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| ***DERUSTING TECHNIQUES***  ***Electrolysis***  ***A simple 2 Amp battery charger and a box of washing soda provides a simple method to remove rust. To make your own rust removal system take a plastic tub of water add washing soda (sodium carbonate, NaCO3) to make the solution conductive (you can also add caustic to remove paint and grease at the same time but it is more dangerous to work with). Two electrodes need to be placed in the water solution. One electrode is the rusted metal to be cleaned (this electrode will gain electrons and give off hydrogen gas, positive terminal) and the other is the sacrificial electrode which will slowly dissolve over time (oxygen gas will be formed at this electrode, negative terminal). The sacrificial anode needs to be made of iron. The larger the surface area of the electrodes the larger the amount of current that will be drawn and the faster the derusting process will proceed. Also, the closer the electrodes are together the faster the derusting process. Connect the negative terminal to the component to be derusted (cathode) and the positive terminal to the sacrificial electrode (anode).***  ***As both hydrogen and oxygen are given off by this process a large battery charge can produce enough gas that could form a flammable atmosphere if the local air movement is not sufficient.***  ***The basis of this rust removal system is that chemical compounds can be decomposed by electricity. By adding electrons to iron oxide (rust) the exposed rust dissolves and provides an easy method of removing rust. By rubbing off the exposed broken down rust the underneath layers can be broken down faster. At the sacrificial anode electrons are lost from the iron, causing an accelerated reaction with oxygen in the water causing sever corrosion at the anode. The washing soda only makes the solution conductive and does not participate in the chemical reaction.***  ***Electrolyte Basics***  ***In water washing soda dissolves to from an aqueous solution.***  ***NaCO3 + H2O Na++ + CO3--***  ***The aqueous solution of washing soda is called an electrolyte, this simply means that the solution will conduct an electrical current. When two electrodes are immersed in the aqueous solution and are connected to opposite poles of a battery or power source a current flows through the solution, and a chemical reaction takes place at each of the electrodes. Usually, either hydrogen is evolved or some metal is deposited at the electrode, called the cathode, which is connected to the negative pole of the power source. A non-metal is generally liberated at the anode. Corrosion always occurs at the anode.***  ***If the electolye is an aqueous solution of sodium hydroxide (caustic, Draino, lye, etc) hydrogen gas will be formed at the cathode (connected to the negative pole) and oxygen gas at the anode (connected to the positive pole). If you wish to silver coat an object a solution of silver nitrate (AgNO3) will deposit Ag at the cathode and oxygen gas at the anode (this is similar for chromium (III) sulfate). The electrolysis of NaCl (salt water) produces chlorine and hydrogen gas and turns the aquous solution turns into NaOH (caustic).***  ***When electrodes are placed into the electrolyte solution and connected to a battery, the positive ions, or cations, migrate towards the negatively charged cathode. Here the cation picks up one or more electrons. The negative ions or anions lose their negative charges by transferring electrons to the anode. In this way electrons are "pumped" out of the solution at the anode, through the external circuit, and back into the solution at the cathode, and the current continues to flow as long as there are positive and negative ions present in the solution.***  ***The anode reaction in any electrolysis will always be oxidation, which occurs at the least positive potential and the cathode reaction will always be reduction which occurs at the least negative potential.***  ***The Formation of Rust***  ***Corrosion of iron and steel by water is an electrochemical process involving dissolution of metal at the local anodes to form metal ions and liberate electrons (oxidation).***  ***Chemical action at the anodic site (Oxidation):***  ***Fe  2e- + Fe++***  ***(Metal) (Electrons) (Ion in solution)***  ***Here is where the corrosion occurs as iron (Fe) leaves the surface and goes into solution.***  ***The simultaneous cathodic reaction is the capturing of the electrons at local cathodes to reduce hydrogen ions in the solution to atomic hydrogen at the metal surface.***  ***Chemical action at the cathodic site (Reduction):***  ***½ O2 +H2O + 2e-  2OH-***  ***Then rust (the oxidation of iron) is formed by the net reaction:***  ***Fe++ + 2OH- Fe(OH)2***  ***Ferric Hydroxide (rust)***  ***In acidic conditions (pH<4.5-6) hydrogen gas is formed and in less acidic water the atomic hydrogen is oxidized by dissolved oxygen to the basic hydroxyl ion OH-, these in turn may precipitate as the metal hydroxide.***  ***The hydrogen formed at the cathode surface will remain there unless there is some removal mechanism (typically the reduction of dissolved oxygen). The accumulation of adsorbed hydrogen is called "polarization", which arrests corrosion so long as the film is undisturbed mechanically and/or unreacted with dissolved oxygen. The accumulation of hydrogen, or other cations, also causes polarization, which is an actual shift of the cathode potential in the anodic direction. Because of the potential change, the amount of corrosion current is largely limited in aqueous environments by the behavior of the cathode. The activity of the cathode is governed by the rate of diffusion of oxygen to the metal surface.***  ***The cathodic control exercised by dissolved oxygen holds for the pH range of 4.5 to 9.5. Between pH 4.5 and 9.5, corrosion of steel is governed almost entirely by dissolved oxygen content within normal metal contents. In the absence of oxygen, the cathode soon becomes covered with absorbed hydrogen which greatly reduces further current flow and corrosion.***  ***Corrosion in water is increased by chlorine ions (as from salt) as it increases the conductivity of the water which permits the corrosion process to affect larger areas and lessens the affect of the precipitation of hydrated iron oxides.