Car and Renewable Energy Storage Accumulators Active Life Extension for Hazardous Wastes Eco-impact Minimization

O. Ustun*, M. Yilmaz*, P. Ali-Zada**, R. N. Tuncay**, H. Mamadov***

*: Faculty of Electrical and Electronics Engineering, Istanbul Technical University, Istanbul, 34469 Turkey,
**: Faculty of Engineering & Architecture, Okan University, Istanbul 34959, Turkey
***: Azerbaijan Technical University, Baku 1143, Azerbaijan
oustun@itu.edu.tr, myilmaz@itu.edu.tr, parviz.alizade@okan.edu.tr, nejat.tuncay@okan.edu.tr, hmamadov@aztu.az

Abstract— ***The chemical nature of an accumulator battery is likely to defeat the ability to charge. Traumatic damage is being caused to the environment by the accumulator waste-pollutants: sulfuric acid and lead from the accumulators. Similar problems arise with different types of accumulators (NiCd, NiMH, Li-ion, Li-Polymer, etc.) This leakage seeps into waterways, soil and the air of the living beings, animals, birds and humans, especially to children. The paper outlines an examination of a cheap and smart experimental charging-discharging device, which helps getting a significant extension of the active life of car and renewable energy storage accumulators, as well as known methods, therefore minimizing the environmental impact of batteries wastes. Having known the limiting crystallization, it is possible to extend the battery active life cycles more than three times, provide a remediation of these environmental polluting effects and diminish the environmental impact of accumulator hazardous wastes on living organisms.***

Keywords - accumulator life extension, hazardous wastes, environmental impact minimization.

I. INTRODUCTION

The problem of disposing the accumulators and plain batteries has become so severe that some governments had passed strict laws trying to control it. Many of them literally ban battery disposal all together. Others mandate some recycling programs, but it is estimated that only about 75% of all dead accumulator batteries, according to Scott (1989) [9], are actually recycled in the developed countries and the remaining are still buried in landfills and impact on the natural environment. Meantime, the other measures need to be taken, especially in the developing and low-income countries. The most effective and obvious measure for reducing the number of discarded electric car accumulators (Fig. 1) is to keep them in service as long as possible. And the most effective way is to use the modern charging-discharging systems. The majority of the old used-up car accumulators are actually still usable. The problem is that their plates have become so coated with the sulfate (or crystals) deposits, that as a result they can no longer accept and release energy as earlier.

Thus, it is very important to study and design some new effective controlled charging-discharging devices keeping an accumulator battery life as long as possible. In the past, nothing could be done for solving this major problem. But now the pulse technology presented by Deordiev (1985) [4] and Scott (1989) [9] and some others can eliminate sulfation or crystal buildup and even cleansing and practically recovering the battery plates. As a result of chemical process,

Fig. 1. Students' project - experimental solar + accumulator car.

the 75-80% of all batteries, that die every year due to sulfation buildup, will last longer because they will not have to be discarded. The pulse technology utilized by these chargers extends battery life significantly by maintaining it in good conditions for long time. These technologies are unique because they are the available techniques for removing almost all sulfation buildup (lead sulfate) from accumulator plates. According to the survey of Scott (1989) [9], the crystal buildups and related problems are the main reasons for more than 80% of all accumulator failures every year.

The increase in number of mobile energy consuming equipment, such as mobile phones, computers and other communications equipment, handheld lights, especially electric vehicles, represents a new challenge to environmental conservation. Large numbers of practically non-recyclable and old recyclable disposable batteries are handled together with communal waste and create a contamination hazard.

The most important sources of the hazard are as follows: a manganese dioxide, mercury oxide, zinc, cadmium, lead and nickel content in the rechargeable batteries. Released into the groundwater, these substances may dissolve in an acidic medium, causing poisoning.

The total replacement of non-rechargeable batteries with domestic rechargeable batteries, which may be used several times over, can help in solving the problem. It is obvious that one rechargeable battery with its lifetime of 500-1500 cycles can replace an equal number of the disposable batteries, thereby decreasing the contamination of the environment.

Today it is recommended to use rechargeable batteries containing different electrodes instead of poisonous ones. The rechargeable batteries should not contain any substances being marked as highly poisonous, but those which may be characterized by the following statements: “May cause cancer; may have a mutagenic effect; damage fertility, etc.”

