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Evaluation of the Technical Feasibility of the Use of Ventilated Gas By the Annular As Fuel for Sucker Rod Pumping Units in Mature Fields

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ABSTRACT: *To meet the demand for oil products, the oil industry needs electricity to keep its systems functional, from drilling to refining. Therefore, the key role of petroleum engineering is to ensure the operation at these stages, especially the production of oil and gas. Oil concessions located far from the range of supplying utilities suffer daily with oscillations in their electricity grids. The present papershows the possibility of energy self-production in wells that use the sucker rod pumping units, proposing the use of the gas ventilated by the annular as fuel for an internal combustion engine, aiming to the continuity of production. For this, a generic well, called BRZ-001, was chosen, with predefined characteristics and conditions. The gas consumption, requested by the chosen engine, was determined using the produced gas flow from the casing's annular and consumption equations. With the results, it was possible to simulate and prove the technical feasibility of the proposal, showing that it is possible to maintain the availability and the production of mature wells stable and satisfactory, even with low gas flows, minimizing the productive losses due to electrical problems.*

Keywords: *Artificial lift, Availability, Gas burning,Internal combustion engines,Sucker rod pumping.*

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I. INTRODUCTION

The energy of greatest consumption, among of all required in Brazil, is electricity. This corresponds to 43.4% of total Brazilian energy demand. In second place are the oil products that, together, serve 28.5% of the country's energy demand[1]. To meet the demand for oil products, the oil industry needs electricity to keep its systems functional, from drilling to refining. Therefore, ensuring the operation of these steps, especially the production of oil and gas, is the key role of petroleum engineering. Oil concessions far from the range of supply of utilities suffer daily with fluctuations in their electricity grids. Therefore, losses due to energy peaks are common. Although electrical systems operate on a permanent basis most of the time, they must be designed to withstand the worst demands that can be made [2].Recillas[3] defines an electrical transient as a sudden change in the energy distribution of a system. Transients are caused by changes in network conditions, for example, opening or closing a switch to turn the system on or off; equipment failure; lightning, etc. Although a transient occurs in a short time (on the order of micro to milliseconds) it can cause serious damage to the system.

Due to the electrical power outages caused by losses in the field production, the present work shows the possibility of energy self-production, proposing the use of the gas ventilated by the annular as fuel for an internal combustion engine, aiming to the continuity of production. The sucker rod pump is the most widely lifting method and there is already a vast technological domain and accumulated experience on this [4]. According to Rossi [5] this method can be used to raise average flows of shallow wellsand the possibility for operating with different fluid compositions and viscosities in a wide range oftemperatures [6]. The BRZ-001 well was chosen to be the object of study, with predefined characteristics and conditions due to the confidentiality of the data imposed by the oil companies. Based on data from a real concession and its respective producing wells, the BRZ-001 belongs to a mature concession and produces through the sucker rod pumping method. The consumption of gas requested by the chosen engine and the gas flow produced by the annular was determined using consumption equations and the OWT (Orifice Well Tester) measurement method, respectively. The characteristics of the gas were determined by a chromatographic analysis, in order to analyze the technical feasibility from self-generation energy.

II. MATERIAL AND METHODS

The Engine

In order to determine the gas consumption required by the system, an internal combustion engine, that operates with produced gas as fuel, was used as a study model. Manufactured by the Argentine company Diadema, the engine selected was the KNG-3200E and its specifications are described in Table 1.

Table 1 - KNG-3200E Characteristics

Manufacturer	DIADEMA
Model	KNG 3200E
Type	Horizontal Natural Gas Engine, 4 strokes
Number of Cylinders	1
RPM range	300-1100 RPM
Maximum Power	32 HP
Fuel	Gaseous Fuels
Fuel Consumption	8700 BTU/HP.h

Source: Adapted fromDiadema Engine [7]

