KEM Innovation/Research Question (max. 4 pages + annex)

TITLE Qualitative risk assessment of long term behavior of a) conventional sealing materials used in well construction, and b) the interfaces of these materials with each other and with the formations.

Objective

Enable justified decisions on matters where the safety of old or abandoned wells may have an impact. Currently the long-term behavior of cement and steel is reasonably understood. But how do the interfaces of cement and formations, or cement and casing behave? How do formations behave over uncemented sections?

In the Netherlands over 1300 onshore wells have been abandoned and in the coming years this number will increase significantly, as will the number of abandoned wells offshore. The sites above these wells will increasingly being used or earmarked for urban development. This raises the need to determine the risks associated with these sites.

The older wells in the Netherlands were constructed from the 1940`s onwards and were built and abandoned using traditional steel casing and oilfield cements. The oldest abandoned wells are now nearly 80 years old. While industry assumes that the sealing capability of the casing, cement, and rock formation will not change over time, this assumption is not well founded.

In some cases, leak paths were introduced during the construction or production phase; if not addressed during the abandonment phase, these may still exist in the abandoned well as micro-annuli. It is not well understood if these micro-annuli remain open, become larger, or close over time due to rock formation movement and/or mineral or petroleum deposits.

This research question attempts to address this issue. Specifically, the project is aimed at obtaining a better understanding of the long-term behaviour and interaction of cement, steel, and rock in abandoned oil and gas wells, and how this influences the integrity of the abandoned well.

State of the art, background

Well abandonment in the Netherlands is regulated through the mining law and regulations. In addition, there are the NOGEPA industry standards 45. These standards have been updated in 2018 and are linked to the newly updated regulations which have come in force in 2019. These standards are based on the current best practices of 'cap-rock restauration', where cement plugs are set over the cap rock interval to seal off the reservoirs below.

Most of the current abandonment methods assume integrity and impermeability of cement. Some new materials are being tested or used, such as bentonite, bismuth. Casing strings are often part of the seal plug. Currently it is thought that the most robust plug is cement wall-to-wall without casing strings over the cap-rock interval.

SPE has organized a workshop on improving the abandonment techniques on 18-22 March 2019 (WPAE Forum, Crown Plaza, The Hague) with some of the key people in well abandonment technology worldwide.

Research Question

The main part of the proposed research will be an extensive literature review to determine previously-obtained knowledge and understanding of this problem. Specific questions to be investigated include the long-term stability of oilfield cement, the effect of corrosion of the steel casing, and the long-term behaviour of the micro-anulus.

1. First stage is a literature study of public studies on long term behavior of cement and cemented casing. Presumably a lot of information will be available within companies such as Schlumberger, BHI and Halliburton. This stage will result in an answer to the question: which are the risk critical elements and parameters determining the long-term sealing capacity of boreholes and can they qualitatively or quantitatively be assessed?

   Second stage could involve detailed studies on:

2. Cement is known to have low permeability; how permeable for the fluids that concern us (gas, oil, water)? How does the permeability of oilfield cement change over a long period of time (e.g. 100 to 500 years) and how does the change affect its sealing effectiveness?
3. How well is steel casing, surrounded by cement, protected against corrosion? How is the corrosion rate affected by the change in permeability of the cement? Will the encased casing corrode in the long term? Can a corroded casing become a leak path?

4. The ‘micro annulus’ could be a conduct for fluids. What is the long-term behavior of the micro annulus? Will it be squeezed tight, or can it erode through flowing liquids? Can it be filled with petroleum or mineral deposits?
5. Is there a micro annulus between cement and formation? How does filter-cake behave, is it permeable?
6. How do plastic formations such as rock-salt and claystone or shale behave around a cemented or uncemented casing, and can they form an effective seal?

It is not foreseen that lengthy laboratory studies are required to come to conclusions on the above. Literature studies on documented effects seen in wells around the world or from laboratory studies carried out by companies or research bodies may be able to answer most of the questions.

Deliverables expected

An inventory of studies and research related to these issues

An analysis of the risk that micro-annuli pose over longer term

An analysis of the risk of cement or casing degradation to the point of failure of the barrier

Timeline

For the first stage draft report expected around March 2021, six months after award. Also, an indication if the below timeframe required to answer the second stage questions is achievable.

The report with results for the second stage is expected September 2021.

Expected use

Contribution to a risk instrument: To help assess the risks of leakage from abandoned wells due to cement degradation in the long term, to help identify any additional mitigation measures, and to help with proper planning by local government / town councils for the future land use above abandoned wells in the Netherlands. It might be used to refine drilling guidelines and inspection

Expertise and tools preferred for the team

Understanding of well construction and well integrity.

Understanding of material behaviour

Cementing expertise

Geological expertise

Quality assurance, Organisational and communication requirements

Regular progress meetings. Scientific review.

References

To be added.