

CLEANER PRODUCTION AUDITING FOR THE MACHINING LABORATORY IN BRAZIL: A CASE STUDY

Brayam Luiz Batista Perini[1]*, Andrea Loureiro de Andrade[1], Alexandre Marcos Ferreira[1], Álvaro Paz Graziani[1], Dhyonatan Santos de Freitas[1], Anderson de Carvalho Fernandes[1]

[1]*Senai/SC University Center - Joinville Campus*

1. Introduction

There is an environmental impact caused by the activities of a machining laboratory in a university, particularly regarding the generation of solid waste (metal chips and scrap) and liquid waste (diluted cutting oil), both of which have significant pollution potential. Considering Brazilian environmental law, the principles and objectives of the National Solid Waste Policy (NSWP)[1], this research aims to implement Cleaner Production (CP) practices as a clean technology to minimize wastes and environmental impacts. This preventive method reduces waste generation and optimizes resource use, promoting sustainability within the educational environment. It could also help the university achieve its sustainable goals [2].

2. Experimental

A machining laboratory located in an educational institution in Brazil was selected for this study. This laboratory is equipped with various machines, including conventional lathes, milling machines, and grinders, where specific cutting tools and cutting oil are used for machining operations. For practical machining classes conducted in this laboratory, different types of steel parts and profiles are acquired. This environment was chosen for an audit aimed at implementing the Cleaner Production technique.

The research was structured into the following stages: (1) environmental diagnosis, identifying flaws in waste disposal and handling processes; (2) brainstorming to generate innovative ideas, such as material reuse and waste segregation; (3) detailed analysis of material inputs and outputs, with emphasis on steels 1020 and 1045 and fluid consumption; and (4) technical and economic feasibility study of the proposed solutions, ensuring they are sustainable and applicable within the laboratory context.

3. Results

The diagnostic conducted in the machining laboratory revealed inadequate waste management practices, highlighting two main issues: the improper disposal of cutting fluid and the lack of segregation of metallic waste. Currently, the cutting fluid is directly discharged into the stormwater system, exposing the institution to environmental and legal risks, considering the classification of oil as hazardous waste according to ABNT NBR 10004 [3]. Furthermore, metallic waste, such as chips and solid pieces, is mixed in the debris container, generating no financial return for the institution. Regarding industrial towels, the institution has a contract with third parties responsible for collecting the used ones (which are no longer fit for use) and restoring the quantities required to ensure the continuation of operational activities.

Based on the diagnosis identified in the initial stage, a brainstorming session was conducted to concentrate ideas and promote the development of possible solutions, applying the CP. Each proposed idea offers substantial advantages, such as cost reduction, enhanced operational efficiency, and adherence to regulatory standards. However, these initiatives also present particular challenges, including initial implementation costs and the requirement for specialized training. This initial survey was essential to identify opportunities for improvement and create an overview of the possibilities for implementing CP [4,5]

The project progressed through a thorough analysis of the input and output processes for 1020 and 1045 steel, uncovering that the existing disposal methods were not economically sustainable. This analysis highlighted opportunities to reuse or monetize metallic waste, improving management efficiency and generating financial gains by recycling materials or reducing operational costs. Additionally, cutting fluid used in machining was found to be improperly disposed of in the sewage system, posing environmental and legal risks. Addressing this was prioritized to ensure compliance with environmental regulations, prevent resource waste,

*Corresponding author: brayam.perini@edu.sc.senai.br

and minimize environmental impact. These initiatives aim to achieve environmental, institutional, and financial benefits, reinforcing the institution's commitment to sustainability and operational excellence.

4. Discussions

To address these issues, two viable proposals were presented as shown on mass balance in Fig. 1: (a) **Cutting fluid reuse system** (Fig. 2**)**: This system includes tanks, a centrifugal pump, and a filter to recover and reuse approximately 60% of the discarded fluid. The initial investment is R$ 2,500.00, with an estimated payback period of less than one year and annual operational cost savings of R$ 11,408.51. (b) **Segregation and commercialization of metallic waste**: By separating chips from solid parts, an annual revenue of R$ 896.64 can be generated through the sale of recyclable materials, with no additional operational costs, as the company responsible for collection provides the container free of charge.

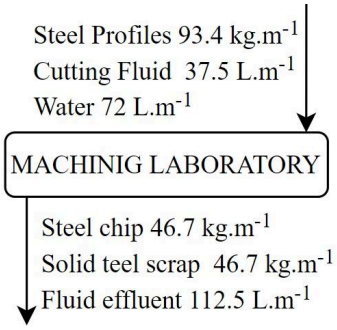


Fig. 1. Mass Balance.

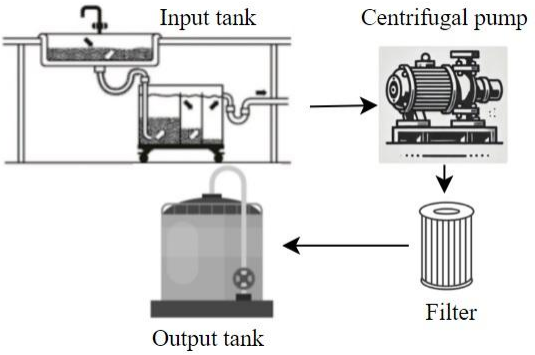


Fig. 2. Operational flow of the reuse system

The implementation of these proposals underscores the technical, economic, and environmental feasibility of aligning laboratory practices with the principles of CP. The fluid reuse system [4], in addition to reducing annual costs, contributes to sustainability by minimizing water pollution and reinforcing compliance with environmental legislation. From a financial perspective, the net savings generated in the second year amount to R$ 8,263.51, demonstrating the potential return and investment efficiency.

The segregation of metallic waste not only generates revenue but also promotes the valorization of recyclable materials, reinforcing the concepts of circular economy. The independent sale of materials to a company that provides the container free of charge and offers R$600 per ton of chips and R$1,000 per ton of solid parts (solid teel scrap). The institution could generate an additional annual revenue of R$896.64. These measures, aligned with the guidelines of the National Solid Waste Policy (PNRS), illustrate how simple and low-cost practices can have a significant positive impact on both the environment and operations.

Beyond practical benefits, the proposed solutions enhance the educational institution's role by incorporating environmental management practices that can be replicated by students in their future careers. This positions the educational institution as a benchmark for sustainability, demonstrating how the education sector can lead initiatives in environmental responsibility and innovation using the CP tool.

4. References

[1] NSWP. National Solid Waste Policy, **Law N° 12,305/2010**. Brasília, Brazil, 08 august (2010).
[2] B.F Gianetti, F. Agostinho, J.J. Cabello Eras, Z. Yang, C. Almeida, J. Clean. Prod., **271**, 122127, (2020).
[3] ABNT **NBR 10.004/2004**. Solid Waste - Classification. Brazilian Association of Technical Standards (2004).
[4] S.I. Hashmi, H.T.S.A. Hewage, C. Visvanathan. Chemosphere, **337**, 139338, (2023)
[5] Y. Gui, L. Yang, L. Shi, G. Liu, Y. Wang. J. Clean. Prod., **355**, 131392, (2022)
[6] G.A. Barboza. Reaproveitamento de Fluidos de Corte na Indústria Metalúrgica. TCC, **UFJF**. Juiz de Fora, Brazil (2018).

*Corresponding author: brayam.perini@edu.sc.senai.br