BSC APPLICATION ON TPM MANAGEMENT – A CASE STUDY IN PROCESS INDUSTRY

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Abstract*. This work proposes an application model based on the Balanced Scorecard (BSC) strategic management methodology in order to assist Planned Maintenance Pillar, which is responsible for the maintenance management in the TPM(Total Productive Maintenance) program, once adopted by an important company of continuous process in pulp and paper branch in Brazil. This methodology allows aligning the performance indicators with the proposal strategy for the pillar (vision, mission and objectives) in terms of financial, clients, internal process and learning and growing perspectives. Besides, it shows the dependency relationship (cause-effect) among the indicators adopted by the pillar in a strategic map, intending to support the decision for better actions (strategic initiatives) that the maintenance function must carry out. BSC stimulates the constant strategy feedback, promoting the continuous improvement and showing a natural evolution in maintenance management function that looks for to reach and sustain the world class pattern on its results.*

Keywords*: Balanced Scorecard, Maintenance Management, Total Productive Maintenance, Performance Indicators*

1. INTRODUCTION

With the Brazilian market globalization, companies have been looking for better results in their manufacturing processes. The World Class Manufacturing (WCM), concept originally introduced by the authors Hayes and Wheelwright in 1984 (Flynn, 1999), arises characterized by high productivity, availability and flexibility. In order to achieve this higher development stage on manufacturing processes the maintenance skills are a key element. The maintenance function adapted for global competition environment characterizes the World Class Maintenance.

Yamashina (2000) considered in his research among Japanese manufacturing companies, that the adoption of TPM (Total Productive Maintenance) maintenance management system along with to JIT (Just in Time) production system, integrated with de quality management system TQM (Total Quality Management) provides the path to reach the WCM concept in processes and innovative products.

Hendry (1998), Tsang (1998), Bond (1999), Liyanage and Kumar (2003), Dunn (2003), assert that the world class performance in maintenance function depends on metrics that can be obtained by a benchmarking process. Therefore, performance indicator systems linked to organization strategy becomes essential to reach the excellence in maintenance processes.

Amendola (2003), Tsang (1998), Ahlmann (2002), Liyanage and Kumar (2003), Dunn (2003), Ellingsen et al., (2002) suggest the Balanced Scorecard (BSC) methodology which proposes to integrate the performance evolution with the maintenance business strategy. Its application has gotten excellent results since its popularization in 1992 by their two authors Robert Kaplan and David Norton.

Considering about the strategic maintenance function for company business, specially in those ones with a continuous process and high stoppage cost; concerning the TPM management inability to visualize the maintenance performance in whole company business by treating the financial indicators and performance indicators separately; and in way to identify the critical points in maintenance management process arises the necessity to adopt a strategic management tool to improve the maintenance process which looks for the world class standards.

The aforementioned limitation motivated the present research, which culminated in the BSC implantation on the Planed Maintenance Pillar in TPM program, which is responsible for the maintenance management in the TPM management system in order to approach the shop floor actions with the maintenance strategic plan and overall enterprise results.

To allow for a better understanding of the research process, a brief introduction to BSC and TPM and their mutual relationship is presented. Furthermore, the implementation of the TPM program by the pulp and paper company KALBIN S.A. is explained.

2. MAINTENANCE MANAGEMENT WITH BSC's METHODOLOGY

Kaplan and Norton (1992) had developed a strategic maintenance system, based in performance indicators, called out of Balanced Scorecard (BSC). Its proposes translate the vision and strategy of a business unit in objectives and targets tangible in all organization levels, reflecting the equilibrium between short term's objectives and long term objectives, using financial and non financial tendency indicators, with internal and external perspectives of

performance. The BSC promotes a performance indicators balanced sight about four perspectives: financial, internal process, learning and growth, as showed in Fig. 1.

