

Case Studies

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Evaluation of a Local Exhaust Ventilation System for Controlling Refractory Ceramic Fibers During Disc Sanding

In 2002, the National Institute for Occupational Safety and Health (NIOSH) conducted an engineering control evaluation at an Ohio company that produced vacuum-formed ceramic fiber parts. The evaluation was conducted at the request of the company to examine the efficacy of a local exhaust ventilation system they had developed to capture and collect airborne refractory ceramic fibers (RCFs) during the sanding of vacuum-formed parts. This case study describes the process and evaluation methods and presents data that demonstrates dramatic reductions in airborne refractory ceramic fiber concentrations.

This is a small company that manufactures vacuum-formed ceramic fiber parts using RCF materials obtained from a vendor. At the time of the survey the company employed 67 workers; 50 worked in the plant and 17 worked in the office. The plant operates 3 shifts with most workers (34) on the first shift. The sanding area is staffed 24 hours a day by one worker. A second worker packs the final product for shipping.

The manufacture of RCF products comprises a number of tasks including: part forming; drying; and finishing, which involves sanding, sawing, or other processes according to customer specifications. The company purchases RCF in bulk and vacuum forms the material into various shapes according to customer specification. Brass-screened dies with perforated screen reinforcements are made to produce the variously shaped vacuum-formed RCF parts. The die is mounted on a dip machine that is operated by a foot pedal-activated control switch to lower the die into the ceramic fiber slurry tank. When the die reaches the bottom of the tank a limit switch is triggered and the vacuum is activated.

The dip machine operator sets a timer according to the part being formed. The timer activates a switch to remove the die from the slurry tank after the part has been formed. The part is then removed from the die by hand and placed on a tray that is placed on a conveyor belt that moves the parts to an oven for drying. After drying, the parts are transferred to the sanding station. All RCF parts are finished on the disc sander designed and fabricated by the company. Once sanded, the part is removed from the station, inspected, and packed into a cardboard tray for shipping.

PROCESS/ENGINEERING CONTROL DESCRIPTION

Disc Sander/Engineering Control Description

The disc sander is mounted on a pedestal to allow the worker to conveniently stand while sanding parts. The sander, which operates at a speed of 1150 revolutions per minute, uses a 20 inch diameter wheel with 50 grit zirconium abrasive. The disc sander was outfitted with a local exhaust ventilation (LEV) system (see Figures 1 and 2). An aluminum shroud encloses the entire disc with the exception of one small opening to allow access for parts to be sanded. Since the shroud opening is adjustable, parts of various dimensions can be sanded easily.

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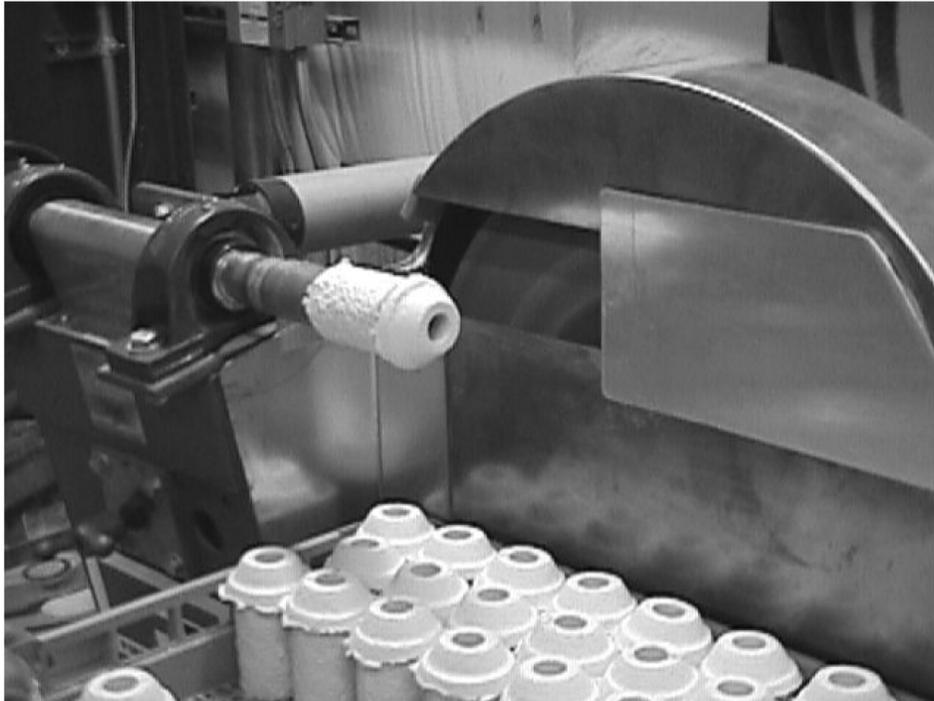


