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Neutrosophic Statistics in the Strategic Planning of Information Systems

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Abstract. The purpose of carrying out an Information System Plan within any organization is to ensure the adequacy between its strategic objectives and the information necessary to support the major objectives. Discovering opportunities to innovate the processes of a company taking advantage of the advantages that information technologies provide, emphasizes the link between technology and business strategies, using information technologies (IT) as a facilitator to transform infrastructure and processes of the business. The success of the strategic planning of systems depends a lot on the support and involvement of the management, the understanding of the business objectives and strategies, the leadership and capabilities of the information system (IS) and IT management, as well as the realism and ability to execute the plan.

Keywords: Information systems, technology, neutrosophic statistics

1 Introduction

The Strategic Information System Planning is defined as the process and documentation in which is identified the portfolio of applications and the technological infrastructure that the company must develop to obtain sustainable advantages over its competitors [1, 2] and its purpose is to review the current state of the organization, the identification of the desired strategic situation and the planning of the projects and changes in the organization necessary to achieve the desired state, in a period of 3 to 5 years [3]. Systems planning has been limited to the technical area and has been conducted by the staff of the systems department to record the evolution of existing platforms, justifying significant new investments or handling user requests [4-8].

A strategy is a set of decisions that are made to achieve something. In the case of an organization, a long-term strategy is what allows to achieve the vision of the organization in the future. This strategy is the result of a series of decisions about its scope, competencies, and management [2]. The Information System strategy [6, 7] has to do with business demand. It is a shared story, a space for dialogue between computing and business.

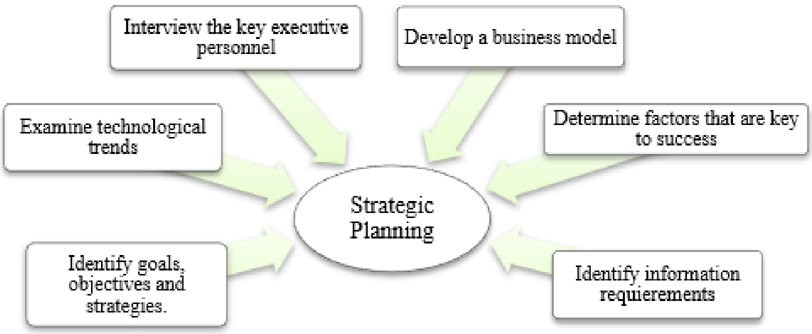

Figure 1. Strategic planning.

According to [4], strategy provides numerous benefits that allow an organization to influence its environment, instead of reacting to it, thus exerting some control over its destiny [2]. The Information System (IS) is the ordered set of mechanisms whose purpose is to manage data and information so that they can be easily and quickly retrieved and processed [9-12]. Its implementation offers the possibility of obtaining great advantages, increasing the organizational capacity of the company, and in this way turning the processes into true competitiveness, which is why an effective system that offers multiple possibilities is necessary, allowing access to the relevant data of frequent and timely manner [13]. Through the adoption of these systems, the manager manages to gather a series of important information, which can impact both the service to the client and internal processes [14] (figure 2).

