"SEMI SOLID FLOW CELL-A PROMINENT ROOTAGE"

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ABSTRACT:

Battery imparts energy in chemical form that can be deputized in the place of fossil fuels in Automobiles. This electrical power is utilised by the automobile ignition system for cranking the engine and for the ensuing operations. The car's battery may also manoeuvre the lighting system and other peripherals. When the alternator fails, the battery is necessitated for powering the vehicle's entire electrical system for a petite period of time. With advancement in the research, it is indisputable that there will be a new age where IC Engines will be renounced. Due to its reliable nature and portability, the flow cell can provide high performance with minimal effluent wastage and it is eco-friendly.

KEY WORDS: SSFC, LITHIUM ION, VANADIUM PHOSPHATE,IC ENGINE,EMISSION.

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BATTERIES IN CONTRAST WITH SSFC:

A battery is a transducer that converts chemical energy into electrical energy and vice versa. Including an anode, a cathode, and an electrolyte, an electrical **battery** is one or more electrochemical cells that convert stored chemical energy into electrical energy. An **automotive battery** is a type of rechargeable battery that supplies electric energy to an automobile. Usually this refers to an **SLI battery** (*starting, lighting, and ignition*) to power the starter motor, the lights, and the ignition system of a vehicle's engine. It may also be a traction battery used for the main power source of a vehicle.

A **flow battery** is a form of rechargeable battery in which electrolyte containing one or more dissolved electro active species flows through an electrochemical cell/stack that converts chemical energy directly to electricity. Additional electrolyte is stored externally, generally in tanks, and is usually pumped through the cell (or cells) of the reactor, although gravity feed systems are also known. Flow batteries can be rapidly "recharged" by replacing the electrolyte liquid simultaneously recovering the spent material for re-energization

The cell potential is determined by the difference between the chemical potential of the lithium in the anode and cathode.The batteries, known as "semi-solid flow cells," store their power in a black gunk that looks like motor oil, which has earned it the nickname "Cambridge Crude." Because charge is stored in this liquid, it would be possible to "fuel up" an electric car with charged liquid electrolyte, just like fueling up at a conventional gas pump.

BATTERY AND ITS CONSTRAINT:

By harnessing electricity to perform the operations that were once performed manually, computers have made obsolete legions of mechanical devices. Now electronics is poised to replace the gas-guzzling internal combustion engine with electric motors driven by pumpable fuels that bear electrons as their active elements. Semi-solid flow cells can be used for such effective replacement.

A second knock against electric vehicles is that their batteries are less energy-dense, and therefore heavier, than an equivalent amount of gasoline. But the new semi-solid batteries could be up to twice as energy-dense as conventional lithium-ion batteries, which mean that car manufacturers could get twice the range out of the same battery mass.

The batteries could also be constructed at lower cost than conventional ones, which makes them suitable for giant, grid-scale applications like storing power from intermittent renewable sources

THE IC ENGINE:

Battery-powered, fuel-cell electric, and hybrid vehicles are technologically viable alternatives to the internal combustion engine now, and they are probable to be economically doable within the decade.

The internal combustion engine is an all-around power source, used in the whole lot from lawn movers to rockets. It is most commonly allied with the car and other road transport vehicles, and it is this union that has come under mounting criticism and scrutiny in recent years. With an upward awareness of the risks of pollution to both health and the environment, the engine has become not as much of desirable one and practical alternatives are being sought by governments, corporations, and environmental groups worldwide.

THE PHENOMENON BEHIND IT:

Essentially, an internal combustion engine facilitates like a cannon. A flammable substance, such as gasoline, is ignited in a small, enclosed space, and the resulting explosion releases energy in the form of expanding gas that can propel an object with great force. A typical car engine has hundreds of such explosions a minute, and harnesses some of the energy produced to turn the drive shaft. As the name implies, the combustion takes place within the engine, as opposed to an external combustion engine, where the fuel burns outside of the engine, such as in a steam-powered train.