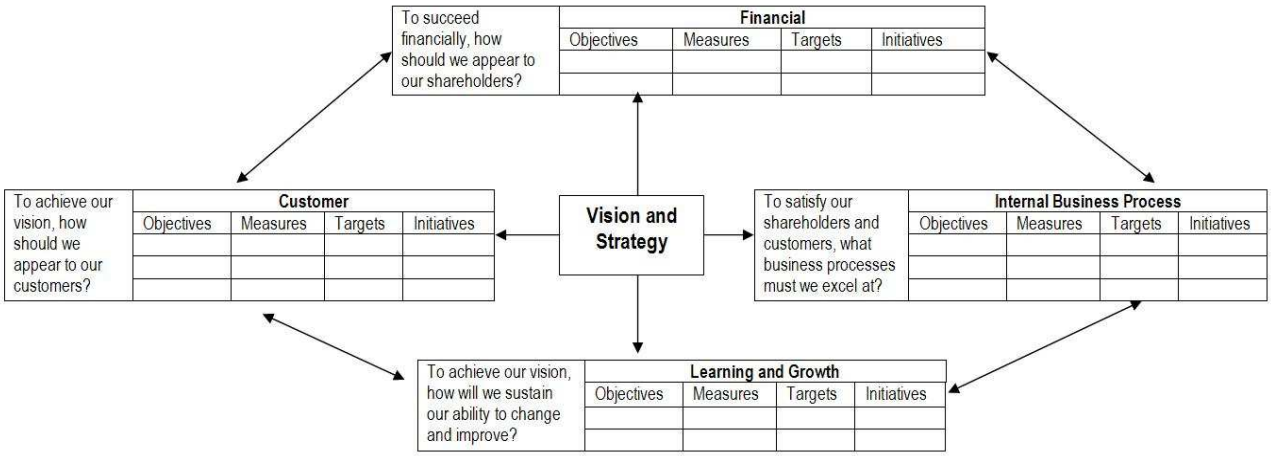

Figure 1 – The Main Framework of Balanced Scorecard (KAPLAN and NORTON, 1996, p. 76)

According Kaplan and Norton (1996) apud Tsang (2002) managers frequently think that the strategy is too abstract to guide in day-to-day decisions. Using the BSC, the strategy is translated in something more tangible and operational – linking long terms objectives, performance metrics, their targets and action plans.

The BSC perspectives can be framed in the maintenance management as follow:

- Financial: performance related to economy and service costs;
- Costumers: plant performance for production, the maintenance costumers;
- Internal Process: maintenance department performance and efficiency;
- Learning and Growth: own staff efficiency and outsourcing efficiency, new techniques use;

Amendola (2005) declares that the primordial advantage is considering the four perspectives simultaneously and the relationship between them, becoming possible to establish a "cause-effect" network and providing strategic initiatives in each level. The connection between the four perspectives constitutes the Balanced Scorecard, providing, in analogy suggested by their authors Kaplan and Norton, a "control panel" for the maintenance administration, as performed in Fig. 2.

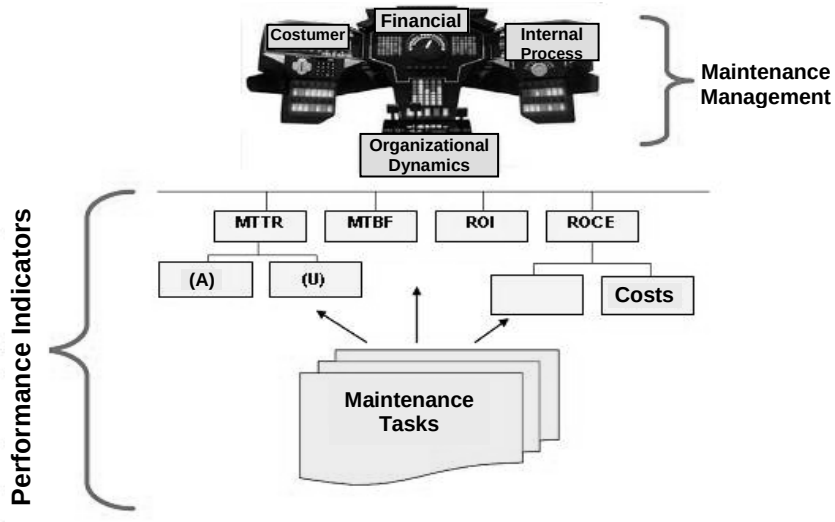

Figure 2 – Indicators control panel (Adopted from AMENDOLA, 2005)

The performance indicators synthesize the maintenance tasks. The main performance indicators are: MTTR (Mean Time to Repair), MTBF (Mean Time between Failure), MDT (Mean Down Time), ROI (Return on Investment) and ROCE (Return on Capital Employed). The first three ones contain the failure rates that complain the corrective and preventive maintenances related with the Availability (A) and Utilization (U) indicators. The last two ones are related with the financial demands associated to maintenance costs. These indicators interact with the maintenance management in an organizational dynamic.

According to Amendola (2003), the methodological mark introduced by Kaplan and Norton can be applied on maintenance management system in what the author calls "Four Stage Model", illustrated in Fig. 3. That implantation

project sequence was adopted by several enterprises in business process and will be able to succeed in maintenance. The model assures the conceptual base from BSC methodology for the actors who it concern, from the shop floor level up to maintenance manager.

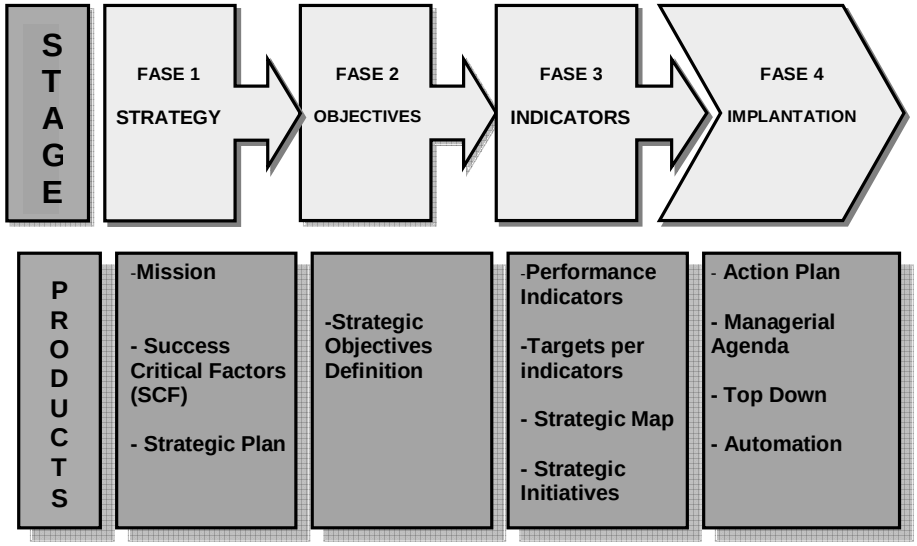

Figure 3 – Four Stage Model (adopted from AMENDOLA, 2003).

