

Uses for constant current power in Industrial Applications

Since current flow is closely related to the flow of charge over time, having constant current control allows the engineer to control the speed of some chemical processes and in certain circumstances reverse it. In industrial applications, the currents involved are often very high and most uses require the current to be precisely regulated and accurately varied or controlled.

This white paper is intended for chemical engineers involved in architecting and controlling chemical processes such as Water Purification, Electrolysis, Deposition and Active corrosion control.

References

www.uk.tdk-lambda.com/genesys

www.uk.tdk-lambda.com/zplus

www.uk.tdk-lambda.com/zup

www.uk.tdk-lambda.com/hws

Uses for constant current power in Industrial Applications

In the vast world of power supply applications, we can identify two main categories for regulating the power applied to the load. The first being 'constant voltage', where the control loop maintains a constant voltage to varying load current demands and the second, 'constant current' where the current is maintained constant to vary the voltage applied to the load.

Since current flow is closely related to the flow of charge over time ($I = \left| \frac{dQ}{dt} \right|$), having constant current control allows the user to control the speed of some chemical processes and in certain circumstances reverse it.

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In this white paper TDK-Lambda's Giacomo Mazzullo will focus on the following processes:

- Water Purification
- Electrolysis
- Deposition
- Active corrosion control

Water Purification

One of the most common methods for ultra-purification of water, even for industrial applications, is water Electrodeionisation (EDI) using ion exchange resins in the form of thin membranes. After various stages of filtration, that removes almost all the salts and minerals from the water, this method removes ions from the water to produce pure water with a high level of purity and very low conductivity.

For filtering, special ion exchange membranes are used that require an external power supply. Depending on the extent and degree of purification desired, this can require a DC power supply voltage up to 600 Volts and currents of several tens of Amps. When applying a voltage between the anode and the cathode of the membrane, the ions dissolved in the water are extracted because they are attracted to, and forced to pass through, the anionic and cationic membranes. The degree of purification depends on the applied current level.

As the conductivity of the water is variable, the system needs to know the amount of charge applied to control the current flow and therefore the right level of purification to be achieved.

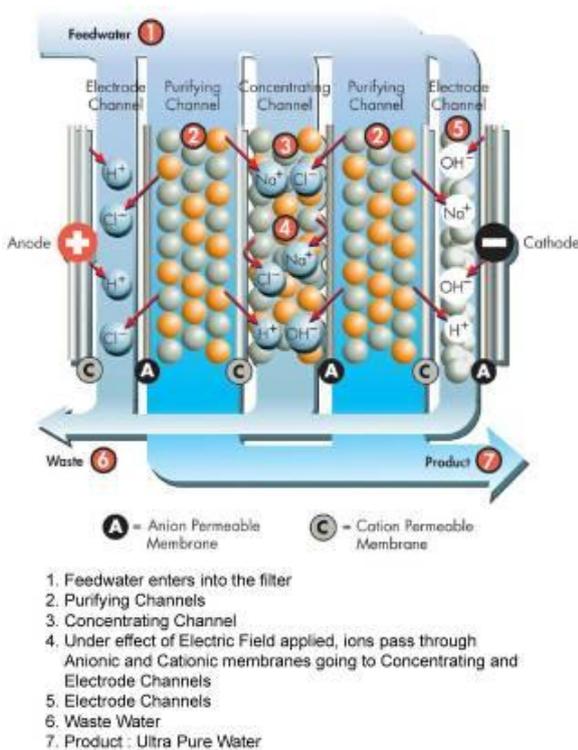


Figure 1 - Ion Exchange Membrane

If the ions concentration of the water were to be too high (high conductivity), a power supply with constant voltage regulation could cause damage to the membranes because of the resulting high current that would flow. Constant current control prevents this from happening by regulating the current to appropriate levels. The use of constant current programmable power supplies allows a highly manageable and flexible control of the water purification process. The use of highly efficient power supplies allows further savings in operating costs.

Electrolysis

An industrial process widely used for the purification of metals (especially aluminium and copper) is electrolysis. The material to be purified is immersed in a 'tub of electrolyte', then a potential difference is applied between the sample to be purified (in the figure, copper acts as the anode) and the cathode is where the pure material is collected.

In this process, the amount of copper deposited or 'purified' is directly related to the applied current. The use of a constant current power supply allows the perfect control of the process.

These processes typically use currents in the order of thousands of Amps, low <5Vdc, operating voltages, and very high power. For example, 15MWh of electricity is needed to produce 1 ton of aluminium.

The use of high-efficiency power supplies clearly creates significant savings in terms of energy bills and operating costs.

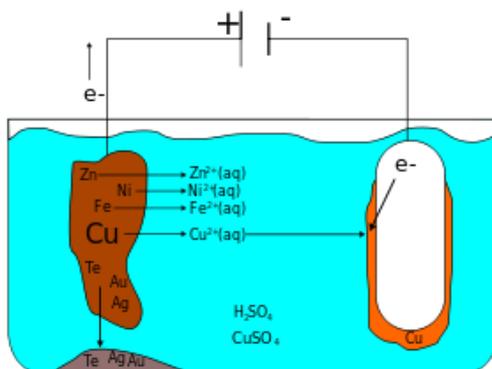


Figure 2 - Schematic Copper Electrolysis

Deposition

Deposition is a process that is regularly used to coat a thin layer of precious materials (gold, chrome, titanium, etc.) onto a substrate that is "technically poor" or with different mechanical characteristics; the primary reason for using thin layer coatings is to obtain a better surface property, which can range from improved hardness or resistance to corrosion, to a glossy or matte appearance.

One of the several different methods of deposition is 'vacuum evaporation'. The basic principle consists of the material to be deposited being evaporated from a source, accelerated by an electric field applied appropriately, and then deposited onto the substrate.

