A STUDY ON THE IMPROVEMENT OF LOW TEMPERATURE PERFORMANCE OF LEAD ACID BATTERIES

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Abstract

The difficulties associated with the operation of lead acid battery at low temperatures are (1) low output capacity (2) poor charge acceptability (3) freezing of electrolyte at the end of discharge and (4) loss of electrolyte because of vigorous gas evolution. It has been proved that the cold performance of the battery is limited by the negative plates in most cases. Attempts have been made from time to time to improve the negative plate performance by incorporating organic additives, usually based on lignin derivatives.

At present most of the leading battery manufacturers in our country are using imported additives for the negative plates. The present paper reports the extent of improvement achieved by using lignin additives prepared from indigenous raw materials. The performance of cells containing eight different negative plate additives were compared with one without any additive. Based on the preliminary results experiments are carried out to optimise the quantity of the additives. The performance of automotive type of batteries containing the additive is compared with similar type of batteries without having any additive in the negative plate.

The lead acid system of storing electrical energy is widely used in different fields of applications, the more important among them is in the car service. In some instances the battery has to operate under extreme weather conditions during the year. It is not unusual for the military vehicles to experience a temperature range from + 45°C to −30°C in some parts of our country. The difficulties associated with fall of temperature while using lead acid batteries are (i) charging is a problem because of increased internal resistance of the cell (ii) freezing of the electrolyte at the end of discharge and (iii) loss of electrolyte during charging because of vigorous gas evolution.

Two possible methods of compensating the effect of low temperature are (i) to heat the battery using an external energy source and (ii) to improve the low temperature performance by some chemical means. Foster[1] has studied the method of heating the batteries using small heaters placed between the ribs of the separators. The energy for heating the battery was supplied by alternating current. This method of heating has only a limited applicability where a. c. source is readily available. Hence most of the investigations carried out on this aspect have been directed towards improving the cold performance of the battery by some chemical methods. It has been proved[2], that the cold performance of lead acid battery is limited by the negative plates in most cases. The use of lignin materials[3] as negative plate addition agent, other organic compounds[4] and ion exchange resins[5] were indicated in patents claiming a good low temperature performance. Ritchie[6] has made an extensive review on this subject of addition agents used in the lead acid battery industry.

With a view to assess the suitability of some of the addition agents for improved cold performance of lead acid battery, a few experiments were carried out at this institute and the results obtained are presented here.

Experimental

A total number of eight negative plate addition agents were taken for study. The addition agents are either organic compounds or commonly used ion exchange resins. Several lead acid cells were assembled with one negative plates at the sides. Though this type of construction is not generally used in the commercial cells, it gives us the scope for studying the negative plate performance. The addition agents were added to the negative paste prior to mixing and comprised 0.5% by weight of the lead oxide. Besides the addition agent all the negative plate compositions contain 0.3% barium sulphate and 0.15% carbon black. Similar cells containing only barium sulphate and carbon black were also assembled for

comparison. These cells were filled up with dilute sulphuric acid and charged. Capacity test at 20 hour rate was carried at room temperature. Then the cells were discharged at fixed rate of 42 amps which corresponds to approximately $3 \times C_{20}$ rate of discharge. This test was carried out at several temperatures from $+30^{\circ}C$ to $+5^{\circ}C$.

Based on the results compositions which have given encouraging results, were taken up for further study. Experiments were carried out to optimise the quantities of these addition agents.

A few automotive type batteries were assembled incorporating these addition agents and their performance at different temperatures was compared with similar type of batteries but without the addition agent.

Results

The list of additives used in this experiments and the average 20 hour rate capacity of the cells containing these additives is given in Table I. It can be noted that the cells containing lignin and benzidine sulphate above have given encouraging results. Fig. 1 gives the performance of the cells at $3C_{20}$ rate at different temperatures down to $5^{\circ}C$. The results are expressed in terms of the discharge time at $27^{\circ}C$ of the control cell taken as 100%. Here again the addition of lignin and benzidine sulphate resulted in a marked improvement in the performance. The improvement in the performance due to the inclusion of ion exchange resin additives is almost negligible.

