PRECISION CLEANING in the Metalworking Industry

A continuing trend in the industry is that cleanliness standards are becoming more stringent and precisely defined.

These tightened cleaning standards are required for components of assemblies with close operating tolerances such as automotive powertrain components (engines, automatic transmissions, fuel delivery systems and steering assemblies). In these applications loose foreign particles can result in costly repairs or even loss of life as in the case of braking and traction controls systems.

For this discussion we are referring to precision cleaning as applications where cleanliness specifications limit maximum permissible contamination to a particle size less than 500 micron or weight of less than 10 milligrams per part. These limits are typically applied to new manufactured parts after the final wash prior to testing or assembly.

The actual cleanliness specifications are normally determined by the OEM based upon clearances between mating parts or the size of orifice a fluid must pass through. Residual particle analysis, commonly referred to as the Millipore test, is typically specified to verify the cleanliness achieved.

In this test the cleaned part is manually washed in a defined manner with a special cleaning solvent that is captured and filtered through a pre-weighed Millipore filter with a precise pore size. The filters are then weighed and examined (with a microscope) to determine the physical properties of the residual contamination for comparison with the particle quantity, weight, size and composition limits specified.

In precision cleaning applications these specifications are good for both the cleaning equipment manufacturer and the OEM, clearly defining the cleaning requirements at RFQ stage and providing a fair and impartial method of evaluating performance after a contract has been issued.

Standard catalogue item aqueous spray or immersion washers will not reliably meet any strict cleanliness specifications. For precision cleaning special features must be added or an entirely new system specifically engineered for the application may be required.

Choosing a Precision Cleaning System

The 1st step in selecting a precision cleaning system is for the potential equipment supplier to properly analyze the application and the contaminated workpiece. Laboratory testing will then determine the process parameters. This is critical as upstream manufacturing processes, production rates, type of contamination, workpiece base material and geometry all have a significant effect on how to clean and what type of equipment is required. A couple of examples are described below:

> Workpiece base material and manufacturing process can have a major impact on the ability of a system to clean effectively. Porous materials such as cast iron or sintered metals may continue to release particles even after extensive cleaning of the same sample. While these particles may be below the maximum permissible size limit in a cleanliness specification, their combined total weight will add to contaminant counted and may cause the cleaning to fail the Millipore test.

If in-process cleaning prior to heat treating is not adequate, residual oils & cutting fluids will not only adversely affect the hardening process, but leave the byproducts of their reaction in the process embedded in the workpiece surface. This type of contamination is extremely difficult to remove in the final precision cleaning stage without resorting to high strength detergents that can potentially damage the workpiece. This problem is obviously more economical to correct by proper in process cleaning than over-sizing the final precision cleaning system.

With aqueous cleaning technology there are 2 different methods used to achieve the cleanliness required:

1. Positive, precision approach.

   Precision aimed spray nozzles attack each orifice or area of the workpiece where contamination can be trapped to ensure its removal.

   If, due to workpiece geometry there are internal passages that are shielded from direct spray contact, special tooling can be clamped to the workpiece and cleaning fluid is forced under pressure through the passages. For more difficult to remove contamination this power flushing can be reversed and/or pulsed to improve cleaning.

   The workpiece itself may be manipulated for better access to cleaning components and provide better draining.

   This method is typically the most energy efficient, requires the least floor space and minimizes work in process. Engineering costs are usually higher and adaptability to different types of workpieces may be limited.

2. Intensified cleaning approach.

   The basic cleaning mechanisms and factors that affect performance of any aqueous system; exposure time, flow, impact, heat and detergent action, are applied in sufficient quantity to achieve the required results. A system using immersion, ultrasonics, spray or a combination of these will clean to the required level if the workpiece is exposed for a long enough time and handled appropriately.

   This method generally has the advantage of reduced engineering costs and greater flexibility to process different workpieces.

Generally a combination of both of these methods is used.

Design & Construction Features of Precision Cleaning Systems

Stainless steel construction. This is important not just for the piping system but also for the actual cleaning/drying enclosures and the workpiece handling system. Corrosion on these surfaces can detach and recontaminate a cleaned workpiece.

Filtration. In addition to the basic filtration required to protect the machinery and prolong solution life, the full flow of any solution that will contact the workpieces must be properly filtered. High efficiency cartridge filters are commonly installed on the pump discharge. Standard bag filters will not reliably trap fine particles. For high production environments, automatic indexing vacuum bed filters can be installed.

Special Piping Design. Systems must be designed to eliminate dead ends that trap contamination and reduce the use of threaded fittings that can introduce contamination at a later date. Sampling ports and valves must be installed at appropriate points so system performance can be analyzed once in production. Critical spray piping and precision manifolds must be easily removed for cleaning to maintain performance.

Special Cleaning Procedures. During the manufacturing process, piping systems and other components must be carefully cleaned and then flushed after assembly to ensure that no contamination is introduced by the cleaning system itself. The completed washer is also cleaned with strong alkali and/or acid detergents to remove all contamination from construction.

Drying and Cooling. Most precision cleaning applications also require drying and cooling the workpiece so it can be tested or assembled. Many of the features used for the precision washer are applicable to drying and cooling systems. Stainless steel construction for air supply ducting and blow-off nozzles, and filtration on blower suctions is required.

Controls & Monitoring. In a high production environment, cleanliness verification is typically performed on only a small sample of workpieces. In order to avoid costly rework due to improperly cleaned parts the cleaning system process parameters and machine functions must be continuously monitored and maintenance warnings automatically issued before performance reaches unacceptable levels.

Other features that may be required include:

Multiple Stages: In some applications multiple wet stages are required. If production rates are high and workpiece contamination is excessive, multiple cleaning stages, each one progressively cleaner are used. If strong detergents are needed, rinse stages are added to remove detergent residue, which may in itself be an unacceptable contaminant.

De-magnetizer: When processing ferrous workpieces, residual magnetism can make particle removal extremely difficult and should be reduced to levels under 3 gauss.

Self–Cleaning Feature: Contamination removed from workpieces will deposit on internal washer surfaces and can detach and recontaminate cleaned parts. In high production environments special manifolds are installed to clean the washer interior. These are actuated manually or automatically depending on application.

Choosing the Right Cleanliness Specification

Obviously, the capital expenditure for a precision cleaning system will be more than that required for a standard washer used in non-precision applications. When purchasing new equipment it is important not to needlessly specify tighter cleanliness standards than are actually required. Keep in mind the following:

Cleanliness levels with maximum particle dimension under 100 microns are extremely difficult to meet in an aqueous type washer. PROCECO can produce equipment to meet these specs, however this requires that parts are discharged into a clean room environment. Airborne particles in shop atmospheres are typically larger than 100 microns.

Cleanliness levels that specify a maximum particle dimension under 50 micron for parts with complex geometry are unreasonable and cannot be reliably achieved with the present aqueous spray cleaning technology.

If you are unsure of what spec to apply, PROCECO has years of experience designing and building precision cleaning systems for all types of industries and can assist in choosing the right specifications. PROCECO's in-house laboratory has all the cleaning and drying equipment on hand to enable our expert engineering team to properly evaluate your requirements and propose an economical solution, custom tailored for your application.

G. Weston 18/03/03