EPiC Series in Computing
Volume 91, 2023, Pages 8–18
Proceedings of 38th International Conference on Computers and Their Applications

Quality assurance in BPMN models in a Biodiesel plant

Narayan Debnath[*], Carlos Salgado[+], Mario Peralta[+], Daniel Riesco[+], Lorena Baigorria[+], Germán Montejano[+]
[*] School of Computing and Information Technology. Eastern International University, Vietnam
narayan.debnath@eiu.edu.vn
[+] Departamento de Informática. Facultad de Ciencias Físico-Matemáticas y Naturales. Universidad Nacional de San Luis, Argentina
{csalgado, mperalta, driesco, flbaigor, gmonte}@unsl.edu.ar

Abstract

The objective of this work is to make a proposal to improve the quality of business processes in a biodiesel plant. As a first approximation, the analysis and studies of the conceptual models of business processes that the company had were carried out, with the aim of being able to have a panoramic view of the current situation of the organization. For this, a framework was applied to measure the quality of business process models, which provides a set of metrics and indicators to carry out said measurement. The objective of the frameworks is providing to the organizations a means to help them to maintain objective and accurate information about the maintainability, understandability, coupling and cohesion of the models, facilitating the evolution of the Business Processes of the companies involved in continuous improvement. It provides support to the management of BPs by facilitating early evaluation of certain quality properties of their models. With this, the organizations benefit in two ways: (i) guaranteeing the understanding and dissemination of the BPs and their evolution without affecting their execution, (ii) reducing the effort necessary to change the models, this reduces the maintenance and improvement efforts. This framework is made up of two evaluation methods. Both methods allow facing the same problem from two different approaches. One approach refers to the numerical and another, is closer to linguistic expressions similar to everyday language. Both methods provide important results to different areas of the business, giving the framework an added value when analyzing the BP conceptual models, since it allows to choose the way to evaluate the models, according to the characteristics that are desired to analyze of the business models.

1. Introduction

The Business Process Modeling (BPM) is an essential step to achieve the objective of a Business Process (BP), that is, as is established by the BP definition, in order to obtain beneficial results for the stakeholders [1]. This is because a BP model describes the activities involved in the business and how they are related to and how they interact with the necessary resources to achieve the objectives of the process [2]. From this point of view, the BPM is used to capture, document or redesign BPs [3].

The BP models presents a global vision of the organization. This vision, allows better understanding of the company´s dynamics and the relationships that occurs within it and with its environment. This is the case both at the field that refers to customers and their suppliers and / or service providers. BPM is the technique par excellence to align the developments with the goals and objectives of organizations, since the models play a fundamental role in the specification of the BP. In the literature, you can find different conceptualizations of BP [4, 5, 6]. Therefore, the Workflow Management Coalition (WfMC) defines a BP as: *A set of two or more procedures or linked activities that collectively perform a business objective or a political goal, normally within the context of an organizational structure in which functional relationships and roles are defined* [7]. However, keeping in mind the various definitions of BPs, it can be said that, normally, a BP: (i) is associated with operational objectives and business relationships, (ii) may be contained entirely within an organizational unit or may encompass different organizations, (iii) has defined conditions that trigger its start, (iv) produce outputs defined at its completion, (v) may involve formal or relatively informal interactions among participants, and (vi) may consist of manual and / or automated activities. The conceptual model development represents a part of BP implantation. It is a key task of the first phases of BP life cycle. The users use the models as tools for easily understanding the process that these models represent. Furthermore, they are the starting point when some changes or adaptations to new business needs are required for BPs. Therefore, the quality of these models is of vital importance to help improving the performance and evolution of the organization and do not become a risk factor. Under these considerations, a framework is proposed to evaluate conceptual models of BP. The objective is to provide means to organizations to help them study the quality of their BP models from the point of view of their **understandability** and **adaptability** to changes. Regarding these characteristics, the **understandability** allows the user to understand if the BP models are suitable, and how to use them in particular tasks and conditions of use. That is, it provides an indication of how easy it is to learn to read and interpret these models in order to understand the reality they are representing. The **adaptability** represents the capacity of the model to be modified effectively and efficiently, due to evolutive, corrective or perfective needs. That is, the modification of the model effectively and efficiently without introducing defects or degrade their understandability.

