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Crude Oil Production Optimization & Reduction In Emission Of Harmful Gases By PAIGL Technology

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Abstract -:
From whole globe the demand of oil and gas is increasing so increase production is most important. To increase oil production from existing wells in an oil field we have to focus much on optimizing oil production. One way to optimize oil production is to find an alternative to existing intermittent gas lift technology. As we study big oil field currently with huge oil and gas operating companies, the gas injection line network is very old and new intermittent gas lift installations on new wells has been connected to the existing network. Now this creates gas starving for the new installations and resulting in inadequate amount of gas production from the well. By introducing Plunger lift technology of artificial gas lift along with existing intermittent gas lift can provide a fool proof solution to the problem and also reduction in injected gas requirement also. Thus, reducing the compressor duty and overall reduction in environmental emission of harmful gases by reducing the diesel engine load required previously for compression. This paper discusses in detail with proof in form of tables, increase in oil production and reduction in injection gas requirement and reduction in emission of harmful gases to the environment.

1.Introduction-: Over the last 25 years or so there has been increasing public concern over the nature and composition of the combustion by-products that are emitted from engine exhaust pipes. Initially the greatest attention was given to petrol engines because in their original form, these engines, excluding smoke or particulates, produced significantly higher emissions than diesel engines. Extensive development of emission controls on petrol engines has reduced the undesirable exhaust gases to levels below that of typical diesel engines.

The main concern with diesel engine emissions has always been smoke because it is clearly visible, particularly at high engine loads. In the past this smoke was considered to be undesirable because of aesthetics and odor but now there is growing concern about the health effects of this particulate matter when it is breathed into the lungs. The term particulates are used to describe the collection of small particles that make up smoke.

1.1. Source of emission-: Exhaust emissions as they are known are just the by-products of combustion of a fuel. For every 1kg of fuel burnt, there is about 1.1kg of water (as vapour/steam) and 3.2kg of carbon dioxide produced. Unfortunately we don't have 100% combustion and so there is also a small amount of products of incomplete combustion and these are carbon monoxide (denoted CO), hydrocarbons (vaporized fuel) and soot or smoke (actually hydrocarbons in a different form). In addition, the high temperatures that occur in the combustion chamber promote an unwanted reaction between nitrogen and oxygen from the air. This result in various oxides of nitrogen, commonly called NOx.

There are also several minor contributors to exhaust emissions which are burnt crankcase oil and sulphur from the fuel. Both of these components will show up mostly as particulates. Oil consumption is obviously a function of engine design and amount of wear but sulphur dioxide is formed from the sulphur in the fuel.

1.2. Measurement of exhaust emissions-: The gaseous emissions are generally measured using electronic instruments but for field use Drager tubes are used. These contain a chemical which changes colour by varying degrees when a particular gas is present. This is most commonly used in underground mines to ensure that engine emissions meet the Mines Department regulations.

Any of the non gaseous emissions from a diesel exhaust are measured as smoke or particulates. This includes smoke, soot and sulphur dioxide. Smoke may be filtered out of the exhaust and weighed or the exhaust passed through an instrument such as a Bosch Smoke Meter that measures opacity i.e. the percentage of light transmittance.

The units of measurement of emissions vary with the application and test procedure. Typical units are ppm, % volume, gm/kw hr, gm/km or gm/test. Currently on road diesel emissions are not measured in Australia but in the future we may adopt regulations from overseas. While it is difficult to quantify the typical emissions from a diesel engine, using the current USA regulations for an approximation, 1kg of fuel would produce around 30gm of carbon monoxide, 3.5gm of hydrocarbons, and 1.7gm of particulates and 8gm of NOx.

Total unwanted emissions which could be attributed to 'inefficient 'combustion accounts for something less than 4% of fuel used. Note that this does not necessarily relate to wasted fuel because these components are the product of incomplete combustion and so have still released much of their energy content. As an aside, this shows that there is not much scope to improve fuel consumption through improved combustion alone.

The emission from new diesel engines used in generator sets has been regulated by the Ministry of Environment and Forest, Government of India. The regulations impose type approval certification, production conformity testing and labeling requirements. Certification agencies includes: 1) Automotive Research Association of India. 2) Vehicle Research and Development Establishment and 3) International Centre for Automotive Technology. The emission standards are listed in Table 1.

