Development of a Decision Support System to increase operational reliability of Hydrocarbon Distribution System

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Abstact - The area of operation of Pemex Logistics is responsible for planning and transporting crude oil according to the operational program, which aim to transport 460,000 barrels per day of which about 75,000 are lost each day equivalent to 16.3% of the program established daily and estimated at USD $ 2,100,000 million. The operation of the turbopumps in the 5th substation is incorrect, presenting problems because of the rotation of human resources at the station. The hiring of new staff without training causes various system failures in the oil pipeline transportation, caused by lack of knowledge and experience to operate a turbopump properly causing unplanned outages in transmission lines and some equipment failures by on line overpressures. The research improves the current system of decision making by integrating fuzzy logic and artificial neural networks in order to increase their operational reliability in their pumping stations, that optimizes suction and discharge capacities between them to avoid variation of capabilities that causes high delays in the oil pipeline system.

The proposed system minimizes the transport problems by 11% in the system of repumping from baseline of 16.3% and representing approximately $1,484,000 million dollars daily, with this standardization of decision-making processes the economic benefit of Pemex is increased.

Keywords - Distribution System; Hydrocarbon; Decision Support System; Fuzzy Logic; Artificial Neural Networks.

[1]

Introduction

The area of Pemex Logistics operates as a subsidiary production company for the management of the parastatal oil company. This branch of Pemex, which main activity is the transport and storage of hydrocarbons and petrochemicals by oil pipeline, as well as shipping by ground and sea both Pemex and third parties. The services offered by Pemex Logistics are extensive and meet the most important quality standards internationally. These services include: storage and transportation of petroleum hydrocarbons and petrochemical hydrocarbons through oil pipelines, tankers, tank cars, operation services, maintenance of oil pipelines, port services, ship repair, crude oil treatment for transport, measurement and quality transportation, among others. The transport of petroleum hydrocarbons is the case study for this research with an approximate value of 460,000 barrels per day transported under the operational program planned monthly. These services are offered to a wide range of costumers that acquire many service units monthly. Given these acquisitions, some customers are highlighted as: Pemex EPS´s, Comisión Federal de Electricidad (CFE), CENAGAS (gas), ASA (aircraft), SEDENA (Mexican Army), service stations, fuel trading, fuel distributors, fuel producers and various third parties

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directly and indirectly related to hydrocarbons. The Pemex Logistics operating model is shown in Figure 1.

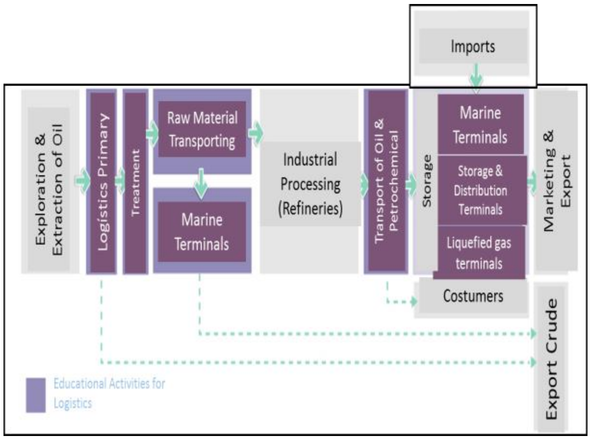

Figure 1. The Pemex Logistics operating model. Based on: Pemex, 2016

Unfortunately, the operational area of Pemex Logistics has reported in recent months several failures in the oil pipeline transportation system, because of this, in each pump station and destination there are approximately 75,000 barrels spilled each day equivalent to 16.3% of the program established daily and estimated at $2,100,000 USD.

Management Pemex Logistics said its main concerns are to know the exact reason why these failures are being generated in the operational area and seek a solution to the problem, because of this the 5th substation is taken as a case study. Operators and experts in the operational area reported, according to their experience, that the main problem lies in which the operation of the turbopumps is not carried out correctly, presenting problems based on knowledge and experience in handling the equipment due to the high turnover of human resources in the substation. Since this technical area of the substation shares the same staff from other similar areas, scheduling operators complies cycles that force them to take participation in all areas of each substation. Since this internal policy of Pemex Logistics causes this rotation, the hiring of new staff without adequate training causes various failures in the oil pipeline transportation system causing unplanned outages in transmission lines and some equipment failures by the overpressure in the line.