The sequence allows capturing and translating the organization strategic objectives in to a measurement system by performance indicators, concerning about a variety of strategic and operational situations that the organizations can pass through.

3. TPM - TOTAL PRODUCTIVE MAINTENANCE

The Total Productive Maintenance (TPM) is an including management system searching for the continuous losses elimination. Thereby, obtaining the permanently evolution of the managerial structure through employees, manufacturing process, quality, products and services constant improvement.

This methodology has been so well received by the plants where it was implanted that, along the years, the TPM concepts passed to be applied in all sector of the company, including improvement quality activities, safety and environmental care, machine, equipments and product design, administrative tasks e many others.

According to Palmeira (2000) the TPM forth generation, initiated in 1999, consider the whole organization involvement in losses elimination, cost reduction and efficiency maximization. It regards a more strategic vision of the administration, a commercial and product development involvement, what makes possible to eliminate the twenty biggest losses among processes, inventories, distributions and purchases losses.

Although, each company, considering its culture, have their peculiarities to implement the TPM program, but some basic principles are common to all them. They are denominated as the "pillars**"** of TPM sustentation (NAKAJIMA, 1989 and PALMEIRA, 2002) and are described as follow:

- Focused or Specific Improvement Pillar: use the corrective maintenance concept to perform in chronics losses related to equipments;
- Autonomous Maintenance Pillar**:** based in theoretical and practical training received by the employees focused in team work spirit for production and maintenance continuous improvement.
- Planned Maintenance Pillar: refers to preventive maintenance routines based on time (TBM-Time Based Maintenance) or on equipment condition (CBM – Condition Based Maintenance), seeking the continuous improvement of the availability and reliability besides the maintenance cost reduction. This pillar is the article's focus where the BSC was applied, as will be showed in the following items;
- Educational and Training Pillar: refers to application of technical and compartmental qualification for team's leadership, flexibility and autonomy;
- Early Management Pillar: based on preventive maintenance concepts where all the previous equipment report or their similar are used in product development in order to build equipments with higher reliability and mantenability indexes.
- Quality Maintenance Pillar: refers to interaction of the equipments reliability, with product's quality and demand attendance capacity.
- Security, Health and Environment Pillar: depends on the others pillars actuation. This pillar has its focus on work conditions continuous improvement and in safety and environmental risk reduction; and

- Administration Process Improvement Pillar: also known as TPM Office, use the organization and waste elimination concepts in administrative routines, which somehow interfere in the production process and equipment efficiency.

4. BSC & TPM

According with the Mcadam and Bailie (2002) research, TPM is not perceived as a significant strategy contributor. In spite of it brings the organization agreement and order necessity, which is so well evidenced, nowadays TPM is associated with basic operational delays measures and with a lack of development in leadership measures, what decrease its reputation in strategic changes. Although, it is not directly linked with the strategic objectives, Mcadam and Bailie indicate TPM as the best strategy to optimize the production costs.

The organizations where the TPM program was adopted, routine services and equipment periodic inspections are made by its operator, while the revisions and main repairs are under the maintenance unit responsibility. The phrase "What can be measure can be done" by Peters and Waterman (1982) apud Tsang (1998) emphasizes that the employees behavior is largely influenced by the performance measure system. For that reason it is desirable that the measure system attend to organization strategy in order to obtain the maximum impact, because the employee's behavior will be appraised by performance indicators, which will be related with the company's maintenance strategy.

Tsang (2002) points the BSC as a way to overcome the Overall Equipment Effectiveness (OEE), the index globally used to measure the results obtained with the TPM implantation (based in equipment availability, operational performance and product quality), inability into provide a holistic assessment for the maintenance organization performance as a whole and for the lack of future representation measures, due to OEE has a equipment focus. Tsang remarks that generic measures like OEE are used to some operational tasks control and feedback, but they are not necessarily useful to evaluate the long term growth. OEE and BSC can be blend in situations where it pretends to create value and the financial restrictions are moderated.

Once defined that the maintenance objectives are compatible with the company strategic positions, becomes necessary to create instruments that allow to visualize how far those objectives are in relation to targets to be reach or, on the other hand, if they are indicating deviations that force to take corrective actions. The objectives, in general, not possess a fast and precise answer for the manager to take actions before the deviations reach a difficult or impossible recovery state.