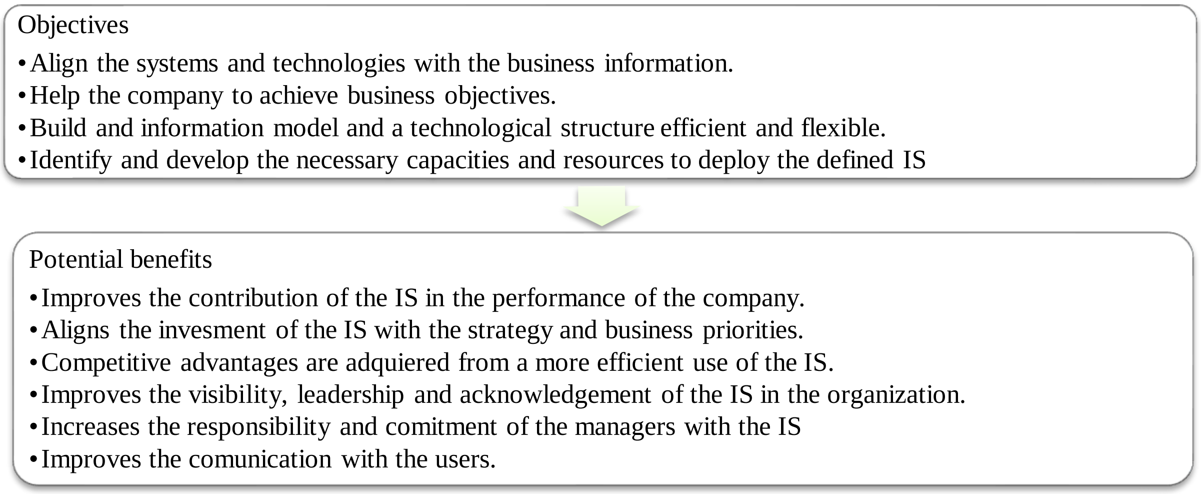

Figure 2. Objectives and benefits of strategic planning.

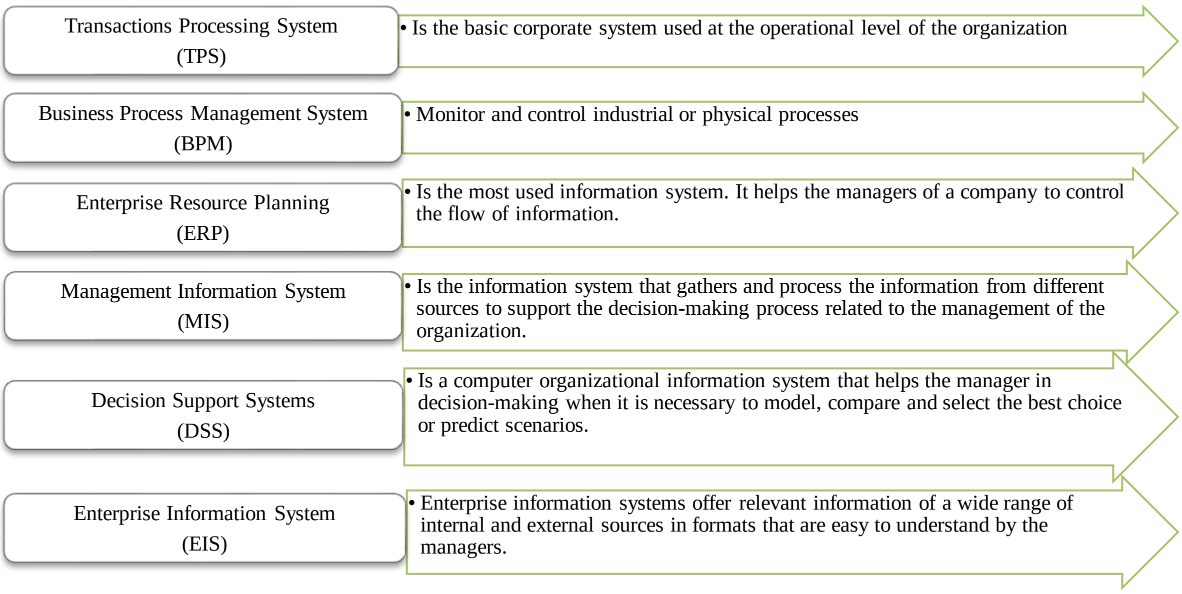

Figure 3. Types of information systems (IS).

The objective of information systems is to understand and analyze how the impact of the adoption of information technologies occurs in companies' managerial and administrative decision processes [15, 16]. Currently, information systems make the business process easier because with the characteristics of the software, export, and import operations are facilitated and in this way all processes are simplified, costs are lowered and there is more security in transactions. These facilities are part of a structure adopted by governments, companies, and many success cases have emerged because of this modernization [17]. Information systems can often fail, not because of technical errors that originated in the computer aspect, but because of cultural visions opposed to the incorporation of this type of tools, since there are still companies that observe with suspicion the possible implementation of information systems in their processes because they imply an enormous change in the organizational and institutional structures of the companies [18].

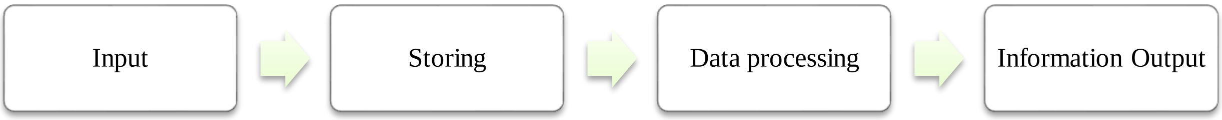

Figure 4. Development of an information system..