Based on what was previously expressed, the application of a framework for the analysis and study of BP models from the perspective of the expected quality characteristics of a BP model in the evaluation of BP models of a medium company is presented. Said framework focuses on the use of continuous logic [8, 9] or fuzzy logic (FL) [10, 11], depending on the characteristics of the models and the processes that these models represent.

2. The framework: F2BPM

The F2BPM framework is a means/ tool that proposes the study and analysis of the BP models of an institution and / or organization. The main objective is to guide the development of such models by specifying requirements and evaluating quality characteristics. This framework is made up of three parts, each of which collaborates with the previous one. These parts are summarized as:

1. Apply the parser to the model, to determine its syntactic correctness.
2. Select and apply the evaluation method, according to the reality or the needs to be evaluated:

a. Method based on continuous logic operators [12], or b. Method based on FL [13].
3. Analyze Results and generate reports and recommendations.

The Syntactic Analyzer checks the correct conformation of the BP model studied. At this stage, it is corroborated, for example, if the model meets or satisfies good practices or modeling guides for conceptual BP models [14]. These practices are summarized below:

G1: Minimize the amount of elements in a model, since its size has a negative impact on its understanding.
G2: Minimize the possible paths of each element, since the greater the number of inputs and outputs that an element has, the more difficult it is to understand.
G3: Indicate, as far as possible, a single starting element and a single final element in each process.
G4: Modeling in the most structured way possible by balancing the decision gates using the gates as parentheses: one to open in possible paths and another to close them to join them again.
G5: Avoid the use of OR gates, since the models containing only AND and XOR gates generally contain fewer errors.
G6: Use "verbal" type labels to define the actions of the tasks, for example "to analyze documentation" instead of "documentation analysis".
G7: Decompose the model if it has more than 50 elements, using, for example, sub-processes to make the general model more understandable.

This is to say, compliance with the modeling guidelines by the BP models means that the models are understandable and adaptable to the needs of the organizations, facilitating the task of the different actors that intervene in the process of BP conceptual modeling. Once the models are correct, we proceed to do the study and / or analysis through the use of one (or both) of the two alternatives provided by the F2BPM framework. That is, to choose to work with: (i) operators of continuous logic, or (ii) to get closer to the natural and proper language of human beings through the use of *FL*, or some of its alternatives, or, if is not clear which of the alternatives is more appropriate for the particular situation, both alternatives can be applied and then perform a comparative analysis of the results obtained.

The motivation of the method that works with operators of the continuous logic, [12], arises from the need of the organizations to have a means that allows to represent their BP in an efficient way and that, in addition, allows them to communicate and interact with other processes. The objective of the method is to provide a means to help designers, analysts and developers involved in the definition and modeling of the BP of an organization, to obtain models of quality processes. Throughout the phases of the method, the most relevant and frequent characteristics that BP conceptual models should satisfy are determined, grouped and analyzed. These characteristics are reflected on a structure that will allow studying the degree to which the models satisfy them. In Figure 1 some desirable characteristics and subcharacteristics are detailed for all BP models. In the next phase of method, elementary criteria are defined that will serve as measures of the degree to which the models evaluated satisfy the individual characteristics. To obtain the overall evaluation, these elementary criteria are combined until a single indicator of the overall satisfaction of the elementary characteristics is obtained, in order to finally carry out an analysis of the results obtained and outline the corresponding conclusions.

1. Task/Activities
   1.1. Simples/Atomics
   1.2. Composed / Subprocesses
2. Synchronization points of the execution flow
   2.1. Decision Points
   2.2. Union Points
   2.3. Split Points in Parallel and / or Concurrent Execution
3. Events
   3.1. Start Events
   3.2. Intermediate Events
   3.3. Final Events
4. Participants / Actors
   4.1. Internals
      4.1.1. Number of Participants/Actors
      4.1.2. Communication between Participants / Actors
   4.2. Externals
      4.2.1. Number of Participants/Actors
5. Resources
   5.1. Produced in the Process (Internals)
   5.2. Externals

Figure 1. Requirement Tree

The second proposed method [13], is based on the fact that a FL system converts input variables (quantitative and qualitative) into linguistic variables through membership functions or fuzzy sets, which are evaluated by a set of fuzzy rules of the if-then type. Then, the outputs of the system become clear values (crisp) through a concretion process (*defuzzyfication*), which provides information for decision making. A FL system uses any type of information and processes it in a similar way as human thought; for this, FL systems are adequate to treat qualitative, inaccurate and uncertain information, which also allow dealing with complex processes, which makes it an interesting alternative for modeling decision-making problems. The diffuse control allows operating with vague or ambiguous concepts of the qualitative human reasoning, based on a mathematical support that allows extracting quantitative conclusions from a set of observations (premises) and qualitative rules (knowledge base).