The review of the literature related to this research shows various contributions by experts in the field of hydrocarbons. These works are the support base for structuring the methodology proposed in this research work, seeking to establish decision criteria for handling operation of a turbopump through a system in the 5th substation of Pemex Logistics. The analysis of the problems of the literature reviewed found several factors of interest, relating a series of events taking place in the operating area of the substation.

The lack of operational reliability of the 5th repumping substation of Pemex Logistics has prevented the optimization and implementation of plans and operational programs, besides negative impact the safety of processes and increased costs associated. Therefore, for some years, it has sought the creation of advisory committees for the operation of government scheme, therefore it is of interest to the 5th substation that this research work will serve as a good scientific contribution for the scientific support of all operational requirements outlined in the government scheme and thereby receive the benefit on both sides of the company (both the government sector and the technical area).

Mohanty et al., (1997) proposed in his study the development of a system of human resource planning for a renowned oil company of multiple divisions in India with the implementation of a DSS, which it has been structured using information resources related to the study area and it focuses mainly on supplying critical tools and resources needed to manage diverse company human resources in order to reduce delays in the implementation of new schemes and extend the business to additional areas [1].

Some research of the past decade focused on the oil sector, provided approaches to process improvement based on intelligent agents (topics of artificial intelligence), Sheremetov et al., developed a contingency management system (CMS), which was implement in the oil complex of the marine zone in the Gulf of Campeche. In a multi-agent environment, a planning method in times of contingency is used for optimization of logistics, with an approach based on fuzzy rules within a model type Mamdani to deduce the subjectivity in the decision-making [2].

Automating operations within a plant processing crude oil is desirable for any entrepreneur in the oil industry, because industrial facilities commonly found in remote areas with difficult access in winter. Chan et al., proposed a DSS for experts to focus on the monitoring area, management and analysis of petroleum production within the company, with the aim of reducing labor access problems in winter seasons, expediting and optimizing decision-making in their personal [3].

The Directorate General of Pemex, established in its former management the key strategic initiatives to improve the functioning of its organization, referring to the integration of technical and government operations, commitment to society and the environment. This was through various indicators of performance evaluation that showed as the outstanding standards achieved that the company desired. The outstanding areas for their achievements are: the industrial safety sector, the efficiency in operations management systems and the global supply chain management, noting that although the operational reliability is not an indicator by which other areas are distinguish, the value of the same is not as negative as can be but this value is causing huge economic losses. This research is expected to serve as support for new labor policies in Pemex as it was the operational reliability model "Reliability Pemex-2008" [4].

The work environment today in Pemex has a missed approach, due to the high percentage of oil spills presenting their marine oil areas which are located in the deepwater horizon country, challenging the capacity to respond of Pemex Refining for the solution of these problems, as mentioned Lifer et al, with the implementation of an evaluation system to determine the proper amount of oil to be extracted from an oil welland obey the performance of the operating scales, these features would be a major pillar for oil spill response time in the country. Lifer concludes that using a multispectral expert system based on artificial neural networks minimizes the percentage of oil spill in the country [5].

Operational decisions for scheduling daily activities for transportation of crude oil are determined on a flow conditions operating report and mechanical integrity of the system, which is generated daily by the control department and it has an important impact on total costs that produce value to the supply chain of the company. Nishi et al., developed an optimal schedule at a low cost of operation consists of a stochastic model of optimization founded on mixed-integer linear programming for programming an oil pipeline connecting a maritime station of an oil refinery and a way of representing uncertainty of oil supply [6].

