The Most Advanced, Automatic,
Non-Disposable Liquid Filtration System

ZERO GRAVITY FILTERS

AUTOMATIC FILTRATION IN THE PARTS WASHING INDUSTRY

Authors:
J. Todd Bruhn, Zero Gravity Filters
William Smith-Haddon, Cross Manufacturing Company

SUMMARY

Engineers and environmentalists around the world are seeking more acceptable solutions to manufacturing problems. The parts cleaning industry in particular has seen stricter controls on the use of many hydrocarbons and waste products, and this has driven the trend towards an aqueous based approach.

Moreover, commercial constraints demand that the modern aqueous parts cleaner be as automatic as possible, minimising the need for manual intervention, and disposable media. Fully automatic, self cleaning, non-disposable filtration technology is now an affordable reality.

This paper has been designed to:-

- Review the case for filtration in the parts cleaning industry.
- Discuss the various existing filtration technologies in use today.
- Explain the advantages of 'Variable Geometry Filtration'.
- Debate the relative merits and demerits of full flow versus sidestream filtration.
- Investigate the economic case for non-disposable filter media.
- Look into a specific parts washer case history application.

AQUEOUS PARTS WASHING

Now that the shift has been made from vapor degreasing to aqueous cleaning, the goal is to minimize the cost of operating an aqueous cleaner yet maximize its cleaning efficiency. Admittedly, much work and progress has already been made regarding water chemistry, parts drying, and oil separation, however; additional work needs to be done on contaminate removal. This is particularly relevant given the larger volumes of water that is required compared to using CFC's.

WHY USE FILTRATION?

Filtration is commonly used on parts washers to remove solid particles that accumulate in the wash water. These particles originate either from the part being washed or from the environment in which the washer is located. In many instances, airborne debris can be a significant source of solids within the tanks. By removing these solids, the following advantages may be attained:

1. Lengthen the time between draining the tanks,
2. increase the cleanliness of the part being washed, and
3. maintain system up-time by protecting spray nozzles.

LENGTHEN THE TIME BETWEEN DRAINING THE TANKS

The accumulation of solids within the parts washer, either from the part or the environment, will continue to accumulate within the tank unless the solids are removed. Typically, this is accomplished by draining, washing, and then refilling the tank. Although this is commonly used, it has several drawbacks.

First, the continual accumulation of debris within the tank will reduce the cleaning efficiency of the parts washer. This will manifest itself in several ways:

1. Parts are being washed with increasingly dirty water,
2. Increased solids levels will begin to clog the spray nozzles which hinder cleaning efficiency, and
3. Solids will degrade the effectiveness of the detergents and chemicals.

Secondly, it is extremely costly to drain and clean these tanks. These costs include the labor to drain, clean, and refill the tank as well as the cost of lost production due to washer down-time. Additional costs include reheating the water and adding the necessary chemicals and detergents. Furthermore, the chemicals contained in the water may create problems for waste treatment.

The removal of these solids on a continual basis through the use of filtration will maintain tank cleanliness and thus lengthen or possibly eliminate the need to drain and refill the tanks.

