AIRFLOW SCIENCES CORPORATION

The Airflow Update

Spring 2022

CFD Modeling Develops an HVAC Solution for an Abrasive Blasting Room

By: Kanthan Rajendran, P.E.

Airflow Sciences Corporation (ASC) recently collaborated with Nederman Canada to evaluate, assess and improve the design of a ventilation system for a sandblasting operation. The end customer performs cleaning and paint preparation activities on large road vehicles such as semi tankers and trailers. They were experiencing poor dust collection inside the building, leading to safety and visibility issues.

Nederman was contracted to design and supply the ventilation system ductwork and the dust collection equipment. By following ASHRAE design practices, the duct system pressure drop and flow balance were optimized by Nederman personnel. ASC was contracted to perform a Computational Fluid Dynamics (CFD) model of the building interior, which provided a clear understanding of the velocity patterns, ventilation quality, dead air zones, and particulate flow behavior in the room. The final design of the supply and return air ductwork was developed via ASC using the CFD model.

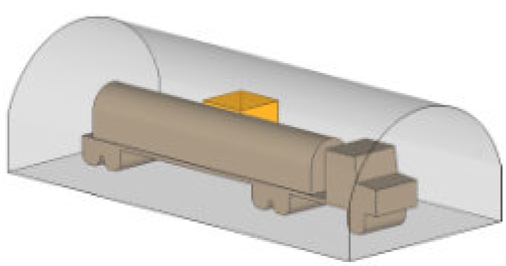

Figure 1: Overview of the sandblasting building

Staff News

A special congratulations is in order for Kim Charette as she reached a major career milestone of being with ASC for 40 years. We appreciate everything she's done and continues to do for Airflow Sciences!

We are thrilled to have two new interns in the office. John Olar is a senior at Walsh College and is our new marketing intern. Logan Szajnecki, Engineering Intern, is a graduate student at Ohio State University where he is studying Aerospace Engineering. It's going to be a great summer having them around.

Congrats to Jacob Morrida on the birth of his daughter, Veronica, this year!

Edited by Courtenay Coleman

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The CAD geometry and photo of Figure 1 provide an overview of the sandblasting building. The overall dimensions of the building are 72ft long x 32ft wide x 20.5 ft high in the center of the domed roof (22m x 9.8m x 6.2m). The side walls are 8ft (2.4m) high. The photos of Figure 2 show the interior during a blasting operation, where a haze of suspended dust is present along with accumulation on the floor and horizontal surfaces.

Figure 2: Interior during a blasting operation

CFD Modeling Details

The CFD analysis evaluated a variety of ventilation system options to determine the arrangement that provides the cleanest operating environment. Each design concept was compared with respect to the air flow patterns, residence time of suspended dust inside the building, and pressure drop.

The design of the ventilation system involved three key elements:

- Air supply ducts which provide clean air to the room. These were located above the vehicle near the roof of the building, emitting air downward to control dust dispersion.
- Intake hoods, located near ground level, connected to a suction fan. Air and dust from the room are drawn into the hoods to clear the room of suspended dust particles.
- A dust collector which is located outside the building. Air and dust drawn through the intake hoods travel through exhaust ducts to the dust collector. Clean air exits the dust collector, goes through the fan, and is recirculated back to the room through the supply ducts.

A typical conventional duct system is shown in Figure 3. The supply ducts are located at the ceiling and the intake hoods are at different heights above the floor. The connecting ductwork from the dust collector are omitted for clarity. Figure 4 shows an alternative design concept that was analyzed, with a full-length perforated supply duct featuring hundreds of small air entry jets .

The supply fan provided a flow rate of 10,000 CFM (283 m^3/hr). This was divided up equally to the different ductwork inlets for each design. Another 2,000 CFM (57 m^3/hr) was introduced from the sand blast gun, with an initial velocity of 8,000 fpm (40 m/s). The location and direction of the sand blast gun injection is variable during actual operation. Several positions were evaluated with the model to obtain representative results.

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In addition to injecting air flow, the sand flow was simulated exiting the gun, dispersing in the air, and being drawn into the intake ducts. Tracking of the flow injected by the sand blast gun was therefore a key part of the CFD modeling. The best ventilation system design would seek to minimize the residence time of suspended particles, drawing them through the intakes and to the dust collector in a uniform and efficient manner.

