Cathodic Protection in the Arctic

IMPRESSED CURRENT SYSTEMS USE PLATINISED ANODES

Corrosion of steel structures in Arctic waters can be even more severe than in warmer environments. It has now been reported that with careful attention to detail during all stages of design, fabrication, installation and operation, impressed current cathodic protection systems, incorporating platinised anodes, can provide an economic and effective means of preventing corrosion on both ships and off-shore structures.

Steel structures partially submerged in sea water may suffer from localised preferential corrosion due to a variety of factors including the joining together of metals with different electrochemical characteristics, non-uniform protection by paint coatings and variable composition of the surrounding water. An appropriate cathodic protection system using either sacrificial anodes or an impressed current can overcome such difficulties. While sacrificial anodes corrode in preference to the structure to which they are attached, in an impressed current system the current produced by the natural electrochemical corrosion process is suppressed by a current from an external power source, which is dissipated over the surface of the structure by means of strategically positioned electrodes made from inert materials such as

The ice-breaking ship "Terry Fox" is one of several vessels operated by BeauDril Ltd. in the Beaufort Sea to be protected against corrosion by an Aquamatic impressed current system, employing platinised titanium anodes. The anodes and the reference electrodes are all recessed into the hull to avoid mechanical damage. To provide proper protection for the propeller, the shaft and the bearings, it is necessary to ensure that there is adequate electrical connection between the propeller shaft and the hull

platinum or iridium supported on titanium or niobium.

The use of impressed current cathodic protection systems to prevent corrosion damage to the underwater hulls of ships was pioneered by the Bureau of Ships of the U.S. Navy Department in the 1950s (1, 2), and since that time such systems have found growing application for the protection of steel hulls of ships (3, 4). The ever-increasing capital and maintenance costs of both ships and marine structures have encouraged the development of sophisticated cathodic protection systems which can economically and effectively protect bare, or partially coated, steel structures under a wide variety of climatic and operating conditions.

Arctic Ice-Breakers

One such system is the Wilson Walton International Aquamatic system, which was selected for installation on the ice-breaking vessel "Canmar Kigoriak" which is operated in the Arctic Ocean by Canadian Marine Drilling, a division of Dome Petroleum. Traditionally, paint and sacrificial zinc anodes have been used to protect the external surface of ice-breaker hulls, but these have not been totally successful, due, in part, to the abrasive action of the ice. The Wilson Walton Aquamatic system incorporates platinised anodes. These are fed with a continually variable electric current, the power being determined by signals from a number of zinc reference electrodes which are used to monitor the electrochemical conditions on the hull. Thus optimum protection of the steel can be achieved however the electrochemical conditions vary.

Following successful trials, the Aquamatic system has now been fitted to several other vessels engaged on ice-breaking and oil exploration work in the Beaufort Sea.

There is a major structural difference between ships' hulls and conventional off-shore oil drilling and production rigs. While the outer surfaces of the former are made up of flat plates, a conventional rig consists of a complex lattice of tubular components, and this adds to the difficulty of designing, engineering and installing impressed current systems to protect them against corrosion. However, the more recent development of semi-submersible drilling rigs and tension-leg production platforms, which are of plate rather than tubular construction, provides an opportunity for the advantageous use of impressed current cathodic protection systems.

The Movable Rig "Molikpaq"

What is believed to be the first impressed current system to be used to protect an off-shore rig working in ice-covered Arctic waters was fitted to the caisson drilling unit "Molikpaq" during August and September 1987. Designed to drill in water 15 to 40 metres deep, the flat-bottomed caisson is floated to location and then sunk onto a prepared base on the seabed, where it is filled with sand or gravel aggregate to enable it to withstand the sideways force of the winter sea ice flow (5).