5. THE TPM PROGRAM ON KLABIN COMPANY

Klabin is the largest paper producer and exporter in Brazil and it is market leader in packaging paper and board, corrugated boxes and industrial sacks. It is also the biggest paper recycler in South America and it produces and sells wood in logs. Founded in 1899, today it has 17 industrial plants in Brazil, spread around eight states and one in Argentina. It's organized in four business units: forestry, paper, corrugated packaging and industrial sacks. The main plant is a packaging paper and board factory located in Telêmaco Borba town, in Paraná state, called KPMA (Klabin Papéis Monte Alegre).

The TPM implantation process in KPMA was impelled by the necessity to compete in world excellence levels and, in the same way, to consolidate a management system that must be disseminated in whole organization, based in problem solution solving, working time and continuous improvement.

Seeking to canalize and to align people and actions in the same direction, the enterprise TPM implantation process was nominated as the SUPERAR program, designation that looks for establish a program main objective - to break the limits and increase the competitiveness.

The program objective is to fetch the continuous overcome, by tools disseminations and resolutions process with team working, where the main assets are the people. For these reasons, the SUPERAR Program Vision was defined as – "*engage employees*, *improve KPI* (Key Performance Indicators) *and achieve the TPM Award"*.

Since 1971, the JIPM (Japanese Institute of Plant Maintenance), main organization responsible for the world TPM dissemination, comes awarding the enterprises, in and out of Japan, which present excellence in TPM implantation and sustentation (NAKAJIMA, 1989).

Figure 4 presents the sustentation pillars of the SUPERAR program. They are constitute by specific activities and particularities like health and safety, quality, maintenance, productive flow, costs, which one responsible for reach the organization goals intended by the program. The pillars' function is to implement the OEE and others performance indicators in each specialty and to identify the improvement points.

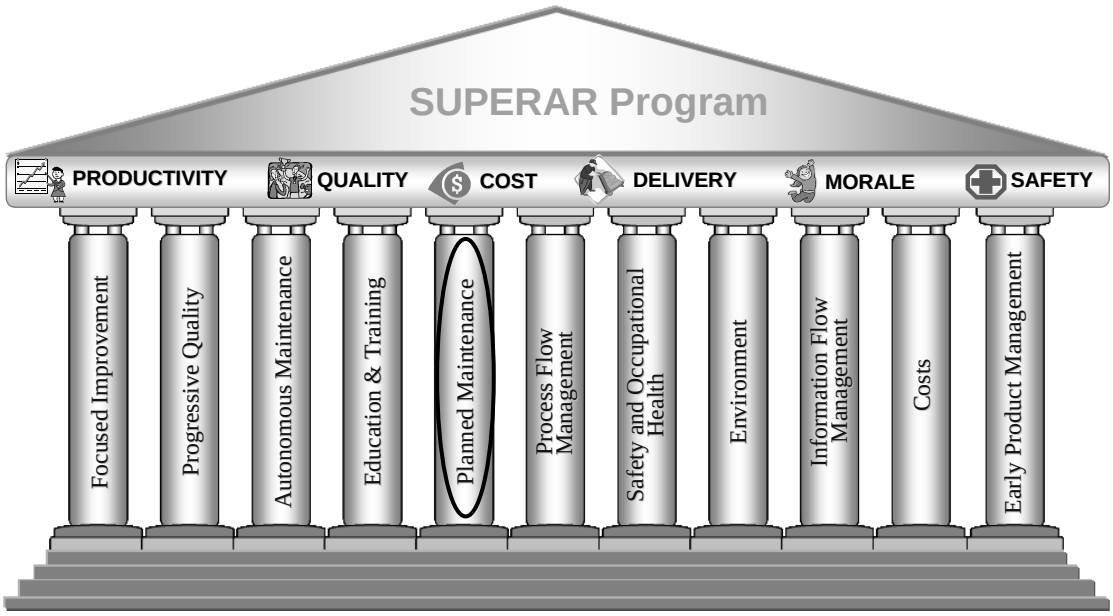

Figure 4 – SUPERAR Program Pillars

Proceeding with the TPM implantation plan the Planned Maintenance Pillar was created, searching for to optimize the maintenance managerial process, establishing politics, methods, activity patters, weak point's elimination, qualifying the employees and involving the production staff in machine control. Founded in its activities was established the Maintenance Planed Pillar Mission which is: **"***Increase the availability and the reliability of the machines and installations with safety and adequate costs.***"**

6. TPM ENVIRONMENT TO BSC IMPLATATION

To apply the BSC methodology in a maintenance organization based in TPM system it was adopted the Four Stage Model described in item 2. This methodology shows to be adequate for managing the maintenance function. It proves to be simple and objective, making possible to show how the BSC can be applied on the Planned Maintenance Pillar environment of the SUPERAR TPM program in KPMA, translating its strategy and showing the BSC's contributions to improve the TPM maintenance management in this company.

The research process is the result of the knowledge expressed in Biasotto's research with the KPMA maintenance department collaboration.

As follow it will be presented the implantation process and the problematic related from this process. Some method adaptations occurred and along the text they will be evidenced.