***  ***Removing Rust***  ***To remove the metal oxide scale or rust the metal-oxide interface anodic reaction has to be reversed i.e. the rusty metal has to become the cathode. This can only be done by forcing the reaction backwards by adding electricity (electrons). To speed up the process an effective electrolyte solution is made by mixing NaCO3 (washing soda, sodium carbonate) in water. By placing the rusty metal in water the surface rust slowly dissolves and dissociates to Fe++ and OH-. The positive ions will travel to the negatively charged cathode (negative pole); the positive ions (cations) are Fe++ and Na++. The negative ions will travel to the positively charged anode (positive pole); the negative ions (anions) are OH- and CO3--. At the positively charged anode (sacrificial anode) the following reaction occurs:***  ***Fe  2e- + Fe++***  ***Fe++ + 2OH- Fe(OH)2***  ***This reaction is accelerated by the induced current and the sacrificial anode rusts (oxidates) quickly.***  ***At the negatively charged cathode (rusty metal) the following reactions occur:***  ***Fe++ + 2e-  Fe***  ***This breaks down the rust Fe(OH)2 (accelerated dissolving) and stops the corrosion process which stops the formation of more rust, eventually all the rust falls off leaving bare unprotected metal. Note this process will not add new iron to the rusted metal it will only remove the rust. The pits will remain.***  ***The water is also electrolyzed during this process and produces Hydrogen gas at the Cathode and Oxygen gas at the anode at a ratio of two volumes of Hydrogen for every one volume of Oxygen gas.***    ***Rust Removal by Electrolysis at Home***  ***Equipment needed:***  ***Battery charger, a typical 2/10 Amp charger works fine. Larger charges may develop enough oxygen and hydrogen that ventilation may need to be considered. I know of at least one set up like this that did cause a small flash fire. Key point the anode is connected to the positive (red) terminal and the object being cleaned is connected to the negative (black) terminal.***  ***Piece of steel that will be turned to rust using this process. Tin cans, pipe, bolts or anything else you have laying around will work. The larger the surface area the better it will work.***  ***Non-conductive container. Plastic works well, the container can be a 5 gallon bucket. eaves trough or even a swimming pool.***  ***Conductive solution. Water with either washing soda or lye/Draino added to it. For every five gallons add half a quart of washing soda or lye/Draino. The mixture ratio is not to important but having a stronger solution will not make the process work better.***  ***Remember the basis is that chemical compounds can be decomposed by electricity. By adding electrons to iron oxide (rust) the exposed rust dissolves and provides an easy method of removing rust. By rubbing off the exposed broken down rust the underneath layers can be broken down faster. At the sacrificial anode electrons are lost in the iron causing an accelerated reacting with oxygen in the water causing sever corrosion in the anode. The washing soda/lye/Draino only makes the solution conductive and does not participate in the chemical reaction.***  ***Place the object that you want to de-rust in a plastic or other non-conductive container. Ideally the container should be big enough to immerse the entire object in the water, but a piece can be done in parts. For example a 4 cylinder block will usually fit in a plastic garbage can or a fender will fit in a small wading pool. Fill the tub with water until the object is immersed then add washing soda (not baking soda). You will need about a tablespoon of soda to a gallon of water. Caustic (Draino) or lye will also work and will have the added benefit of stripping paint or grease at the same time. A caustic or lye solution will also produce heat to help in the stripping process. Remember to always add caustic or lye to water and not the other way around and always wear rubber gloves and safety glasses. Now place your iron (stainless steel works too) sacrificial anode in the water. The anode can not touch the object to be derusted or you will just short out the charger. Be careful that the anode is not just barely touching the object to be derusted as it is possible for a single object to be rusted on one side and rust removed on the other side (I have accidentally done it). The iron electrode works best if it surrounds the object to be cleaned since the cleaning is "line of sight" to a certain extent. The iron electode will be eaten away with time. Old tin cans work as good anodes and will dissolve quickly, pieces of thin pipe work well too. The larger the surface area of your anode the more current will be drawn and the faster the process will work. If your surface is large enough the water will actually warm-up, when the water is warm the process works real good in a caustic/lye solution where you also need to degrease (such as an engine block). Beware that the metal can become so warm that it can melt a plastic container (even with only a small 10 amp charger) so make sure you check the set-up every couple of hours until you feel comfortable to leave it alone longer.***  ***Key point the anode is connected to the positive (red) terminal and the object being cleaned is connected to the negative (black) terminal. Making sure you have good contact with both terminals, this can be difficult with heavily rusted objects.***  ***Turn on the power. If your charger has a meter, be sure come current is flowing, try and keep the flow below maximum. The current draw can be controlled by moving the anode away from the object to be derusted or using a smaller anode. Fine bubbles will rise from both objects (remember oxygen and hydrogen hazard). Go away and come back in a few hours. Rub the object with steel wool or under running water with a plastic pot scrubber. The rust should shrub off leaving a clean metal finish underneath. A total clean surface will appear black, and all metal pits will show. Remember this process will not replace metal it just removes the rust. Depending on the amount of original rust, you may have to re-treat. The clean object will acquire surface rust very quickly, so wipe it dry and dry further in a warm oven or with a hair dryer. You can also apply a light coat of oil to stop flash rusting.***  ***There are lots of variants: suspending an electrode inside to clean a cavity in an object; using a sponge soaked in the electrolyte with a backing electrode to clean spots on large objects or things that shouldn't be submerged (like parts with lots of wood).*** |
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