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Motivation & Concept

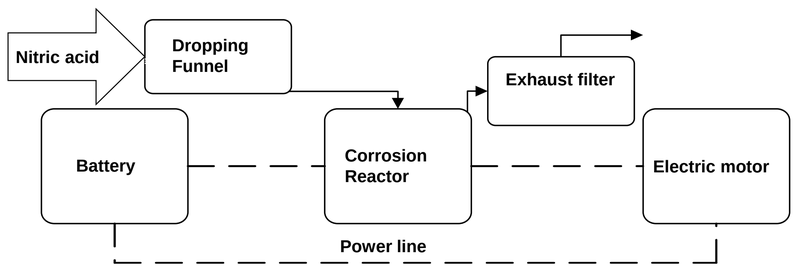
Motivation

In the chemical industry, corrosion is usually a reaction to avoid, as it leads to damage to equipment, pipes, and other parts. Therefore, it is often tried with great effort to prevent corrosion processes by using, for example, stainless steels. The term corrosion is generally understood as a change in the material properties through a reaction with the environment.

In addition to weathering processes and biocorrosion, special attention is paid to so-called chemical corrosion in industry. The most well-known chemical corrosion process is the rusting of iron by oxidation with oxygen. Corrosion reactions are influenced by many parameters, such as temperature. This year's ChemCar of TU Dortmund uses the corrosion of a copper cable to control the distance.

Concept

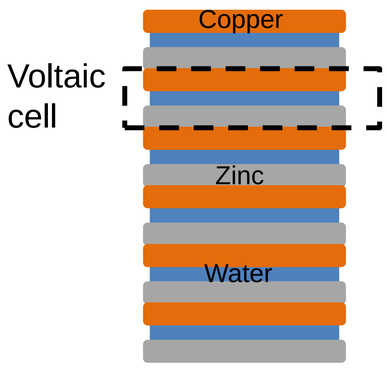
In this concept, an electric motor is powered by the use of a battery. The power line is made of copper, which is decomposed by nitric acid to stop the movement of the ChemCar. Adjusting the acid concentration affects the rate of corrosion of copper, interrupting the flow of current at a certain time.



Technical Realization

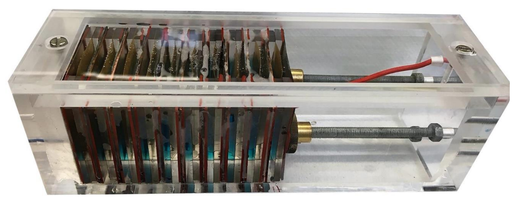
Voltaic pile

The original voltaic pile consists of several galvanic elements. Each element is composed of a copper sheet, water and a zinc sheet. In a voltaic cell a zinc plate serves as the anode and a copper plate as a cathode. Since no copper ions are given, hydrogen forms at the cathode instead of copper. In order to avoid the creation of hydrogen, the concept was changed.



Battery

The battery consists of several individual voltaic cells connected in series (voltaic pile). The cathode and the anode are surrounded by two electrolytes (copper sulfate and sodium sulfate) which are separated by a membrane. By adding the copper sulfate electrolyte, copper is formed instead of hydrogen at the cathode. The following reactions take place at the respective electrodes:



anode reaction: $Zn \rightarrow Zn^{2+} + 2\,e^-$

cathode reaction: $Cu^{2+} + 2\,e^- \rightarrow Cu$

Termination reaction

The ChemCar is stopped by interrupting the electrical circuit. This is achieved by a corrosion reaction using nitric acid:

Corrosion reaction: $3\,Cu + 8\,HNO_3 \rightarrow 3\,Cu(NO_3)_2 + 2\,NO + 4\,H_2O$

Thus, there is no more energy available for the electric motor and the movement of the car. Due to rolling resistance and the resistance in the electric motor the ChemCar comes to a halt.

