Probabilistic Neural Network- based system for Well characterization in Oil Industry

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Abstract: In this work it is presented the use of a probabilistic neural network for well characterization according to their condition. This characterization may be: continuous, erratic or intermittent, permitting to supervise the most important variables of the process that can affect in a significant way the levels of production of the producing wells.

Key-words: Well classification, Probabilistic Neural Network, Artificial Intelligence, Oil Industry, Radial Basis Function.

1 Introduction

The well characterization is one of the key processes on the Venezuelan Oil Company (PDVSA) business, since it permit the supervision of the relevant variables behaviours and maintain the production level expected in each one of the wells used by the company, with a minimum impact in the differed production.

It is important to supervise the behaviours of the process variables in order to maintain the production levels inside an appropriate margin that allow completing with the acquired commitments. This task is given by the early detection of abnormalities or deviations in the production, the identification of the cause and the application of the appropriate correctives together with the units dedicated to the programming, extraction and wells maintenance.

The process of characterization allows detecting and correcting production problems associated with wrong operation of the well equipment. This is an intensive knowledge activity, so the effectiveness of it depends basically on the well data availability in the amount and quality required by the process.

On the other hand, neural networks have been used in a great amount of industrial applications and have been particularly successful in the pattern recognition tasks, due to the capability of learning complex behaviours using data acquired from the processes and with that information then determine the associated operational condition.

In this work it is presented the well characterization using probabilistic neural nets and is organized as follows: In section 2 it is introduced the process of well characterization, in section 3 it is described the design for well characterization using probabilistic neural networks, in section 4 it is presented the conclusions and respective recommendations.

2 Well characterization

For well characterization it is necessary to collect data concerning the behaviour of the production variables including the surface pressures and data corresponding to the well production infrastructure. This data is collected by the Optimization Engineer and using the available tools and their knowledge they proceeds to determine the origin of the problem that could be presenting in the well, in order to proceed to their correction.

The Figures 1 and 2 present the place where the measurements of some of the variables necessary for the well characterization are taken. These variables are described next:

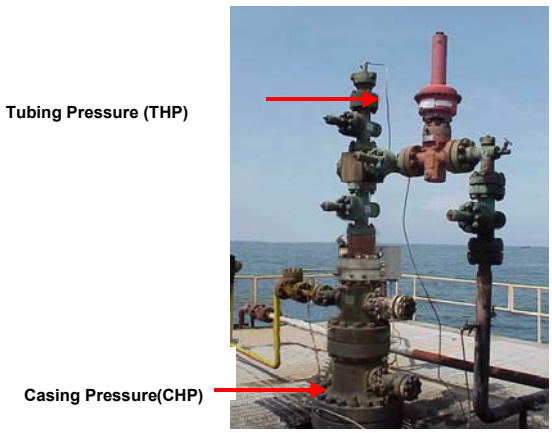

Figure 1. Lift Gas Lift Well

Casing Pressure (CHP).
This pressure registers the injection of the gas to be distributed along the pipeline with the purpose of activating the underground valves. It is one of the most important variables to evaluate in order to understand the behaviour of well gas injection, since it determinates the condition of the underground equipment. Their range of operation is from 0 to 2000 PPC (pounds per centimeter).

Tubing Pressure (THP).
It is the pressure with which the column of Petroleum is lifted and is measured in the bolster of the well. It offers an indicative of the production stability, being their range of operation between 0 and 1000 PSI (pounds per square Inch). The tubing pressure is considered as normal for wells that produce toward the flow stations for low pressure, a value between 80 and 150 PSI, and as normal for wells that produce to flow stations pressures between 180 and 250 PSI. The discharge and low pressure requirements for production are governed by the infrastructure, for which the flow stations were designed, at the crude reception moment.