An adequate information system offers significant and notable satisfaction to the users who operate it, due to its ease of use and constant access, which may result in employees achieving the objectives set by the company. Therefore, to become more competitive, organizations must take into account their employees as those resources that can be improved through education and training, when applying information technology [14, 19]. This work is developed in a process control system, by understanding a whole range of equipment, computer programs, and operating procedures in oil refining, it is important to mention how the entire company is connected in this system from the operator to the company's management who, based on this information, is in charge of structuring the business expansion plan. From the analysis of the information systems and determining the factors that intervene in the crude oil process control system, we can define the following aspects:

1. Problem situation: incidents in the oil refining process
2. Main objective: use of information systems to achieve a competitive advantage in an oil refining plant and detect incidents in the process
3. Specific objectives:
   3.1. Determine the factors that affect the oil production variable
   3.2. Carry out the measurement and modeling of the variable
   3.3. Analyze the potential alternatives to determine the incidents that influence the oil refining process through information systems.

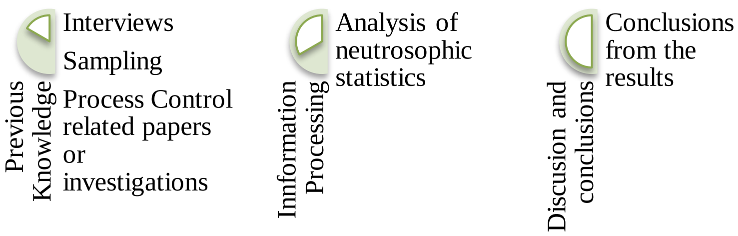

Figure 5. Development of the research..

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that event E will occur [20], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = \left(T(x), I(x), F(x)\right)$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x [21-43].

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [44], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [45]. In short, the Neutrosophic Logic [46, 47], Neutrosophic Sets and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development. The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [48]. Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [49], while "I" is the indeterminacy part of the neutrosophic number $N = a + bI$.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}, \bar{x}_b = \frac{1}{n_N}\sum_{i=1'}^{n_N} X_{iu}\, n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows:

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\begin{bmatrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\(a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\(a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{bmatrix}, I\epsilon[I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [50].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U]$$

3 Results

Data collection

After analyzing the different approaches in introducing the document, we proceed to apply the techniques outlined above, for a better operation of industrial processes and the impact of information systems. After analyzing the acquired data, the significant degree of indeterminacy and the modeling approach are detected with the use of neutrosophic statistics for the studied variable. From the results obtained from the information and the consensus of the experts, the factors that most affect the process control system implicit in the variable were determined (Table 1).

Variable analyzed: functionality of the crude oil process control system, for a sample of n = 110 for each factor (f).

Parameters	Initials	Factors that affect the oil refining process	Scale	Incidence range
Cost-effectiveness	DI	Decrease in income	[0; 3]	From 0 to 3 times a day, the accounting measurement indicator reported low income below plan
Performance	LPP	Low production performance	[0; 4]	From 0 to 4 times a day, the software reported a slight decrease in production
Quality	VCC	Variations in the quality of crude oil	[0; 5]	From 0 to 5 times a day, the quality technician reported variations in the quality of the crude

Safety	MI	Maintenance increase	[0; 3]	0 to 3 times per day the instrumentation and control sensors detected a failure in the production system
Infrastructure	IB	Increased breakage	[0; 3]	From 0 to 3 times a day minor maintenance was performed at the refinery reported by a safety sensor

Table 1. Values provided by the SI, in the incidents of crude oil development

For the modeling of the neutrosophic statistics, we decided to code the factors to make the results viable (Table 2).

Code	Initials	Factors that affect the oil refining process
L	DI	Decrease in income
M	LPP	Low production performance
N	VCC	Variations in the quality of crude oil
Ñ	MI	Maintenance increase
O	IB	Increased breakage

Table 2. Determining factors in the oil refining process

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the oil refining process are analyzed. For each factor, an incidence is analyzed in days for each factor, which makes up the set of effects on oil production (table 3).