FIGURE 1. Disc sander with shroud and unsanded ceramic sleeve part

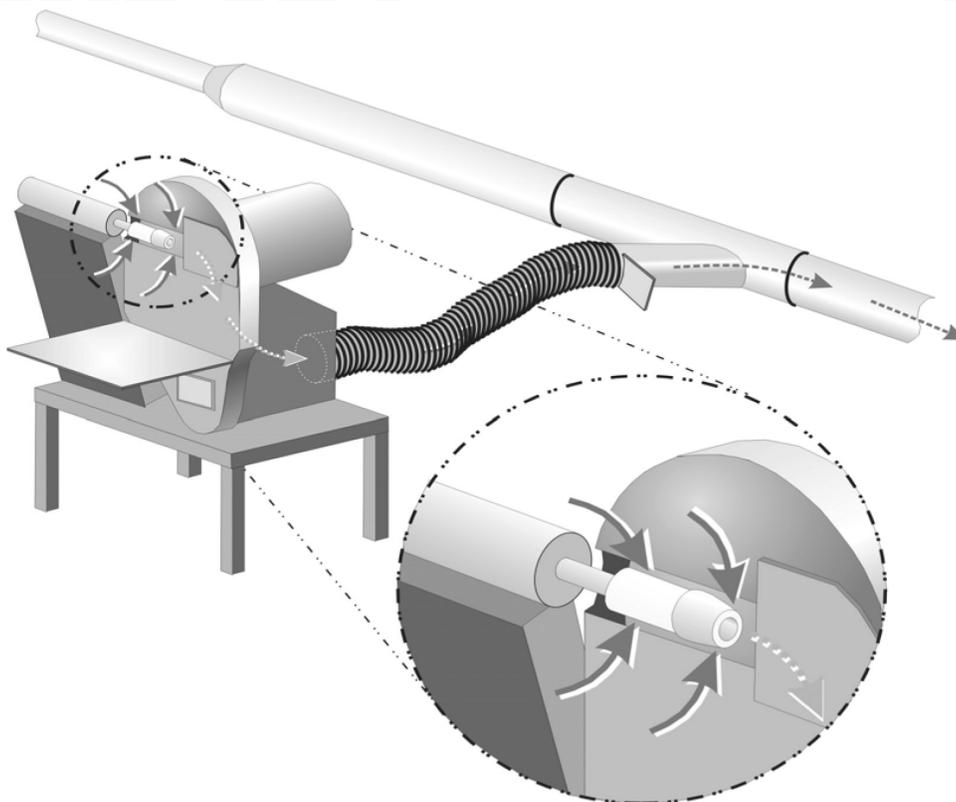


FIGURE 2. Sketch of disc sander with ventilation system details

A ventilation duct take-off is located on the lower rear of the sander and uses a 6-inch flexible duct that connects into a rigid aluminum main exhaust duct that also provides exhaust outlets for other workstations within the plant. A Pitot tube traverse was performed in the 6-inch rigid duct to determine the exhaust airflow rate for the shroud ventilation system. The velocity in the duct was 5400 feet per minute, which yielded an overall exhaust flow rate of 1060 cubic feet per minute.

The part used during the control evaluation was a ceramic fiber sleeve, approximately 2 inches in diameter and 4 inches long (Figure 1). Excess material formed during the die casting process was removed by sanding the part surface smooth to bring it to the specified dimension. This part is used in foundry operations to house and protect instrumentation used to test high temperature process parameters.