INCREASE THE CLEANLINESS OF THE PART BEING WASHED

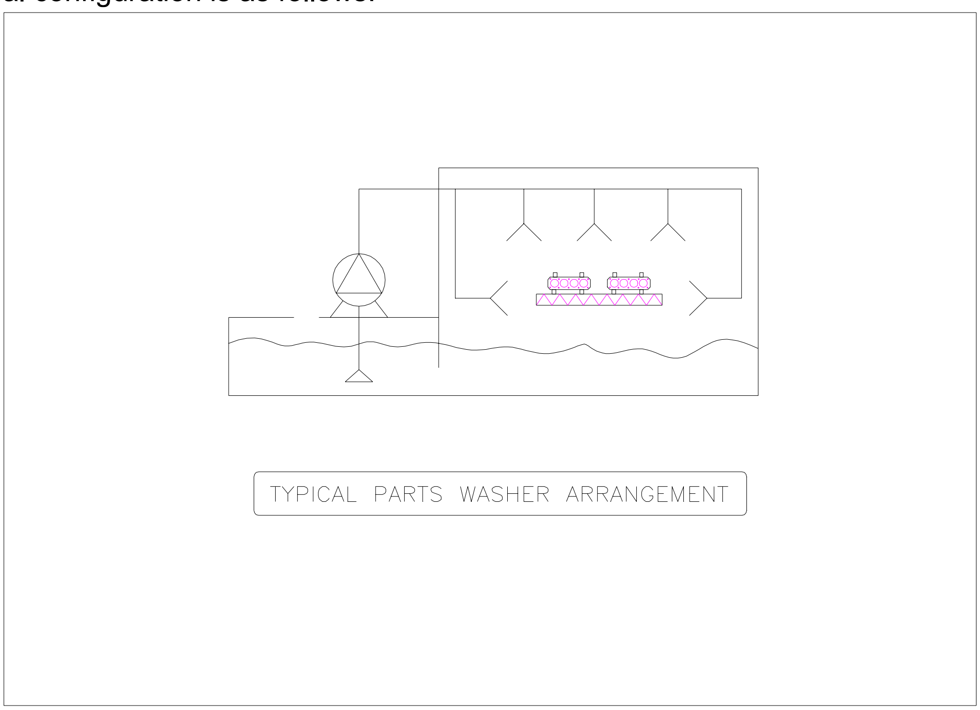
As mentioned in the prior section, the accumulation of debris within the tanks will reduce the cleaning efficiency of the parts washer. This will eventually lead to the parts not meeting their cleanliness specification. This results from 'carryover dirt' or dirt that remains on the part. This problem will typically reveal itself in an increased number of rejected or reworked parts. This generally occurs in painting operations or where dirt remains within holes or small crevices that require a tolerance in subsequent operations.

The first stage to eliminating 'carryover dirt' is to have clean, solids free water.

MAINTAIN SYSTEM UP-TIME BY PROTECTING SPRAY NOZZLES

The use of spray nozzles within the parts washing industry is fairly common and is often a critical step in the cleaning process. The use of high pressure pumps and nozzles with increasingly smaller orifice openings are becoming more common.

A typical configuration is as follows:



As illustrated in the drawing, water is drawn from a large tank and pumped to rows of spray nozzles. These nozzles are usually positioned in the washer to clean a specific part. As such, it is critical that as many nozzles as possible are spraying the part. To achieve this, two things must be overcome.

First, as the water used to clean the part is recirculated back to the same tank from which it was drawn, this will obviously increase the solids level within the tank. This will eventually clog the spray nozzles.

Second, it is very difficult to determine when a nozzle has clogged. It is usually discovered through the production of dirty parts and the correspondingly increase in reworked parts.

DISADVANTAGES OF EXISTING FILTRATION TECHNIQUES

Despite all the advantages of using filtration, many parts washers do not use filtration and many users complain of the associated maintenance. Some with experience of filtration carry memories of constantly blocked screens, flow starvation, and significant time and money to manually clean the filter. However, these same users will agree that filtration is an important step in maintaining cleaning efficiency.

The most common type of filter used on parts washers are of the disposable media type, usually either cartridges or bags. The dirty water flows through the filter medium trapping the dirt on the outside of the media while providing relatively clean water to the system. The trapped particles eventually offer resistance to the flow of water through the filter and the differential pressure across the filter increases. At some point, the filter medium has to be discarded and replaced with new.

The frequency at which these filters are changed is dependent on several factors, including:

1. The amount of dirt in the system,
2. the system's flow rate,
3. the micron retention of the filters, and
4. the amount of filter surface area available.