6.1. Stage 1: Strategy

The first stage objective is to integrate the BSC with the Planned Maintenance Pillar plan highlighting the BSC contribution to visualize the relationship among the shop floor and the top management strategic planning.

Figure 5 shows the BSC's dynamics where the questions defining the Success Critical Factors – SCF to reach the pillar Mission in the SUPERAR program Vision, already described in item 5, will be made. Beginning with the financial perspective, these four perspectives will take shape for the BSC bases where all the strategy translation process for the maintenance management will proceed.

The SCF correspond to main objectives or actuation lines where the pillar team must perform to succeed in their maintenance management. The SCF defined by the pillar team are searching for:

- Reduce, eliminate and prevent breakdowns;
- Implement a Planned Maintenance System;
- Support the groups of Autonomous Maintenance;
- Support the Quality Guarantee System; e
- Control and reduce the maintenance costs.

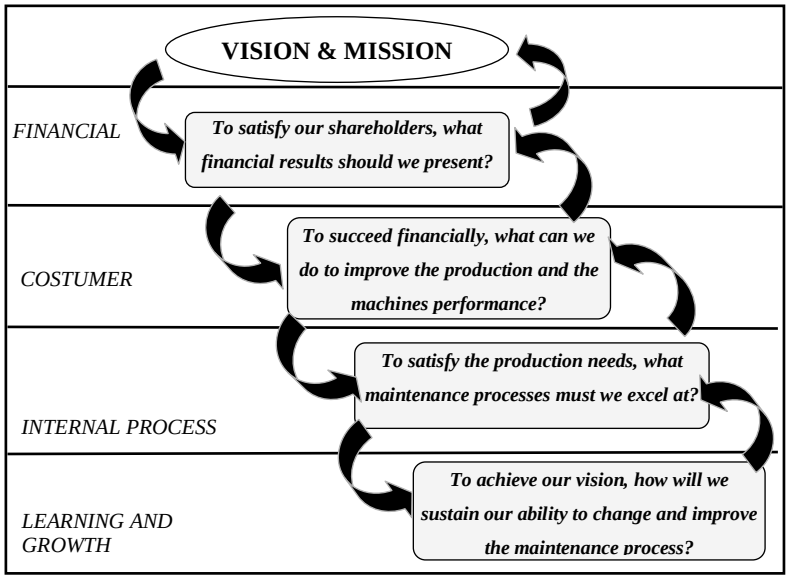

Figure 5 – BSC dynamic to define the SCF

Once the SCF were identified, a cause-effect analyses must be done, which requires care in considering possible conflicts between perspectives, as well as some synergy. In others words, this cause-effect analysis defines if the SCF are or are not mutually encouraging to reach the pillar Mission.

Adopting the SCF defined by the Planned Maintenance Pillar for the maintenance function in the BSC's four perspectives, based in the BSC dynamic from Fig. 5, it can be established the strategic planning map for the pillar to reach the Mission, as showed in Fig. 6.

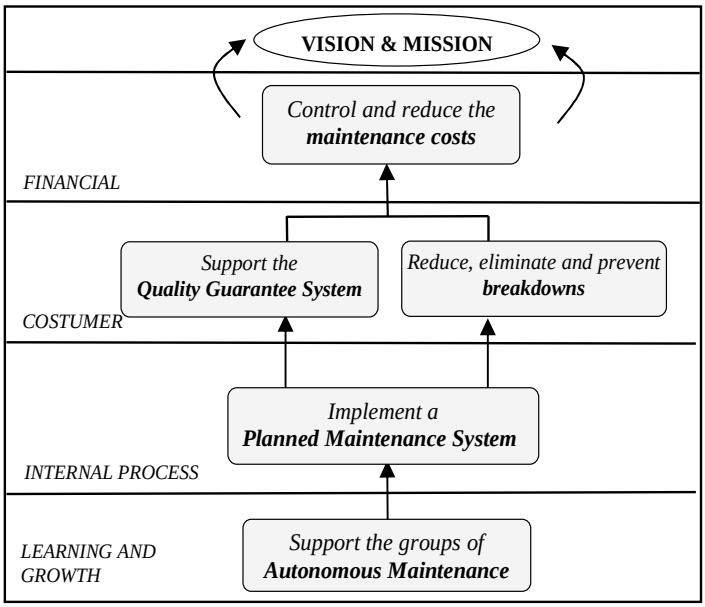

Figure 6 – Planned Maintenance Pillar Strategic Planning Map with their SCF

From this preliminary strategic map it is possible to see orderly that the maintenance costs control and reduction (financial perspective) will occur through the breakdowns reduction, elimination and prevention jointly with the quality guarantee system in services to operation (costumer perspective), what will be possible with the planned maintenance system adoption in the maintenance department (internal process), which depends of the autonomous maintenance teams qualification (learning and growth), the staff responsible for the plan operation and maintenance. With this relationship it is perceived that the SCF of the autonomous maintenance team support, based in employee's training and qualification, characterizes the motive force for the pillar to obtain success in the others BSC's perspectives.