Process Description

The partially automated sanding process consists of:

1. Removing the unfinished part from a box and placing it on a spindle.
2. Activating a pneumatic air cylinder by a foot pedal, which causes the spindle to rotate and drives the part into the sanding wheel.
3. Sanding the part to the required dimensions.
4. Once the part is sanded, the spindle returns to its starting position and the part is removed from the spindle, packed by hand in a box for inspection, and shipped.

The cycle time controls the duration of the contact between the part and the sanding wheel. The operator can adjust the timer to allow the work to proceed at a comfortable and efficient pace. The cycle time used during the trial runs was 1.7 sec while the typical cycle time used by an experienced operator is 0.75 sec.

METHODS

Evaluation of the Effectiveness of the Control

Three trials were conducted both with the exhaust ventilation system on (control-on) and with the system off (control-off). The control-on trials were done before the control-off trials to minimize the effect of cross contamination between runs. The same operator was used in each trial to minimize the effect of human variation. Each control-on trial lasted for approximately 10 min allowing the operator to sand between 88 and 92 parts. The control-off runs were conducted after the first shift ended, when the work area was vacant. The duration for the control-off trials was reduced to 5 min (46 pieces) due to concerns that high airborne fiber release might lead to filter overloading. Following the completion of each run, the ventilation system was turned on and the area was cleaned using a HEPA vacuum to minimize contamination between runs.

Ambient air dust concentrations were monitored using a Met One, model 227B, handheld particle counter (Pacific Scientific Instruments, Grants Pass, Ore.). The Met One is an

optical particle counter that uses light scattering to measure and count particles. The dust from the process contains a mix of particles and fibers that may not be accurately sized due to the effect of fiber orientation on light scattering. Therefore, this instrument was used only to determine when gross area dust concentrations had reached background levels prior to initiating a new trial and not for control evaluation purposes.

PERSONAL AND AREA SAMPLING

Personal samples were collected using SKC Inc. Airchek 2000 model 210-2002 sampling pumps (Eighty Four, Pa.). Since concentrations were unknown, 2 personal samples were collected on the operator at flow rates of 2 and 3 L/min in order to collect a quantifiable amount of fibers while attempting to minimize possible filter overloading. An area sample located close to the process was collected at a flow rate of 15 L/min using a Gilian Aircon 2 high-volume air pump (West Caldwell, N.J.). Personal and area samples for fibers were collected on 25 mm diameter, mixed cellulose ester, 0.8- μ m pore size filters. The samplers consisted of three-piece cassettes with a 50-mm electrically conductive extension cowl. Samples were analyzed for fibers by phase contrast microscopy according to NIOSH Method 7400, "B" counting rules.⁽¹⁾

RESULTS

Table I contains the individual sample results. The differences between personal samples collected at each sample flow rate (2 or 3 L/min) were minor and did not affect the estimates of exposure reduction. The personal breathing zone (PBZ) average concentration decreased from 44 fibers/cubic centimeter (f/cc) with the control off to 0.35 f/cc with the control on. Figure 3 shows the average fiber concentrations

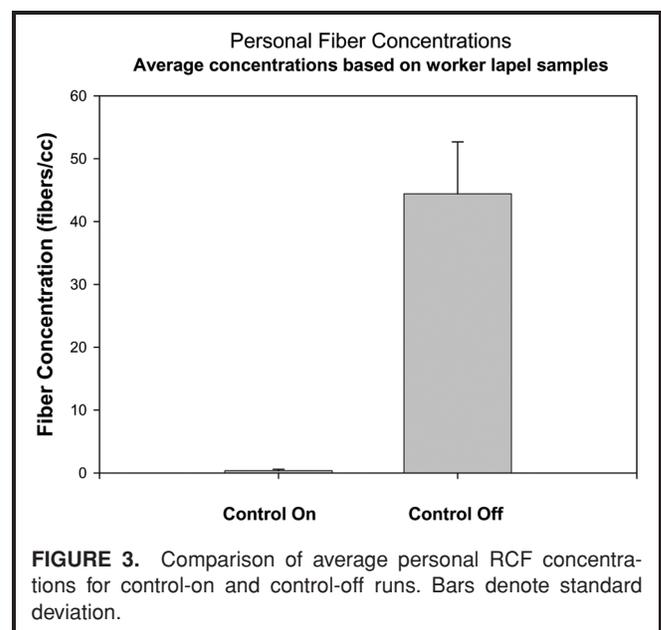


FIGURE 3. Comparison of average personal RCF concentrations for control-on and control-off runs. Bars denote standard deviation.