As a sealed lead-acid accumulator battery gets older or sits unused for long periods of time, the lead sulfate crystals appear on the battery plates and enlarge the area where they create a quasi insulating barrier. Before long they build up and become so intense that the battery can no longer accept or release its nominally stored energy. This is the main reason all the lead-acid batteries die in “harness”. Similar problems arise in different forms of crystallizations, on their electrodes, a layer of NiCd, NiMH, Li-ion, Li-Polymer even in the modern accumulators. The plate’s corrosion (crystallization) is the main cause and effect behind decreased accumulator battery performance with age. According to Scott (1989) this effect is almost linear.

The study describes both accumulators for powerful cars and renewable energy storage accumulators, hand-held power tools (such as power saws, drills, screwdrivers, etc.) and similar devices and also describes the various principles and devices of some known and designed by authors (patented) asymmetrical pulse charger-dischargers – sophisticated, plain and the simplest ones with their diagrams and real oscillograms.

II. ACCUMULATORS FOR MOBILE DEVICES

Today for mobile devices, portable computers and mobile renewable energy equipment there are used most of all the following accumulators: sealed lead-acid (SLA), nickel-cadmium (NiCd), nickel-metal hydride (NiMH), lithium-polymer (Li-Pol) and lithium-ion (Li-ion) ones. Besides, the lithium-polymer (Li-Pol) accumulators are becoming more and more popular in the sphere of cellular phones and portable computers. The major technical characteristics of their main types are shown in Buchmann, (1999) [6], Vasiliev (2000) [10].

A. Simple Pulse Charger-Dischargers

There are several approaches to charging processes and battery chargers designs. The main of them are: Slow Charger, Quick Charger and Pulse Charger-Discharger. The last one frequently helps in battery desulfation (de-crystallization) processes and extends accumulator life. Therefore, a charger-discharger is under rapt attention in the paper. It has been shown in Deordiev (1985) [4], Dmitrienko (1987) [5], and Scott (1989) [9], that due to a regular charging-discharging service of every accumulator, the number of working cycles can reach as high as 4000 instead of 1500 cycles guaranteed by manufacturer (or to extend its life 2-3 times); but providing a seldom-used charging service, the number of working cycles is reduced more than 3-4 times. It is not recommended to reject even an old accumulator beforehand: there is a treatment, based on different pulse charging-discharging devices, which may help to recover the accumulator battery. Unfortunately, some of the charging-discharging devices are rather expensive.

The main point of the paper is to present to low-income consumers the simplest and cheapest options, as well as the electronic diagrams of the charging-discharging simple or controlled devices (of almost the same efficiency, as well-known ones), which can be assembled in any school workshop using elements of electronic scraps just to extend life of the accumulator.

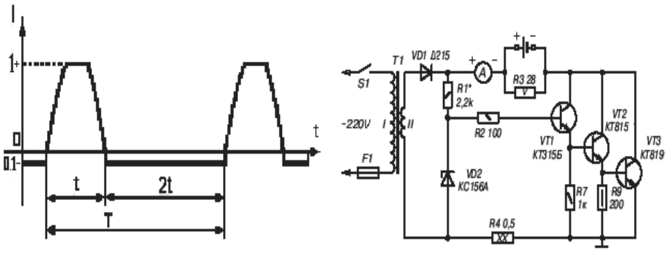

Fig. 2. Recommended by Deordiev C.C. (1985) [4] charger-discharger and its current oscillogram.

The recommended in Russia Deordiev (1985) [4] long time ago well-known asymmetrical charging-discharging device and its current oscillogram are presented on Fig. 2. The device provides all the required charging current, I_{ch}, and controls the recommended, based on Deordiev’s many years experience in USSR, discharging current, $I_d \approx (0.05 - 0.12)\times I_{ch}$; on R_3 – an optimal $I_d \approx 0.1\times I_{ch}$. The other diagrams [Scott (1989) and Liaskovskiy (1998)], consisted of more than 40 electronic elements, are relatively sophisticated and complicated.

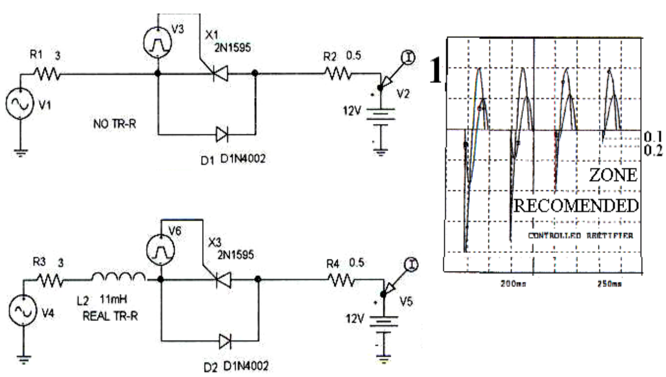

Fig. 3. One-phase diode-thyristor asymmetrical pulse charger-dischargers.

