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Produced Water from Production Oil and Gas

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Abstract: In the process of producing oil, natural gas and coal bed methane there are large quantities of water that are found in the same underground formations (reservoir). The quantity of this water generated each year is so large that it represents a significant component in the cost of producing oil and gas. In this study we discuss produced water as part from the process of producing oil and gas and we intend to covers many aspects of produced water to develop future research programs as well as the chemical and physical characteristics of produced water and its potential impacts on the environment. Produced water properties and its volume are vary throughout the lifetime of the reservoir, while salt content (salinity, conductivity, or total dissolved solids TDS) is also a primary constituent of concern in onshore operations. In addition, produced water contains many organic and inorganic compounds that must be taken into consideration. Some of these contents are naturally occurring in the produced water while others are related to chemicals that have been added for well control purposes. The paper also discusses numerous options for managing produced water. The options are minimize the amount of produced water that reaches the surface, those that reuse and recycle produce water and those that involve disposal of produced water. The options (reuse and recycle) includes underground injection to stimulate additional oil production, use for irrigation, livestock or wildlife watering and habitat and various industrial uses such as dust control, vehicle washing, power plant makeup water and fire control. Finally the produced water management costs have been illustrated.

Key words: Water · Oil · Gas

INTRODUCTION

What Is Produced Water?: In subsurface formations, naturally occurring rocks are generally permeated with fluids such as water, oil, or gas (or some combination of these fluids). It is believed that the rock in most oil-bearing formations was completely saturated with water prior to the invasion and trapping of petroleum [1]. This water is frequently referred to as "connate water" or "formation water" and becomes produced water when the reservoir is produced, produced water, dissolved or suspended solids, produced solids such as sand or silt. Also production of coal bed methane (CBM) involves removal of formation water so that the natural gas in the coal seams can migrate to the collection wells. This formation water is also referred to as produced water. It shares some of the same properties as produced water from oil or conventional gas production, but may be quite different in composition.

Produced Water Characteristics: Understanding a produced water's characteristics can help operators increase production. For example, parameters such as total dissolved solids (TDS) can help define pay zones [2] when coupled with resistivity measurements. Also, by knowing a produced water's constituents, producers can determine the proper application of scale inhibitors and well-treatment chemicals as well reservoir problem areas. Salt content (expressed as salinity, conductivity, or TDS) is a primary constituent of concern in onshore operations. In addition, produced water contains many organic and inorganic compounds. These vary greatly from location to location and even over time in the same well.

Produced Water from Oil and Gas Production: Produced water is separated from gas during the production process. In addition to formation water, produced water from gas operations also includes condensed water. Produced waters from gas production have higher

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Table 1: Comparisons between produced water from oil and gas production

Parameters	Produced waters discharged from oil platforms	Produced waters discharged from gas/condensate platforms
Toxic	1	10
Volume of produced waters	High (6-10 bbl)	Low
Content		Produced waters from gas production have higher contents of low molecular-weight aromatic hydrocarbons such as benzene, toluene, ethyl benzene and xylene (BTEX) than those from oil operations; hence they are relatively more toxic than produced waters from oil production.
pH	pH levels of 6-7.7	About (3.5-5.5).
Chloride concentrations range	12 to 100 g/L	less than 1 to 189 g/L
Total impact	High	Low

contents of low molecular-weight aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylene than those from oil operations comparisons between produced water from oil and gas production are shows in Table (1).

Produced Water from Coal Bed Methane (Cbm) Production: CBM produced waters differ from conventional oil and gas produced waters in the way they are generated, their composition and their potential impact on receiving environments. Beneath the earth's surface, methane is adsorbed onto the crystal surfaces of coal due to the hydrostatic pressure of the water contained in the coal beds. For the methane to be removed from the crystalline structure of the coal, the hydrostatic head, or reservoir pressure, in the coal seam must be reduced. CBM produced water is generated when the water that permeates the coal beds that contain the methane is removed. In contrast to conventional oil and gas production, the produced water from a CBM well comes in large volumes in the early stages of production; as the amount of water in the coal decreases, the amount of methane production increases. CBM produced water is reinjected or treated and discharged to the surface.

The quality of CBM produced water varies with the original depositional environment, depth of burial and coal [3] and it varies significantly across production areas. As CBM production increases and more water is produced.

Produced Water Management Options: There are many approaches to managing produced water; some of these are discussed in this study. The most appropriate option for a given location will be a function of several factors, including site location, regulatory acceptance, technical feasibility, cost and availability of infrastructure and equipment. The primary alternatives being used today are underground injection, discharge and beneficial reuse. Water management technologies and strategies are in terms of a three tiered waste management or pollution prevention hierarchy [4]. In the first tier (water minimization), processes are modified, technologies are adapted. The second tier is reused water or recycled. Some water cannot be recycled or reused and must be disposed of by injection or discharge.