Since 1990, the South Korean government has been working on expanding the portfolio of products and services offered to the international market for its gas pipelines. From July 2013, it has established a total of 173 kilometers of new pipeline across the country. This pipe has several purposes including the oil transportation service by pipeline. Of these pipelines, 31 kilometers were canceled because of the financial problems facing the country. To meet this challenge, Choongwan Koo et al., developed a DSS to ensure optimal design of a new, zooming in on the profitability of the established area. It was decided for a case-based reasoning approach as the most important method of research, as it is essential to send historical data for reference to determine the optimal size of the gas pipeline mileage to be installed in the area in order to facilitate decision-making from the practical point of view [7].

Szmerekovsky et al., proposed in his work a deterministic model based on mixed-integer linear programming (MILP) for the supply chain of crude oil in deep water with the objective of determining the optimal distribution center of oil extraction sites, extraction capabilities management of the machinery used, transport modes and volumes of hydrocarbon extraction. This model minimizes the cost of various stages in the supply chain of the oil sector, deducing various products and machinery used in the process throughout the work areas [8].

It should be mentioned that not only a transport network by petroleum products establishes a high degree of operational risk, shipping is a primary means for the movement of intercontinental crude oil, it represents 1.7 million tons per year, this amount is greater than that obtained through a large fleet of tankers of crude oil. Because of this, Oliveira et al., proposed through his research a mixed-integer linear programming, the authors use the operating cost and key operational risk factors affecting the oil pipeline transportation system. These factors programmed routes and schedules to a heterogeneous fleet of petroleum tankers, the model estimates that the cheapest route does not necessarily generate the highest profits for the company, with the application of these intelligent models a better use of decision-making is achieved [9].

The use of heuristic models currently facilitates and reduce subjectivity in different working conditions, as the model proposed by Ahmed Bham et al., this model with a heuristic algorithm, is based on the generation of marine patterns, as is the volume-weight ratio of the load to be transported, the point of maximum load estimate, among others in order to solve a problem in routing of ships for proper system programming and maritime transport of crude oil [10].

The challenges in the petrochemical industry are increasingly complex, but with the appearance of full-scale disruptive technologies, they have prompted a new revolution that has the potential to radically change industrial processes, incorporating factors such as materials control, manufacturing, supply change management, engineering and life cycle of an input. Recently, the intelligent company has embraced a disruptive manufacturing methodology and has turned it into an important part of the oil industry. Troubleshooting systems and thinking systems for the intelligent companies should be a priority. For example, a case study of a driving force for the improvement of an intelligent company. Defang et al., proposed an investigation focused on a life cycle assessment model, in which the more representative factors of an intelligent company for the oil industry are presented taking into account possible technical factors for the future of the petrochemical industry from an academic and industrial point of view [11].

The technological breakthrough that brings the creation of new industrial systems positively impacts the world, developing the economy. The oil sector has an important influence on social stability worldwide Shujie Liao et al., present in their scientific work, the key challenge of crude oil in global supply chain, which is now considered, more like a constant factor than as a trend increasingly defined. In addition, the fluctuating price of crude oil when emergencies occur, active plans strategic reserves of crude oil. It contains high influence factors for global economic development of nations, because of all this, in this research work the case analysis tool is proposed as the best option for solving such problems [12].

A major theme for its relevance today in the oil industry focuses on the decision criteria of staff and the effectiveness of the organization for decision making, as the operating safety of operations of all personnel within the company. A. Antonovsky et al., discusses his work, incorporating engineering-based tools dedicated to the evaluation of maintenance effectiveness and reliability of the equipment industry in the oil sector which reflect a high performance in operational effectiveness of oil industry personnel [13].

Bai Yang et al., (2016) proposed a decision model in which three main aspects that are associated with the oil strategic reserves in their country are discussed. First, what is the optimal amount of extraction of hydrocarbons for the country, taking into account an approach response to the various risks in the price of oil on the global market? Secondly, how would it affect the various countries in the world market the implementation of the policy or actions on the oil strategic reserves in the country? Such as, the price set by supply and demand of crude oil. Third, to what extent a disruption of crude oil extraction in the country can induce a crisis in sales prices of the barrel worldwide? For these purposes, the study proposes a process model based on a decision methodology Markov to minimize subjectivity in decision making [14].