Days	Neutrosophic frequencies				
	DI	LPP	VCC	MI	IB
1	[2 ; 2]	[3 ; 3]	[5 ; 5]	[3 ; 3]	[1 ; 1]
2	[0; 0]	[4 ; 4]	[2 ; 7]	[1 ; 4]	[2 ; 5]
3	[0; 2]	[3 ; 6]	[2 ; 4]	[1 ; 2]	[3 ; 6]
4	[3 ; 4]	[4 ; 8]	[5 ; 6]	[0; 3]	[0; 1]
5	[3 ; 4]	[0; 0]	[3 ; 7]	[1 ; 4]	[1 ; 4]
6	[0; 3]	[0; 1]	[1 ; 3]	[0; 0]	[0; 1]
7	[3 ; 4]	[3 ; 6]	[1 ; 5]	[2 ; 2]	[2 ; 3]
8	[0; 1]	[4 ; 4]	[4 ; 6]	[3 ; 4]	[0; 3]
9	[3 ; 5]	[4 ; 7]	[3 ; 8]	[1 ; 3]	[3 ; 6]
10	[1 ; 4]	[0; 4]	[1 ; 1]	[1 ; 2]	[2 ; 3]
11	[1 ; 1]	[0; 3]	[1 ; 4]	[3 ; 5]	[0; 3]
12	[3 ; 5]	[1 ; 2]	[4 ; 6]	[3 ; 5]	[2 ; 5]
13	[1 ; 3]	[3 ; 4]	[4 ; 4]	[3 ; 5]	[2 ; 3]
14	[3 ; 5]	[2 ; 6]	[0; 2]	[3 ; 3]	[2 ; 5]
15	[3 ; 6]	[3 ; 4]	[3 ; 3]	[3 ; 3]	[2 ; 3]
16	[3 ; 4]	[4 ; 6]	[4 ; 8]	[1 ; 1]	[2 ; 5]
17	[3 ; 3]	[1 ; 1]	[4 ; 8]	[2 ; 3]	[2 ; 5]
18	[0; 2]	[0; 2]	[4 ; 8]	[3 ; 4]	[2 ; 4]
19	[2 ; 2]	[1 ; 2]	[4 ; 7]	[2 ; 3]	[3 ; 3]
20	[0; 0]	[3 ; 4]	[1 ; 4]	[2 ; 5]	[1 ; 1]
0-110	[163; 332]	[217; 410]	[256; 557]	[181; 351]	[169; 335]

Table 3. Neutrosophic frequencies of factors

The neutrosophic frequencies of occurrence of the determining factors in the process control system for the oil refining plant were analyzed, in 110 days, with an occurrence level of [0; 8] for each factor per day and a total indeterminacy level of l = 169, m = 193, n = 301, ñ = 170, o = 166, and a level of representativeness of [47.07%; 54.04%], on the days in which there were 8 effects per factor, with an incidence of more than 50% in terms of variations in crude oil quality. It should be noted an increase in the reports of SI linked to the refining process of crude oil refining (table 3).

The results provided by the IS (from the industrial sensors, recording of the quality parameters, and the machine control room) of the effects that affect the process (table 4) can be understood as the factor implied by a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$. The values of the neutrosophic means and the level of variations of the activated sensors in the event of possible damage or breakage, which constitute a danger for the development of the process, are calculated. Depending on the level of affectations, the neutrosophic standard deviation is used and which affectation requires a greater incidence in oil refining, the values are calculated.

Factors	$\bar{x}_N$	**YN**	**CVN**
Decrease in income	[1,482; 3,018]	[0.741; 2,189]	[0.5; 0.725]
Low production performance	[1,973; 3,727]	[1,094; 2.63]	[0.554; 0.706]
Variations in the quality of crude oil	[2,327; 5,064]	[1,633; 3,424]	[0.702; 0.676]
Increase in maintenance	[1,645; 3,191]	[0.704; 2,155]	[0.428; 0.675]
Increased breakage	[1,536; 3,045]	[0.718; 2,181]	[0.467; 0.716]