Each of the next presented two asymmetrical charging-discharging devices diagrams has got the discharging thyristor rated for ~10% of charging current, but there are smaller resistances to discharge in the total circuits and less unfounded power losses. The recommended by Ali-Zada and Uyar (2004) working charge-discharge zone is shown on the oscillogram of Fig. 3.

The other cheap and even simpler one-pulse diode-diode type asymmetrical pulse charge-discharge rectifier presented by Gazizov M. (1986) [3] is presented on Fig. 4,with the same recommended $I_d \approx 0.1 \times I_{ch}$, but nevertheless it can be varied by choosing the resistors. Its main disadvantage is the additional power losses in the both resistances as well.

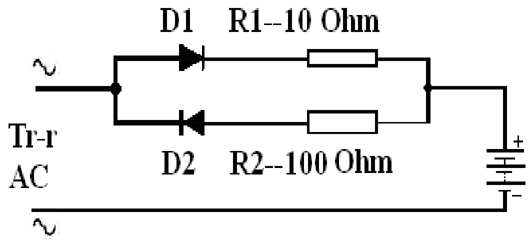

Fig. 4. One-phase simple diode-diode asymmetrical pulse charger-dischargers.

B. Main Principles of Designing a Simple Diode-Capacitor Pulse Charge-Discharger.

For the students' project design of the solar + accumulator car, the recommended charger-discharger is shown in Fig. 5.

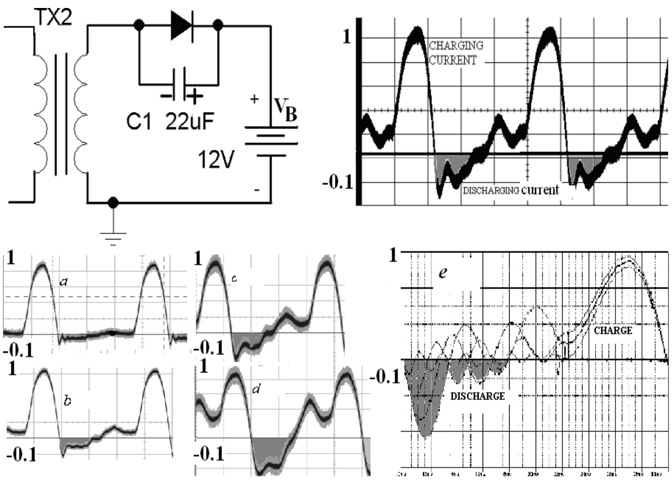

Fig. 5. Pulse charge-discharger with capacitors (*a* – 4.7µF, *b* –14.7µF, *c* – 22µF and *d* – 47µF) parallel to diode and real oscillograms; *e* – results of multi-variant studying the PSpice-model.

The basic diagram of a simple, one-diode, cheap pulse charging-discharger presented by Mammadov and Ali-Zada (2007) [8] is shown on Fig. 5. Adding a capacitor (an electrolytic or other one) in parallel to the diode helps getting the charge and the discharge current. During the positive half-wave of the transformer's secondary voltage through the diode, there takes place the process of charging the battery. Limiting the reverse current value is an important issue.

Consequently, during the negative half-wave of the secondary voltage, there takes place the discharging procedure in the battery (recover accumulator): it is happened due to the two sources in-series of the capacitor charging process: the battery voltage V_{bat} and the secondary maximum voltage V_{2max} connected in sequence with the negative half-wave of the transformer.

It makes together almost the double battery voltage providing the discharging current which can be controlled by the capacitance value of the capacitor. The procedure repeats periodically.

Due to the transformer inductance here are some small fading periodical processes being even beneficial for the de-sulfation (de-crystallization) processes according to Scott (1989) and Ali-Zada and Uyar (2004).

This cheapest pulse charging-discharging device, PSpice model, has been carefully analyzed during the study and the results are shown in Fig. 5.