The selection of suppliers with artificial intelligence techniques already applied in the gas industry and oil. David A. Wood et al., proposed in their study, recognition of 30 criteria for evaluation of service suppliers and field development projects through the oil industry. Suppliers are evaluated based on these criteria with different levels of subjectivity and uncertainty using linguistic labels which are then changed into numerical sets that facilitate decision making within the system. In this research work, the techniques of multi-criteria decision making are used, this tools comprising fuzzy TOPSIS and flexible entropy weighting [15].

This research proposes a DSS based on fuzzy logic and artificial neural networks validated in a case study in Mexico which aims to increase operational reliability of the 5th substation Pemex Logistics; in addition, the repumping process can be standardized in this way to ensure proper maintenance of auxiliary equipment and pipelines connecting a network of substations. The contribution of this study, allowed Pemex Logistics to optimize operating capacity, suction and discharge along its entire network of repumping substations, seeking to avoid the variation of capabilities that causes high delays in the transport system of oil by pipeline.

2. Methodology

The DSS structure is based on the integration of two artificial intelligence techniques highly effective in modeling the knowledge and experience of the operators of the turbopumps and in predicting outcomes. The techniques used are fuzzy logic (FL) and artificial neural networks (ANN). FL capitalizes on the knowledge based on the experience of individuals directly involved in the system, and ANN predicts a value through historical data from the system under study. The methodology for the development of DSS is shown in Figure 2.

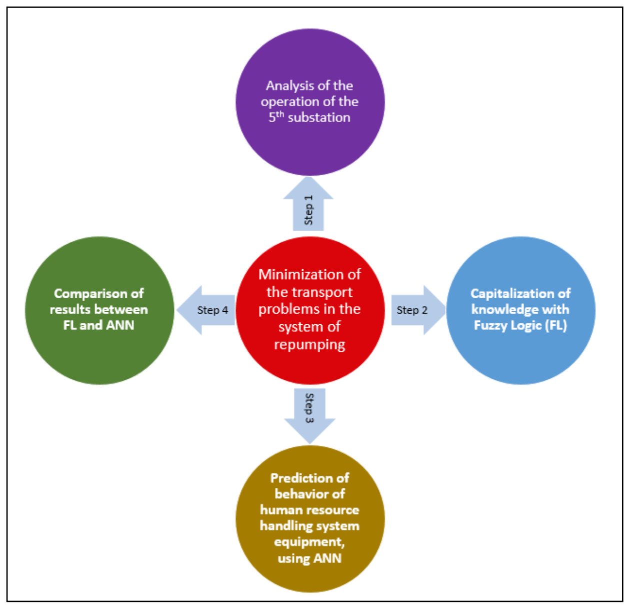

Figure 2. Methodology proposal. Source: Ojeda, 2016.

2.1 Analysis of the operation of the 5th substation

At this stage, the operation the 5thsubstation is analyzed, which is responsible for receiving the hydrocarbon from the 4th substation in Zapoapita, Veracruz, where crude oil is sucked and this passes over a filtering and measurement process as well as supply the same if necessary within the 5th substation, for which the operating department makes the right moves to ensure the operational reliability of the oil pipeline transportation system to send hydrocarbon to the 6th substation located in Maltrata, Veracruz, in which, with a sequential system repumping oil continues with the flow of the product to reach the distribution and supply terminal located in Venta de Caprio for sale and marketing nationally and internationally. Based on a risk analysis approach the case located in the 5th substation is analyzed with classification system elements into three categories:

Deterministic values, variables and uncertain parameters. Since it is not possible to work this information by classical mathematical methods, the creating DSS needs techniques that allow the interaction of the system elements obtaining with this the support of decision making. Turbopumps must operate efficiently without causing fluctuations in the suction and discharge pressures. The classification of the system elements is shown on Table 1. It seeks to contribute by SSD proposed, predicting the behavior of the system elements to eliminate operational errors generated in the work area from the technical area. With this, the input variables for the fuzzy logic model were established and also established and also the variables that were assigned valued from the database for the artificial neural network model were established.

Table 1. Classification of elements of the 5th substation.
Source: Ojeda, 2016.