When you have inaccurate and insufficient information, using statistical tools is not enough to obtain significant results. FL arises precisely to deal with this type of problems and to achieve an optimal solution. In this way, a combination between a FL system and the experience or knowledge that decision makers have is an excellent way to obtain good results. In the BP models development process often the information, about the business rules to model, is usually imprecise or insufficient, which leads to the models being imprecise. Based on what was expressed, the use of FL in the evaluation of these models will allow, through the mechanisms provided by these logic, to evaluate imprecise and ambiguous situations produced in the construction of the models.

3. Case Study: Evaluation of the PN Models of a Biodiesel Company

One of the fundamental aspects of any evaluation method is to show that it is of practical use. To achieve this goal, [15] presents a classification of three work proposals: (i) Experimentation, (ii) Cases of study, (iii) Surveys. For the practical validation of the method, and following the classification proposed in [15], a case study is presented in which the framework was applied to analyze the BP model of a local company. The decision to use case studies for the validation of the framework was due to the fact that, in the evaluation of a method for evaluating BP models, in general, there is no absolute control of the variables to be evaluated. This is because, in most cases, these variables depend on the particular reality that is being studied. For this reason, the application of case studies was considered more appropriate than the realization of experiments, in which it is necessary to have a greater control of the intervening variables, or the development of surveys, for which a certain history of application of the method and the opinion of those who used it should be available.

The main point was to improve the quality in a biodiesel plant in regards to the processes. But this brought with it an extra weight that had to be worked with a fuel that respects the environment, which does not contain sulfur, therefore it does not contribute to the greenhouse effect, it generates fewer emissions of polluting gases and substances that are harmful to health, such as carbon dioxide, carbon, soot or benzene. These are some of the qualities of the fuel, but BP needed to be optimized in order to guarantee quality throughout the plant process. As a first task, a meeting was held with the directors of the company. There, they had access to the scant digitized documentation that the company had.

The general process is briefly described. There is an input of crude oil, to the degummed sub-process, which is rectified, removes the acidity, to do so, eliminates fatty acids and phosphorus. To achieve this, they go through a trans-sterilization process to obtain biodiesel. In the middle of the process of obtaining biodiesel, it is possible to extract glycerin, that it is also subjected to a process of separation of fatty acids that, to a lesser extent, have still remained from the trans-sterilization process, for now to obtain glycerin in two varieties, a concentrated glycerin that is exported and another of lesser quality that is sold at national level for the production of other products such as soaps among others.

Based on the above, the case study was the application of the framework for the evaluation of the BP models of the company, which aims to position itself successfully within the market. Thus, According to what the framework establishes, the BP models owned were analyzed, and were determined if they were syntactically correct through a parsing based on ALLOY [16, 17]. When checking this syntactic validity, it was necessary to prove if the model reliably represents the business logic. So, the part two of the framework were applied, in which the method to be used for the evaluation of the models is determined. In this stage, the method based on FL were chose. The choice of this method is due to the use of FL [13], which allows a closer approach to the way of thinking of human beings; allows representing the ambiguities that arise in terms of the interpretation of the different business rules that may arise. Below is a summary of the evaluation:

PHASE 1: Based on the BP model that the company owned (figure 2) and, using a set of defined metrics to measure the elements of a model, the data of the different components are collected. The amount of the different elements is counted as: tasks, events, floodgates, among others. The information obtained is summarized in the table 1. It should be noted that, in these table, the metrics have been grouped according to the contribution they provide to the good practices associated with the BP model.

PHASE 2: The method proposes a set of variables of predefined inputs and outputs. This set can be extended, if necessary, by the members of the quality team involved in the process of quality evaluation of the models.

