Getting Corrosion Protection from Aqueous Inhibiting Compounds

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The cost of finishing a part can be 10 percent of the total part cost. With that kind of investment, it's important to keep the part from corroding. Ferrous (iron-containing) metals and non-ferrous metals, such as Al, Cu and Zn, corrode. There are two basic types of corrosion-inhibiting compounds: aqueous (water soluble) and organic (oil soluble). Organic inhibiting compounds tend to give longer shelf life than aqueous inhibiting compounds, but are harder to remove from the part. In addition, an organic inhibiting compound must be removed from the part to do follow-up operations such as painting, plating or welding. In contrast, many aqueous inhibiting compounds do not interfere with subsequent operations and do not have to be removed at all. This quality offers an extreme advantage over organics, if only aqueous compounds offered the shelf life of organic compounds. Used correctly, however, aqueous compounds can offer significant shelf life.

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INTRODUCTION

Mass finishing is the art of accomplishing processes on a large number of parts in a short period of time. The functions of these processes include: cleaning or degreasing, deburring, burnishing, surface improvement, corrosion inhibition and drying. These processes are carried out when the proper equipment and compounds work in tandem. The cost of finishing a part can be 10 percent of the total part cost. With that kind of investment, it is important to keep the part from corroding - when mass finishing is done on a part it leaves the surface of the part susceptible to corrosion. Ferrous (iron-containing) metals and non-ferrous metals, such as Al, Cu, and Zn, corrode.

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TYPES OF INHIBITING

There are two types of inhibiting: inhibiting during processing, and inhibiting for shelf life. It is very important to understand that these two are completely different operations. Many processing compounds offer adequate corrosion protection while the operation (cleaning, deburring, burnishing, etc.) is taking place by removing any oxidation that may occur on the surface of the part. So even though the compound is being used at a small concentration (usually 1-2%), the part does not corrode.

Inhibiting for shelf life is more difficult since there is no process occurring to keep the oxidation products from depositing on the part. To get shelf life the oxidation process must be stopped, slowed down or redirected. There are three components that need to be present for oxidation to occur: metal, moisture, and oxygen. It is obvious that the metal can not be taken out of the picture unless a permanent coating of teflon, paint, powder coat, or other corrosion-resistant material is attached to the part. Many inhibiting compounds work on the other two components to stop the rusting process.

It is extremely difficult to keep oxygen out of the equation unless the part is stored in a nitrogen atmosphere which would be expensive and highly impractical. Likewise, moisture is almost always present in an unaltered atmosphere. Inhibiting compounds (both organic and aqueous) work by negating one or both of these components.

TYPES OF INHIBITING COMPOUNDS

There are three types of inhibiting compounds: aqueous, organic, and emulsion. Aqueous inhibiting compounds are ones that are completely soluble in water while organic compounds are ones that are completely insoluble in water. Emulsion compounds contain constituents of both water and oil and are easily identified by their cloudy appearance.

There are many water soluble salts that are formulated into aqueous inhibiting compounds but the two most common are amine carboxylate/borate salts and sodium nitrite. Both salt solutions work in the same way in that they attach to the surface of the part and keep the moisture away from the part as well as slow down the oxidation process. The active ingredients in aqueous inhibiting compounds have chelating properties - they chemically react with metal atoms to form complex molecules with the metal becoming part of the molecule. This keeps the corrosion-resistant particles on the surface of the part.

Generally, the compound is used at 5-25% solution in water; while the solution is functional when used at ambient temperature it is quite common to heat the solution to 100-160ºF. If the solution is used at less than 5% concentration insufficient corrosion resistant particles are deposited onto the surface. If the solution is used above 25% a tacky film may appear on the part. The solution is applied to the part by dipping the part into the solution or by spraying the part with the solution. It only takes a few seconds for sufficient corrosion resistant materials to attach themselves to the part.

It is important to keep the concentration at the proper levels. The chelating properties of inhibiting compounds cause the corrosion resistant particles to be dragged out of the solution faster than water. This causes the solution to dilute. In addition, many of the water soluble inhibitors are biodegradable - they get broken down into carbon dioxide and water by microorganisms. The only downfall of being biodegradable is that microorganisms will build up in the solution within weeks (possibly days in hot weather). This will cause dilution of the solution as well as odor problems. It is therefore very important to change out the dip or spray tank frequently or put biocides in the solution to control the microorganisms. Even if biocides are used, the solution must be changed periodically.

To get maximum shelf life from aqueous inhibiting compounds, it is essential that the part be dried after being dipped or sprayed before being packed for shipment or storage. The corrosion resistant particles are less volatile than water, so when drying, the water evaporates leaving the inhibitors. However, if any moisture is left on the part, the water will carry the inhibitors away leaving the part susceptible to oxidation once again. The same condition will occur in high humidity or if parts are stored outside unprotected from rain.

There are several ways to dry the parts. The most common way is to simply let them air out until they are dry. This is OK except if there are areas on the part where the water/solution could puddle. If the solution puddles, oxidation will occur even though inhibitors are present. The water does not allow the corrosion resistant particles to adhere to the part. In addition, water is present in such excess, that the oxidation process will proceed. Even if the inhibiting solution is at a concentration of 20% that means that 80% of the solution is water. Unfortunately simple air drying does not give the best results for protecting the part from rust.