In plan, the caisson takes the form of a square with 111 metre sides, but with the corners chamfered off. When it was constructed, all external steel surfaces below the water line were coated with a 250 micrometre thick layer of coaltar epoxy paint. However, when the rig was moved after only two years of operation, the steel was bare at and below the water line, and overall some 50 per cent of the coating had been lost due to the abrasive action of ice. With the rig expected to have a life of 20 years, the decision was then taken to fit a Wilson Walton International cathodic protection system.

A particular advantage of an impressed cathodic protection system is that the current can be adjusted automatically in response to any changing environmental or operational condition, due to factors such as variations in sea water temperature and salinity, or changes in the area of the exposed steel resulting from deterioration of painted surfaces, and thus the level of cathodic protection can be continually optimised.

Platinum electrodeposited on titanium was selected as the anode material because of its known properties in the environmental conditions expected (6), which included sea water

The stationary caisson rig "Molikpaq" has horizontal loads of up to 500 pounds per square inch exerted on the hull as ice, four metres or more in thickness, attempting to flow past—due to the rotation of the earth—piles up above and below sea level. To prevent corrosion of the steel hull, twenty-four anode assemblies are employed, each of which carries two anode mounting plates which also act as primary dielectric shields

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The anode assembly shown here consists of two anode mounting plates arranged side by side and surrounded by an ice fender. The four active anode strips of platinised titanium are clearly visible. At this stage the platinum is covered by protective coatings but when the rig is ballasted down for drilling operations, the unprotected anodes are some 9 metres below the normal water line. Each platinised titanium strip is supplied with DC power through a dedicated cable. If necessary the anodes can be unbolted and replaced by a diver, but are expected to have a life of twenty years

temperatures of -3 to $+10°C$, air temperatures of -50 to $+20°C$ and scouring by sea ice. A proprietary thermosetting plastic incorporating a glass filler was to serve as a combined anode mounting and primary dielectric shield. Two platinised titanium strips were arranged on each anode mounting plate, the current density in the strip being about 200 A/m^2 and the system capacity being in excess of 2000 A. Two anode mounting plates were used for each assembly and four assemblies were used on each of the four major faces of the rig, with another two on each of the four corner faces. This distribution provided a uniform level of protection on all parts of the submerged steel structure, including the central filled core. High purity zinc was used for the twenty-four reference electrodes and the necessary DC electricity was provided by twelve power supplies.

Summary and Conclusions

Following many years of proven success in preventing the corrosion of ships' hulls, an impressed current system employing platinised titanium anodes has now been used to protect cathodically a steel caisson rig working in the Arctic Ocean, north of Canada. The experience gained during the installation and running of this system can be expected to result in further use of similar systems as the search for oil and gas deposits extends into even more hostile environments.

Acknowledgement

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Homogeneous Catalyst Research Kit

Homogeneous catalysts play an important part in many industrial processes, and contribute to the production of over 21 million tonnes of organic products. Their industrial use is mainly related to large volume commodity chemicals where the activity and selectivity achieved with rhodium catalysts is notable in, for example, hydroformylation and carbonylation reactions. Homogeneous platinum group metal catalysts are now finding increasing application in industrial research and development laboratories for the synthesis of fine chemicals and pharmaceuticals.

In order to assist organic chemists to select catalysts which are amenable to process scale-up, Johnson Matthey are now offering a Homogeneous Catalyst Kit which comprises ten platinum group metal complexes and five phosphines. The use of these enables a variety of catalytic transformations to be carried out on a laboratory scale, including: allylic alkylation, aryl-alkene coupling, carbonylation, heterocycle formation, hydrogenation and isomerisation.

The kit includes traditional catalysts, such as Wilkinson's Catalyst, which have been widely utilised in research laboratories, together with newer catalysts which enable more selective hydrogenations to be carried out and which also permit carbon-carbon coupling reactions. The catalysts are reasonably robust and are stable under normal laboratory conditions.

The Johnson Matthey Homogeneous Catalyst Kit is now available and further information about it can be obtained by writing to the Johnson Matthey office at Orchard Road, Royston, England, or to the European Associate Houses.