Fuels And Instrumented Layout

The characteristic of the fuel can have a considerable influence on the design, production, efficiency, fuel consumption and in many cases the reliability and durability of the engine [8].An important feature of the fuel that allows us to choose which type is most suitable for the engine is the heating value. Gas Processors Suppliers Association - GPSA [9] defines heating value with the amount of ideal heat released by a complete combustion of a mass unit or volume of the fuel, during a complete combustion at constant pressure. The heating value of a fuel provides the "energy content" of the fuel, regardless of whether or not the combustion is carried out.According to the manufacturer, the KNG-3200E works with various gaseous fuels besides the gas produced, such as: butane, propane and LPG. For the proposed project, these gases would only be used in emergency cases. Despite of the versatility of the chosen motor, to generate energy from the gas ventilated by the annular, it was necessary to propose an instrumented layout, which had two priorities: to channel the gas, previously ventilated to the atmosphere, to the intake of the engine and to control variables such as pressure and level to protect the equipment and production characteristics of the BRZ-001.For example, if gas production reduces, for an unexpected reason, an automation system would open the valve of an emergency gas cylinder and keep the engine running, allowing a future correction.

Table 2 shows the LHV (Lower Heating Value) of the suggested gaseous fuels for the engine.

Table 2– Gaseous Fuels

Gas	**Lower Heating Value**(Kcal/Kg)
Propane	11,065
Butane	10,919
LPG	11,139

Source: Adapted from U.S. Departmentof Energy [10]

Gas Flow Data Acquirement

To determine the gas flow rate through the annular of the BRZ-001 well, the low-pressure measurement method called OWT (Orifice well tester) was used.The OWT consists as a type of orifice plate flow meter, which represents a classic example of measurement with physical contact between the fluid and the meter[11]. The orifice plate is a restriction which is usually placed in a pipe and forms the primary element of a measuring system. The measurement systemOWT is basically composed of the meter itself, the pressure record gauge and the flow thermometer. Table 3 describes the components of the basic OWT measurement system.

Table 3 - Basic components description

Nº	**Description**	**Nº**	**Description**	**Nº**	**Description**
1	Orifice Well Tester	5	Nipple de 2"	9	Silicone Hose
2	Orifice Plate	6	T-Fitting	10	Pressure Gauge
3	Joint Sleeve	7	Adapter Fitting		
4	Nipple de 2"	8	Temperature Gauge		

Consumption Equations

To calculate the amount of fuel required by the engine to operate for 24 hours, the produced gas must have the necessary flow to supply the KNG-3200E consumption and a high LHV to perform an efficient burning and generate enough energy for the operation. According to the engine specifications given by the manufacturer, the KNG-3200E's consumption is 8700 BTU / HP.h. This means that in an hour of operation at one HP of power, it converts 8700 BTU into kinetic energy. To calculate the amount of energy required by the motor to operate at its maximum power, just use (1):

$$E = C\left(\frac{BTU}{HP.h}\right) \times P(HP)(1)$$

Where **E** is the amount of energy requested, **C** is the motor consumption and **P** is the engine maximum power. Converting the energy **E** found by (1) in KJ / h and substituting in (2) we have:

$$V = \frac{E\,(\frac{KJ}{h})}{LHV\,(\frac{KJ}{m^3})}(2)$$

Where **V** is the required gas flow (m^3/h) and **LHV** is the lower heating value of the produced gas. With a result of (2), it is possible to obtain the gas volume needed to keep the engine running at its maximum power for one hour.

III. RESULTS AND DISCUSSIONS

The Layout

The gas that was previously vented to the atmosphere will be channeled through a small gas liquid separator to eliminate the maximum of the liquid fraction present in the produced gas. Upon entering the separator, the gas strikes a deflector plate and is forced to proceed through a longer path till the exit point. With the reduction of its kinetic energy, the droplets of liquid present in the gas begin to condense on the mesh pad and settle to the bottom of the vessel until the limit set by the high-level switch opens the solenoid valve and drains the fluids into the containment dikes. When leaving the separator, the gas goes straight to the pressure reduction system present at the motor inlet. If the gas production falls due to problems in the subsurface assembly, the low-pressure switch - PSL will open the valve of the gas cylinder to maintain the engine operation, as shown in Fig.1.

