

# Cold Heavy Oil Production with Sand – Amplification in Unconventional Resources

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## ABSTRACT

Albeit the unconventional resources involve many problems in exploration and production; these are gaining huge momentum since the huge demands of oil and gas are not gratified by the conventional sources. **Heavy crude oil**, being one of the unconventional sources, is the oil that is highly viscous, and cannot easily flow to production wells under normal reservoir conditions.

Many techniques are used for extracting heavy oil with **Cold heavy oil production with sand (CHOPS)** being one of them. CHOPS is a technique for extracting difficult heavy crude oil (having API gravity < 20) where sand is used as a means for enhancing the productivity of the oil well. CHOPS was developed in the 20<sup>th</sup> century when it was discovered by small local operators that sand producing wells produced better and was promoted since it was economical compared to other methods. This method is being successfully used in vertical or deviated wells in few parts of the world.

Through this paper, we will study the CHOPS method, where it has been used and how this could be used and promoted in India. Also, along with it, the limitation of CHOPS in horizontal wells will be discussed and the possible method which can be used to resolve it will be brought up. With some major heavy oil discoveries in India, this will provide a means to extricate oil with profitable recoveries, responding up to an extent to India's oil demand.

**Keywords:** Heavy Crude oil, CHOPS, Sand, Unconventional sources, Horizontal wells.

## INTRODUCTION

With the conventional oil production declining, more and more efforts are being put up in the unconventional sector to fulfill the demands. The conventional oil has tentatively reached its peak in the last decade though still have not declined completely. All industry experts, researchers are working on the convoluted exploration and production of the unconventional resources which involves tar sands, shale gas, coal bed methane, heavy oil etc so as to avoid any significant decline in oil production when conventional resources disappear. This paper studies about the Heavy Oil production, specifically focusing on Cold Heavy Oil Production with Sand (CHOPS) used for the same.

Heavy oil is the crude oil having API gravity  $10^{\circ} - 22.3^{\circ}$ , Viscosity 100-1000 centipoises and specific gravity 0.92. More than two-third of the world's total oil reserves are heavy oil and bitumen. The main

challenge which heavy oil production holds is its low flow capacity, making its high resource base unworthy by producing much lower amount of oil than is typically produced from a reservoir.

There are a numerous number of methods which are being used to increase the productivity from heavy oil reservoir. Some of them are VAPEX (Vapor Assisted Petroleum Extraction), SAGD (Steam Assisted Gravity Drainage), THAI (Toe to Heel Air Injection) and CHOPS (Cold Heavy Oil Production with Sand). VAPEX is a non-thermal recovery method that involves injecting vaporized solvents into heavy oil creating a vapor chamber for oil to flow. SAGD is a thermal in situ recovery method that involves drilling two horizontal wells, one above the other through which steam is continuously injected softening bitumen so that it drains into the lower wellbore and is pumped to the surface. THAI involves in-situ combustion but with horizontal wells so that the combustion products and heated hydrocarbons flow almost immediately downward into the horizontal production well. CHOPS involve the deliberate initiation of sand influx during the completion procedure increasing the permeability of the reservoir allowing heavy oil to flow.

Now, let's discuss about CHOPS in detail initiating with the method involved. Then, moving forward to its development history and listing various oil fields where it has been used with success. After which, its use and promotion in India will be discussed and finally concluding with its limitation.

## **CHOPS EVOLUTION AND PROCESS:**

First heavy-oil belt was discovered in 1920's in the Lloydminster area of Canada. Formerly, this heavy oil containing high asphaltene content was used as a feedstock for asphalt products and was extracted using pump jacks and small perforations. Expensive gravel packs, slotted liners and screens were used in the unconsolidated sandstone reservoirs with open hole completion in order to avoid the migration of formation sands into the tubing or surface casing. Experimentally, it was discovered that wells that continued to produce sand tended to extract more heavy oil as compared to those with screeners. The production increased by about ten times and the extra sand produced was used for laying the roads.