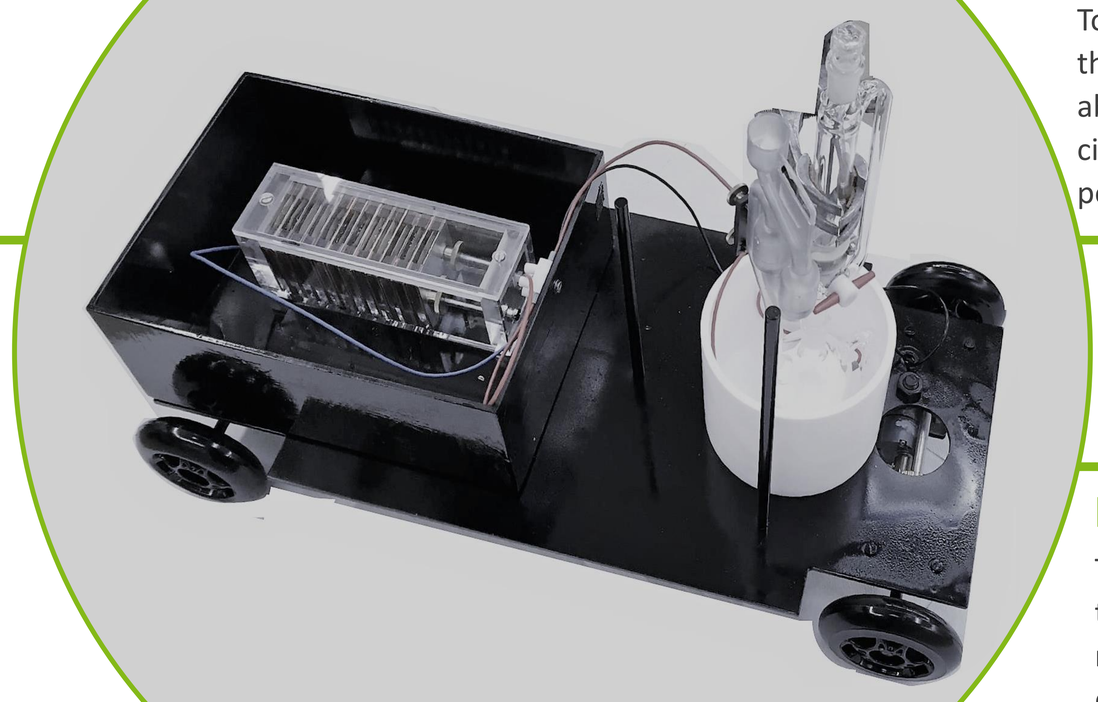
Corrosion reactor

The corrosion reactor consists of a Teflon part and a glass bowl. In the Teflon part, five copper wires with a diameter of 0.09 mm are clamped.

The top of the glass bowl is connected to the dropping funnel. Additionally, the glass bowl contains an exhaust air opening and an opening for air supply.

Collecting Pan

In the event that a chemical leaks out of the reactor or out of the battery, collecting pans are attached around all the components in which liquids are present.



Valve with abrasive contact

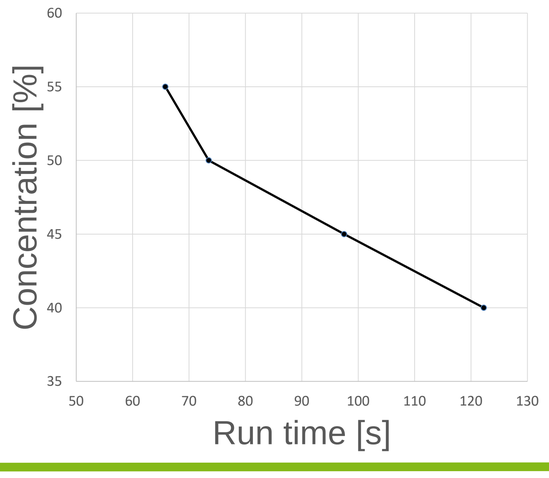
To close the electric circuit and add the nitric acid at the same time, a abrasive contact is used. The electric circuit is closed only at a certain position of the valve.

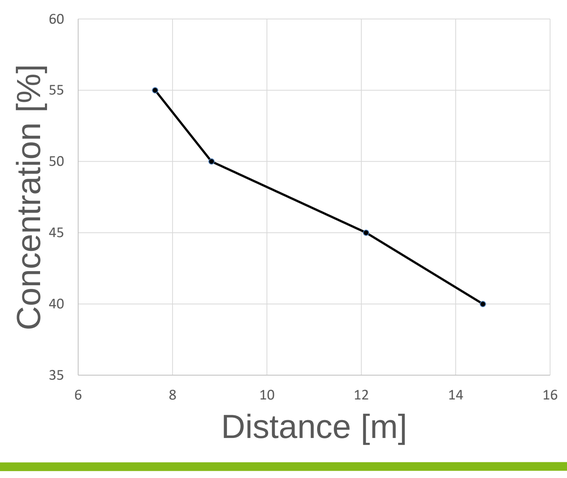
Calibration

To set the distance, the relevant parameters have to be set. For this purpose, one parameter was changed while the others were kept constant. It was found that the most important parameters are temperature and concentration.

The temperature, on the wire can be assumed as the temperature of nitric acid.

Increasing the acid concentration increases the corrosion rate up to a maximum concentration at which the reaction is not limited to components but surfaces.





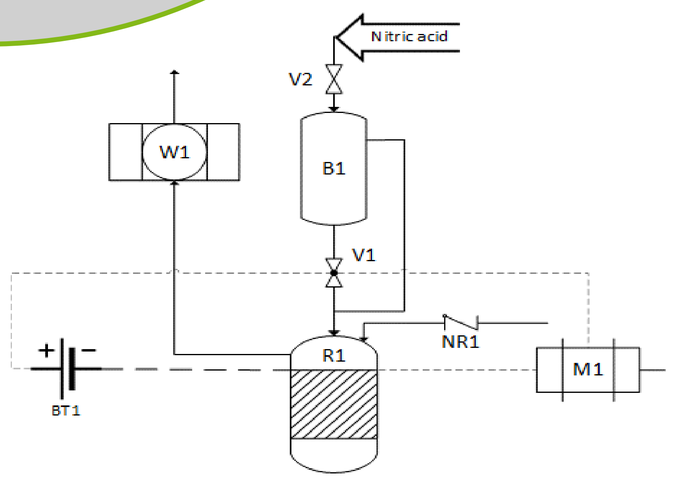
Electric Motor

To change the electric energy into kinetic energy an electric motor is used. The motor works at 0.32 A and 11 V and has a Power of 3.5 W.

Exhaust filter

The resulting nitrogen oxides are passed through a exhaust filter before leaving the reactor room. As a result, the resulting nitrogen dioxide are disproportionated.

Flowsheet



V1	Valve with abrasive contact
V2	Valve 2
B1	Dripping funnel
NR1	non-return valve
W1	Exhaust filter
R1	Corrosion reactor
M1	electric motor
BT1	Battery