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Efficient Setup Reduction Strategies

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Abstract

This project aims to implement a reduction in setup time in milling lines. The proposal focuses on identifying and proposing improvements through standardizations to increase operational efficiency. The project aligns with the UN's Sustainable Development Goals (SDGs), particularly regarding innovation and sustainability in industrial operations. The research addresses the setup stage, which involves tool changes and adjustments between production orders. As setup is often a bottleneck in manufacturing systems, minimizing this time directly enhances productivity and industrial competitiveness.

Keywords
Setup time reduction, Production Engineering, Operational Efficiency, Standardization

1. Introduction
Proposal and Project Purposes:
The project proposes the implementation of a setup time reduction in the operation's mill, aiming to optimize the setup time in the milling lines, which are critical activities in production processes. This proposal is directly related to the theme of optimization and operational efficiency, addressed in the production process management curriculum component. The solution found aims not only to optimize the setup time but also to propose a standardization of activities, ensuring that the operation is more agile and efficient.

Sustainable Development Goals (SDGs): The project is aligned with SDG 9 (Industry, Innovation, and Infrastructure), which encourages the construction of resilient infrastructures and the promotion of inclusive and sustainable industrialization. The reduction of setup time contributes to energy efficiency and the reduction of resource waste, promoting more sustainable practices.

• Global Context:
In the current global scenario, where industries are increasingly pressured to adopt sustainable and efficient practices, setup time reduction stands out as a strategic initiative. Global supply chain disruptions and the need for quick adaptability have made production flexibility a competitive advantage. This reinforces the relevance of implementing Lean tools, such as SMED, that allow organizations to be more agile and resilient.

• Justification:
The main problem that the project aims to solve is the long setup time in the milling lines, which results in a loss of time and resources during production. Implementing improvements in this process is essential to increase competitiveness and efficiency. The execution of the project offers the opportunity to optimize setup time, increasing productivity and reducing operational costs. Additionally, by implementing standardizations, the organization can

achieve more rigorous and consistent quality control. Reducing setup time is fundamental to ensuring greater efficiency in the production process, directly impacting the organization's ability to meet demand, minimizing idle time, and improving resource utilization. Thus, the project becomes crucial to achieving productivity and sustainability goals. The innovation lies in the application of the SMED methodology, a modern and efficient tool for process optimization. The project's differential resides in the structured approach to analysis and proposal of improvements, based on in loco visits and observations, ensuring that the solutions are applicable and realistic for the given environment.

2. Literature Review

2.1 Contextualization

In recent years, companies have been seeking practices that enable the continuous improvement of their processes. In this context, Continuous Improvement stands out as an essential approach to optimize and drive organizations in their constant pursuit of positive results. Various methodologies and tools, such as Lean Manufacturing, Kaizen, Six Sigma, and PDCA, are widely used to achieve these objectives. Among these methodologies, Setup Reduction emerges as one of the most effective tools to reduce setup time and increase productive efficiency, applicable in different industrial sectors (Franciane Lima Rosa).

2.2 Setup Reduction and the Toyota Production System

According to Womack and Jones (2004), Setup Reduction is one of the few methodologies of the Toyota Production System that was not created directly within Toyota Motors Company Ltd. The tool was developed with the collaboration of consultant Shigeo Shingo, who was called by Taiichi Ohno to adapt the setup time reduction technique to Toyota's reality. Although the concept of quick setup originated in Japan, similar techniques had already been implemented in the United States. This development occurred in the context of increasing competitiveness, where supply exceeded demand, encouraging frequent variations and product substitutions to meet market needs more quickly. Thus, there is a transition from mass production to lower volume production, adaptable and capable of responding quickly to consumer demands (Pereira; Cristina, 2010).

2.3 Objective of Setup Reduction

Shingo developed the Setup Reduction method with the goal of optimizing tool changeover time. The method was applied to welding simulator machines at Fatec Cruzeiro, aiming to demonstrate the benefits obtained from its implementation. Although this study focuses on simulators, it also highlights the advantages of applying the method to different production systems (FATEC). Generally, setup time is considered a loss for industries, as the team and processes remain idle while maintenance or operation prepares the machinery. Although the setup does not add direct value to the customer, it is indispensable for the proper functioning of the production line. Therefore, the Setup Reduction technique is relevant, aiming to reduce the preparation time of machines and equipment and decreasing the hours spent in the process (Universidade Tecnológica Federal do Paraná).