Of the suggested set of input/output variables, the following were taken for analysis. The choice of variables was limited to the metrics that allows the model to be addressed in terms of the components of most interest and that were the basis for the evaluation. In this sense, the following variables were taken:

INPUT: Number of Tasks/Activities of the model, Number of Gates, Number of Processes, Match Start and Final Events, Number of internal, intermediate and external events; Numbers of both Internal and External Resources; Number of Internal and External Participants.

OUTPUT: Understanding of the model, Maintainability of the model, Coupling Level, Cohesion Level.

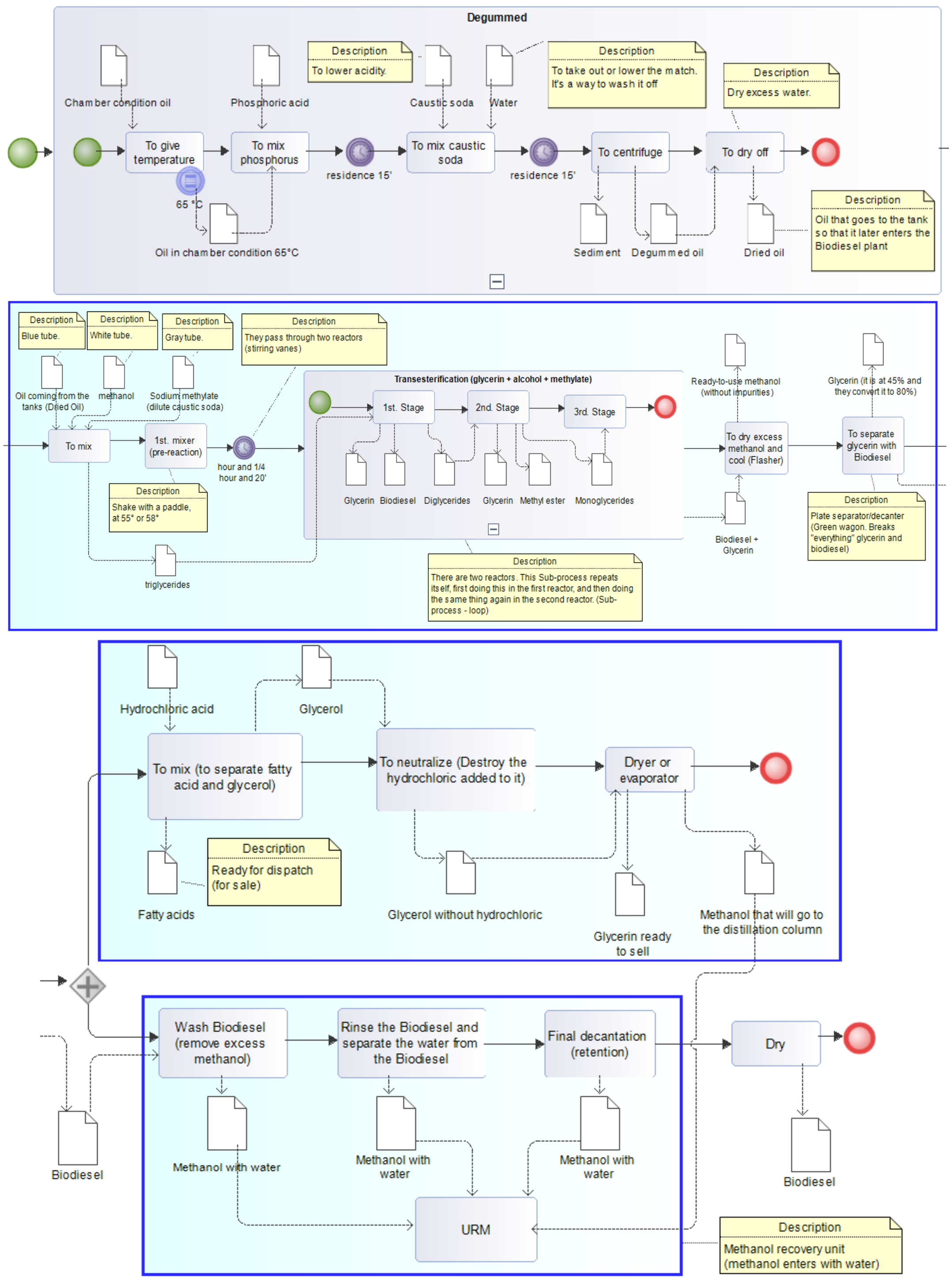

Figure 2. BP Model

Table 1. Used Metrics

TASKS/PROCESSES	GATES	EVENTS	PARTICIPANTS	RESOURSES
TNT = 18	TNGD = 0	TNSE = 2	NPI=12	NRI=8
TNCS = 0	TNGU = 0	TNIE = 4	NPE=2	NRE=23
	NPF = 1	TNEE = 4		

According to the phases of the method, once the variables have been defined, membership functions that indicate the degree of belonging of an element in a given universe must be established. The belongings functions that are used in this analysis are those proposed in the method presented in [13]. Figures 3 and 4 show these functions for the resources and events elements respectively.

Membership Functions	Function µ A(x)	Input Variables	Parameters
A1: Scarce	0 if x <= a or x >= b (x-a)/(m-a) if a < x <= m (b-x)/(b-m) if m < x < b	Number of resources (internals and externals)	a = 5 b = 19 m = 12
A2: Several	0 if x < a or x > d (x-a)/(b-a) if a <= x <= b 1 if b < x <= c (d-x)/(d-c) if c < x <= d	Number of resources (internals and externals)	a = 14 b = 20 c = 27 d = 33