Based on the above results, the performance of a number of cells containing various proportion of lignin and benzidine sulphate, we studied in order to optimise the quantity of the additives. The tests were conducted at $3C_{20}$ rate of discharge and various temperatures from $+30^{\circ}C$ to $-40^{\circ}C$. The results are given in figures 2 and 3. It may be seen that there is an increase in discharge time upto a proportion of 0.5% by weight and thereafter it decreases with further increase in the quantity of the additives.

The extent of improvement in the high rate performance obtained as a result of lignin additive in automotive type battery plates can be seen from figures 4 and 5. Here two sets of batteries were assembled, the first set consists of 6 volts 110 Amp hrs capacity and the other is 12 volts 92 Amp hrs capacity. In each set, 4 batteries were assembled, two with additives and two without additives.

Discussion

The use of lignin as an additive is known in battery industry as early as 1920. However a number of varieties of lignin derivatives are known depending upon the method employed for isolating the lignin from different types of wood, thus making the choice of proper quality of lignin for batteries more difficult. Most of the leading battery manufacturers in our country are using proprietary materials such as VINDYKE BROWN or XEWOXYL which are imported at present. The lignin derivative described in this paper is prepared from indigenous materials.

In a previous paper[7], it was shown that the addition of carbon black to the positive plate improves the capacity output. In order to get improved performance both positive plate and negative plate additives can advantageously be used as described in an Indian Patent[8].

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Table I. 20 Hour rate capacity of cells containing different addition agents in the negative plates (0.5% by wt.)

Serial No.	Name of the addition agent		20 hr capacity at 27°C (Amp-hrs)
A	No addition	....	14.3
B	Lignin	....	20.2
C	Dialdehydestarch	....	16.6
D	Amberlite IR 120	....	17.2
E	Deacidrte	....	16.5
F	CNSL resin	....	15.9
G	Sulphanilic acid	....	13.0
H	Dianisidine	....	12.6
I	Benzidine sulphate	....	18.7

