"The Use of the Balanced Scorecard (Bsc) to Improve the Operational Performance of the Machining Area in A Metal-Mechanic Sector Company"

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ABSTRACT: *This article presents the implementation of the Balanced Scorecard (BSC) as a strategic tool for reducing the percentage of dimensional scrap, specifically associated with the deformed-diameter defect, in the machining area of a company in the metal-mechanic sector. Based on an initial diagnosis, dimensional scrap was identified as a critical performance indicator, leading to the design of a BSC focused on the internal processes and quality perspectives. In parallel, Root Cause Analysis (RCA) was applied, and the actions were aligned with the requirements of the AS9100 Rev. E standard, aimed at risk management and the fulfillment of quality objectives. Actions implemented included changing or standardizing the inspection method, systematically verifying machine alignment, and using a scrap dashboard for continuous monitoring. The results for the April–October 2025 period show a progressive decrease in dimensional scrap from 15% to 7%, demonstrating that the BSC, when integrated with quality tools, constitutes an effective framework for improving operational performance in machining processes.*

KEY WORDS - *Balanced Scorecard, Continuous improvement, Machining, Root Cause Analysis, Scrap.*

I. INTRODUCTION

The metal-mechanic industry faces increasing demands in terms of quality, compliance with specifications, and waste reduction. In machining processes, one of the most relevant indicators is the scrap percentage, particularly dimensional scrap resulting from deviations in critical characteristics, such as the diameter of machined parts. High scrap levels directly impact operational performance, affecting productivity, delivery times, and process reliability. [1], [2].

In this context, the Balanced Scorecard (BSC) has become established as a management system that enables organizations to translate strategy into concrete indicators and targets, organized into four perspectives: financial, customer, internal processes, and learning and growth. [1], [3]. When applied to production processes, the BSC helps connect quality outcomes (such as scrap reduction) with strategic objectives related to competitiveness and efficiency. The company under study—an organization in the metal-mechanic sector dedicated to machining components—identified the defect of 'deformed diameter' as the main contributor to dimensional scrap in the machining area. Despite having a quality management system based on AS9100, scrap monitoring was carried out reactively and with limited visual support. This prompted the design of a BSC focused on internal processes and the integration of analysis tools such as RCA to address the root causes of the problem.

The objective of this article is to present the implementation of the Balanced Scorecard to reduce the percentage of dimensional scrap in the machining area, demonstrating the relationship between the initial diagnosis, the design of the BSC, the application of RCA, and the results obtained in scrap reduction during the January–October 2025 period.

II. LITERATURE REVIEW

2.1 Balanced Scorecard and operational performance

The Balanced Scorecard, proposed by Kaplan and Norton [1], [3], emerged as a response to the need to complement traditional financial indicators with measures related to customers, internal processes, and learning and growth. Its application in industrial environments has proven effective in aligning process improvement with organizational strategy. [4], [5]. In manufacturing companies, the BSC has been used to monitor indicators of quality, productivity, cycle times, and on-time delivery performance. [6].

The literature reports cases of BSC implementation in small and medium-sized companies in the metal-mechanic sector, where its usefulness has been demonstrated for structuring continuous improvement initiatives and making the impact of tactical actions on strategic results visible. [6].

2.2 Dimensional scrap and machining quality

In machining processes, dimensional scrap is associated with deviations in critical dimensions (diameter, length, concentricity, etc.), caused by factors such as tool wear, machine misalignment, thermal variations, clamping errors, or failures in the inspection method. [2], [7]. Reducing dimensional scrap is key to improving operational performance and customer satisfaction.

2.3 Root Cause Analysis (RCA) and risk-based standards

Root Cause Analysis (RCA) is a structured methodology that allows the identification of the root causes of quality problems, supported by tools such as the 5 Whys and the Ishikawa Diagram. [8], [9]. In management systems based on standards such as AS9100, risk-based thinking and attention to root causes are central elements for preventing the recurrence of nonconformities. [10], [11].

Integrating RCA with the BSC makes it possible to link the technical causes of problems with strategic indicators, ensuring that corrective actions are reflected in the improvement of key metrics such as the scrap percentage. [8].

III. METHODOLOGY

The methodology applied in this study was divided into four main phases, aligned with the continuous improvement cycle:

3.1 Phase 1: Diagnosis of dimensional scrap

A diagnosis of the scrap records from the machining area was carried out, identifying the main types of defects. The results indicated that the 'deformed diameter' defect represented the highest percentage within dimensional rejections. Data from January–March 2025 provided by the company were used as a reference. Based on this diagnosis, deformed-diameter scrap (% of total production) was defined as the main process indicator.

