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PLANAR MULTIELECTRODE-ARRAY-SENSOR FOR CORROSION MONITORING

by

AYSHA SALMAN

The undersigned certify that they have read, and recommend to the Postgraduate Studies Programme for acceptance this thesis for the fulfilment of the requirements for the degree stated.

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PLANAR MULTIELECTRODE-ARRAY-SENSOR FOR CORROSION MONITORING

by

AYSHA SALMAN

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PERAK

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DECLARATION OF THESIS

Title of thesis	Planar Multielectrode-Array-Sensor for Corrosion Monitoring

I AYSHA SALMAN, hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTP or other institutions.

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Dedicated to My Husband

Salman

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ABSTRACT

Corrosion is a constant threat to industries in particular the oil and gas. Its adverse effects on assets such as pipelines and equipments may lead to losses in millions of dollars. Since it is a natural process, it cannot be eliminated altogether. However, appropriate corrosion monitoring techniques and preventive measures can help to control it to a greater extent. In this research, a PCB-based multielectrode array sensor (MAS) for localized corrosion rate monitoring is demonstrated. It is fabricated using typical PCB processes with Cu discs acting as the planar sensing electrodes. It is ~2x2 inches in size and truly planar making it more suitable to be used in confined spaces as compared to other techniques like probe-based MAS or corrosion coupons.

It is tested in 3%wt sea salt solution to check its corrosion detection capability. Its response to change in corrosive environment is also assessed by varying the solution concentration from 3%wt to 9%wt. The obtained corrosion rates are validated using established corrosion monitoring technique like electrochemical impedance spectroscopy (EIS). Furthermore, robustness of PCB-based MAS is checked in HCl and NaCl solution using three types of conformal coatings namely; acrylic, cyanoacrylate and epoxy. Effects of these three types of conformal coatings on PCB-based MAS performance is also tested and analyzed in detail.

The results show that the corrosion rates obtained from the PCB-based MAS agrees reasonably well with published corrosion rates. It also shows that the MAS can detect the change in corrosive solution concentration efficiently. As for the conformal coatings, it is found that acrylic coated PCB-based MAS provides reasonably accurate corrosion rate although with a shorter sensor lifetime. Cyanoacrylate and epoxy, on the other hand, inhibits corrosion increasing the sensor lifetime but at the expense of inaccurate corrosion rates.

ABSTRAK

Kakisan ialah satu ancaman kepada industri negara terutamanya di dalam industri minyak dan gas. Kesannya kepada aset-aset seperti paip dan peralatan boleh menjuruskan kepada kerugian yang bernilai jutaan ringgit. Oleh kerana ianya adalah satu proses yang berlaku secara semulajadi, kakisan tidak dapat dihapuskan secara sepenuhnya. Namun begitu, dengan menggunakan teknik pengawasan kakisan dan mengambil langkah-langkah pencegahan yang sesuai, kakisan boleh dikurangkan. Di dalam kajian ini, pengawasan kadar kakisan menggunakan pengesan deretan multi-elektrod (MAS) yang planar berdasarkan PCB akan ditunjukkan. MAS dibuat menggunakan proses PCB menjadikan kepingan tembaga sebagai elektrod untuk mengesan kadar kakisan. Ianya berukuran ~2 x 2 inci dan benar-benar planar menjadikan ia lebih sesuai untuk digunakan didalam tempat-tempat yang sempit berbanding dengan teknik-teknik yang lain seperti MAS berdasarkan pasak atau kupon kakisan.

MAS telah diuji didalam 3% air laut untuk mengenalpasti kebolehannya untuk mengesan kakisan. Respons MAS kepada perubahan persekitaran yang mengarat juga telah diuji dengan merubah kepekatan larutan dari 3% kepada 9%. Kadar kakisan yang diperolehi pula telah dibandingkan dengan teknik pengawasan kakisan yang selalu digunapakai seperti spektroskopi rintangan elektrokimia (EIS). Tambahan pula, ketahanan MAS juga telah diuji didalam larutan HCl dan NaCl menggunakan tiga jenis lapisan konformal iaitu acrylic, cyanoacrylate dan epoxy. Kesan-kesan dari penggunaan lapisan konformal tersebut terhadap prestasi MAS telah diuji dan dianalisa secara terperinci.

Hasil kajian menunjukkan kadar kakisan yang diperolehi dari MAS berdasarkan kepada PCB hampir sama dengan kadar kakisan yang telah diterbitkan di jurnal-jurnal. Ia juga menunjukkan MAS boleh mengesan perubahan persekitaran yang

mengakis dengan efisien. Kajian mengenai lapisan konformal pula menunjukkan MAS yang dilitupi dengan lapisan arylic boleh memberi kadar kakisan yang agak tepat walaupun dengan jangkahayat pengesan yang pendek. Cyanoacrylate dan epoxy pula menunjukkan sifat menghalang kakisan yang dapat memanjangkan jangkahayat pengesan akan tetapi menghasilkan kadar kakisan yang kurang tepat.