Today, the internal combustion engine is the dominant automotive engine worldwide. However, there were many other alternatives proposed and produced in the early days of automobiles, including electric, steam, and even liquid air-powered cars. Electric cars were also quieter—some were almost silent—and did not produce unpleasant exhaust fumes.

NEED FOR REPLACEMENT:

Though the internal combustion engines are noisier, hotter, and dirtier than electric motors, they began to dominate the car market. Other types of cars had their own problems. Early electric batteries were heavy and corroded quickly, needing to be replaced every two years, and there were many cases of battery leaks producing noxious fumes.

While these engine-driven cars dominated the twentieth century, the twenty-first seems likely to see the reintroduction of electric cars. There are compelling reasons to find alternatives, from a greater awareness of the effects of pollution and dread over global warming, to concerns that the supply of oil is drying up and making it more difficult and costlier for extraction.

The substitute to the internal combustion engine is the electric powered vehicle. Small numbers of battery-powered, fuel-cell electric, and hybrid electric vehicles are in use today, and there is a worldwide race to pursue more of the new technology vehicles on the road.

REDUCING THE EMISSIONS:

Catalytic converter malfunctions produce significant increases in hydrocarbon(HC), carbon monoxide (CO), and nitrogen oxide (NOx) emissions of 297%, 211%, and378%, respectively, during cruising operations. Furthermore, increases of 63.4%, 26.9%, and 76.1% are observed during acceleration manoeuvres. Under extremely aggressive driving conditions, both normal and high-emitting vehicles produce very high emission rates. The highest impact of catalytic converter malfunction occurs in the 45- to 85-km/h speed range at mild acceleration levels for HC and CO emissions and between 20 and 55 km/h at high acceleration levels for NOx emissions. catalytic converter malfunctions produce overall increases in HC, CO, and NOx emissions in the range of 251%, 225%, and 336%, respectively

Some of the minor emissions of IC engines are

DIURNAL

Gasoline evaporation increases as the temperature rises during the day, heating the fuel tank and venting gasoline vapours.

RUNNING LOSSES

The hot engine and exhaust system can vaporize gasoline when the car is running.