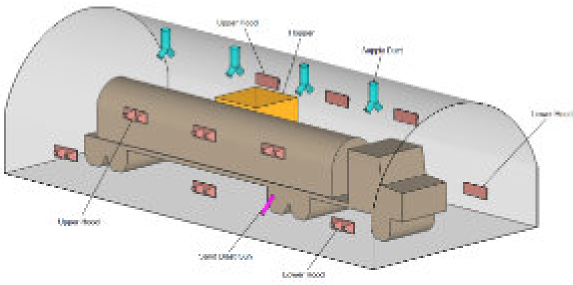

Figure 3: Conventional duct system

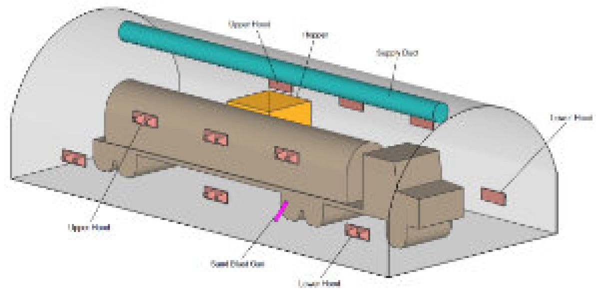

Figure 4: Alternative design concept

There are 6 intake hoods located along each side of the building, for a total of 12 intake hoods (shown in Figures 3 & 4). Flow is drawn from the room, through these intakes, to a dust collector (Figure 5), and to the fan. The air is then recirculated back to the building, entering through the supply ducts.

Figure 5: Dust collector

The primary purpose of the CFD modeling was to assess the effectiveness of the ventilation system. In addition to evaluating the velocity patterns in the building, the residence time of the sandblast gun discharge was calculated throughout the model domain. The model thus identifies how varying flow patterns in different areas of the building can affect residence time. For example, residence times can be much longer than average in regions of stagnant or recirculating flow, while residence times are shorter than average in regions where short-circuiting is occurring. Ideally, the residence time would be uniform throughout the entire building.

Results

Initial simulations with the conventional duct design showed non-uniform flow patterns due to the higher velocity jets exiting the supply duct. The design activity then focused on the full-length perforated duct concept. Example CFD results are depicted in Figure 6 for this design. Flow pathlines are shown emanating from the supply ductwork, flowing through the room, and being drawn into the intake hoods. The supply air, with its many injection points, is well dispersed over the length of the building with this concept, allowing for more uniform flow patterns.

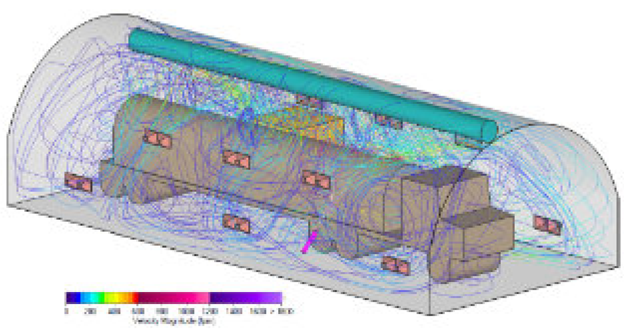

Figure 6: CFD results from the alternative design

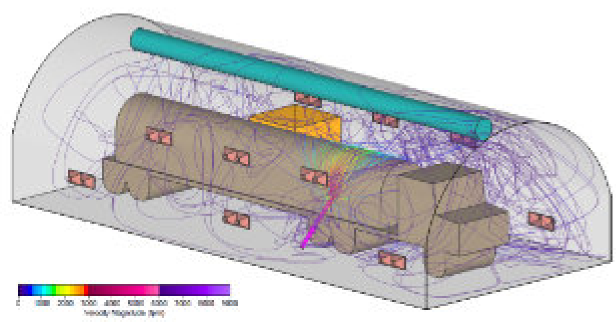

Figure 7: CFD pathlines emanating from the sandblasting

Figure 7 presents flow paths starting from the sandblasting gun. The very high velocity air and dust impact the tanker and slide along the surface. Some larger particles will drop to the floor, but very fine particles will stay suspended, traveling with the air, and eventually be drawn into the hoods. Minimizing this residence time, by avoiding dead air spaces, was a primary design goal.

Figure 8 quantifies the residence time of sandblast air/dust in the room. These contour plots depict the time for the air/dust to travel within the room before being drawn into the intake hoods. This value is also called "age of air" by HVAC engineers. The goal of the project was to provide the lowest and most uniform residence time throughout the building. The full-length duct design concept resulted in the best performance to minimize the suspended dust.

