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ENVIRONMENTAL BENEFIT OF USING NICKEL-CONTAINING MATERIALS IN THE OIL AND GAS PRODUCTION INDUSTRY

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ABSTRACT

Oil Companies are responding to the demand to operate their businesses in a sustainable way. Measures adopted include seeking to reduce emissions and to maximise their production of so-called "stranded" gas which otherwise can make no contribution to the world's energy demand. In this climate it is likely that the oil and gas industry will increasingly seek to justify any aspect of its business, including its choice of materials, in order to boost its 'sustainability rating'.

Nickel-containing stainless steels and nickel alloys play an important role in providing corrosion resistant, and hence leak resistant, materials of construction for projects internationally. Some of these materials also play a critical role in handling gas production, particularly in liquefied form, thus helping to develop difficult-to-access gas reserves.

Whilst the full life-cycle of nickel-containing materials in the oil and gas industry is difficult to assess, their inherent re-useability in consecutive projects and the scope for re-cycling at the 'ultimate' end of their use means that they make a very strong contribution to the overall sustainability of the oil and gas industry.

KEYWORDS

Nickel, stainless steels, CRAs, sustainable development, environment, LNG

WHAT IS ENVIRONMENTAL SUSTAINABILITY?

The 1997 UN commission on environment and development gave the following definition of sustainable development:

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

These "needs" are very loosely defined, encompassing economic, environmental and social needs. Sustainable development for business is essentially enlightened self-interest. Quite simply, any business sector needs sustainable societies in order to protect its own sustainability; in other words, businesses here for the long term have to think about sustainable development.

Not only should businesses *wish* to develop in a sustainable way out of self-interest, but also, they have to because legislation is being drawn up on this issue. A recent presentation

(Ong.D) expressed the view that future EU directives will establish civil liability and corporate environmental management standards such that companies, and *individuals within companies*, could be held responsible for criminal negligence in not carrying out environmentally sustainable practice in their pursuit of their business.

The removal of hydrocarbon resources from the ground is inherently not a sustainable development and the oil industry is therefore facing a hard task in presenting a positive 'spin' on its activities. Nevertheless, the industry is genuinely responding to the challenge of sustainable development. This paper illustrates how this is being addressed and shows how nickel containing materials do contribute to making hydrocarbon extraction more sustainable.

HOW DOES THE OIL AND GAS INDUSTRY RESPOND?

A big challenge for the world is that 93% of global car use is gasoline and even if the Kyoto agreements were implemented, gasoline would still account for 83% of car use in the year 2020. Oil demand is also increasing by 2% per year and worldwide people want low cost energy. Various operating companies are contributing to the need for the industry to be seen to respond to this new challenge of meeting the world's energy needs, whilst operating in a sustainable way.

On the formal front, the UK Offshore Operators Association (UKOOA) has developed a Sectoral Sustainability Strategy with four main headings:

- *Economic* – sustaining the economic health of the industry and supporting the UK economy in which it operates
- *Social* – the industry's relationship with its current and future workforce and with the communities in which it operates.
- *Environmental Performance* – the industry's relationship with the physical environment with which it operates.
- *Resource Stewardship* – the use of natural resources and the legacy the industry will leave.

This report, published in April 2001 has been reported variously to be "ambitious and challenging" (Helen Liddell, UK Minister, Department of Trade and Industry) and "woolly" (Paul Carslake, Editor "The Engineer", May 2001).

More than formal words, there is interest in what the industry is *doing*. Typically companies have focussed on reducing unwanted emissions (reducing flaring and preventing leaks). Taking steps beyond these points, which benefit both the "environmental image" as well as the balance sheet requires greater commitment.

Other oil industry "sustainable" initiatives (which take the broader view of the definition) include developing cleaner fuels, introducing environmental and social impact assessments on new projects and also monitoring and positively supporting biodiversity in all their locations.

BP has indicated their pledge to reduce carbon dioxide emissions by 10% from the 1990 base level to 2010 despite an increase in overall hydrocarbon production. Emissions have been reduced by reducing flaring, tightening emissions at refineries, limiting the use of energy by the company itself and in investing in new technology (particularly in renewable energy such as solar power and in the development of hydrogen as the clean fuel for vehicles) (Mogford, J.).

Shell has introduced the evaluation of the carbon loading of planned projects (Murphy, A.). Until recently projects have been evaluated on normal economic criteria (capital cost, present value, life cycle cost, rate of return etc.,). Evaluation has always been made on the basis of zero cost for carbon. Carbon losses through, for example, emissions, have been assumed to have no value in the context of the complete project. Shell has now studied the likelihood of future carbon taxes and considered scenarios for future cost of carbon tax. Their present model assumes that a carbon tax of $5/t will apply up until the year 2010 and beyond that a price of $20/t of carbon (note: other scenarios where the carbon tax was as high as $50/t are presently considered to be less realistic).

On this basis, projects can therefore be evaluated based on the anticipated levels of emissions over the years of the project and the cost per year in terms of a carbon tax can be assigned. That cost can be considered along with other economic factors and in some cases might result in projects which were otherwise economic now becoming less acceptable and other projects being ranked higher.