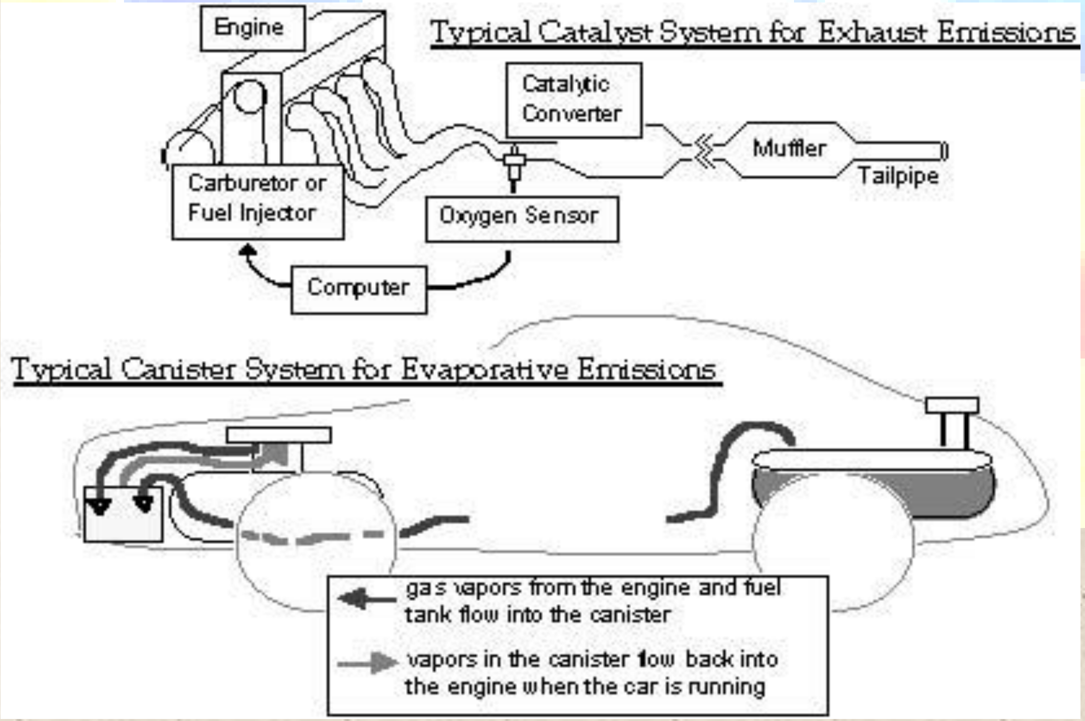
HOT SOAK

The engine remains hot for a period of time after the car is turned off, and gasoline evaporation continues when the car is parked.

REFUELING

Gasoline vapours are always present in fuel tanks. These vapours are forced out when the tank is filled with liquid fuel.

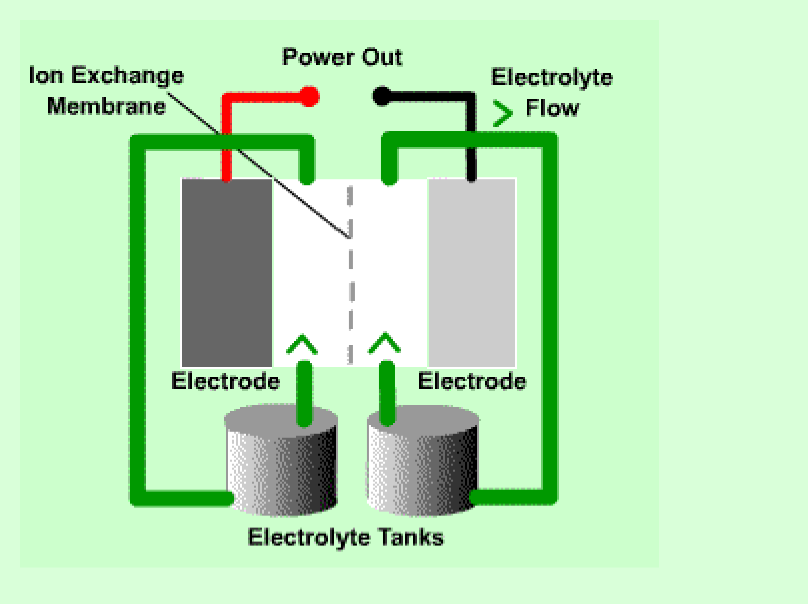
METHOD TO MINIMISE EMISSION



These complexities involved in the IC engines and its emission can be truncated by employing Semi Solid Flow Cell.

FLOW CELL WORKING:

Flow cells allow storage of the active materials externally to the battery and these reactants are circulated through the cell stack as required. The first was Zinc/chlorine battery in which the chlorine was stored in a separate cylinder. It was first used in 1884 by Charles Renard to power his airship La France which contained its own on board chlorine generator.



Modern flow cells are generally two electrolyte systems in which they act as liquid energy carriers, are pumped simultaneously through the two half-cells of the reaction cell separated by a membrane.

