the effectiveness of the methodology used, especially the steps of Quick and Deep Assessment, which is where is the analysis of macro-economic impact so that will be achieved with determined action and the detailed study of the root causes of the problems. This allows assertiveness and delivering impressive results quickly.

For this use case for oMO™, the client decided not to include the long-term sustainability layer. Although it is strongly recommended continuous monitoring of business KPIs (tangible gain) and control loops performance KPIs (intangible gain), tied to a particular Sprint, in order to sustain the results.

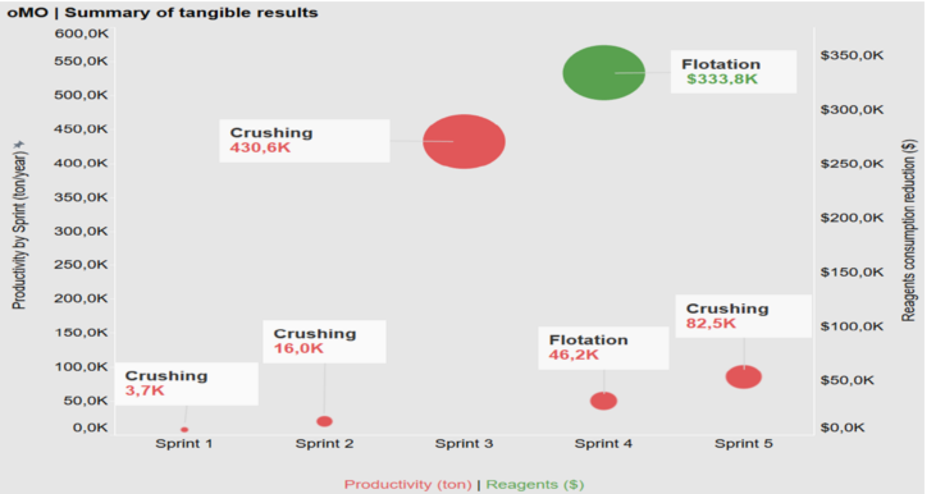


**Figure 5 -**Summary of tangible results

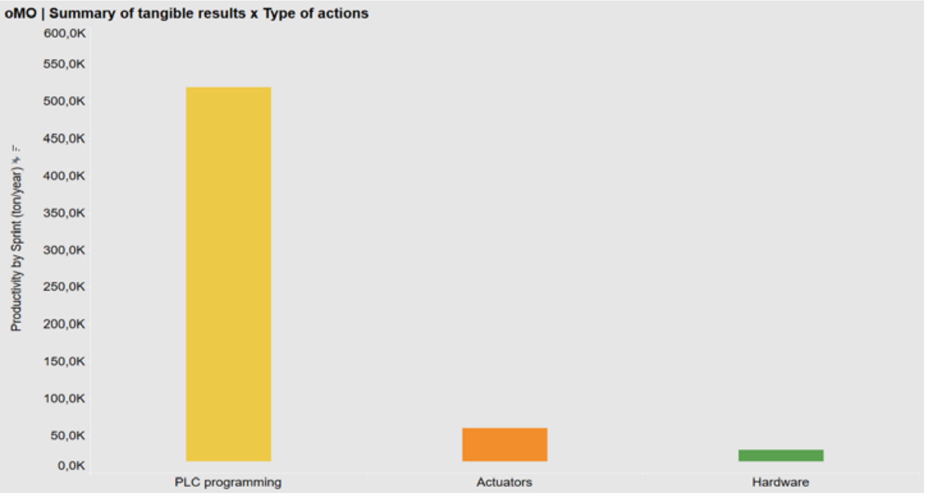


**Figure 6 -** Summary of tangible results versus type of actions

Another important point to remember is that during these four Sprints no control loop monitoring software and no advanced analytics tool were used (because the customer does not have such tools and choose not to use oMO™'s own tools). This proves that optimization is not restricted only to control loops and independent of software. On the other hand, the lack of tools impacts the productivity of the team that performs the work.

Another complete use case for oMO™, including its PID performance analytics and advanced analytics tools, was at Nexa Resources' Smelter plant in Juiz de Fora, Brazil. Because it is a recent work, the steps of Smart Action have not yet been implemented and, because of this, there are no tangible results. However, it is interesting to talk about the co-creation model that was done together with Nexa, in which oMO™ was developed and deployed in a customized way for the specific problems and needs of Nexa Resources.

## 3CONCLUSION

The present work shows that the change of mindset regarding the methodology, the format of the services and the business model is feasible and allows the delivery of tangible results and payback extremely fast. It is possible to mention as main aspects of the success of the applied methodology: the change of approach (pivot) in the quick assessment phase; perform all phase of the sprint; keep focus on sprint and combine a remote strategic team with local team focusing on the same goal.
The results obtained and presented are motivating and encourage the continuous search and evolution of this business model, to try to reach other industrial processes, making them more efficient and sustainable.

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