An example of this may be a project which will produce a lot of oil and would appear to be quite economic but is located in some isolated place where the co-produced gas cannot be exported and for geological reasons cannot be re-injected into the reservoir. If that gas therefore has to be flared it carries with it a high level of emissions with subsequent carbon cost. That project may therefore rank lower than a project where the overall hydrocarbon production may be less but all hydrocarbons produced can be fully contained and safely exported resulting in a much lower carbon tax.

Despite the high aims which leading companies may have they are still conscious of the problems which need to be addressed. For example, in the year 2000, BP paid out nearly £20 million in fines or penalties in more than 50 cases of pollution around the world. The industry record in some parts of the world has been particularly poor, sometimes for complex reasons. Often the reasons are not attributable to negligence on the part of the operating companies themselves, and sometimes they are as a result of well-intentioned 'sustainability initiatives' such as making compensation payments for spills which then increase acts of deliberate sabotage. An example would be Nigeria, where between 1986 and 1996 the total volume of oil spills was equivalent to 10 times the Exxon Valdes. Vast quantities (probably 3trillion cu ft) of gas have been flared to date as there has been relatively little option of what to do with the gas. It is believed that there is 13trillion cu ft of gas still in place in Nigeria and a relatively trivial amount of this will be utilised for power generation.

HOW DOES NICKEL PLAY A ROLE?

Nickel is a vital alloying element in stainless steels and nickel alloys. These classes of materials, typically referred to as Corrosion Resistant Alloys, CRAs, cover a wide range of mechanical and corrosion properties, which are utilised in many applications in the oil and gas industry.

Two key characteristic properties of these nickel-containing materials can be readily shown to contribute to the sustainability of the oil and gas industry, as outlined below: corrosion resistance and toughness.

Corrosion Resistance

The first characteristic is the corrosion resistance of different grades of CRAs used for key equipment, from the production tubing through to the oil and gas treatment plant. Corrosion resistant stainless steels and nickel alloys are generally targeted towards aggressive production streams because of safety considerations. Their higher capital cost, relative to plain carbon steels, has always to be justified, and this is frequently done by taking a life cycle cost approach.

In this new era with a drive for environmental sustainability, the use of corrosion resistant nickel-containing materials has an added bonus in reducing one source of unplanned hydrocarbon emissions into the environment by preventing leaks. This reduces the potential future carbon tax because of reduced risk of emissions. This has a life cycle cost benefit, but also has an environmental life cycle benefit.

Various CRAs have been chosen for flowlines throughout the world with more than 1500km put into service since over the last 30 years. None of these flowlines has failed in service because of corrosion problems in the production environment, whilst the service conditions are the most aggressive which are encountered internationally.

Quantifying the use of CRAs in production plant equipment is harder to do, but materials from duplex stainless steels to nickel alloys like alloy 825 and 625 are frequently required to handle corrosive environments particularly associated with untreated natural gas.

CRAs are generally selected with care and used in the most efficient ways. A nice example is the use of CRAs as cladding on carbon steel, which provides the required corrosion resistance whilst utilising the nickel content in an efficient way.

Without these nickel-containing materials the risk of failure resulting in leaks would be higher, or there would be a need for replacement of the equipment if constructed of materials with a more limited life like carbon steel – possibly associated with a need for injection of non-recyclable, environmentally harmful, chemicals to inhibit corrosion rates.

Toughness

The second key characteristic is toughness; additions of nickel to steel giving a beneficial improvement of toughness which is used in safely handling cryogenic liquids, including liquefied natural gas (LNG) at around –164degC. Nickel steels and austenitic stainless steels are standard materials for facilities handling LNG. They are used for process equipment, piping, vessels and storage tanks, principally because of their excellent mechanical properties in the service conditions.

Coping with ‘unusable’ gas in a sustainable way is a challenge very widespread throughout the oil and gas industry and it is one where the use of these nickel-containing materials can play a very significant role. The most obvious example is the development of stranded gas reserves which would otherwise be inaccessible or wasted.

Gas reservoirs, which are isolated from an obvious market, may be successfully developed if the technology exists to convert the gas into a form which allows it to be transported. Of particular concern is gas production associated with offshore reservoirs, particularly where the reservoirs are small in size and do not warrant building a pipeline for export. There are several competitive technologies available, one of which – small scale production of LNG - has been discussed for a number of years, but which recent studies have concluded is viable (Bliault, A.). Whilst offshore LNG production can be shown to offer cost benefits (up to 30% of some offshore projects), it is also increasingly seen as 'essential' technology, as gas flaring and gas-re-injection are seen as poor options in the context of environmental constraints and the drive to sustainable development. LNG production would depend very strongly on the use, for example, of stainless steels, for much of the necessary piping and equipment as these would provide the required toughness for the service conditions.

GENERAL MATERIALS SELECTION ISSUES

Correct selection of appropriate materials could be a significant contributor to whether certain technological approaches for specific projects will be successful. Making a technical success of projects which will result in lower emissions, reduced levels of 'unusable' or 'inaccessible' hydrocarbon resources can be a very positive contribution to the overall rating of a project in both economic and sustainable terms.