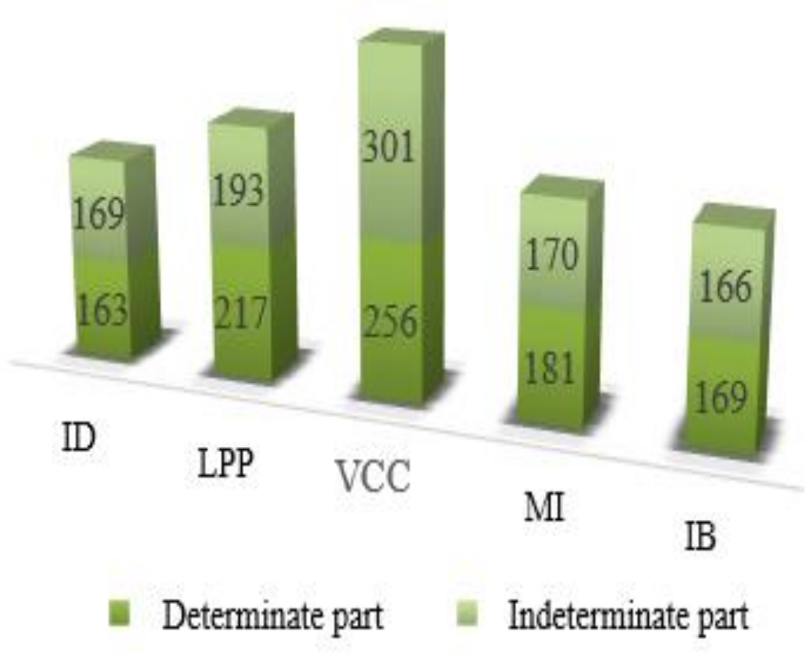

Table 4. Neutrosophic statistical analysis of incidents in the oil refining process

Figure 6. Neutrosophic bar graph of the incidents in crude oil production.

In table 4, it was determined that the factors, *Variations in crude oil quality* and *Low production Performance*, constitute an average of greater incidence on the other factors. This means that the VCC and LPP factors are the ones that most affect the refining process, while the value of CV_{NIM} in the increase in maintenance is lower than the rest. This means that the result of the MI factor has a more consistent, coherent, and precise impact when evaluating the indeterminacy in the possible breaks (Figure 5).

Comparative analysis

ID

To calculate the associated referent indeterminacy measure for the form of neutrosophic numbers (Table 5), the results show that the values range from $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U] CV_N \in [CV_L ; CV_U] CV_N$0.675 to 0.725 with the 36.6% indeterminacy measure generating an increase in maintenance at the refinery associated with the effects of the remaining factors.

Factors	$\bar{x}_N$	**YN**	**CVN**
DI	1,482; 3,018 I;I ∈ [0; 0.50]	0.741 + 2.189 I; I ∈ [0; 0.66]	0.5 + 0.725 I; I ∈ [0; 0.31]
LPP	1,973; 3,727 I;I ∈ [0; 0.47]	1,094 + 2.63 I; I ∈ [0; 0.58]	0.554 + 0.706 I; I ∈ [0; 0.21]
VCC	2,327; 5,064 I;I ∈ [0; 0.54]	1,633 + 3,424 I; I ∈ [0; 0.52]	0.702 + 0.676 I; I ∈ [0; 0.38]
MI	1,645; 3,191 I;I ∈ [0; 0.48]	0.704 + 2.155 I; I ∈ [0; 0.67]	0.428 + 0.675 I; I ∈ [0; 0.36]
IB	1,536; 3,045 I;I ∈ [0; 0.49]	0.718 + 2.181 I; I ∈ [0; 0.67]	0.467 + 0.716 I; I ∈ [0; 0.34]

Table 5. Neutrosophic forms with the measure of indeterminacy

Discussion

In this investigation, it was determined that high-quality devices are of vital importance, as these will affect the production system. The quality of the devices, as well as the periodic tests of accuracy, are the key so that the data obtained in the measurements can remain reliable. Chips, like sensors, play a fundamental role in the prediction and prevention of numerous aspects, satisfying the needs of many diagnostic applications, which is why it is important to make the best decisions in the search for the best results. The efficiency of industrial processes always guarantees competitive differences and good productive and economic results and gains efficiency and safety.

Conclusions

Nowadays, information systems make business more accessible, since with the characteristics of the software operations are facilitated and in this way all processes are simplified, costs are lowered and there is more security in transactions. In a process control system, the functionality and review of the technical state of the chips according to the expiration date is important, since these are the ones that will determine any failure in the production process. Advances in electronics, computing, and robotics will facilitate this exhaustive monitoring of the process. With the analysis of the neutrosophic statistics, it was determined that the variable in the oil refining process is affected by the increase in maintenance and the continuous stoppage of production, with a level of indeterminacy of 36.6%, so that, If the equipment is replaced, the breakages and with it the maintenance will decrease, proportionally affecting the reduction of the remaining factors. The neutrosophic statistical analysis shows the increase in maintenance with a lower CV value, as a determining factor to improve the production process. Based on this result, it was concluded that with the use of quality sensors, advantages can be obtained over the competition and thus the expansion of the business.

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