

## **DRYING after Aqueous Cleaning**

With aqueous based cleaning, workpiece drying is an essential element of the process. Level of dryness required varies from simply removing excess water to prevent spills and maintain a clean, safe work environment, to dry for critical processes such as thermal deburring, leak testing and assembly.

Drying is accomplished primarily by evaporation and physical displacement. Evaporation rate is dependant on difference in vapor pressure between the water on the part and the air used for drying. Increase in part and air temperature, and increasing the flow and velocity of the air all contribute to increased drying effectiveness. Pressure is used to provide the high speed impact to displace water from the workpiece or spread it over an extended surface area to improve evaporation.

In many cases where washing temperature is high (140°F+), parts will dry in ambient air within minutes of exiting the washer and no extra drying system is required. If this is not the case, the following systems are available.

### **1. High Impact Air Blow-Offs**

High-impact air blow-off systems (HIABO) are designed to shear off droplets and trapped liquid from part surfaces, consequently spreading the moisture over a larger surface area and thereby accelerating the evaporation process. When properly designed, these systems can remove over 95% of the moisture from the part surface. This system is suitable for high production items such as automotive power train components and will dry with a minimum exposure time (typically 15 to 60 seconds). The system requires minimal floor space and does not increase demand on plant compressed air supply since a blower is used to supply air for drying.

The moisture shearing effect of a high-impact air blow-off is produced with a pressure blower capable of generating 2.0-3.0 PSI pressure and a specially designed, precision air knife producing air speeds ranging from 100–350 MPH.

By design, in order to double the evaporation rate of a blow-off system, the air speed must be increased by a factor of 5. However, simply spreading the solution across twice the surface area will produce the same result. Given that a well-designed HIABO system can easily spread a moisture droplet across 15 times its original surface area, it requires 38 times less air than a low-impact system to achieve the same result.

Regenerative blowers are typically used in these systems and inherently increase the air temperature by compression. At the discretion of the designer, the total ambient air stream temperature can be raised by as much as 20°F, effectively doubling the evaporation rate. For more difficult applications an electric heater is installed downstream of the blower to increase temperature up to 250°F.

The air used for drying is not recirculated in this system, so only clean dry air (supplied by the blower from plant atmosphere) contacts the workpiece. The process enclosure is exhausted at a rate slightly higher than the blower capacity to evacuate water removed from the workpiece and prevent escape of the hot humid air into plant atmosphere.

Blowers are selected depending on the application. PROCECO supplies units with flow capacities up to 850 scfm and pressures up to 100" w.c. (3.6 psi).

A number of methods are used for delivering the air to the workpieces:

#### **Linear Air Knives**

These are typically used for general purpose drying to remove excess water and in applications where different workpieces will be processed through the same equipment. Using multiple air knives for prolonged exposure can produce excellent drying results even on complex workpieces. The air knives are designed to cover the entire workpiece silhouette. This system requires relative movement between workpiece and air knives. This is accomplished by moving the workpiece past the fixed air knives or by reciprocating the air knives past a fixed workpiece. PROCECO designs and manufactures a complete line of high efficiency, low noise air knives.

### Precision Nozzles

High flow nozzles are precision aimed to dry specific areas while the workpiece is stopped in an indexing system. This is typically used for workpieces with complex geometry, such as automatic transmission valves and any item with large blind holes or internal cavities.

### Positive Pressure Drying.

Some workpieces with complex internal passages (such as fluid control valves for braking and traction control systems, and distribution manifolds for diesel injection systems) are extremely difficult to dry as the internal wetted surfaces are not in line of sight of the air nozzles. In this case specially designed manifolds are clamped to the workpiece and air is forced through the passages for rapid drying.

## **2. Recirculating (Low Impact) Blow-Offs**

For larger workpieces, such as assembled transmissions, a system using a combination of the principles used in convection ovens and high impact blow-offs is often recommended. A medium pressure (6" to 45" w.c., 0.2 to 1.6 psi) radial blower is used to recirculate heated (150 to 250°F) air for convection drying and supply high velocity air through precision aimed nozzles or air knives to physically displace water from difficult areas of the workpiece. Typical exposure time required is 1 to 3 minutes.

A percentage (20 to 50%) of the main airflow is exhausted to remove the evaporated water. This system requires more floor space than a high impact air blow-off but less than a convection oven. Heating requirements are also less than a convection oven but the higher horsepower, high speed blowers generate more noise than the low pressure blowers used in convection ovens.

## **3. Compressed Air Blow-Offs**

This system uses the impact from high pressure plant supplied compressed air (at 20 to 100 psi) to physically displace the water. This is the least expensive system to purchase and requires the least amount of floor space.

Compressed air systems are generally used to remove excess water from specific areas of a workpiece and not as complete drying solutions.