3.2 Phase 2: Design of the Balanced Scorecard

A specific BSC was designed for the machining area, prioritizing the perspectives of internal processes, quality, and learning and growth. Table 1 shows a simplified example of the objectives defined for each perspective.

Table 1. Excerpt of the Balanced Scorecard for the machining area, with a focus on dimensional scrap. Author's own elaboration

Perspective	Strategic Objective	Indicator	2025 Target
Internal Processes	Reduce dimensional scrap due to deformed diameter	% of dimensional scrap	−15% annually with respect to initial value
Quality	Increase compliance with critical specifications	Conforming pieces / total pieces	≥ 98%
Learning and Growth	Standardize inspection and alignment methods	% of trained operators	100%

In addition, a strategic map was developed linking learning objectives (training and standardization), internal processes (scrap reduction), customer-related goals (higher satisfaction), and financial goals (improved margins) [1], [3]. Figure 1 shows the simplified strategic map focused on reducing dimensional scrap.

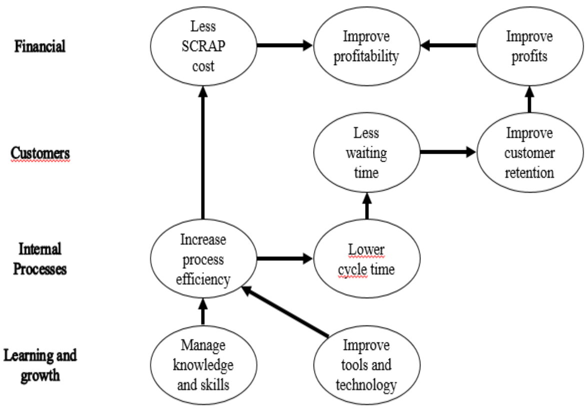


Figure 1. Simplified strategic map focused on reducing dimensional scrap

3.3 Phase 3: Root Cause Analysis (RCA)

For the “deformed diameter” defect, an RCA was applied using:

- Ishikawa Diagram (man, machine, method, material, environment, measurement), as shown in Figure 2.
- 5 Whys to deepen the analysis of the causes.

In summary, the dominant causes identified were:

- Machine misalignment (supports, spindle, clamping).
- Variability in the dimensional inspection method.
- Tool wear or inadequate tool selection.

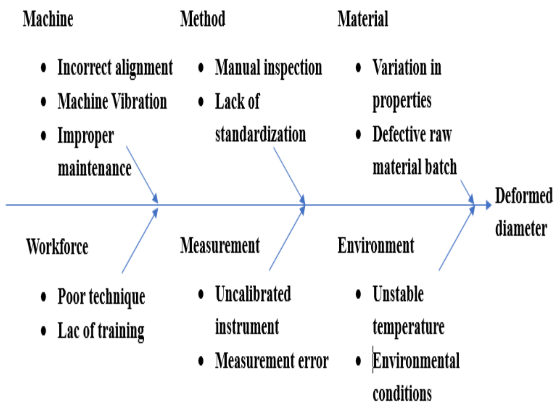


Figure 2. Ishikawa Diagram for “deformed diameter” defect

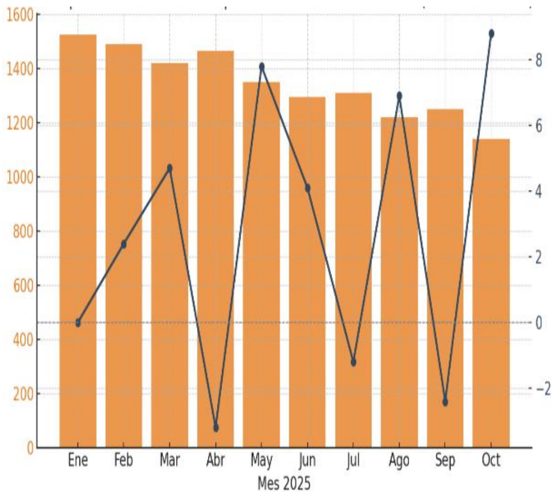
The Ishikawa Diagram presented in Figure 2 makes it possible to identify, in a structured manner, the potential causes that contribute to the occurrence of the ‘deformed diameter’ defect, classified as dimensional scrap. The analysis shows that the issue does not originate from a single point in the process, but rather results from the interaction of multiple factors distributed across the six classic categories: Machine, Method, Material, Labor, Measurement, and Environment.

3.4 Phase 4: Implementation and monitoring

Based on the BSC and the RCA, the main improvement actions were defined:

- Implementation of a machine alignment checklist prior to each production batch using a verification sheet (checklist).
- Standardization of the diameter inspection method (use of Pin Gauge or the defined method) and acceptance/rejection criteria through the Standard Operating Procedure (SOP) guide.
- Monthly monitoring of the percentage of dimensional scrap through a scrap dashboard linked to the BSC indicators.