SCF identified and its cause relations understood, the next step involves identifying adequately the strategic objectives that shows where the maintenance must to act to reach success.

6.2. Stage 2: Strategic Objectives

Giving continuity to strategy translation process, in this stage it is identified where the Planned Maintenance Pillar must to act to succeed in its Mission. Therefore in this stage, according to Amendola`s methodology, the strategic objectives are identified, starting from the SCF deployment considered in the previous stage.

The strategic objectives relate to the key actuation points where the pillar must act, showed in Tab. 1, which are based in availability, reliability, costs, energy consumption, systemic improvement and employee's characteristics. Now the pillar key actuation points are identified as objectives related to strategy, demonstrating specifically where the pillar management must act to succeed in its strategy.

Table 1 – Strategic Objectives for the Planned Maintenance Pillar

BSC`S PERSPECTIVES	SUCCESS CRITICAL FACTORS - SCF	STRATEGIC OBJECTIVES
FINANCIAL	**Control and reduce the maintenance costs**	**Costs** ✓ Material waste reduction ✓ Spare parts reduction ✓ Rework elimination
		Power consumption ✓ Usage optimization ✓ Losses reduction
COSTUMER	**Support the Quality Guarantee System & Reduce, eliminate and prevent breakdowns**	**Availability** ✓ Breakdown reduction ✓ MDT and MTTR reduction ✓ Maintenance schedule improvement
		Reliability ✓ Increase MTBF ✓ Breakdown prevention ✓ RCM and FMEA
INTERNAL PROCESS	**Implement a Planned Maintenance System**	**Systematic improvement** ✓ Ideal policy of Maintenance ✓ Breakdown analysis system ✓ Support to Autonomous Maintenance ✓ Support to Quality System
LEARNING AND GROWTH	**Support the groups of Autonomous Maintenance**	**Employees** ✓ Skills' development (operator and maintenance worker) ✓ Occupational accidents' reduction

6.3. Stage 3: Performance Indicators

Using performance indicators and having them actualized and accessible for the whole corporation is the fundamental path to succeed in any management program. Linking the performance indicators with the strategic planning in BSC perspectives becomes possible to perceive the maintenance staff actions in relation to the maintenance strategic planning. The performance indicators selected to evaluate the Planned Maintenance Pillar evolution are related in Tab. 2 concerning the strategic objectives in the BSC`s four perspectives.

In Tab. 2 analyzes, it can be observed that the indicators used by the pillar, sometimes, refers to more than one strategic objective. The "Replacement Pieces**"** indicator refers as much to the strategic objective of the ideal maintenance policy (systemic improvement) in the internal process perspective, as it indicates the spare parts reduction (costs) in the financial perspective.

The other internal process indicator, the "Monthly Number per Machine Breakdown**"** refers to the fact that it must have a breakdown analyses system (systemic improvement), as well as to the breakdown prevention (reliability) and breakdown reduction (availability).

On the other hand, some pillar strategic objectives as spare parts reduction and rework elimination (costs), in BSC`s financial perspective, are not directly contemplated by a indicator. These pillar strategic objectives are indirectly appraised by "Maintenance Cost (% cost based on costs of the base year 2002)" and **"**Maintenance Specific Cost**"** indicators**,** besides the "TFG - General Accidents Frequency Rate" and "Training" indexes which measuring the pillar management performance in the learning and growth strategic objectives from BSC.

Table 2 – Planned Maintenance Pillar indicators

BSC	SCF	STRATEGIC OBJECTIVES	PERFORMANCE INDICATORS	UNITY
FINANCIAL	**Control and reduce the maintenance costs**	**Costs**	**Maintenance Cost (% cost based on costs of the base year 2002)**	**%**
			Maintenance Specific Cost	**R$/t**
		Power consumption	**Specific Consumption of Power**	**MWh/t**
			Specific Consumption of Steam	**Gcal/t**
COSTUMER	**Support the Quality Guarantee System & Reduce, eliminate and prevent breakdowns**	**Availability**	**OEE Fabric - Availability of Maintenance**	**%**
			MDT per Machine	**hours**
		Reliability	**MTBF per Machine**	**days**
			MTBF per Plants	**days**
INTERNAL PROCESS	**Implement a Planned Maintenance System**	**Systematic improvement**	**Replacement Pieces - Average of Time of Permanence in Stock**	**years**
			Monthly Number per Machine Breakdown	**Breakdown/ Machine**
LEARNING AND GROWTH	**Support the groups of Autonomous Maintenance**	**Employees**	**Training**	**hours training/ man/year**
			TFG - General Accidents Frequency Rate	**index**

To justify the dependency relation and functionality of each indicator, it is now elaborated a indicator's strategic map in Fig. 7, to demonstrate the indicators alignment with the pillar strategic, that is, the Mission, SCF and strategic objectives in the BSC`s perspectives, such as its inter-relations. Because, as it was mentioned by Kaplan and Norton (1997) – "so that BSC reflects the strategies of the organization, it is fundamental that the four perspectives reflect the cause-effect relations between them, because the strategy is a set of hypotheses on cause and effect analyses".