Compressed air blow-offs with precision aimed nozzles are often used to compliment other drying systems to remove water from difficult areas of the workpiece, such as blind holes. These nozzles can be also mounted on retractable manifolds so they can be automatically positioned to address areas of the workpiece that are inaccessible to fixed nozzle manifolds or air knives due to restrictions imposed by workpiece handling methods.

For clearing water from small bore holes and blind tapped holes the operation of the nozzles is rapidly pulsed for more effective operation.

The major disadvantages to compressed air blow-offs are the high demand on plant compressed air supply and generally higher noise levels than other blow-off methods.

To reduce demand a single nozzle can be mounted on a multi-axis transport system to clear multiple orifices on a workpiece. Flow amplification nozzles can be used which entrain surrounding air with the compressed air jet to significantly increase flow with a minimal reduction in pressure. These nozzles also reduce noise levels. On high production equipment, part sensors are installed so that the air blow-off is only actuated when a part is present.

Compressed air blow-offs will also reduce part temperature (5 – 10°F dependant on exposure time & flow) which can be a desirable feature if cool parts are required for downstream processes.

#### 4. Vacuum Dryers

This process relies on evaporation only and no heat is used. The workpiece is placed in a sealed vessel and a vacuum pump is used to rapidly (10 seconds or less) evacuate the vessel to an absolute pressure of 3 to 5 Torr. The vapor pressure of water is thus reduced to a point where it will evaporate at below 40° F. This process quickly dries the workpiece and since no heat is added, the heat of evaporation lost also cools the workpiece. In many applications this cooling effect can eliminate the need for separate cooling tunnels required to bring workpiece temperature down to acceptable levels for safe handling or processing in downstream operations such as gauging, leak testing and assembly. Typical cycle time for parts such as automotive power train components is between 20 and 60 seconds.

Vacuum drying is used when critical processes require absolutely dry parts and is best suited for removing thin water films that cover the entire workpiece surface.

Pooled water or filled blind holes will not dry quickly with the vacuum process. A regenerative blow-off for rough drying is typically installed upstream in this case.

The vacuum system is the most energy efficient drying system available, requires minimum floor space and no exhaust connections outside the plant.

#### 5. Convection Ovens

This process relies mainly on heat to evaporate the water from the workpiece. A low pressure (1 to 4" w.c., .04 to 0.14psi) radial blower is used to circulate a high volume of heated air past the workpieces. These systems normally operate in the range of 250 to 350°F. To conserve energy the air is recirculated. A percentage (10 to 30%) of the main airflow is exhausted to remove the evaporated water.

Convection ovens typically require longer cycle times (1 to 10 minutes), significantly more floor space and use more energy than the other drying methods described, but the effectiveness of the process is not as dependant on workpiece geometry. No special workpiece fixturing or precision aimed nozzles are required; anything that will fit through the oven will dry.

For large workpieces, such as electrical control cabinets and automotive sheet metal stampings, convection ovens are normally the most practical solution.

#### **Additional points to consider when designing a drying system:**

- 1) Part orientation is very important; parts must be positioned so they drain effectively and areas of the part that trap water are directly exposed as close as possible to the air knife or blow-off nozzles.
- 2) Threaded holes are difficult to dry. High impact air blow-offs are usually necessary.
- 3) Blind holes are more difficult to dry than through holes, and vertical blind threaded holes on the top horizontal surface of the part are almost impossible to dry completely. Precision aimed, pulsed compressed air blow-offs are normally required.
- 4) Small bore holes (under 1/16" Ø) are almost impossible to dry completely. Positive pressure drying is normally required.
- 5) Low density parts that do not store significant heat (e.g. aluminum sheet or plastic construction) will not dry rapidly in ambient air when they exit the equipment.
- 6) Formed sheet metal parts such as pans that have seams, rolled or double wall lips are difficult to dry as they may continue to leach water from the seams after part has past the blow-off. In extreme cases a convection oven is the only solution.
- 7) Continuous channels in topside horizontal surfaces such as large O ring grooves and lips of pans are difficult to blow-off since the water tends to simply move along the channel. For these applications high impact air blow-off with multiple or reciprocating air knives are effective.

- 8) Wash process has a major effect on drying capabilities.
  - a. Higher operating temperature will aid drying.
  - b. City water only does not drain off parts as effectively as R.O. or De - I water, or water (in rinse stages) with detergent residue from previous stages or with a rinse aid.
  - c. When using high temperature blow-offs it is important to choose appropriate detergents and rust inhibitors that do not leave behind excessive residue when the water is evaporated. This residue can coat the blow-off chamber and may eventually detach and recontaminate the workpieces. If this is unavoidable automatic cabinet cleaning systems must be installed.
  
- 9) In applications requiring tight cleanliness standards it is important that the drying system is constructed to prevent recontamination of a precision cleaned workpiece. Blower suction filters and stainless steel construction for piping, air knives and nozzles are required to ensure that that only clean air contacts the workpiece.

G. Weston, 12-05-03