Engine power (p)	Date	CO	HC	NO_X	PM	SMOKE
		g/kWh				1/m
p≤19kW	2004.01	5.0	1.3	9.2	0.6	0.7
	2005.07	3.5	1.3	9.2	0.3	0.7
19kW≤P≤50kW	2004.01	5.0	1.3	9.2	0.3	0.7
	2004.07	3.5	1.3	9.2	0.3	0.7
50kW≤P≤176kW	2004.01	3.5	1.3	9.2	0.3	0.7
176kW≤P≤800kW	2004.11	3.5	1.3	9.2	0.3	0.7

Table 1: Emission standard for Diesel Engines ≤ 800 kW for Generator set.

Date	CO	NMHC	NO_X	PM
	mg/Nm^3	mg/Nm^3	ppm(v)	mg/Nm^3
Until 2003.06	150	150	1100	75
2003.07-2005.06	150	100	970	75
2005.07	150	100	710	15

Table 2: Emission limits for Diesel Engines >800 kW for Generator sets.

2. Study-:

Following data is studied for appropriate result:

1. The sizes of gas field compressor engines range from 25 to 1500 hp, with approximately 40% of gas being compressed with engines smaller than 500 hp.
2. Gas field compressor engines are operated continuously through the year at constant load. The average load on a compressor engine is 40%.
3. In the initial year of operation, wells do not required compression. After the first year, almost all gas is compressed using reciprocating engines. Generally these engines are fueled with raw natural gas from the field, but many engines. Generally these engines are fueled with raw natural gas from the field, but many engines are fueled with treated natural gas. A very few gas compressor are driven with electric motors.
4. A majority of the compressor engines in the study area are leased. The current tread is for this friction to increase.
5. The annual emissions from gas field compressor engines <500 hp in the study area are listed in the following table. Overall these emissions from small engines are additional to point source emissions from natural gas operation. However, it is possible that an emission source include in the totals below is

also the totals below is also reported in the point source inventory, if the site was required to report emission for reasons other than the small engine.

Pollutant	Emissions in Designated Inventory Year (ton/yr)			
	1999	2002	2007	2010
CO	21796	23354	23113	22569
NO_X	19,561	20,949	20,786	20,298
VOC	573	613	610	596
$PM_{2.5}$	192	202	202	197
SO_2	6.4	6.6	6.6	6.5

Table 3. Emissions in Designated Inventory Year by each Gas.

6. The estimated uncertainty of the resulting at the inventory country level is 128%. The uncertainty is primarily attributable to the large uncertainty associated with the emission factor used in this study. It was also influenced significantly by the uncertainty in the distribution of engine type.

5. Calculation -: Emission calculation from diesel sets used for natural gas compression:

	CO	CO_2	HC	NO_X	O_2
Density (g/ft^3)	32.97	51.81	16.33	54.16	37.18
Density of diesel fuel= 3212 g/gal weight fraction of C in diesel fuel = $\frac{12.011}{[12.011+(1.80*1.008)]}$ = 0.869 from the relation $CH_{1.80}$ Mass of c in 1 gal. of diesel fuel =3212 g/gal. 0.869 = 2791 gC/gal.					

Table 4. calculation of weight fraction of carbon.

	NO_X (g/hr)	CO_2 (g/hr)	gal/hr
ARITHMETIC MEAN FOR ALL TESTS			
High value	329	16,578	1.65
Low value	55	3,915	0.39
Average value	144	8,224	0.82
Standard Deviation	72	3571	0.40
Coefficient of Variation	0.5	0.43	0.43
Low RPM avg. (600-800 rpm)	114	5805	0.58
High RPM avg. (1000-1200 rpm)	190	11815	1.18
WEIGHTED AVERAGE VALUES (70% high RPM, 30% Low RPM)			
Weight Average Value	160	9411	0.94
WEIGHTED AVERAGE VALUE (60% High RPM, 30% Low RPM)			
Weighted Average Value	167	10012	1.00

Table 5. Arithmetic mean for all tests.

4. Emission Equation -: The following equation is general model to develop the emission inventory.

$$E_{ijk} = Q_i*F_{1i}*F_{2j}*C_i*H_j*EF_{jk}*1/2000$$

Where:

E_{ijk} = Emissions in country i. for engine type j. and pollutant k (tons/yr).

Q_i = Gas produced in country i (Mscf/yr).

