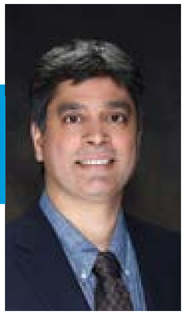

AN INSIDER'S PERSPECTIVE

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Ventilation in Blast Machines

Introduction

Without an exception, every functional blast machine whether cleaning, peening, or performing a similar action, is ventilated by a dust collector and exhaust fan. This collector takes several forms from a simple "sock" in a small manual blast cabinet to a programmable cartridge-type collector or wet collector for special applications. For those of you wondering the relevance of this discussion to shot peening machines, a vast majority of your airblast peening machines use the ventilation volume and exhaust fan static pressure to pneumatically convey the media through the machine. This is commonly referred to as "vacuum reclaim." Before we get into the depth of our discussions, allow me to relate my initiation into ventilation and dust collection as a young engineer in India.

My employer was a company that manufactured dust collection systems to ventilate any dust emanating source including blast machines. This comprised of furnaces for fume extraction, cement plants with its multiple dust sources and so on. My work instructions were simple: (a) drive around until you see brown smoke from a stack, (b) go in and sell your dust collection solution! One such not-so-cold call to an electric arc furnace location put me in contact with a plant manager that was convinced with my pitch of how this marvel of a box with filters was going to solve his pollution control problem. When we started discussing operating costs, I was duly informed that he would only operate the 75 HP exhaust fan connected to the dust collector "as needed".

Further enquiry revealed that my customer's problem was not pollution control, but pollution control authorities! Therefore, the exhaust fan in his power-strapped neighborhood would only be operated in the presence of, and to appease authorities! This anecdote is also to validate that this literary product has been generated without ChatGPT or CoPilot's active assistance!

The need for ventilation

When starting up a blast machine, the sequence commences with powering the motor driving the exhaust fan. As a result, the machine is always under negative pressure. All other motors that power the different reclaim system components in a mechanical reclaim system such as scalping drum, if provided, bucket elevator and screw conveyors are then sequentially energized. Blasting generates dust, the concentration of which is dependent on several factors such as the abrasive/media, contaminant being cleaned, and surface being impacted during shot peening. If not evacuated, this dust will mix with the abrasive/media creating an environment that is not conducive for continued machine operation. I am trying to also gear this discussion to blast cleaning which should explain my use of "abrasive"— a term typically reserved for cleaning applications. Recommended ventilation velocity in cleaning applications is around 3500 FPM. Without adequate ventilation velocity, not only will the parts remain covered by a layer of dust, but will also result in the blast machine operating with dust visually escaping from the cabinet and other areas— neither a desirable nor an acceptable outcome.

A significant percentage of aerospace components are manufactured from aluminum, titanium, magnesium, and such exotic alloys that could potentially generate explosive dust when impacted with media. Therefore, ventilation design in machines processing such components is extremely critical. Ventilation velocity requirement is higher with a minimum 4500 FPM along with several additional requirements to handle explosive dust safely. Dust collectors handling such dust are equipped with explosion vents, fire-retardant cartridges, sprinklers, and rotary airlock valves that continuously discharge the collected dust from the hopper. Ventilation ducting is provided with inspection ports and fitted with a no-return valve to prevent the possibility of the dust collector fire backtracking to the blast machine.

Fire and explosive dust

Proper design of the ventilation system and dust collector for dust with explosive tendencies starts with analyzing the dust for its Kst and Pmax values. The explosion severity is categorized as Pmax (measurement of maximum pressure that the dust could exert when exploding in a closed space). Kst value of a dust indicates the relative severity of a dust explosion when compared to other types of dust. Other factors that will be revealed during dust analysis are MIE (Minimum Ignition Energy), which is the lowest amount of heat or energy that could cause your dust to ignite, and MEC (Minimum Explosive Concentration), which is the smallest amount of dust in the air that will ignite and cause an explosion.

These are factors that dust collector manufacturers will consider when calculating the deflagration venting area required for your dust. Deflagration or explosion venting is like the rupture disk in a furnace, which releases excessive amounts of energy (generated during an explosion) by rupturing the explosion vent. If your dust collector is located outdoors, you will need to provide a controlled perimeter to prevent pedestrian access around the collector. If your machine happens to be at the center of your facility without easy access to the outside, and the collector can only be located indoors, your explosion/deflagration vent needs to be further protected by flameless venting which allows for the controlled explosion to take place inside the flameless vent.

In addition to all the above, your insurance company will likely stipulate the make and type of components to be used along with an approval requirement on the final design. In summary, ventilating dust that could catch fire or explode requires careful attention.

Ventilation and media reclaim

Our discussion above mainly referenced ventilation for the primary purpose of dust evacuation from the cabinet. However, in airblast machines that generate low volumes of metallic media flow or non-metallic media such as glass bead, ceramic, or aluminum oxide (such as in grit blasting applications), media reclaim is accomplished using vacuum reclaim systems.

The exhaust fan (sometimes referred to as the blower) generates the volume and static pressure to evacuate the cabinet and pneumatically transport media from the cabinet reclaim hopper to a cyclone reclaimer that separates usable media from the dust which is finally sent to the dust collector.

The static requirement of this system is dependent on several factor such as (a) type of media being conveyed, with metallic particles requiring more effort to transport, (b) the length through which it needs to be transported, (c) diameter and routing of the duct—with the addition of elbows contributing to the static requirements. Precise calculation of the static pressure is important for power sizing of the exhaust fan motor.