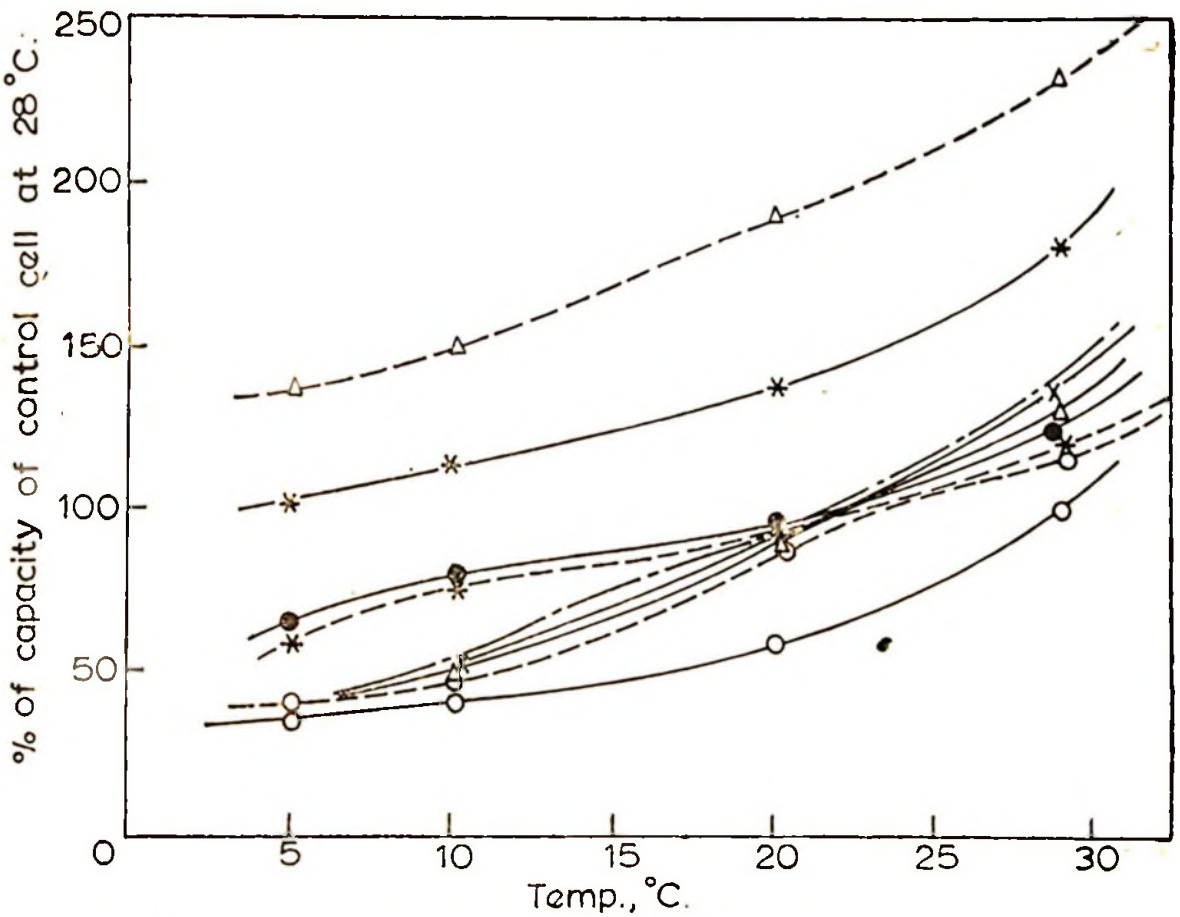


Figure 1 Comparative performance of lead acid cells containing various types of negative plate addition agents,