A3: Many	0 if x <= a or x >= b (x-a)/(m-a) if a < x <= m (b-x)/(b-m) if m < x < b	Number of resources (internals and externals)	a = 30 b = 60 m= 45

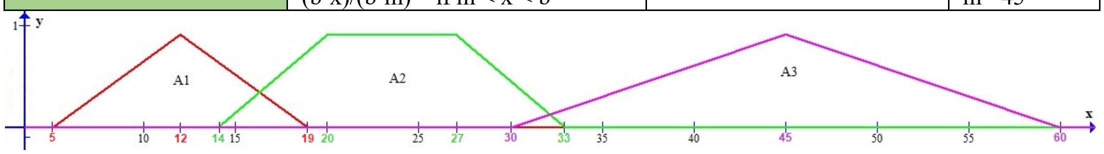

Figure 3. Membership Functions for resources

Membership Functions	Function µ B(x)	Input Variables	Parameters
B1: Scarce	0 if x <= a $2*[(x-a)/(b-a)]^2$ if a < x <= m $1-2*[(x-b)/(b-a)]^2$ if m < x <= b 1 if x > b	Number of Events	a = 5 b = 13 m = 9
B2: Several	0 if x <= a or x >= b (x-a)/(m-a) if a < x <= m (b-x)/(b-m) if m < x < b	Number of Events	a = 9 b = 29 m= 19
B3: Many	0 if x <= a or x >= b (x-a)/(m-a) if a < x <= m (b-x)/(b-m) if m < x < b	Number of Events	a = 26 b = 66 m= 46

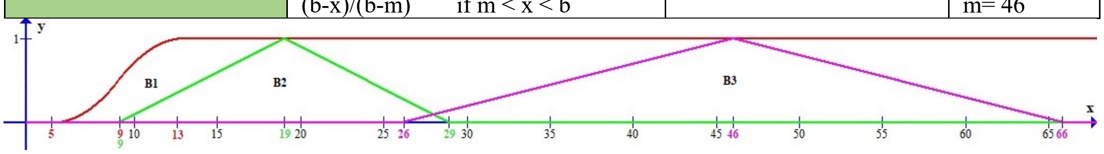

Figure 4. Membership Functions for events

PHASE 3: At this stage, the decision to choose the knowledge base for the application of the method must be taken. The knowledge base contains the information associated with the domain of reality that is being studied.

At this point, must be defined the linguistic rules that will serve to make decisions that, in turn will decide the way that the evaluator or who has to make the decisions must act. The rules follow the common sense of system behavior and are written in terms of the labels of membership functions. For the example that is studied there, are defined a total of 30 rules. Nevertheless, for the present example only the rules whose antecedents were calculated in the previous stage will be triggered. For example, for the variable resources: Several, Scarce, Many and for the variable Events: Several, Scarce, Many.