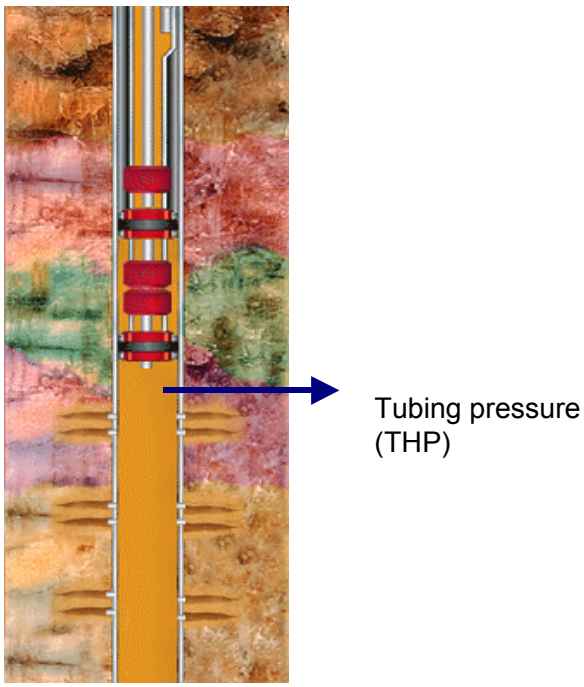

Figure 2. Gas Lift Well

Instantaneous Gas Injection flow (QGI).
This variable allows studying the conditions of gas consumption made by the well, since the hydrocarbon flow column lift, toward the surface, depends on it. The normal well consumption, for the cases considered in this work, doesn't exceed the 2.5 MMCNFD (millions of cubic normal feet per day).

Gas line Pressure (PMAN).
It is the pressure used by the Gas Multiple for distributing to each well the injection pressure. This pressure could be regulated using on the multiple, strangler valves, according to the well consumption pressure obtained by the Production Engineer.

3 The Probabilistic Neural Network design for well characterization.

The developed system for well characterization, allows maintaining the production levels with the patterns behaviour identification of crude producing wells variables and permits, also, modelling reference behaviour patterns for variables of process in order to use them for identifying or characterizing process variables behaviours.

The developed tool is based on one of the technologies of the Artificial Intelligence area: Artificial Neural Nets. The application characterizes wells that produce under the gas lift method and makes the behaviour characterization of the basic variables of the well.

The variables of the well that could be characterized using the application are:

¨ Casing Pressure (CHP)
¨ Tubing Pressure (THP)
¨ Instantaneous gas injection flow (QGI)
¨ Pressure of the gas lift multiple (PMAN)

The behaviours that the application could identify for the mentioned variables are:

- Continuous
- Erratic
- Intermittent

The first condition to be verified is if the well presents a Continuous behaviour and, in case of being not continuous, then it is verified if its condition is Erratic or Intermittent (see figure 3).

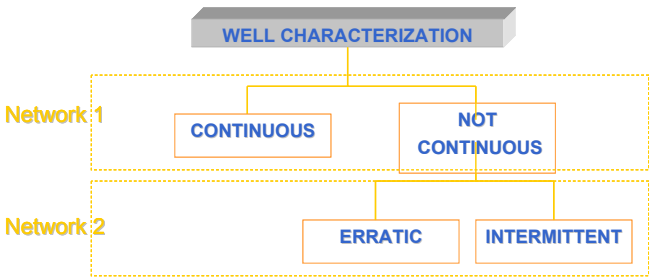

Figure 3. Well Classification according to their condition

These behaviours will be explained next:

The Continuous behaviour: stays in a small range of pressures, being the most common behaviour in the Gas Lift wells.

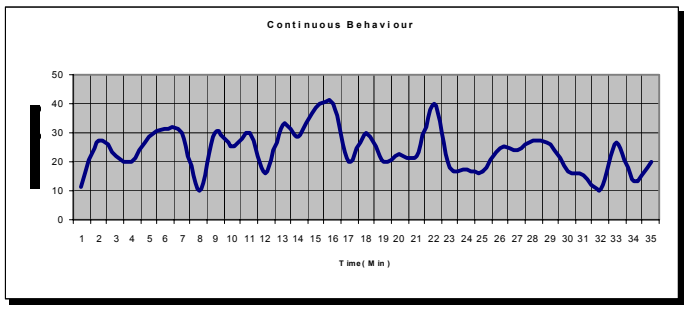

Figure 4. Continuous Behaviour

The Erratic behaviour doesn't have a defined form, it behave temporarily Continuous and partially Intermittent as is shown bellow