F_{1i} = Fraction of wells requiring compression in county i

F_{2j} = fraction of compration load represented by engines<500 hp. Of type j

C_i = Compression requirements for county I (hp-hr/Mscf)

H_i = Brake specific fuel consumption for engine type i (MMBtu/hp-hr)

EF_{ij} = Emission factor for engine type j, and pollutant k (lb/MMBtu)

1/2000 = Conversion from lbs of emissions of tons of emissions

5.Production optimization -: Involves the determination of optimum well controls to maximize an objective function such as cumulative oil production or net present value. In practice, this problem additionally requires the satisfaction of physical and economic constraints. Plunger lift was originally developed and used to unload liquids from gas wells. Later its use was extended to produce oil from high GLR wells. Production optimization ensures that wells and facilities are operating at their peak performance at all times to maximize production. Frequent changes in well and surface equipment down time, maintenance work, evolving reservoir conditions etc. usually make it impossible for the team to keep the asset tuned for optimal operating conditions.

The current manual production optimization approaches are both time consuming and error prone due to the complexity and large volume of data that have to be considered. In the present work, several tasks and processes have been streamlined and automated with effective linkages to achieve a near real time optimization. The measure calculate-control cycle is implemented every twenty-four hours, a procedure which maintains the system at optimal operating conditions almost all the time. A multi-disciplinary team approach has been used to implement the process of production

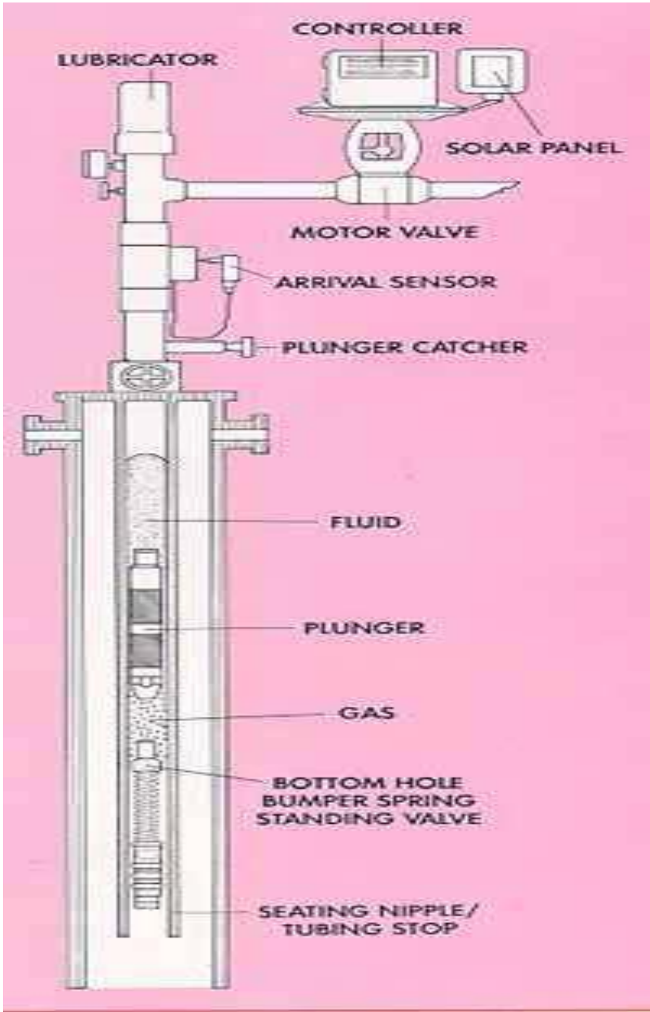

Fig. 1 Plunger lift (Courtesy Kermit Brown)

Optimization using Internet, computer network, communication links, timely team meetings and corporate database. The focus has been on reducing the cycle time for conversion of data to information, decisions, and actions by developing an appropriate system. The benefits of optimization are significant. Gains include a moderate improvement in uptime, along with a significant improvement in produced volume and overall reduction of lifting and operating costs.

Conventional plunger lift uses the energy of the gas stored in the tubing casing annulus to lift a liquid slug accumulated in the tubing. Conventional plunger lift is possible in an oil well only if it has a minimum required formation GLR. If the GLR is less than the minimum required, gas will have to be injected into the tubing-casing annulus to lift the plunger with the liquid slug.

There are a large number of intermittent gas lift wells operating in fields spread over many operating Regions. In intermittent gas lift wells, the injected gas penetrates the liquid slug causing some of the slug fluid to slip downward with the consequent loss of oil production.