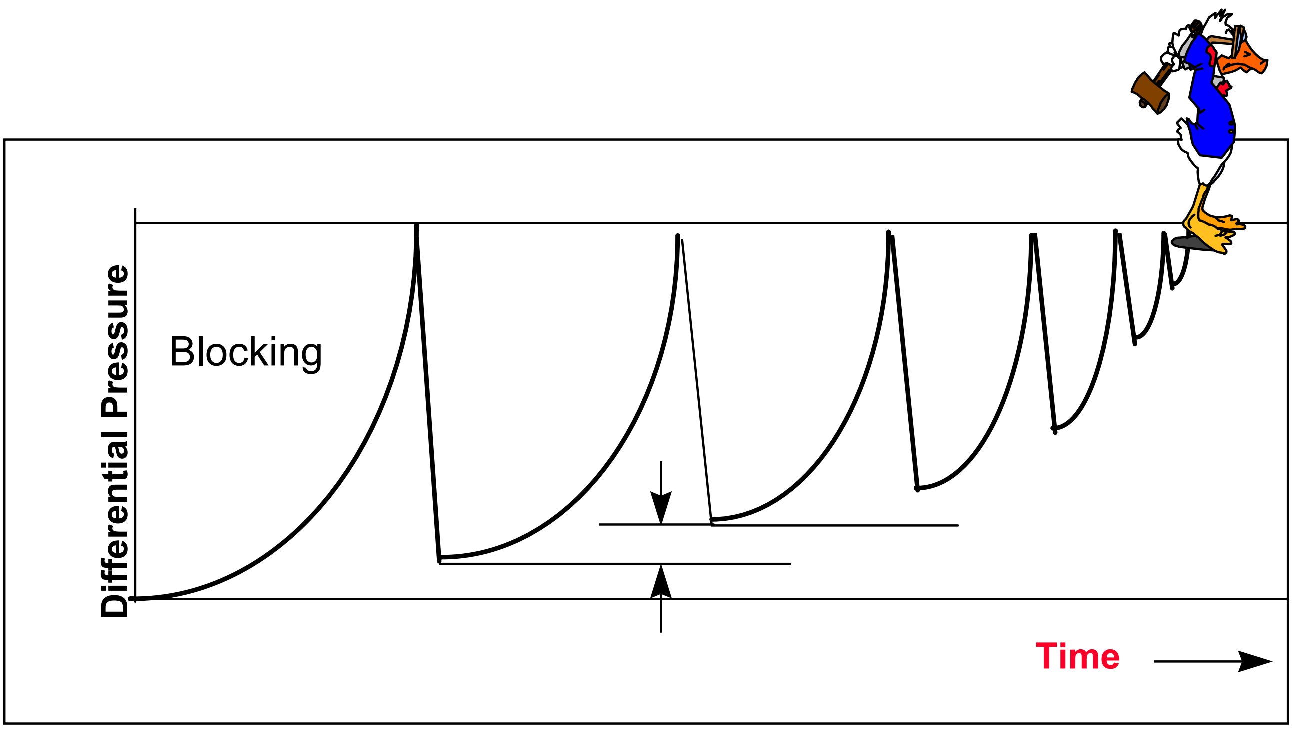
Typically, points one through three are dictated by the process and therefore to lengthen the time between filter changes, companies have either oversized the filter or added redundant systems, both of which add cost without significantly reducing the inconvenience or cost of maintaining the filters.

To alleviate the drawbacks of using disposable filters, yet maintain the inherent advantages of providing filtration on parts washers, several automatic backwashing filters have been used. Typically, they can be categorised as a wedge wire type design or 'fixed screen'.

Fixed screen elements tend to become blocked very easily due to contaminants becoming 'locked' in the filtration gaps. However, over time, incomplete cleaning leads to an unacceptable pressure drop. The elements then require manual cleaning, which is not only inconvenient but extremely costly.

Some filter systems have tried to destabilize these particles through the use of suction, scraping, and/or high pressure have proved ineffective at maintaining a continuously clean screen. Although the cleaning efficiency is sometimes improved, the equipment is either too complicated or requires too much maintenance.