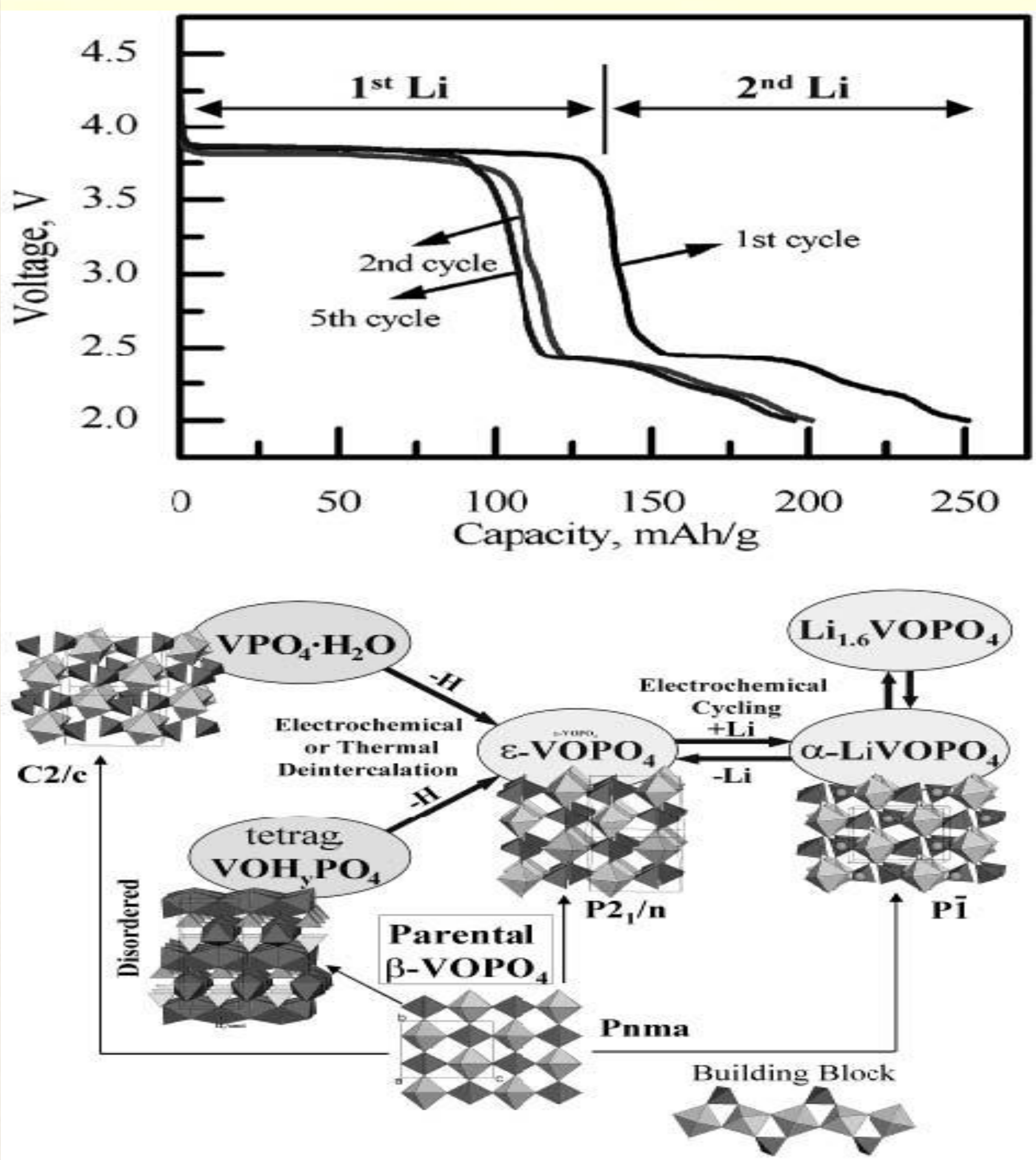
On charging, the electrical energy supplied causes a chemical reduction reaction in one electrolyte and an oxidation reaction in the other. The thin ion exchange membrane between the half-cells prevents the electrolytes from mixing but allows selected ions to pass through to complete the redox reaction.

On discharge the chemical energy contained in the electrolyte is released in the reverse reaction and electrical energy can be drawn from the electrodes.

When in use the electrolytes are continuously pumped in a circuit between reactor and storage tanks. High power batteries are constructed using a multiple stack of cells in a bipolar arrangement.

The power rating of the system is fixed and determined by the size and number of electrodes in the cell stacks, however the great advantage of this system is that it provides almost unlimited electrical storage capacity, the limitation being only the capacity of the electrolyte storage reservoirs.

ROLE OF VANADIUM PHOSPHATE IN FLOW CELLS



The VOPO4 compound has particularly interesting properties, with an approximately 4 V flat discharge potential some 0.5 V higher than LiFePO4 and with higher electronic conductivity, leading to the possibility of attaining higher power systems than for LiFePO4 but at the expense of higher cost. The VOPO4 can be synthesized by removal of the hydrogen atoms from VPO4,2H2O(dH2VOPO4) either thermally or by electrochemical de-intercalation.

