How the Desulfator Really Works

Hi all! Let me introduce myself. I am a retired electrical engineer with 30+ years of experience in high tech R&D projects. I now live in Montana and have lots of battery trouble. Having a two fishing boats, two snowmobiles, two ATV's, a lawn tractor and two trucks, I have a lot of problems each spring getting stuff started. An Internet search led me here.

I was prepared to refute the "resonant frequency" theory; however I think everyone will agree it is now debunked. In July of 2005 Don Denhardt is quoted as saying, "The sulfate crystals do not vibrate or resonate. That was a theory proposed initially but has since been debunked…In the end, it's the voltage, not the vibration, that works... At least, one myth has been debunked. The process moves on...Desulfation does work." So I will not waste the space to debunk the already debunked theory.

I will concentrate on how the desulfator really works. This theory assumes that the mechanism is the electrostatic force caused by the voltage applied to the battery. To recap: sulfation is the build up of lead sulfate on the battery plates. Sulfate is a dielectric material with a dielectric constant around 35. As the sulfate forms, it reduces the operating surface area of the plates and therefore raises the internal resistance of the cell. It also forms a capacitor with one side the plate of the battery and the other side the electrolyte of cell. There is a capacitor on each plate on the cell. The conductivity of the electrolyte connects the two capacitors in series. From this theory we should expect to find that a sulfated battery could be modeled as a resistance in parallel with a capacitor. More on this later.

When a capacitor is charged with a voltage, a force of attraction exists on the two plates, regardless of the polarity of the voltage. Since one plate is the electrolyte, which is free to move, the force will be felt by the sulfate crystals. The application of a pulsed voltage causes the electrolyte to vibrate like an ultra-sonic cleaner and thus scrubs the plates of the sulfate.

The equation of the force of attraction is F=0.5*C*V*V/t, and is taken right out of the engineering handbook. Astute observers will note that this is nothing more than the energy stored in the capacitor divided by the thickness of the dielectric, t. Given that C=K*Eo*A/t the final formula becomes: F=K*Eo*A*V*V/(t*t), where A is the area of the plate, Eo is the permittivty of free space, K is the dielectric constant of the sulfate, and V is the applied voltage. Note that the force is proportional to V*V making it independent of polarity.

As we can see, the force is dependent only on the voltage, not the current. Given the low impedance of the cell it may take a high current to achieve the voltage. This also tells us that the force is inversely related to t*t, so that a heavily sulfated cell gets less scrubbing action and will take longer to desulfate.

One can verify this model by measuring a battery, as I have done, using modified version Alastair's test circuit, with the sine wave generator replaced with a square wave. Set the generator to a low frequency, say 100Hz and measure the peak-to-peak voltage, replace the cell with a resistance box and adjust it to the same voltage. This will tell you the resistance of the cell. Several of my gel batteries came out in the range of about 500-1000 ohms. Then set the generator to a high frequency of say 100kHz and notice the voltage becomes a triangle wave. Measure the peak to peak voltage and then use a capacitance box to achieve the same voltage. This will tell you the capacitance of the cell. Mine was about 0.01-0.02 uF.

Now lets discuss how the circuit works with the battery. When the transistor turns off, the current stored in the inductor causes it to "flyback" until the output diode conducts. The current starts flowing in the battery. This forms a resonant circuit with the output inductor (220 uH) in series with the capacitor of the cell. The output voltage is one quarter of a cycle of the resonate frequency (about 100kHz in my case). When all the energy in the inductor is transferred to the capacitor, the diode turns off as the current has gone to zero. This means the rise time of the peak voltage is slow, in the order of about 2.5 usec. When the diode turns off the cell discharges itself with its internal resistance (the time constant is about 10 usec) until it reaches the residual cell voltage or the transistor turns on again. These waveforms are shown on some of the posts to this board. Of course, the exact values will depend on the cell in question. Any high frequency ringing seen in these photos are the result of parasitic lead inductance and capacitance of the circuit and are not due to the "resonance" of the crystals.

Now let us turn to the operating parameters. The maximum scrubbing effect will depend on the pulse width, pulse repetition frequency (PRF), and the conductivity of the electrolyte. Since physical movement is required, the force must be applied long enough to accelerate the electrolyte and move it far enough to do some good, so too short a pulse is not good. In order to get the maximum scrub, the relaxation time between pulses must be long enough to allow the electrolyte to return to its starting point. Since it is not driven while relaxing we can expect that the relation time will be many times longer than the drive pulse. Waiting longer than this is not efficient. Since we have no detail about the dynamics of the electrolyte, we cannot calculate these values. The PRF must also lie in the range of frequencies in which the electrolyte is a good conductor. This is between 1kHz and 10MHz, so we have lots of latitude here. It should be noted that a heavily sulfated cell would have lower conductivity as the acid has been depleted from the cell by the sulfate. It is clear that experimentation is required to optimize these values.

That is all for now, I have my flame suit on so blast away, Ed.