2.4 Application and Benefits of Setup Reduction

The application of Setup Reduction details the entire process of product or material changeover (setup), with the goal of identifying activities that negatively impact execution time. This tool offers an effective way to improve setup time by optimizing the process of configuring tools and devices (Universidade Tecnológica Federal do Paraná). Setup Reduction is based on techniques that allow the tool changeover process to be completed in less than 10 minutes. Although, in some situations, it may not be feasible to achieve this time without significant investments, applying the concepts of Setup Reduction can lead to significant reductions in changeover time in most cases (TCC Cesar Takeshi Kanzawa). When correctly implemented, Setup Reduction brings benefits such as reduced production costs, increased productive potential of machines, and elimination of rework and material waste. Additionally, it provides greater customer satisfaction by meeting deadlines and allows the company to offer a wider variety of products (Franciane Lima Rosa). Furthermore, Setup Reduction helps increase the operating time of machines and equipment in the production area, resulting in greater production capacity. It reduces costs, improves the quality of processes and products, decreases waste and rework, and reduces inventory and lead time, increasing system flexibility and responsiveness to customers (Emerenciano; Marcos, 2017).

2.5 Integration with Other Lean Tools

To achieve the desired time reduction, Setup Reduction can be integrated with other Lean tools. The implementation of process improvements is possible based on the collection of information about changes and the analysis of data on tool changes. The successful implementation of Setup Reduction resulted in an 18% reduction in setup time, without compromising process quality and ensuring standardization through support documents approved by the company (Politécnico).

2.6 Practical Example of Optimization: Formula 1
A practical example of optimization like Setup Reduction can be seen in Formula 1 pit stops, where teams spend hundreds of hours designing devices, machines, and perfecting their skills to reduce transition time. Each element of the process is carefully analyzed, simplified, or eliminated to reduce changeover time, and the execution of a standardized and highly optimized process is essential to achieve minimal times (FM2S Consultoria, 2017).

2.7 Importance of Organizational Commitment
Like all Lean methodologies, Setup Reduction requires the commitment of the entire organization. For its success, it is necessary to provide adequate infrastructure, as well as invest in training and awareness about the importance of reducing setup time (Evangelista; Gabriela, 2021). Additionally, the method demands a complete mapping of all parts, conditions, and actions required during machine operation, using a checklist. Checking the state of all components and researching the most efficient method of moving dies during machine operation are essential to optimize the setup (Shingo; Shigeo, 1996).

2.8 Opportunities
The application of Setup Reduction in industries shows great potential for optimizing processes, reducing setup times, and increasing productive efficiency. Integrating this methodology with other Lean tools, such as Kaizen and PDCA, further strengthens gains in flexibility and market responsiveness. Companies seeking continuous improvements, as proposed by the Kaizen method, can maximize customer value and eliminate waste through the implementation of tools like Setup Reduction (Franciane Lima Rosa).

3. Methods
The method used in this work for setup reduction in a milling line of a chemical industry was structured in several stages, aiming for a detailed analysis and the implementation of effective improvements. The step-by-step study was as follows:
First, an on-site visit to the equipment was conducted, where the operation and conditions of the milling line were directly observed. This stage was crucial to understanding the context and identifying possible points for improvement. Next, a video of the setup being performed was analyzed. This visual analysis allowed the identification of specific stages of the process that could be optimized. Additionally, process flowcharts and audio recordings clarifying the company's team doubts were used to complement the understanding and ensure that all stages were well documented and understood.

After the initial analysis, a brainstorming session with the working group was conducted to generate possible improvement ideas. This collaborative process was fundamental to exploring various perspectives and creative solutions. The generated ideas were then filtered and organized, resulting in a list of viable proposals.

During the analysis of the milling line setup, several improvement opportunities were identified that could increase efficiency and reduce setup time.

To validate the proposals, a detailed presentation was prepared and submitted to the company's team for feedback and approval. This step ensured that the suggestions were aligned with the company's expectations and needs.