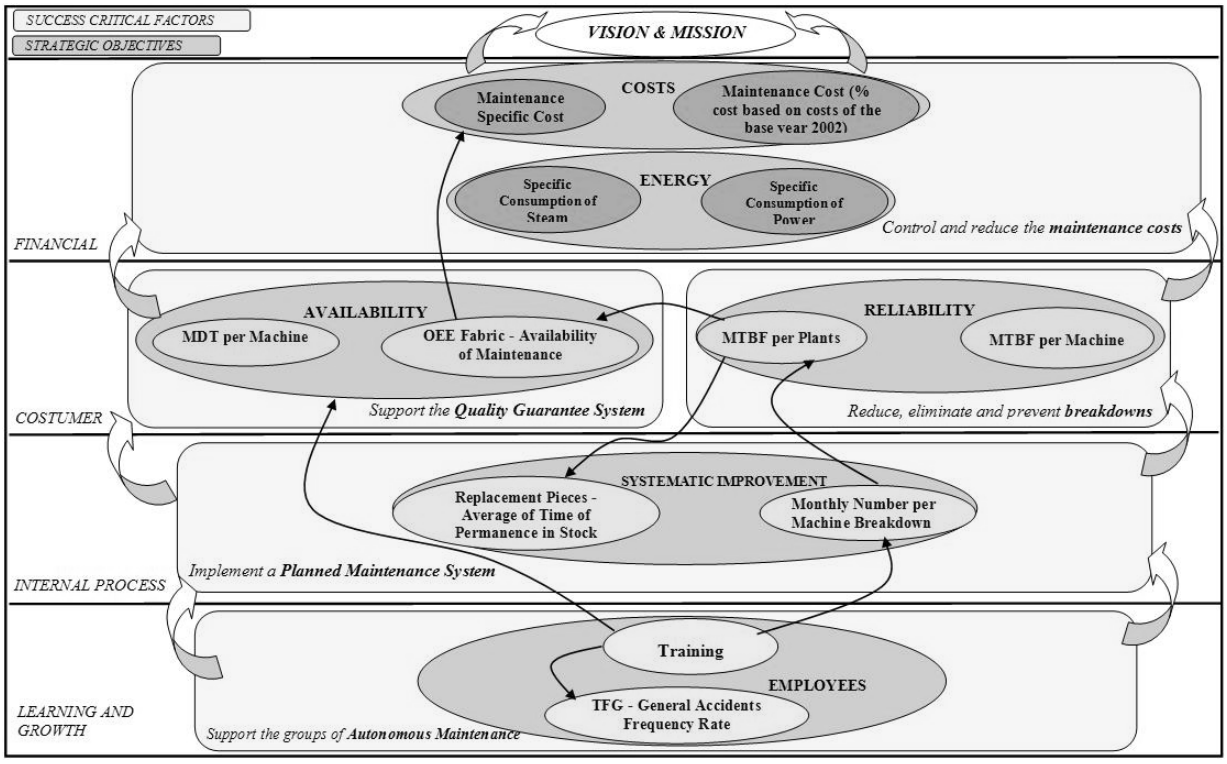

Figure 7 - Indicator's strategic map for the Planned Maintenance Pillar

The arrows in the strategic map showed in Fig. 7 demonstrate the cause-effect relations between the indicators, where the main function is to assist the pillar management in the proper strategic initiatives definition to accomplish the pillar's strategic objectives, as considered in Tab. 2.

For instance, with the arrows in Fig. 7 map, it is possible to visualize that the strategic initiative to increase the employee's "Training" hours will impact in a "Monthly Number per Machine Breakdown" reduction, increasing the time between failures, the MTBF, promoting a higher availability plant, by the OEE maintenance rate (which is calculated by the sum of the stop times for maintenance intervention, scheduled or not, above solar time, excludes the general stoppage), consequently it will have a smaller "Maintenance Specific Cost". This strategic initiative comes from a SCF proposed in the Planned Maintenance Pillar strategic planning map in Fig. 6, the "Support to Autonomous Maintenance" which is the "Skills' development" strategic objective on Tab. 1. In the same way, through this strategic initiative there is a pillar Mission accomplishment, it means, "Increase the availability and the reliability of the machines and installations with safety and adequate costs", mentioned in item 5 of this article.

These and other cause-effect relations can be established between the indicators, allowing to manager to identify the deficiencies in maintenance process, assisting in decision taking for proper strategic initiatives in the sight of the strategic objectives, also becoming possible for the pillar team to project scenarios for future improvements.

Now, in analogy to Fig. 1, it is introduced in Fig. 8 the Balanced Scorecard to the Planned Maintenance Pillar from SUPERAR program in TPM implantation in KPMA. In which it is possible to visualize in the four BSC`s perspectives: the pillar's vision and strategy, the pillar's strategic objectives, the performance indicators to evaluate the success in these objectives accomplishment, the targets for each indicator, here exemplifying the targets for 2006, and indicating the proper strategic initiatives to reach the goals proposed for each indicator.

