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# Painting of metal products

## Why are products painted?

Painting of metal products is used to give the products surface properties that it doesn’t have naturally. Without painting metal products start to rust and erode and in case of wood products surfaces are easier to clean when they have a lacquer layer on them. So, the surface durability of the products is improved with painting. In addition, the surface color can be freely chosen, the shininess of the surface can be adjusted, and the surface structure can be adjusted. Painting can also be used for insulation such as fire insulation, humidity insulation and hygienic insulation. Painting increases the cost of manufacturing but it’s aim is to increase the life cycle of the product, lower the cleaning costs for the surfaces and to give the product a good-looking finish. Generally painting can be divided into two distinct categories. Painting for corrosion protection and painting for looks but often the needs overlap and both are needed. Corrosion protected paint coat is typically multi layered wet coat that is painted with high-pressure spray-painting machinery. When demanding good looking finish, the shininess of the surface, evenness of the paint coat, evenness of the color and wear resistance of the coating are some common demands. Common painting methods for good-looking finish are powder coating or wet painting.

## Chemical pretreatment of products

Chemical pretreatment is used to process the surface of products so that the surface can be coated with paint or other coating methods without problems. Chemical pretreatment is used for products that are manufactured from steel, zinc coated steel or from aluminum.

|  |  |  |
| --- | --- | --- |
| Impurity | Source of impurity | How to remove |
| Safety oil and grease | Added during manufacturing to prevent rusting | Mineral oils removable by water or solvent based washing procedures. Vegetable and animal greases hard to remove |
| Salts | Transportation or from human hand sweat | Removable by water-based washing procedures |
| Carbon dust and soot | Cold rolling | Removable by alkali or solvent based washing procedures |
| Cutting fluid | Sawing, milling, etc | Removable by water-based washing procedures |
| Pulling lubes and soaps | Manufacturing of wire and tube products | Removable by water-based washing procedures |
| Metal chips | Metalworking processes | Mechanical washing |
| Rust and surface rust | Storing in humid conditions, “old” material | Can’t be removed by washing. Acid pickling required or mechanical processing. Surface rust removable by chemical procedures |

Table 1: Impurities on metal surfaces

Results of chemical pretreatment are affected by four different factors. Them being used chemical, temperature, time, and mechanical movement. These four factors make up a cleaner’s circle, often known as a Sinner’s circle.

Kuva, joka sisältää kohteen ympyrä, keltainen, symboli, viiva

Kuvaus luotu automaattisesti

Figure 1: Sinner’s circle

Breaking down the Sinner’s circle:

1. Chemical: Chemicals used in cleaning need to be capable of removing the desired impurity from the material. It’s also important since other three factors can’t be increased indefinitely. The concentration of the chemical can be increased to increase its effectiveness and it needs to be kept clean. Chemicals lose their effectiveness when used for cleaning and the removed impurities need to be removed from chemical if it is to be reused. Often that isn’t financially feasible, and the cleaning chemical can be said the be one time use only.
2. Mechanical movement: Mechanical movement improves the results of washing and often it is mandatory for a good result. Movement can be produced by a few different methods. In spray washing processes the movement is produced by the spraying itself. In immersion washing the movement can be produced by pumping, where the solution bath is mixed by pumping the solution out and back into the bath. Alternative method is to use a mixer that uses blades to mix the solution. Ultrasonic sound can be used to drastically increase the results of the washing. Ultrasonic can also remove impurities that can’t be removed normally by washing procedures. Blowing air into solution is a simple way to create movement that improves results. Downside being it creates fumes which means that it isn’t preferrable when using chemicals that have solvents. It creates fumes even when the solution is fully water based and lowers the temperature of the solution bath which decreases the results of wash. It’s better used for rinsing the parts than in active cleaning. Used air in also needs to clean and free of oils. Movement can also be simply introduced by moving the work piece in solution. Movement is also important in rinsing where the remaining solution is removed from work piece.
3. Time: Time is an important part for the results of washing. By increasing the time work piece spends in solution bath the better results can be expected. But too long time can damage washed work piece and can create deposits that are hard to remove. Long time will also increase the cost of pretreatment.
4. Temperature: Increased temperature improves washing results. Different chemicals have different operating temperatures so temperatures should match the used chemicals. Too high temperature increases water evaporation, chemical fumes, and energy costs.