Most cyclone reclaimers are designed with tuning capability that allow pressure balancing inside the unit to cater to different media types and sizes—the goal being the separation of dust to the collector and retention of useful media within the system. The above is true for blast cabinets and automated airblast machines with a finite physical volume in the range of 6'-7' cube.

Manual airblast rooms that are larger in physical volume than specified above follow a different ventilation path. Manual airblast rooms may be designed with a vacuum reclaim system where the operator sweeps up or by some means directs the spent abrasive into a suction point such as in a corner of the room, or along a hopper across the width of the room. The suction required to move this media through the reclaim system components described earlier is provided by a dedicated exhaust fan and dust collector. This is in the tune of no more than 1000 CFM. However, this unit is not responsible, or capable of ventilating the entire blast room.

Room ventilation is governed by ACGIH (American Conference of General Industrial Hygienists). Commonly accepted practices dictate a ventilation velocity of 50 FPM cross draught through the blast room. This means that ventilating a room with a cross-section of 10′ x 10′ will require 10' x 10' x 50 FPM = 5000 CFM of ventilation volume that the exhaust fan should be able to generate. Such rooms are designed with air inlets that will allow the entry of fresh air into the room. Vent plenums, complete with baffles are provided at the end opposite to the air inlets to facilitate ventilation of dirty air after it has picked up dust in its travel across the cross-section of the room. Room ventilation will also include the air volume from ventilating reclaim system components including bucket elevators and airwash separators with fixed volumes based on the manufacturer's design standards.

ACGIH uses a criterion for ventilation requirements of smaller cabinets where the operator accesses the inside through a handhole while stationed outside the cabinet. Due to their reduced physical volume, a minimum air changes per minute model is used to calculate the ventilation volume. For example, a cabinet with a physical volume of 125 cubic feet will be subject to say five air changes per minute which brings the total ventilation volume requirements to 125 x 5 = 625 CFM.

Ventilation in wheelblast machines

Ventilation requirements for wheelblast machines are structured as follows:

1. The first step is to determine the duty condition. Heavy-duty cleaning involves castings (removing sand), forgings (heavy descaling), rust and paint. Medium-duty cleaning consists of cleaning structural steel, prefabricated weldments, and new steel with mill scale. Shot peening is categorized as light-duty. As we know, if you are removing material from the component being peened, you are not doing it right. Peening requires the part to be clean, else you are peening the layer of scale or another contaminant and not the component.

2. Step 2 is the volume generated by the type of cabinet such as a batch style car table room, spinner hanger, continuous travel style, etc., with each style presenting its unique ventilation requirements. The calculation for a large car table style room is as described in an earlier section for manual airblast rooms.
3. Step 2a is for cabinet styles such as spinner hangers and those with a pass-through configuration. The blast wheel HP is used as a reference when determining ventilation volume for such designs. For example, the ventilation volume for a pass-through cabinet with 4 x 30 HP wheels for a light-duty application is determined as: First wheel: 1000 CFM (determined and adopted based on field data), second wheel: 600 CFM, followed by 300 CFM for each additional wheel—in our example that would be 2 x 300 = 600 CFM for a total of 1000+600+600 = 2200 CFM. To put this in perspective, the same cabinet would require 2000+1200+1600 = 4800 CFM had this been a heavy-duty cleaning application as in cleaning sand from castings. Multiplying factors are applied for wheel HPs below or above 30 HP. In case you are wondering about the source of these volumes, I have used the example from the design standards of a well-known blast machine manufacturer to help explain the concept. Every manufacturer has their own standards for designing their machine's ventilation requirements.
4. Step 3 is to determine ventilation volumes from reclaim system components such as bucket elevator housings and airwash separators. These requirements are volume-based and directly proportional to the quantity of abrasive being propelled by the blast wheel(s). For example, consider the same machine as used in our earlier illustration. Let us assume that each wheel flows 400 lb/min of media. This adds up to 1600 lb/min. The airwash separator sizing is determined by a conservative recommendation of 40 lb/inch of lip. Therefore, this machine will be best served by a 40" airwash separator. The ventilation requirement for a 40" airwash separator operating light-duty is 500 CFM, which gets added to total ventilation volume.
5. Similarly, other auxiliary units such as the blow-off, touch-up cabinets, etc., contribute to the total volume required to be ventilated from the blast machine.

Issues in ventilation

Some of the common issues I have seen designers and users struggle with over the years:

- Insufficient ventilation volume – this will result in inadequate cabinet ventilation. This could be due to a fundamental mistake in not following norms when calculating ventilation requirements.
- Insufficient static pressure – this could be due to re-location of the dust collector after the initial installation calculations, additional elbows and anything that increases resistance to free flow of ventilation air.
- Not accounting for high dust loading. This leads to diminished life of filter media (cartridges, bags, etc.)
- Inspection of ventilation ductwork – dust and abrasive/media will collect inside the ductwork and should be regularly cleaned out. Inspection ports are required at defined intervals to facilitate this activity. Such accumulations will not only impede air flow but also pose a significant safety hazard to personnel working directly below the ductwork.
- Blast gates (dampers) not inspected regularly—gates could be worn or closed shut due to machine vibration. Insufficient openings or wide-open gates will affect system ventilation.

Conclusion

Our discussion here is a top-level summary of ventilation requirements in a blast machine. Each element identified here deserves its own discussion, such as vent plenum design, use of pre-collectors, velocity tuning using blast gates to retain good media within the machine and so on. I look forward to continuing this discussion at a future date and trust that this provides impetus for you to examine the system with which you are currently working.