HIGH VELOCITY, LOW VOLUME DUST CAPTURE DURING GRINDING USING PORTABLE TOOLS

Andrew A. Katko
Manager, Dust Control
Hoffman Air & Filtration Systems
Syracuse, New York

ABSTRACT

The high velocity, low volume dust capture method has been shown to be effective in controlling dust during chipping and grinding of castings using portable tools. Two inplace and functioning systems are described, as well as the ways that worker objections to use of the systems were overcome to the point where the workers don't want to perform their job without this dust control method in operation.

THREE IMPORTANT DESIGN FACTORS

Time does not permit me to go into the design aspects of a high velocity, low volume dust control system here. Suffice it to say that there are no magical formulae, etherial air quantities, or mystic knowledge necessary to design a successful high velocity, low volume system. A working system is made up of three separate but interrelated factors: engineering, common sense, and system compatibility. An explanation of the above can best be made by describing two working high velocity, low volume dust control systems in foundries and what went into their development.

THEORY OF OPERATION

The high velocity, low volume method of dust control is based on the principle of getting a small nozzle or a suction hood within 1.3 cm (one-half inch) of the source of dust generation. The air entering this nozzle must be moving fast enough to overcome the velocity of dust generation and effect capture of dust particles. This is the unique high velocity concept of picking up dust at the source. A velocity sufficient to do this is termed the capture velocity, defined as:

> Air velocity at any point in front of the nozzle or hood necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the hood.

Much of the dust that we attempt to capture is respirable (less than 10 micrometers in diameter) and capable of entering and being retained in the lungs. Many times this "culprit" is not visible unless it is spotlighted using a high intensity lamp, strong flashlight, or some similar lighting device. The remainder of the dust is usually visible to the naked eye and is made up of what we call heavy particles, which, although airborne, lose their velocity quite rapidly and fall to the floor at a short distance from the source. We are not nearly as concerned with heavy particles as we are with respirable dust. But a good hood design on a tool used by a sensible operator will eliminate the respirable dust and also a great majority of the "heavies".

HOOD DESCRIPTIONS

Before discussing the application of the high velocity, low volume dust capture method to the cleaning and finishing of castings, a few of the capture hoods that are used in those systems will be described.

Figure 1 shows a cone grinder hood which provides an equal distribution of exhaust all around the abrasive tool. The closeness of the hood to the tool is adjustable. In this as in all the other figures, the hose connections are shown but the hoses are not attached. This hood attaches to a 3.8cm (1.5 inch) diameter hose. The hood is sturdy enough for the worker to grip it in one hand and the tool itself in the other to give him better control in its use.

Figure 2 is a 15.2cm (6 inch) cupstone grinder; this hood takes a 5.1cm (2 inch) diameter hose. The hood on the chipping hammer in Figure 3 is not as awkward as it looks. This hood is used in the second example which follows. It takes a 3.8cm (1.5 inch) diameter hose and has rotational and axial adjustments.

It was necessary to construct the hood in this manner because the worker grips the chisel with one hand to properly guide the tool. The adjustability of the hood allows him to change bits readily, and to compensate for either a longer or shorter chipping chisel. Figure 4 shows a 17.8cm (7 inch) cut-off disc hood. Here the outer edge of the disc is used for cutting pieces off the casting, slicing bolts, etc. The four holes in the end of the hood are not for picking up dust, though they do capture some at that point. They are placed at that point to enable even air flow through the hood to prevent heavy spot wear. This tool takes a 5.1cm (2 inch) diameter hose. Figure 5 shows a 17.8cm (7 inch) grinder hood. Here the worker uses mainly the front bottom quarter of the tool. This hood also is adjustable to some extent to accommodate workers who grip the tool in slightly different fashions.

SYSTEM 1

Description of Problem

This foundry uses a standard coke-fired cupola operation to melt mixed foundry cast scrap in one heat a day, producing anywhere from 72-90 metric tons (80-100 T) of castings a day. The castings weigh between 272-1130kg (600-2500 lb) each.