H2VOPO4 on electrochemical oxidization in a LiPF6/EC-DMC solution gives VOPO4,that can be reduced by reversing the current flow to give first LiVOPO4 As expected from the ease of these reactions, the structures of all four compounds are closely related.

If still a higher redox potential is desired, then heating VOPO4 with LiF and carbon black at 550 °C for 15 min and then rapidly cooling to room temperature leads to the formation of LiVPO4F.This compound is iso-structural with LiMPO4(OH) (M) Fe, Mn). It has a potential of 4.2 V and a capacity of 0.55 Li per formula unit or 156 mAh/g.

SEMI SOLID FLOW CELL:

- New Lithium rechargeable semi-solid flow cell offers energy densities an order of magnitude greater than previous flow batteries making possibility for applications in transportation and grid-scale storage. The technology could even make “refueling” such batteries as quick and easy as pumping gas into a conventional car.
- One important characteristic of the new design is that it separates the two functions of the battery — storing energy until it is needed, and discharging that energy when it needs to be used — into separate physical structures. (In conventional batteries, the storage and discharge both take place in the same structure.) Separating these functions means that batteries can be designed more efficiently.
- On using established lithium intercalation compounds, energy densities of 300–500 Wh L^{-1} (specific energy of 130–250 Wh kg^{-1}) at system-level costs, depending upon the chemistries, of \$250 kWh^{-1} and \$100 kWh^{-1} could be delivered. The new SSFC system retains the inherent advantages of a flow architecture while dramatically increasing energy density by using the suspensions of energy-dense active materials in a liquid

electrolyte. Assuming solid content of 50%, the volumetric capacity of the semi-solid suspensions is 5–20 times greater than that of aqueous redox solutions (≈2M).

- The semi-solid approach may be applied to aqueous chemistries, in which the volumetric energy density is also 5–20 times greater since cell voltages remain limited by electrolyte hydrolysis to≈1.5 V. However, when applied to non-aqueous Li-ion chemistries, energy density is further increased by another factor of 1.5–3, in direct proportion to cell voltage.
- Another potential advantage is that in vehicle applications, such a system would permit the possibility of simply "refueling" the battery by pumping out the liquid slurry and pumping in a fresh, fully charged replacement, or by swapping out the tanks like tires at a pit stop, while still preserving the option of simply recharging the existing material when time permits.
- They found that a semi-solid system with 40 vol% solids in each suspension has the following theoretical energy densities for the two semi-solids combined:

➢ $LiCoO_2$–$Li_4Ti_5O_{12}$(2.35 V average discharge voltage) has 397 Wh L^{-1} (168 Wh kg^{-1});

➢ $LiNi_{0.5}Mn_{1.5}O_4$–$Li_4Ti_5O_{12}$ (3.2 V average discharge voltage) has 353 Wh L^{-1} (150 Wh kg^{-1}); and

➢ $LiCoO_2$–graphite (3.8 V average discharge voltage) has 615 Wh L^{-1} (309 Wh kg^{-1}).

KEY FEATURES OF SSFC:

- The cathodes and anodes of the battery are particles that are suspended in the liquid electrolyte.
- The two different suspensions are pumped through systems separated by a thin porous membrane.
- The design also separates the storing and discharging of the battery into two different physical structures
- The new material is able to store energy in "suspensions of solid storage compounds" and the "charge transfer is accomplished via dilute yet percolating networks of nano scale conductors."

LITHIUM IN SSFC:

The anode, in the case of a lithium battery, is the source of lithium ions. The cathode is the sink for the lithium ions and is chosen to optimize a number of parameters, discussed below. The electrolyte provides for the separation of ionic transport and electronic transport, and in a perfect battery the lithium ion transport number will be unity in the electrolyte.

The lithium ions flow through the electrolyte whereas the electrons generated from the reaction,

$$Li \rightarrow Li^{+} + e^{-}$$

go through the external circuit to do work. Thus, the electrode system must allow for the flow of both lithium ions and electrons.