Throughout the project, Trello software was used to track tasks and assign owners for partial deliveries. This tool facilitated project management, allowing continuous and collaborative monitoring, ensuring that all group members were involved and informed about the progress of activities.

This structured and collaborative method allowed for a comprehensive analysis and the implementation of effective improvements in reducing the setup time of the milling line, contributing to the efficiency and competitiveness of the operation.

4. Data Collection

Data collection was carried out in several stages to ensure comprehensive and accurate analysis. Initially, during the on-site visit, we gathered visual and contextual information about the work environment and the general operation of the equipment. Although we were unable to observe the setup directly, this visit provided us with an initial understanding of the process and operational conditions.

After the visit, a recording of the setup being performed was sent, which allowed us to collect detailed visual data on each stage of the process. We meticulously analyzed the video to identify critical points and possible improvements. Additionally, process flowcharts and audio recordings clarifying the company's team doubts were used to complement the understanding and ensure that all stages were well documented and understood.

To clarify additional doubts that arose during the video analysis, the advisor directly contacted a Grace collaborator. This contact was essential to obtain additional information and ensure a complete understanding of the process, allowing us to advance with more precise and effective optimization proposals (Figure 1- Figure 2).

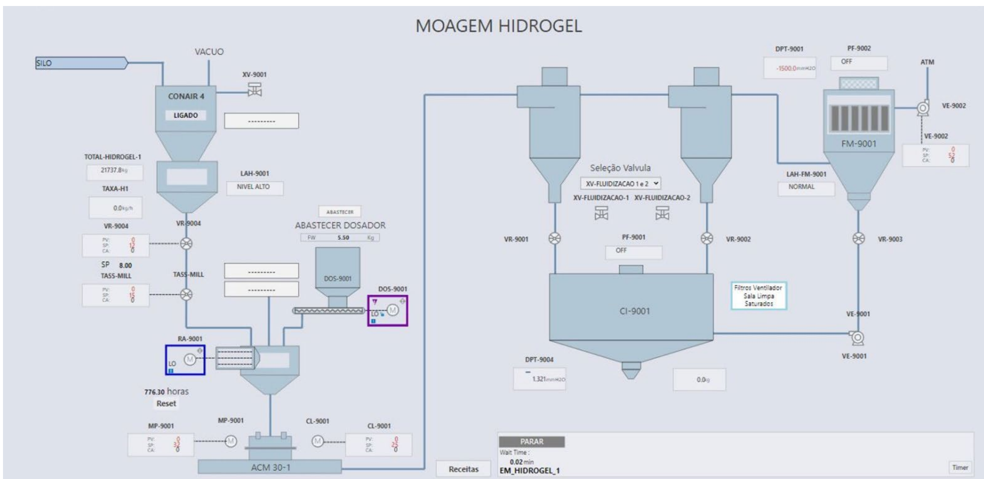

Figure 1. Milling Process Flow
Source: Provided by Grace.

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Figure 2. Sending of the videos Source: Provided by Grace.

5. Results and Discussions

5.1 Numerical Results

The following is the conclusive report with the simulation of 3 scenarios for time reduction (minutes) over the course of a year. The reduction numbers were calculated based on the data provided by the company and the specifications of the proposed component manufacturers (Table 1):

Table 1. Numerical results

Once a day	Twice a day	3 times a day
Current total annual time: 17,520 minutes **New total annual time:** 2,372.5 minutes **Total annual reduction:** 15,147.5 minutes	**Current total annual time:** 35,040 minutes **New total annual time:** 4,745 minutes **Total annual reduction:** 30,295 minutes	**Current total annual time:** 52,560 minutes **New total annual time:** 7,117.5 minutes **Total annual reduction:** 45,442.5 minutes

Source: Prepared by the authors.

