SHALE GAS- FUTURE SCOPE & CHALLENGES

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Abstract— **Coal is the major fuel for India today. But with the depleting coal reserves and the increasing demands of fuel, we need an alternative. Shale gas (a form of natural gas available in shale rocks) is the most promising alternative. Shale gas is considered to create less harm to environment, as compared to coal. The exploration techniques include hydraulic fracturing and horizontal drilling. But these techniques have certain drawbacks related to land and water resources. There are companies which have found an alternative technique-Waterless fracturing. The liquid propane gas fracturing among the various techniques is found to be more viable. The exploration techniques are found to be cheaper than coal mining in the long run. Also it can reduce our energy import bills.**

Keywords-shale gas, Hydraulic Fracturing, Horizontal Drilling, waterless fracturing, liquid propane gas fracturing

I. INTRODUCTION

The population of our country is 1.27 billion and the energy requirements are equally large. It is expected to rise by 7-8% annually. Energy security is at the forefront of the Indian government's agenda, and unconventional resources like shale oil and shale gas have the potential to improve its situation. The U.S. experience with shale gas resulted in more advanced knowledge of the extraction process and also allowed a decrease in production costs and drilling time. In India, coal dominates the energy markets – coal imports increased to a record of 135 million tons in the last fiscal year. – shale gas can prove to be a promising alternative in terms of cost and environmental impacts.

Initially, the prices of shale gas may not be economically viable as the cost of end products are hiked depending on fuel prices but it could be an economic alternative to meet the energy demands in long run.[1]

II. SHALE GAS

Shale gas is natural gas trapped in small spaces of shale, a fine grained type of a sedimentary rock. This rock shale is composed of mud silt, clay and organic matter.

Shale gas consists mainly of methane. It also has components of Natural Gas Liquids (NGLs) like ethane, propane, butane and also carbon dioxide, nitrogen and hydrogen sulphide.

A. Analyzing Reservoir Data

The most common methods used by reservoir engineers to determine the reserves are volumetric calculation, material balance calculation, analysis of decline curves and reservoir simulation and modeling- the most effective model. [2]

1) Volumetric Calculations:

This method works best in high permeability gas reservoir where drainage area and gas recovery efficiency are known with reasonable certainty. It provides accurate estimates of the amount of original gas in place and gas reserves.

2) Material Balance Calculations:

As gas is produced, it becomes difficult to obtain accurate data of the drop in reservoir pressure. So this method cannot be used.

3) Decline Curve Analysis:

The production from the gas reserve changes at a decreasing rate over the time. In the first year, the rate of decline is high. The decline rate reduces with time and after several years can be approximated by an exponential function. After a certain rate is obtained, it can be assumed for the remaining life of the well. It also makes the point that if a shale gas well pays out in the first few years, it is an economic investment.

4) Reservoir Modeling Method:

In this method, a semi-analytical method or finite difference method model are calibrated with the already obtained historical data. The best use of shale gas reservoir simulation is done by comparing the result of the what if analyses with the actual field production data by which it is easy to understand the different fracture treatment alternatives and effects of drilling on gas production and economics. This is the most accurate way to estimate gas reserves.

B. Technology

The production of shale gas employs the technology of hydraulic fracturing and horizontal drilling.

Hydraulic fracturing is the technique which uses huge amount of water along with additives (generally hydrocarbons).As shown in figure1, the process includes two phases:

Drilling phase: The wells are drilled vertically up to a depth above the available shale rocks. Horizontal drilling is employed roughly above 150m of shale. The time required for drilling is three to six weeks and depends on the depth and horizontal length of the well. A three layer steel casing is used to prevent accidental contamination of ground water reserves.

Hydraulic Fracturing: Water mixed with sand and additives, is pumped at extremely high pressures into the wells. Here water is used to create the fractures, while sand helps to keep the fractures open and allow the gas to flow into the well. The frack fluid consists of: 95% water, 4.5% sand and 0.5% additives. The fracking process takes up to 10 days.