(1) A —0—0— (2) B —Δ—Δ—
(3) C —0—0— (4) D —●—●—
(5) E —χ—χ— (6) F — · — · —
(7) G —*—*— (8) H —Δ—Δ—
(9) I —*—*—

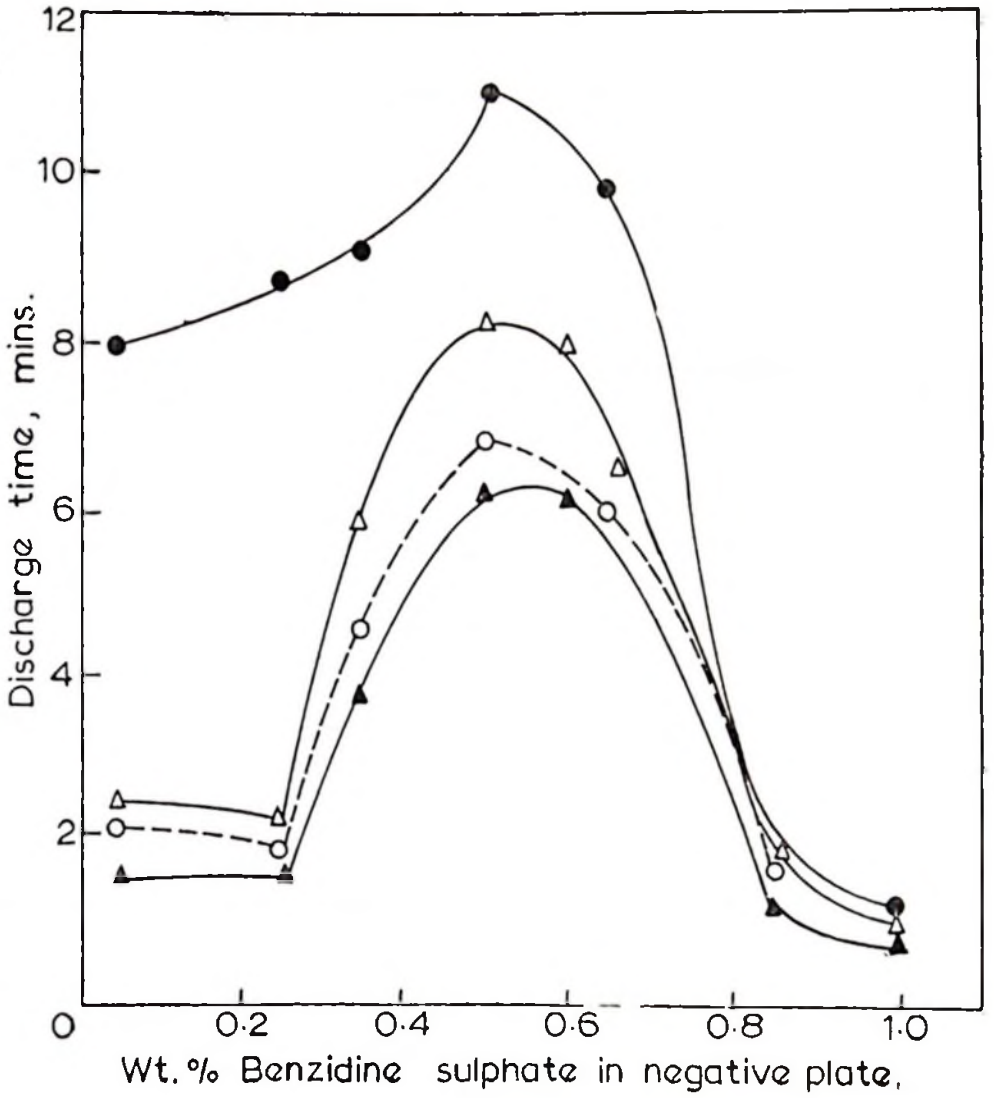


Fig. 2 High rate performance of negative plates containing different proportions of addition agent at different temperature.

Name of the addition agent : Benzidine sulphate.

Rate of discharge : 42 amps,

1) —●—●—28°C
2) —Δ—Δ—Δ—20°C
3) —○—○—○—10°C
4) —▲—▲—▲—5°C (closed)

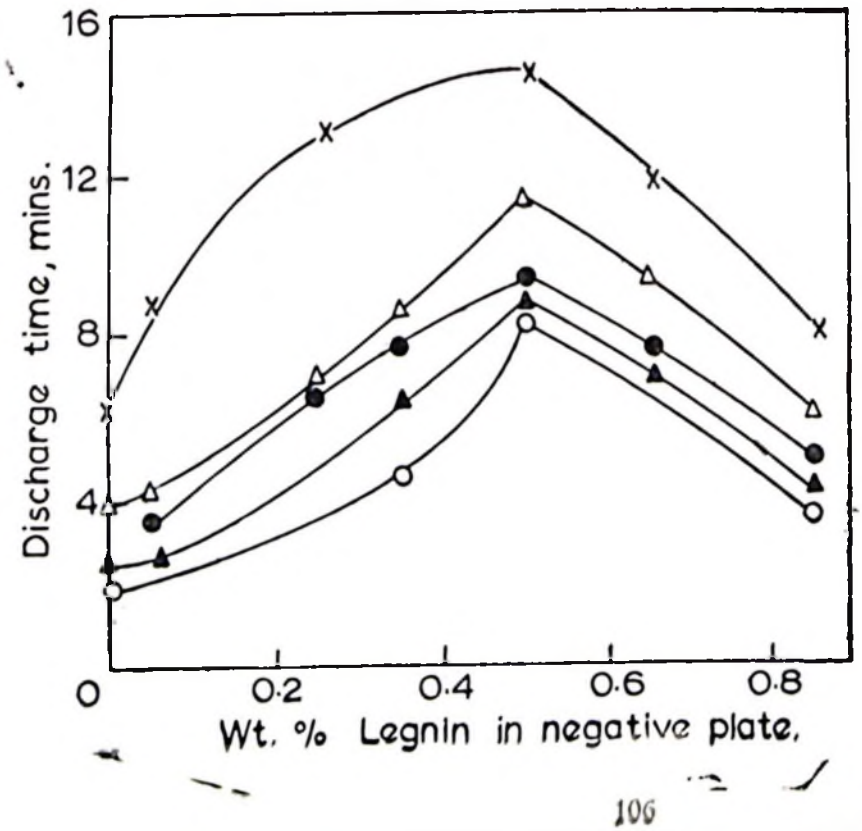


Fig. 3. High rate performance of negative plates containing different proportion of addition agent at different temperatures.