From the knowledge base, the subset of rules for the understandability feature is shown below.

Rule 1: IF (Several Resources) **and** (Several Events) **THEN** Moderately Understandable
Rule 2: IF (Several Resources) **and** (Scarce Events) **THEN** Mostly Understandable
Rule 3: IF (Many Resources) **and** (Several Events) **THEN** Moderately Understandable
Rule 4: IF (Many Resources) **and** (Scarce Events) **THEN** Mostly Understandable

PHASE 4: *Obtaining concrete values and system adjustments*: Until now, each of the four rules has been evaluated. The next step is to determine the fuzzy output by comparing the forces of all the rules that specify the same consequence, that is, the same output action.

At this stage, the ultimate goal is to find abrupt outputs. For this, each fuzzy output that were found in the previous stage of the evaluation rules, will modify their respective output membership function. The labels for these output functions refer to the understandability of the BP model, that is, they will be: Mostly Understandable, Moderately Understandable and Understandable. From the set of proposed output variables, this work only shows what concerns to model understandability (Table 2).

Table 2. Membership Functions for Understandability

Membership Functions	Function µ B(x)		Input Variables	Parameters
D1: Understandable	0 1 (d-x)/(d-c)	if x > d if b <= x <= c if c < x <= d	Number of Events	b = 0 c = 20 d = 30
D2: Moderately Understandable	0 (x-a)/(m-a) (b-x)/(b-m)	if x <= a or x >= b if a < x <= m if m < x < b	Number of Events	a = 25 b = 55 m= 40
D3: Mostly Understandable	0 (x-a)/(m-a) (b-x)/(b-m)	if x <= a or x >= b if a < x <= m if m < x < b	Number of Events	a = 50 b = 85 m= 70

A summary of the evaluation is shown below.
Input linguistic variables: Events, Resources.
Fuzzy Sets: Resources (x): Scarce, Several, Many (A1, A2, A3)
Events (y): Scarce, Several, Many (B1, B2, B3)
Output linguistic variables: Understandability of model
Fuzzy Sets: Understandability (w): Understandable, Moderately Understandable, Mostly Incomprehensible (D1, D2, D3).
Application of metrics to the model under study: **Events:** 10 and **Resources:** 16.

To Resources

$\mu A1\ (x=16) = \frac{b-x}{b-m} = \frac{19-16}{19-12} = \frac{3}{7} = 0.43$

$\mu A2\ (x=16) = \frac{x-a}{b-a} = \frac{16-14}{20-14} = \frac{2}{6} = 0.33$

$\mu A3\ (x=16) = 0$

To Events

$\mu B1(y=10) = 1 - 2 * \left[\frac{y-b}{b-a}\right]^2 = 1 - 2 * \left[\frac{10-13}{13-5}\right]^2 = 0.72$

$\mu B2\ (y=10) = \frac{y-a}{m-a} = \frac{10-9}{19-10} = \frac{1}{9} = 0.11$

$\mu B3(y=10) = 0$

Evaluation of Rules

Rule N° 1: $\mu A2(x) = 0.33$; $\mu B2(y) = 0.11$ ***Rule N° 2***: $\mu A2(x) = 0.33$; $\mu B1(y) = 0.72$
Rule N° 3: $\mu A3\ (x) = 0$; $\mu B2(y) = 0.11$ ***Rule N° 4***: $\mu A3\ (x) = 0$; $\mu B1(y) = 0.72$

So far, each of the four rules has been evaluated. The next step is to determine the fuzzy output by comparing the forces of all the rules that specify the same consequence, that is, the same output action. In simple terms, if two or more rules try to affect the same output, the rule that is truer (of greater strength) will dominate. The method for the evaluation of rules used here is called MIN-MAX [18, 19], since it takes the minimum of the conditions to determine the strength of each rule and takes the stronger rule for each consequent, which determines the outputs. The following values were obtained from the evaluation: $\mu B2(y)$=0,11 – $\mu A2(x)$=0,33 – $\mu A3(x)$=0 – $\mu A3(x)$=0.