In many cases the use of CRAs gives a major long term benefit which totally outweighs the short term higher capital cost. There are many examples of operations around the world now where the past selection of materials was made on a management-intensive basis. The selection of carbon steel, with known demands in terms of ongoing corrosion inhibitor injection, inspection and maintenance was quite acceptable in the scenario with excess manpower availability. As these operations have matured, the number of personnel has been reduced in operations, inspection, and corrosion engineering, whilst ageing facilities are demanding ever more attention to keep them safe.

By comparison, installations which have made judicious use of CRAs in critical corrosive service have been able to tolerate the changing manpower situation with at least the CRA parts of plant being much more free of problems. Essentially, the use of nickel-containing CRAs allows certain plant to be operated over the longer term with a much higher level of confidence and significantly reduced risk of failure. Such installations are also well placed to continue safe operation for longer than the originally intended project life, with obvious benefits in both economic and sustainability terms.

CRA equipment may also be re-used at the end of a project and re-cycled at the ultimate end of service as discussed below.

WHAT IS THE NICKEL LIFE CYCLE IN THE OIL AND GAS INDUSTRY?

Sustainability requires keeping control of the full life cycle of materials used. Manufacturing stainless steels and nickel alloys has its own energy and environmental cost, a deficit which has to be recouped through the life of the materials in question.

Balancing the environmental impact of producing a nickel-containing material with the environmental benefit that the material can provide in service is not easy. This equation is complex to evaluate in any particular case and more work is required to gather the data to investigate this further. Some information on the life cycle impact of primary nickel is available at www.nidi.org. The nickel industry would welcome any case histories or insight into the broader life cycle of nickel-containing products in the oil and gas industry.

Factors to consider in evaluating the environmental benefit of using materials are:

- The length of the service life
- The potential for re-use in other projects
- The ability to re-cycle when the useful life is over
- Avoidance of use of environmentally harmful chemicals

Applications of stainless steels and nickel alloys in the oil and gas industry aim to provide for the full life of the project. This ability to provide a long life has been recognised as an important reduction of overall environmental impact. Longer life means lower overall emissions and lower overall energy inputs. In the context of the oil and gas industry, where initial project life is often extended due to improvements in production technology over the duration of the project, the ability of installed CRA equipment to remain in service for extended periods is very significant.

The corrosion resistance of nickel containing materials means that at the end of their project life they may be re-used. Commonly in the oil and gas industry where developments are densely located, existing pipelines may be used with new projects 'tie-ing in' to existing pipelines. Such re-use is particularly safe in the case of corrosion resistant alloy lines.

Similarly, CRA downhole tubing will be inspected during a workover and often re-used in a new well with comparable conditions. CRA equipment used on floating facilities (e.g. FPSOs, future floating LNG production barges), which are towed to new locations, can continue to provide service for the duration of several consecutive projects, whilst carbon steel components may require maintenance or have to be replaced at intervals.

Eventually, if re-use is not possible, the CRA parts may be recycled. Because of their high end of life value and their concentrated use, a high percentage of nickel containing CRA products are collected, sorted and remelted, many into stainless steel. Recycleability is a key factor to establish the "more sustainable consumption" to which the European Commission aspires. Nickel and stainless steel put into a product today can be seen as adding to the above ground- reserve of nickel for future generations. Nickel is not consumed, it is used. In terms of environmental impact, "re-usable" resources should be considered as the same as "renewable" resources. As such, nickel poses no fundamental challenge to sustainable development or to sustainable consumption (Kirman, I.).

CONCLUSIONS

It is likely that the oil and gas industry will increasingly seek to justify any aspect of its business, including its choice of materials, in order to boost its 'sustainability rating'.

Use of nickel-containing stainless steels and nickel alloys in the oil and gas industry does contribute to making some projects more sustainable. Their contribution to making the production of stranded gas an economic and technical reality is one key example.

Whilst the full life-cycle of nickel-containing materials in the oil and gas industry is difficult to assess, their inherent re-useability in consecutive projects and the scope for re-cycling at the 'ultimate' end of their use means that they make a very strong contribution to the overall sustainability of the oil and gas industry.

REFERENCES

Bliault, A., "Shell Floating LNG Plant, Technology Ready for Project Development", Offshore May 2001, pp102-104.

Kirman, I, "Nickel and the Future: The Contribution of Nickel to the Environment and the Quality of our Everyday Life", CRU 4th World Stainless Steel Conference, Monte Carlo, March 20th 2001

Mogford, J., "Developing a Sustainable Environmental Policy", Conference on Developing a Sustainable Environmental Strategy for Commercial Success in the Upstream Oil and Gas Sector, London, April 2001

Murphy, A., "Investing in a Carbon Constrained Future", Conference on Developing a Sustainable Environmental Strategy for Commercial Success in the Upstream Oil and Gas Sector, London, April 2001

Ong, D., "Recent developments in International and EC Environmental Law: Implications for the UK Offshore Oil and Gas Sector", Conference on Developing a Sustainable Environmental Strategy for Commercial Success in the Upstream Oil and Gas Sector, London, April 2001