Till the 1970's heavy oil didn't get much importance due to low oil prices and heavy processing that it required for ultimately producing light oil. However, with an increase in oil prices during 1980's and the emergence of progressing cavity (PC) pumps heavy oil production gained its momentum. PC pumps is based on the principle that as its rotor rotates there is advancement of the fluid through the cavities making flow of fluid proportional to the rotation of the discrete cavities. With developments in the quality of PC pumps and more cost- effectiveness has led to more interest in the CHOPS method.

### **The production variations in a CHOPS well with time:**

- Initially, sand production rate is high in turn enhancing the oil production rates.
- With time (several months) the sand influx rates decline and oil production increases tremendously.
- These oil production rates decline as reservoir impairments begin to govern. Throughout this time GOR values remains consistent (quintessential of a conventional oil well).
- During the later stages when large amounts of sand has been produced, gas cap begin to develop in the well bore increasing the GOR values.
- Now due to higher permeability and long channels water influx becomes prominent.
- Sometimes sudden halt of sand production leads to no oil production indicating perforation blockage or sand compaction in the well bore which require workover process.

### **Different forces responsible for sand influx:**

- Gravitational forces from overlying strata causing development of vertical stresses. This helps to yield and expand sand
- Natural formation pressure which suspends sand in heavy oil.
- Foamy oil flow phenomenon which help in maintaining pressure and flow rate. The gas bubbles expand which leads to advancement of heavy oil towards the well bore.

Preliminary operation required to initiate sand influx include creation of large diameter perforations (>20 mm) and placement of progressive cavity pumps in the inlet below the lowest perforation.

### **Mechanisms involved in flow:**

There are basically reasons which are responsible for the amplification in fluid flow in this method –

- The fluid mobility increases due to sand influx as the Darcy velocity increases. This increase is due to the fact that a mobile medium leads to the increase in the fluid velocity ( $v_f$ ) as then differential velocity ( $v_d$ ) is calculated. In case of an immobile medium Darcy velocity is calculated with respect to a fixed frame of reference and hence is comparatively low.

$$V_d = V_f - V_m \quad (\text{in case of mobile medium})$$

This effect is valid only until there is huge sand influx in the early stages. With time as sand influx decreases, the importance of this effect diminishes.

- As sand comes out of the well there is a formation of a magnified zone of permeability. The space created is in the form of channels (wormhole) which is either empty or contains a slurry of sand, oil, water and gas.
- As the well pressure decreases, exsolution of the gases present in the oil takes place. This leads to formation of bubbles and hence foamy oil is developed in the well. These bubbles form an internal force for the fluids to flow. Since these bubbles do not coalesce there is no process by which gas pressures decrease. Hence. There is maintenance of GOR value.
- There are a number of reasons which leads to blockage of the pores in a well causing impairment. Firstly, Heavy oil consists of asphaltenes, semi- solid materials which tend to aggregate in low pressures causing pore blockage. Secondly, the fine grained sediment in the reservoir rocks may move due to viscous force drag or due to high pressure gradient again leading to blockage of pore throats. Lastly, the formation waters containing mineral species may also precipitate at the pores. But, in this method due to continuous movement of sand these blockages are eliminated and hence, there is less likely chance of well impairment leading to continuous productivity.

## **POPULARITY OF CHOPS**

Chops has been used in extraction of heavy oil in various reserves of the world and have been a successful method.

It has been widely used in the Canadian heavy oil belt with high production rate.

- Luseland oil field
- Faja del Orinoco
- Lindbergh oil field

- Plover lake field
- Cactus Lake field
- Peace river oil sands

It has been used in China during late 1990's. It has got success in the

- Nanyang oilfield, Hebei
- Liaohe oil field , Liaoning Province
- Jilin oil field

This method is also accepted in the Venezuela heavy oil reserves.

## **CHOPS IN INDIA?**

India has huge demands for oil and the current production rates have not been able to fulfill the same. Furthermore, with conventional oil not fulfilling the demands it is necessary to move to the unconventional oil. With some major heavy oil discoveries in India, we need to give importance to this resource implement recovery methods with good productivity rates for exploiting it.