The cleaning room in this facility is on a high volume, production line basis. Eight to ten workers are constantly grinding, chipping, and

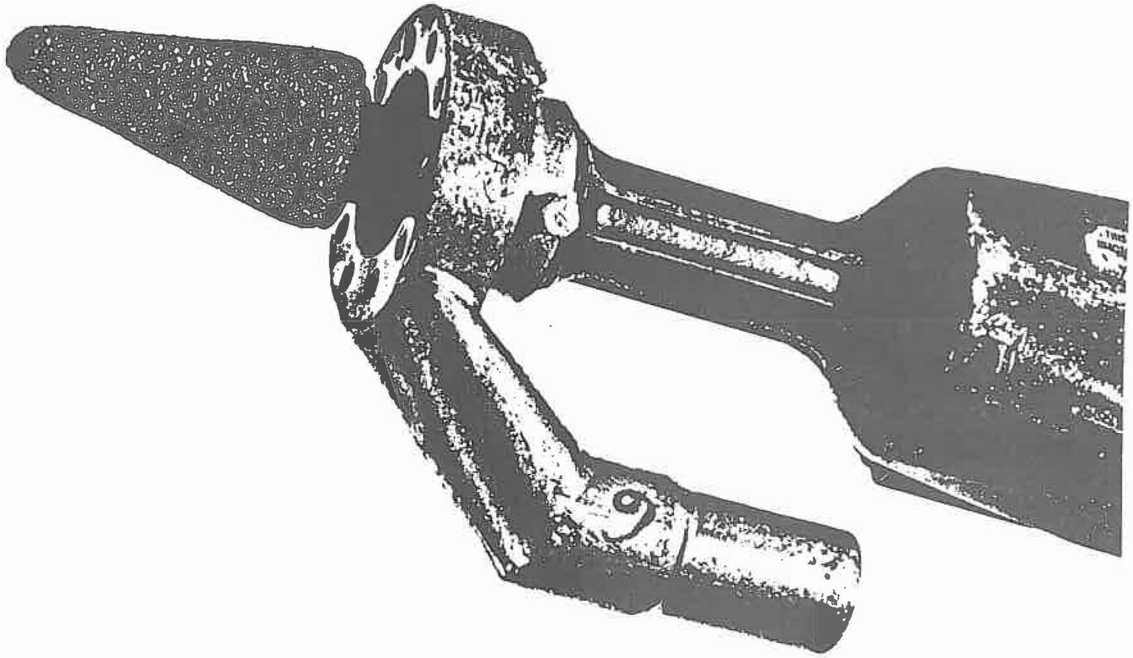

Figure 1. Cone grinder hood.