That is, it must be both a good ionic conductor and an electronic conductor. Lithium batteries have made substantial and significant gains in the last 30 years from becoming a curiosity to becoming the dominant rechargeable battery for consumer portable applications. However, the next market opportunities will be much tougher to conquer as they mostly demand higher power capabilities at lower costs and often in larger systems with enhanced safety.

WHY LITHIUM ION ?

The lithium ion battery has the three same basic internal structures a cathode, anode, and electrolyte. In the case of the Li-ion battery the cathode is either lithium cobalt oxide, lithium iron phosphate, or lithium manganese oxide. The anode is typically graphite or a lithium graphite alloy.

When Li-ion cells are discharging, the lithium is extracted from the anode and inserted onto the cathode. When the Li-ion cell is charging the lithium-ions reverse flow depositing ions onto anode from the cathode. The electrolyte is typically a lithium salt.The prime markets are the high-power segment presently dominated by the environmentally unfriendly Ni/Cd battery and the HEV segment presently occupied by the Ni/metal hydride battery.

The layered oxides will, without doubt, continue their ongoing improvement with mixed transition metals slowly displacing the pure cobalt system; they appear to offer enhanced safety with enhanced capacity at a lower cost and are drop-in technology. The lithium iron phosphate cathode offers the first potentially low-cost cathode.

USING LITHIUM ION:

- Wide variety of shapes and sizes efficiently fitting the devices they power.
- Much lighter than other energy-equivalent secondary batteries
- High open circuit voltage in comparison to aqueous batteries.
- This is beneficial because it increases the amount of power that can be transferred at a lower current.
- No memory effect.
- Self-discharge rate of approximately 5-10% per month, compared to over 30% per month in common nickel metal hydride batteries, approximately 1.25% per month for Low Self-Discharge NiMH batteries and 10% per month in nickel-cadmium batteries.
- Lithium-ion do not have any self-discharge
- Components are environmentally safe as there is no free lithium metal

ADVANTAGES OF SSFC:

Common battery faults include:

- Shorted cell due to failure of the separator between the positive and negative plates
- Shorted cell or cells due to build up of shed plate material below the plates of the cell
- Broken internal connections due to corrosion
- Broken plates due to vibration and corrosion
- Low electrolyte level

- Cracked or broken case
- Broken terminals
- Sulfation after prolonged disuse in a low or zero charged state

By implementing the SSFC these outlined faults can be eradicated in a better fangled way.

APPLICATIONS OF FLOW CELL:

- **Load Balancing** → where the battery is connected to an electrical grid to store excess electrical power during off-peak hours and release electrical power during peak demand periods.
- **Storing energy** → from renewable sources such as wind or solar for discharge during periods of peak demand.
- **Peak shaving** →where spikes of demand are met by the battery.
- UPS, where the battery is used if the main power fails to provide an uninterrupted supply.
- **Power Conversion** → because all cells share the same electrolyte/s. Therefore, the electrolyte/s may be charged using a given number of cells and discharged with a different number.
- **Electric vehicles** → because flow batteries can be rapidly "recharged" by replacing the electrolyte.
- **Stand-Alone Power System** → The battery can be used alongside a solar or a wind power to compensate for their fluctuating power levels and alongside a generator to make the most efficient use of it to save fuel.

CONCLUSION:

There have been several developments which could bring electric vehicles outside their current fields of application, as scooters, golf cars, neighbourhood vehicles, in industrial operational yards and indoor operation. In few decades, the electrification of transport in a full-fledged manner will be a major breakthrough in the field of automobile. So, further revolutionary discoveries in the field of flow cells can be imparted for the above mentioned breakthrough. In order to supply an intermittent energy source, Battery and storage technology is advancing rapidly.

Flow cells can effectively replace the complexities of the IC Engines. The yield of the Flow batteries can be recompensed with the outturn of IC Engines by Battery Swapping. This new preference, the SSFC can substantiate affluent grades and can be applied for diverse fields.

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