Next, the Centroid of Gravity method is applied. Each output membership function is cut (lambda cut) at the level indicated by its respective output. The resulting cut membership functions are then combined to calculate their center of gravity:

$$\textbf{Output} = \frac{\sum_{i=1}^{n} x_i \mu_c(x_i)}{\sum_{i=1}^{n} \mu(x_i)}$$

$$\textbf{Output} = \frac{75*0{,}11+255*0{,}33+525*0}{1{,}2+1{,}98+0} = \frac{8{,}25+84{,}15+0}{3{,}18} = \frac{92{,}4}{3{,}18} = 29{,}05$$

PHASE 5: *Analysis and Documentation of the Obtained Results*: This stage corresponds to the final stage of the method. In it, an analysis and comparison of the results obtained in the evaluation of the models with respect to the preferences of the users, obtained in the application of the method, must be carried out. In addition, the evaluation process and the obtained results must be documented, so that the documentation serves as a reference and history of the evolution of the studied BP model in future evaluations of models. This documentation can serve as a point of reference and comparison at the evaluation of new models and BPs. This phase deals with activities of analysis and comparison of the preferences of quality and the obtained results. Based on the established goals, and the point of view of those interested in the models and BPs to be evaluated, this stage culminates with the conclusions and recommendations of the case.

Both Framework methods define a phase of analysis of results. This stage is one of the most relevant activities of the Framework. Therefore, it is extremely useful to have the information gathered during the application of the method selected for the evaluation collected on structures and representations that are clear to read and interpret. Therefore, the method proposes a standard form that should be completed once the evaluation of the models has been carried out. The form allows, among other things, to keep in mind what membership functions were used; if they were defined by the evaluating group or if others previously defined and stored in a repository were used. There is also information about the models evaluated, and the analysis of the results obtained. In addition, data of the models, the evaluators are recorded and, if there are previous evaluations, a reference to them is included. These references serve as a point of contrast to analyze and evaluate the evolution of the models.

Finally, a field is included where a report of the analysis of the results can be presented. For reasons of space, the structure of the form is not shown in this paper. At this point, when analyzing the results of the framework application, emphasis was placed on the Understandability of the results delivered and presented in the forms, and the perception of the different actors involved in the modeling process. For the case study, we worked with a group of 20 people, including administrative staff, technicians, quality staff, analysts and designers. From the calculation of the output made in the previous point it can be seen that the model studied is MEDIUMLY COMPREHENSIBLE.

4. Conclusions

Continuous improvement is a fundamental tool for all companies because it allows renewing or improving their BP. This implies a constant updating that makes the organizations more efficient and competitive. The BP model is the basis for better understanding the operation of an organization, documenting and publishing the processes seeking standardization in the organization, achieving greater efficiency in the operation and integrating solutions in service-oriented architectures. These characteristics give the organization a valuable tool to stay at a competitive level. Thus, the BP models are fundamental when analyzing the correctness and quality of the processes that they model.

From this point of view, the use of the framework is proposed with the possibility of applying any of the two methods that compose it. The first of the methods pursues the objective of providing organizations with a means to help them maintain objective information about the maintainability of the models. This facilitates the evolution of the BPs of the companies that constantly evaluate their processes to be involved in continuous improvement. In addition, it provides support to the management of BPs by facilitating the early evaluation of certain quality properties of their models. With this, the organizations benefit in two ways: (i) guaranteeing the understanding and dissemination of the BPs and their evolution without affecting their execution; (ii) reducing the effort necessary to change the models with the consequent reduction of maintenance and improvement efforts. However, when developing BPMs, information about the business rules that must be represented and modeled is often imprecise or insufficient, leading to inaccurate models. From this perspective, FL provides mechanisms to analyze and simulate human reasoning.

Under these considerations, the BPs of a Biodiesel producing company were analyzed, looking for decision-making points that would improve losses, waste, and plant shutdowns for different reasons. This paper presents one of the tasks that were carried out in order to understand and control the biodiesel production process. Among the points to analyze that were detected at the beginning are: 1. Waiting in production for complete deposits. 2. Idle times of the employees. 3. Shutdown of the plant due to waiting time for: a) Raw materials; b) Withdrawal of Fuel. 4. Management estimates.