For an average estimation, a simulation was performed using Excel with the =RAND function (to generate a random number between 0 and 1) following a probability distribution (1 - 20%, 2 - 50%, 3 - 30%) and we obtained the following result:

- **Total time with the current setup:** 26,565 minutes
- **Total time with the new setup:** 3,795 minutes
- **Total time saved over 365 days:** 22,770 minutes

The implementation of quick-release clamps and quick-release screws, along with vibration and level sensors, will result in a significant reduction in setup time over a year. This will not only increase operational efficiency but also reduce the risk of screw wear and the need for additional tools, improving operator safety and productivity. For the application of these improvements, the following costs were estimated for the purchase and installation of the equipment (Table 2- Table 3)

Table 2. Equipment Purchase

Item	Custo (R$)
Grampos Tensor de Aperto Rápido	R$ 369,60
Parafusos de Aperto Rápido	R$ 1.000,00
Sensor de Vibração	R$ 6.500,00
Sensor Ultrassônico	R$ 3.000,00
Total	**R$ 10.869,60**

Source: Prepared by the authors.

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Table 3. Labor Costs

Item	Custo (R$)
Grampos Tensor de Aperto Rápido	150
Parafusos de Aperto Rápido	300
Sensor de Vibração	900
Sensor Ultrassônico	900
Total	**2.250,00**

Source: Prepared by the authors.

5.2 Graphical Results.

The graphs below illustrate the current value, in minutes, spent on each process, and the expected scenario with the improvements (Figure 3):

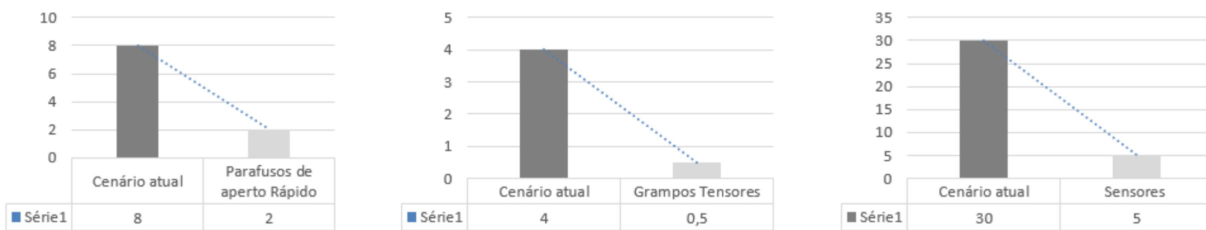

Figure 3. Graphical results in time reduction (min). Source: Prepared by the authors.

5.3 Improvement Proposal

After completing the aforementioned steps, the following improvement proposal was developed:

Application for Quick-Release Clamp KIFIX KF943 D
Retention Force: Up to 680 kgf (approximately 6670 N).
Description: This clamp has a three-point articulation mechanism, known as "knee or elbow action," which generates significant retention force. It uses lever mechanisms to apply pressure, being 3 to 10 times faster than traditional methods.

Example: According to the video sent, there are 4 screws located at the end of the piece that can be easily replaced by the clamps. In one of the examples, a screw stripped, increasing the time required for the operation. In the video, the operator took 2 minutes to open the mill, using two tools. Replacing them with KIFIX clamps can significantly reduce this time (Figure 4).

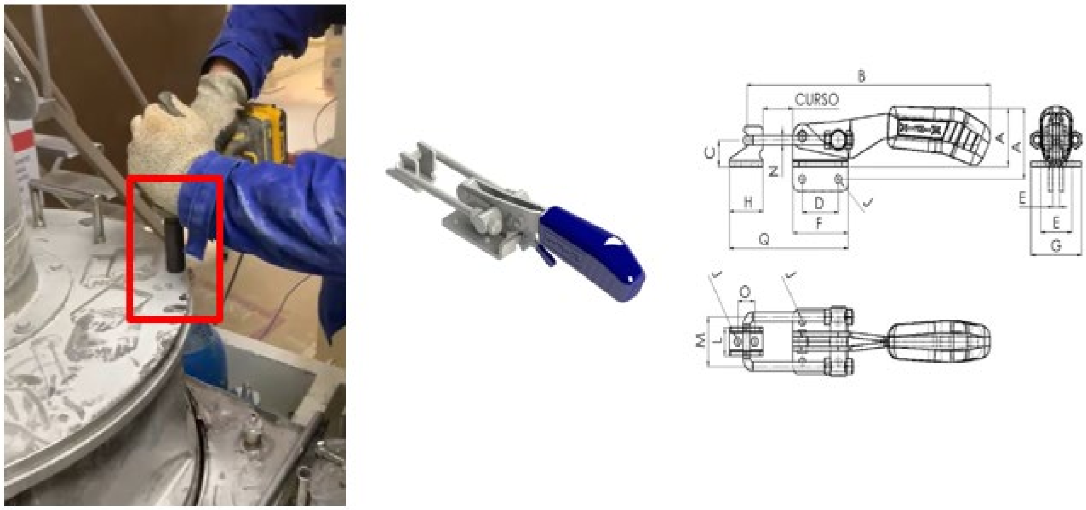

Figure 4. Installation Location and Illustration of Clamp Operation Source: (Kifix).