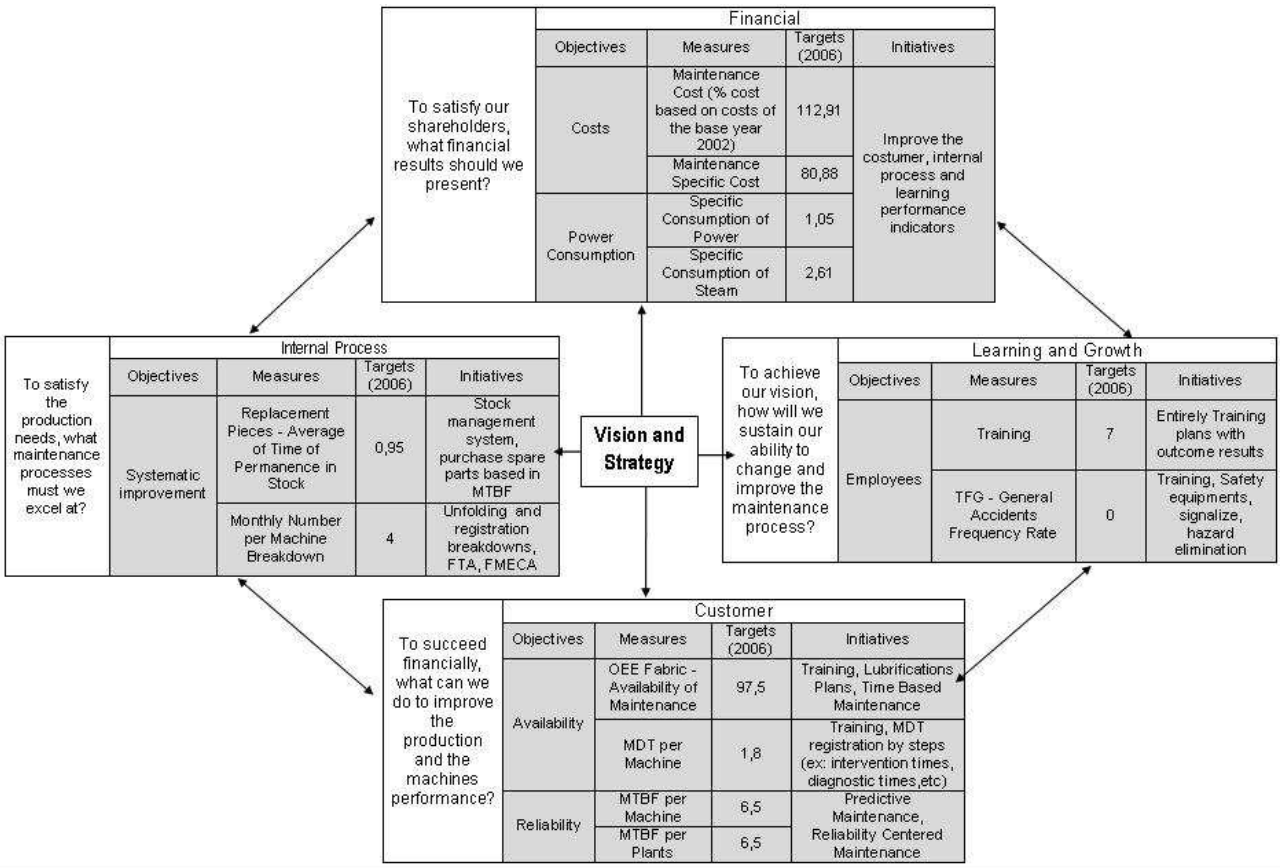

Figure 8 – BSC to Planned Maintenance Pillar

With this model, the pillar's management can be carried out from its performance indicators as foresees the BSC's methodology, visualizing not just the cost indicators reduction (financial perspective), as the actual administration focus, but considering that this reduction will depends on the plant availability and reliability indexes (costumers). In turn the plant availability and reliability depends on the breakdown number reduction (internal process), what it is possible through the operators and maintenance workers training (learning and growth). In such a way every strategic initiative taken to reach the goals will be associated with a performance indicator, that in turn it will be associated with the pillar's strategy in a balanced way in the four BSC`s perspectives. From this alignment results the strategic management to Planned Maintenance Pillar to TPM program.

7. CONCLUSIONS

The BSC implantation orienting the maintenance management realized by the pillar, as it showed, don't need any organizational change, therefore it is only necessary to add the holistic vision promoted by the BSC`s perspectives in the meetings already practiced by the pillar's team.

The BSC strategic management promotes a constant reevaluation of the maintenance strategy actions taken in a continuous improvement cycle, corresponding to the BSC`s greatest contribution for TPM maintenance management which searches for the WCM concept, not characterized as a steady ideal in the processes, but a constantly improvement state.

In this context, BSC represents a natural evolution in maintenance process. Linking the maintenance mission, vision and objectives to their performance indicators and showing the impact of each indicator variation in the maintenance planning, which constitutes the strategic management for maintenance. Besides, emphasizes in the learning and growth perspective, that the staff training in new techniques and the constant search for benchmarking in maintenance process become the strategy in continuous improvement.

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