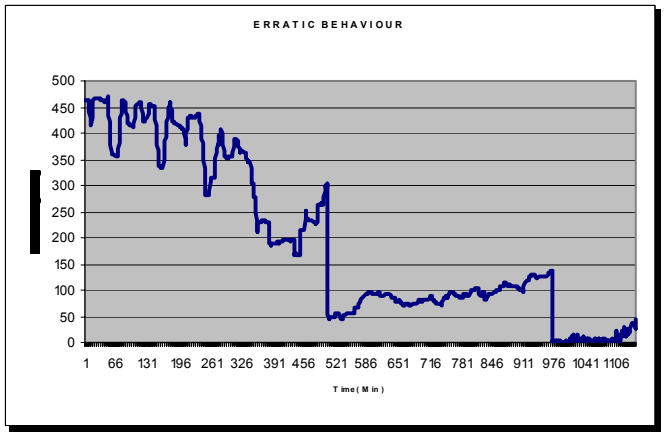

Figure 5. Erratic Behaviour

Lastly, the intermittent behaviour varies with a fixed frequency, this means that the signal clearly presents harmonics and their behaviour is repetitive, this behaviour is not very frequent in Gas Lift wells and their behaviour is observed next.

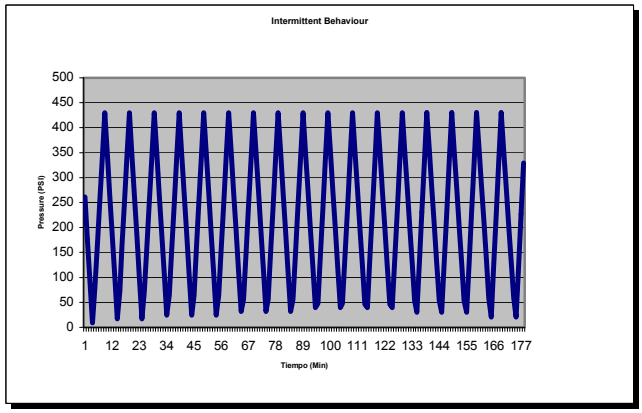

Figure 6. Intermittent Behaviour

Since this is a clear classification problem, one of the better options for their training and operation is using a radial base function type structure called "Probabilistic Neural Network", which are special for classification cases and whose operation is based on similarity measurements between the presented patterns and the available ones. On these nets it is important to take care, as in any another system that one could use for pattern recognition, about the quality of the data that is going to be used for their adjustment, so it is necessary to revise carefully the available data in order to verify their quality and real classification. It may be important the use of statistical data analysis techniques for obtaining the appropriate files to be used in the training phase.

The probabilistic neural network was trained using as input signals the standard deviation (s) and variation coeficient($\sigma / \bar{x}$) that is the relation between the standard deviation and the mean, calculated from the measurements obtained in the 75 previous minutes to the classification, for all the measured variables (CHP, THP, etc.).

The Probabilistic neural network possesses two layers: The first is a radial base functions layer, which calculates the similarity measurement between the presented pattern and the training pattern, and the second layer is a competitive one, whose mission is determining the class to which the presented pattern belong. For this, the second layer accumulates the similarity measurements found by each of the obtained classes in the first layer and selects the one that have more probability of being the appropriate class.

The Figure 7 presents an outline of the Probabilistic Neural Network designed

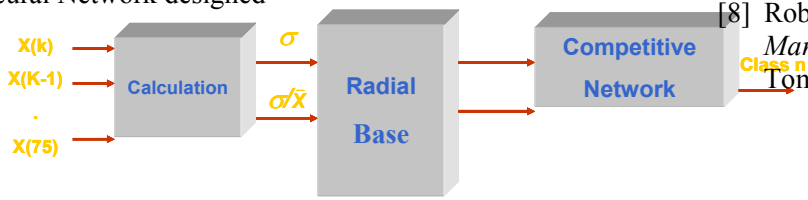

Figure 7. Implantation scheme of Probabilistic Neural Network for well classification

4 Conclusions

- Probabilistic Neural Networks are an excellent alternative for designing applications in the area of patterns recognition and/or classification, needing a special care with the selection of the data that will be used in the training phase, because this algorithm is based on comparison between the presented patterns and the training patterns, it is necessary to guarantee that the data to be used is significantly representative of each operational condition.
- It can be uses data transformations techniques, Cluster analysis techniques or any another statistical technique that can help in adapting the the Probabilistic Neural Network inputs.
- One of the mayor benefits that may be obtained with the use of this type of tools is that they allow maintaining the well production level in the required levels, because they permit to detect differed production problems in automatic form.

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