Application of Quick-Release Screw Kipp K0362
Clamping Force: Designed for forces exceeding 140 N.
Description: This screw has an ergonomic lever that allows for quick and secure tightening, ideal for industrial applications.

Example: In the video sent, there are 10 screws that can be replaced by Kipp lever screws. The operator took between 3 to 4 minutes to open the piping, using two tools. Replacing them with quick-release screws can reduce setup time and simplify the process(Figure 5).

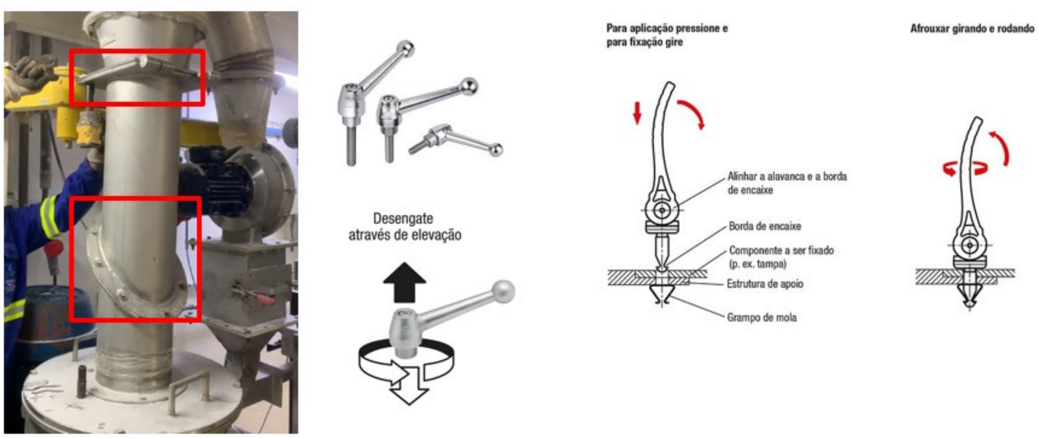

Figure 5. Installation Location and Illustration of Screw Operation. Source: (Kipp).

Application of Wilcoxon 786A Vibration Sensor
Installation: Mounted externally on the equipment body. Detects vibrations through the surface where it is installed, allowing for internal state monitoring without the need to disassemble the equipment.
Application: Ideal for continuous machine monitoring and detection of faults or wear. This sensor can help identify problems before they cause unplanned downtime, improving preventive maintenance and reducing setup time.

Application of Pepperl+Fuchs UC2000-30GM-IUR2-V15 Ultrasonic Sensor
Installation: Can be mounted externally, usually at the top of a silo or container. It emits ultrasonic waves that reflect off the internal material, allowing for non-contact level measurement.

Application: Used to monitor the level of solid or liquid materials in silos, tanks, and other containers. This sensor can provide accurate data on material levels, helping to optimize the setup process and reduce the time needed for manual adjustments (Figure 6).

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Figure 6. Sensor Models Source: (Wilcoxon) e (Newark).

5.4 Validation

On November 18, 2024, a meeting was held with the Grace team to present and validate the improvement proposals. During the meeting, each suggestion was detailed, explaining the expected benefits and how each proposal could be practically implemented.

Fortunately, all our proposals were well received by the Grace team. They considered the suggestions feasible and showed interest in conducting tests to verify the effectiveness of the proposed improvements. The validation of the proposals was a crucial step, as it ensured that our ideas were aligned with the company's needs and expectations and paved the way for the next phase of implementation and practical tests.