Deterministic values	Variables	Uncertain parameters
Distance pipeline through the right of way of Pemex Logistics	Capacity suction pressure turbopumps	Total suction capacity next station to send product (Maltrata 6th station).
Diameter pipeline	Capacity discharge pressure turbopumps	Total discharge capacity of the station that carries the product (Zapoapita 4th station)
Types of transporting hydrocarbon mixtures	Hydrocarbons flow rate in pipelines	Operational reliability of the transport system of the 5th station
Transportation program established	Hydrocarbons repumping time	
Auxiliary equipment operating within the 5thsubstation	Auxiliary equipment available	

2.2 Capitalization of knowledge with Fuzzy Logic (FL)

In stage 2, with the use of FL technique, the expertise of workers operating the turbopumps is capitalized. This knowledge is represented through membership functions, which combines the functions of probability distribution that follows each input variable Mamdani model. It is considered as input variable number 1: "The discharge capacity of hydrocarbon from the 4th substation located in Zapoapita, Veracruz”. It is set as input variable 2: "The suction capacity of the 6th substation located in Maltrata, Veracruz”, and it is set as input variable 3: “The operational reliability of oil pipeline transportation system of the 5th substation located in Ciudad Mendoza, Veracruz”. With the interaction of these important functions in the system of repumping oil from Pemex Logistics, and supported by a model of FL, predicting that the two output values will be obtained, these standardize the criteria for operational decisions from workers of the 5th substation. The two output variables are: “The proper pressure of hydrocarbons suction of the 5th substation”, just as “The proper pressure of hydrocarbons discharge of the 5th substation”, these, working with the numerical interpretation of system operating pressures of transportation pipeline, established by the policies of repumping oil from Pemex Logistics For which a code flow arrows set to facilitate the reading of the operator and optimize decision-making within the system. The prediction based on the FL techniques detects the probability of each entity and connects all relations of the entities that produce goods and accurate results. The Mamdani fuzzy logic system used shown in Figure, 3.

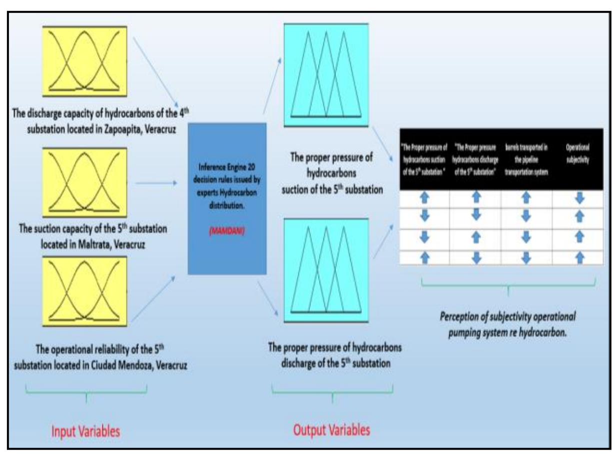

Figure 3. Fuzzy logic model. Source: Ojeda, 2016.

Each rule in the DSS is a possibility of occurrence. Each and every one of these rules have been analyzed and validated by the expert to be used, in order to generate accurate estimates in this case study. In Table 2, a representative fraction of the total of the rules used in this study (which are based on the expertise of the operators) is observed. The fuzzy rules have the following nomenclature, {F = out of operation, B = low, P = Average, A = high, M = Bad, R = Regular and Bo = Good}.

The response surface plots (RSP) allow us to meet the practical needs given the conditions to evaluate the system either to predict or optimize. The RSP facilitate their reading levels interpreting calorimetrically response surface plots show the irregular behavior of the variables, And expresses graphically with a colorimetric support, which intensify colors or degrade according to the behavior of the system. In Table 3, an explanation of the respective colors used in this investigation is shown.