III. A SMART SELF-CONTROLLING CHARGER-DISCHARGER

The block-diagram offered by Mammadov and Ali-Zada (2007) of the self-controlled, on the recommended level $I_d \approx 0.1 \times I_{ch}$, more sophisticated variant of the pulse charging-discharging diagram of Fig. 5 is shown in Fig. 6. Here is additional Block 1 for smartly, automatically changing the value of the capacitor, connected in parallel with the diode, to an appropriate value. There are two current sensors: for reading A1-charging and A2-discharging currents; and Block 2, which makes a comparison between their readings $\Delta I = (I_d - 0.1 \times I_{ch})$ and reacts in the quasi-fuzzy logic way:

If $\Delta I > 0.11 \times I_{ch}$, Block 2 sends a signal to Block 1 to reduce its capacitance, and conversely,

If $\Delta I < 0.099 \times I_{ch}$, Block 2 sends a signal to Block 1 to increase its capacitance, and finally,

If $0.11 \times I_{ch} > \Delta I < 0.099 \times I_{ch}$, Block 2 does not send any signal to Block 1 – no need to change its capacitance (to avoid the relay blinking).

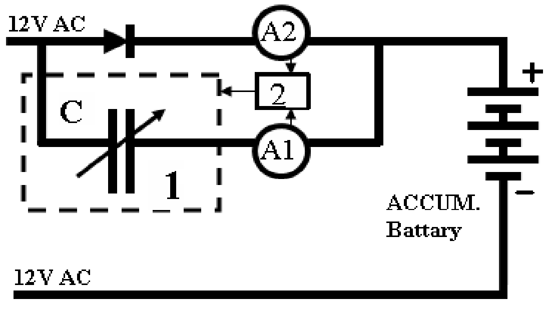

Fig. 6. Diagram of a self-controlled device.

Here it is simply used the relay natural dead band. All these things are beneficiary in keeping the recommended level $I_d \approx 0.1 \times I_{ch}$ constant, while the charging current I_{ch} varies (due to any reason) throughout the battery treatment process.

It should be taken into consideration that almost all the time the process of charging any accumulator occurs at the maximum permissible level of the charging current and it automatically diminishes to zero only at the closing charging stages [1,2].

So, it is enough just having two capacitors of value C_{min} and C_{ad} to curry smartly the de-crystallization discharging process; and the circuit is simplified just to the current relay and two capacitances (in Fig. 7: V_{qch} – quick charge voltage, V_{ch} – normal charge voltage and V_{dec} – de-crystallization voltage).

The relay-controller approach to quick-charging the accumulator battery had been presented in detail in the authors' paper based on fuzzy logic theory (Ali-Zada and Uyar (2004) [1, 2], and so the life-saving electrical discharging (de-crystallization) simplified fuzzy rules, mentioned above, can be just added to the total fuzzy rules table.

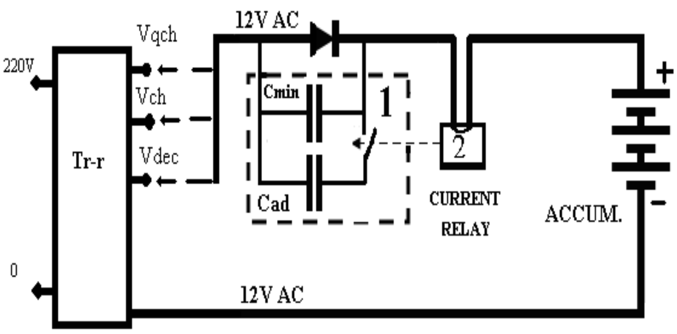

Fig. 7. Plain diagram of the simplest battery-life-saving smart charging-discharging device.

But, as it was pointed out here before, the main point of the paper is to present the simple electronic devices, both the simplest and cheapest but effective enough, for low-income people. The electronic circuits of the charging-discharging devices can be assembled easily even by students in any school workshop from elements of electronic scraps. Therefore it can help in minimizing an environmental impact of accumulator wastes.

IV. CONCLUSION

While limiting crystallization, it is possible to extend the life cycle of a battery more than three times, to provide a remediation of these environmental polluting effects and to diminish the ecological impact of accumulator wastes on living organisms. The pulse charge-discharge device with the parallel capacitors to the diode was tested on the several dozens SLA of Istanbul Technical University's experimental solar-electric vehicle accumulators for the de-sulfation (resumption) process (PSH-1280 F2, Hr, 12V, 8.5 A) and on the numerous Li-polymer (P-100AASJ) accumulator batteries for the de-crystallization process; and the device had shown good results – better, than that guaranteed by manufacturers, similar to the same resumption efficiency as the mentioned above others methods [11, 12]. It can be used as quick chargers for electric tools' Li-polymer accumulators, for normal SLA car battery chargers, portable computers, power stations control DC relay system chargers, telephone centrals, train wagon accumulators controlled chargers, renewable energy power storage accumulator structures and other equipment.

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