CHEMICAL ECONOMICS

UNDERGROUND COAL GASIFICATION - THE BEST THING SINCE SLICED BREAD?

Many major chemical processes require the production of synthesis gas (a mixture of carbon monoxide and hydrogen) from coal or natural gas. The synthesis gas is then converted into hydrogen, ammonia synthesis gas, methanol or high quality fuels and chemicals by the Fischer-Tropsch process. Synthesis gas can also be used to generate electricity in a gas turbine as for instance in the Integrated Coal Gasification Combined Cycle (IGCC) route to potentially carbon free power production. In these processes synthesis gas production is the principal unit operation of highest capital cost. So what if a route could be developed that substantially eliminated the capital cost of synthesis gas production. The best thing since sliced bread? This is the main driver behind Underground Coal Gasification (UCG) technology.

The earliest suggestion that the gasification of coal could be conducted underground appears to be by C.W. Siemens in an address to the Chemical Society of London in 1868. Independently in Russia, Mendeleev was encouraged by observations on underground mine fires in the Urals and started to develop detailed designed for UCG which was published throughout the 1880s and 1890s. In 1910, a patent was granted to Anson Betts for a method of utilising unmined coal which describes the basis for many of the future developments. Betts ideas where verified in trials in several parts of the world.

In the early part of the 20TH century, most industrial cities where polluted by the mass burning of coal. This led to the suggestion by William Ramsey in 1912 that the pollution could be eliminated if the coal was gasified underground and piped to the surface. Ramsey's suggestion was widely reported and spurred interest in UCG trials in America and Britain. Ramsey became credited with inventing the concept.

Lenin (then in exile) wrote an article in praise of Ramsey's "invention" noting that the fate of mineworkers would be different under communism. And what Lenin said had to be proved correct and so it was that the USSR made major attempts to bring UCG to fruition. Unfortunately UCG theory proved difficult to reduce to practice and there was very little success with only one operation remaining at Angren in Uzbekistan.

The general layout of the process is shown in Figure 1. The prime targets are deep coal seems typically deeper than 500m. This coal could be contaminated with salt or be steeply dipping seams which makes them poor targets for conventional mining. However, these seams are often targets for coal seam gas (CSG) recovery and hence a potential source of conflict of interest with CSG developers.

Two wells are drilled into the seam at a distance apart. These wells are connected by natural fractures (cleats) in the coal. Air or oxygen is sent down one of the wells and combustion initiated at the base of the well. The burning process follows these cleats with the coal burning out forming a cigar shaped cavern towards the second well from which the combustion gases are removed. The process progresses until all of the coal is consumed. Unlike conventional underground mining operation the UCG process can theoretically remove all of the coal present, this further makes the process attractive.

During the 1980s, following the oil shocks of the 1970s, the US Department of Energy funded a major series of trials of UCG in the US. This work program resulted in confirming many of the USSR results and defined the boundaries of the technology. Some of the more important issues identified were:

- The coal measure has to be very deep. Burning coal generates a cavity and collapse of the roof can cause subsidence which travels to the surface. This can also lead to escape of toxic gases through the strata to the surface.
- Partial combustion produces toxic materials which remain in the cavity (phenols, aromatics etc.). Many of these materials are water soluble and will contaminate the local aquifers. Not only should the UCG combustion cell be isolated from usable (near surface) aquifers, preferably by the presence of impervious layers, but the nature and flow rate of the aquifers around the cell (immediately above and below it) should be known. Determining the flow of underground aquifers is not a trivial task and it may take several years to determine the hydrodynamics of the system properly.
- The strata above and below coal measures can contain sufficient combustible materials that combustion outside the cell (towards the surface) occurs. This could destabilise the cavity roof and lead to loss of product (which is toxic) to the surface. it is important to know the detail of the upper and lower strata and the likely effect of high temperatures and oxygen on them.
- Control of the combustion process is only by the flow of oxidant to the cell and the pressure in the cell. The pressure in the cell is limited to that of the hydrostatic pressure around the cell which maintains the combustion products within the cell. Overpressure could cause products to move outside the confines of the system and contaminate surrounding areas.
- Published data indicates that it is very difficult to get a good mass-balance for the operation. Often 20 to 30% of the theoretically produced synthesis gas is missing; this suggest significant losses outside the system.