IV. RESULTS



The results obtained after implementing the Balanced Scorecard (BSC) in the machining area of the company under study were analyzed, focusing on the reduction of dimensional scrap, specifically the 'Deformed Diameter' defect, identified as one of the main contributors to the scrap percentage generated in 2024 and part of 2025.

Based on the proposed improvement actions, the change in the inspection method (from the Vision System to the Pin Gauge method), and the verification of machine alignment, a pilot plan was implemented from April to July 2025, and the results obtained during August, September, and October of the same year were collected.

Table 2 presents the percentage of scrap due to deformed diameter generated from January to October 2025. (Monthly comparison by scrap percentage) (Table from January to October).

Table 2. Monthly percentage of dimensional scrap due to deformed diameter.

Month 2025	Scrap Generated (pieces)	Scrap reduction (pieces)	% Scrap Reduced
January	1,527	0	0
February	1,490	37	2.40
March	1,420	70	4.70
April	1,465	-45	-3.20
May	1,350	115	7.80
June	1,295	55	4.10
July	1,310	-15	-1.20
August	1,220	90	6.90
September	1,250	-30	-2.40
October	1,140	110	8.80

As shown in Table 2, there is a positive monthly average of 8.80% in October for scrap associated with deformed diameter. Inspection using the Pin Gauge system and routine machine calibration were the main contributors to this improvement. Figure 2 presents the amount of scrap generated (pieces) monthly during 2025, showing the percentage of monthly reduction or increase in the scrap level due to deformed diameter.

Figure 4. Behavior of Scrap Generated from Deformed Diameter (Jan-Oct 2025).

As shown in Figure 4, the behavior of the scrap generated reveals peaks of reduction in April, July, and September, which coincide with the integration of the Pin Gauge inspection system and the routine machine calibration within the alignment system. The overall trend shows a sustained reduction, reaching an average monthly improvement of 3.2%, within the annual target of a 10–15% cumulative reduction.

The comparison between the initial and final BSC can be carried out once the year 2025 concludes. The improvement should be reflected particularly in the Internal Processes perspective, since this study focused on addressing the deformed-diameter defects classified as dimensional

V. DISCUSSION

The results indicate that integrating the BSC with quality tools such as RCA and AS9100-aligned controls enabled a sustained reduction in dimensional scrap.

First, the BSC facilitated:

- Focusing efforts on the critical indicator (percentage of dimensional scrap)
- Translating strategic goals (improving operational performance) into concrete scrap-reduction targets
- Monitoring progress through a visual dashboard, improving internal communication

The RCA made it possible to connect the metric with specific technical causes, ensuring that the proposed actions (machine alignment, inspection standardization) were not generic but targeted at the points with the greatest impact [8], [9].

Also, alignment with AS9100 Rev. E reinforces the focus on risk management and nonconformity prevention, ensuring that scrap reduction is not merely situational but sustainable [10], [11].

The behavior is consistent with what is expected following the implementation of a systematic improvement and control plan for the machining process.

VI. CONCLUSION

The implementation of the Balanced Scorecard in the machining area made it possible to structure a measurement and monitoring system focused on reducing dimensional scrap, linking daily operations with the organization's quality and continuous improvement strategy. The 'deformed diameter' defect was identified as the main cause of dimensional scrap; its treatment through RCA allowed the definition of precise actions regarding machine alignment and the inspection method. The results for the January–October 2025 period show a progressive decrease in the percentage of dimensional scrap, from approximately 15% to 7%, representing a significant improvement in machining process performance. The integration of the BSC, RCA, and AS9100 Rev. E strengthened a data-driven, risk-based, and strategically aligned approach, demonstrating that these tools can be effectively combined in companies within the metal-mechanic sector.

VII. FUTURE WORK

As future work, the following is proposed:

1. Introduce training hours for the employees involved, based on the two actions carried out in the study: changing the sequence when aligning the machines and replacing visual inspection with the Pin Gauge method.
2. Implement the Process FMEA tool, focusing on identifying potential failure modes related to scrap generation so they can be anticipated. For this, it is necessary to have a timely failure. detection system.

ACKNOWLEDGMENTS

The authors express their gratitude to the metal-mechanic company that enabled the development of this study, as well as to the machining-area personnel for their collaboration in data collection and the implementation of improvement actions. Likewise, the support of the academic advisors from the Master's Program in Industrial Engineering is acknowledged for their methodological and technical guidance throughout the development of this research.

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