Response surface plots obtained by the DSS shown in Figure 4, indicate that the higher the discharge capacity of the 4th substation that carries the hydrocarbon and the higher the value of the operational reliability of the transport system of the 5th substation receiving the hydrocarbon, better performance was achieved in the output variable in this case which increases their productivity value is the proper pressure of total suction of the 6th substation receiving the hydrocarbon. For example, in the first response surface plot, the output variable is analyzed: The proper pressure of the hydrocarbons suction of the 5th substation", and the input variables: "The operational reliability of the 5th substation" and "The discharge pressure capacity of the 4th substation located in Zapoapita, Veracruz" and is the substation that transports the oil to the 5th substation located in Ciudad Mendoza, Veracruz. With this, it can be seen that an operational reliability of 80 kg/cm^2 (which is considered "good" by the Fuzzy logic model) of the 5th substation and a discharge capacity of hydrocarbon from the 4th substation of 70 kg/cm^2 (which is considered "high" by the fuzzy logic model). For the output variable "The proper pressure of hydrocarbons discharges of the 5th substation" with a suction capacity of hydrocarbons of 50 kg/cm^2, this parameter is considered "high" according to colorimetric analysis (shown in yellow). In plot number two, the analysis is carried out with the same input variables of the previous example, but now evaluating the response variable: "The proper pressure of the operating discharge of the 5th substation".

Table 2. Fuzzy inference rules. Source: Cid, 2016.

Total suction capacity, the next station to send product (6th station)	Total discharge capacity of the station that carries the product (4th station)	Operational reliability of the transport system of the 5th substation	Proper pressure of the total suction of operation.	Proper pressure of the total discharge operation
F	F	F	F	F
B	M	B	B	B
P	R	P	P	P
A	Bo	A	A	A

Table 3. Colorimetry set for the response surface plots. Source: Cid, 2016.

	HIGH LEVEL OPERATING PRESSURE
	AVERAGE LEVEL OPERATING PRESSURE
	LOW LEVEL OPERATING PRESSURE
	PRESSURE LEVEL OUT OF OPERATION

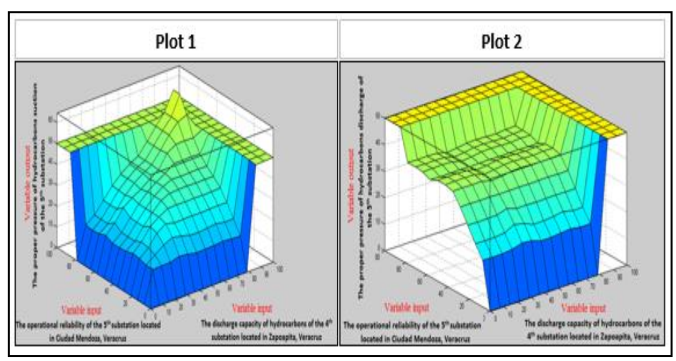

Figure 4. Response surface plots. Source: Cid, 2016.

2.3 Prediction of behavior of human resource handling system equipment, using ANN.

In stage 3, an ANN was used to predict the output variables based on historical data provided by Pemex Logistics, the type feed-forward back propagation network is used, using this type of network facilitated the training of ANN due to their statistical properties, ensuring the quality of the predictions. They are established as input variables of numerical type: "The discharge capacity of hydrocarbon from the 4th substation located in Zapoapita, Veracruz”. Second variable input as: "The suction capacity of the 6th substation located in Maltrata, Veracruz" and as a third variable input: "The operational reliability of the oil pipeline transportation system of the 5th substation located in Ciudad Mendoza, Veracruz". The input variables presented above, represented a very important role in the system of repumping of oil Pemex Logistics, these variables supported the ANN in obtaining results that minimize the presence of subjectivity of staff working at the 5th substation. These results are appointed: “The proper pressure of the hydrocarbons suction of the 5th substation”, and “The proper pressure of the operating discharge of the 5th substation” which validate the correct operation of the technique FL, with the numerical interpretation of operating pressures of the oil pipeline transportation system established by the policies of oil repumping of Pemex Logistics to validate and consolidate the smooth operation of the DSS, reading the operator and optimize decision making within the system. This way, it can analyze the database that feed the ANN, seeking useful indicators to train workers in the 5th substation, in using the DSS and thus reducing subjectivity in the decision criterion of repumping system. Feed-forward back propagation networks used have at least one closed cycle neural activation which are distinguished by the existence of feedback loops between neurons of the same, or different layers and can be competitive type. An ANN is designed as follows: first with an architectural design, after is carried out training, and last a validation of the results is made and tested for final implementation. The structure used for the development of an artificial neural network shown in Figure 5, and the final architecture of the ANN is also shown in Figure 6.