During the past decade the development of UCG became of interest in Australia, particularly Queensland. This was driven by high oil prices and the identification of large untapped coal reserves. There were several projects aimed at producing fuels (Linc Energy, Coogar Energy), power (Carbon Energy) and ammonia (Liberty Resources). Some of these projects were enthusiastically endorsed and promoted by both the Commonwealth and the Queensland government. Of these projects the Carbon Energy technology utilised a novel directional drilling approach to burn the coal across a coal face which was developed by CSIRO.

The Carbon Energy project is in the process of proving that the combustion cell can be safely closed down and the coal field and surrounding aquifers successfully rehabilitated to normal. There have been significant concern with the outcome of the Linc Energy and Coogar Energy projects with claims of water and air contamination. All of the active projects have now ceased by government edict.

Australian experience with UCG delivers several lessons:

- UCG, like many other so called novel and innovative processes, has a long history and lessons learned from previous work are often ignored in the rush to achieve the desired outcome.
- Project promotion by "blue sky thinkers" often ignores (deliberately?) serious issues or cost constraints on the technology.
- Unwarranted enthusiasm and euphoria can influence government decision making just as easily as private equity. When the project goes sour, this euphoria quickly turns to panic resulting in bans shutting down possible viable technology.

In Australia today UCG is a dead technology option. Development has now been transferred to other countries such as South Africa where it is reported that UCG is being used to supplement fuel to a power station.

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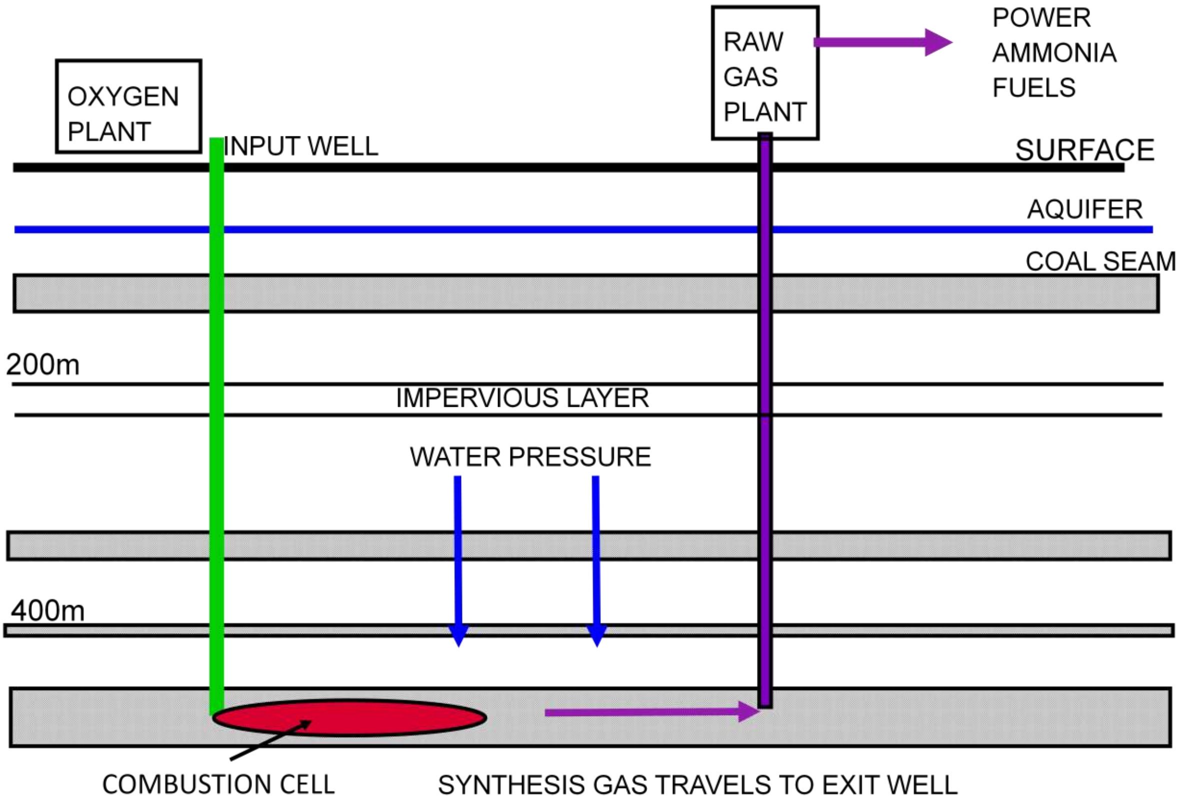

Figure 1: Illustrative diagram of a UCG operation