6. Conclusion

Through a meticulous and collaborative approach, it was possible to identify and propose significant improvements that not only meet the established objectives but also provide a unique contribution to the company's operational efficiency.Initially, an on-site visit was conducted to get to know the facilities and understand the equipment's operation. Although it was not possible to observe the setup directly during the visit, subsequent video analysis and additional data collection allowed for a detailed understanding of the process. Tools such as flowcharts and audio recordings were used to clarify doubts and ensure that all steps were well documented. The improvement proposals included replacing traditional screws with quick-release clamps and quick-release screws, as well as implementing vibration and level sensors. These changes were based on provided data and manufacturer specifications, ensuring a grounded and practical approach.The simulation of expected results indicated a significant reduction in setup time, with substantial annual savings. The validation of the proposals by the Grace team was a crucial step, confirming the feasibility of the suggestions and paving the way for implementation and practical tests.The acceptance of the proposals demonstrates the relevance and applicability of the suggested improvements, aligning with the company's needs and expectations. From an academic perspective, this study contributes by demonstrating how structured methodologies like SMED can be effectively applied in complex industrial environments, offering both theoretical and practical insights. The measurable time savings and cost estimates provided reinforce the practical value of this study. Furthermore, the results indicate the potential for scalability and integration with other Lean tools in different industrial settings.

In conclusion, the implementation of the proposed improvements will result in a more efficient, safe, and productive operation, benefiting both the company and its employees. This work exemplifies how the application of continuous improvement methodologies can generate tangible and significant results, contributing to the competitiveness and sustainability of the chemical industry.

References

Feamig, PROPOSIÇÕES PARA A REDUÇÃO DO TEMPO DE SETUP NO PROCESSO PRODUTIVO DE IMPRESSOS. 2015. Disponível em: https://singep.org.br/4singep/resultado/556.pdf. Acesso em: 12 nov. 2024.

Mackenzie, Redução do tempo de Setup em uma indústria de pisos de madeira no interior de São Paulo. 2020. Disponível em: https://dspace.mackenzie.br/items/c89c7a64-504f-4c67-8751-4a59dcbeb9e8. Acesso em: 12 nov. 2024.

Scielo, Um método para o cálculo do benefício econômico e definição da estratégia em trabalhos de redução do tempo de setup. 2010. Disponível em: https://www.scielo.br/j/gp/a/pHC7STmRBbwgFbFt9HVSZyf/?lang=pt&format=html. Acesso em: 12 nov. 2024.

UNESP, Redução de tempos de setup: aplicação de troca rápida de ferramentas em indústria de bebidas. 2015. Disponível em: https://repositorio.unesp.br/items/e316871b-35dd-4dc2-a86e-41c1d6b1dd3f. Acesso em: 12 nov. 2024

FLUMINENSE, Universidade Federal, ANÁLISE DA APLICAÇÃO DO MÉTODO SMED NA REDUÇÃO DO TEMPO DE SETUP EM CONJUNTO COM O TRAVEL CHART, EM UMA INDÚSTRIA DO SETOR METAL MECÂNICO. 2014. Disponível em: https://www.uniara.com.br/arquivos/file/ppg/engenharia-producao/producao-intelectual/dissertacoes/2014/fabio-ferreira-cardoso.pdf. Acesso em: 12 nov. 2024.

KIFIX, Grampo de Aperto Rápido Tensor KIFIX KF943 DV 1200Kgf. Disponível em: https://loja.kifix.com.br/grampo-de-aperto-rapido-tensor-kifix-kf943-dv-1200kgf-842. Acesso em: 12 nov. 2024.

KIPP, Parafuso de Aperto Rápido Kipp K0362. Disponível em: https://www.kipp.com.br/br/pt/Produtos/Dispositivos-de-controle-Elementos-normalizados/Posicionadores-com-mola-Pinos-de-reten%C3%A7%C3%A3o-Pinos-de-bloqueio-esf%C3%A9ricos/Pinos-de-reten%C3%A7%C3%A3o/Pinos-de-reten%C3%A7%C3%A3o-de-a%C3%A7o-ou-a%C3%A7o-inoxid%C3%A1vel-sem-colar-com-man%C3%ADpulo-de-cabe%C3%A7a-cogumelo-pl%C3%A1stico-pino-de-guia-para-travamento-prolongado-e-contraporca.html. Acesso em: 12 nov. 2024.