The following chart illustrates this point by plotting differential pressure against time. As shown, over time a filter's differential pressure will increase as debris accumulates on the filter. At some predetermined set-point, a filter will initiate a backwash. However, because particles become wedged in a 'fixed screen' design, the filter does not return to its clean differential pressure. This shortfall highlights the filter's inability to clean itself, and is indicated by the two arrows. As this process continues, eventually the system must be taken off-line and manually cleaned.

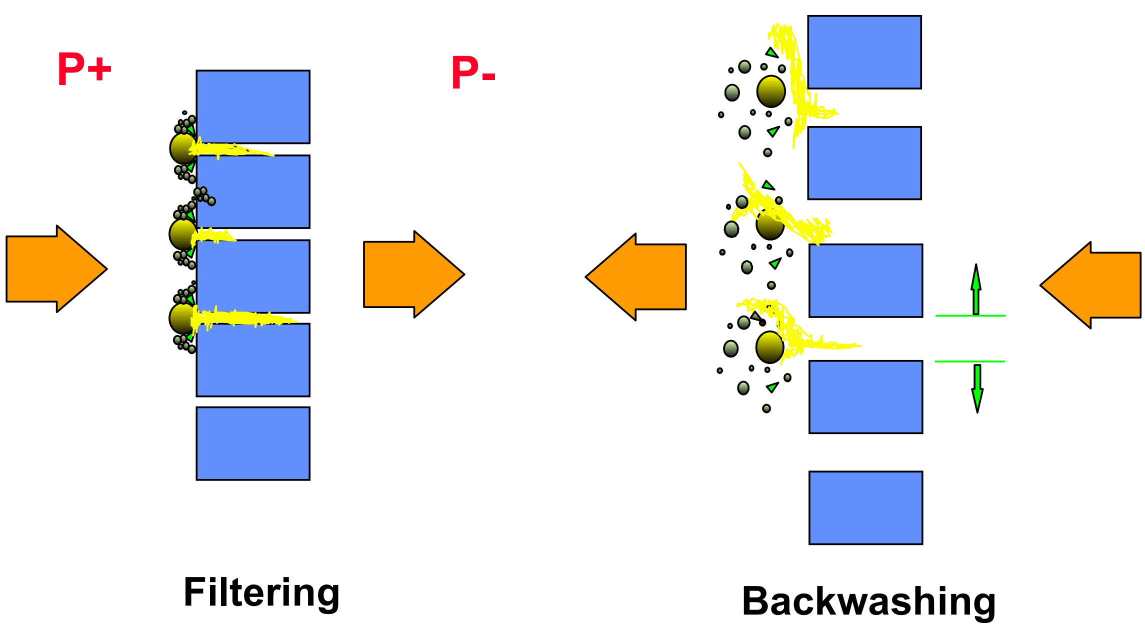


INTRODUCTION TO THE ZERO GRAVITY FILTER

Research on a new element design began due to the inability of conventional filters to sufficiently clean themselves. This research has led to a breakthrough in coil spring manufacturing. Through a highly technical and patented process, a wire is wound on a mandrel with a variable pitch that allows the coil to open evenly during backwash.

This opening allows any 'lodged' or 'wedged' particles to be easily removed in that the gap which has trapped the particles has now been increased. In addition, while open, liquid flowing in a reverse direction will cause the turns of the coil to shimmer, which further enhances the backwash process. This can be achieved with relatively low inlet pressures and with a fraction of the water loss compared to the old fixed element design.

Variable Geometric Filter



Unlike conventional 'fixed screen' designs, the zero gravity filter will return to a clean differential pressure after each and every backwash. Due to its cleaning efficiency, this type of design lends itself very well to automatic controls. Complete filtration systems incorporating the zero gravity filter are designed to operate 24 hours per day, seven days per week without manual intervention.