It is estimated that 5-7 % of the starting slug per thousand feet of lift fallback during the upward movement. As well, a large part of the gas is notable to perform useful work in piston-pushing the oil slug above it.

The inherent inefficiency of intermittent gas lift owing to fluid fall back from the liquid slug during its upward travel can be overcome by introducing a solid interface between the slow moving liquid and the fast-moving gas in the form of a plunger. This type of installation is termed **plunger-assisted intermittent gas lift** or PAIGL. A decrease of injection gas requirement and possible increase of liquid production can be expected by converting intermittent gas lift wells, to plunger-assisted intermittent gas lift mode. Intermittent gas lift wells which have paraffin deposition problems are also suitable candidates for installation of this lift mode. The tubing will be kept free from paraffin, with the up and down motion of the plunger, which would work as scrapper. This will result in savings on regular scrapping jobs.

The report discusses the conventional plunger lift (for high GLR oil wells and gas well liquids unloading applications) and then plunger assisted intermittent gas lift. The design of plunger lift

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system, description of the down hole and surface equipment required, guidelines for installation, operation and monitoring of the plunger lift installations and some case histories have been given. This mode of lift has been used on a big scale in wells operated by BP Amoco and other companies and has resulted in increased liquid production and substantial injection gas savings.

The plunger-assisted intermittent gas lift as an alternative mode to intermittent gas lift mode is attractive since the increase in liquid production and savings in injection gas is expected and capital investment is also low. No extra surface equipment except the plunger, bumper spring, lubricator containing striker pad, catcher assembly, bumper spring and flow outlets with chokes/valves are required. However, plunger lift will not perform well in wells producing appreciable sand with the oil.

7. Result -:

Expected Performance with PAIGL

Well No A-1

Tubing load (% of casing press	Pressure build –up time in minutes	Starting slug height in Meters
65	13	98.3
60	10	83
55	6	67.5
50	2	52

Cycle time	Cycles per day	Injection gas per cycle
35	40	43
30	48	42
24	59	59
19	77	77

Injection gas per day	Avg BHP	Expected liquid production
1720	16.97	13.66
2018	16.22	13.75
2416	15.47	13.78
3080	14.7	13.89

Tubing LOAD (% OF CASING PRESSURE	Press build up time	Starting slug height
65	26	98.2
60	20	82.8
55	14	67.4
50	9	62

Cycle time in Minutes	Cycles per day	Injection gas per cycle in M^3
23	61	86
19	73	84
16	91	82
12	118	80

Injection gas per day M^3 / day	Average bottom hole pressure in Kg / cm^2	Expected Liquid production in M^3 / day
5226	18.65	12.41
6113	17.64	12.57
7439	16.61	12.52
9406	15.56	12.57

Estimated performance with intermittent gas lift mode:

Action	Potential Gas Saving from Incremental gas production and Avoided Emission (Mcf/Year)	Value of Gas Saved (s)	Typical Setup and Installation Costs (S/well)	typical payback
Install a plunger lift system	4700-18250 per well	$14100-$54750	$2000-$8000 per well	<1 year

Graphs representing emissions of harmful gases produced during natural gas compression and emitted into atmosphere before and after