The most effective way to dry the part after applying the inhibiting solution is to send the part through heated crushed corn cob. Corn cob is crushed to a consistent grain size (usually 10-60) and placed in a vibratory machine and heated externally. Crushed corn cob is exceptional at absorbing the moisture from the part, but with the external heat lets go of the moisture very easily. The part is usually dry in less than two minutes. The corn cob can also be treated with extra inhibitors to give even longer shelf life. An added bonus of the crushed corn cob is the part gets a buffed look.

The other effective way of drying the part is with forced air. This can be at ambient temperature or heated. The biggest concern with this method is that the pressure of the air can blow the corrosion resistant particles off the part with the water. Another concern with this method is that if the air is too hot it can adversely affect the shelf life. If the air is too hot, it tends to hold more water (warm air holds more moisture than cold air). A micro-atmosphere is produced around the part - especially if the parts are packed hot. Once the air cools, it can not hold as much water, so the moisture condenses onto the parts causing the corrosion resistant particles to rinse off, or causing the moisture to puddle on the part.

Organic inhibiting compounds work on the principle that water is not soluble in oil so these compounds put an impenetrable film on the part to keep moisture from coming in contact with the part. Many organic soluble additives are available and work in the same manner as water soluble additives in that they attach themselves to the surface of the part through chelating activity. Like aqueous rust inhibitors, organic compounds are usually applied via dip or spray at ambient or elevated temperatures.

The only advantage that organic rust inhibitors offer over aqueous rust inhibitors is the increased shelf life. In some cases, this is enough to select organic compounds over aqueous compounds. Indeed, in some instances, parts can be stored over one year with no corrosion occurring. Unfortunately, organic rust inhibitors offer many disadvantages over aqueous rust inhibitors.

First and foremost, organic inhibitors are water insoluble and must be handled with care especially as wastes. Sometimes the waste oil can be reclaimed and reused but some of it must be disposed of without causing detrimental impact to the environment. Second, organic inhibitors can be flammable or combustible - at least more so than aqueous inhibitors. This is especially important when using organic inhibitors at elevated temperatures. Third, organic inhibitors tend to be large nonvolatile molecules causing increased drying time of parts.

Fourth, organic inhibitors can be difficult to mix. Organic rust inhibiting additives tend to be large, nonvolatile molecules. As such they are usually solid at room temperature - if not solid, very thick and viscous. In many cases, to get the additives to mix into the carrier oil or solvent, both the additives and carrier must be heated to 130-140ºF. Not only does this take extra energy (raising cost of production), but it also adds an extra hazard. Organics at these temperatures can cause discomfort or even burns to the skin.

Some inhibiting compounds come in emulsions which are mixtures of oil soluble additives and water. This is accomplished with the help of emulsifying agents which are partially soluble in water. These attempt to give rust protection like organic inhibiting compounds while still maintaining aqueous properties. And indeed some of these can be quite effective.

The advantages of emulsion inhibiting compounds are: they can be handled like aqueous compounds in that they are diluted with water, and they can be treated like water waste most of the time. In addition, the film that is deposited on the part is less intrusive like an aqueous inhibiting compound. The biggest disadvantage is that even though they contain organic constituents, they are still aqueous and will not give as long of shelf life as organic inhibiting compounds. Thinking that they have organic inhibitors in them may give a false sense of security about the effectiveness of these compounds. Being aqueous, the concern of moisture puddling still exists; if puddling occurs, oxidation can proceed.

WASTE TREATMENT

Organic inhibiting compounds usually must be sent off site to be treated, if treatment is possible at all. Sometimes special equipment can be used to purify some of the waste oil for reuse by distillation, extraction, and/or filter methods. The waste treatment of organic inhibiting compounds is the least desirable quality of these compounds.

Aqueous inhibiting compounds can often be treated with special chemicals to drop out metal fines, oils, and other contaminants that build up in the solution. Equipment to do this can often be set up on site. This equipment usually consists of a mixing tank in which the waste water is pumped and treated - first with a coagulant that chemically and physically collects the dissolved and suspended particles into tiny "pinfloc". Then a flocculent is added to gather the tiny particles into larger ones that can be filtered easily. The water can then either be sent to drain or in some cases reused. The resulting sludge can normally be sent to a landfill (pending proper analysis).

As stated before, aqueous inhibiting additives work because of their chelating properties. Chelating agents chemically react with a metal atom forming a complex molecule with the metal becoming part of the molecule. This is good for inhibiting but not so good for waste treatment. Once the chelating agent reacts with the metal atom it does not want to let go. This means that the entire molecule has to be treated instead of a single metal atom or ion. The unfortunate aspect of this is that these complex molecules are very soluble in water and are very difficult to get to coagulate or flocculate and drop out of the solution. In the event that the solution can not be treated it may have to be disposed of as hazardous waste or treated with a more complex setup.

CONCLUSION

All metals corrode. It is important to keep metals from corroding especially considering that finishing the part may be 10% of the total part cost. Keeping a part from corroding during process is completely different than protecting for shelf life. Generally, organic inhibiting compounds offer significantly longer shelf life than aqueous inhibiting compounds, however used wisely aqueous compounds can offer more than adequate shelf life.

The biggest cause of failure with aqueous inhibiting compounds is misuse. The most important rules to follow when using aqueous inhibiting compounds are: always keep the concentration of the solution at the appropriate level, keep the solution clean and change it out periodically, do not use too much heat in the inhibiting process (especially the drying phase), and make sure the part is dry before packaging and storing. When these rules are followed, corrosion can be stopped.