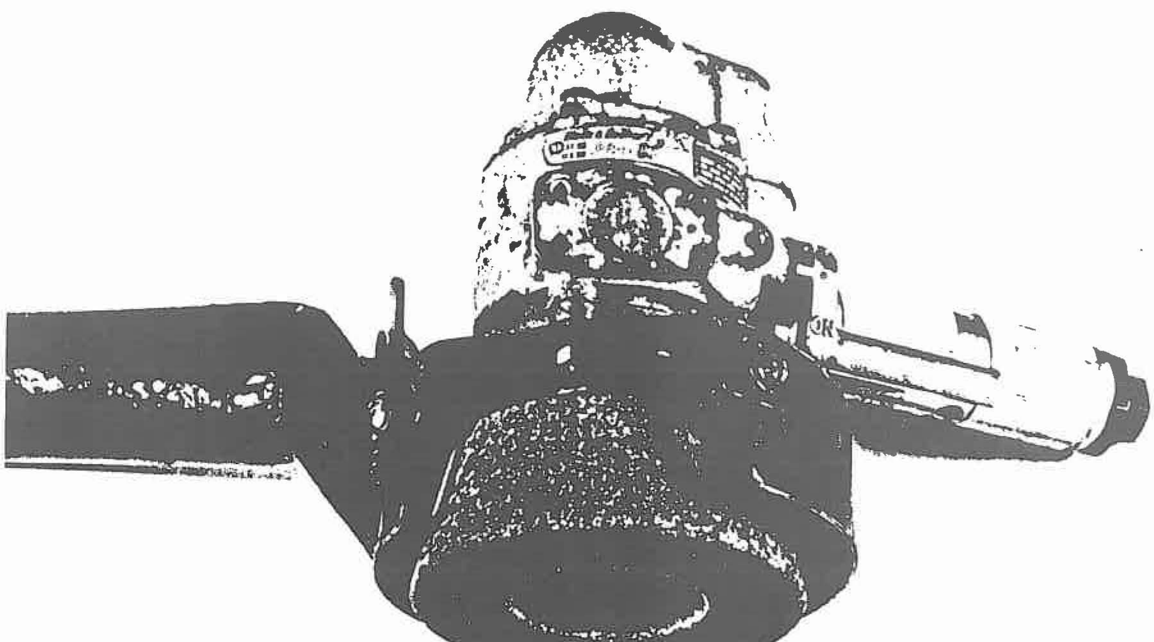

Figure 2. Cupstone grinder hood.

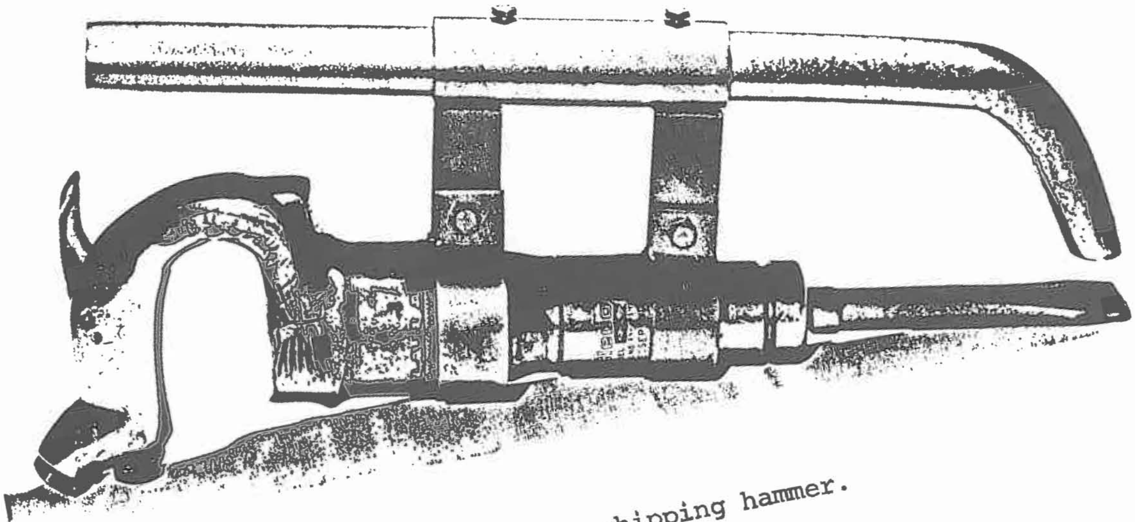

Figure 3. Hood on chipping hammer.