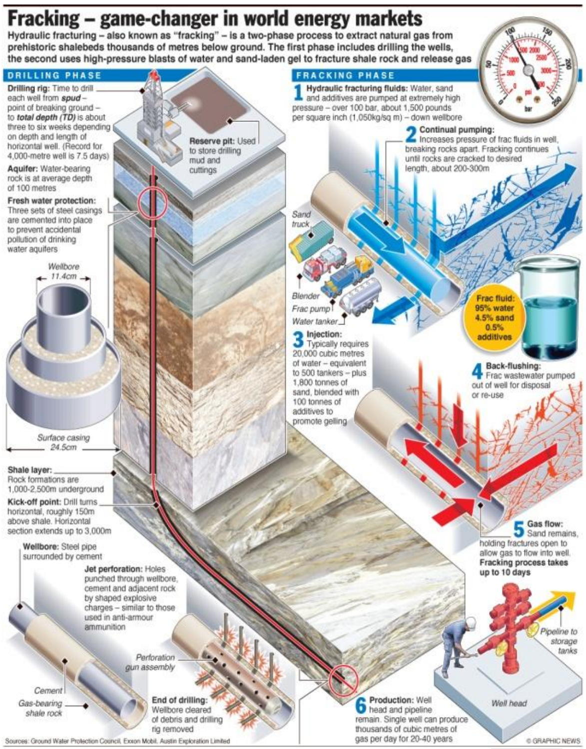

Fig. 1 Fracturing Technology [3]

The following chemicals are used:

a. Acid: dissolves minerals and initiate cracks. E.g. hydrochloric acid

b. Biocide: removes bacteria from water used. E.g. Quaternary ammonium chloride.

c. Cross linker: thermosetting gel able mixture is used in fracturing. This thermosetting resin is foamed at the surface and pumped down the hole and creates fracture at proper fracturing conditions. These are mainly cross linked polymers of aminoplast or amino resin and gel formed of phenol and formaldehyde resin.

d. Corrosion inhibitor: prevents corrosion.

e. E.g. methanol and formic acid.

f. Friction Reducer: slicks the water to minimize friction. E.g. polyacrylamide

g. Gelling agent: thickens water to suspend sand. E.g. guar gum, petroleum distillates.

h. Non emulsifier: to prevent emulsification. E.g. isopropanol, ethylene glycol

i. PH stabilizer: it stabilizes the ph for better effectiveness. E.g. Potassium hydroxide, acetic acid.

Figure2 shows the proportion of chemicals used

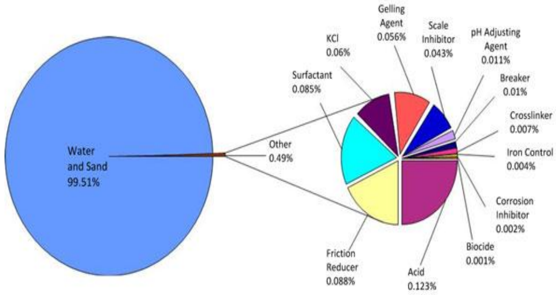

Fig. 2 Fracturing Chemicals [4]

III. WATERLESS FRACTURING

The major issues regarding the hydraulic fracturing technique in India are:

Large volume of water is required for the process.

The water is to be blended with some combination of chemicals, salts and sand to fracture the rocks and liberate hydrocarbons. This water when flows out of the well have to be treated.

The environmental concerns are there in the form of contamination of groundwater, increase in greenhouse gases, harmful for agriculture, treatment of waste water which adds to the cost for water based hydraulic fracturing.

The valuable alternative (non-water-based) fracturing fluid technologies recognized both from literature and field applications, are:

a. Propane (LPG) based fluids;
b. Gaseous or Liquid N_2;
c. Helium;
d. Liquid CO_2;
e. Methanol;
f. Oil-based fluids

A. Propane (LPG) Based Fluids

What is LP Gas Fracturing?

Propane is gas at normal temperature and pressure. It exists in a virtually incompressible gel like phase when cooled and pressurized. LPG fracturing uses this propane gel in place of water to both fracture the rock formation and deliver proppant.

Environmental Advantages

LPG fracturing is advantageous as it reduces water use per frack treatment from 60,000 gallons to zero. Also, the LPG process uses less total fluid volume than standard fracturing.

This reduction in total volume implies less transport trucks, smaller drill sites, and lower associated land use and emissions.

LPG fracturing solves the problem of produced water pollution and disposal. Unlike propane, water is a polar, inorganic molecule, making it a ready solvent for underground salts and minerals. When this water used in fracturing comes in contact with the ground water reservoir, it contaminates it with seabed salts, heavy metals, and radioactive elements. While these substances are naturally occurring, they are not usually found on the surface and are potentially harmful to plant and animal life.