## Choosing the correct chemical pretreatment method

Choosing the correct pretreatment method depend on many factors. The most important factor is the used material. Usually, material is steel, but zinc coated steel and aluminium are also often pretreated. The chosen pretreatment agent needs to compatible with used material.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Example Product | Environmental requirements | Washing + rinsing | Iron phosphate coating | Iron phosphate coating + passivation | Zinc phosphate coating + passivation |
| Single use products and products that don’t require rust prevention | Used inside, low requirements | X | X |  |  |
| Light fixtures, stands and similar | Used inside, medium requirements |  | X |  |  |
| Work equipment | Used inside, low requirements |  | X |  |  |
| Refrigerators, freezers, and home appliances | Used inside, high requirements |  |  | X |  |
| Machines and products that need to protected | Used outside, medium requirements |  |  | X | X |
| Products in wet rooms. | Used inside, really high requirements |  |  |  | X |
| Work machines, vehicles, and car parts | Used outside, high requirements |  |  |  | X |

Table 2: Pretretment methods before powder coating for different products

Pretreatment methods capability to remove impurities needs to be considered so that the desired quality requirements can be met.

By washing the product can be cleaned so that it can be painted. Phosphating can be used to increase the total surface treatments capability to prevent rusting. Pretreatment and painting as a whole determine how good corrosion resistance can be achieved. Table 2 shows generally what sort of pretreatments needs to be done for products that have different corrosion resistance requirements before powder coating. For wet coat painting the quality of paint, layer thickness and the number of paint layers affect the corrosion resistance. Hence the pretreatment requirements are lower for wet coat painting and a good corrosion resistance can be achieved even without phosphating. Downside being that it requires corrosion preventive paints and thick layers.

Pretreatment also needs to be feasible for the part. In field situations pretreatment methods are limited due to environmental and work safety reasons and huge parts can’t be easily immersion bathed. Small parts aren’t feasible to pretreat if it can’t be done paint shop or near it.

If part is sandblasted or acid pickled after washing to remove remaining rust, the wash is used to remove all other impurities that can be removed by washing.

Pretreatment cost is one factor that needs to be kept as minimal as possible. That’s why the best method isn’t always chosen for the product if the overall requirements aren’t too high. For products that require high quality finish a method that provides consistent results is chosen even if it increases costs. Overall cost of the surface treatment is the deciding factor, by spending more in pretreatment costs can be saved in painting. The cost of chemicals for surface treatment is small compared to operation and equipment costs.

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Kuvaus luotu automaattisesti

Figure 2: Factors for choosing chemical pretreatment.

Ideally you want to maximize the corrosion resistance properties and feasibility while minimizing costs, post-processing, material, and impurities.

## Washing metal products

Washing is used when you want to remove grease and other impurities before painting. Washing doesn’t provide any corrosion resistance if material is steel, phosphating is required for increased corrosion resistance. Washing is commonly used for aluminium and zinc coated steels before painting and for repainting. Different washing agents are used to remove different impurities. Following are water-based washing solutions that are made by adding chemicals to water.

### 4.1 Alkaline washing

Alkaline washing procedure removes almost all possible impurities from the product. For efficient alkaline wash washing solution needs to be heated to around 40-80°C. Temperature depends on the removed impurities and how badly contaminated product is. Washing agents needs to be vigorously stirred in immersion washing or sprayed right into surface to get a good result. After washing the product needs to be immediately rinsed because washing agent residues hinder paint from sticking to surface. After rinsing product needs to be immediately dried to prevent rusting. Alkaline washing is used as is for grease removal and as a pretreatment before zinc phosphating. Alkaline washing agents are either strongly alkaline or mildly. Strong alkaline agents are used when washing steel products, mild agents are used for aluminium or zinc coated products.

