Absorption of CO_2 gas through electro-reduction of molten salt for metal treatment proces

By

Project leader:

Dr. Nancy Julius Siambun

Co-researcher:

Farm Yan Yan, Mohd. Azlan bin Ismail, Choong Wai Heng, Yoong Hou Pin, Prof. Yeo Kiam Beng @ Abdul Noor.

Project report submitted for SGPUMS SLB0006.

Faculty of Engineering

Universiti Malaysia Sabah.

May 2014

ABSTRACT

Molten salt carburisation process using electro-reduction of molten salts containing carbonate salt has been investigated using CO_2 as a continuous source of carbon. The effectiveness of electro-carburisation under various CO_2 concentrations for mild steel sample and an attempt to electro-carburised stainless steel has also studied. The selection of molten salt mixture for electro-carburisation of mild steel and stainless steel was based on effective carburisation temperature, salt melting temperature and thermal stability. Mild steel was successfully electro-carburised at 800°C in two type of carbonate salt mixture (Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3). Microstructural changes as revealed by optical were featured by the increase of the carbon rich cementite phase (Fe_3C) at the expense of the original ferrite phase near the surface of the carburised samples. Micro-hardness profiles measured from the surface to the centre of the electro-carburised samples presented clear evidence of carbon penetration as a function of the electrolysis voltage, and the activity of carbonate ions in the molten salts. The carbon-hardened case was up to 0.60 mm in thickness with hardness 1100HV in 60 minutes carburisation at 800 °C. Carburisation process is not possible at for stainless steel due to the formation of protective coating at high temperature, therefore usage of Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3 were not suitable. Molten salt Li_2CO_3-Na_2CO_3-K_2CO_3 that has melting temperature below 500°C was identified suitable for stainless steel sample. No prominent case hardening obtained by stainless steel in 60 minutes carburisation under 500°C temperature, however microstructural changes revealed by optical microscope shows martensite structure presence and changed in size when cell voltage was varies. It is suspected that electro-carburisation at more than 60 minutes is required to make significant case hardening depth.

Abstrak

Di dalam kajian ini, proses rawatan haba bagi meningkatkan kekerasan permukaan logam yang dikenali sebagai 'carburisation' mengunakan kaedah elektrolisis garam carbonate lebur, dengan kehadiran gas CO_2 sebagai sumber carbon telah dijalankan. Fokus kajian adalah menjalankan rawatan haba dengan kepekatan CO_2 yang berbeza bagi sampel keluli rendah karbon, dan percubaan electro-carburisation bagi sampel keluli tahan karat. Pemilihan jenis garam lebur untuk proses rawatan haba keluli rendah karbon dan keluli tahan lasak adalah bergantung kepada suhu rawatan, suhu lebur garam, dan kestabilan garam. Keluli rendah karbon telah berjaya di rawat pada suhu 800°C dalam garam lebur Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3. Perubahan mikrostruktur melalui mikroskop optik menunjukkan pertambahan fasa-kaya karbon (Fe_3C) pada permukaan logam. Analisis mikro-kekerasan dari permukaan ke bahagian pusat sampel menunjukkan pertambahan kuantiti karbon yang meningkat dengan kenaikan voltage, di mana aktiviti ion-ion karbonat turut meningkat. Logam yang telah dirawat selama 60 minit pada 800°C, mempunyai kedalaman 'case-hardening' sebanyak 0.6 mm dan kekerasan permukaan 1100HV. Di sebabkan keluli tahan karat cenderung membentuk lapisan pelindung pada suhu yang tinggi, maka garam lebur Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3 adalah tidak sesuai. Walau bagaimana pun, garam lebur Li_2CO_3-Na_2CO_3-K_2CO_3 dikenal pasti sesuai bagi keluli tahan karat. Rawatan haba selama 60 minit tidak menunjukkan peningkatan 'case-hardening' pada keluli tahan karat, walau bagaimana pun, struktur martensite dikesan pada sampel-sampel yang dirawat dalam pelbagai voltage. Adalah dicadangkan tempoh rawatan haba perlu dipanjangkan bagi mendapat kedalaman 'case-hardening' yang ketara.