Water Minimization Options
Options for Keeping Water from the Wells:

- Mechanical Blocking Devices
- Water Shut-Off Chemicals

Options for Keeping Water from Getting to the Surface: Lifting water to the surface represents a substantial expense for operators. The process of lifting and managing the water at the surface puts the water in a location where it can harm the land surface and surface or ground water resources. A variety of technologies have been developed that attempt to manage water either in the well bore itself or at a remote location like the sea floor. These technologies do minimize the volume of water that comes to the surface.

- Dual Completion Wells
- Downhole Oil/Water Separators
- Downhole Gas/Water Separators
- Subsea Separation

Water Recycle and Reuse Options: In many cases, produced water can be put to other uses. Sometimes the water can be used without treatment, particularly when the produced water is very clean to start with (e.g., many samples of CBM water) or the end use does not require high water quality (e.g., some water flood projects). In many other cases, the water must be treated before it can be reused. The cost of treating the water to meet an end use is an important factor in determining the types of reuse options that will be considered. This section describes a variety of approaches to recycling and reusing produced water. A recent report that focuses on beneficial reuse of CBM produced water [5] provides more detail on many of the options described as.

Underground Injection for Increasing Oil Recovery: The most commonly used approach for managing onshore produced water is reinjection into an underground formation. Although some produced water is injected solely for disposal, most produced water (71%) is injected to maintain reservoir pressure and to hydraulically drive oil toward a producing well. This practice is referred to as water flooding, or if the water is heated to make steam, as steam flooding. When used to improve oil recovery, produced water ceases being a waste and becomes a resource. Without that produced water to use, operators would need to use other surface or groundwater supplies as sources of water for the water or steam flood. Typically, for water flooding, sufficient produced water volumes may not be available for injection. In these instances, other sources of water must be used to supplement the water flooding operation. Historically, freshwater sources have been used for this purpose.

Injection for Future Use: Some types of produced water are relatively fresh and can be used directly with little or no treatment. This is particularly true for produced water from some CBM fields. This water may be used immediately for beneficial reuse or it can be injected into an aquifer where it can be recovered for later use. This process is known as aquifer storage and recovery (ASR). Brost (2002) describes an operation in the Kern River field of California in which a blend of produced water and treated groundwater is filtered then sent to the local water district for use in both irrigation and aquifer recharge.

Use by Animals: Some produced water is clean enough to be used directly or after some degree of treatment by animals (i.e., livestock or wildlife) as a source of drinking water or, in the case of fish and waterfowl, as habitat. This section describes several possible alternatives for beneficial reuse for animals.

Livestock Watering: Livestock can tolerate a range of contaminants in their drinking water. At some concentrations, the animals, although still able to survive, will begin to show someimpairment. [5] provides a table showing the total dissolved solids (TDS) levelsthat are appropriate for livestock watering. In general, animals can often tolerate a higherdegree of TDS if they are gradually acclimated to the elevated levels. Water with TDSless than 1,000 ppm is considered to be an excellent source water. Water with TDS from1,000 up to 7,000 ppm can be used for livestock but may cause some diarrhea [5].

Wildlife Watering and Habitat: Some Rocky Mountain area CBM projects have created impoundments that collect andretain large volumes of produced water. In some cases, these may have surface areas ofat least several acres. These impoundments provide a source of drinking water forwildlife and offer habitat for fish and waterfowl in an otherwise arid environment. It isimportant to make sure that the quality of the impounded water will not create healthproblems for the wildlife. The impoundments can also provide additional recreational opportunities for hunting, fishing, boating and bird watching.

Irrigation of Crops: Crop irrigation is the largest single use of freshwater in the world, making up 39% of all freshwater withdrawn, If produced water has low enough TDS and other characteristics, it can be a valuable resource for crop irrigation.

Examples of Use of Produced Water for Irrigation: Wyoming: [5] provides two case examples from Wyoming of irrigation usingCBM water. The first project was conducted by Fidelity Exploration and Production.

They irrigated livestock forage using pure CBM water on some plots and CBM waterblended with surface water on other plots. Both pure and blended irrigation water createdadequate crop production. When pure CBM water was used, it needed to be applied at ahigher rate because the plants could not utilize it as efficiently as the surface water.

The second project was conducted by Williams, a CBM producer. Large lands were irrigated areas that previously had supported only the local drought-tolerant vegetation. Following irrigation with CBM produced water, the land was able to support healthygrass crops to serve as feed for livestock.

Industrial Uses of Produced Water: In areas where traditional surface and groundwater resources are scarce, produced water may be substituted in various industrial practices as long as the quality of the produced water meets the needs of the industrial process with or without treatment. Produced water is already being used for several industrial uses and may be suitable for others. These are.

