Analyzing the Effects of Pressure and Flow in Power Spray Washing

With the goal of differentiating themselves from the competition, some aqueous washer suppliers have marketed high pressure as the single most important factor in parts cleaning. As will be shown in the paragraphs that follow, that is simply not the case. Just as aqueous spray washing may not be suitable for certain applications such as semi-conductors or optics, high pressure power spray washing may not be suitable for certain applications such as large parts with intricate passages or shaded areas. In order to understand the benefits of using high pressure water in power spray washing applications, we must first understand what factors play a role in parts washing.

Washing is the process of dissolving or suspending soils in water and then flushing them away. Power spray washing processes combine chemical, thermal and mechanical energies to remove soils from a substrate (workpiece). Chemical energy relates to the chemical reaction used to dissolve or remove the soil from the workpiece. Thermal energy relates to the temperature at which the chemical reaction takes place. The rate of a chemical reaction can often be increased with an increase in temperature. Temperature will also play an important role in cleaning when the soil to be removed can be melted away or loosened by the effect of heat. Therefore, if the cleaning process works by chemical reaction such as that between a grease/oil and an alkaline cleaner; or an acidic chemistry removing rust or welding scale; or a paint coating undergoing chemical decomposition; then flow will play a more important role than pressure. Adequate flow will ensure that once the soil has been removed from the workpiece, it is flushed away and that fresh chemistry continually comes into contact with the contaminated workpiece.

The third form of energy used in power spray washing, mechanical energy, is the spotlight of this analysis as it relates to the pressure and flow of the spray leaving the spray manifolds. Pressure can be very effective at penetrating the surface of a soil that is deposited on the workpiece. Provided that direct impingement is possible, the penetration or cutting edge of a water jet can physically separate a layer of paint, baked on dirt or carbon from a surface. The water jet's ability to penetrate and separate the dirt from a workpiece is a function of the water impact force.

Fluid mechanics reveals that the average impact of a water jet that comes in contact with a surface is proportional to the flow times the velocity at impact divided by the impact surface area:

$$\frac{Q * V_2}{A_2}$$

Where Q is the volume of water hitting the cleaning surface; V_2 is the velocity of water at the cleaning surface and; A_2 is the area of contact at the cleaning surface.

Related theory also states that the initial velocity (V_1) of the water jet leaving the spray nozzle is proportional to the **square root of the pressure** (P_0) of the fluid **prior to exiting** the nozzle.

$$V_1 \cong \sqrt{P_0}$$

However, once the water jet has exited the nozzle, the pressure becomes atmospheric and the stored energy is transformed into kinetic energy as fluid velocity. However, as the water jet travels over time the following conditions occur:

1. Drag forces quickly cause the water jet to decelerate and hence **V_1 to decrease**.
2. The nozzle fan **area increases** with distance until it contacts the surface A_2.

This can easily be observed by examining the spray pattern of a household garden hose.

Both of these factors are detrimental to the impact force. Therefore **the proximity of the nozzle to the workpiece is very important** for the impact force to have any effect at penetrating the contaminant or dislodging any partially loose material on the workpiece.

Flow on the other hand will not vary between nozzle and workpiece and as a result becomes more effective at cleaning larger surfaces. Therefore, flow is directly correlated to productivity or the time required in cleaning a surface. On a similar note, by narrowing the nozzle fan angle from say 50° to 15°, the contact area can be decreased thus increasing the impact per unit area. However, decreasing the contact area must be compensated by increased cycle time or additional nozzles in order to fully cover the total surface area of the workpiece.

From an energy perspective, the energy required to develop the flow will effectively be used since all of the flow will reach the workpiece, however the energy used to develop the pressure is easily lost in spray angles and the distance between the nozzles and workpiece if the distances are great. This energy is also dissipated once the water jet has contacted the surface. From an equipment standpoint, higher pressure centrifugal pumps used to re-circulate cleaning solutions are generally more expensive and less efficient; however the cost of heating and filtering higher flows tends to be more costly.

In conclusion, energy in the form of heat, a chemical reaction, and pressure and flow all play different but combined roles in power spray washing. Just as one would not use an artist brush to paint a picket fence, neither should one be led to believe that pressure alone is the most important factor in power spray washing. As part of the selection process, a true assessment of the cleaning requirements should be discussed with reliable sources, able to back-up their claims with process testing and/or testimonials from existing customers.

Written by Robert Burns, P.Eng.

President, Proceco Ltd.

PROCECO has over 30 years experience in aqueous spray applications ranging in pressures from 30psi to 10,000psi and flows from 5gpm to 1600gpm. PROCECO's extensive applications experience includes high flow aqueous cleaning tasks such as precision parts cleaning to degreasing of railway bogies and high pressure spray applications such as carbon removal and hydro deburring.