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TRANSPORT PROPERTIES / BEHAVIOUR OF CARBURIZATION USING MOLTEN SALT TECHNIQUE FOR METALLURGICAL APPLICATIONS

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SINOPSIS

Leburan garam karbonat adalah dikenalpastikan sebagai pengganti mandian tosik sebatian kimia proses traditional penkarbonan secara leburan garam. Dalam peringkat awal, kerja-kerja penyelidikan telah dijalankan untuk mengenalpasti kesesuaian jenis proses penkarbonan secara leburan garam dan sampel analisis. Melalui kerja penyelidikan ini, pengubahan dan perekaan elektro-penkarbonan prosess telah dibanggunkan. Proses elektro-pemkarbonan yang dijalankan dalam sistem tertutup dengan penggunaan CO_2 bersama gas lengai SnO2 sebagai anod dan keluli rendah karbon sebagai katod. Penggunaan asalan grafik sebagai anod adalah tidak bersesuaian dan akan mendatangkan penghakisan akibat penggunaan jangka masa panjang. Oleh begitu, grafik anod digantikan dengan *tin oxide* dalam proses elektrolisis. Dalam penyelidikan ini, dua jenis campuran garam 0.8 Na_2CO_3-0.2 NaCl and 0.5 Li_2CO_3-0.5 K_2CO_3 dalam nisbah molar.telah digunakan.

Proses penkarbonan boleh dipengaruhi oleh beberapa-berapa faktor, ini termasuklah kadar voltan sel yang digunakan dalam proses elektrolitik, kelajuan gas karbon dioksida, tempoh penkarbonan dan jenis garam karbonat. Daripada hasil kajian sampel elektro-penkarbonan dengan garam Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3 dengan tempoh masa maximum penkarbonan 60 min, campuran garam Na_2CO_3-NaCl memerlukan voltan sel minimum 2.5 V berbanding dengan Li_2CO_3-K_2CO_3 yang hanya memerlukan minimum 2.0 V voltan sel. Ini menunjukan penggunaan garam campuran Li_2CO_3-K_2CO_3 adalah lebih berkesan dari Na_2CO_3-NaCl yang memerlukan keperluan tenaga atau takat suhu leburan yang tinggi. Dalam proses elektro-perkarbonan, penyejukan kadar cepat (*quenching*) adalah amat diperlukan. Sampel akan bersifat lembut dan mulur jikalau tidak melalui penyejukan kadar laju walau menjalani voltan tinggi elektro-penkarbonan.

Proses elektro-penkarbonan adalah lebih berkesan jika dibandingkan dengan mandian tosik sebatian kimia (8–11% NaCN) atau penkarbonan leburan garam lain. Kedalaman penkarbonan keluli karbon rendah sehingga 0.62mm melalui proses elektro-penkarbonan. Untuk mencapai kedalaman penkarbonan yang sama, kaedah penkarbonan suhu tinggi diperlukan.

Kerja-kerja penyelidikan atau kajian lanjutan melibatkan mikrostruktur analisis dan ujian kekerasan Vicker diperlukan untuk menkaji kesan-kesan gas campuran CO_2-N_2, tempoh penkarbonan dan variasi molar nisbah dan campuran garam Na_2CO_3-NaCl. Selain daripada itu, kerja-kerja penyelidikan lanjutan juga akan menumpukan penggunaan garam campuran lain seperti Li_2CO_3-Na_2CO_3 dan Na_2CO_3-K_2CO_3 dalam proses penkarbonan cara leburan garam.

SYNOPSIS

Molten salt electrolytic carburisation process using carbonate salt has been identified as a method to eliminate the toxic cyanide bath in the conventional method of molten salt carburisation. A preliminary research work was to identify methods of molten salt carburization and suitable sample analysis to determine the effectiveness of carburisation process. Modification and design of electro-carburisation process was successfully developed in this research work. The electro-carburisation was carried out in-lab close system with introduction of CO_2 and inert SnO_2 as anode and mild steel as cathode. The initial usage of graphite anode had shown pitting after the electrolysis and severe corrosion with long term electrolysis. Therefore, graphite anode was replaced with tin oxide anode for the electrolysis system. Two types of salts mixture were use in this research such as 0.8 Na_2CO_3-0.2 NaCl and 0.5 Li_2CO_3-0.5 K_2CO_3 molar ratio.

Cell voltages applied to the electrolytic process, carbon dioxide gas flow rate, the period of carburisation, and the type of carbonate salt has been identified as parameters that affects the carburisation process. Studies on the potential applied on samples electro-carburised in Na_2CO_3-NaCl and Li_2CO_3-K_2CO_3 salts has been carried out and has shown that a minimum of 2.5 V cell voltages for Na_2CO_3-NaCl salts mixture and a minimum of 2.0 V cell voltages for Li_2CO_3-K_2CO_3 are necessary to achieve a maximum carburisation of mild steel in 60 min. Carburisation in Li_2CO_3-K_2CO_3 salts is also found to be more effective that required lower energy or molten temperature as compared to electro-carburisation in Na_2CO_3-NaCl salts. Quenching after electro-carburisation process is found necessary to ensure effective carburising. Non-quenched samples have also shown to characterise a softer and ductile properties although electro-carburised at higher cell voltages.

Comparing the electro-carburisation process with the molten cyanide process and other molten salt carburisation, the electro-carburisation process has shown to be more efficient than the conventional toxic cyanide bath (8–11% NaCN) carburisation, and other non-cyanide molten salt carburisation. The case depth of mild steel sample electro-carburised has achieved 0.62 mm. Higher carburising temperature (above 920 °C) was required for other method to achieve such comparable case depth.

Ongoing testing/analysis for microstructure and Vickers hardness analysis such as the effects of CO_2-N_2 gas mixture, the carburising period and variation of Na_2CO_3-NaCl molar ratio is continuously pursued. Future work shall hope to focus on the usage of various carbonate salts mixture, i.e. Li_2CO_3-Na_2CO_3 and Na_2CO_3-K_2CO_3.