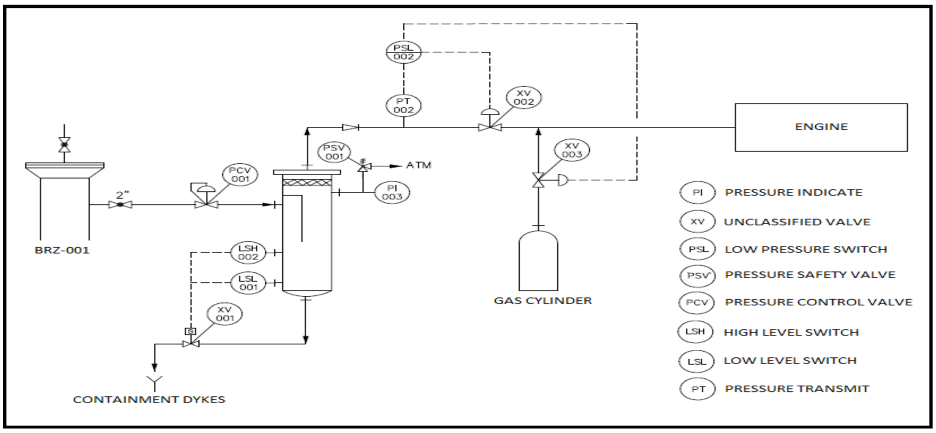

Figure 1 - Project Layout

Fuel Consumption

Table 4 lists all the necessary data to perform the consumption calculations of bothgas produced andemergency gas system.

Table 4- Required data for the consumption calculations

Variable	Value	Unit
Produced gas LHV	53,297.5	Kj/m³
LPG lower heating value	11,139	Kcal/Kg
KNG-3200E Consumption	8,700	BTU/Hp.h
KNG-3200E Maximum Power	32	HP
Produced Gas Flow	360.35	Nm³/day

With the data in Table 4 and (1)it's possible to determine how many BTUs per hour will be necessary for operates the engine at its maximum power:

$$E = 8{,}700(\frac{BTU}{HP.h}) \times 32(HP)$$

Therefore, the energy required when the engine is running at 32 HP equals to 278,400 BTU / h or 293,712 KJ / h. This result shows that to keep the engine running for one hour at 32 HP the fuel should convert its burning to this amount of energy. With this result and using the LHV of the gas produced it is possible to determine the gas flow needed to generate the same amount of energy:

$$V = \frac{293{,}712\ (\frac{KJ}{h})}{53{,}297.5\ (\frac{KJ}{m^3})}$$

To produce the energy required for the engine to operate at 32 HP, it will take 5.51 m³/hour of produced gas. Since the company'sstandardprocedure requires a 24 hours operation, it is calculated:

$$V = 5.51\ \times 24 = 132.3\ m^3/day$$

In this way, 132.3 m³ of produced gas is required to operate the BRZ-001 for 24 hours. Considering the emergency case where the subsurface assembly fails and the gas flow reaches the operational limit, the automation system will put the fuel gas cylinder in use and a dialer will send a warning to those in charge, that the emergency system is active. Since the lower heating value of LPG is 11,139 Kcal / kg or 46,605.6 KJ / kg, it is estimated that 151 kg of LPGis required to keep the engine running for 24 hours.

IV. CONCLUSIONS

Eliminating power peaks and maintaining the availability of any well is critical to keep a stable and satisfactory production. Stopping the system implies loss of production, problems with bottom equipment (solids deposition) and operating costs. The project has proven its technical feasibility because the gas vented by annular BRZ-001 has sufficient flow to keep the motor running. The OWT test indicated a flow rate of 360.35 Nm³ / day, though the engine only needs 132.3 m³ to operate for 24 hours. Therefore, the KNG-3200E will only work with 36.71% of the maximum daily gas flow potential, that is, well below safety margins. In other wells, with different gas flow rates, just choose the engine with adequate power for the operation and use the same consumption equations to determine if the amount of gas produced by this another well can maintain the operating time requested by the company.

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