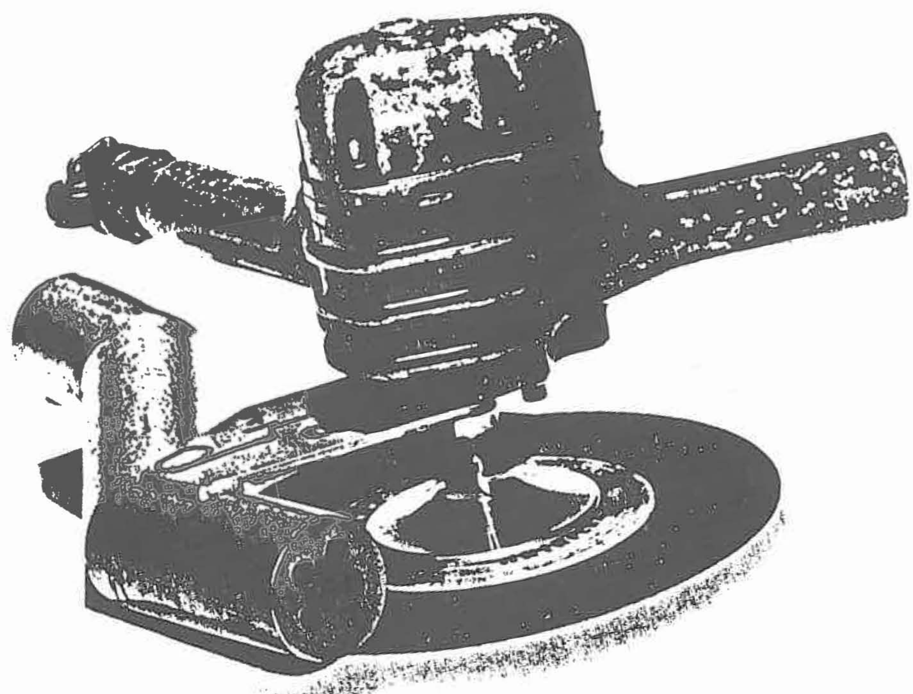

Figure 4. Cut-off disc hood.

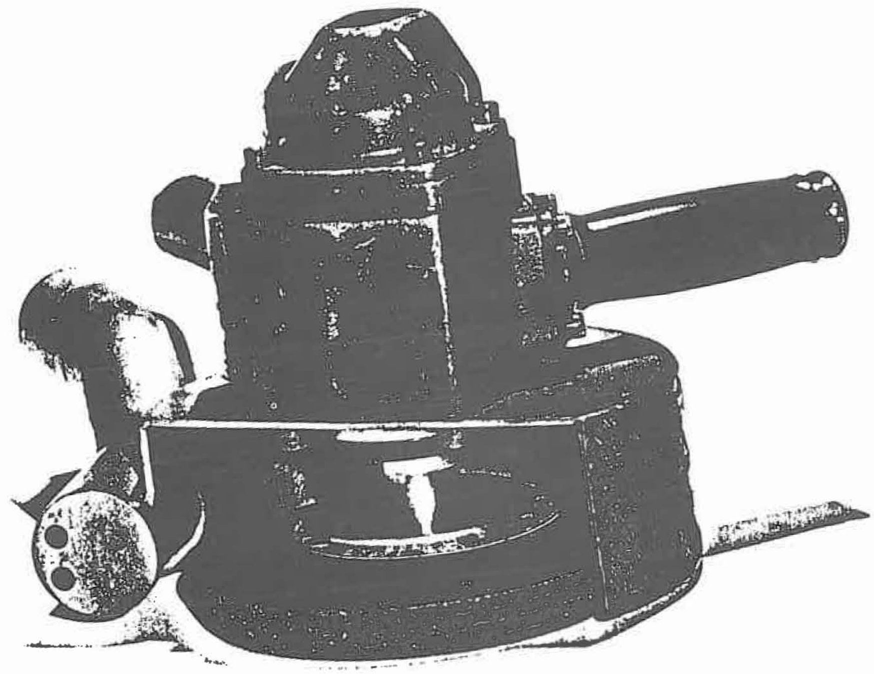

Figure 5. Disc grinder hood.

finishing these large castings. The room itself is approximately 12.2m (40 ft) wide by 18.2m(60 ft) long with a 6.1m (20 ft) ceiling. Before the system was put into operation, it was impossible to see from one end of the room to the other because of the dust. Other workers in the facility would carefully avoid this area when going from one section of the foundry to the other even though it meant a longer walk and sometimes going outside in the cold weather. When the system was originally designed, hoods were proposed for the cupstone grinder, chipping hammer, and the cone grinders. The 15.2cm (6 inch) cupstone grinders generate upwards of 80% of the dust in the area. Grinding dust generated by the use of the chipping hammers, cone grinders and the moving of the castings made up the remainder of the dust problem.

System Description

From our observation of the cleaning room process and our previous knowledge we designed a 15cm (6 inch) cupstone grinder hood to draw 340m^3/hr (200 cfm) and have a hood loss of 3.72cm Hg (1.5 inch Hg). The chipping hammer hood was designed for 220m^3/hr (130 cfm) and a 6.2cm Hg (2.5 inch Hg) loss. The cone grinder was designed for 255m^3/hr (150 cfm) and a 7cm Hg (2.8 in. Hg) loss. The exhaust hoses were fairly short in length averaging 3-3.6m (10-12 ft) long.

