Payame Noor University

School of Science

Department of Chemistry

Modification and Modeling of the Some Properties in the Lead-Acid Batteries

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in Analytical Chemistry

By

Maryam Mahdipour

Supervisors

Dr. Mohammad Ali Karimi

Dr. Hassan Karami

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IN THE NAME OF GOD

MODIFICATION AND MODELING OF THE SOME PROPERTIES OF LEAD – ACID BATTERIES

BY

MARYAM MEHDIPOUR

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.... M.A. Karimi, Ph.D., Assist., Prof. of Chemistry (Supervisor)

.... H. Karami, Ph.D., Assist., Prof. of Chemistry (Supervisor)

M.F. Mousavi.. M.F. Mousavi, Ph.D., Prof. of Chemistry

.... E. Shams Soolari, Ph.D., Assoc., Prof. of Chemistry

..M.M........ M. Mazloum Ardakani , Ph.D., Assoc., Prof. of Chemistry

.... M. Oftadeh, Ph.D., Assist., Prof. of Chemistry

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Dedicated to:

My dear husband,

BABAK

Who is,

My whole entity, ecstasy, truthfulness and lives story,

My confidant, far look and hope blossom.

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Abstract

Lead acid technology currently remains the most reliable, safe and affordable power source. None of the new developed battery types (e.g. Li-ion and Ni-MH batteries) has so far reached the commercial success of the lead-acid battery. This is partly a result of continues development and evolution of the lead-acid battery, which has led to major improvements in performance.

Lead acid batteries have a very large range of applications. Each use requires a specific technology in order to withstand the accompanying stress placed on the battery. Low cost, easy recycling and ready availability of raw materials are the main qualities of this battery system. They are widely used for power sources of automotive starters and interruptible power supplies (UPS), and the applications to power supplies for hybrid cars and load leveling systems are widely tried.

At the first part of this research cold cranking test for 17 sealed lead-acid batteries with grids of lead-calcium alloy at -18 °C was performed at different discharge currents. Time-voltage behavior of the batteries during of 10 s discharge and voltage values at discharge times of 30, 60 and 90 s and time of discharge for reaching to final voltage of 6V are critical points in the cold cranking test, which were modeled by artificial neural networks in MATLAB 7 media. 9 discharge currents were used for training set, 5 discharge currents for prediction set and 3 discharge currents for validation set. Maximum

prediction errors in modeling of time-voltage behavior during 10 s discharge (model 1), voltage of critical points of 30 s, 60 s, 90 s (model 2) and time of reaching to final voltage of 6V (model 3) were under 3.1%, 3.3%, and 3.5%, respectively for each model. The obtained results showed that the model can be used in battery industries for prediction of cold cranking behavior of the lead-acid batteries at high discharge current based on experimental cold cranking data at low discharge currents without using of expensive and complex instruments. It was made an applicable file (EXE file) based on the obtained model by WinNN 32 for inexpert operators in industries of lead-acid batteries.

The second part is devoted to the effect of sodium sulfate as negative paste additive on the performance of the lead-acid battery. The six different percentages of sodium sulfate were added to negative paste. The effect of sodium sulfate on discharge capacity, cycle life and cold cranking ability of the sealed lead- acid batteries were investigated. Batteries contain sodium sulfate in negative plates at low amount (0.1 wt %) showed a remarkable electrical behavior during the test. Results indicate that the capacity of the lead-acid batteries improved up to 3% before cycling test and with the use of sodium sulfate as additive of negative paste. Also adding of sodium sulfate caused the increase in time of reaching to cut off voltage of 6 V at cold cranking test more than 17%. The main effect of sodium sulfate is to increase the cycle life of the lead- acid batteries over than 18%. In addition, the present additive caused to increase the discharge capacity of the negative electrodes containing 0.1 wt% sodium sulfate more than 12% with respect to negative electrode without sodium

sulfate at the end of cycle life test. Scanning electron microscopy (SEM) was used for the investigation of paste morphology.

Keywords: Cold Cranking, Artificial Neural Network, Modeling, sodium sulfate, negative paste additive, Sealed Lead-Acid Batteries.

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