Cold Production in Western Canada: A Step Forward in Primary Recovery

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Canadian Heavy Oil and Bitumen Production

Canada’s heavy oil and bitumen resources are extensive. They are located in the northern portion of the Western Canadian Sedimentary Basin (WCSB). The WCSB contains an estimated 1.7 trillion bbl of bitumen in place, primarily in three deposits — Athabasca, Cold Lake and Peace River. Canada’s current production of bitumen exceeds 1.2 million bbl/d. The choice of technology for recovering bitumen is delineated by the depth of the sand. For deposits less than 50 m from the surface, open pit mining operations are used to recover the oil sands and then the bitumen is recovered from the mined sand; for deeper deposits, in situ recovery technologies that reduce oil viscosity and enable oil to flow must be used. Steam-assisted gravity drainage (SAGD) is in an early commercial phase of implementation. Other in situ recovery technologies are at an early pilot stage or laboratory stage. Approximately 60% of Canada’s bitumen production is from surface mining operations, although it is estimated that less than 10% of Canada’s bitumen resource is recoverable by surface mining.

A number of methods are used to recover Canada’s heavy oil, including conventional primary production, water flooding, unconventional primary production (cold production) and to a lesser degree, various thermal in situ recovery techniques similar to those used for deeper bitumen resources. Cold production is a recovery technique

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For the Lloydminster block in which a substantial quantity of sand is produced deliberately along with oil, water and gas. Cold production has become the recovery technology of choice for most heavy oil fields in the Lloydminster block, accounting for nearly half of western Canadian heavy oil production.

Heavy Oil
Production of heavy oil in western Canada dates back to at least the 1940s in the Lloydminster block. Initially, primary production methods were used. Primary production continues to be an important form of recovery for the shallow, thin regional sands that predominantly characterize the heavy oil resource in the WCSB. Water flooding is another conventional recovery technology that continues to be employed successfully for heavy oil production in western Canada. An unconventional form of primary production, involving the co-production of sand, has been developed in the Lloydminster block as a commercial recovery technology. Over the past fifteen years this technology, known locally as cold production, has emerged as the dominant heavy oil production method in the WCSB. Thermal recovery technologies have been tested to a limited extent in some of the thicker channel sands that are interspersed among the thin regional sands. These technologies include steam flooding and CSS, in situ combustion, and SAGD. While a combination of steam flooding and gravity drainage has proved successful in some locations (e.g. Pikes Peak), and SAGD has been operated successfully in others, thermal recovery methods remain only of marginal importance for the heavy oil resources in the WCSB due to the relative scarcity of sufficiently thick sands in which to employ them.
Cold production is an unconventional primary recovery process in which sand is produced deliberately along with oil, water and gas. It is implemented in vertical, slant, or deviated wells with a progressive cavity (PC) pump. Production rates are improved substantially over conventional primary production, by as much as a factor of ten. Recovery factors tend to be higher as well, typically in the range of 8-15% OOIP. Cold production has become the recovery technology of choice for most heavy oil fields in the Lloydminster block. It currently accounts for nearly half of western Canadian heavy oil production, at approximately 230,000 bbl/d.

There is considerable evidence to indicate that sand production causes long channels of increased permeability.
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**Холодная добыча**

Холодная добыча представляет собой нетрадиционный способ первичной добычи, при котором песок специально извлекают вместе с нефтью, водой и газом. Он реализуется в вертикальных, наклонных или наклонно-направленных скважинах с применением винтового насоса кавитационного типа. Темп добычи существенно улучшается по сравнению с традиционным способом первичной разработки не менее чем на порядок. Коэффициенты отдачи также зачастую выше, обычно в диапазоне 8—15 % от первоначальных геологических запасов. Холодная добыча стала лучшим выбором для разработки нефтяных месторождений с наиболее высокой вязкостью на участке в Ллойдминстере. С ее помощью добывается почти половина вязкой нефти в западной Канаде — порядка 230 000 баррелей в день.

Существует большое количество данных, указывающих на то, что при добыче песка образуются длинные каналы с увеличенной проницаемостью («червоточины»), которые разрастаются из скважины внутрь нефтеносного пласта на расстоянии от 200 м и более. Основным свойством данного способа является образование и закачивание в червоточины вспененной нефти, по мере того как они разрастаются внутрь (wormholes) to grow out from the well into the reservoir, for distances of 200 m or more. A central feature of the process is the formation and flow of foamy oil into wormholes, as they grow into the reservoir. The wormholes provide improved access to the reservoir. Among the advantages of cold production is its success in very thin sands, for zones with a net pay as low as 2m.

The development of cold production as a successful commercial heavy oil recovery technology in the WCSB has been field-driven from the outset. Field experience has lead to an optimal operating strategy for a wide variety of field conditions: a fairly rapid initial draw down (over a period of several weeks to a few months) followed by maintenance of very low bottom hole pressures (preferably less than 5 joints of fluid).

Since the cold production process depends on the continuous transport of sand along the entire length of a wormhole, from its tip to the well bore, it should not be surprising that cold production wells are not long-lived. Some last for 8-10 years or more, but many do not live nearly that long. The principal cause of failure is watering out (very high water cut) generated by water influx. Once water has infiltrated a wormhole network, it can be transported rapidly to the associated well and subsequently
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to interconnected offset wells. A secondary cause of failure is lack of inflow, likely caused by a blockage near the well or farther out in the wormhole network and/or by a lack of drive. Efforts are continuing to develop technologies for the remediation and stimulation of cold production wells, but successful results have been few and far between.

International Adoption of Cold Production

Although cold production was established as a successful commercial technology for heavy oil recovery in western Canada, it did not start there. Deliberate and aggressive sand production was practised in California heavy oil reservoirs (e.g. Midway, Sunset, Cat Canyon) prior to the First World War. Pays were generally much thicker than in Canadian reservoirs, in the 30-100 m range. Even without PC pump technology, individual wells reportedly produced several thousand cubic metres of sand over a 40-year life.

Producers whose assets include thin heavy oil reservoirs elsewhere in the world are viewing the success of cold
production in the WCSB with interest. The key reservoir conditions that appear to be necessary for the cold production process to succeed in western Canadian reservoirs include: unconsolidated, clean sands (very low fines content); a minimum oil viscosity; mobile oil; and, a minimum initial gas-oil ratio (GOR). These conditions may also be found in reservoirs outside of Canada (e.g. in Alaska, Albania, California, Colombia, Kazakhstan, Kuwait, Oman, Russia, Venezuela). Currently, few of these reservoirs are being exploited commercially through cold production. In order to accelerate the screening of prospective international reservoirs for cold production, a technical examination of the feasibility of the process would likely need to be undertaken on a case-by-case basis, in combination with field trials.