This polluted water must then be either filtered and treated or disposed off through injection back underground. Conversely, as a non-polar hydrocarbon, propane does not dissolve such substances and will return to the surface unpolluted.

Production Advantages

In addition to alleviating environmental concerns, LPG fracturing may also offer production advantages. When a well is fractured using a water-based fluid, some of that water inevitably remains behind causing damage to the formation. That is, the residual water blocks tiny channels in the rock, reducing permeability and inhibiting gas flow.

Using LPG as a fracturing fluid offers an elegant solution to this issue. Propane is pumped down the wellbore in a liquid state under high pressure and low temperature. However, as the fracturing of the rock alleviates pressure, and the liquid begins to heat back up, the propane reverts to a gaseous state. Rather than blocking gas flow, the propane then mixes with the natural and they flow up the wellbore in solution.

Unlike water, propane and natural gas mix well and have similar flow properties. In fact, propane is often a natural component of natural gas in small concentrations. Upon reaching the surface, the propane can then be separated and sold, rather than incurring treatment and disposal costs like water.

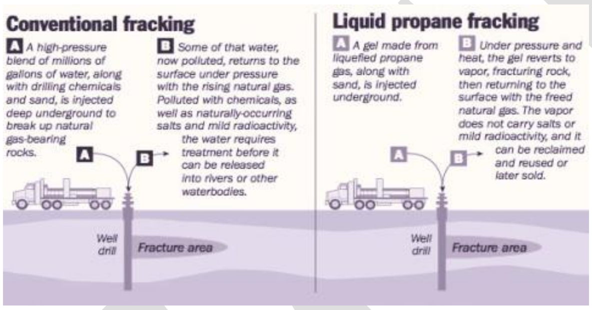

Fig. 3 Comparing conventional and liquid propane [5]

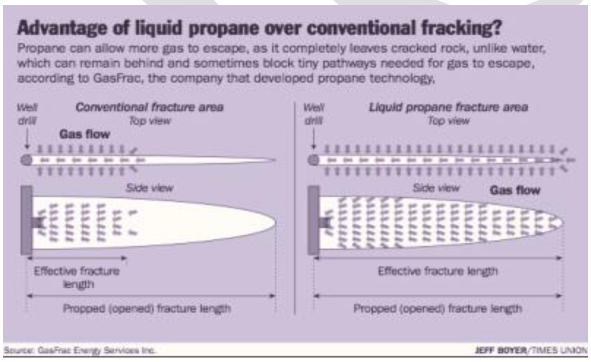

Fig. 4 Advantage of liquid propane over water

Economic Hurdles

Despite the numerous environmental and functional advantages, LPG fracturing remains relatively obscure and seen mainly as a niche technology—a viable option for production in water sensitive conditions but not a likely replacement for hydraulic fracturing across the board.

LPG fracturing lacks infrastructure.

Unlike hydraulic fracturing, propane gas fracturing requires specialized equipment to perform all operations under the pressure and low temperatures needed to keep propane in a liquid state. As propane is also a volatile and flammable material, monitoring devices and safety equipment is necessary to minimize operating risks. These tools are expensive to buy, build, and run. [5]

B. Gaseous and Liquid N_2 Fracturing

Some or all the fluids used in hydraulic fracturing is replaced by nitrogen gas which can fracture at high pressure. N_2 is gas at room temperature but can be liquefied by cooling and pressurizing.

Types of Nitrogen Fluids

Pure nitrogen gas fracturing

It exclusively uses nitrogen with negligible amount of water. Due to compressibility pure nitrogen is ineffective at greater depths. Also it is a poor proppant carrier due to its low density and viscosity. As a result pure nitrogen gas fracturing is efficient in specific type of formations, less than 5000 feet.

Nitrogen Foam Fracturing

Nitrogen is mixed with water and other additives and is then cooled to form denser foam like liquid. The nitrogen content varies from 53-95% depending on the characteristic of the formation. It is a better proppant carrier and capable of fracturing at greater depths due to higher density and viscosity of the foam.

Nitrogen Energised Fracturing

It consists of a fluid containing less than 53% of nitrogen. The remaining fluid consists of water and small amount of chemical additives. It helps in increasing flow back and allows less water to remain trapped in the ground. It is used in fracturing at greater depths. It is not as water efficient as higher nitrogen content fluids, it is a vast improvement on standard hydro-fracturing.