WILCOXON, Sensor de Vibração Wilcoxon 786A. Disponível em: https://wilcoxon.com/786a/. Acesso em: 12 nov. 2024.

NEWARK, UC2000-30GM-IUR2-V15. Disponível em: https://www.newark.com/pepperl-fuchs/uc2000-30gm-iur2-v15/ultrasonic-sensor/dp/65H6306. Acesso em: 12 nov. 2024.

Biographies

Víctor Henrique Sampaio is a Data Analyst with extensive experience in ERP and BI systems. He is currently working as a Data Analysis Consultant at Smurfit WestRock, where he has made significant contributions to process optimization and data-driven decision-making. Víctor's key responsibilities include ERP Kiwiplan system parameterization, KPI construction in Power BI, and the development of custom tools for supply chain management. Víctor is pursuing a degree in Production Engineering at FACENS University, Sorocaba, São Paulo, Brazil, expected to be completed in 2025. He has also completed several technical courses, including Data Analytics Essentials from Cisco Network Academy, advanced Microsoft Excel from Global School, and various other courses in logistics and supply chain.

Pablo Henrique Hernandes Ramos is a Production Engineering student at FACENS, currently in his ninth semester. With experience in industrial operations and process optimization, he has worked with AutoCAD, Excel, SAP, Power BI, and other tools. At Gerdau, he supported rolling mill production, managed safety and performance indicators, and coordinated outsourced teams. Now interning at Schaeffler, he focuses on Industrial Sales and Pricing, handling quotations, cost analysis, and product development for the LATAM market. Previously, as a Project Analyst at BASSEIFER, he specialized in structural project interpretation and budget management. He expands his expertise with certifications in Advanced Excel and process management.

Hyago Duque Gazda has a degree in Logistics and works as a Full Logistics Analyst at Toyota do Brasil, where he has already accumulated four years' experience, being responsible for the logistics planning of parts collections for the Sorocaba plant. During his career, he had the opportunity to work for three weeks in Thailand, which contributed to his international experience. He has extensive knowledge of road transportation, negotiating with suppliers and developing logistics projects.His main responsibilities include forecasting demand, calculating volumes, managing KPIs, routing, team management, as well as negotiating with suppliers and carriers. He is also responsible for coordinating the team's activities and schedule.Hyago is currently studying Production Engineering at FACENS (Faculdade de Sorocaba) and is due to graduate at the end of 2025.

Nicolas Gonzalez Vallarelli is a Commercial Sector Professional with extensive experience in sales and client relationship management. He is currently working as a Sales Consultant at Andremar Veiculos, where he has made significant contributions to revenue growth and customer satisfaction. Nicolas's key responsibilities include developing sales strategies, managing client accounts, and providing tailored solutions to meet customer needs. Nicolas is pursuing a degree in Production Engineering at FACENS University, Sorocaba, São Paulo, Brazil, expected to be completed in 2025. He has also completed several technical courses, including Sales Techniques from Udemy, Advanced Negotiation Skills from MOOC, and various other courses in marketing and business development
Gustavo Penafiel Luiz is a Project Engineering Intern at ZF do Brasil, focusing on process and people management. He is pursuing a Production Engineering degree at FACENS University (graduating in 2025). Previously, he interned at Schaeffler Brasil Ltda., working with SAP, Sales data analysis, and at Geocontrole BR Sondagens S.A., gaining experience in geotechnical analysis. He completed a high school exchange in Minnesota, USA, holds a Power BI certification, and was part of the V8 Racing team at FACENS, contributing to project management for the Formula SAE Brazil competition.

Matheus Kmez Alves is a commercial director and works as a PCD for the company. He currently works as a commercial representative for Henriplast, where he has closed several contracts and negotiations. Matheus' main responsibilities include aligning the entire PCD in packaging production, in order to have the best profit and the least loss in machinery setup. Matheus is studying Production Engineering at FACENS University, Sorocaba, São Paulo, Brazil, with completion scheduled for 2025. He has also completed relaxed courses in sales and communication. As contribuições acadêmicas não são claras e suficientemente explicadas. Além disso, o texto não trouxe nenhuma contextualização ao atual cenário mundial. Outro aspecto importante é a necessidade de apontar algumas conclusões e resultados que foram observados na pesquisa.