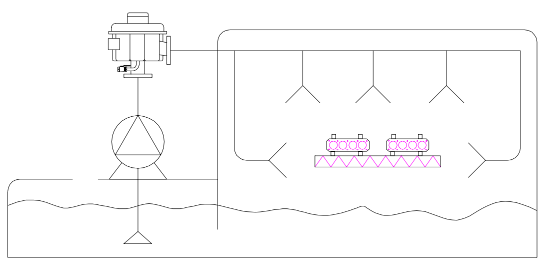
WHICH SYSTEM IS RIGHT FOR YOU?

There are two basic approaches to removing solids within a parts washer, full flow or side-stream filtration. The choice is dependent on the following factors:

- How much dirt is being introduced into the system? Higher dirt loading will favor full flow.
- How stringent is the cleanliness specification? Higher specifications favor full flow.
- Budget allocation? Generally full flow filtration is a more expensive option.

FULL FLOW FILTRATION

The principle advantage of full flow filtration is that all water being pumped to the system will be filtered. This will ensure that all particles above a certain micron rating will have been removed prior to the water reaching the nozzles and the part. In this configuration, the filters are providing 100% protection of the nozzles. This approach is recommended for all critical cleaning operations in that system down-time due to clogged nozzles is eliminated (assuming proper micron specification). Furthermore, cleaner parts are achieved through properly functioning nozzles as well as 'dirt free' water cleaning the part.



FULL FLOW FILTRATION

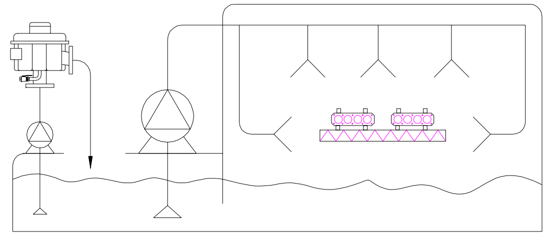
SIDE STREAM FILTRATION

Side stream filtration is recommended for applications where the goal is to remove solids from a tank on a continuos basis. This is differentiated from full flow filtration in that although both approaches remove contaminants from the tank, only with full flow filtration are the spray nozzles being fully protected.

Benefits of side stream filtration include lower capital costs as well as a filtration system that is independent of the washer. This allows the filter to operate continuously, even when the washer is off-line. Another advantage of side stream filtration is that it allows agitation of the water within the tank which helps prevent the build-up of debris.

Furthermore, as the filtration loop is independent of the washer, it is possible alter to the micron rating and filtration flow rate at will, without affecting the parts washer's hydraulic performance.

This is sometimes desirable since the required micron rating is not always easy to predict. It is also useful when a washer is to be used for a number of different parts. For example the micron rating and flow rate required for simple swarf removal will be significantly different from the filtration parameters for fines removal applications.



TYPICAL SIDESTREAM ARRANGEMENT

BUYING DECISION - AN ECONOMIC APPROACH

When evaluating the decision to purchase a capital item, such as an automatic backwashing filter, many companies use various capital budgeting techniques, including ratio analysis. These ratios include return on capital, net present value, internal rate of return, and payback period. The payback period is commonly used due to its simplicity and ease of calculation.

The payback period is defined as the number of years required to recover the cost of a capital item and is commonly used in evaluating capital budgeting projects. The payback period is calculated as follows:

period = initial investment divided by cash inflow

The initial investment is the capital outlay or the purchase price of the equipment or in this example a filter. The cash inflow is the amount of money saved by using the new filter compared to either no filtration or the existing filter. A hypothetical (although not that hypothetical) example will best illustrate the calculation of the payback period.