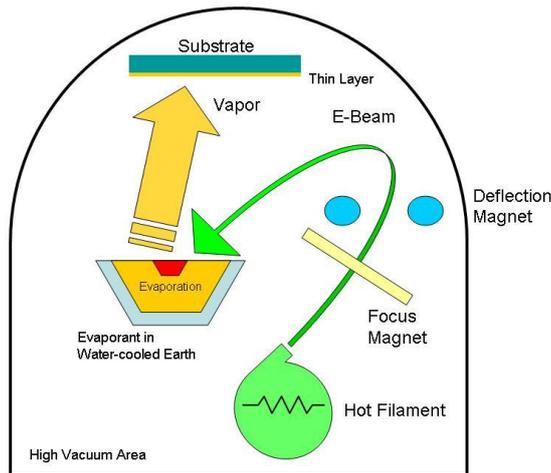


Figure 3 - Electron Beam Evaporation

Electron Beam Evaporation is a process that takes place in a vacuum chamber. The filament is heated by applying a DC voltage across its terminals and, when it has reached a suitable temperature, electron extraction is possible. Using an applied electric field, these electrons are accelerated from the filament to the crucible that holds the material to evaporate. The beam is focused using the magnetic fields generated by the coils present close to the source and crucible.

Constant current power supplies are used to power the filament, magnets and focus circuitry (see Fig. 3) in order to:

- Ensure the temperature of the filament remains constant; any fluctuations may result in variation in the flow of emissions.
- Focus the beam using Magnetic Flux (programming the current allows the user to vary the focus of the beam)
- Maintain deflection of the magnetic flux (programming the current allows the user to vary the beam's deflection)

The precise control of all these parameters, together with the use of high performance power supplies with low ripple and high dynamic response, allows the user to obtain a deposition of high quality and uniformity. A better, more reliable process minimises waste and increases product reliability.

Active Corrosion Control

Bridges, ships and offshore wind turbines are three examples where the prevention of corrosion of the structure is very important and greatly reduces operating costs of these facilities.

For environmental reasons, the traditional passive 'Sacrificial Anode' method of corrosion control, as shown in Fig. 4, is increasingly being replaced in favour of 'Active' prevention, which is implemented by applying an 'impressed current', see Fig. 5.

In the passive method, the anode of a different metal to the structure is 'sacrificed' in order to ensure that the structure is protected from corrosion. In the 'active' method, a sophisticated electronic current control system is taken to inject a reverse current to that generated from corrosion to protect the structure.

In the first case, it is easy to deduce the need to periodically replace the sacrificial anode (with consequent costs and dispersion of metals in the water), in the second case the only costs will be that of the system and the energy used.

High efficiency and the ability to control current and voltage across the broadest possible range are the main characteristics required for power supplies deployed in these applications.

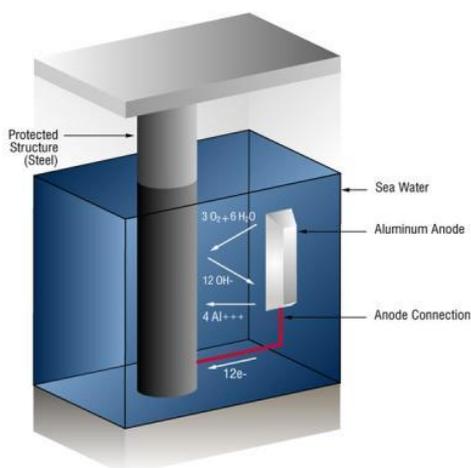


Figure 4 - Prevention of Corrosion - Sacrificial Anode

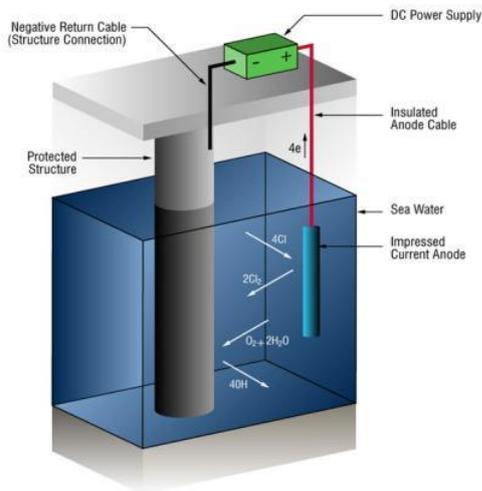


Figure 5 - Prevention of Corrosion - Impressed Current

TDK-Lambda Solutions

TDK-Lambda is a world leader in technological research in the field of power supplies and has developed several 'Constant Current' power supply solutions.

The ZUP, Z + and Genesys™ allow full control of the current and the output voltage, as well as feedback on the same parameters. In addition, the availability of isolated interfaces, analogue, digital RS232/485, IEEE488 and LAN allows a high flexibility of integration and system control. The power ratings range from 200W to 15KW with the possibility of placing up to 4 units in parallel, to increase the power up to 60KW and output currents up to 4000A.



Figure 6 - TDK-Lambda - ZUP Series, Z + and Genesys™

For OEM systems that require power supplies capable of operating in environments with a high degree of pollution, TDK-Lambda has specially developed the HWS / HD Series for heavy industrial applications. This series has a Lifetime Warranty and Extended Temperature Operating Range as well as a 'conformal coating' protection. For this family, the power ratings range from 15W to 1500W.



Figure 7 - TDK-Lambda - OEM Power series HWS / HD

In addition, TDK-Lambda has the capability to optimise a standard product or even develop a custom solution to meet the specific needs of a particular user application.

For more information about TDK-Lambda's power supplies, please visit:

www.uk.tdk-lambda.com

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