Dust Control: In most oil fields, the roads are unpaved and can create substantial dust. Some oiland gas regulatory agencies allow operators to spray produced water on dirt roads tocontrol the dust. This practice is generally controlled so that produced water is notapplied beyond the road boundaries or within buffer zones around stream crossings andnear buildings [7].

Vehicle and Equipment Washing: In Ref. [5] notes that some state and federal agencies recommend that vehicles andequipment leaving production sites be washed to control the possibility of distributingseeds of undesirable weed species.

Oil Field Use: In ref. [9] the authors describes a program in New Mexico through which produced water is treated to remove hydrogen sulfide and then is used in drilling operations. This beneficial reuse saves more than 4 million bbl per year of local groundwater.

Use for Power Generation: In at least one case, produced water is used to supply water to make steam. About 360,000 bpd of produced water from a ChevronTexaco facility in central California is softened and sent to a cogeneration plant as a source of boiler feed water [7].

Another potential use of produced water is cooling water. The electric power industry is the second largest user of freshwater in the United States, making up 38% of all freshwater withdrawn, or 150 billion gallons per day [9]. Conventional surface and ground water sources are no longer sufficient to meet increasing power plant needs in many parts of the country.. The researchers will evaluate the quality, quantity and location of the produced water. They will also evaluate the existing produced water collection, transportation and treatment systems for possible use in delivering cooling water to the generating station.

Fire Control: Fires often break out during the driest portions of the year and in areas experiencing drought conditions. In many cases, only limited surface and ground water resources are available for fire fighting in these areas. Although application of large volumes of saline produced water can have an impact on soils, this impact is far less devastating than a large fire. They reports that firefighters near Durango, Colorado [5], used CBM produced water impoundments as sources of water to fill air tankers (helicopters that spray water onto fires) during the summer of 2002.

Other Uses: When water is scarce, its value increases. In water-poor areas, it may be cost-effective to treat produced water for use in many applications. It is likely that the range of potential uses will be expanded in the future. This is clearly an area where additional research could be continues.

The Cost of Produced Water Management: This part discusses the components that contribute to water management costs, It is well understood that for conventional oil and gas production, the volume of water produced by a well and a field will increase over time and the volume of oil and gas produced will decline. At some time, the revenue from the oil and gas is not sufficient to cover the costs of operation (a growing portion of those costs will be water management) and the well will be shut in.

Components of Cost: Produced water management is generally expensive, regardless of the cost/barrel, because of the large volumes of water that must be lifted to the surface, separated from the petroleum product, treated (usually) and then injected or disposed of. The following list includes many of the components that can contribute to overall costs:

- Site preparation
- Pumping
- Electricity
- Treatment equipment
- Storage equipment
- Management of residuals removed or generated during treatment
- Piping
- Maintenance
- Chemicals
- In-house personnel and outside consultants
- Permitting
- Injection
- Monitoring and reporting
- Transportation
- Down time due to component failure or repair
- Clean up of spills
- Other long-term liability.

As an example of how a large, multinational company looks at cost, Shell's cost distribution is reported as [10], pumping (28%), deoiling (21%), lifting (17%), separation (15%), filtration (14%) and injecting (5%) see Fig. (1).

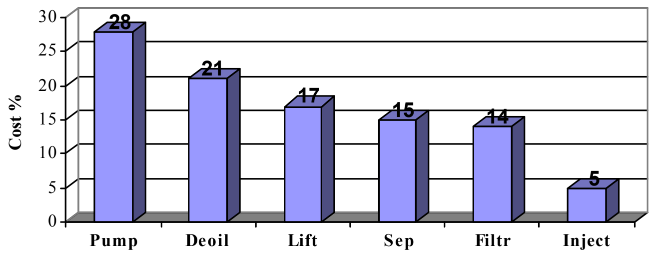

Fig. 1: Cost distribution

CONCLUSIONS

During production of oil, natural gas and coal bed methane there are large quantities of water that are found in the same underground formations (reservoir). The quantity of this water generated each year is so large that it represents a significant component in the cost of producing oil and gas. Produced water properties and its volume are vary throughout the lifetime of the reservoir, while salt content (salinity, conductivity, or total dissolved solids TDS) is also a primary constituent of concern in onshore operations. Some of these contents are naturally occurring in the produced water while others are related to chemicals that have been added for well control purposes. The paper also discusses numerous options for managing produced water. The options are minimize the amount of produced water that reaches the surface, those that reuse and recycle produce water and those that involve disposal of produced water. The options (reuse and recycle) includes underground injection to stimulate additional oil production, use for irrigation, livestock or wildlife watering and habitat and various industrial uses such as dust control, vehicle washing, power plant makeup water and fire control. Also the produced water management costs have been illustrated.

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