It is recommended to repeat the training stage until the RNA present coefficients is greater than 0.85 in the stages of validation, testing and training. Ensuring this to be a correct prediction. According to Figure 7, the following coefficients are observed: 0.98578 in training, 0.98861 in validation and 0.94775 in tests, these coefficients are close to 1 and clearly indicate that the DSS is highly reliable and can be used with full confidence.

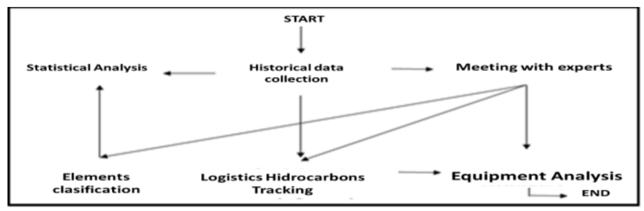

Figure 5. Structure used for the development of an ANN. Source: Ojeda, 2016.

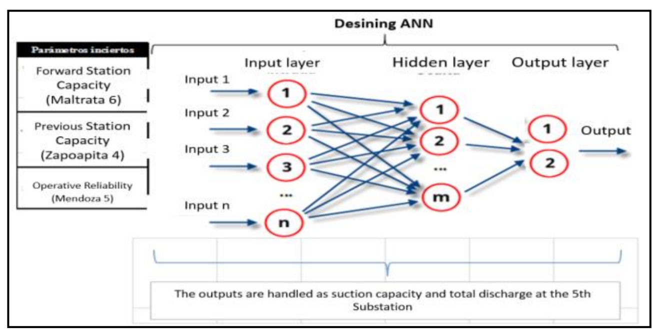

Figure 6. Architecture of ANN. Source: Ojeda, 2016

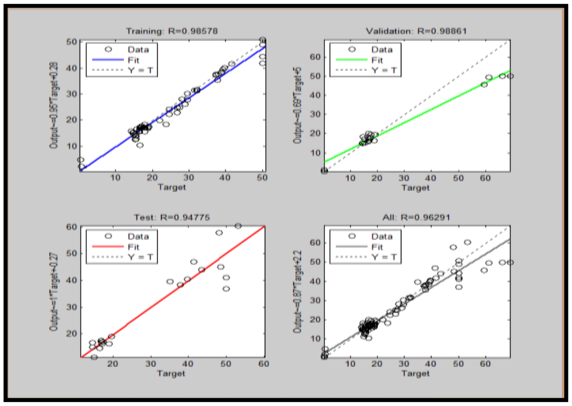

Figure 7. Training ANN. Source: Cid, 2016

2.4 Comparison of results between FL and ANN models, in minimizing operational subjectivity

The two techniques applied in this research, work within the limits of permissible operation established by the company, to ensure the operational reliability of its facilities, these limits of permissible operation are shown in Table 4. In carrying out the comparison of the two techniques, it is observed that both results are very similar in assessing each of the uncertain parameters affecting the output variables and their direct impact on the expected result. It can be deduced that the greater the efficiency of operations in these processes, the suction and discharge pressure will grant better performance, and thus subjectivity is reduced at high levels. The above analysis can be observed in Table 5.

In Figure 8, an estimated correlation coefficient of 0.9988 is observed FL model based on the expertise of the operators. Also, a correlation coefficient of 0.9988 is determined for ANN model based on historical data is observed. After performing this step several times, it follows through the DSS, that these coefficients are the optimal values.

Table 4. Limits of permissible operation of the repumping substations. Source: Cid, 2016.