TABLE I. Airborne RCF Sample Results

Run Number	Control Status	Sample Location	Flow Rate (L/min)	Elapsed Time (min)	No. of Pieces Processed	Concentration (f/cc)
1	On	Lapel	2	10	88	0.65
1	On	Lapel	3	10	88	0.59
1	On	Area	15	10	88	0.36
2	On	Lapel	2	10.7	92	0.22
2	On	Lapel	3	10.7	92	0.28
2	On	Area	15	10.7	92	0.11
3	On	Lapel	2	9.5	92	0.22
3	On	Lapel	3	9.5	92	0.16
3	On	Area	15	9.5	92	0.12
4	Off	Lapel	2	4.3	46	37.92
4	Off	Lapel	3	4.3	46	35.28
4	Off	Area	15	4.3	46	Overloaded
5	Off	Lapel	2	4.4	46	50.20
5	Off	Lapel	3	4.4	46	36.99
5	Off	Area	15	4.4	46	Overloaded
6	Off	Lapel	2	4.3	46	53.05
6	Off	Lapel	3	4.3	46	Overloaded
6	Off	Area	15	4.3	46	Overloaded

measured on the lapel and the associated standard deviation for the control-on and control-off trials.

DISCUSSION

The pedestal disc sander operation is used frequently in RCF part processing to obtain a desired product dimension. In disc sanding, the surface of the RCF work piece is abraded to yield the proper profile. The friction between the wheel/belt and the work piece results in the release of particles and fibers. Those particles are ejected at high speeds along a path tangential to the rotation of the wheel. The respirable particles, if not captured, can be carried into the breathing zone of the worker resulting in exposure to the RCF fibers and dust particles.

The use of a nearly completely enclosing shroud along with an exhaust flow rate of approximately 1000 cfm resulted in a statistically significant reduction of at least 98% at a lower confidence interval of 95%. Following completion of the control-on trial runs, additional task length sampling revealed that a worker's PBZ exposure was 0.25 f/cc as determined over a 47-min sampling period (1440 parts processed) during standard operation (with control-on). This sample demonstrated that the control effectively reduced the fiber concentration in the PBZ even at higher production rates (30 ppm for this worker versus 9 ppm for the experimental runs).

The exhaust flow rate of 1000 cfm is higher than that specified by the *Industrial Ventilation Manual*, which recommends an exhaust flow rate of 550 cfm for an 18–26 inch diameter sanding disc (design plate VS-95-12).⁽²⁾ However, this system

was evaluated while other exhaust hoods, which are connected to the same exhaust fan, were not in operation. It is important to consider the impact of the reduced flow rates that will be encountered when multiple exhaust hoods are operating simultaneously. Reportedly, only one operation uses the ventilation system during a typical day. However, if more than one workstation requiring the use of the ventilation system is operated at the same time as the disc sanding operation, additional testing should be conducted. The use of more than one workstation at a time will reduce the airflow rate to each individual workstation and may result in reduced collection efficiency or inadequate duct transport velocity.

CONCLUSIONS AND RECOMMENDATIONS

Engineering controls that can significantly reduce operator exposure can be manufactured and installed on standard disc sanders. However, proper design and maintenance are keys to their effectiveness. Thorough system checks should be performed periodically to verify that the system is operating as designed. Those checks should include visual inspection of the work area and the ventilation system to detect any damage to the shroud or ducting. The work area should be kept clean and the ducts should be checked for settled fibers and dust. Fiber and dust buildup in the ducts are signs of inadequate transport velocity. Also, checks of static pressure and duct flow rates should be performed and compared with the values specified in the American Conference for Governmental Industrial Hygienists' *Ventilation Manual*.⁽²⁾

The most pertinent evaluation of system performance is the measurement of worker exposure. Worker exposure to RCF

materials should continue to be monitored on at least an annual basis to verify that the system continues to provide good control of airborne fibers.

The implementation of the LEV system described in this case study reduced operator exposure by two orders of magnitude. The development and testing of well-designed LEV control systems can provide valuable information to the large number of customers/end users of RCF materials.

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