Environmental and Production Advantages

Reducing the amount of water in the fracturing fluid also reduces the amount of chemical additives required. After the nitrogen foam or liquid nitrogen is used to fracture the formation, it is obtained on the surface in the form of gas which can be safely released into the atmosphere.

As nitrogen returns to gaseous phase after fracturing, it returns up the well bore instead of causing blockage.

Economic Hurdles

Nitrogen fracturing operation requires specialized equipment to transport and pump nitrogen gas under required high pressure and low temperature. These equipments require significant initial investment. [6]

C. Helium

Chimera Energy, a US based company uses "dry fracturing" or "exothermic extraction." This new extraction method does not use steam, LPG gel, natural gas or the pumping of anything hot into the well being used. The process uses only inert elements that are non-toxic and non-caustic. The well for this operation consists of a vertical section and a horizontal section.

Here, the horizontal well casing is perforated pneumatically that allows the extraction process to reach the target area surrounding the casing. The moveable pressure plugs are placed at optimum distance to segment the horizontal section and allow required pressure. It depends on the size of the casing in the well.

Helium is the 2nd most abundant element in the Universe and it is less water soluble than any other gas known. Under exothermic control, Helium will increase in volume 757 times in transitioning from a liquid to gaseous form. The helium in liquid state is used to create fractures. Helium's diffusion rate through solids extremely high, eliminating the need for solvents in the process.

The process is not disclosed by Chimera Energy but it is based upon the unique properties of helium.

Chimera Energy claims the process is compatible with any existing well in the world. [7]

D. Liquid CO_2 Fracturing

Without the presence of any other carrier fluid, the proppant is placed in the formation without causing damage of any kind.

The process is economic, rapid clean-up is possible.

The gas has low viscosity, high tubular friction is caused, pressurized blending equipments are required, technical costs are increased as compared to water jobs.

E. Methanol

In formation with severe liquid trapping problems, non aqueous methanol fluid may be an excellent solution

(Applications are found in Canada and Argentina).

The advantages are low surface tension (helps flow back even of the formation water), high formation compatibility, high vapour pressure.

The major concerns are safety issues related to low flash point of methanol, flammable nature (and flame invisibility), 25 -30 % higher technical costs respect a same size water base job.

F. Oil-based Fracturing Fluids

Historically, oil-based fluids have been widely used in hydraulic fracturing. Lately, compared to water, those fluids are considered more expensive to use and operationally difficult to handle. Therefore, they are now used mainly in formations that are known to be extremely water-sensitive.

A single fracturing job on an average uses 130,000 gallons of diesel.

The major technologies under waterless fracturing used today are the fracturing through propane or CO_2 gas.[8]

IV. COMPARISON WITH OTHER ALTERNATIVES

India has the potential for producing shale gas but needs to overcome many challenges so that the private companies can take part in shale gas exploration smoothly.

The liberalization in government policies will encourage the same.

The use of waterless fracturing techniques for shale gas exploration can solve the major issues of water in India. The use of liquid propane gas and liquid nitrogen are considered to be feasible alternatives.

The technologies like algae based bio fuel, jatropha based bio fuel require considerable amount of land and water. They are still under development so as to give that much yield to be commercialized. The development of algae specie used as a fuel requires proper nurturing under specific physical conditions. On the other hand, the yield of shale gas can be estimated; once the production capabilities of each well are known. While shale gas being a type of natural gas can be utilized with the same technology. Shale gas proves to be more economic as compared to these fuels in long run.

The major problem with the renewable sources like the solar energy, wind energy, tidal energy, wave energy, etc.... depends on the climatic conditions of each part of the country. They are converted to electrical energy directly or indirectly (through conversion to mechanical energy) and then can be used.

The main problem in harnessing the solar energy is that the conversion to electricity from the photovoltaic cells is very low. The production of energy through wind depends on the climate of the particular region. It requires a large amount of land. The major issue is impact on wildlife.

V. CONCLUSION

The shale reserves are limited and can serve India for only 33 years from now. But it can prove to be very useful as an immediate fuel source for today. Meanwhile, very promising technologies for bio fuels can be produced, experimented and commercialized in India.

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