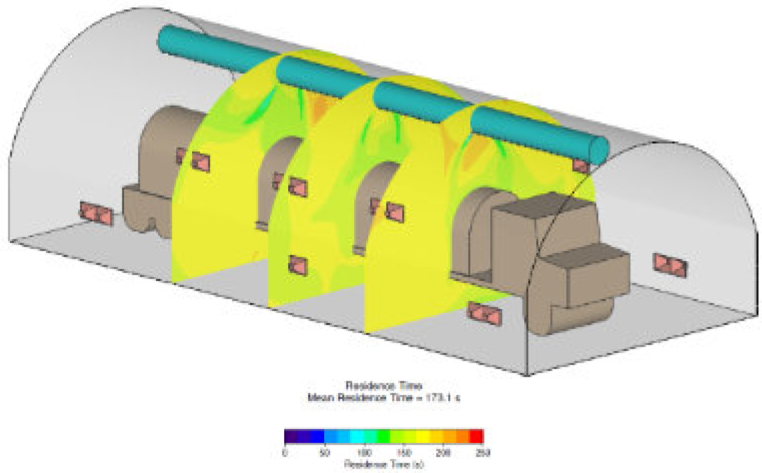

Figure 8: Residence time of sandblast air/dust in the room

Final Installation

The final optimized design featured 2 full-length perforated supply ducts, as shown in Figure 9. These were connected to 2 fans and dust collectors for redundancy and operating flexibility. Some of the 12 intake hoods that draw the air/dust from the building are also shown in Figure 9.

Figure 9: Final optimized design with 2 full-length perforated supply ducts

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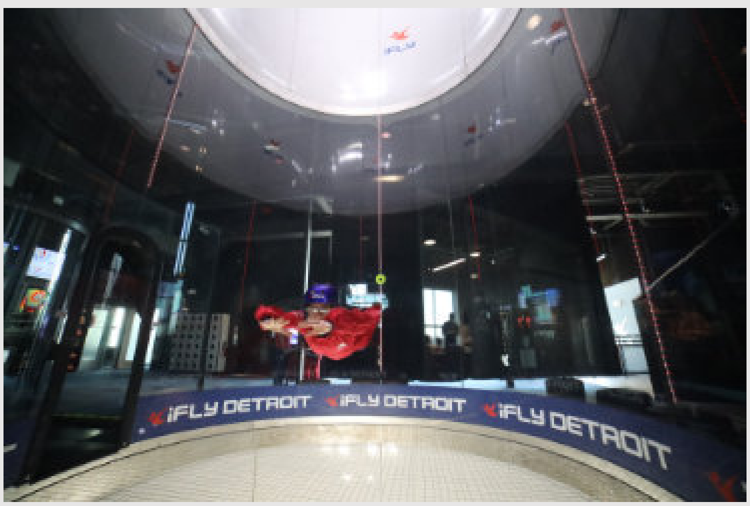
The customer has been operating the sandblast building with the new HVAC system for over 2 years and reports that the new installation resulted in a night and day difference -- they can now see clearly from the front of the shop to the back when sand blasting is taking place.

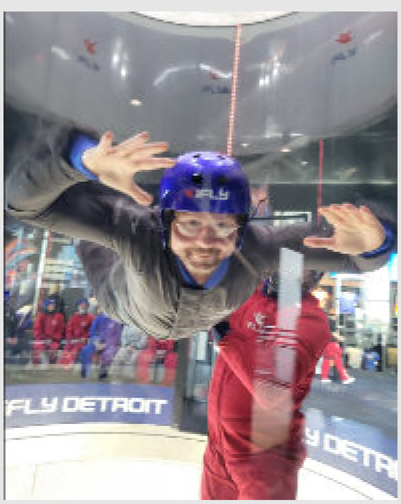
Questions?

The authors would be pleased to answer any questions about this type of CFD modeling and design. Please send any inquiries to engineering@airflowsciences.com.

ASC Visits iFly

We recently got to check out the vertical wind tunnel at iFly Detroit. Enjoy these photos of ASC staff flying!





Flow Modeling for Cryptocurrency Mining

By: Dr. Kevin Linfield, P.E., P.ENG.

Bitcoin. Ethereum. Dogecoin. Tether. Do flow engineers care about crytocurrencies? YES! But... maybe not in the way you are thinking. Ponder data centers, clean rooms, grow rooms, and warehouses. The HVAC systems for all of these facilities are extremely complex and require very specific temperature and humidity control. The same cooling requirements apply to data miners for various cryptocurrencies. Whether you are utilizing thousands of GPUs for Bitcoins or CPUs for Bytecoin, the power required, and hence the heat released, is enormous.