In the BP models studied, they reflected that plant stoppages occurred repeatedly, because the tanks were full and the biodiesel was not withdrawn by the customers. This caused lost time for employees with the expenses that were incurred and final products in warehouses without the possibility of having movements. Initially, it led to expanding the capacity of the storage tanks to 1,000,000 liters, what relaxed the stoppage of the plant from the perspective of stock management. But there was still a problem with the logistics of the clients in the withdrawal of the merchandise. Regarding the purchase of the raw material, it was possible to see that there was a gap between the communication of the internal actors of the biodiesel plant. An excess of internal messages with unnecessary waiting time for administrative order, that they produced a plant stoppage every 45 days, due to a problem of an internal logistical/administrative nature. This ends up being solved by setting a minimum stock alert that anticipated purchases.

References

[1] A. Sharp and P. McDermott, "Workflow Modeling: Tools for Process Improvement and Application Development.," *London: Artech House,* 2001.

[2] T. Dufresne and J. Martin, "Process Modeling for e-Business," *Spring 2003, INFS 770 - Methods for Informations Systems Engineering: Knowledge Management and E-Business. George Mason University,* 2003.

[3] B. Mora, F. Ruiz, F. García, and M. Piattini, "Experiencia en transformación de modelos de procesos de negocios desde BPMN a XPDL.," *IDEAS,* 2007.

[4] C. Jiménez, L. Farías, and F. Pinto, "Análisis de Modelos de Procesos de Negocios en relación a la dimensión informática.," *Revista Electrónica del DIICC. http://www.inf.udec.cl/revista/ediciones/edicion9/cjimenez.pdf,* 2004.

[5] G. Sparks, "An Introduction to UML.," *The Business Process Model. Sparx Systems, www.sparxsystems.com.au,* 2000.

[6] Z. Irani, V. Hlupic, and G. M. Giaglis, "Business Process Re-Engineering: a Modeling Perspective," *International Journal of Flexible Manufacturing Systems,* pp. 99-104., 2001.

[7] WfMC, "Terminology & Glosary," Workflow Management Coalition. Document Number: WFMC-TC-1011. Document Status: Issue 3.0, 1999.

[8] J. J. Dujmovic, "A Method for Evaluation and Selection of Complex Hardware and Software Systems," *The 22nd International Conference for the Resource Management and Performance Evaluation of Enterprise Computing Systems. CMG96 Proceedings,* vol. 1, pp. 368-378, 1996.

[9] J. J. Dujmovic, "Quantitative Methods for Software Evaluation," *Lecture Notes, Graduate*

Software Engineering Program. Universidad Nacional de San Luis, San Luis, Argentina., 1998.
[10] L. A. Zadeh, "Fuzzy Sets," *Information and Contgrol,* vol. 8, pp. 338-353, 1965.
[11] L. A. Zadeh, "Outline of a new approach to the analysis of complex system," *IEEE Transaction on System Man and Cybernetics,* vol. 1, pp. 28-44, 1973.
[12] N. Debnath, C. Salgado, M. Peralta, M. Berón, D. Riesco, and G. Montejano, "MEBPCM: A Method for Evaluating Business Process Conceptual Models. A Study Case.," presented at the 9th ITNG, Las Vegas, Nevada, USA, 2012.
[13] N. Debnath, C. Salgado, M. Peralta, D. Riesco, L. Baigorria, and G. Montejano, "A Fuzzy Logic-based Method to Evaluate the Quality of Business Process Models," in *CATA 2017*, 2017.
[14] J. Mendling, H. Reijers, and W. van der Aalst, "Seven Process Modeling Guidelines," *Information & Software Technology,* vol. 52(2), pp. 127-136, 2010.
[15] C. Robson, *Real world research: A resource for social scientists and practitioners-researchers*: Blacwell, 1993.
[16] R. Gheyi, T. Massoni, and P. Borba, " Formally introducing Alloy idioms," in *Brazilian Symposium on Formal Methods.*, 2007, pp. 22–37.
[17] D. Jackson, "Software Abstractions: Logic, Language, and Analysis." *MIT Press, Cambridge,* 2006.
[18] W. van Leekwijck and E. E. Kerre, "Defuzzification: criteria and classification. Fuzzy Sets and Systems.," pp. 159–178 1999.
[19] D. P. Madau and L. A. Feldkamp, "Influence value defuzzification method. Fuzzy Systems.," pp. 1819–1824, 1996.