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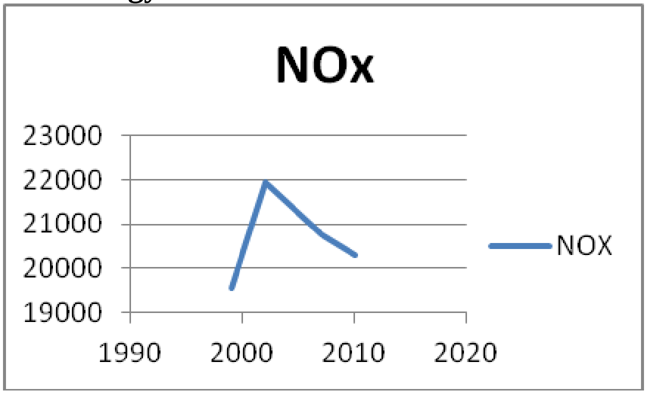
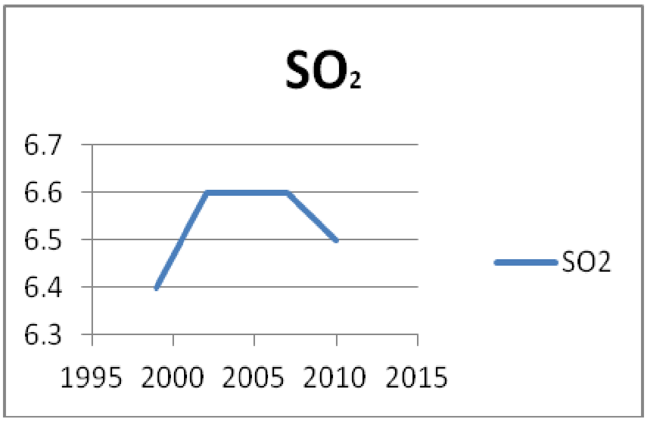
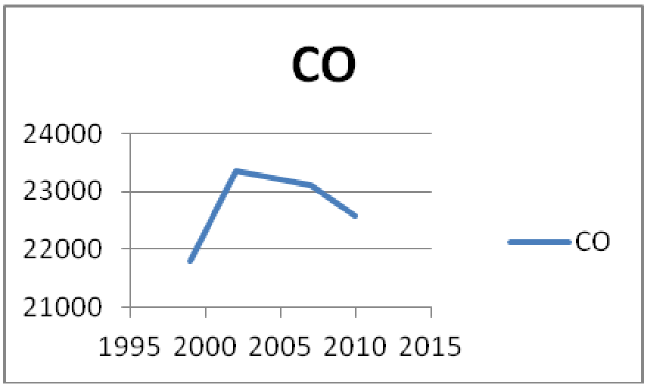
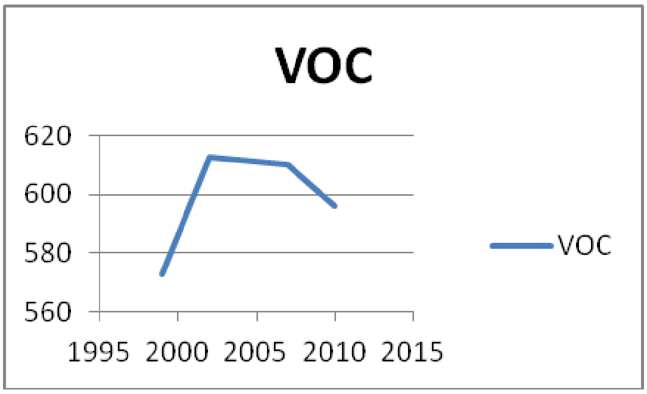
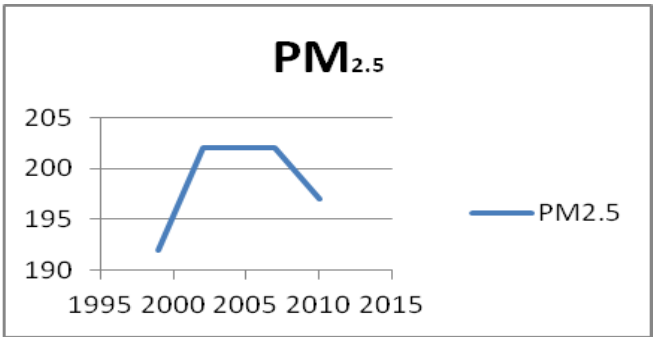
installing Plunger Assisted Intermittent Gas lift Technology.











Result table: Optimized Production

Expected liquid gain with PAIGL	Saving in injection gas with PAIGL
1.25	1843
1.28	2145
1.30	2677
1.32	3345

8. Conclusion & Recommendation-:

1. Savings in injection gas with plunger assisted intermittent gas lift technology is about 1843 m^3/d.
2. 1 MMSCFD = 28316.847 M^3D
3. 672695 M^3/YEAR = 23.755 MMSCFD of natural gas is saved / year.
4. 1 MMBTU = 2.7 US $ current rate
5. 1000 ft3 = 1 MMBTU
6. 1 M3 = 35.31 FT^3
7. 23752860 FT^3 / YEAR
8. 23752.86 MMBTU/ YEAR
9. 64132.722 $ / YEAR SAVING IN GAS CONSUMPTION.
10. Emission calculation from diesel sets used for natural gas compression
11. Huge reduction in harmful gases emission by application of PAIGL as natural gas required for lifting oil is reduced thus reducing the amount of compression required.

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