Due to the abrasiveness of the material that is picked up and the high transport velocities schedule 40 pipe was used with cast iron drainage fittings for the remainder of the ducting leading to the air cleaner. These fittings are easily replaced when worn and also have the advantage of ready access for cleaning. The heavy duty piping system is connected to a large Vacumatic separator which filters out approximately 0.76m^3 (27 ft^3) of iron dust in one week's operation. In this particular instance a separator with an extended shell length was used to give more than normal storage volume. No preseparator was necessary, however, the filtration section did contain heavy duty dacron bags and had an air to cloth ratio of approximately 6 to 1. The bags were cleaned by a pneumatically operated Vacumatic shaker which automatically shook the bags at a preset timed cycle.

This vacuum system was also used for reclaiming sand and for general casting cleanup throughout the facility.

Resolution of Operational Problems

The hoods furnished for the chipping hammer and the cone grinder did work satisfactorily but in a number of cases they prevented the worker from properly doing the job, requiring a design modification to be used in those special cases. It was necessary for the chipping hammer to get into long bolt holes some 25-30cm (10-12 inch) deep and no incumbrance could be tolerated around the shaft of the chipping chisel. The problem was solved very successfully by affixing a heavy duty magnet to the hose and placing the suction inlet off of the tool but very close to the vicinity where the chipping work was being done. The same method was used for the cone grinder.

Another early problem which was overcome was worker acceptance. The hose and the hood on the 15.2cm (6 inch) cupstone grinder did pose a handling problem to the workers at first; but within a very short period of time, they adapted to the situation after they realized the benefits they were receiving by using the dust control system. The workers had been told at the outset that they must use the system, that it was a necessary part of their jobs and, if they wished to retain their jobs, the system must be used. Strong words, yes, but words that paid off in the long run. After a few weeks of operation, the system was shut down for minor repairs and adjustments and the amount of grumbling and complaining while the system was down was something quite gratifying to hear.

Effect on Dust Levels

The main reason for the installation of the above system was to reduce the level of silica dust in the cleaning room to a level that would be acceptable to OSHA. After the system was installed and running for a few months, OSHA returned and found that what had been an intolerable workplace before, now met the OSHA requirements.

SYSTEM 2

The second system, at another foundry cleaning room operation, involved the use of chipping hammers, disc grinders, cut-off wheels and cone grinders on castings ranging from a few hundred kilograms to well over the ten metric ton range. All of these tools were fitted with high velocity, low volume exhaust hoods. The total high velocity, low volume dust control system consisted of two equal 56 kilowatt (75 hp) systems, each having its own separator and air cleaner with the storage shell volume increased as in the previous system. Each system was designed for 23cm Hg (9 inch Hg) of vacuum at approximately 3740m^3/hr (2200cfm) each. A modulating bleed system was installed to keep each of the centrifugal exhausters out of the surge range when only a few of the inlets were active.

One of the two systems was connected through a primary separator which is placed in the shot blast area of this foundry. Here the suction was used for retreiving the shot and depositing it in the primary separator for reuse. The rest of this high velocity, low volume dust control system was connected into the inlet of this preseparator. Both secondary separators and the exhausters were located outdoors and, as in the previous system, the bags were automatically shaken by the Vacumatic separator at frequent intervals to remove the accumulated dust.

The system was designed for 12 active inlets; at times there could be six operators on one casting. Accommodating this mode of operation necessitated the use of hoses around 7.5m (25 ft) long. In order to cut down the friction loss in the hose and still provide the flexibility of working freely on and around a large casting, as well as reducing the total horsepower required to operate the system, the 3.8cm (1.5 inch) hose attached to the chipping hammer or the cone grinder was connected to 5.5m (18 ft) of heavy duty 5.1cm (2 inch) hose which could be laid along the foundry floor. The larger hose resulted in a lower transport velocity and thus a lower friction loss through the additional hosing.

