**Cleaning complex geometric parts in single piece flow**

Impingement vs. Ultrasonic Cleaning

A program engineer is presented with a challenge. A new part is manufactured containing different types and grades of steel, brass and other material. The part is designed with one deep hole, several threaded small holes, and a series of threaded shallow blind holes. In addition, the part must meet an objective cleanliness level dictated by the customer.

This cleanliness level has multiple requirements. The part must be 98% oil free upon completion, as measured by a Phase Imaging system. A Millipore gravimetric method will weigh the part also, and the filtered contaminant weight of the part must not exceed .5mg per part. Also, the part can contain no particles over 20 microns in size.

To conclude the challenge, the manufacturer must produce 2,800 parts per 8-hour shift. Meeting the cleanliness requirement while maintaining this rate of production will be a difficult task.

Faced with this challenge, many program managers assume an ultrasonic cleaning system will be the best method for cleaning the part. This method creates intense, high frequency vibrations that are used to attack the part and clean it.

However, an ultrasonic method may not the best choice for this situation. Ultrasonic cleaning requires exacting conditions in order to be successful. There must be enough energy created to clean the entire surface and no surface can be shielded by other parts or material. In addition, there must be sufficient time for the ultrasonic method to work. If these conditions are not met, the process becomes less effective.

**<u>Energy</u>**

The Industry standard for determining the amount of energy necessary is cited in the Cleaning Technology Handbook, published by Parts Cleaning Magazine in December 1998. The handbook states that:

> "The sum of the part's cross-sectional areas should not be greater than 70% of the ultrasonic tank's cross-sectional area. In addition, the workload mass to volume ratio should be no greater than 30% in parts cleaning and no greater than 15% in precision cleaning applications."

**<u>Production Rate</u>**

If the ultrasonic method is used, it will present problems in meeting the production rate requirements. In order to meet the rate and use the ultrasonic process, a large number of parts will have to be loaded together, cleaned together, and transferred to the next stage together. When using this method with an ultrasonic cleaner, problems can arise.

The transfer baskets used for the parts can waste the ultrasonic energy. All exposed surfaces will be cleaned by the ultrasonic cleaner, including the exposed portions of the transfer basket. This wastes energy the cleaner needs to reach the parts. The larger the basket, the more energy wasted. Parts stacked on each other or blocked by the basket will not be cleaned, as they are not exposed.

The parts may be re-contaminated when removed from the cleaner as well. As cleaning takes place, the oil released from the parts will be sent into the tank. The oils with a lighter gravity than water will rise to the surface. When the process is complete, the basket will rise up out of the water. Obviously, it will pass through this layer of oil, which leads to the chance that parts will pick up some oil during the move.

Finally, research cited by the Dec. 1998 Parts Cleaning Magazine shows that particles less than 25 microns in size are not effectively eliminated by ultrasonic cleaning, which is unacceptable given the requirements of our project.

**Alternative Method**

An indexing conveyor is an effective alternative to ultrasonic cleaning for the case presented. The conveyor consists of the following steps:

1. Part is manually or robotically loaded onto a specifically designed nest or fixture to be held in place for transfer from stage to stage.
2. The oriented part indexes to the point where a pneumatically activated manifold with a rubber gasket is energized, and moved down onto the fixture swallowing up the part.
3. Heated, chemically blended solution floods the part by being pumped through the manifold. This solution drains out the bottom of the fixture.
4. The gasketed manifold is then lifted while solution continues to spray over the part. Sheer force of fluid combines with temperature and the chemical to flush oil and particulate from all crevices, holes, threads and surfaces.
5. Part is indexed to next fluid stage for corrosion protection if necessary.
6. Part is then indexed to the next stage where the part is vacuum dried. Here the part is engulfed with a rubber gasketed manifold that creates a vacuum that allows the mechanism to lower the boiling point of water so that all liquid is evaporated before the manifold is released.
7. Part is then indexed to the unload stage where the robot or operator is able to remove a clean, dry part that is neither too hot or too cold.

The sequence of operations can be timed to meet the necessary production requirements. This system also offers greater flexibility than the ultrasonic method. Pumps, vacuum dryer, manifolds and pneumatic activators all can be sized to achieve the necessary action to adequately flush the part and evaporate the moisture. Devices such as washer fluid management, filtration, and in-process treatment options can all be added to the system as required.

This system can effectively meet all production and cleanliness requirements presented in the challenge, making it a more attractive option than the ultrasonic method.