A manufacturer currently uses bag filters to remove aluminum fines from their parts washer to meet its cleanliness specification and to lengthen the time between bath changes. The manufacturer changes the bags two times per shift and operates two ten hour shifts. Therefore, in a single day, a total of four bags are replaced. The washer operates seven (7) days per week, and consumes 28 bags per week or 1,400 bags per year (50 week year). The annual operating cost of the existing bag filter system is estimated as follows:

<u>Bag Cost</u>

Unit Bag Cost	$6 per bag
Annual Bag Usage	1,400 bags
Total Bag Cost	$8,400

<u>Labor Cost</u>

Hourly Wage	$20 per hour
Total time for bag changing	30 minutes
Annual number of bag changes	1,400
Total Labor Charge	$14,000

<u>Disposal Cost</u>

Disposal Cost per bag	$2
Annual number of bag changes	1,400
Total disposal cost	$2,800

<u>Administrative Costs</u>

This does not include the administrative costs of ordering, receiving, and storing of the bags nor the cost of disposing of the bags. In addition, we have ignored the costs of any downtime associated with maintaining the bag filters.

<u>Total Costs</u>

Total direct cost of operating the bag filter system is $18,375.

The next step is to calculate the annual operating costs of a comparable zero gravity filter.

Annually renew all O'rings	$100
Hourly Wage	$20 per hour
Total Hours	2
Total annual operating costs	$140

Assume that over the life of the automatic filter, replacement of worn parts occurs every two years at an average annual cost of $750.

Total annual operating cost of the Phoenix is $890.

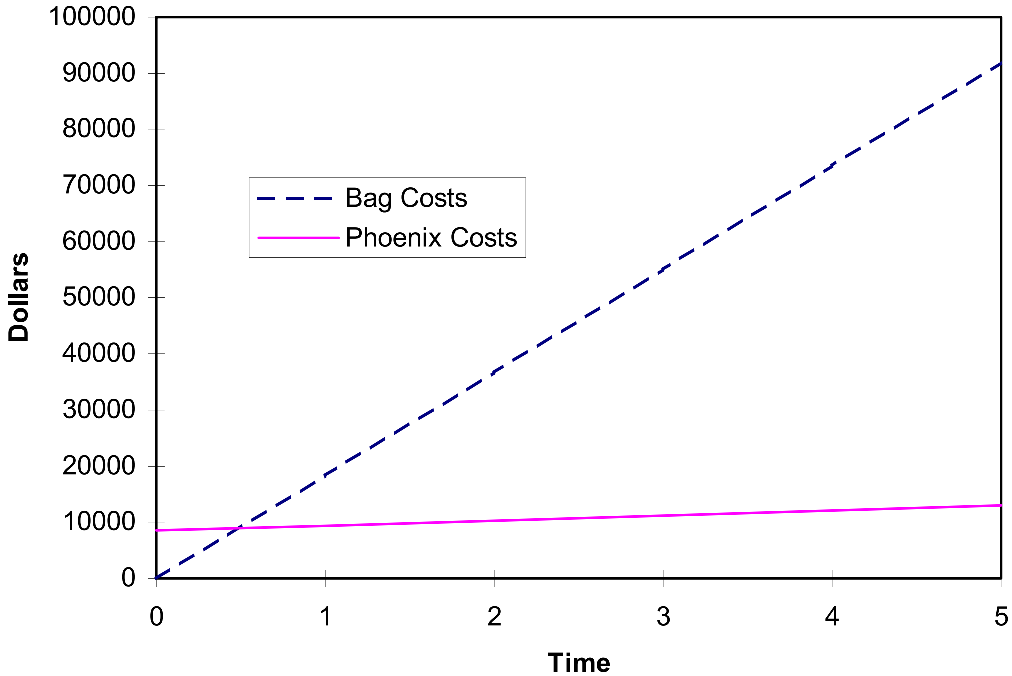
To calculate the payback period to replace the existing bag filter system with an automatic filter is calculated as follows:

payback period = (initial cost)/(net cash inflows) = ($8,500)/(18,375-890)

(8,500)/(17,485) = .50 or 6 months

Acceptable payback periods range between 1 and 2 years and depends on the industry and whether the item is classified as a maintenance or process application. Certainly, a six month payback would be acceptable for any company. This is illustrated graphically as follows.