There have been several heavy oil discoveries in India with the major discoveries being in Rajasthan. The heavy oil discoveries include:

- 130 million tonnes of 'heavy oil deposits' at Baghawala sandy desert area in Rajasthan's Barmer district by OIL.<sup>1</sup>
- North Kadi field of Western Onshore Basin by ONGC.<sup>2</sup>
- Heavy oil reserves in an oil well in the Nachna area, Jaisalmer. (Again by OIL)<sup>3</sup>

### **Why should CHOPS be used in India?**

CHOPS is a primary method of production with high success rates. In-situ thermal combustion has not been successful in Indian wells due to lack of technology creating a need for primary methods. Moreover, CHOPS does not require much technological advancements in which India lacks till date and also is an economical method as it rules out the use of expensive slotted liners though requires workover strategies. Hence, it can be used and applied in heavy oil reserves so that oil resources of India are amplified meeting the demands.

## **LIMITATION**

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<sup>1</sup> "OIL finds heavy oil deposits in Rajasthan". *Business Standard* 4 Sep. 2009, Jaipur. Web.

<sup>2</sup> *News*. (2011, April 28). Retrieved 2014, from ONGC Videsh Ltd.: <http://www.ongcvidesh.com/NewsContent.aspx?ID=868&AspxAutoDetectCookieSupport=1>

<sup>3</sup> "OIL India finds new oil reserves in Nachna Area". *The Times of India* 6 Dec. 2012, Jaipur. Web.

CHOPS method has proved to be of huge success in vertical wells. Though in case of horizontal wells, this method has not been fortunate as wells tended to get plugged during production. A possible reason for this plugging is that due to slow velocity and difference in elevation, there is a tendency that sand settles at the sub region of the well ultimately plugging it. One of the highlighted limitation of CHOPS method is that it requires frequent clean outs which increases the cost of production making it uneconomical. However, there are many studies that have been working in order to combat this limitation.

SAND ON DEMAND (Brigida Meza-Diaz, 2013) is the strategy proposed in horizontal wells for high production rates by this method. According to this rather than aggressively producing sand, a controlled sand production would prove efficient. A controlled production was possible to achieve is certain parameters were controlled. Various parameters and their effect on the plugging of wells are analyzed in these studies. The attributes examined include slot size, confining stress, fluid velocity and sand grain distribution. Observations are briefed below:

- A critical pressure gradient is required for initiation and maintaining of the sand influx. This gradient depends on the pressure gradient of the slot. Hence, slot size is important for sand production. A well sorted sand required low pressure gradient as compared to a poorly sorted grain and henceforth sand influx was not achieved in poorly sorted sand.
- For well sorted sand, the variations in flow rate did not affect the sand production. For poorly sorted sand, larger slot sizes were required for continuous production. In case of smaller slot sizes, the flow rate had to be low in the initial stages and then incremented in order to maintain this flow.
- A higher confining stress was required in poorly sorted sands as compared to the well sorted sands.
- A wide sand grain distribution promotes the formation of arches and also promotes sand bridging.

A managed sand production could be achieved by proper selection of the various parameters involved and this was also able to create high permeability zones. Hence, a managed production reduced the chances of well plugging at the same time producing high amounts of oil.

## CONCLUSION

CHOPS is a simple yet effective way of producing heavy oil with higher recovery.

This method despite of success and low economic costs has not been adopted permanently in many areas.

- This lack of receipt is due to the fear that the sand may block the well bores which actually does not happen. But it leads to cleaning of the blocked pores.
- Also, the lack of technology in the refining industry for upgradation of the heavy oil is also a barrier in its success. Though with time, as technology is improving this barrier is slowly diminishing.
- Another reason for its denial is the huge amounts of sand produced. These sands were earlier used for laying roads but with roads becoming thicker it is not recommended by the government. A solution to this problem is the pumping of sand with the heavy oil in the salt caverns below the reservoir known as the Super sump. With natural settling the oil comes to the top and is then extracted leaving sand behind in the caverns.

These problems are now negligible due to advancement in ideas and technology with time. Hence, can be used in the wells even which have been shut down (at low economic rates as compared to that required for new wells).

To gratify the increasing world demands of oil, this method can be one of the means for the same and being an easy and less expensive one could be economical with today's oil rates.

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