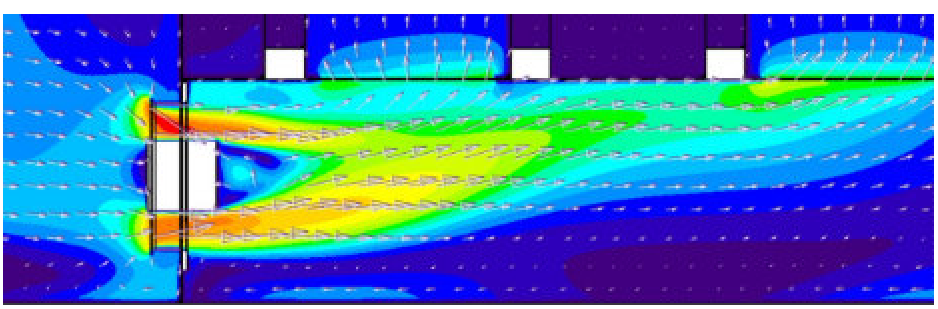
Racks of miners produce a significant amount of heat

Even with 2022's market volatility, as of June 2022 the global crypo market cap is US$983 billion. Number-crunching "mining" facilities are taking over former industrial spaces. And all of these systems need flow modeling to ensure the heat buildup doesn't cause these miners to shut down. Proper cooling is crucial to efficiently mine cryptocurrencies.

Whether air or liquid cooled, this heat has to be removed quickly and efficiently so these computers can continue to run as fast as possible. As the temperatures increase, the hashrate goes down. Overheating electronics and processing units lead to automatic shutdowns, and if these machines are not cranking, money is not being made.

Internal Flows

Data miners such as the Bitmain S19 are often housed in former industrial buildings, warehouses, or even transformed shipping containers. The latter, often called Pods or Mining Containers, feature some HVAC challenges that benefit greatly from flow modeling. Often, in all of these facilities, outside air is drawn in through hoods or louvers (featuring air filters), conditioned (if necessary), circulated through the miners, and exhausted from the room via fans and vents. The purpose of flow modeling is to help determine whether there are areas within the building that are likely to result in miner performance degradation. Using Computational Fluid Dynamic and laboratory modeling, ASC can examine the flow through and pressure drop across the banks of miners. Flow results are plotted and analyzed as contours of velocity, temperature, and pressure with the main goal to ensure adequate cooling throughout the miner banks. Sometimes layout changes are required. Other times, changes to the fans or HVAC ducts will mitigate hot spots.



Velocity contours inside an enclosure

Flow Modeling for Cryptocurrency Mining

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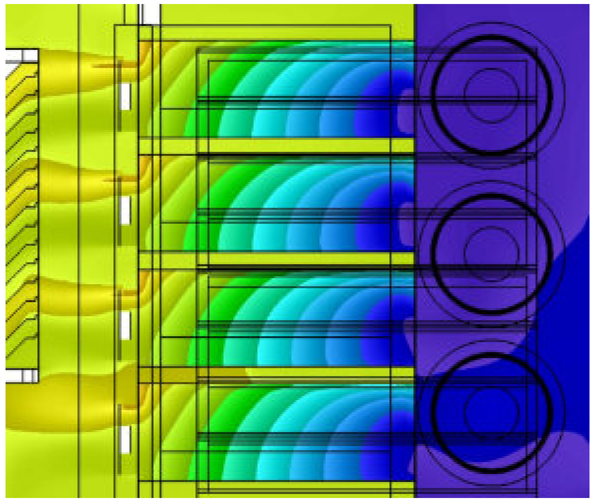

Temperature inside an enclosure

External Flows

Venting hot air from mining facilities is required, but companies need to pay attention to the resulting exhaust plume. Under certain conditions, hot exhaust air from one building will be drawn into the inlet of another building, reducing the cooling capacity and subsequently mining performance. Dispersion analysis for this type of situation can be performed using both computer and laboratory flow modeling techniques. The numerical approach, CFD, utilizes sophisticated software and high-speed computers to predict the flow patterns and mixing including velocities, pressures, temperatures, and exhaust gas re-ingestion. Laboratory modeling and wind tunnel testing are another technique for flow analysis and design. Large fans are used to direct flow over scale models of the buildings, while smoke injection, tracer gas injection, and other techniques are used to visualize and assess exhaust heat flow patterns.

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