Name of the addition agent : Lignin compound

Rate of discharge : 42 amps,

1) —×—×—×—28°C
2) —Δ—Δ—Δ—20°C
3) —●—●—●—15°C
4) —▲—▲—▲—10°C (closed)
5) —○—○—○—5°C

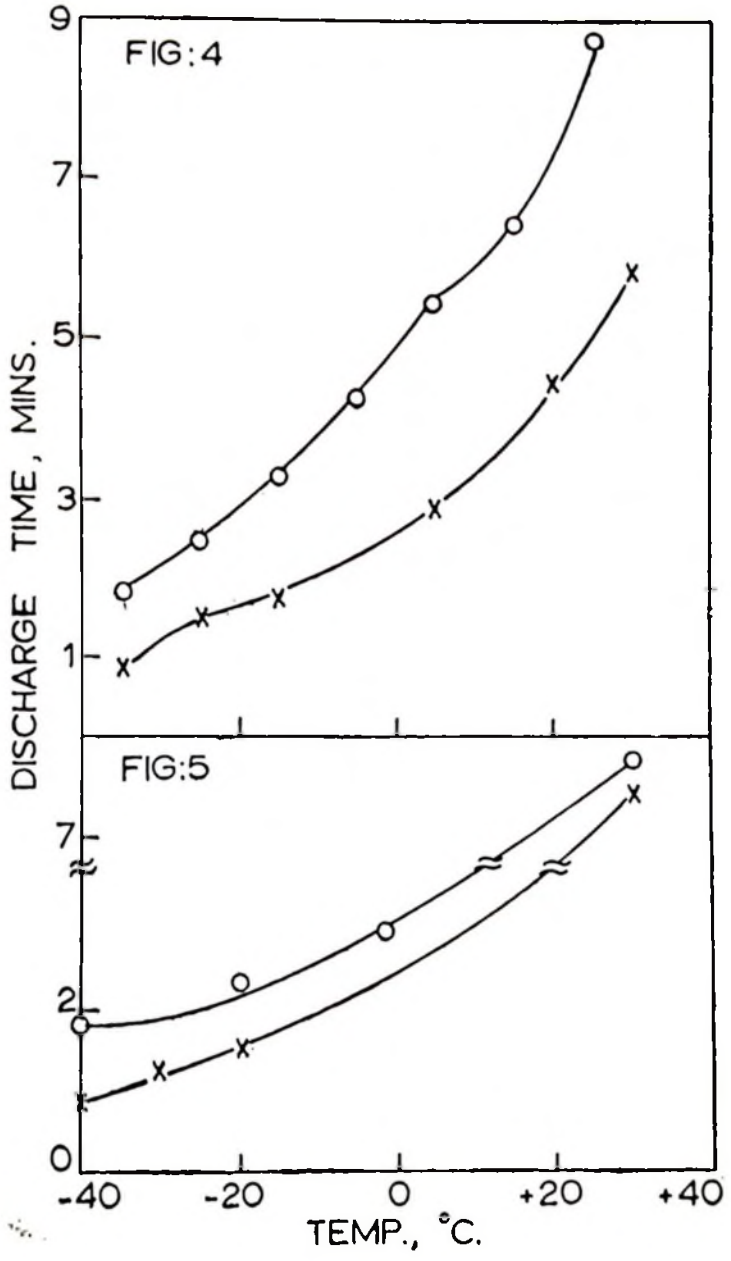


Fig. 4 High Rate Performance of automobile battery with and without negative plate additive (6V, 110 AHS),

—0—0—0— With additive (lignin)

—χ—χ—χ— Without additive

Fig. 5 High rate performance of automobile battery with and without negative plate additive (12V, 92 AHS),

—0—0—0— With additive (lignin)

—χ—χ—χ— Without additive