Comparison of Costs



Of note, the two lines cross at approximately six months. This illustrates that the higher operating costs of the bag filters quickly offset the initial outlay of a zero gravity automatic filter.

CASE HISTORY

Application Background

Surface finishing in the automotive parts industry is critical to ensuring consistent high quality end products. Prior to painting, components are thoroughly degreased and washed in parts washer. The number of washer/rinse stages varies depending on the type of part to be finished. Typically, the more stages, the higher the visibility of the component on the finished automobile. Particulate matter is removed from the part at each stage and consequently, the stages begin to collect dirt. If the level of dirt is allowed to build within the washer stages, imperfections in the part's final finish begin to appear. These parts are ultimately rejected and represent a significant rework cost to the automotive surface finisher. Traditionally, washer stages have been operated in one of two ways to address dirt. In many operations, the wash waters from stages 1 through 3 are recirculated through a 50μ filter bag. While the remaining stages periodically add high quality wash/rinse water to the system and allow dirt levels to flush to drain.

Filter and Water Facts

The typical operating costs for this manufacturer's 50μ bags were in the order of $9,500 per year. High quality water treatment loses were in the order of $7,200 per year. These are raw costs and do not include labor or disposal costs. In many operations, due to reduced maintenance staffing and the inconvenience of replacing the filter bag, routine bag replacement is often overlooked. This results in a higher part's rejection rate from all stages due to dirt.

Trial Agreement

A Tier II automotive manufacturer agreed to an on-site trial using the 'zero gravity' filter to evaluate the following purchasing criteria.

1. Will the 'zero gravity' filter provide as effective filtration as their 50μ bag filters?
2. Will the 'zero gravity' filter reduce the current part's rejection rate due to dirt?
3. Will the 'zero gravity' filter provide automatic, continuous backwashing?
4. Will the 'zero gravity' filter eliminate the ongoing cost of replacing bag filters?

Trial Period

During a 48 hour trial period, the 'zero gravity' filter was installed on the first stage of a five stage parts washer. The first stage of a parts washer always has the heaviest dirt loading. The manufacturer's Stage 1 was serviced by a 1,200 gallon reservoir containing a Gluconic acid solution. The filter unit ran continuously through the trial period, backwashing approximately 200 times. Backwash cycles occurred initially every five minutes until an equilibrium was achieved and thereafter, approximately every 15 minutes. To recover the washer chemical, the backwash was collected in a 10μ filter bag and discharged back into Stage 1.

Although filtered effluent samples were not taken for independent evaluation, the manufacturer's Quality Assurance department became an integral component in the evaluation. By checking paint imperfections in the finished parts before, during and after the trial period, **the manufacturer attributed a decrease in the final part's rejection rate to the 'zero gravity' filter.**

In summary, the trial period satisfied the manufacturer's criteria for application on their parts washer. First, filtration efficiency, as measured by a reduction in rejected parts, demonstrated that a 50µ 'zero gravity' filter was superior to the 50µ bag. Second, the 'zero gravity' filter operated automatically on an aggressive chemical cleaner for the duration of the trial. Without supervision or manual cycle modifications, the Phoenix continuously adjusted cycle times to reflect dirt loading rates.

Conclusion

The manufacturer, based on the trial, purchased a Phoenix filter system for their existing parts washer. Due to the reliability and success of the filter to remove dirt from the washer a second Phoenix has been specified for a new washer which is part of an overall facility expansion. Reductions associated with water treatment have not yet been addressed. As part of an overall strategy for better water conservation, water recovery and recycle techniques will be incorporated into the design of the new washer. The Phoenix is a key element in the water reduction flow sheet.

CONCLUSIONS

Environmental constraints and regulations, together with commercial pressures will become more rather than less demanding in the coming years.

The modern, automatic, self-cleaning filter addresses both of these issues for the parts washing industry.

It is easily adapted to almost any design of parts washer and can deliver better quality parts, freedom from blockages, freedom from laborious bag changing while providing a long term cost benefit stream.