Dispositives	Permissible limits of operation of the substation 4th (Kg/Cm^2)	Permissible limits of operation of the substation 5th (Kg/Cm^2)	Permissible limits of operation of the substation 6th (Kg/Cm^2)
Maximum Operating Pressure	79	55	74
High discharge Pressure alarm	80	56	75
Shooting at high Pressure discharge	80.5	63	75.5
Relief valve discharge shot	81	81	76
Low suction Pressure alarm	6	14	5.5
Shot low suction pressure	4	12	4
Shot suction relief valve	80.5	80.5	75.5

Table 5. Validation of the results of ANN and FL models. Source: Cid, 2016.

The suction pressure of the 5^{th} substation (Kg/Cm^2)	The suction pressure of the 5^{th} substation (Kg/Cm^2)	The discharge pressure of the 5^{th} substation (Kg/Cm^2)	The discharge pressure of the 5^{th} substation (Kg/Cm^2)
0.5	0.9	16.7	15.9
0.2	0.2	0.4	0.5
0.7	0.5	38.9	40.1
37.9	38.2	0.3	0.5
14.8	15.1	17	16.7
14.6	14.2	16.8	17.1
15.3	16.8	19.6	20.6

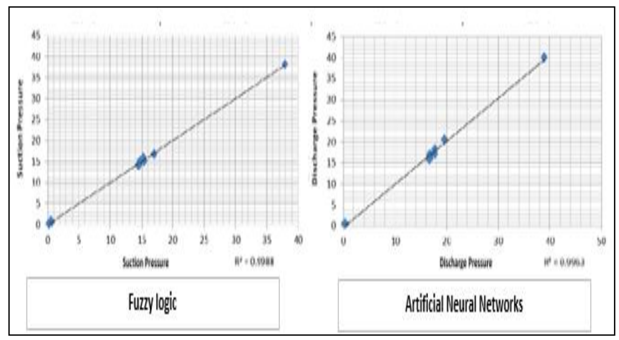

Figure 8. Correlation plots of ANN and FL models. Source: Cid, 2016.

After validating the DSS and performing various tests in practice, the DSS establishes and standardizes decision criteria for managing the operation of the turbopumps by operators, and consequently spills caused by uncertain factors of the 5th substationare reduced. Daily planning is aimed at transporting 460,000 barrels of which about 75,000 are lost each day. This amounts to 16.3% of the program established daily; taking the price per barrel at about $ 49.79 USD in the first quarter of 2015, a loss equivalent to $ 2,100,000 million is estimated. The proposed DSS minimizes transport in the system of repumping of oil 11% from baseline 16.3%, accounting for about $1,484,000 million dollars daily. With this standardization of decision making processes the economic benefit of Pemex is increased.

Conclusion

By implementing the DSS based on artificial intelligence techniques, indicators were obtained to measure the improvement of the process of hydrocarbon distribution in the company. Therefore, it can identify the standardization of decision criteria the management in the operation of the turbopumps by operators, this due to an increase in operational reliability by controlling the machinery. Therefore, the number of transport line stoppages was reduced.

"Pemex Logistics" does not record research work where artificial intelligence techniques are used to improve their processes, therefore, this study is very important because it aims to show the company's new international trends in decision making. The contributions reached at the end of the study, are shown below:

A methodology based on a DSS to minimize operational subjectivity of staff of Pemex Logistics substations, which proposes within its structure the use of artificial neural networks to know the pattern of behavior of the input and output variables, which cause subjectivity in operating personnel. It also makes predictions of the behaviorof suction pressure and the discharge of hydrocarbons from the 5th substation based on training of a robust set of data.

The study shows a new practice in making decisions "Pemex Logistics", which makes decision making easier in the energy sector. The technical benefit to Pemex Logistic is the minimization of operational subjectivity of its staff, which results in reducing problems by overpressure in the system, oil spills and an unnecessary reduction of the mechanical integrity of the oil pipeline transport system of the Mendoza sector. Thus, the operational reliability of transportation of hydrocarbons applicable in international areas is ensured. Spills in the transport system of repumping were reduced to 11% from the initial value of 16.3%, depending on the operational program, which aim to move 460,000 barrels per day, of which Pemex loses about 75,000 each day and this is estimated at $2,100,000 million dollars. The approximate 11% decrease in oil spills represents $1,484,000 million dollars daily, increasing the economic benefit of Pemex.

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