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Kuvaus luotu automaattisesti

Figure 3: Alkine wash process.

|  |  |
| --- | --- |
| Washing Agent Component | Function |
| Sodium Hydroxide | The powerhouse of washing agent, increases pH of solution, breaks down impurities and binds them to solution |
| Sodium Polyphosphate | Helps surfactant to remove impurities and softens water |
| Sodium Gluconate | Bind the hardness of water and dissolves organic metal compounds |
| Surfactant | Removes oils and binds it to washing solution also lowers surface tension of water |

Table 3: Components of highly alkali washing agent.

|  |  |
| --- | --- |
| Good properties of alkaline washing | Bad properties of alkaline washing |
| Effectively removes all impurities | Washing agent is corrosive, hand washing not feasible |
| Is fire resistant and doesn’t corrode steel | Needs to be heated to be effective |
| Cheap | Needs to be fully removed from surfaces |
| Rinsed parts need to be dried fast in oven because of the risk of rusting |
| Highly alkali washing agent can’t be used for zinc coated steel or aluminium due to corrosive properties. If pH less than 10 it can be used but loses some effectiveness |
| Used washing agent needs to be neutralized |

Table 4: Good and bad properties of alkaline washing

### 4.2 Emulsion washing

|  |  |
| --- | --- |
| Good properties of emulsion washing | Bad properties of emulsion washing |
| Effectively removes all impurities | Washing results not that great |
| Removes even thick layers of impurities | Needs to be rinsed |
| Can be used in hand washing | Needs to be dried |
| Can be used to wash aluminium | Health risks |
| Cheap | Can be fire risk |
| Can be used to wash painted surfaces |  |

Table 5: Good and bad properties of emulsion washing.

### 4.3 Acid washing

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Kuvaus luotu automaattisesti

Figure 4: Acid wash process.

### 4.4 Iron phosphate coating

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Figure 5: Three-stage iron phosphating.

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Kuvaus luotu automaattisesti

Figure 6: Seven-stage iron phosphating

### 4.5 Zinc phosphating

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Kuvaus luotu automaattisesti

Figure 7: Six-stage zinc phosphating

Kuva, joka sisältää kohteen viiva, muotoilu

Kuvaus luotu automaattisesti

Figure 8: Nine-stage zinc phosphating

## Problems in washing and phosphating.

|  |  |
| --- | --- |
| Problem | Cause |
| Sediment on surfaces during immersion washing | Dirty washing solution and inefficient rinsing |
| Products rusty after immersion washing and drying | Product in wrong position during washing or drying |
| Oil stains on product after immersion washing | Product in wrong position or solution bath has incorrect solution |
| Bath foams during spray washing | Temperature too low |
| Surface rust in surfaces during spray washing | Rinsing water dirty or acidic |
| White spots of surface during spray washing | Rinsing water dirty or acidic |
| Phosphate or paint surface has droplet marks | Rinsing water dirty or acidic |
| Dry spots in surface | Worn down or wrongly positioned nozzles |
| Surface has stripes or rusted areas in spray washing | Ineffective oil/grease removal |
| Surface passivates in spray washing | Rinsing water is too hot  Rinsing water is too acidic  Rinsing water is too dirty  Not enough water |
| Phosphate coating is too thing or surface rust in spray washing | Too high free acid score  Too small total acid score  Too small accelerator score  Too low temperature |
| Inefficient grease removal in spray washing | Nozzles pointing in wrong direction or clogged nozzles  Too long time since bath was replaced  Too low temperature  Weak spraying pressure  Too low washing agent concentration |

Table 6: Problems in washing and phosphating.

Solvent cleaning

|  |  |  |
| --- | --- | --- |
| Solvent | Good properties | Bad properties |
| Flammable solvents | No need for rinsing | Risk of fire |
| No need to dry with heat | Occupational safety risk |
| Doesn’t rust products | Environmental risk |
| Removes greases | Solvents are expensive |
| Washing equipment are simple | Doesn’t remove salts |
| Doesn’t leave residue in surfaces | Dirty solvent is hazardous waste without distillation |
| Hand washing is feasible | Not feasible for big products |
| Non-flammable solvents | Removes greases exceptionally well | High environmental risk |
| No need for rinsing | Solvent emissions aren’t allowable |
| No need to dry with heat | High occupational safety risk |
| Doesn’t rust products | Dirty solvent is hazardous waste without distillation |
| Doesn’t leave residue in surfaces | Not feasible for big products |
| Washing is easy to automate | Expensive |
|  | Method is deprecated |

Table 7: Properties of solvent cleaning agents

## Mechanical pretreatment of metal surfaces

WIP

## Spray painting

WIP

## Powder coating