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Steam Actuated In-Situ Combustion - An Advancement in EOR

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SUMMARY

In-situ combustion (ISC) is used widely but with limited field success due to vast capital costs, operating expenses, flue gas emissions, water treatment and handling costs are associated with it. There is a need to optimize efficiency of recovery process by lowering air requirement, environmental impact, and costs of technique. As the principle recovery mechanisms for combination of steam and combustion processes are steam distillation, viscosity reduction and thermal expansion of oil. Therefore steam extracts lighter hydrocarbon fractions, so that the residue becomes heavier, mixing of distilled component with initial oil results in lighter produced oil. Thus the use of steam in combination with air reduces air requirement with low emission of flue gases during the process. Three important mechanism on which thermal recovery methods depends are thermal expansion, viscosity reduction and steam distillation. Combustion tube run experiments were carried out to obtain the information about the reservoir and to find the combustion parameters. Combination of ISC and steam flooding increases the life of project and at the same time minimizes emission of flue gases during process and thus improves recovery.

Introduction

In-situ combustion (ISC) and hot fluid injection are the two important process of Thermal Enhanced Oil Recovery (EOR). In ISC, air is injected into a heated section of the reservoir, when temperature reaches a threshold value then oxygen in the air reacts with oil to generate heat, flue gases and also cause cracking of hydrocarbon. ISC is used widely but with limited field success due to vast capital costs, operating expenses, flue gas emissions, water treatment and handling costs associated with it. There is a need to optimize efficiency of recovery process by lowering air requirement, environmental impact, and cost of technique.

Three important mechanism on which thermal EOR methods depends are thermal expansion, viscosity reduction and steam distillation. During dry ISC, huge amount of generated heat is left unused in the burnt region, while unused heat behind the combustion front can be recovered by the use of steam in combination with air in ISC process. The principle recovery mechanisms for combination of steam and combustion processes are steam distillation, viscosity reduction and thermal expansion of oil. Steam extracts lighter hydrocarbon fractions, so the residue becomes heavier, mixing of distilled component with initial oil results in lighter produced oil.

For oil production by combination of steam and combustion process, information about the relative importance of combustion and steam front is very useful. Therefore, Combustion tube run experiments were conducted to obtain the information about the reservoir and to find the combustion parameters. Combination of ISC and steam flooding increases the life of project and at the same time minimizes emission of flue gases during process and thus improves recovery.

Method/Theory

In literature, it has been seen that the growth of burn zone is directly proportional to amount of injected air; therefore maximum air injection rate indicates the minimum lifetime of the project. The effect of steam on both heavy and light oil has been studied and the use of steam drastically reduces oxygen consumption during low temperature oxidation (LTO), while increases the oxidation period during high temperature oxidation (HTO), and also decreases the production of carbon monoxide caused by coke combustion.

Experiments were conducted to study the air and steam injection process at reservoir condition. Experimental setup includes combustion tube, heating and data acquisition system, flow analysis and flow control system. Firstly, steam and air are injected in reservoir element and ignited, and the resulting elevated temperature front is tracked as it progresses through the tube. The produced gases are metered and their composition is determined, and produced liquids are captured, separated and analysed. All of this information is then gathered and a complete analysis of the laboratory burning behaviour was made.

Laboratory combustion tube experiment shows that steam in co-injection with air changes the combustion parameters like front velocity, quantity and quality of fuel, residual oil saturation, air requirement and ultimately the recovery of oil. Temperature profile shows that all zones are stable and combustion front is sustained and propagated. Analysis of produced gas, water and oil are carried out. Produce gas analysis shows complete combustion and no hydrocarbon gases are present and produce fluid analysis shows that the oil produce is lighter than the initial oil.

Figure 1 Front velocity at reference temperature 300°C.

Conclusion

- Steam distillation vaporizes lighter component below its boiling temperature and extracts it from original oil and residue becomes heavier.
- Steam distillation reduces the residual oil saturation and lowers atomic H/C ratio of crude oil.
- Steam increases the front velocity of the combustion front and O₂ consumption period during the HTO temperature range.
- Lower air requirement and minimum emission of hydrocarbon and flue gases.
- Use of steam in combination with air increase efficiency of ISC process and also increase the life of the project with least environmental impact.

References

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