PREREQUISITES FOR A SUCCESSFUL DESIGN

Proper hood design is essential for the high velocity, low volume system to be effective. Before a dust control hood is designed and built, the use that the operator makes of the tool must be carefully evaluated, including how the tool is held, what portion of the tool is utilized for certain tasks and what types of castings are being processed.

The information compiled should be discussed with the operator and the supervisor including the effects that particular practices will have on the ability to capture toxic dusts. The purpose of the system should be explained in advance, as well as the personal benefits to the worker and the need for cooperation if the project is to be successful. No matter how well we engineer, design and install a system, if the operator is against it, it will never work properly.

The use of a high velocity, low volume system is not limited to hand held tools. Swing frame grinders, cut-off wheels, and pedestal grinders also lend themselves to this approach.

SYSTEM FLEXIBILITY

One must also take into consideration when evaluating the benefits of a high velocity, low volume dust control system that it also provides the foundry with a vacuum cleaner for housekeeping and maintenance.

In conclusion I would like to quote a foundry user of a high velocity, low volume system: "This system, in addition to increasing productivity, has a definite effect on product quality. With dust removal at the source, the workers have a clear unobstructed view of the work piece and they don't have to wear cumbersome dust respirators.

QUESTIONS, ANSWERS, AND COMMENTARY

Question (F. Boelter, OSHA):

I've heard many foundrymen say that the greatest problem with the HVLV system is it works fine on flat surfaces but doesn't work at all on curved surfaces. Can you respond to that?

Answer (A. Katko):

Yes. If you could construct the ideal hood, it would pick up everything if the surface of the workpiece is flat. When the surfaces to be cleaned are curved, some of the heavy particles will escape capture. If the tool is used properly and if it is the proper tool for the job then most of the heavy particles would be captured along with the respirable dust when working on curved surfaces.

In some foundries a single tool is used for three or four jobs. When this procedure is followed the tool may produce dust in a variety of ways which are difficult to control with a single hood technique.

I repeat, proper use of high velocity low volume hoods on portable tools requires that the right tool be used for each particular operation. When this is accomplished, worker acclimation to the hoods is simplified.

Question (J. Calhoun, White Consolidated Industries, Inc.):

Are you saying that the dust in the area is reduced or just the dust in the small sphere to which the worker is exposed?

Answer (A. Katko):

With each hood the dust in the area that the worker is working in is reduced. In the cleaning room, if there are seven or eight people working with tools with hoods on them, the area can be brought down within OSHA limits without any problems. Of course, there is other dust generated in the plant. Forklift traffic can cause substantial amounts of airborne dust. This and other sources besides the cleaning and finishing operation contribute to background dust levels.

Question (J. Calhoun):

Let's assume that the background dust level is well below the permissible exposure limit. Have tools with the high velocity, low volume devices been tested under such a condition on a pilot basis on the same day at the same location, some with and some without hoods, so that a direct measurement of this technique's effectiveness could be obtained?

Answer (A. Katko):

Yes. And it has been successful. We have done it in our own foundry and in our test lab.

When a high velocity, low volume system is installed after we have had a chance to survey the application right from the start, we will gurantee the results of the system. But, then, again, I think what's in everybody's mind is: I have a tool, can it work on mine? It may not. In one of the examples I just presented we had to take the hoods off some of the tools in that foundry and use a magnet to position the suction hose close to the point of dust generation to overcome an interference problem.

Question (R. Crane, Duraloy Blaw-Knox, Inc.):

I noticed in the examples the absence of what I call a horizontal grinder. Do you have any hood applications for that type of a grinder?

Answer (A. Katko):

Yes, quite a few on horizontal grinders, cone grinders and even radial wheel grinders.

Question (G. Cusamano, Aer-X-Dust Corp.):

Have you any sound level readings on that depressed center wheel in terms with that sharp cut-off on the air entry?

Answer (A. Katko):

No, we do not have sound level ratings on that specific tool. We do have them on others, which we've tested in our lab. We do not have sound ratings of tools out on the job.

Only once has someone come back to us because of a noise complaint and we fixed it. In most cases the noise is less than that generated by the tool without a hood.

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NIOSH Project Officer: Dennis O'Brien
Project Manager: Robert C. Scholz

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